MARINE ATLAS

MAXIMIZING BENEFITS FOR

SOLOMON ISLANDS

MACBIO

MARINE SPATIAL PLANNING

Marine Spatial Planning is an integrated and participatory planning process and tool that seeks to balance ecological, economic, and social objectives, aiming for sustainable marine resource use and prosperous blue economies.

The MACBIO project supports partner countries in collecting and analyzing spatial data on different types of current and future marine resource use, establishing a baseline for national sustainable development planning of oceans.

Aiming for integrated ocean management, marine spatial planning facilitates the sustainable use and conservation of marine and coastal ecosystems and habitats.

This atlas is part of MACBIO's support to its partner countries' marine spatial planning processes. These processes aim to balance uses with the need to effectively manage and protect the rich natural capital upon which those uses rely.

For a digital and interactive version of the Atlas and a copy of all reports and communication material please visit **www.macbio-pacific.info**

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AUTHORS: **Philipp Gassner, Levi Westerveld, Lysa Wini-Simeon, Rosalie Masu, Agnetha Vave-Karamui, Anja Nicolay-Grosse Hokamp, Miles Macmillan-Lawler, Kate Davey, Elaine Baker, Malcolm Clark, John Kaitu'u, Hans Wendt** and **Leanne Fernandes**

2019

MACBIO
Marine and Coastal Biodiversity Management in Pacific Island Countries

SPREP Secretariat of the Pacific Regional Environment Programme
IUCN
giz
On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

GRID ARENDAL

FOREWORD

While the ocean covers more than two thirds of the Earth's surface, the oceanic territory of Solomon Islands is more than 47 times larger than its land territory. With an exclusive economic zone (EEZ) of 1.34 million km^2, Solomon Islands is a large ocean state.

This island nation contains many marine ecosystems, from globally significant coral reefs to mangroves, seagrass areas, seamounts and deep-sea trenches supporting at least 1,019 fish species, including sharks and rays, as well as whales, dolphins and sea turtles. We are committed to conserving this unique marine biodiversity.

Solomon Islands' marine ecosystems are worth at least SI$2.6 billion per year—comparable to the country's total export value. We are strongly committed to sustaining these values to build an equitable and prosperous blue economy.

The country's history, culture, traditions and practices are strongly linked to the ocean and its biodiversity. By sharing and integrating traditional and scientific knowledge, we are navigating towards holistic marine resource management.

Traditionally, Solomon Islands' coastal villages manage inshore marine resources. We are striving to work together to sustainably manage all of Solomon Islands' coastal marine areas (traditional fishing grounds) for the benefit of empowered and resilient communities.

At the same time, Solomon Islands is experiencing the direct effects of climate change on its ocean and island environments.

By strengthening global partnerships, we are proudly taking leadership in climate change policy and global ocean governance. Further, through integrated and participatory planning, we are aiming to balance economic, ecological and social objectives in this EEZ for the benefit of current and future generations.

In doing so, we can maximize benefits from the ocean for Solomon Islands, its people and its economy.

This is where the Solomon Islands Marine Atlas comes into play. Improvements in research over the years have enabled us to better understand the ocean system and to develop solutions with a sustainable approach. A lot of data have become publicly available, with this atlas compiling over a hundred data sets from countless data providers to make this treasure trove of marine and coastal information accessible and usable for the first time—as maps with narratives, as data layers and as raw data.

In its three chapters the atlas sets out to illustrate:

- What values does the ocean provide to Solomon Islands, to support our wealth and well-being?
- How should we plan the uses of these ocean values and best address conflicts and threats?
- On what levels and in which ways can we manage uses of, and threats to, our marine values?

The atlas can help decision makers from all sectors appreciate the values of marine ecosystems and the importance of spatially planning the uses of these values.

Practitioners can assist these planning processes by using the accompanying data layers and raw data in their Geographic Information Systems.

While the atlas provides the best data currently publicly available, information about Solomon Islands' waters is constantly increasing. Therefore, the atlas is an open invitation to use, modify, combine and update the maps and underlying data.

Only by involving all stakeholders in a nationwide Marine Spatial Planning (MSP) process can we truly maximize benefits for Solomon Islands.

The e-copy and interactive version of the Solomon Islands Marine Atlas are available here: http://macbio-pacific.info/marine-atlas

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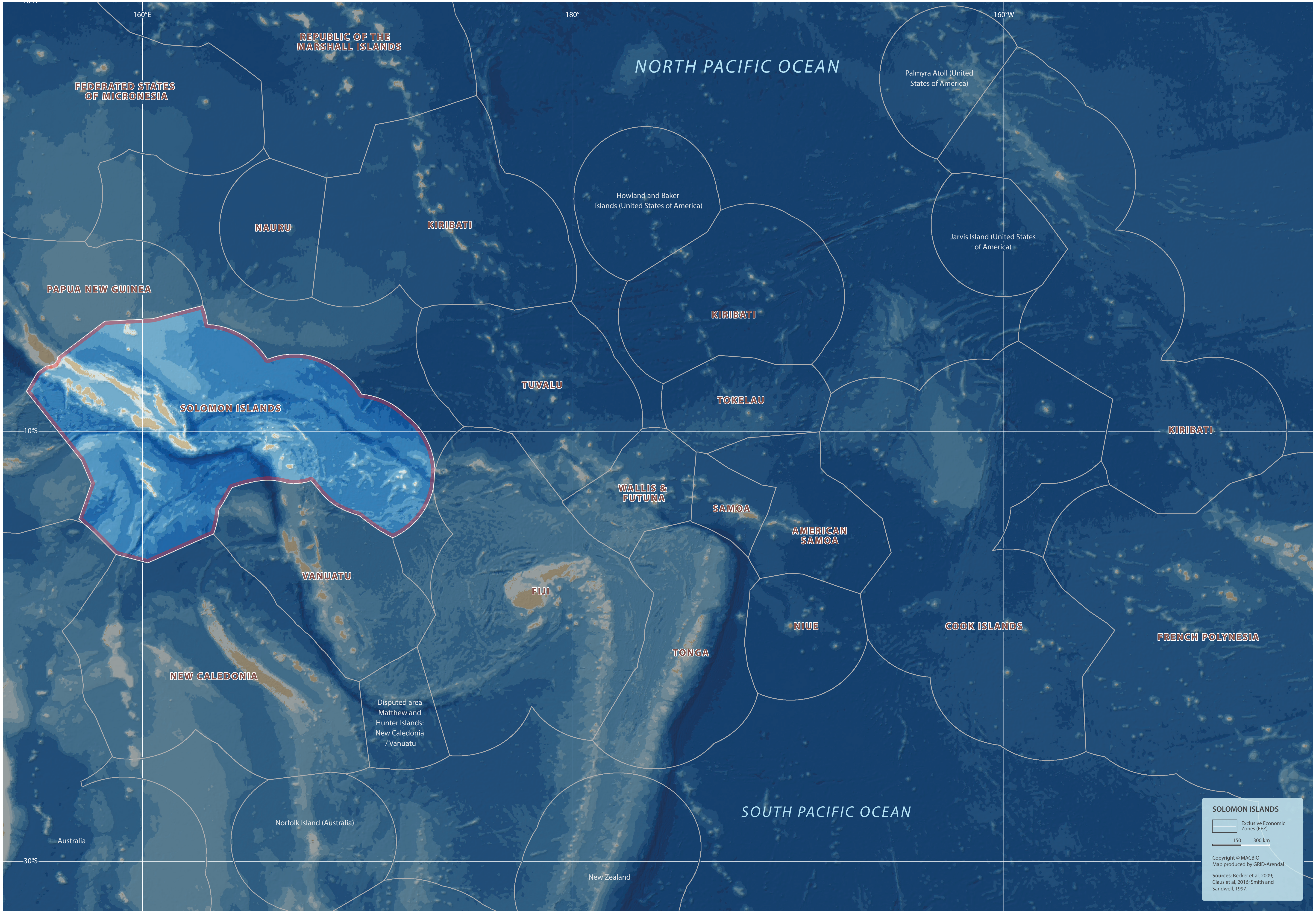
160°E
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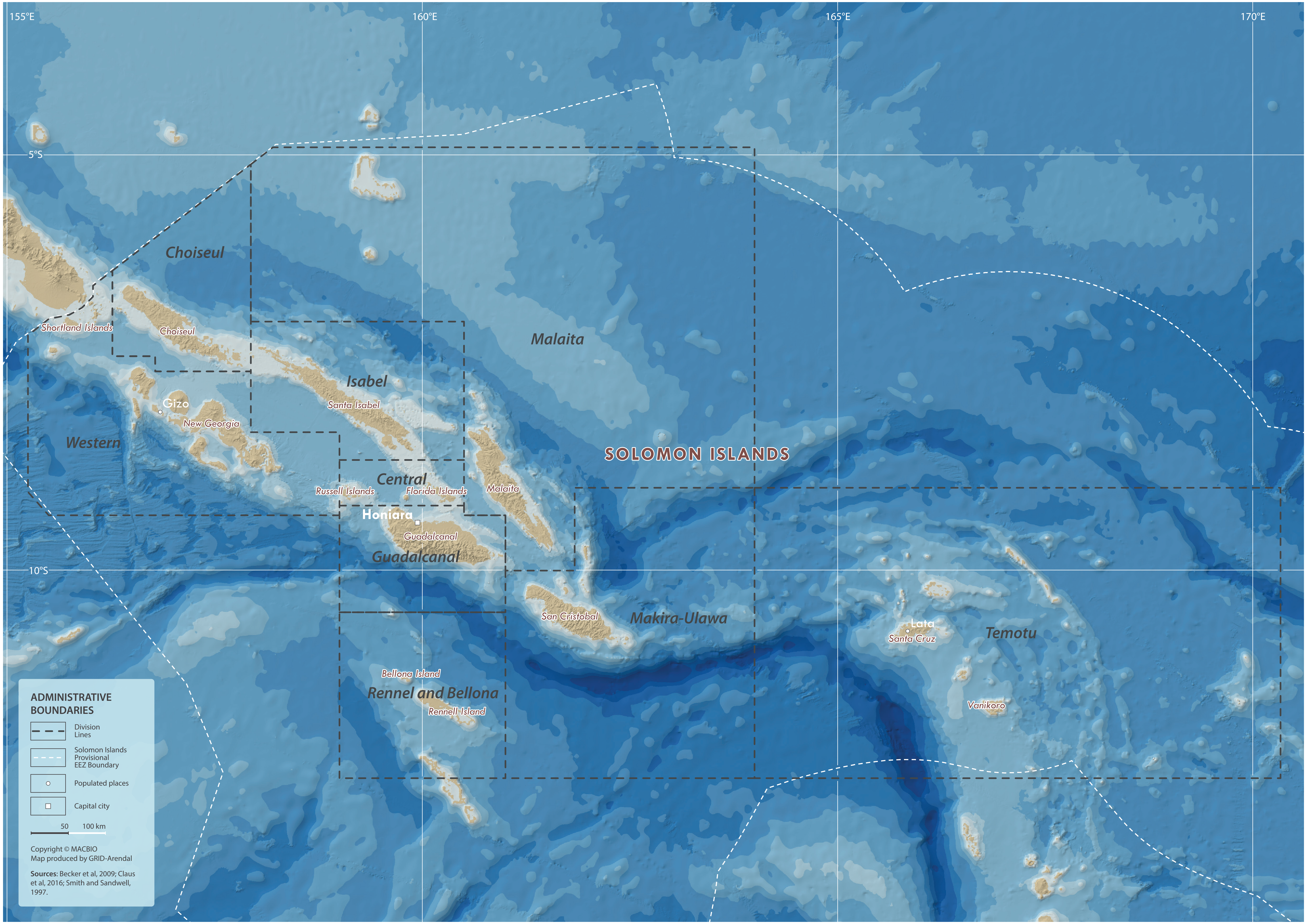
REPUBLIC OF THE MARSHALL ISLANDS
FEDERATED STATES OF MICRONESIA
NORTH PACIFIC OCEAN
Palmyra Atoll (United States of America)
Howland and Baker Islands (United States of America)
Jarvis Island (United States of America)
NAURU
KIRIBATI
PAPUA NEW GUINEA
KIRIBATI
SOLOMON ISLANDS
TUVALU
TOKELAU
KIRIBATI
WALLIS & FUTUNA
SAMOA
AMERICAN SAMOA
VANUATU
FIJI
NIUE
COOK ISLANDS
FRENCH POLYNESIA
TONGA
NEW CALEDONIA
Disputed area Matthew and Hunter Islands: New Caledonia / Vanuatu
Norfolk Island (Australia)
Australia
New Zealand
SOUTH PACIFIC OCEAN
SOLOMON ISLANDS
Exclusive Economic Zones (EEZ)
150
300 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Smith and Sandwell, 1997.


155°E
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Choiseul
Shortland Islands
Choiseul
Isabel
Santa Isabel
Malaita
Gizo
New Georgia
Western
SOLOMON ISLANDS
Central
Russell Islands
Florida Islands
Malaita
Honiara
Guadalcanal
Guadalcanal
San Cristobal
Makira-Ulawa
Lata
Santa Cruz
Temotu
Bellona Island
Rennel and Bellona
Rennell Island
Vanikoro
ADMINISTRATIVE BOUNDARIES
Division Lines
Solomon Islands Provisional EEZ Boundary
Populated places
Capital city
50
100 km
Copyright © MACBIO
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Sources: Becker et al, 2009; Claus et al, 2016; Smith and Sandwell, 1997.

A LARGE OCEAN STATE: ADMINISTRATION

Solomon Islands' ocean provides a wealth of services to the people of Solomon Islands, and beyond. The ocean and its resources govern daily life, livelihoods, food security, culture, economy and climate.

The South Pacific is a sea of islands (see previous map). While these Pacific Island countries are often referred to as small island states, the map shows that they are in fact large ocean states. Solomon Islands is the third largest island country in the Pacific after Papua New Guinea and Fiji. Solomon Islands' coastline is 9,880 kilometres and its provisional exclusive economic zone (EEZ) —at 1.34 million km^2—is the second largest in the Pacific.

Solomon Islands has a reef area of around 5,750 km^2 and a total mangrove area of 642 km^2. The country is composed of roughly 1,000 islands divided into nine provinces, each with a different environment, population density and culture. In addition to this heterogeneity, there are three levels of governance over the oceans: customary, provincial and national. Approximately 80 per cent of the country's total land area is customary land, which includes foreshores and reefs. This gives villagers control and ownership over such land, as well as rights to use its resources, which are acknowledged by authorities and in some national and provincial laws.

As regards local government, the country is divided into 10 administrative areas: nine provinces (administered by elected provincial assemblies) and one capital city, Honiara (administered by the Honiara Town Council). The provinces, as shown on the map, are: Choiseul, Guadalcanal, Isabel, Makira-Ulawa, Malaita, Rennell and Bellona, Temotu, Western and Central.

Special rights

An exclusive economic zone (EEZ) is a sea zone that extends up to 200 nautical miles (nmi) from a country's baseline. Solomon Islands' EEZ, prescribed by the United Nations Convention on the Law of the Sea (UNCLOS), gives Solomon Islands special rights regarding the exploration and use of marine resources below the surface of the sea. The territorial sea, within 12 nmi from the baseline, is regarded as the sovereign territory of Solomon Islands in which it has full authority.

On 7 July 1978, Solomon Islands gained independence from Britain. The country is a constitutional monarchy with Queen Elizabeth II as head of state, represented by the Governor-General who must be a national citizen. The Governor-General is elected by Parliament, as is the Prime Minister, who chooses Cabinet members. The Cabinet is responsible to the House of Assembly and is vested with executive power. The Governor-General appoints the Chief Justice of the Supreme Court on the advice of the Prime Minister and leader of the opposition. The unicameral National Parliament has 50 members, who are elected for a four-year term in single-seat constituencies. Since Solomon Islands has a multiparty system with numerous parties, it is uncommon for a single party to gain power alone. Parties must therefore work together to form coalition governments. Parliamentary representation is based on single-member constituencies and there is universal suffrage for citizens over 18 years of age.

Through this system, the government makes important decisions about their citizens, the country's economic development and the sustainable use of their abundant natural resources from both their land and ocean.

Given the large size and cultural significance of the ocean, Solomon Islands is considered one of the world's large ocean states.

VALUING

Marine ecosystems in Solomon Islands provide significant benefits to society, including nutrition and livelihoods for the people of Solomon Islands, the Pacific and around the world. Limited land resources and the dispersed and isolated nature of communities make the people of Solomon Islands heavily reliant upon the benefits of marine ecosystems.

These benefits, or ecosystem services, include a broad range of connections between the environment and human well-being and can be divided into four categories.

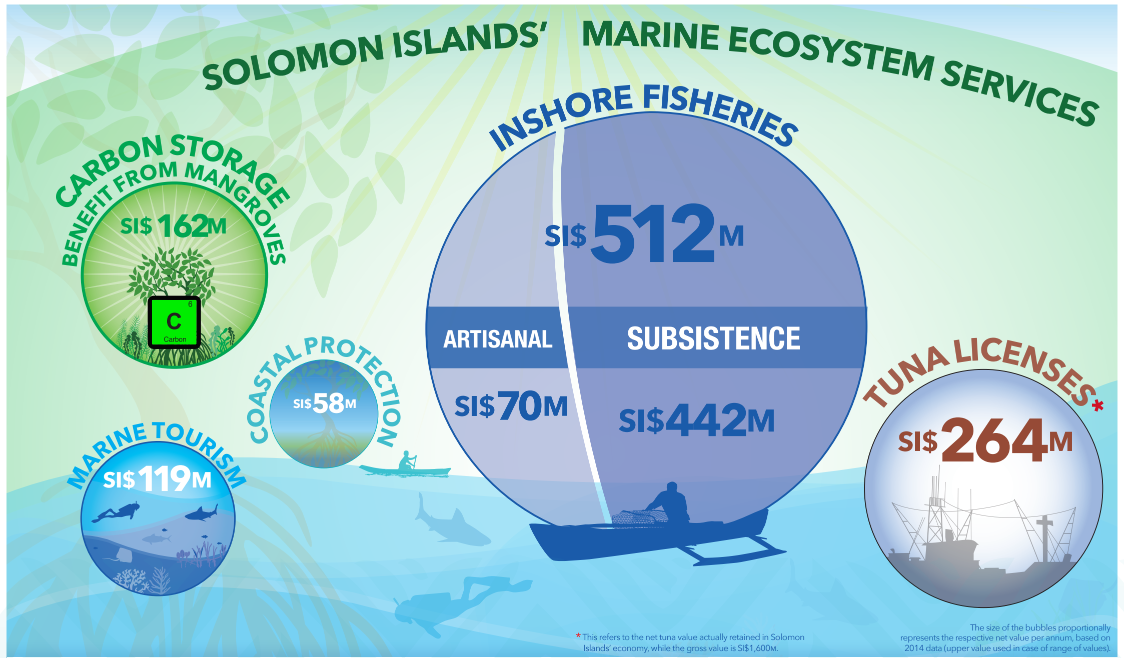
1. Provisioning services are products obtained from ecosystems (e.g. fish).
2. Regulating services are benefits obtained from the regulation of ecosystem processes (e.g. coastal protection).
3. Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (e.g. traditional fishing and traditional marine resource management systems).
4. Supporting services are necessary for the production of all other ecosystem services (e.g. nutrient cycling, biodiversity).

The maps in this chapter showcase, firstly, the biophysical prerequisites underpinning the rich values and benefits provided by marine ecosystems. These range from the volcanism at the depths of the ocean that formed the islands and atolls that now provide a home to many, to the prevailing flow of currents and the role of plankton in the ocean's life cycle, among many others.

Based on the combinations of biophysical conditions, the ocean provides a home to many different species, from coral-grazing parrotfish on the reefs to the strange and mysterious animals of the deep. These and many other species and the unique marine ecosystems on which they rely are featured in the maps to follow.

Appreciating the rich diversity of marine ecosystems helps in understanding their importance to Solomon Islands. Quantifying the benefits of marine ecosystems in the Pacific makes it easier to highlight and support appropriate use and sustainable management decisions. Despite the fact that more than 95 per cent of Pacific Island territory is ocean, the human benefits derived from marine and coastal ecosystems are often overlooked. For example, ecosystem services are usually not visible in business transactions or national economic accounts in Pacific Island countries. Assessments of the economic value of marine ecosystem services to Pacific Islanders can help make society and decision makers alike aware of their importance.

The goods and services provided by the Solomon Islands' marine ecosystems are huge. They are comparable to the country's total export.

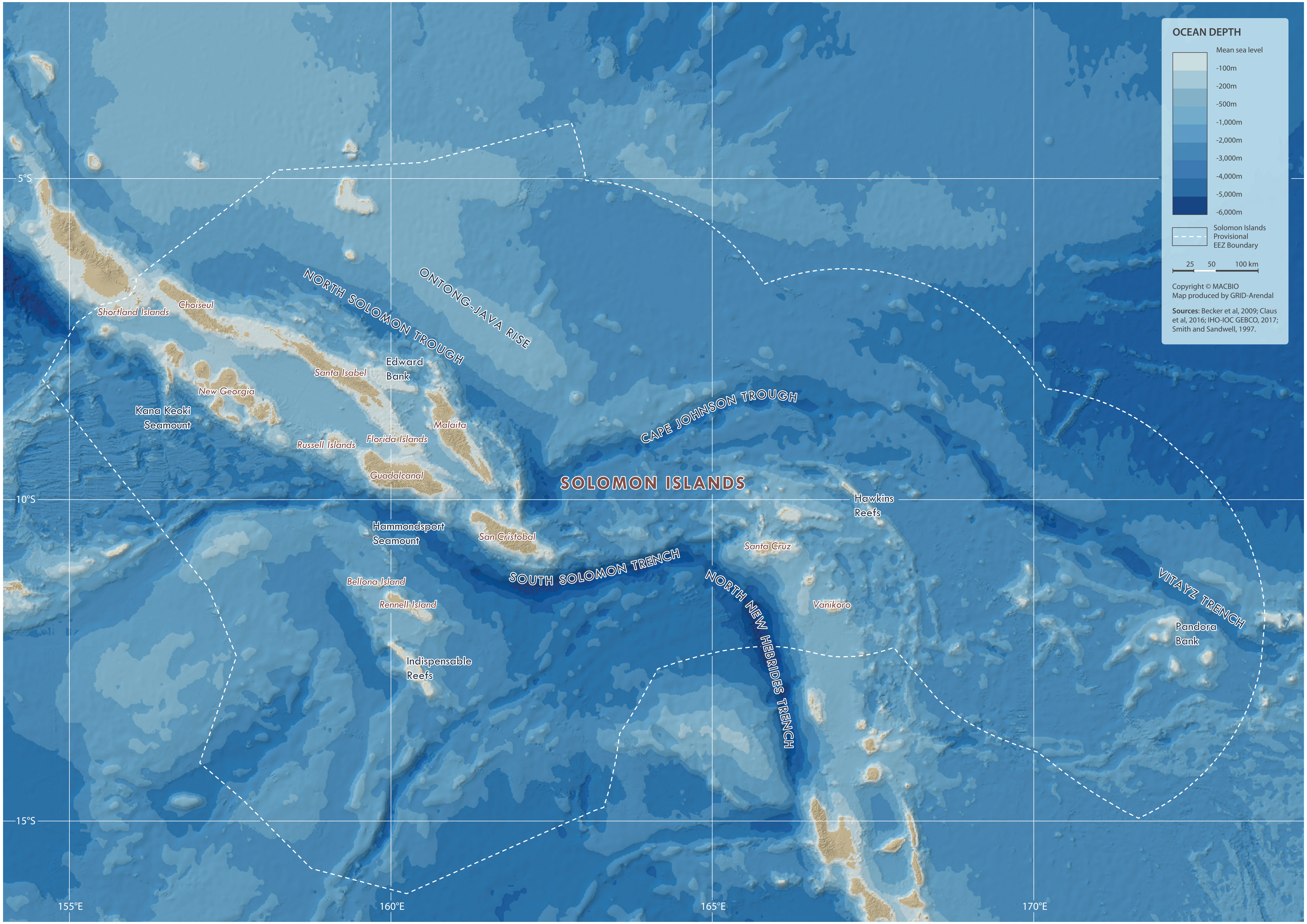


Solomon Islands' marine ecosystem services are valuable and diverse, yet often hidden.

Solomon Islands' marine ecosystem services need to be fully recognized and sustainably managed or they may be lost forever.

Solomon Islands has therefore undertaken economic assessments of its marine and coastal ecosystem services, and is working on integrating the results into national policies and development planning. These economic values are also featured in the maps of this atlas, to help maximize benefits for Solomon Islands.

For further reading, please see **http://macbio-pacific.info/marine-ecosystem-service-valuation/**


OCEAN DEPTH
Mean sea level
-100m
-200m
-500m
-1,000m
-2,000m
-3,000m
-4,000m
-5,000m
-6,000m
Solomon Islands Provisional EEZ Boundary
25
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; IHO-IOC GEBCO, 2017; Smith and Sandwell, 1997.
5°S
10°S
15°S
155°E
160°E
165°E
170°E
SOLOMON ISLANDS
NORTH SOLOMON TROUGH
ONTONG-JAVA RISE
CAPE JOHNSON TROUGH
SOUTH SOLOMON TRENCH
NORTH NEW HEBRIDES TRENCH
VITAYZ TRENCH
Shortland Islands
Choiseul
Santa Isabel
Edward Bank
New Georgia
Kana Keoki Seamount
Malaita
Russell Islands
Florida Islands
Guadalcanal
Hammondsport Seamount
San Cristobal
Bellona Island
Rennell Island
Indispensable Reefs
Hawkins Reefs
Santa Cruz
Vanikoro
Pandora Bank

STILL WATERS RUN DEEP: OCEAN DEPTH

It is important to understand how ocean depth influences both the distribution of life below the surface and the management of human activities along the coasts of Solomon Islands.

Standing on Solomon Islands' shore and gazing into an alluring turquoise lagoon, it is hard to imagine how deep the ocean truly is. Less than 2 per cent of Solomon Islands' national waters are shallower than 200 metres, while the other 98 per cent are up to 8,000 metres deep. Changes in ocean depth, also known as bathymetry, affect many other dimensions of human life and natural phenomena.

Bathymetric maps were originally produced to guide ships safely through reefs and shallow passages (see chapters "Full speed ahead" and "One world, one ocean"). Since ocean depth is correlated with other physical variables such as light availability and pressure, it is also a determining factor in the distribution of biological communities, either those living on the bottom of the sea (benthic), close to the bottom (demersal) or in the water column (pelagic).

In addition, bathymetry significantly affects the path of tsunamis, which travel as shallow-water waves across the ocean. As a tsunami moves, it is influenced by the sea floor, even in the deepest parts of the ocean. Bathymetry influences the energy, direction and timing of a tsunami. As a ridge or seamount may redirect the path of a tsunami towards coastal areas, the position of such features must be taken into account by tsunami simulation and warning systems to assess the risk of disaster.

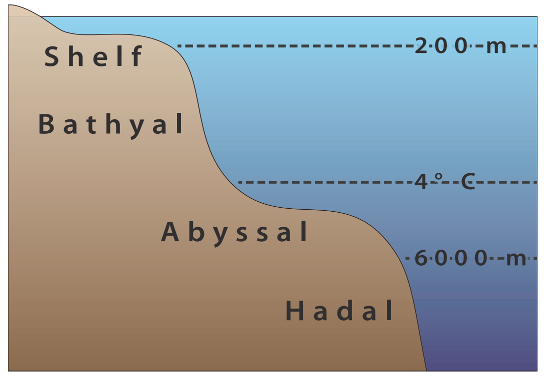
The bathymetry of Solomon Islands is complex (see map), reflecting the meeting of two large tectonic plates: the Pacific and Australian plates. Solomon Islands' archipelago is part of a fragmented island arc running north-west to Papua New Guinea and south-east to Vanuatu. The Central Solomons Trough is a composite basin separating the country's two main island chains. This trough is 475 kilometres long, 90 kilometres wide and 1,800 metres deep.

The country's complex geology includes unique systems of underwater troughs, trenches and several active seismic fracture areas. A discontinuous trench runs south of the island chains; the western part of this trench is known as the New Britain Trench, while the eastern part is known as the South Solomon Trench, where the maximum depth reaches over 8,000 metres. The South Solomon Trench connects with the North New Hebrides Trench to the east, with depths reaching over 9,000 metres—the deepest in Solomon Islands' jurisdiction. A less well-defined trench system, which includes the West Melanesian Trench, North Solomon Trench, Cape Johnson Trench and Vitiaz Trench, runs to the north and east of the archipelago (Krüger, J. and Sharma A., 2008).

North of this trench system is the Ontong Java Rise, an area of elevated sea floor more than 2,000 metres above the abyssal sea floor. East of the Ontong Java Rise, the depth of the abyssal sea floor gradually increases from 3,500 metres to over 5,000 metres. South of the Vitiaz Trench and several ridges and seamounts, including the shallow Pandora Bank area, the sea floor rises to the surface. This area connects to the Fiji Plateau, where the abyssal depth reaches around 3,500 metres.

South of the South Solomon Trench, the abyssal sea floor is generally between 3,000 and 4,500 metres deep. There are also several remote shallow areas, such as the Indispensable Reefs, which reach the surface. Along the western boundary with Papua New Guinea, there is another area of raised sea floor less than 500 metres deep. The Pocklington Trough is directly north of this area, with depths of more than 5,000 metres. Further north is an area of fractured sea floor, extending down to Papua New Guinea.

The complex bathymetry surrounding Solomon Islands interacts with deep ocean currents creating opportunities for upwelling and enhanced marine biodiversity.

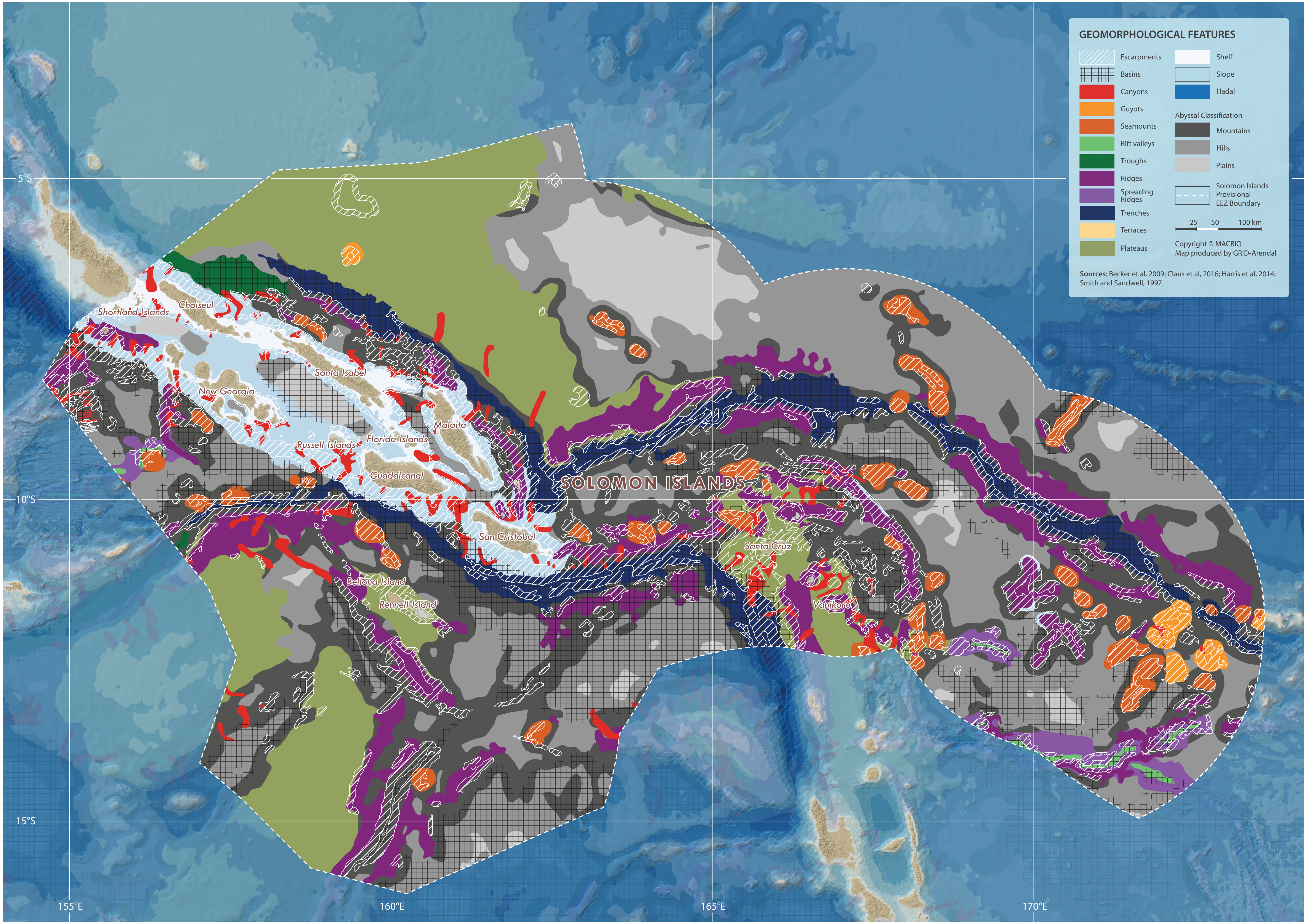


The sea floor can be divided into several different zones based on depth and temperature: the sublittoral (or shelf) zone, the bathyal zone, the abyssal zone and the hadal zone. The sublittoral zone encompasses the sea floor from the coast to the shelf break—the point at which the sea floor rapidly drops away. The bathyal zone extends from the shelf break to around 2,000 metres depth. The lower limit of the bathyal zone is defined as the depth at which the temperature reaches 4°C. This zone is typically dark and thus not conducive to photosynthesis. The abyssal zone extends from the bathyal zone to around 6,000 metres. The hadal zone, the deepest zone, encompasses the deep-sea floor typically only found in ocean trenches, such as the North and South New Hebrides Trenches.

Under the United Nations Convention on the Law of the Sea (UNCLOS), a coastal state has specific sovereign rights to the seabed, its subsoil and superjacent waters within its EEZ (article 56). Within areas of extended continental shelf, defined under UNCLOS article 76, a coastal state has sovereign rights to certain natural resources on the seabed and subsoil, but not to superjacent waters.

Shaking Gizo

On the morning of 2 April 2007, residents in the village of Gizo in Solomon Islands awoke to an earthquake, which created a 12-metre-high wave. Fifty-two people lost their lives and 13 villages were destroyed. If the earthquake had struck earlier in the morning, when people were still asleep, the toll may have been much higher. Thousands of people were left homeless and damage was estimated in the millions. Within 15 minutes, a tsunami warning was issues for the Pacific, from Australia to Alaska, creating panic along the eastern Australian coast 2,100 kilometres away. Beaches were closed, some schools and day-care centres were evacuated and ferry services were halted in Sydney Harbour amid fears of a repeat of the 2004 Indian Ocean tsunami disaster. This not only shows how far tsunamis can travel, but also how important bathymetry is for the effect of tsunamis. Fortunately, on this occasion the bathymetry worked in favour for Sydney, which only experienced an "extreme tide".


GEOMORPHOLOGICAL FEATURES
Escarpments
Basins
Canyons
Guyots
Seamounts
Rift valleys
Troughs
Ridges
Spreading Ridges
Trenches
Terraces
Plateaus
Shelf
Slope
Hadal
Abyssal Classification
Mountains
Hills
Plains
Solomon Islands Provisional EEZ Boundary
25 50 100 km
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Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Harris et al, 2014; Smith and Sandwell, 1997.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Malaita
Russell Islands
Florida Islands
Guadalcanal
San Cristobal
Bellona Island
Rennell Island
Santa Cruz
Vanikoro
5°S
10°S
15°S
155°E
160°E
165°E
170°E

VOYAGE TO THE BOTTOM OF THE SEA: GEOMORPHOLOGY

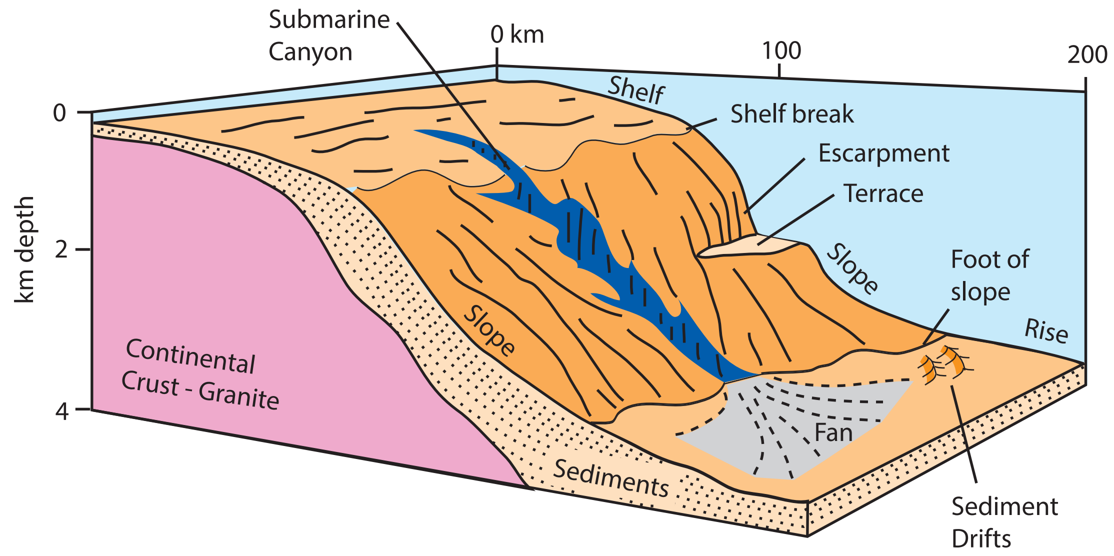
Solomon Island's sea floor is rich in physical features that affect the distribution of biodiversity, fishing grounds and deep-sea minerals.

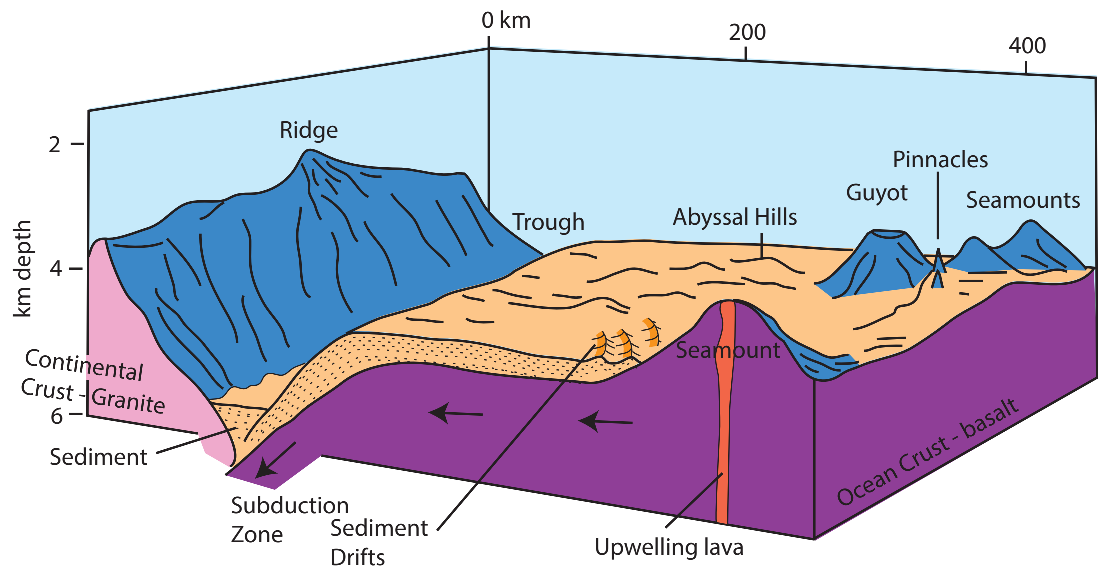
The nation's seascape is as diverse underwater as its landscape above, including towering underwater mountains (seamounts) that attract migratory species from hundreds of kilometres away, and deep-sea canyons that carry nutrient-rich water from the deep ocean to the shallow areas. Geomorphology (the study and classification of these physical features) reveals both the geological origin of the features as well their shape (morphology), size, location and slope.

The geomorphology of the sea floor influences the way the ocean moves (see also chapter "Go with the flow"), wind direction and the distribution of water temperature and salinity (see also chapter "Hotter and higher"). These factors affect the distribution of biological communities, resulting in different biological communities being associated with different types of sea-floor geomorphology. For example, seamounts generally have higher biodiversity and a very different suite of species to the adjacent, deeper abyssal areas.

Similarly, different economic resources are often associated with different features. Many fisheries operate on certain features, such as the shelf, slope or over seamounts, based on where their target species occur. In Solomon Islands, important deep-sea snapper is mostly found on outer reef slopes and around seamounts (mainly in depths from 100 to 400 metres; see chapter "Fishing in the dark"). Furthermore, different types of deep-sea mineral deposits are also associated with different features, such as the sea-floor massive sulfide deposits found along mid-ocean ridges (see chapter "Underwater Wild West").

Solomon Islands' waters harbour 18 different geomorphic features, which are presented in this map and associated figures. The distribution of geomorphology reflects many

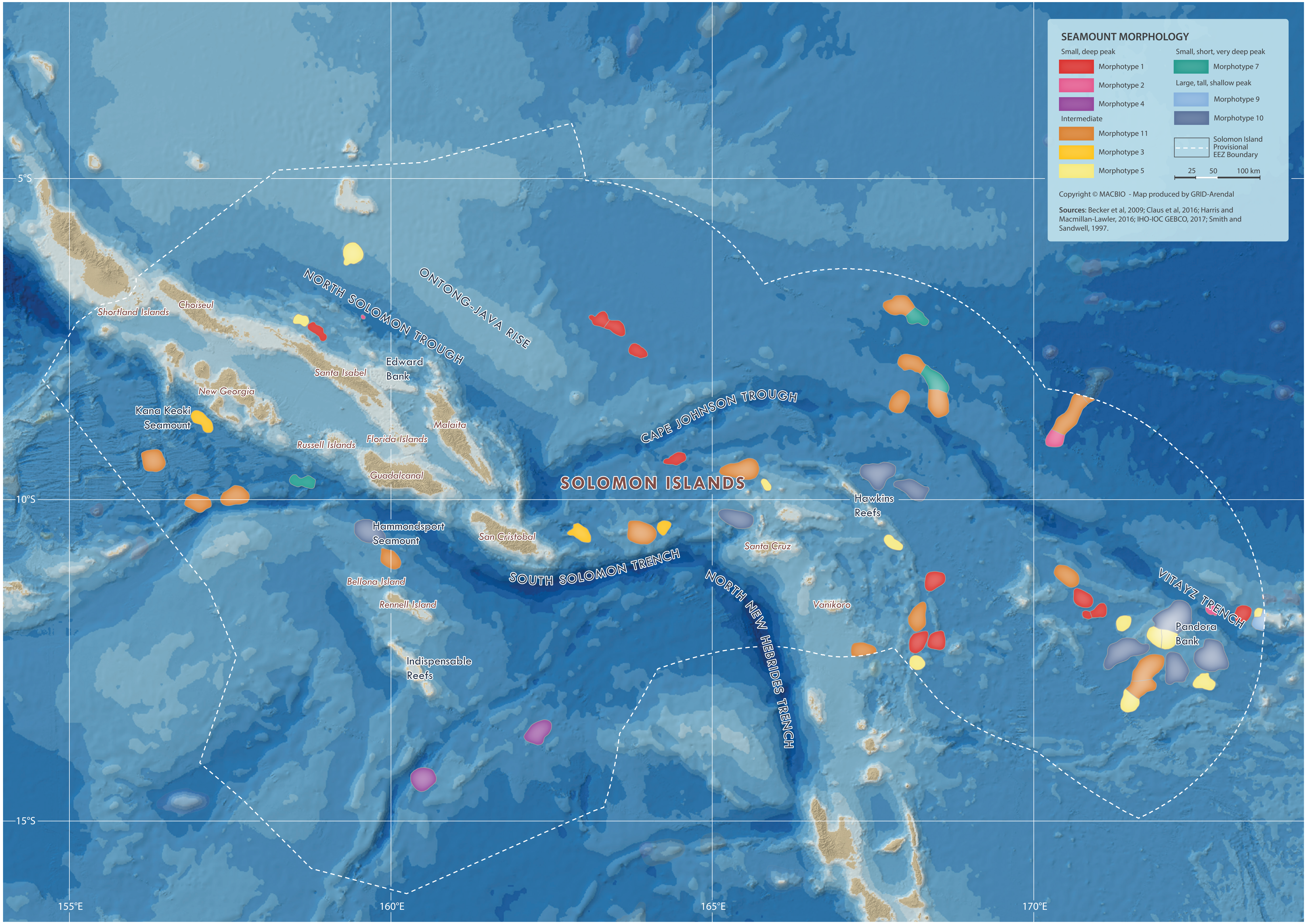




of the patterns observed in the bathymetry map, as geomorphology is primarily a classification of the shape of the sea-floor features. Some notable features in Solomon Islands' waters include 52 seamounts and seven guyots. Seamounts are large—at least 1,000 metres high—conical mountains of volcanic origin, while guyots are seamounts with flattened tops (see chapter "Underwater mountains"). In addition to seamounts, there are numerous large ridges throughout Solomon Islands' western and southern waters. These ridges rise more than 1,000 metres from the surrounding sea floor and their steep sides interact with currents, creating important habitats for many species.

Solomon Islands has narrow continental shelfs which are characteristic of Pacific Islands. The adjacent sloping areas are incised with numerous large submarine canyons, of which there are 135 in Solomon Islands' waters. These canyons are characterized as areas of high biodiversity due to their steep sides featuring rocky slopes, strong currents and enhanced access to food. They also act as a conduit between the deep-sea floor and the shallow shelf areas. On all these features, areas of steep sea floor (escarpments) are likely to contain hard substrate which, coupled with increased current flow, create ideal habitats for filter-feeding organisms such as sponges and cold-water corals.

The trench and trough systems to the north and south of the main islands have some of the deepest waters in the Pacific Ocean, with depths over 9,000 metres in Solomon Islands' waters. The area also has many small- to medium-sized basins. Deeper areas can act as sinks, accumulating materials that have sunk in the water column, including pollution from human activities. The numerous plateaus in this region are also likely to interact with currents, creating further unique habitats.


SEAMOUNT MORPHOLOGY
Small, deep peak
Morphotype 1
Morphotype 2
Morphotype 4
Intermediate
Morphotype 11
Morphotype 3
Morphotype 5
Small, short, very deep peak
Morphotype 7
Large, tall, shallow peak
Morphotype 9
Morphotype 10
Solomon Island Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO - Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Harris and Macmillan-Lawler, 2016; IHO-IOC GEBCO, 2017; Smith and Sandwell, 1997.
5°S
10°S
15°S
155°E
160°E
165°E
170°E
SOLOMON ISLANDS
NORTH SOLOMON TROUGH
ONTONG-JAVA RISE
CAPE JOHNSON TROUGH
SOUTH SOLOMON TRENCH
NORTH NEW HEBRIDES TRENCH
VITAYZ TRENCH
Shortland Islands
Choiseul
Santa Isabel
Edward Bank
New Georgia
Kana Keoki Seamount
Malaita
Russell Islands
Florida Islands
Guadalcanal
Hammondsport Seamount
San Cristobal
Bellona Island
Rennell Island
Indispensable Reefs
Hawkins Reefs
Santa Cruz
Vanikoro
Pandora Bank

UNDER WATER MOUNTAINS: SEAMOUNT MORPHOLOGY

Solomon Islands has 59 submarine mountains (seamounts and guyots). Seamounts enhance productivity and act as biodiversity hotspots, attracting pelagic predators and migratory species such as whales, sharks and tuna. Vulnerable to the impacts of fishing and mineral resource extraction, seamounts are becoming increasingly threatened.

Seamounts are important features of the ocean landscape, providing a range of resources and benefits to Solomon Islands. Many have elevated biodiversity compared to surrounding deep-sea areas. They can therefore function as stepping stones, allowing hard substrate organisms to disperse from one underwater island to another, thereby expanding their range across ocean basins. Seamounts are also key locations for many fisheries (see also chapter “Fishing in the dark”) and are known to contain valuable mineral resources (see also chapter “Underwater Wild West”). As demand for these resources continues to grow, the need for focused management is increasing. The adverse impacts of mismanaged mineral resources extraction have the potential to severely impact seamount ecosystems.

Just like mountains above the sea, seamounts differ in size, height, slope, depth and proximity, with different combinations of these factors recognized as different morphotypes likely to have different biodiversity characteristics (Macmillan-Lawler and Harris, 2015). The map presents a classification of seamounts identified by Harris et al. (2014) into morphotypes within Solomon Islands’ waters. Physical variations such as depth, slope and proximity are known to be important factors for determining the structure of biological communities. For example, many species are confined to a specific depth range (Rex et al., 1999; Clark et al., 2010). Therefore both the minimum depth (peak depth) and the depth range (height) are likely to be strongly linked to the biodiversity of a given seamount.

Slope is also an important control in the structure of seamount communities, with steep slopes, which are current-swept, likely to support different communities to flat areas, which may be sediment-dominated (Clark et al., 2010). Seamounts in close proximity commonly share similar suites of species with one another and also with nearby areas of the continental margin.

The 59 seamounts and guyots in Solomon Islands’ waters represent eight of the 11 global morphotypes. Understanding this distribution of the different morphotypes is important for prioritizing management actions. For example, seamounts with shallow peak depths that fall within the Epipelagic (photic) zone are hotspots for biodiversity. In Solomon Islands’ case, this includes the large, tall and shallow peaked seamounts (morphotypes 9 and 10), most of which are found to the east of the main islands, with a cluster around Pandora Bank. One of these large seamounts, known as Charlotte Bank, is situated in both Solomon Islands’ and Fiji’s waters, with a small part also in the high seas. This area is part of a joint submission between Solomon Islands and Fiji to the United Nations Commission on the Limits of the Continental Shelf (CLCS).

In Solomon Islands’ waters, 65 per cent of seamounts are part of the intermediate seamount group (morphotypes 3, 5 and 11). These are small to medium in size, with medium heights and a gradation in peak depths from moderately shallow through to moderately deep. Those with moderately shallow peak depths are more likely to be exposed to fishing impacts than deeper-peaked ones. The remaining seamount morphotypes are characterized by deep to very deep peak depths, so are less likely to be targeted directly by fishing. However, with the push to explore seabed mineral resources—with their associated cobalt-rich crusts—are likely to come under increasing pressure.

Sharkcano

In June 2014, staff of the EYOS Expeditions cruise ship noticed discoloured water and disturbances on the surface in the distance. As the vessel approached the area, large plumes of water broke the surface roughly once every 10 minutes. They were puzzled, wondering whether it could have been a shark or a whale, though the plumes appeared too big. Just before the ship left, the sea seemed to erupt and a huge plume of water and ash shot high into the air. What the crew and passengers had witnessed was a classic example of an underwater volcano eruption in Solomon Islands. The submarine Kavachi volcano south of the islands of Gatokae and Vangunu has been active for some years, erupting frequently. The eruption was exciting news, prompting a team of scientists to explore the volcano with an underwater robot a year later as part of a National Geographic expedition. What they found was even more exciting. In the depths, they saw a “sharkcano”—sharks living inside one of the most active underwater volcanoes on Earth!

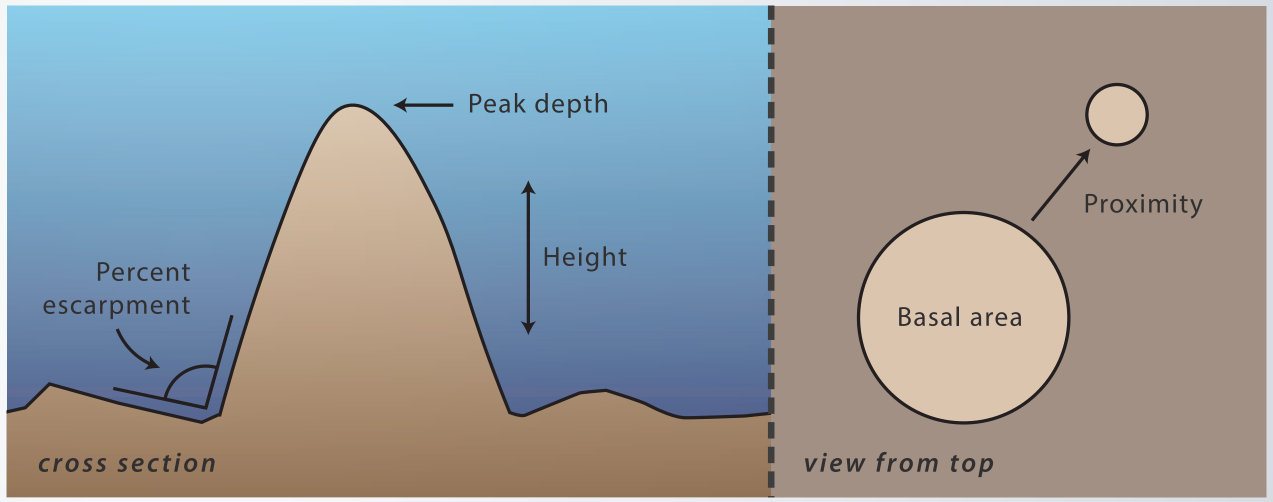
Seamount morphotypes found in Solomon Island waters

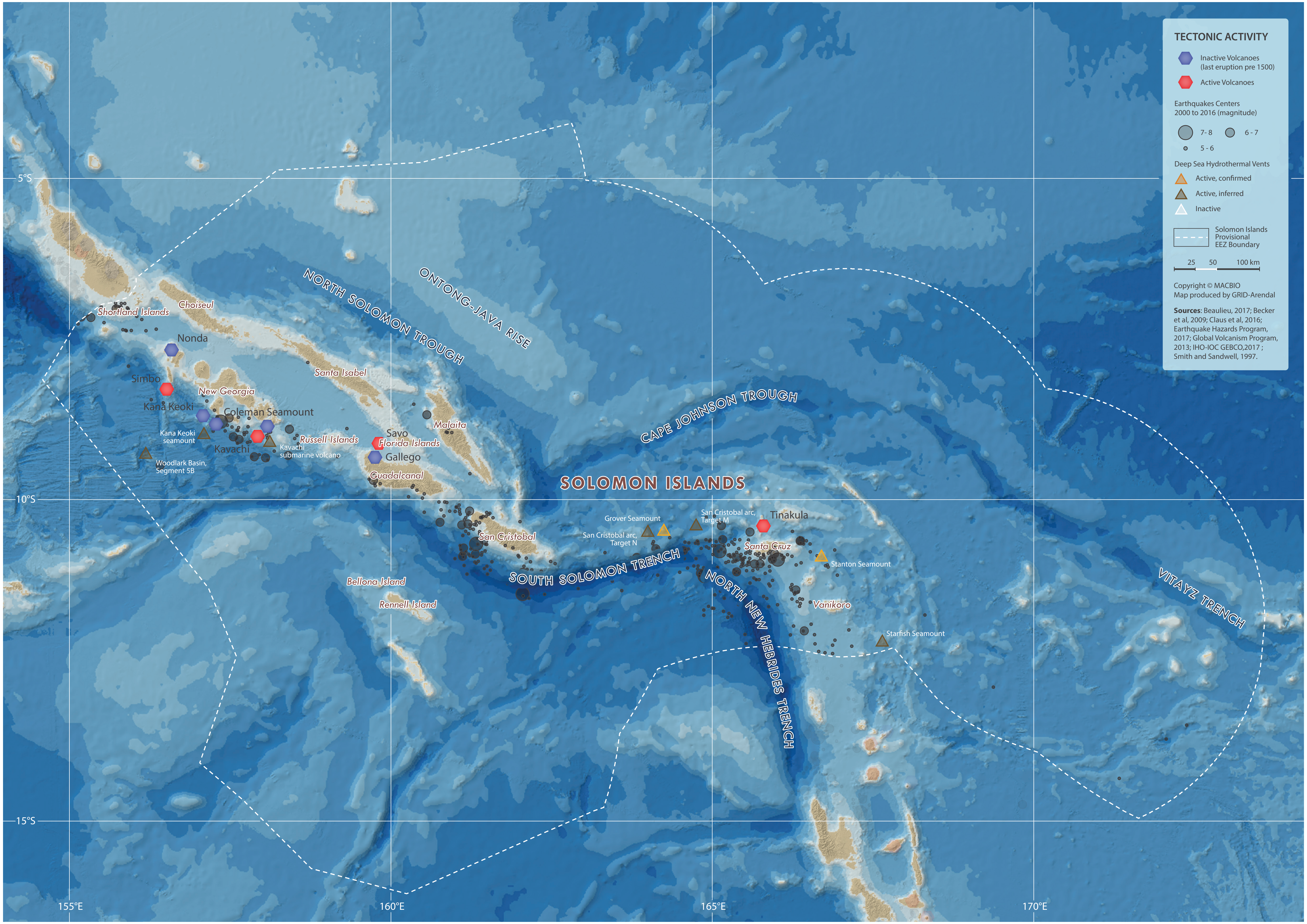
Large and tall seamounts with a shallow peak – *Morphotypes 9 and 10*.

Medium-height seamounts with moderately deep peak depths – *Morphotypes 3, 5, and 11*.

Small seamounts with a deep peak – *Morphotypes 1, 2, and 4*.

Small and short seamounts with a very deep peak – *Morphotypes 7 and 8*.




TECTONIC ACTIVITY
Inactive Volcanoes (last eruption pre 1500)
Active Volcanoes
Earthquakes Centers 2000 to 2016 (magnitude)
7-8
6-7
5-6
Deep Sea Hydrothermal Vents
Active, confirmed
Active, inferred
Inactive
Solomon Islands Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Beaulieu, 2017; Becker et al, 2009; Claus et al, 2016; Earthquake Hazards Program, 2017; Global Volcanism Program, 2013; IHO-IOC GEBCO,2017 ; Smith and Sandwell, 1997.
SOLOMON ISLANDS
NORTH SOLOMON TROUGH
ONTONG-JAVA RISE
CAPE JOHNSON TROUGH
SOUTH SOLOMON TRENCH
NORTH NEW HEBRIDES TRENCH
VITAYZ TRENCH
Shortland Islands
Choiseul
Nonda
Simbo
New Georgia
Santa Isabel
Kana Keoki
Coleman Seamount
Kana Keoki seamount
Kavachi
Kavachi submarine volcano
Russell Islands
Savo
Florida Islands
Malaita
Gallego
Guadalcanal
Woodlark Basin, Segment 5B
San Cristobal
Bellona Island
Rennell Island
Grover Seamount
San Cristobal arc, Target N
San Cristobal arc, Target M
Tinakula
Santa Cruz
Stanton Seamount
Vanikoro
Starfish Seamount
5°S
10°S
15°S
155°E
160°E
165°E
170°E

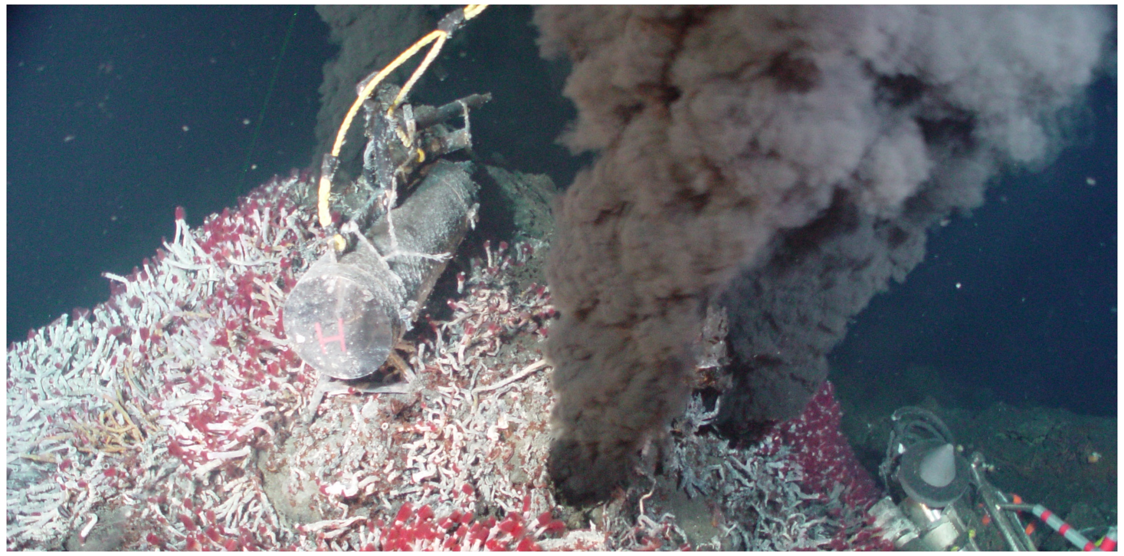
SMOKE UNDER WATER, FIRE IN THE SEA: TECTONIC ACTIVITY

Solomon Islands is located on the Pacific Ring of Fire, a highly active tectonic zone. Above water, this tectonic activity means that Solomon Islands is under threat from possible earthquakes and tsunamis. Underwater, the tectonic activity produces magnificent underwater volcanoes and hydrothermal vents which, in turn, spawn unique complex but fragile ecosystems that contribute to Solomon Islands' rich marine biodiversity. These features also deposit minerals, making them an attractive, if conflicting, target for deep-sea mining exploration and extraction.

The Solomon Islands are relatively young in geological terms and began forming when the south-west boundary of the Pacific plate came into contact with the Australian plate around 55–40 million years ago (Ma). The islands were formed through three main geological processes. The north coasts of Santa Isabel, Malaita and Ulawa were formed around 4 Ma through obduction (a process in which the sea floor is forced upward) and is geochemically similar to the Ontong Java Plateau (Petterson et al., 1999). Choiseul and Guadalcanal have characteristics typical of islands originating from a mid-ocean spreading centre process, whereas the island of Makira has a mix of characteristics from both types (Petterson et al., 1999). Volcanic activity also formed many of the islands and occurred in two distinct phases: first, from 62 to 24 Ma and second, from 7 Ma to present day (Petterson et al., 1999). These volcanic processes helped shape the island arc seen today.

This tectonic activity shapes not only the islands of Solomon Islands but also its undersea landscape. In these tectonically active areas of sea floor, features known as hydrothermal vents are often found. These are fissures in the Earth's surface from which geothermally heated water (up to 450°C) escapes. Under the sea, hydrothermal vents may develop black or white smokers. These roughly cylindrical chimney structures can reach heights of 60 metres, forming from either black or white minerals that are dissolved in the vent fluid.

The black and white smokers and their mineral-rich warm water attract many organisms and have unique biodiversity. Chemosynthetic bacteria and archaea, both single-celled organisms, form the base of a food chain supporting diverse organisms, including giant tube worms, clams, limpets and shrimp. Some scientists even suggest that life on Earth may have originated around hydrothermal vents. Along with their unique biodiversity, these vents are also a hotspot of minerals. Massive sulfides (including gold and copper), cobalt and rare earth metals occur in high concentrations in vent systems, which are increasingly being explored for their mineral resources (see also chapter "Underwater Wild West").

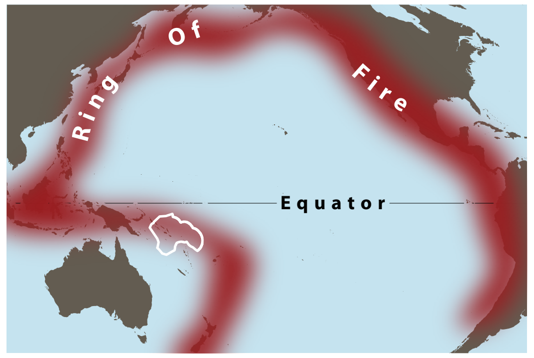


The Sully Vent in the northeastern Pacific Ocean provides an example of the diverse communities around hydrothermal vents.

Many Anomuran crabs attached to a hydrothermal chimney at 2,397 metres depth.

Warm and cozy

When a team of scientists from the University of Rhode Island explored the sea floor north-west of the Galapagos Islands in 2015, they made an unexpected discovery. At a hydrothermal vent they found large numbers of perfectly fine eggs very close to the boiling water. The eggs were those of deep-sea skate (relatives of sharks and rays), which use the hot water from vents to accelerate the development of the embryos. While this may seem strange, it is not uncommon. Several species of shark swim straight through the bubbling hot water in the crater of the submarine Kavachi volcano (see also chapter "Underwater mountains"). This impressively shows that the presumably toxic environment around vents in fact supports a whole community of life.



The Pacific region is one of the most tectonically active regions in the world. The Pacific Ring of Fire, stretching clockwise from New Zealand all the way around to South America, is home to around 90 per cent of the world's earthquakes. Pacific Island countries such as Solomon Islands, which lay between the Pacific and Australian tectonic plates, are subject to volcanic and seismic activity. The activity affecting Solomon Islands is primarily centred on the southern side of its islands at the edge of the large ocean trenches—the New Britain, South Solomon and North New Hebrides Trenches. This means that many earthquakes are focused either near or directly on the main islands of Solomon Islands. Numerous magnitude 6 earthquakes or above have occurred in this region, with several of the larger ones measuring over magnitude 8. Earthquakes can, under certain circumstances, generate tsunamis. For example, in 2015 an 8 magnitude earthquake hit Solomon Islands, generating a small tsunami that killed nine people and caused major damage to coastal infrastructure (see also chapter "Voyage to the bottom of the sea").

As the map shows, Solomon Islands' waters harbour not only numerous deep-sea hydrothermal vents, but also nine volcanoes. At least four of these (Kavachi, Savo, Simbo and Tinakula) are still active. Tinakula is highly active and erupts andesitic ash almost every week. Its last large eruption was in 1985. Kavachi is a shallow submarine volcano, which forms a temporary island during its eruptive phase, an event that occurs every 4–8 years according to the World Organization of Volcano Observatories. Savo and Simbo have not had any major eruptions in recent years, but still remain active.

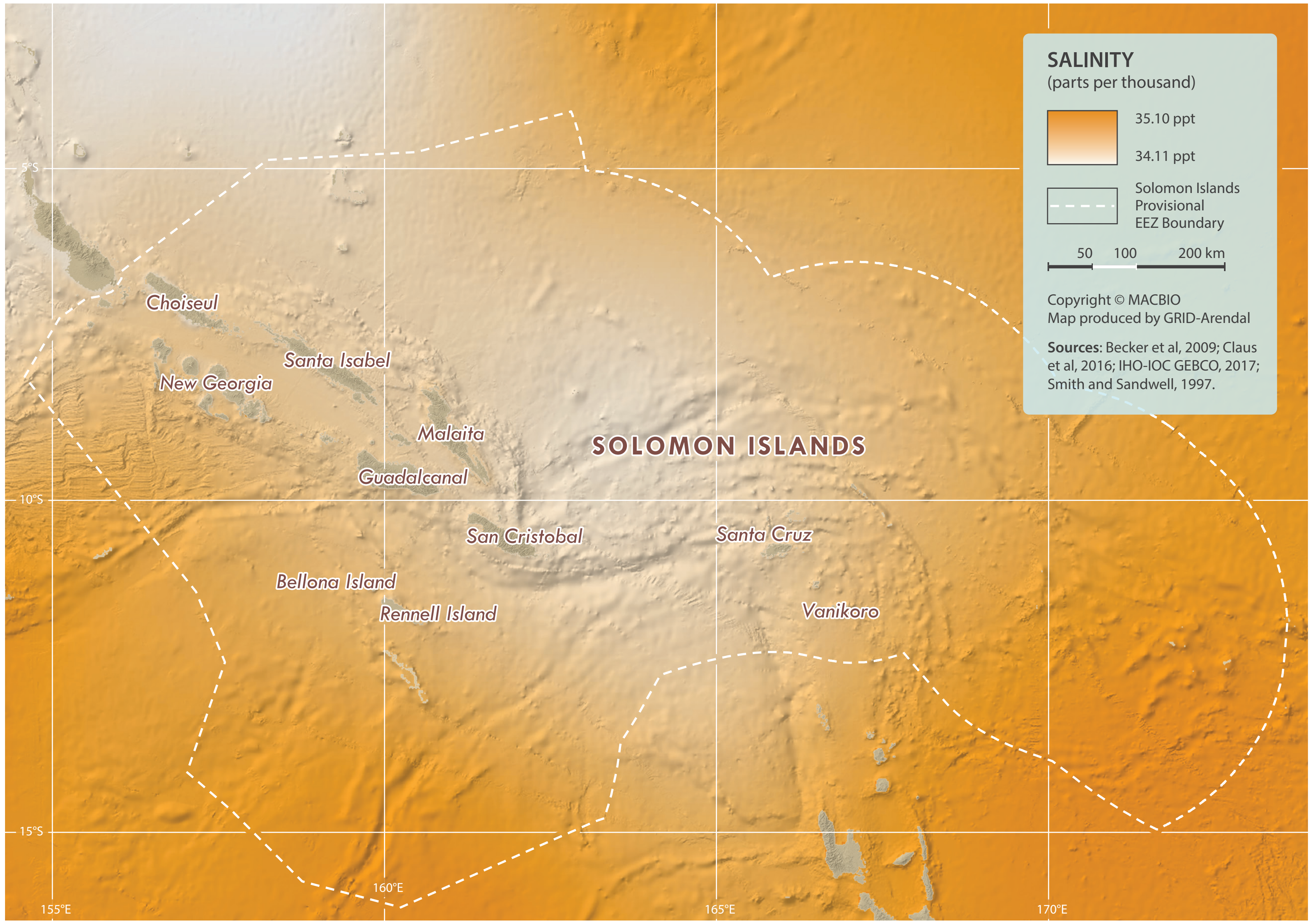
Tectonic activity is a key to the creation of the Pacific Islands and atolls, many of which sit upon active or inactive volcanoes (see also chapter "Underwater mountains").

GO WITH THE FLOW: SALINITY AND SURFACE CURRENTS

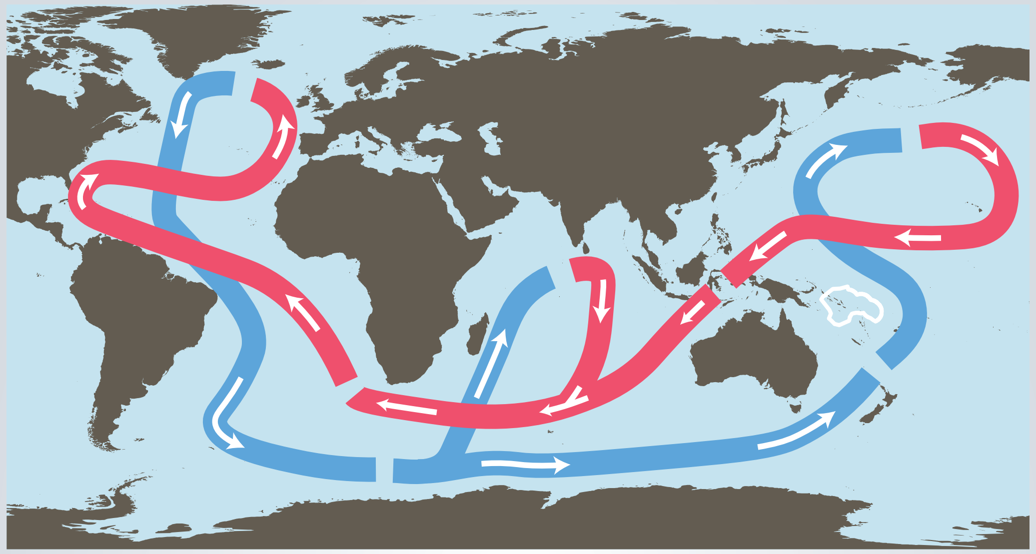
Ocean currents are driven by a combination of thermohaline currents (thermo = temperature; haline = salinity) in the deep ocean and wind-driven currents on the surface. Ocean currents affect climate, the distribution of biodiversity and the productivity of the seas, particularly during extreme El Niño years.

Salinity also greatly influences the distribution of marine life (Lüning, 1990; Gogina and Zettler, 2010). Salinity is the concentration of dissolved salt, measured as the number of grams of salt per kilogram of seawater. The salinity of the global oceans is generally around 35, with a maximum salinity of over 40 found in the Mediterranean and Red Seas, and a minimum salinity of less than five in parts of the Baltic and Black Seas. Generally, salinity is higher in the warmer low-latitude waters and lower in the cooler high-latitude waters. The salinity of Solomon Islands' waters has a narrow range—between 34.3 in the central part of the EEZ and 35 in the southern part of the EEZ. Salinity also varies by depth, with a strong salinity gradient forming in the upper layers, known as a halocline.

In contrast to the deep-sea currents, Solomon Islands' surface currents are primarily driven by wind. Their direction is determined by wind direction, Coriolis forces from the Earth's rotation, and the position of landforms that interact with the currents. Surface wind-driven currents generate upwelling in conjunction with landforms, creating vertical water currents. The westward flowing South Equatorial Current, which is strongest south of the main islands of Solomon Islands, is driven by the south-east trade winds. Its general westward flow is broken into zonal jets (Webb, 2000), which are thought to be the result of a number of processes, including the structure of the mid-Pacific winds, which induce mid-basin bands of stronger flow, curl dipoles behind the islands, and the blocking of currents by the islands (Kessler and Gourdeau, 2006). Webb (2000) showed that the extensive shallow topography around Vanuatu, New Caledonia and Solomon Islands resulted in the formation of prominent zonal jets at the northern and southern extremities of the islands. North of the Solomon Islands, the Equatorial Counter Current has more influence.



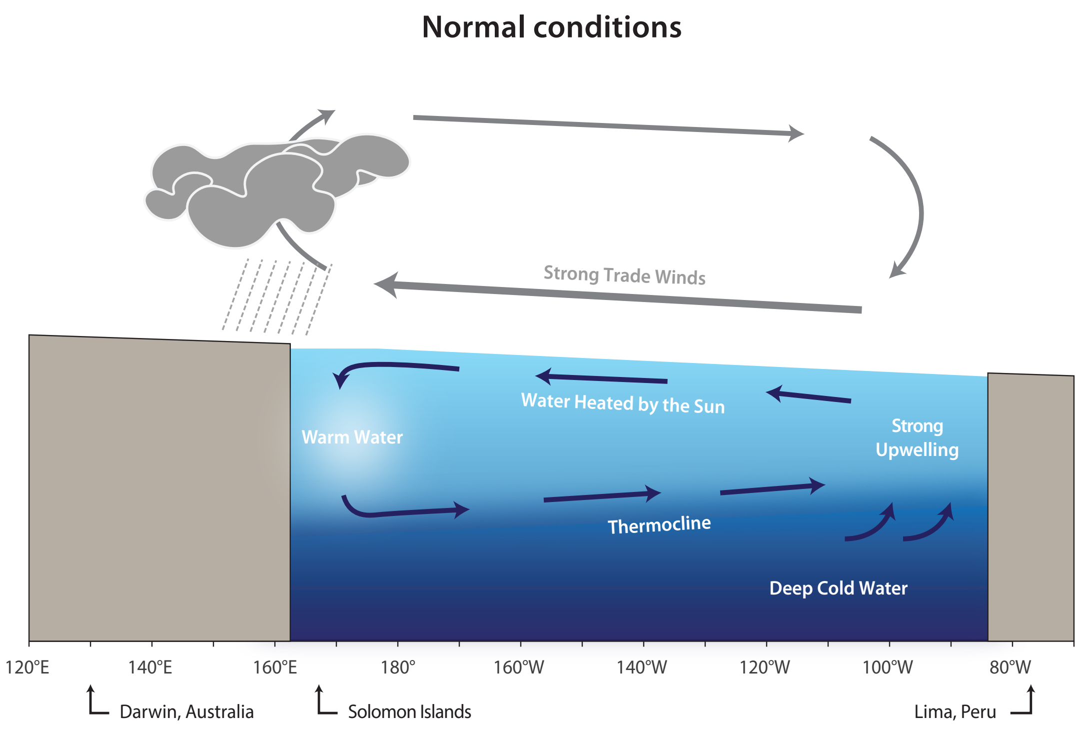
A trip around the world

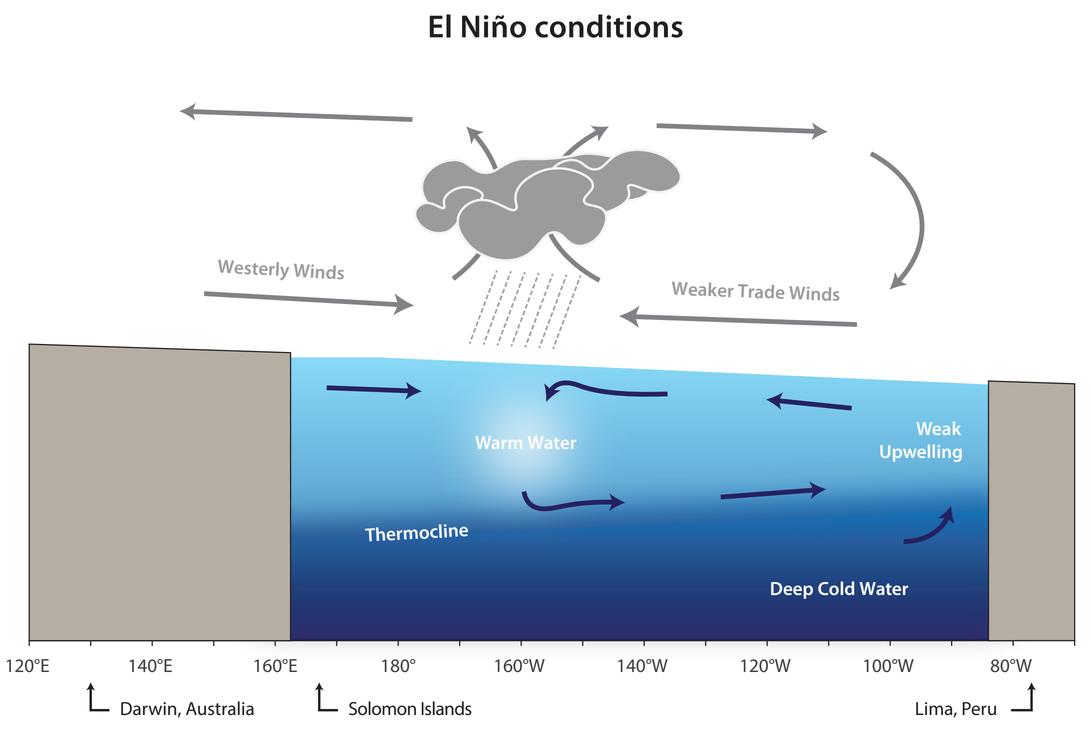


It took Magellan more than three years (from 1519 to 1522) to be the first person to circumnavigate the Earth. The current record for this trip is 67 hours by plane and 50 days by sailboat. Water in the ocean is not in such a rush, taking much more time on its journey on the global ocean conveyor belt. Within this belt, the ocean is constantly in motion due to a combination of thermohaline currents in the deep, and wind-driven currents at the surface. Cold, salty water is dense and sinks to the bottom of the ocean, while warm water is less dense and remains at the surface.

The global ocean conveyor belt starts in the Norwegian Sea, where warm water from the Gulf Stream heats the atmosphere in the cold northern latitudes. This loss of heat to the atmosphere makes the water cooler and denser, causing it to sink to the bottom of the ocean. As more warm water is transported north, the cooler water sinks and moves south to make room for the incoming warm water. This cold bottom water flows south of the equator all the way down to Antarctica. Eventually, the cold bottom waters returns to the surface through mixing and wind-driven upwelling, continuing the conveyor belt that encircles the globe (Rahmstorf, 2003), crossing the Pacific from east to west.

A full circle takes about 1,000 years. No rush at all!





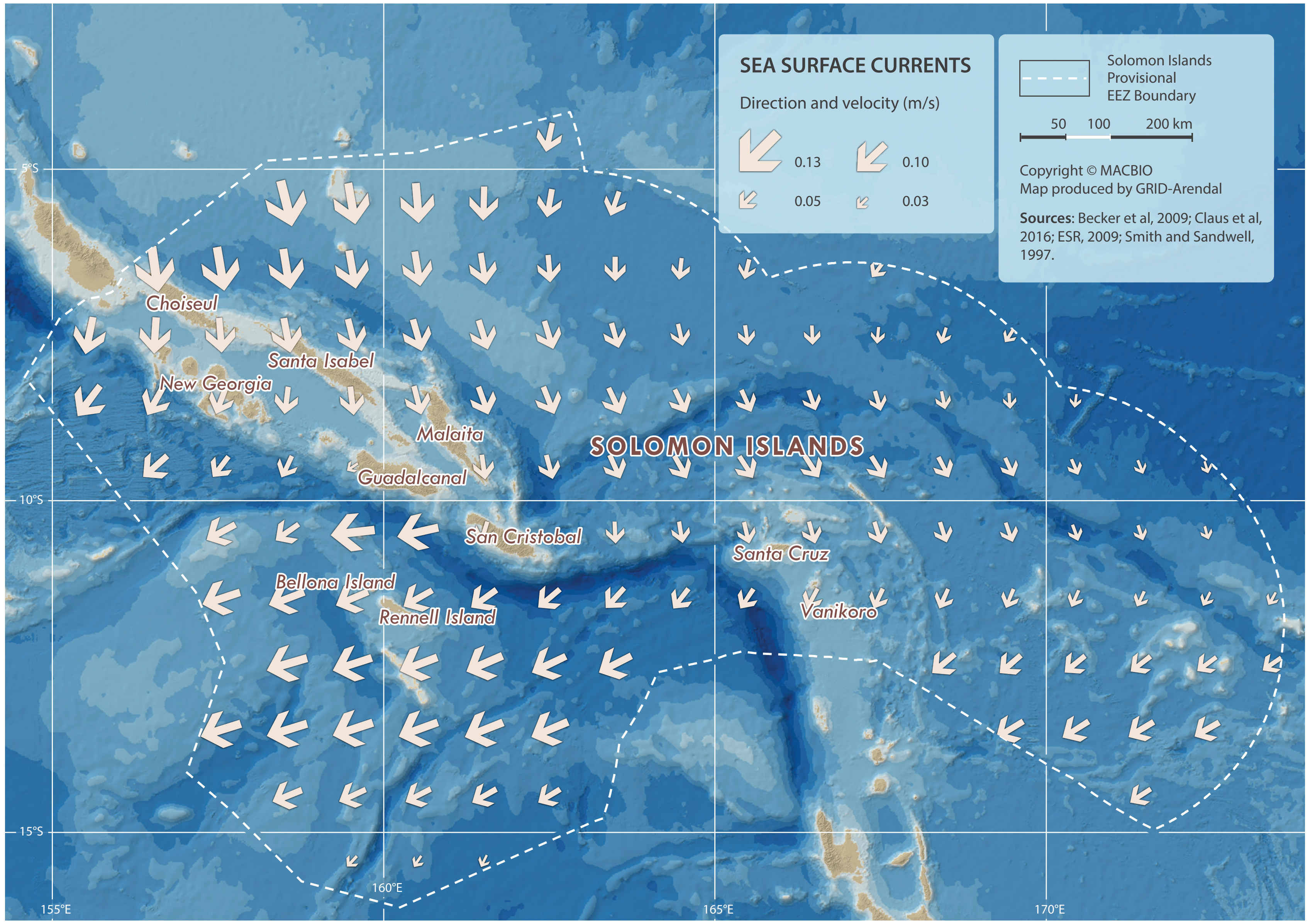
Both kinds of currents—the thermohaline ones in the deep water and the wind-driven one on the surface—are very important to Solomon Islands. On their journey, water masses transport two things around the globe and through Solomon Islands' waters. Firstly, matter such as solids, dissolved substances and gases are carried by the currents, including salt, larvae (see also chapter "Travellers or homebodies"), plastics and oil (see also chapters "Plastic oceans" and "Full speed ahead"). Secondly, currents transport energy in the form of heat. Currents therefore have a significant impact on the global climate.

El Niño is an example of the big impact that regional climate variability related to ocean currents has on Solomon Islands (see graphs and chapter "Hotter and higher"). Normally, strong trade winds blow from east to west across the Pacific Ocean around the equator. As the winds push warm surface water from South America west towards Asia and Australia, cold water wells up from below in the east to take its place along the west coast of South America. This creates a temperature disparity across the Pacific, which also keeps the trade winds blowing. The accumulation of warm water in the west heats the air, causing it to rise and create unstable weather, making the western Pacific region warm and rainy. Cool, drier air is usually found on the eastern side of the Pacific.

In an El Niño year, the trade winds weaken or break down. The warm water that is normally pushed towards the western Pacific washes back across, piling up on the east side of the Pacific from California to Chile, causing rain and storms and increasing the risk of cyclone formation over the tropical Pacific Ocean (Climate Prediction Center, 2005).

On the other side, the western Pacific experiences particularly dry conditions. The periods 1997–1998 and 2014–2016 were among the strongest events on record. For example, in 2015, both Papua New Guinea and Solomon Islands experienced unusually dry and cold conditions, resulting in water shortages and frosts, which wiped out many food crops. Moreover, El Niño contributes to an increase in global temperatures. In the particularly hot year of 2015, El Niño was responsible for about 10 per cent of the temperature rise. In turn, rising global and ocean temperatures may intensify El Niño (Cai et al., 2014).

In summary, sea currents driven by wind, heat and salinity influence not only Solomon Islands' marine biodiversity, but also its rainfall patterns and temperature on land.



STIR IT UP: MIXED LAYER DEPTH

Solomon Islands' waters stirred by winds and heat exchange. How deep this disturbance goes influences both the climate and the marine food chain.

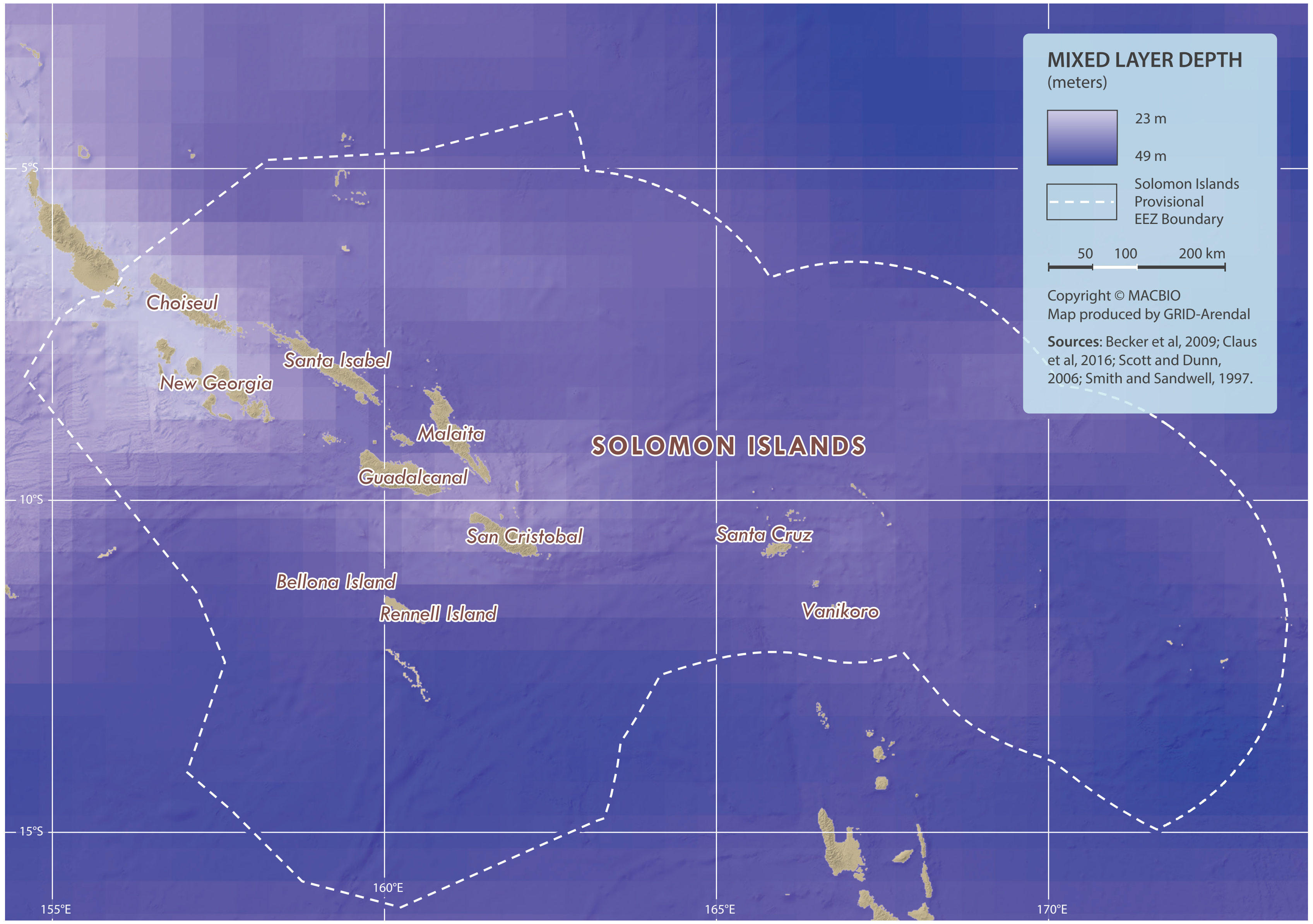
The waters surrounding Solomon Islands are often choppy and turbulent, creating a 'mixed layer' in the upper portion of sea surface where active air–sea exchanges cause the water to mix and become vertically uniform in temperature and salinity, and thus density.

The mixed layer plays an important role in the physical climate, acting as a heat store and helping regulate global temperatures (see also chapter "Hotter and higher"). This is because water has a greater capacity to store heat compared to air: the top 2.5 metres of the ocean holds as much heat as the entire atmosphere above it. This helps the ocean buffer global temperatures, as the heat required to change a mixed layer of 25 metres by 1°C would be sufficient to raise the temperature of the atmosphere by 10°C. The depth of the mixed layer is thus very important for determining the temperature range in Solomon Islands' waters and coastal regions.

In addition, the heat stored within the oceanic mixed layer provides a heat source that drives global variability, including El Niño (see also chapter "Go with the flow").

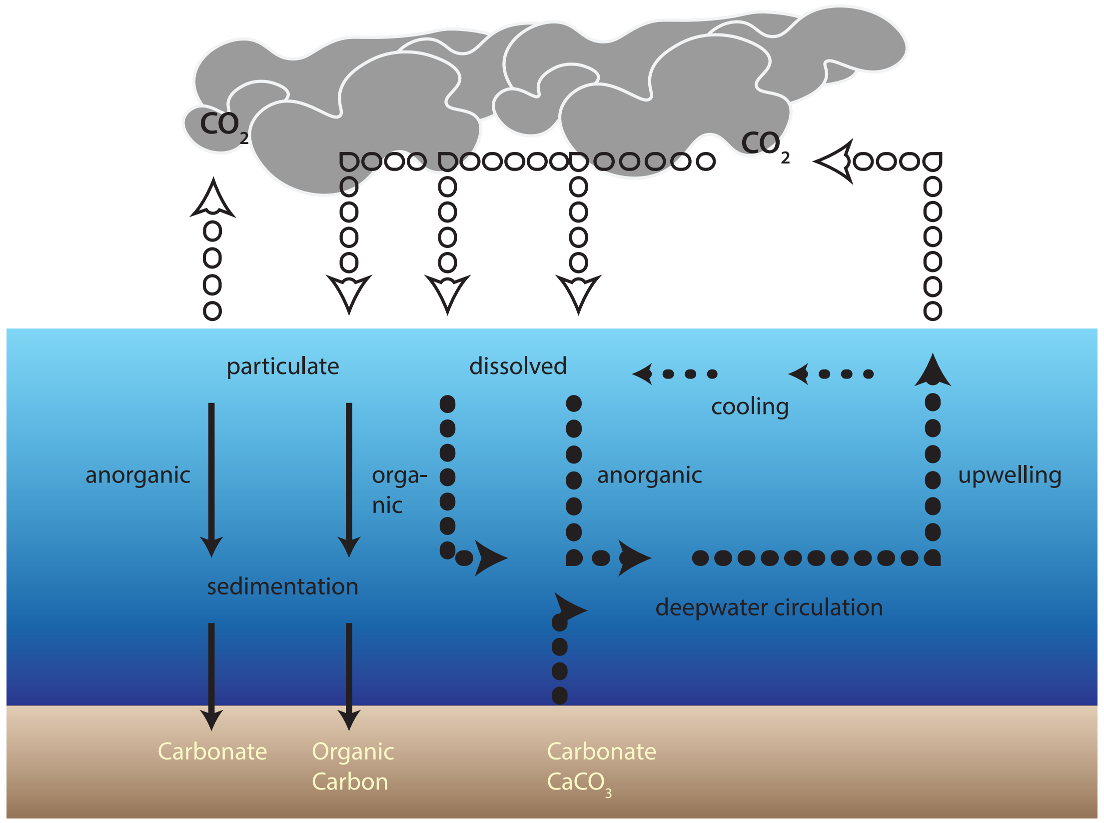
The mixed layer also has a strong influence on marine life, as it determines the average level of light available to marine organisms. In Solomon Islands and elsewhere in the tropics, the shallow mixed layer tends to be nutrient-poor, with nanoplankton and picoplankton supported by the rapid recycling of nutrients (e.g. Jeffrey and Hallegraeff, 1990; see also chapters "Soak up the sun" and "Travellers or homebodies"). In very deep mixed layers, the tiny marine plants known as phytoplankton are unable to get enough light to maintain their metabolism. This affects primary productivity in Solomon Islands' waters which, in turn, impacts the food chain. Mixed layer depth can vary seasonally, with consequential impacts on primary productivity. This is especially prominent in high latitudes, where changes in the mixed layer depth result in spring blooms.

The depth of the mixed layer in Solomon Islands' waters ranges from 23 metres to a maximum 45 metres, with a mean depth of around 35 metres. Pelagic and benthic species contribute to Solomon Islands' rich marine biodiversity, are part of complex food chains and form important habitats. The deepest mixed layer depths are found in the southern parts of Solomon Islands' waters—an area that corresponds to the strongest sea surface currents from the South Equatorial Current. Globally, mixed layer depths range from 4 metres to almost 200 metres depth. The deepest mixed layer depths are generally found in the sub-Antarctic regions and the high latitudes of the North Atlantic.



PUMP IT: PARTICULATE ORGANIC CARBON FLUX

Solomon Islands' sea has valuable ocean pumps that control nutrients, fuel marine life and affect carbon storage.

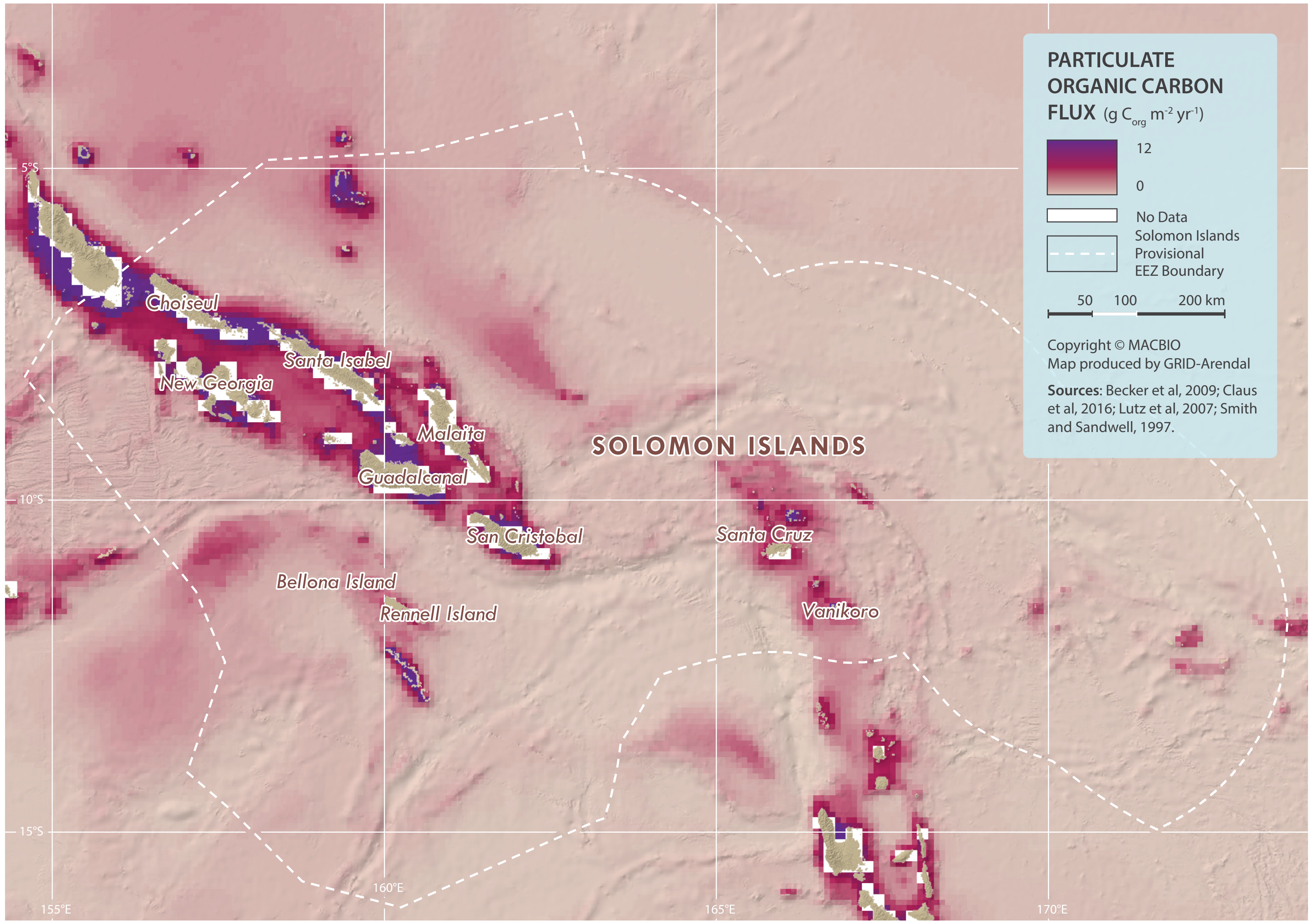


Oceanic carbon naturally cycles between the surface and the deep via two pumps of similar scale (see graphic). The solubility pump is driven by ocean circulation and the solubility of carbon dioxide (CO_2) in seawater. Meanwhile, the biological pump is driven by phytoplankton (see also chapter "Soak up the sun") and the subsequent settling of detrital particles or the dispersion of dissolved organic carbon.

Solomon Islands' ocean pumps are measured by particulate organic flux (the total amount of organic carbon reaching the sea floor) as seen on the map. Organic detritus passing from the sea surface through the water column to the sea floor controls nutrient regeneration, fuels benthic life and affects the burial of organic carbon in the sediment record (Suess, 1980). As the ocean's biological pump is a direct pathway that allows carbon from the atmosphere to be sequestered in the deep-sea floor, it is one of the mechanisms that moderates climate change.

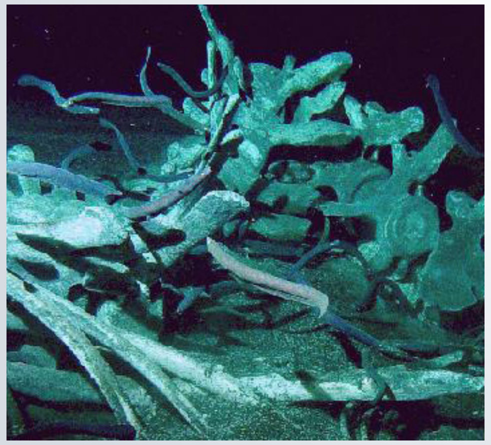
Solomon Islands' ocean pumps are a key part of blue carbon—the carbon captured by the world's oceans and coastal ecosystems. The carbon captured by living organisms in the oceans is stored as biomass and can be trapped in sediment. Key carbon-capturing ecosystems include mangroves, salt marshes, seagrasses and potentially algae (see also chapter "Home, sweet home"). The social value of carbon sequestration by mangroves and seagrasses in Solomon Islands has been estimated to be worth up to US$1.4 million per year (Pascal et al., 2015).

The patterns of particulate organic carbon flux in Solomon Islands' waters closely reflect the depth of the sea floor, with higher rates in the shallow water compared with the deep. Particulate organic carbon flux is low throughout the majority of Solomon Islands' waters, with rates of less than 1 gram of organic carbon/m2/year reaching much of the deep-sea floor. This is consistent with deep-sea rates globally. The maximum rates of particulate organic carbon flux occur in the shallow coastal zones, where rates are up to a maximum of 12 grams/m2/year.



Whale falls

Until the mid-nineteenth century, European whale hunters took whales and their teeth from the Solomon Islands. Nowadays, there is fortunately no more whaling and several whale species are commonly sighted throughout the islands. Whales now more commonly die of natural causes, rather than from hunting. This means that when a whale passes away, its carcass sinks to the bathyal or abyssal zone, deeper than 1,000 metres (Russo, 2004; see also chapter "Still waters run deep"). On the sea floor, it can create complex localized ecosystems that can sustain deep-sea organisms for decades. Moreover, a whale carcass contains a lot of carbon, which it transports to the bottom of the sea. This transport is part of the biological pump—the flux of organic material from the surface ocean to depth. Food falls (such as whale carcasses) may contribute up to 4 per cent of the total carbon flux to the deep ocean (Higgs et al., 2014).



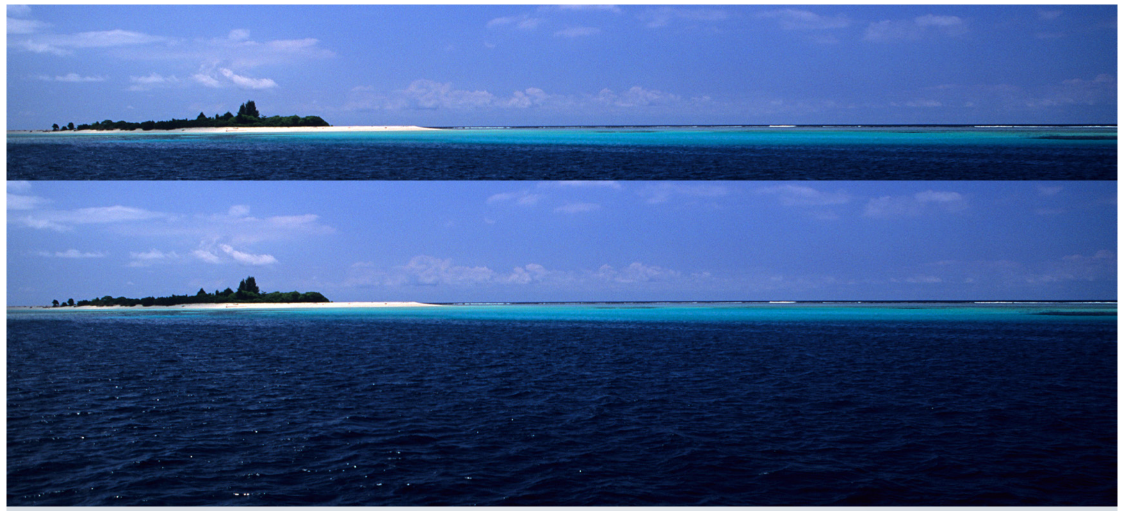
SOAK UP THE SUN: PHOTOSYNTHETICALLY AVAILABLE RADIATION

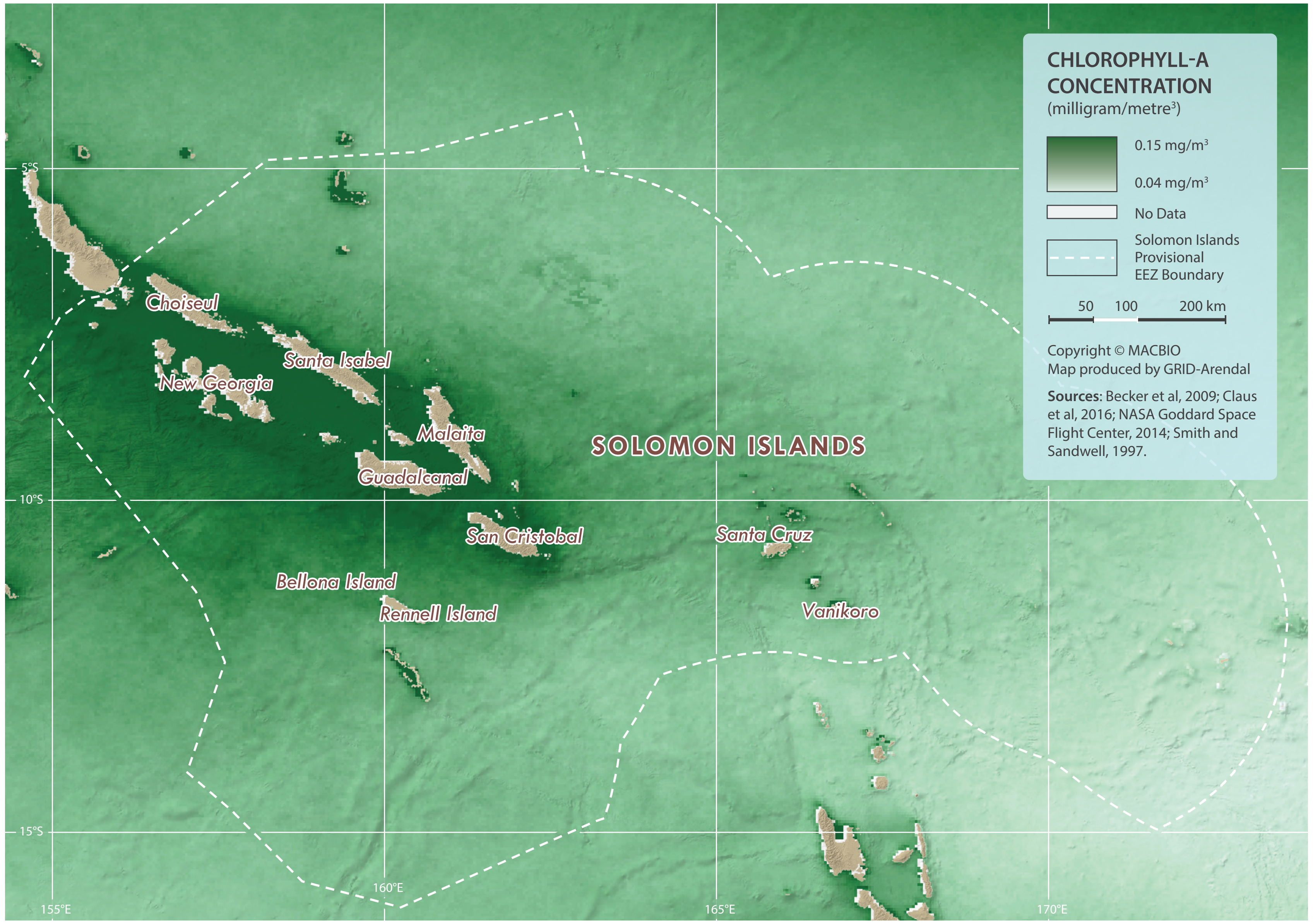
The amount of light available in Solomon Islands' waters determines the growth of plants, including tiny phytoplankton—the basis of the marine food chain—and thus the rate of carbon capture.

However, in Solomon Islands' coastal waters, increased nutrients from land-based activities, such as farming and wastewater treatment, can result in harmful algal blooms. These blooms can affect coastal habitats, for example the growth of macroalgae can smother coral reefs and limit light availability, both of which can lead to rapid declines in reef biodiversity (Fabricius, 2005). Blooms can therefore have a detrimental impact on living creatures and ecosystems, resulting in fish die-offs, water being unsafe for human consumption, or the closure of fisheries.

Marine phytoplankton, however, play a key role in the global climate system and in supporting Solomon Islands' complex marine food webs. Understanding their spatio-temporal variability by analysing chlorophyll-a concentrations is therefore an important goal of present-day oceanography. Consequently, chlorophyll-a concentration is routinely measured in the ocean and is also considered to be an important parameter of global physical-biological oceanic models.

Globally, photosynthetically available radiation is highest in the tropics and decreases at high latitudes, with some variation due to cloud cover and other atmospheric conditions. As a result, the photosynthetically available radiation is moderately high and relatively similar throughout Solomon Islands' waters, with higher radiation in some areas near the main islands and in the north.





Ocean gardens

For plants to thrive, they need three things: water, sunlight and nutrients. In Solomon Islands' sea, the first is obviously not an issue. The second is also not a problem, with the sun shining on Solomon Islands' tropical waters year-round. Thus, there is always radiation available for photosynthesis—the process used by a plant to convert light energy into chemical energy that can later be released to fuel its activities. However, the third requirement, nutrients, is often the limiting factor in the seas of Solomon Islands.

The energy from sunlight is absorbed by green chlorophyll pigments that transform sunlight into energy. Only sunlight of a specific wavelength range (400 to 700 nanometres) can be converted into energy. This wavelength range is referred to as photosynthetically available radiation, also known as photosynthetically active radiation.

Growing in Solomon Islands' sunlit surface waters is a myriad of tiny plants called phytoplankton, which literally means drifter plants (see also chapter "Travellers or homebodies"). They are full of chlorophyll, which gives them their greenish colour. Chlorophyll absorbs most visible light, but reflects some green and near-infrared light. There are six different types of chlorophyll molecules, with chlorophyll-a the most common type in phytoplankton. Measuring chlorophyll-a concentration gives a good indication of primary productivity in the oceans.

Nevertheless, marine plants cannot live off water and light alone. They also require nutrients, including iron, nitrate and phosphate (see also chapter "The dose makes the poison"). Since these nutrients are generally low in Solomon Islands' waters, phytoplankton quickly consume nutrients whenever they do become available. There is a school of thought that fertilizing areas of ocean may stimulate phytoplankton growth, capturing carbon which may sink to the ocean floor (see also chapter "Pump it"). Could this be the solution to climate change (see also chapter "Hotter and higher")? However, the many ocean fertilization experiments worldwide using iron, phosphate or nitrate have yet to show feasibility on a scale large enough to reduce global emissions (Matear, 2004).

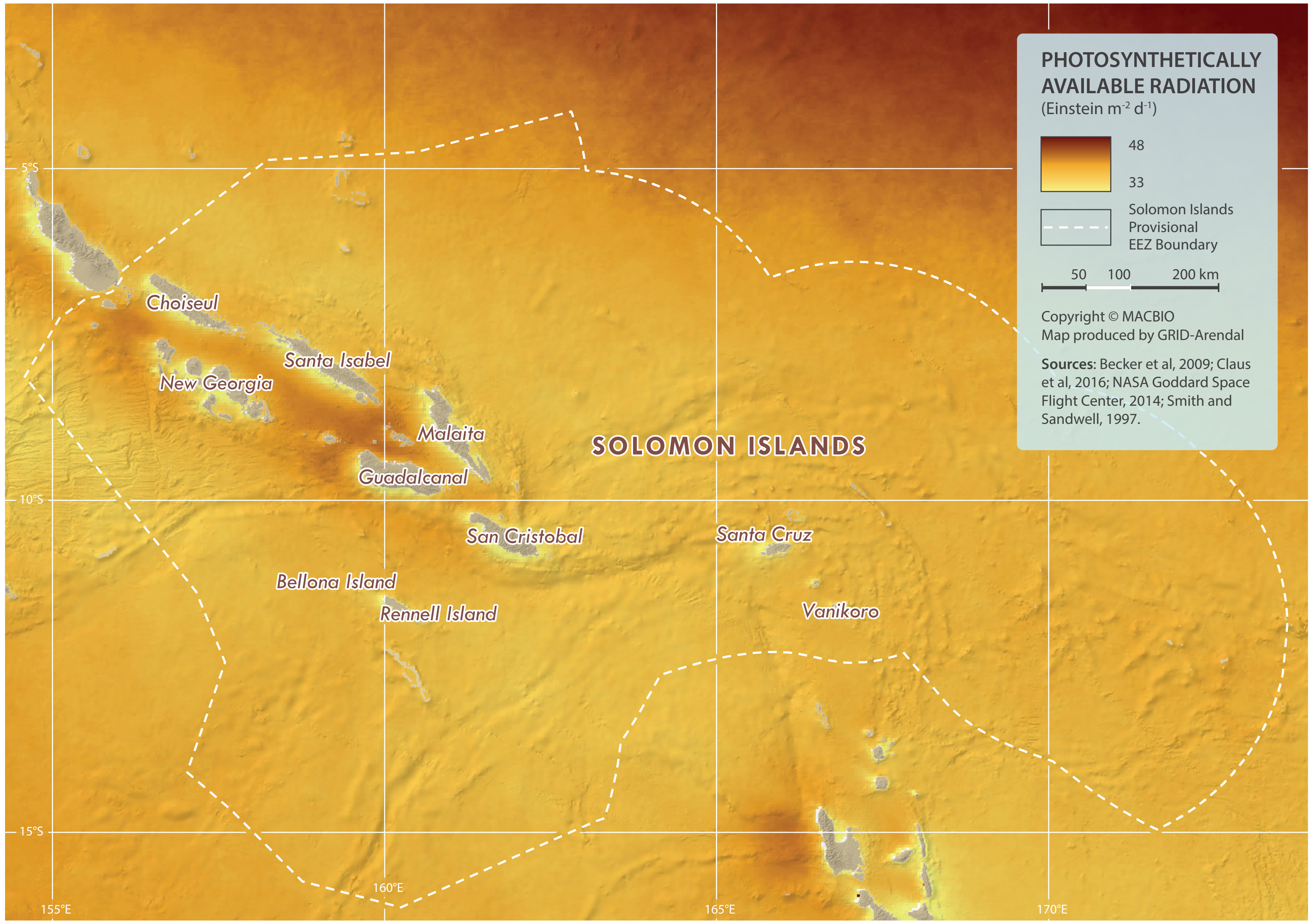
Around the main islands, photosynthetically available radiation tends to be higher on the south-eastern side of the islands compared to the north-western side. This is a reflection of the local climatic conditions, with the predominantly easterly trade winds (see also chapter “Go with the flow”) resulting in less cloud cover over the leeward side of the larger islands (Solomon Islands Meteorological Service, 2016).

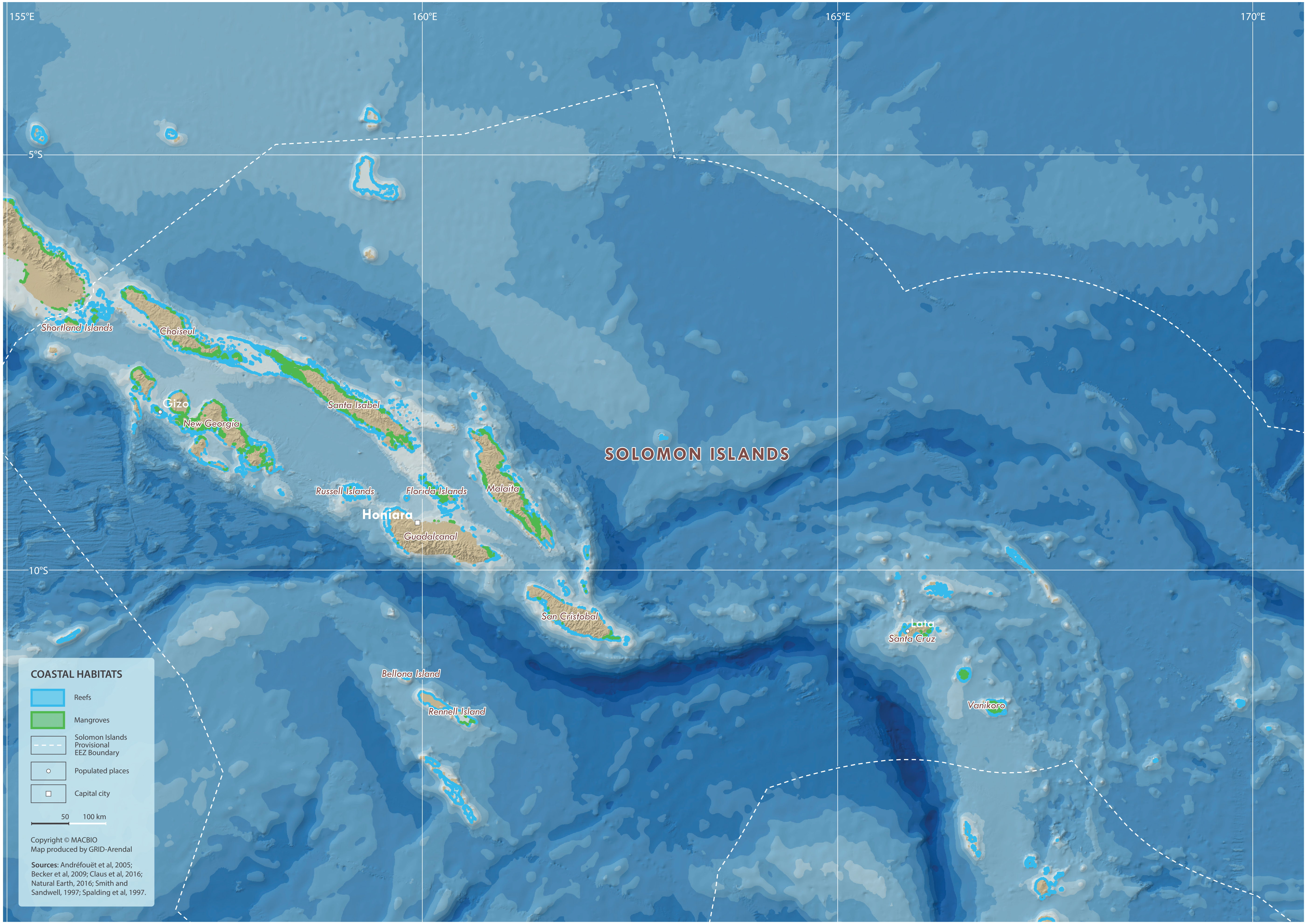
There is also seasonal variation in photosynthetically available radiation in Solomon Islands. The greatest variation occurs around the main islands and in the very northern part of Solomon Islands’ waters, where photosynthetically available radiation varies by up to 20 per cent throughout the year. This is in part due to changes in atmospheric conditions, such as cloud cover. In Honiara, the average percentage of the sky covered by clouds experiences significant seasonal variation, with the cloudiest days occurring in December to March and the least cloudy days in July to September.

The chlorophyll-a concentration in Solomon Islands’ waters is generally very low, with concentrations in its offshore waters less than 0.1 gram per m3 of seawater. Most of the tropical regions of the open oceans have similarly low chlorophyll-a concentrations. In contrast, within temperate and arctic regions, these concentrations can approach 1 gram per m3 of seawater. The shallow coastal regions of Solomon Islands have increased chlorophyll-a concentrations, with up to 2.5 grams per m3 of seawater. Again, this is low compared to many coastal regions around the world, where chlorophyll-a concentrations can reach over 10 grams per m3 of seawater. The low concentrations of chlorophyll-a in Solomon Islands’ waters reflect the low availability of key nutrients. Compared to large continental landmasses, with large river discharges that can carry nutrients into the sea, Solomon Islands is a small island nation with comparatively small nutrient inputs into the marine environment. However, at the local or bay scale, nutrient inputs may still be significant.

Euphausia superba, phytoplankton from the Antarctic, is an example of the basis of the marine food chain.

In the south-western tropical Pacific Ocean, strong seasonal and inter-annual variabilities in the chlorophyll-a concentration have been observed (Dupouy et al., 2004). Strong chlorophyll-a enrichments have been documented around the Solomon Islands, and between New Caledonia and Vanuatu, with weaker enrichments found around Fiji or Tonga. The annual variation in chlorophyll-a around Solomon Islands is low, with variation up to 6 grams per m3 of seawater in some coastal areas.




155°E
160°E
165°E
170°E
5°S
10°S
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
Gizo
New Georgia
Russell Islands
Florida Islands
Malaita
Honiara
Guadalcanal
San Cristobal
Lata
Santa Cruz
Vanikoro
Bellona Island
Rennell Island
COASTAL HABITATS
Reefs
Mangroves
Solomon Islands Provisional EEZ Boundary
Populated places
Capital city
50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Andréfouët et al, 2005; Becker et al, 2009; Claus et al, 2016; Natural Earth, 2016; Smith and Sandwell, 1997; Spalding et al, 1997.

OCEAN VALUES

HOME, SWEET HOME: COASTAL HABITATS

Solomon Islands' famous hospitality extends to the thousands of species that call its coral reefs, mangroves and seagrasses home. These habitats house countless plants and animals that store carbon and help protect Solomon Islands' coastal inhabitants.

The previous set of maps in the "Supporting values" section of the report took us on a journey from the ocean floor all the way to the surface, demonstrating the colourful biophysical features of Solomon Islands' waters. While they are fascinating in their own right, the combination of features such as bathymetry, geomorphology, currents, nutrients and plankton are also important factors in the distribution and health of Solomon Islands' coastal habitats.

Coastal protection is a key ecosystem service with two components: the prevention of erosion and the mitigation of storm surges. Coastal ecosystems prevent coastal erosion by reducing the effects of waves and currents and also helping regulate the removal and deposition of sediment (erosion and accretion). Furthermore, they provide increased short-term protection against episodic events, including coastal floods and storm surges. The benefits of this protection against extreme weather events include minimizing damage to homes, buildings and other coastal infrastructure and on important resources such as crops.

Residents of Solomon Islands came to realize these benefits in May 1986, when Tropical Cyclone Namu devastated many of the nation's islands. Cyclone Namu is considered to be the worst tropical cyclone to have affected Solomon Islands on record, with over 150 fatalities reported. However, without the protection that coral reefs and mangroves provide to most of Solomon Islands, the damage could have been a lot worse. Every year, reefs and mangroves mitigate damage to houses and hotels across Solomon Islands by up to SI$58 million (Arena, 2015), demonstrating just how valuable marine and coastal ecosystem services are to Solomon Islands.

Coastal habitats such as mangrove forests, seagrass beds and coral reefs play an important role in stabilizing shorelines. As human density increases however, so too does the impact on these important coastal habitats.

The role of mangroves in coastal stabilization is well known. They protect coastal areas from erosion, storm surges (especially during cyclones) and tsunamis. Their massive root systems are efficient at dissipating wave energy and slow down tidal water so that suspended sediment is deposited as the tide comes in, with only the fine particles resuspended as the tide recedes. In this way, mangroves help build their own environment. Given the uniqueness of mangrove ecosystems and the protection they provide against erosion, they are often the subject of conservation programmes and are commonly included in national biodiversity action plans.

Seagrasses are another important coastal habitat that form extensive meadows in the coastal areas they colonize. Their leaves can also slow currents, and their roots and rhizomes trap the sediments in which they grow, thereby enhancing the stability of the substrate. Seagrasses can also dissipate the energy of waves by up to 40 per cent, which can in turn increase the rate of sedimentation. As such, seagrass beds effectively help protect against waves and limit coastal erosion.

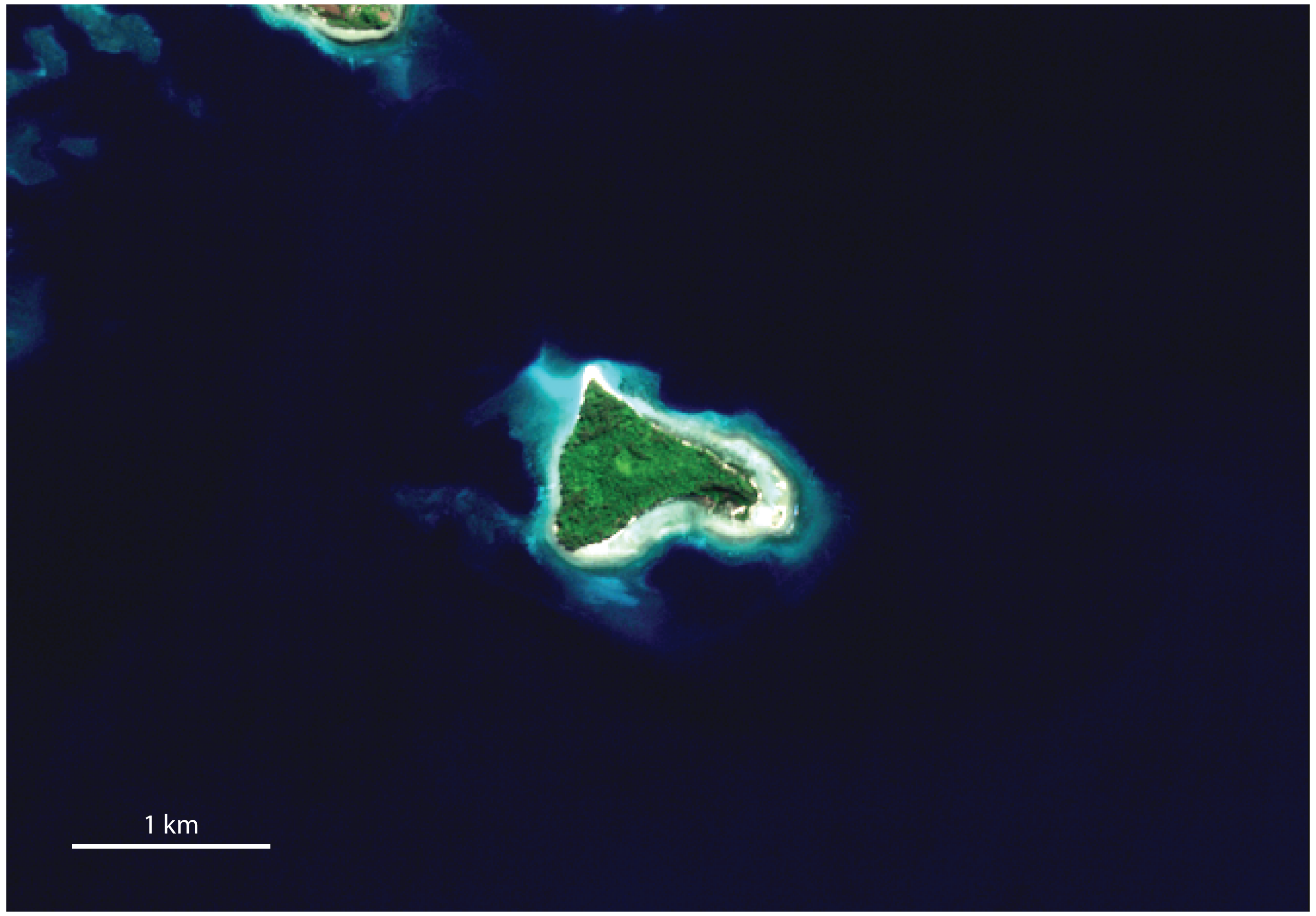
In addition to protecting the coast, Solomon Islands' coastal habitats also act as nursery areas for fish and support food security, livelihoods, tourism and other human activities. Based on village-derived economic data, it is estimated that a minimum annual subsistence value of US$345–1,501 per household is generated from mangroves in Solomon Islands (Warren-Rhodes et al., 2011). Seagrass meadows and mangroves are also recognized as important carbon stores, with the preservation of healthy mangrove systems contributing to climate change action. Mangroves are Solomon Islands most extensive type of wetland vegetation (Bani and Esrom, 1993), with forests covering almost 65,000 hectares and containing around 25 mangrove species (Warren-Rhodes et al., 2011). The social benefit of carbon sequestration by mangroves in Solomon Islands' EEZ is estimated to be worth up to SI$162 million (Arena, 2015).

The map of coastal habitats presents the distribution of coral reefs and mangroves. Shallow coral reefs form some of the most diverse ecosystems on Earth. Despite occupying less than 0.1 per cent of the world's ocean surface, they provide a home for at least 25 per cent of all marine species, including fish, molluscs, worms, crustaceans, echinoderms, sponges, tunicates and other cnidarians. Coral reefs provide many benefits to people living in coastal areas, including food provision, supporting artisanal and commercial fisheries, tourism opportunities and coastal protection. Solomon Islands is surrounded by fringing and barrier reefs.

Coral reefs in Solomon Islands have some of the highest diversity in the world, with almost 500 different coral species (TNC, 2004). Solomon Islands is the easternmost part of the Coral Triangle, the world's coral biodiversity hotspot, which also includes Indonesia, Malaysia, Papua New Guinea and Timor-Leste.

Seagrass beds are highly diverse and productive ecosystems that can harbour hundreds of associated species from all phyla, for example, juvenile and adult fish, epiphytic and free-living macroalgae and microalgae, molluscs, bristle worms, and nematodes. These beds occur in the sheltered waters of many islands of Solomon Islands. In a 2004 survey, 10 species of seagrass were found, representing 80 per cent of all seagrass species in the Indo-Pacific region (TNC, 2004). Some seagrass meadows measured up to 1,000 hectares in size, while others were 37 metres in depth (TNC, 2004). However, seagrass maps have not been presented in the map of coastal habitats as there are currently no comprehensive publicly available data that adequately capture the distribution of seagrass in Solomon Islands.

Although coastal habitats are some of the most productive and valuable marine habitats, they are also some of the habitats most vulnerable to human activities (see also chapters "Reefs at risk", "From ridge to reef" and "Turning sour"). These habitats therefore require special consideration in the management of human activities.



Fringing reef around Mandoliana Island

Barrier reef west of Vonavona Island

Ontong Java Atoll north of Isabel Province

Patch reef east of Ghizo Island

SHAPING PACIFIC ISLANDS: CORAL REEFS

Solomon Islands’ reefs are not only important coastal habitats; they are also transforming and shaping Solomon Islands’ coastlines, islands and atolls.

Corals play a fundamental role in the development of island nations such as Solomon Islands, with coral reefs having helped transform and shape the very outline of Solomon Islands’ coasts, islands and atolls. But how do coral reefs do this, especially considering that corals are tiny animals, belonging to a group of animals known as cnidaria, which also includes jellyfish and sea anemones?

Firstly, corals secrete hard calcium carbonate exoskeletons, which support and protect their coral polyps. The resulting calcium carbonate structures hold the coral colonies together. Most coral reefs are built from stony corals, which consist of polyps that cluster together and grow best in warm, clear, sunny, nutrient-poor, agitated water, which also needs to be shallow, as corals are dependent on light. But where does the shallow water come from in the middle of the ocean?

Charles Darwin was wondering the same. Following his voyage of the world on HMS Beagle in 1842, he set out his theory of the formation of atoll reefs. He theorized that uplift and subsidence of the Earth’s crust under the oceans was responsible for atoll formation (see also chapter “Smoke underwater, fire in the sea”). Darwin’s theory, which was later confirmed, sets out a sequence of three stages for atoll formation, starting with a fringing reef forming around an extinct volcanic island. As the island and ocean floor subsides, the fringing reef becomes a barrier reef, and ultimately an atoll reef as the island subsides below sea level.

A fringing reef can take 10,000 years to form, while an atoll can take up to 30 million years. When an island is undergoing uplift, fringing reefs can grow around the coast, but if the coral is raised above sea level, it will die and become white limestone. If the land subsides slowly, the fringing reefs keep pace by growing upward on a base of older, dead coral, forming a barrier reef enclosing a lagoon between the reef and the land. A barrier reef can encircle an island, and once the island sinks below sea level, a roughly circular atoll of growing coral continues to keep up with the sea level, forming a central lagoon. Barrier reefs and atolls do not usually form complete circles, but are broken in places by storms. Like sea level rise (see also chapter “Hotter and higher”), a rapidly subsiding bottom can overwhelm coral growth, killing the coral polyps and the reef through “coral drowning”. Corals that rely on their symbiotic zooxanthellae can drown when the water becomes too deep for their symbionts to adequately photosynthesize due to decreased light exposure (Spalding et al., 2001).

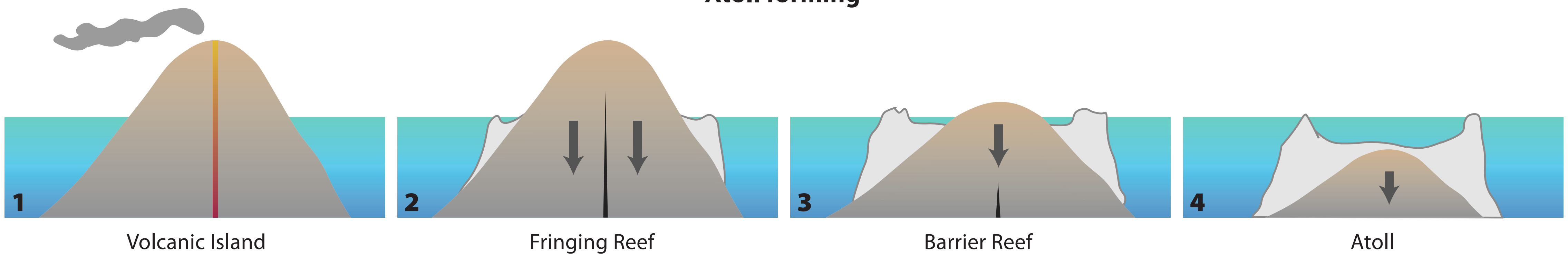
Solomon Islands has an estimated reef area of 5,750 km^2 (Morris and Mackay, 2008). Nearly 500 different coral species have been observed in Solomon Islands, making the area a coral diversity hotspot. The coral reefs are mainly fringing and intermittent around all of the islands (Sulu et al., 2003). While there are several small barrier reefs throughout Solomon Islands, including those along the north-east coast of Choiseul, in eastern Makira, north-east of the Russell Islands and around the eastern Santa Cruz Islands (Sulu et al., 2003), large barrier reefs, such as the Great Sea Reef (Cakaulevu) in Fiji, are rare. Atolls are also uncommon in Solomon Islands, with Ontong Java in the north being the only large atoll. There are also several mid-ocean reefs where the sea floor rises from the ocean depths, such as the Roncador and Bradley reefs south of Ontong Java in the north and the Indispensable Reefs in the south (Sulu et al., 2003). The main types of reef found in Solomon Islands are:

- *Fringing reef:* A reef that is either directly attached to a shore or borders it, with an intervening shallow channel or lagoon. This is the most common type of reef and is found along the coast of most islands.
- *Barrier reef:* A reef that is separated from a mainland or island shore by a deep channel or lagoon.
- *Atoll reef:* A more or less circular or continuous barrier reef that extends all the way around a lagoon without a central island, for example, the Ontong Java Atoll.
- *Patch reef:* A common, isolated, comparatively small reef outcrop, usually within a lagoon or embayment. Patch reefs are often circular and surrounded by sand or seagrass.
- Mid-ocean reef: A shallow isolated reef with no land or lagoon.

Underwater rainforests

Around 80 per cent of Solomon Islands’ land is covered by forest and its sea also features the proverbial “rainforests of the sea”, coral reefs. These reefs are rich in biodiversity and harbour many more plants and animals then the nation’s forests above sea level. Solomon Islands has one of the most diverse coral reef systems in the world, thanks to its highly varied marine habitat. The country’s coral reefs are mainly fringing and are intermittently distributed around its islands. At least 485 coral species belonging to 76 genera have been identified in Solomon Islands’ waters, which are also home to at least 1,019 fish species belonging to 82 families. Solomon Islands is the easternmost part of the Coral Triangle, one of the world’s coral reef hotspots. Such a diverse ecosystem is very valuable to Solomon Islands, providing habitat, shelter and tourist destinations (see also chapters “Home, sweet home” and “Beyond the beach”).

Atoll forming



TRAVELLERS OR HOMEBODIES: MARINE SPECIES RICHNESS

Solomon Islands' marine environment hosts two types of animals: pelagic species and benthic species, both of which are important and biologically interconnected.

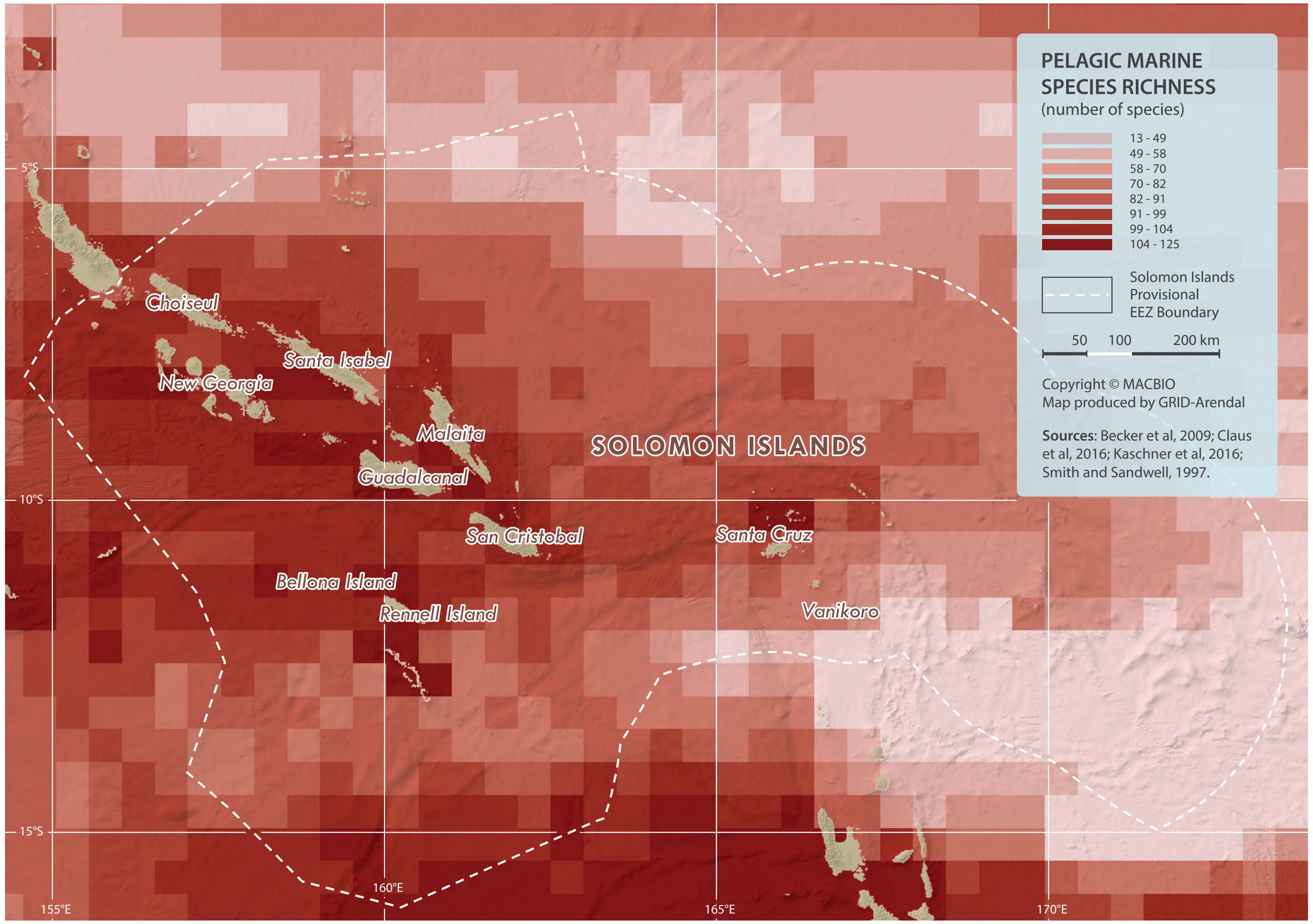
Pelagic species are those that live in the water column away from the sea floor and coast. Often these species migrate across vast areas of ocean, driven by oceanic conditions and seasonal food availability (see also chapter "Go with the flow"). On the other hand, benthic species are those that live on or close to the sea floor. Unlike pelagic species, which migrate large distances, benthic species are often associated with specific sea-floor features and either are attached to the substrate or very site-specific.

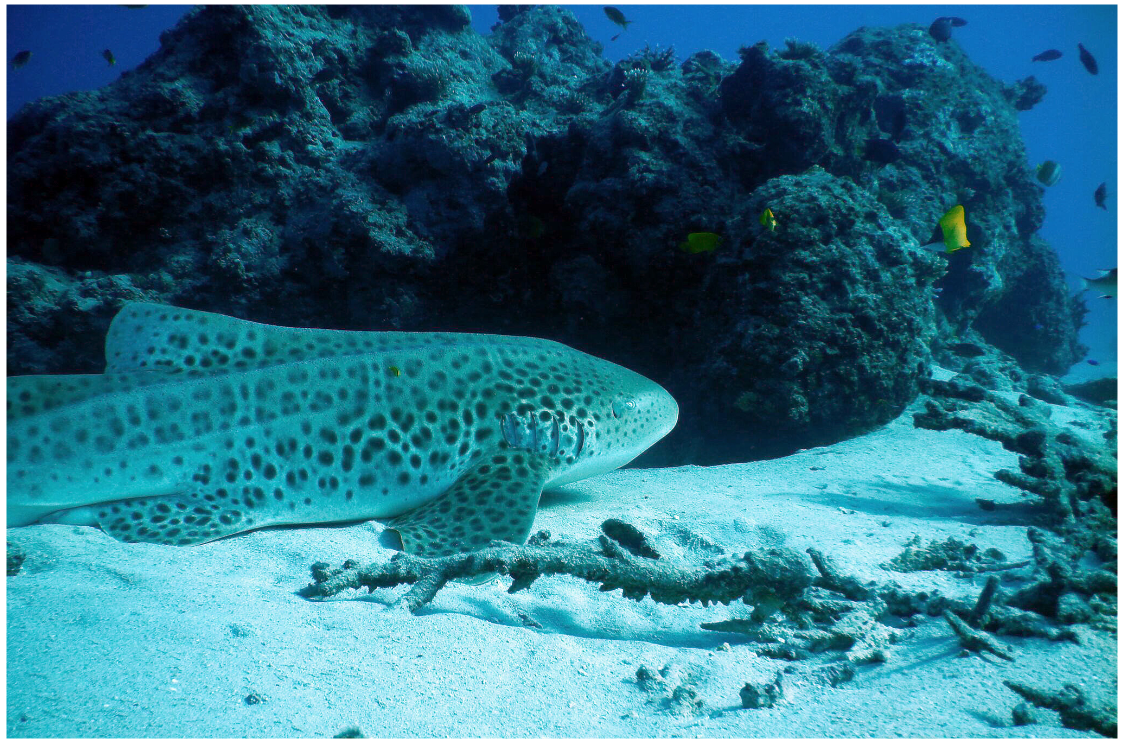
Both pelagic and benthic species contribute to Solomon Islands' rich marine biodiversity, are part of complex food chains, and form important habitats. Furthermore, many commercially important species of both types are found in Solomon Islands' waters. Commercially important pelagic species include several species of tuna, such as albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) tuna and several important commercial billfish species, such as blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*).

There are also some pelagic shark species, including the blue shark (*Prionace glauca*), oceanic whitetip (*Carcharhinus longimanus*), shortfin mako shark (*Isurus oxyrinchus*), and silky shark (*Carcharhinus falciformis*). Pelagic species also include the smaller species that support these large commercially important species (see also chapter "Fishing in the dark"). The routes these species take to migrate, and thus the connectivity of their habitats, are an important consideration for marine management and conservation planning.

With the second highest coral diversity in the world and over 500 coral species, Solomon Islands' waters are home to numerous benthic species. Many invertebrates (those without a backbone) are found in soft sediment habitats and on rocky substrates. According to the Ocean Biogeographic Information System, Solomon Islands has numerous marine invertebrates, including 885 species of bivalve (such as oysters and mussels) and gastropods (such as snails and slugs), 285 crustaceans (such as crabs, lobsters and shrimps) and over 200 echinoderm (including starfish, sea urchins, and sea cucumbers). Many benthic species form habitats in Solomon Islands' shallow waters, including corals, seagrass, mangroves and algae (see also chapter "Home, sweet home").

In general, species richness can be used as an indicator of conservation significance. It does not, however, provide information on





The Zebra shark is found throughout the tropical Pacific, but listed as an endangered species.

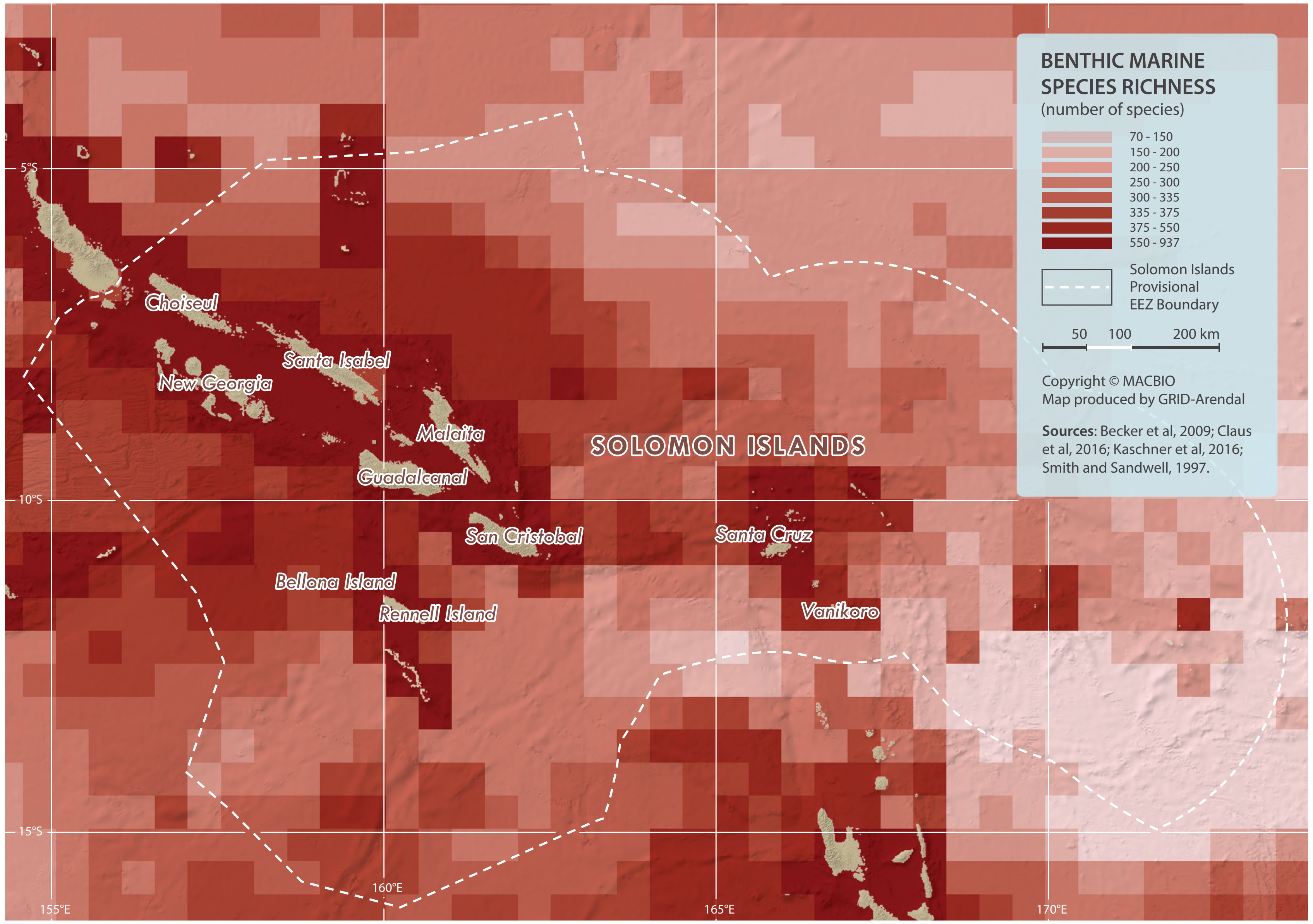
species composition, nor does it identify whether there are rare or priority species in an area. Furthermore, areas with similar species richness may have very different species present, which would affect the conservation and management measures required.

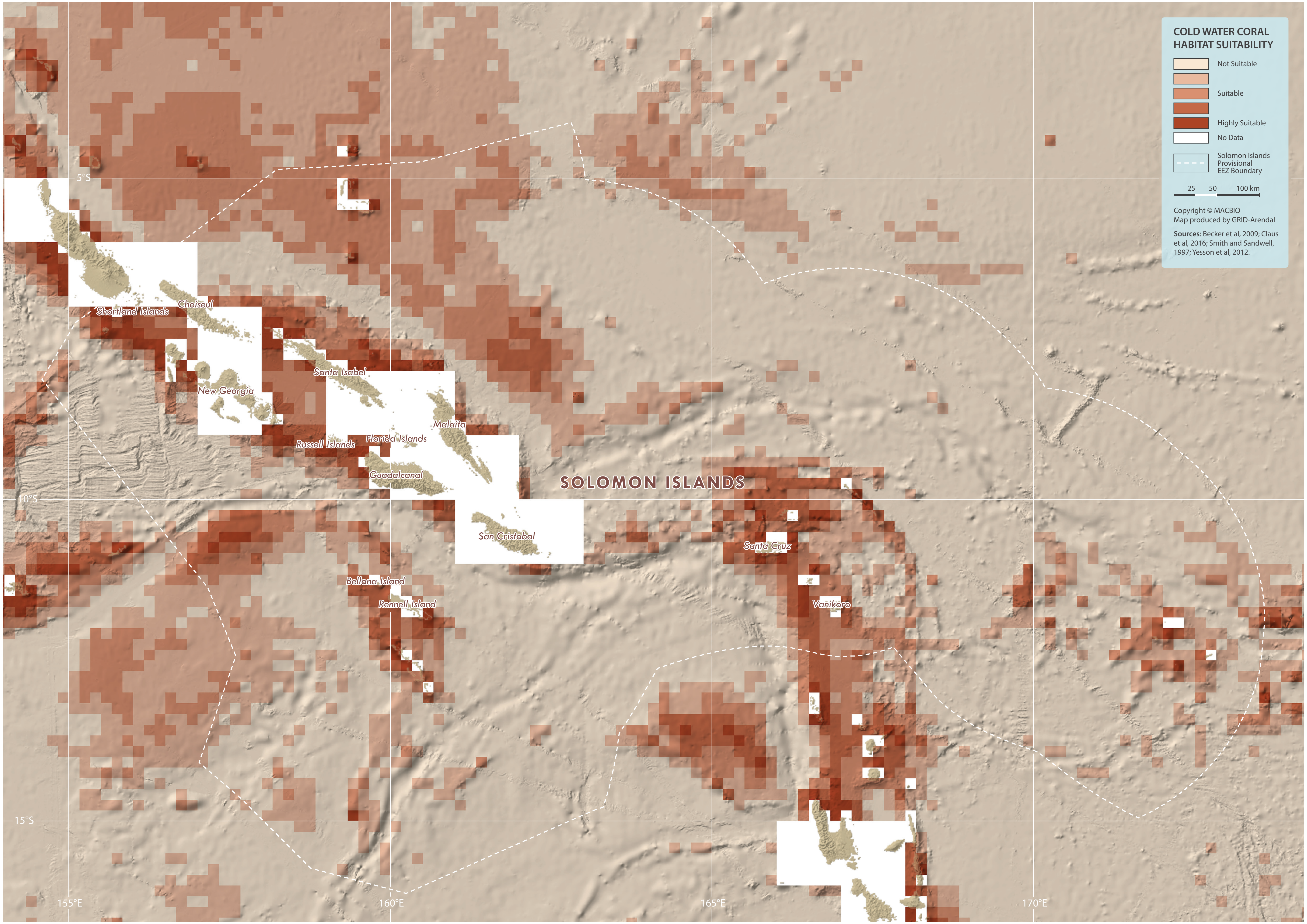
Globally, pelagic fish are generally more abundant in tropical waters and decrease as latitude increases. As the map shows, within Solomon Islands' waters, there is a trend for lower species richness in the northern and eastern parts of Solomon Islands' waters, with higher pelagic richness around its islands and offshore reefs and shallows, such as the Indispensable Reefs in the south (see also chapter "Voyage to the bottom of the sea"). Large geographic features that rise from the sea floor, such as seamounts and mid-ocean ridges, interact with currents (see also chapter "Go with the Flow"), allowing pelagic fish abundance and biomass to peak deep in the water column (Sutton et al., 2010). Furthermore, migrating species, including whales, frequently pause over seamounts and other shallow geographical features (Garrigue et al., 2015).

Similarly, tropical waters tend to have a higher benthic species richness than waters at higher latitudes. Again, in Solomon Islands' waters, there is a trend for higher benthic species richness around the country's islands and shallow offshore reefs, such as the Indispensable Reefs and Ontong Java. This reflects the high coral reef diversity and associated species, as well as the global trend of higher benthic species richness is shallowed waters compared to deep waters. Benthic species were found to be least diverse in the deep waters in the eastern part of Solomon Islands' waters.

Pelagic or benthic?

Some marine species move from one place to another, while others tend to stay in the same location. These species are described as either "pelagic" or "benthic" (see also chapter "Still waters run deep").




COLD WATER CORAL HABITAT SUITABILITY
Not Suitable
Suitable
Highly Suitable
No Data
Solomon Islands Provisional EEZ Boundary
25
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Smith and Sandwell, 1997; Yesson et al, 2012.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Malaita
Russell Islands
Florida Islands
Guadalcanal
San Cristobal
Santa Cruz
Bellona Island
Rennell Island
Vanikoro
5°S
10°S
15°S
155°E
160°E
165°E
170°E

HOW MUCH DO WE REALLY KNOW? COLD WATER CORAL HABITATS

While quite a lot is known about Solomon Islands' inshore environment, some habitats are hard to explore and map. For example, although cold-water corals can be common and important deep-sea species, little is known about their distribution and abundance in Solomon Islands' waters. Their sensitivity to human impact and future climate change should be considered when assessing management options for deep-sea ecosystem conservation.

The Moon or the Sea?

There is a common misconception that we know more about the surface of the Moon than the ocean floor and that 95 per cent of the ocean is unexplored. The chapter "Voyage to the bottom of the sea" showed that we actually know a lot about the ocean floor. The entire ocean floor has been mapped to a maximum resolution of around 5 kilometres, unveiling most features larger than 5 kilometres across (Sandwell, 2014). However, only 0.05 per cent of the ocean floor has been mapped to a high level of detail, meaning Solomon Islands' waters undoubtedly hold a lot of secrets, including deepwater or cold-water corals. These corals have a depth range extending from around 50 metres to beyond 2,000 metres deep, where water temperatures may be as cold as 4°C (see also chapter "Still waters run deep"). While there are nearly as many species of cold-water corals as shallow-water corals, only a few cold-water species develop into traditional reefs. This is also why they are much harder to discover and map than their shallow-water counterparts. Nevertheless, scientists have created habitat suitability models that use information on the physical environment to predict their distribution and provide an understanding of their ecological requirements.

Corals are not restricted to shallow-water tropical seas. Cold-water corals are regarded as occurring deeper than 50 metres, and include five taxa and over 3,300 more species than their better known tropical coral reef counterparts: order *Scleractinia* (hard, stony corals), order *Zoanthidea* (zoanthids, gold corals), order *Antipatharia* (black corals), subclass *Octocorallia* (soft corals, gorgonians, bamboo corals), and family *Stylasteridae* (lace corals) (Roberts et al., 2009). They are widespread throughout the Pacific Ocean.

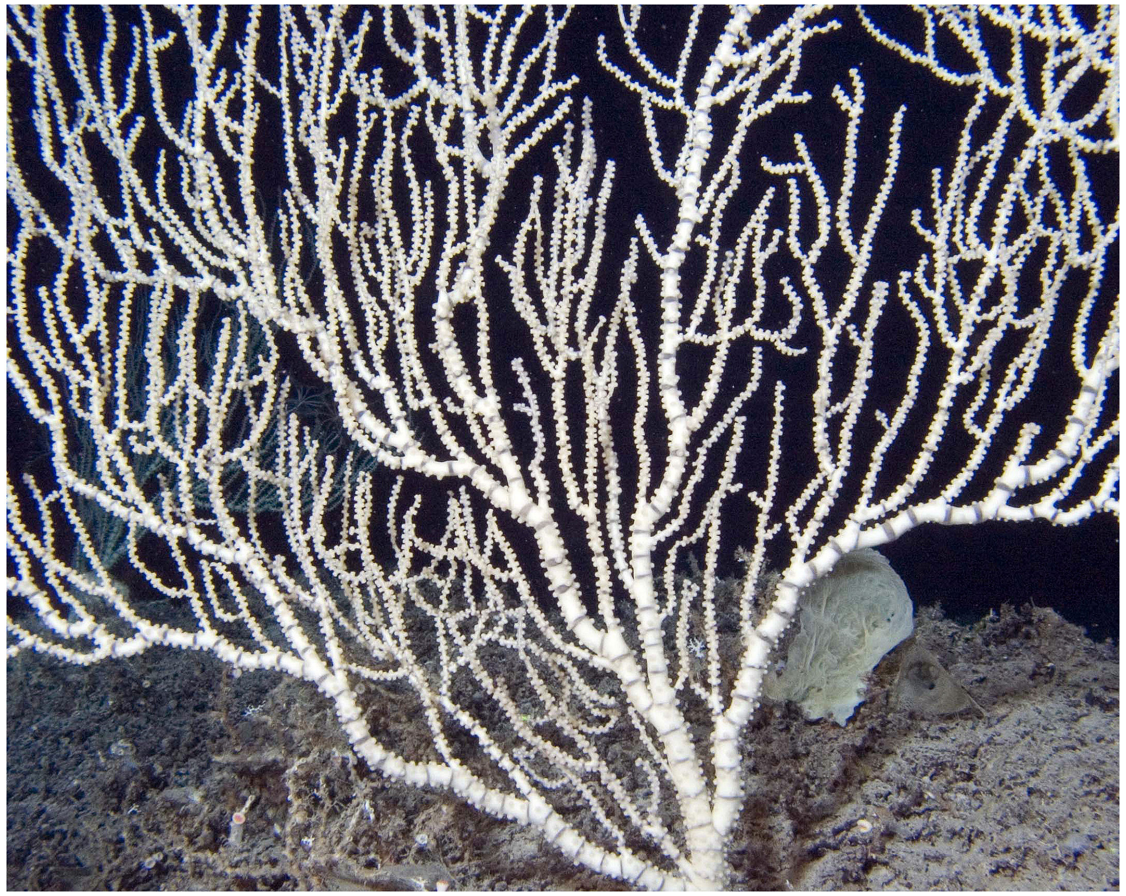
At present, cold-water corals have no economic importance for Solomon Islands, though some species are used in jewellery production. However, many of them have been recognized as playing important ecological roles in the deep sea, since they can form large reef-like structures or have complex growth forms which in turn provide habitat for many associated invertebrate and fish species.

Cold-water corals are widely regarded as being susceptible to damage from human activities, such as direct effects from fishing, deep-sea mining and submarine communication cables (see also chapters "Fishing in the dark" and "Underwater Wild West"), as well as more indirect impacts of pollution and climate change (see also chapters "The dose makes the poison" and "Turning sour"). Many species of cold-water coral are structurally fragile, and hence easily broken. They can also be long-lived and slow-growing, meaning that any recovery from damage is slow. Therefore, the presence of cold-water corals can be an important indicator of the need to manage human activities to avoid or minimize impacts on these deep-sea ecosystems. The presence of cold-water corals can therefore be used as an important indicator for managing human activities in order to avoid or minimize impacts on deep-sea ecosystems. For instance, octocorals are one of the groups that FAO lists as potentially Vulnerable Marine Ecosystems (FAO, 2009), and which are required under United Nations resolutions to be protected from deep-sea fishing. They are fully protected in some countries (e.g. New Zealand).

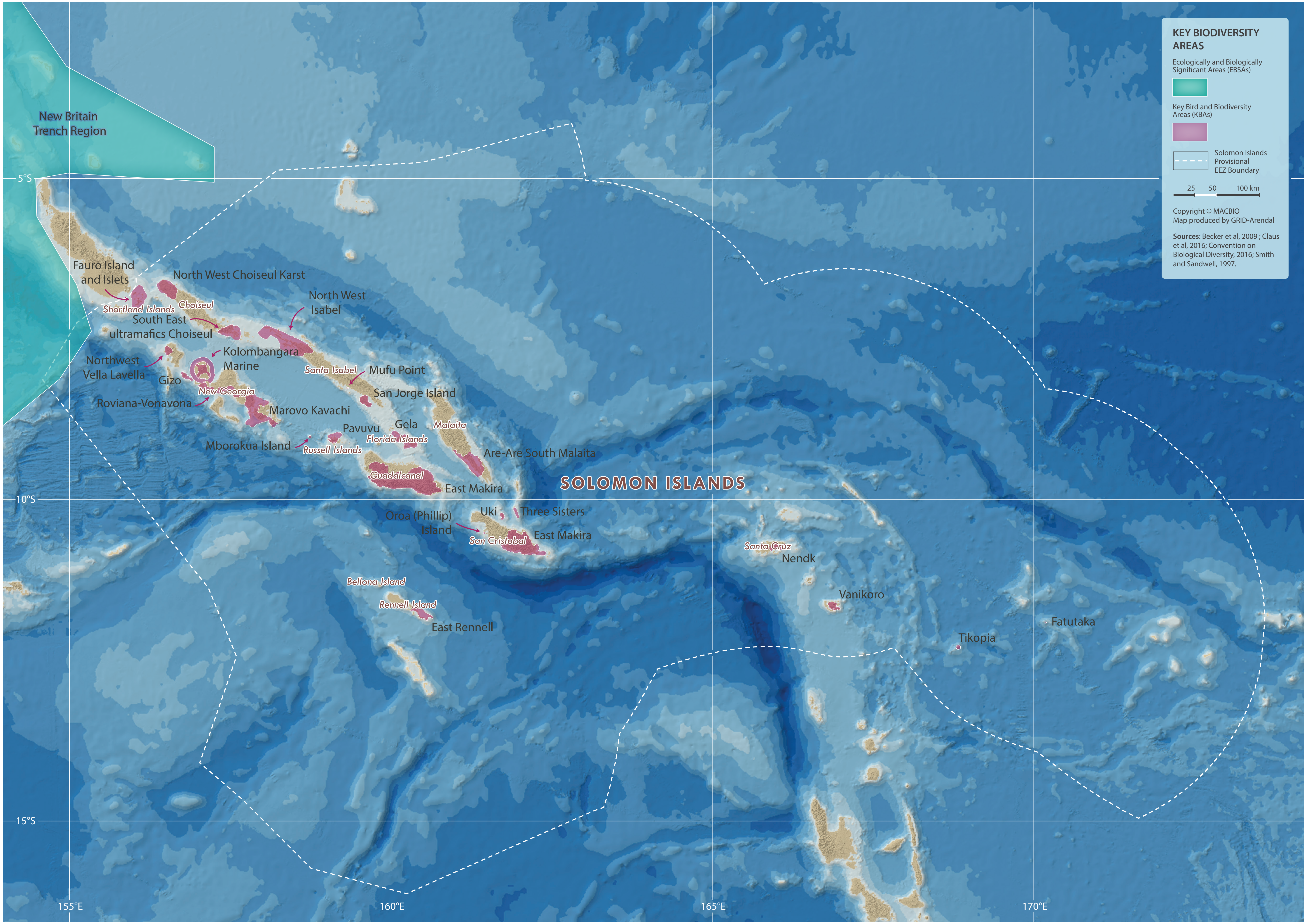
Habitat suitability was highest along the major bathymetric features in the EEZ, with high predicted occurrence on seamounts to the south-east of the main islands and the island slopes of Santa Isabel, New Georgia and Choiseul, as well as the Santa Cruz Islands in the south. The distribution largely follows depth, with topography also a factor. These deeper slope and seamount features are shallower than many of the abyssal plains in the EEZ, with higher food availability. The steep topography provides hard rocky substrate which the corals need for attachment.

Although not presented, similar analyses have been carried out for five species of stony coral (order Scleractinia) (Davies and Guinotte, 2011). Depth, temperature, aragonite saturation state and salinity were the key environmental drivers for this taxonomic grouping. The published figures do not indicate high suitability for these corals around Solomon Islands.

The presence of cold-water corals can be an important indicator for managing human activities to avoid or minimize impacts on deep-sea ecosystems. The habitat suitability map, although based on presence-absence rather than abundance, gives an indication of which areas may need protection from disturbance of the sea floor or climate change.



The bamboo coral Keratoisis grandiflora, which has been recorded in Solomon Islands' waters.


KEY BIODIVERSITY AREAS
Ecologically and Biologically Significant Areas (EBSAs)
Key Bird and Biodiversity Areas (KBAs)
Solomon Islands Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009 ; Claus et al, 2016; Convention on Biological Diversity, 2016; Smith and Sandwell, 1997.
New Britain Trench Region
Fauro Island and Islets
North West Choiseul Karst
North West Isabel
Shortland Islands
Choiseul
South East ultramafics Choiseul
Kolombangara Marine
Northwest Vella Lavella
Gizo
Santa Isabel
Mufu Point
San Jorge Island
New Georgia
Roviana-Vonavona
Marovo Kavachi
Gela
Malaita
Pavuvu
Florida Islands
Mborokua Island
Russell Islands
Are-Are South Malaita
Guadalcanal
East Makira
SOLOMON ISLANDS
Uki
Three Sisters
Oroa (Phillip) Island
San Cristobal
East Makira
Santa Cruz
Nendk
Vanikoro
Bellona Island
Rennell Island
East Rennell
Tikopia
Fatutaka
5°S
10°S
15°S
155°E
160°E
165°E
170°E

NATURE'S HOTSPOTS: KEY BIODIVERSITY AREAS

Solomon Islands' waters host a large variety of marine habitats. The characteristics of Key Biodiversity Areas mapped here can support the further development of management options to balance human activities and protect vulnerable species and ecosystems.

The previous maps show Solomon Islands' impressive richness of natural wonders and their value to Solomon Islands. However, as the ocean and the atmosphere do not have borders that restrict the migration of species or the flow of carbon (see also chapters "Go with the flow" and "Travellers or homebodies"), these high-value areas in Solomon Islands' waters also have international significance. It is therefore important for Solomon Islands to identify and designate hotspots that are key to global biodiversity and climate as part of a global effort to conserve biodiversity. Such hotspots are called Key Biodiversity Areas (KBAs), which extend the concept of the 13,000 Birdlife International Important Bird and Biodiversity Area (IBA) sites worldwide to other species and include Ecologically or Biologically Significant Areas (EBSAs) described under the Convention on Biological Diversity (CBD).

Marine conservation in Solomon Islands is guided by the goals and objectives laid out in three laws: Environment Act 1998, Wildlife Protection and Management Act 1998 and Protected Areas Act 2010. These laws along with the country's ratification of the CBD in 1995, link national action with these more global and regional initiatives. These areas (KBAs, IBAs and EBSAs) are defined as sites that contribute significantly to regional or global persistence of biodiversity, and consider attributes such as uniqueness or rarity; importance for life-history stages of key species; threatened, endangered or declining species; vulnerability to, or slow recovery from, disturbance; productivity; diversity and/or naturalness.

Solomon Islands' KBAs are important habitats, e.g. for bird nesting, benthic and pelagic species.

The determination of KBAs can bring a site into the conservation agenda that had not previously been identified as needing protection. It is important to note that while EBSAs identified under the CBD criteria have no official management status, KBAs can be recognized under national legislation. The New Britain Trench Region, which overlaps with the far western part of Solomon Islands' waters, has been identified by the Secretariat of the CBD as an EBSA. While EBSAs have no official management status in Solomon Islands, they can act as focal areas for conservation or additional management. KBAs and IBAs have also been identified in Solomon Islands, and can be used to identify species that warrant conservation priority due to their ecological role, cultural significance, uniqueness (e.g. endemic status) and rarity (e.g. threat status on the IUCN Red List). As knowledge of the characteristics of such prospective areas develops, they can become critical elements of an integrated protected area network that can ensure key ecological sites are protected, yet still allow human activities to occur in an environmentally sustainable way.

Many Pacific Island countries rely heavily on tourism, with part of its success based on countries' natural and unspoiled environments. There is a growing demand worldwide to manage marine ecosystems in order to prevent and minimize harm from human activities. Effective conservation areas or plans can therefore benefit a country's tourism potential and also improve consumers' acceptance of products if they are proven sustainable.

The map shows the distribution of EBSAs and KBAs in island and offshore areas of Solomon Islands.

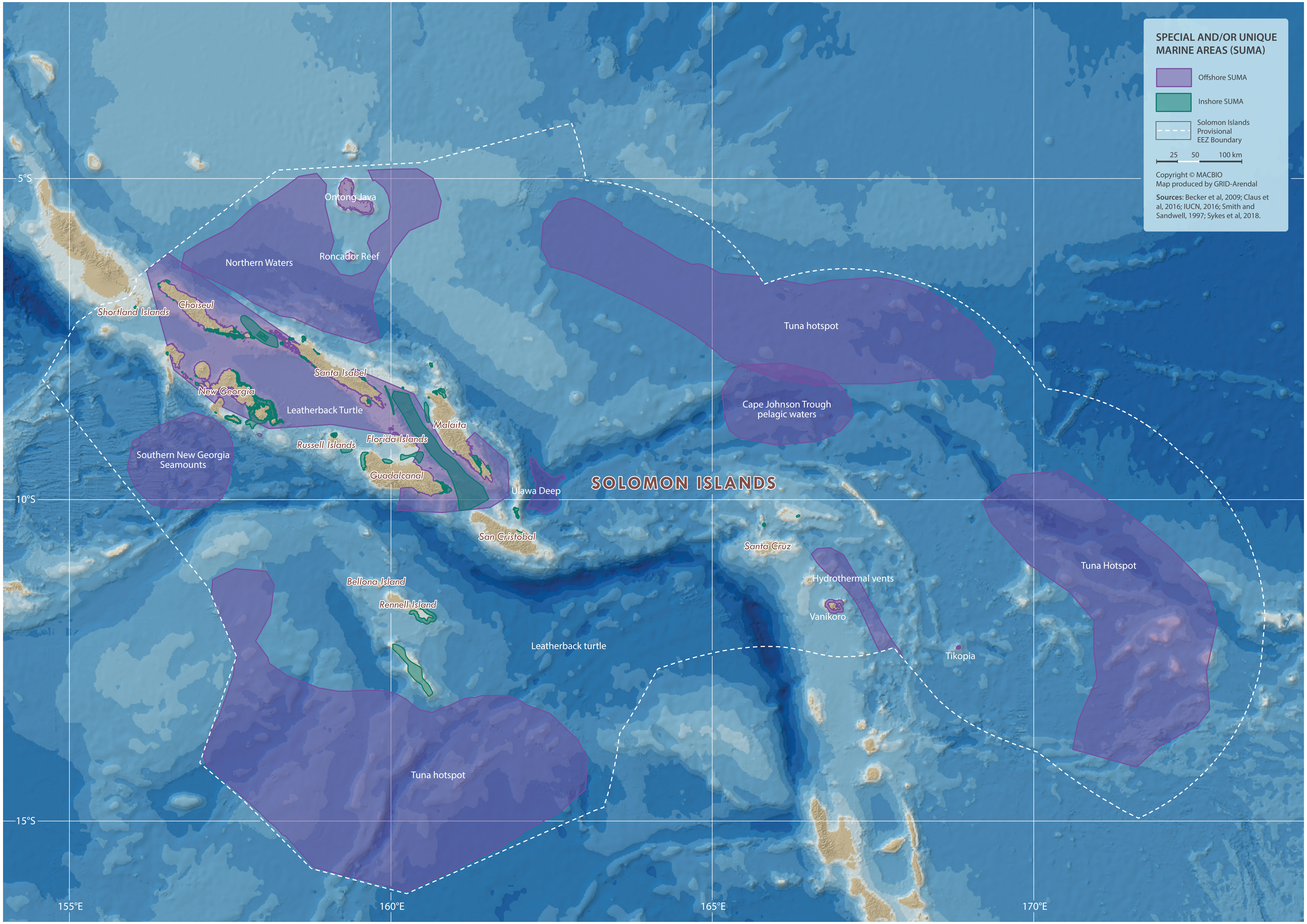
In November 2011, the Secretariat of the Convention on Biological Diversity hosted a regional workshop to facilitate the description of EBSAs for the western South Pacific Ocean (CBD, 2012). The boundaries of the New Britain Trench Region EBSA overlap the north-western margin of the provisional EEZ boundary of Solomon Islands, though it is unclear whether this was intentional. In the overlapping area, the trench continues past the western side of the New Georgia Islands and likely includes some seamounts - both habitats cited in the justification of the EBSA. The CBD has subsequently approved the EBSA.

There are 37 KBAs in Solomon Islands, though most of focus on terrestrial biodiversity (Birdlife International, 2018a). The country also has 11 IBAs, but again, most of these focus on land-based birds. The main exception to this is the Kolombangara Marine IBA, which is a 7 kilometre seaward extension around Kolombangara Island, just north of New Georgia Island. This is an important area for the potentially very rare Heinroth's shearwater (Birdlife International, 2018b).

EBSAs and KBAs have no official management status, but are components of efforts by the CBD and International Union for Conservation of Nature (IUCN) to identify species that should be prioritized for conservation based on their ecological roles, cultural significance, uniqueness (e.g. endemics) and rarity (e.g. threat status on the IUCN Red List) and to describe the marine habitats in which these species are likely to be found, and which may therefore need protection.

There are over 80 marine protected areas (MPAs) in Solomon Islands (Marine Conservation Institute, 2018) that require consideration, though these are often informal, small and very close to the shore, covering reef areas, bays and nearshore island regions.

Together with marine reserves and protected areas, KBAs and EBSAs can help develop an appropriate network of multiple-use managed areas.


SPECIAL AND/OR UNIQUE MARINE AREAS (SUMA)
Offshore SUMA
Inshore SUMA
Solomon Islands Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; IUCN, 2016; Smith and Sandwell, 1997; Sykes et al, 2018.
SOLOMON ISLANDS
Ontong Java
Roncador Reef
Northern Waters
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Leatherback Turtle
Malaita
Florida Islands
Russell Islands
Southern New Georgia Seamounts
Guadalcanal
Ulawa Deep
San Cristobal
Tuna hotspot
Cape Johnson Trough pelagic waters
Santa Cruz
Hydrothermal vents
Vanikoro
Tikopia
Tuna Hotspot
Bellona Island
Rennell Island
Leatherback turtle
Tuna hotspot
5°S
10°S
15°S
155°E
160°E
165°E
170°E

SPECIAL AND UNIQUE MARINE AREAS

To prioritize management and/or protection of Solomon Islands' waters, local marine experts came together to identify areas in Solomon Islands' waters that are special and/or unique.

Solomon Islands' KBAs (see previous chapter) emphasize not only the importance of marine biodiversity to Solomon Islands, but also to the world. Much of Solomon Islands' waters are pristine and contain very diverse physical and ecological environments, which in turn support a huge range of marine life, yet a great deal remains undocumented. As the resources of both the nearshore and offshore marine environments are vital to the well-being and prosperity of the country and its people, their sustainable management and conservation are in the interests of both resource managers and general population.

So how can sustainable management be achieved? One requirement is to set agreed management priorities, which allow for an incremental, inclusive and sustainable management and conservation approach to Solomon Islands' valuable biodiversity. To help achieve this, the important concept of KBAs was complemented and extended by the identification of Special and Unique Marine Areas (SUMAs) and bioregions (see "Beyond the hotspots").

SUMAs are areas that are particularly important in maintaining Solomon Islands' biodiversity. They can serve as priority areas for management actions within Solomon Islands' marine environment. It is important that these areas are identified and agreed upon by a broad cross section of local users and experts to ensure they have validity in relevant decision-making processes.

Between 2015 and 2018, local users and subject experts were involved in a process to share their knowledge and identify and map 70 SUMAs. As part of this process, a workshop was held in 2017 to identify and map 65 SUMAs. Prior to this workshop, the Government of Solomon Islands and the Marine and Coastal Biodiversity in Pacific Island Countries (MACBIO) project team spent two and a half years collating, assessing, preparing and mapping open source and freely available data on, among other things, the special and/or unique marine features of the Solomon Islands. In total, there were 60 data sets available for use in the workshop, of which 46 were related to biodiversity and 14 to human use of marine areas. The local users and experts contributed their local knowledge of the area and were guided by four criteria in identifying SUMAs in Solomon Islands' waters: biophysical justification, geographic explicitness, availability of information sources, and international and national obligations.

This effort built upon and updated previous efforts, including the information on EBSAs.

Ranging from mangroves and seagrasses to deep-sea trenches, canyons and seamounts, these marine areas are some of Solomon Islands' most biologically important. These sites, together with the corresponding report "Biophysically Special, Unique Marine Areas of Solomon Islands", will assist in the selection of marine managed protected areas, to achieve 10 per cent coverage of Solomon Islands' waters (see also chapter "Solomon Islands' commitment to marine conservation") (Daniela et al., 2018). Moreover, they provide site-specific information for local or national-level decisions, policies, plans or analyses that refer to marine places. Information relating to each site is intended to inform the following management responses:

1. Permitting and licensing decisions;
2. Environmental impact assessments;
3. National and local development planning decisions;
4. Decisions by communities and various levels of government about where to locate marine protected/managed areas.

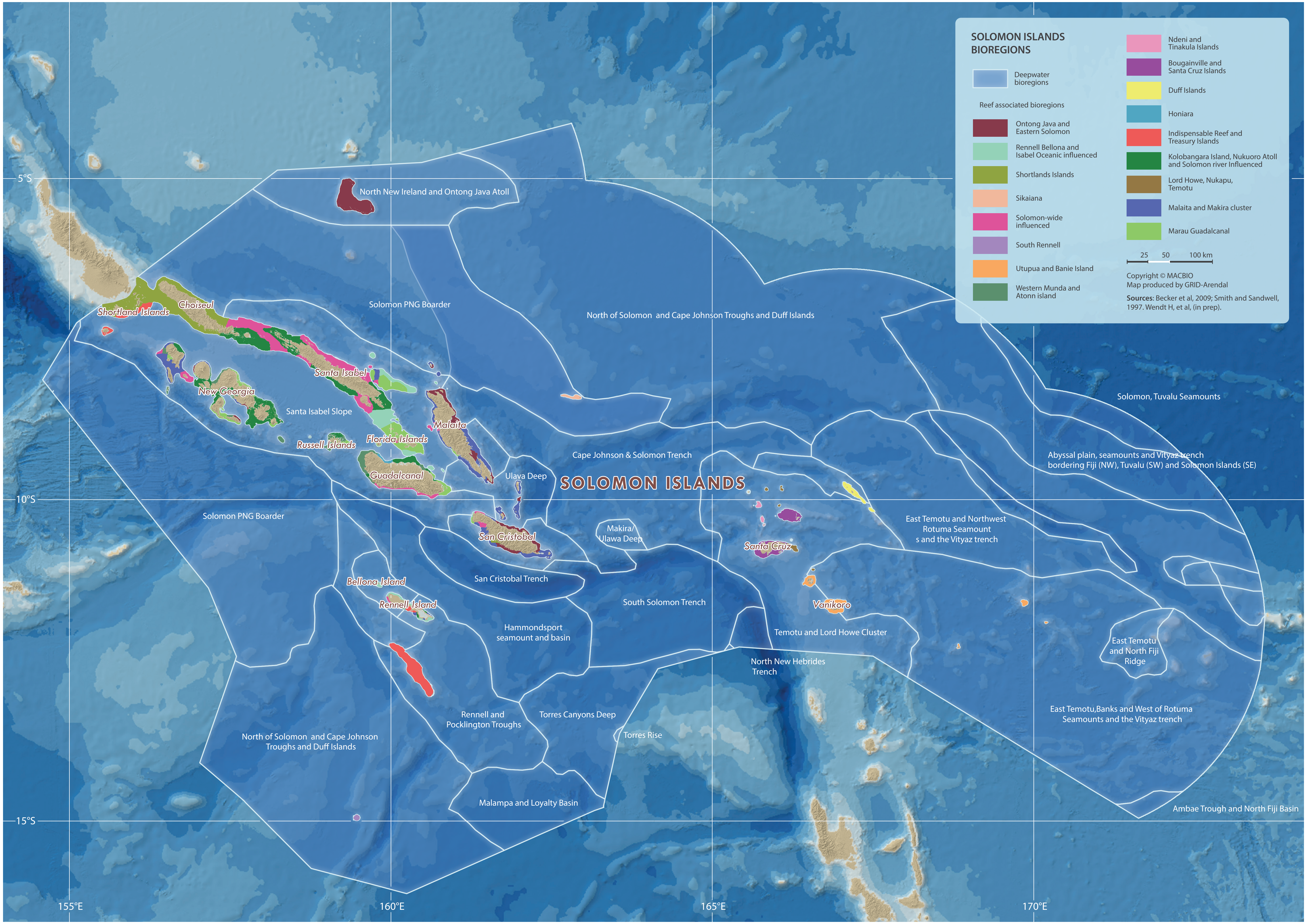
The maps show a total of 70 offshore and inshore sites. These SUMAs reflect the immense variety of marine habitats within the islands, reefs and surrounding oceans of Solomon Islands. Much of this information has been published in formal papers and reports, but there is also a great vein of local knowledge held by the traditional resource owners themselves, which should be taken into account when describing what is special and unique.

Special and unique: Arnavon Islands

In the Arnavon Islands, a group of islands in Isbael Province, near Wagina Island in Choiseul Province, 20 nesting female Hawksbill turtles have been fitted with satellite trackers in the last two years. These trackers show that the turtles travelled almost directly to the relative safety of the Great Barrier Reef in Queensland, Australia, roughly 2,000 kilometres away. Turtle tagging is a prime example of an activity that Solomon Islands is carrying out within a marine protected area that represents one of the Pacific's most important biodiversity hotspots. The Arnavon Community Marine Conservation Area (ACMCA) was established in 1995 with support from The Nature Conservancy and is administered by a group of previously inimical communities with a shared conservation vision. As one of the world's most important sites for Hawksbill turtle nesting, the primary goal is their protection. Since the creation of the ACMCA, the marine ecosystem of

the Arnavon Islands, which comprises 157 km² between the islands of Santa Isabel and Choiseul in the Manning Strait, has experienced a remarkable recovery, including a twofold increase in Hawksbill turtle nests, as well as increases in other species, such as giant clams and sea snails. The Arnavon Islands are truly a special and unique area.

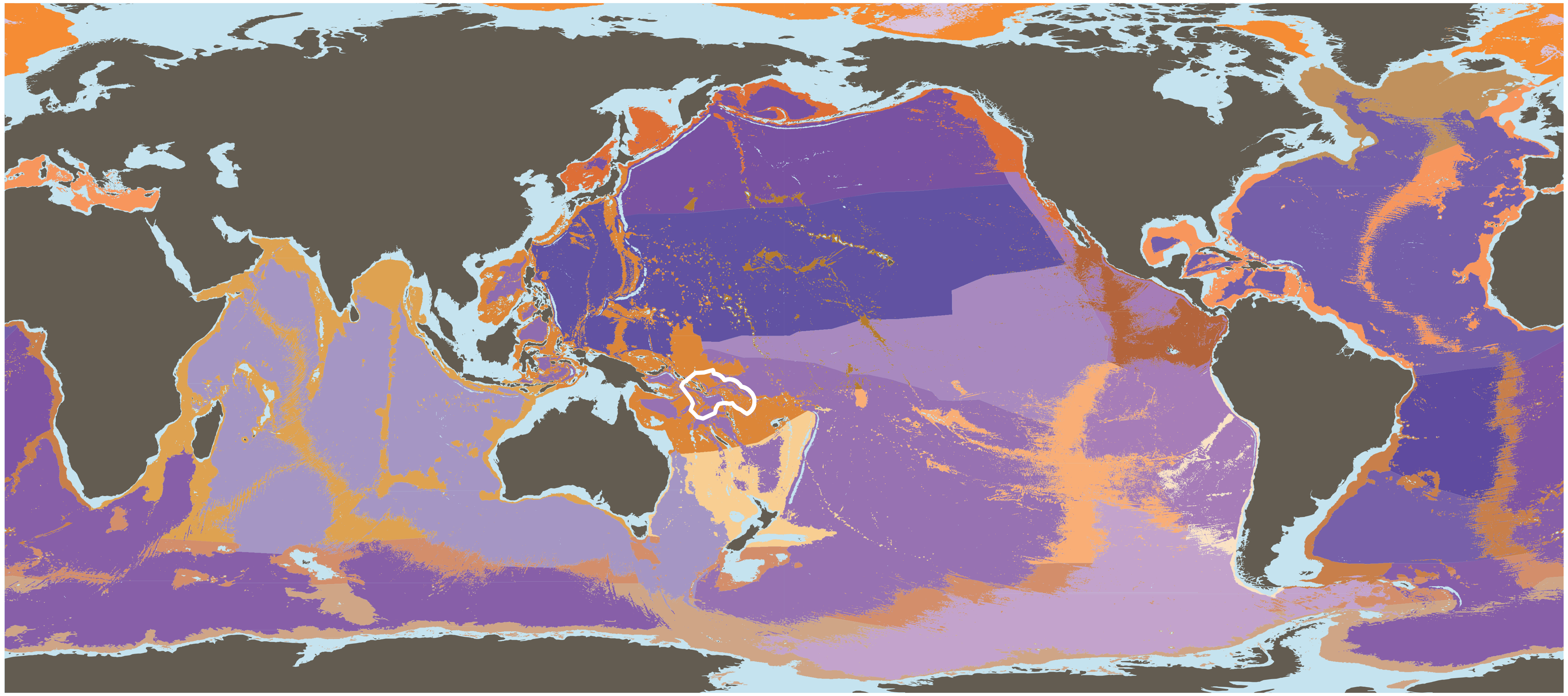
Read more: The Arnavon Community Marine Conservation Area in the Solomon Islands: a review of successes, challenges, and lessons learned.



SOLOMON ISLANDS BIOREGIONS
Deepwater bioregions
Reef associated bioregions
Ontong Java and Eastern Solomon
Rennell Bellona and Isabel Oceanic influenced
Shortlands Islands
Sikaiana
Solomon-wide influenced
South Rennell
Utupua and Banie Island
Western Munda and Atonn island
Ndeni and Tinakula Islands
Bougainville and Santa Cruz Islands
Duff Islands
Honiara
Indispensable Reef and Treasury Islands
Kolobangara Island, Nukuoro Atoll and Solomon river Influenced
Lord Howe, Nukapu, Temotu
Malaita and Makira cluster
Marau Guadalcanal
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Smith and Sandwell, 1997. Wendt H, et al, (in prep).
SOLOMON ISLANDS
North New Ireland and Ontong Java Atoll
Solomon PNG Boarder
North of Solomon and Cape Johnson Troughs and Duff Islands
Solomon, Tuvalu Seamounts
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Santa Isabel Slope
Malaita
Florida Islands
Russell Islands
Guadalcanal
Ulava Deep
Cape Johnson & Solomon Trench
Abyssal plain, seamounts and Vityaz trench bordering Fiji (NW), Tuvalu (SW) and Solomon Islands (SE)
Solomon PNG Boarder
San Cristobal
Makira/ Ulawa Deep
Santa Cruz
East Temotu and Northwest Rotuma Seamount s and the Vityaz trench
Bellona Island
San Cristobal Trench
Rennell Island
South Solomon Trench
Vanikoro
Hammondsport seamount and basin
Temotu and Lord Howe Cluster
East Temotu and North Fiji Ridge
North New Hebrides Trench
East Temotu,Banks and West of Rotuma Seamounts and the Vityaz trench
Rennell and Pocklington Troughs
Torres Canyons Deep
Torres Rise
North of Solomon and Cape Johnson Troughs and Duff Islands
Malampa and Loyalty Basin
Ambae Trough and North Fiji Basin
5°S
10°S
15°S
155°E
160°E
165°E
170°E

BEYOND THE HOTSPOTS: BIOREGIONS

Ideally ecosystem-based marine planning should be based on comprehensive data that represents all of Solomon Islands marine plants and animals. This data, however is rarely available for any country. To overcome this limitation, surrogates can be used to classify the marine environment into spatial units, or bioregions, that host similar plants and animals.



The GOODS biogeographic classification from 2009 is an example of a global bioregionalization.

Solomon Islands' waters are full of valuable marine biodiversity. To sustainably manage and protect Solomon Islands' rich marine recourses, its government is committed to delivering a comprehensive, ecologically representative network of managed and protected marine areas (see also chapter "Solomon Islands' commitment to marine conservation"). Ideally ecosystem-based marine planning should be based on comprehensive biodiversity data that represent all of Solomon Islands' marine plants and animals in its entire marine environment.

While a lot of data are accessible—as the maps in this atlas show—comprehensive data are not available for any country, including Solomon Islands. To overcome this limitation, surrogates must be used to classify the marine environment into spatial units, or bioregions, that can host similar plants and animals. These surrogates include factors such as salinity (see also chapter "Go with the flow"), pH (see chapter "Turning sour") or phosphate concentration (see chapter "The dose makes the poison"). Analysing and clustering such data results in spatial units, called marine "bioregions". These bioregions present comprehensive descriptions of the marine biodiversity of Solomon Islands and can be used for conservation, management and planning.

Such marine classification and the use of bioregions is not a new concept, as bioregions have been produced before at various scales in other countries, regions and globally, including some that encompass Solomon Islands. The graphic provides one example of a global bioregionalization, the Global Open Oceans and Deep Seabed (GOODS) biogeographic classification, undertaken by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2009.

Classifications such as GOODS are very useful on a global scale. However, Solomon Islands' large EEZ is divided into merely three bioregions, making the existing classifications of the marine environments, both coastal and offshore, too coarse to inform most national marine planning processes in Solomon Islands. This calls for more detailed bioregions to inform marine planning. In 2016, in-country experts came together to describe preliminary marine bioregions for Solomon Islands, supported by the MACBIO project. These include 33 deepwater and 18 reef bioregions (Wendt et al., 2018), as shown on the map.

Using these bioregions as substitutes to describe the suite of marine biodiversity in Solomon Islands, an ecologically representative system of managed and protected areas can be built. This is done by representing an example of every bioregion within an area, as well as examples of all known habitats and ecosystems (see also chapters "Nature's hotspots" and "Special and Unique Marine Areas"). The bioregional approach assists planners with the fact that not all habitats and ecosystems are known and mapped.

PLANNING

The previous section on "Valuing" revealed the diversity and richness of Solomon Islands' biophysical features, the ecosystems they underpin, and the many goods and services they provide to Solomon Islands. This section will look at how the many human uses of these values interact and how these uses can be planned.

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More than 98 per cent of Solomon Islands' total jurisdiction is ocean. The ocean is vitally important to Solomon Islands, providing food and income, coastal protection, carbon storage, and essential habitat for marine plants and animals. Furthermore, coasts and oceans are heavily intertwined with Solomon Islands' cultures, traditional knowledge and practices, while the economic, social and ecological benefits provided by marine ecosystems are worth billions of dollars to Solomon Islands every year.

Despite the high value of the ocean to Solomon Islanders, to date, national development and conservation planning has largely focused on land. However, recent studies show that better planning for oceans can bring significant economic, social and environmental benefits. Marine Spatial Planning (MSP) can help Solomon Islands realize and maintain these benefits.

MSP is most useful if countries:

- have (or expect) human activities that adversely affect biodiversity in marine areas
- have (or expect) competing human activities within a given marine area
- need to decide which marine spaces are most suitable for new or additional economic development activities such as tourism, deep-sea mining or mariculture
- want to prioritize marine resource management efforts in parts of, or all, marine areas or
- need a vision or scenarios of what marine areas could or should look like in another 10, 20 or 30 years

MSP can help address these issues. Similar to land-use planning but relating instead to the sea, it is a tool in the marine resource management toolbox that also includes input controls (e.g. on fishing effort), process controls (e.g. permits) and output controls (e.g. quotas). MSP is an intersectoral and participatory planning process that seeks to balance ecological, economic and social objectives, aiming for sustainable marine resource use and prosperous blue economies.

The concept of MSP is not new and countries are already applying aspects of it, such as designated shipping lanes, fishing areas, locally managed marine areas (LMMAs), or MPAs. However, some of these existing examples have, at times, been declared opportunistically without an overarching and integrated planning process. When declared in isolation, individual spatial planning tools may not secure the ecosystem services that people rely on in the medium and long term.

A more comprehensive and integrated MSP process can support and guide sectoral planning efforts, but does not replace sectoral planning. A more holistic MSP process will reduce the conflicts between the marine environment's different users and uses, while maximizing the social, economic and ecological benefits people receive from the ocean.

The maps in this chapter show how Solomon Islands can plan the uses of the rich values its marine ecosystems provide, be it fishing, tourism, mining or vessel traffic. At the same time, MSP is also a powerful tool for avoiding conflicts and managing threats, such as marine debris, pollution or impacts from climate change, as featured in the maps.

Further reading: **http://macbio-pacific.info/marine-ecosystem-service-valuation/**

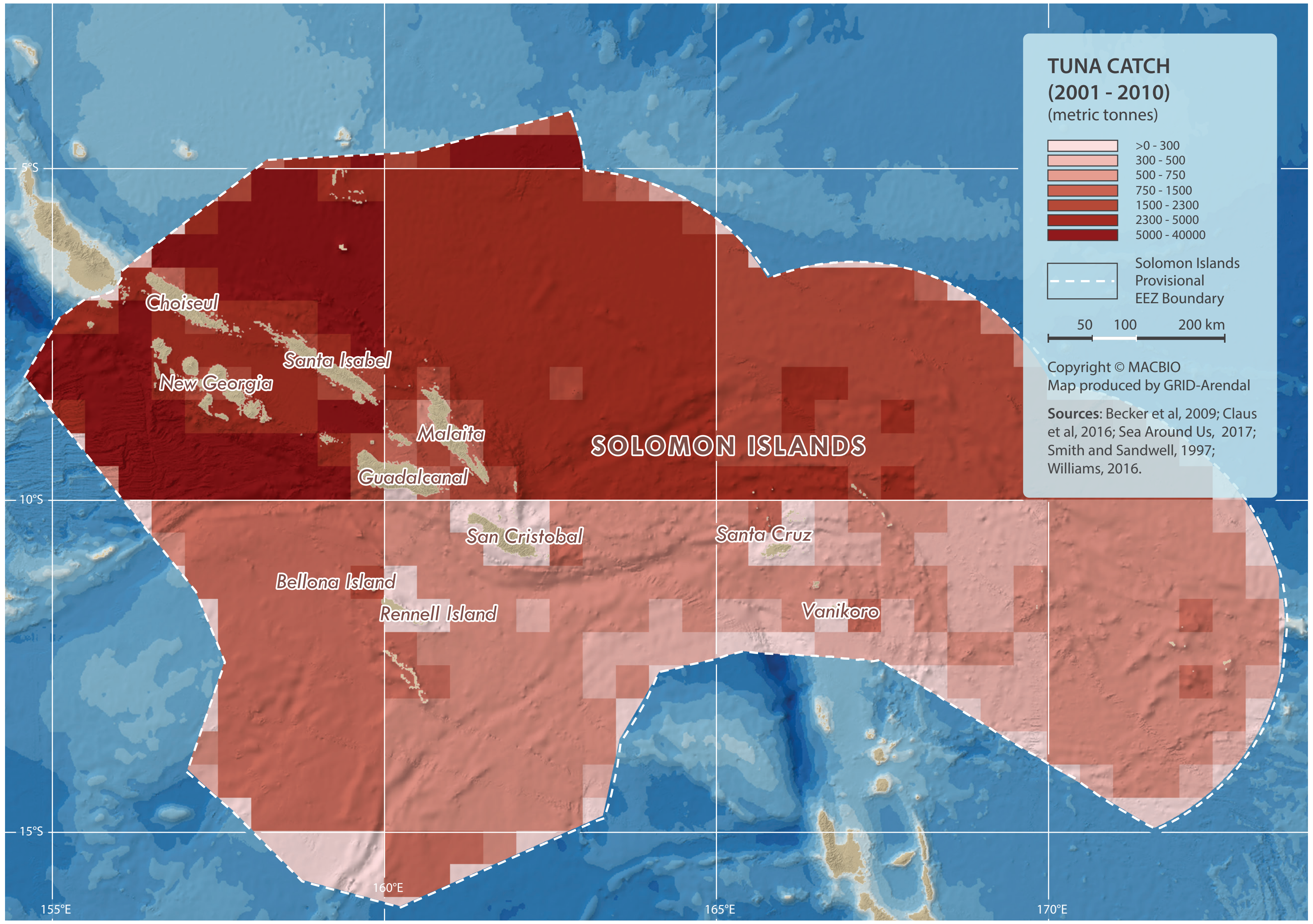
FISHING IN THE DARK: OFFSHORE FISHERIES

Offshore fisheries are an important resource for Solomon Islands in terms of income and economic development, as well as employment and local food. Knowledge of the distribution and amount of catch is crucial for the regional management required to ensure these fisheries are sustainable.

There are two different types of fisheries in Solomon Islands: those close to the shore (see also chapter “Small fish, big importance”) and those offshore (see also chapter “Travellers or homebodies”).

Tuna are the basis of important commercial fisheries for many island nations in the South-West Pacific. Typically four main species are taken: skipjack (*Katsuwonus pelamis*), albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), and yellowfin (*Thunnus albacares*). The fisheries are managed by the Western and Central Pacific Fisheries Commission (WCPFC) and cover the entire western Pacific Ocean to longitudes of 150°W in the North Pacific and 130°W in the South Pacific. Additionally, the Pacific Islands Forum Fisheries Agency and the Oceanic Fisheries Programme of the Secretariat of the Pacific Community provide support for fisheries management and research. Typically, there are 3,000–4,000 vessels operating each year, and the total tuna catch exceeds 2 million tons per year. Knowledge of the catch composition, amounts and distribution is necessary to understand how best to balance the exploitation of such fishery resources with the conservation of stocks, and other values for the islands.

The only large-scale commercial fishery in Solomon Islands is for tuna. These fish are an important source of food for local small-scale fisheries and a major source of income for the country through foreign vessel licensing and fees for transhipments of tuna catch in Honiara. Tuna fisheries contribute SI$264 million to Solomon Islands’ economy. Interestingly, inshore fisheries yield a higher amount with a total of SI$512 million per year (Arena, 2015).



In addition to license fees, Solomon Islands is well known in the Pacific for its cans of processed tuna. SolTuna is the country’s only tuna processing facility, based in Noro in Western Province. The company employs over 1,800 workers, making it a significant private sector employer. Most of SolTuna’s products are exported as tuna loins to the European Union, though the company also manufactures a substantial amount of canned tuna, which contributes to food security in Solomon Islands and the region. Tuna accounts for 90 per cent of the Solomon Islands’ marine exports.

Commercial fisheries catch tuna in Solomon Islands using longline, pole-and-line and purse seine methods. Between 2001 and 2010, longline fishing was highly variable, with 0 to 113 vessels using this method each year. The total catch was about 17,000 tons over this period, comprising albacore (49 per cent), yellowfin (38 per cent) and bigeye (12 per cent) tuna. No longline vessels reported fishing between 2006 and 2009, at a time when the 2007 tsunami had affected the islands. Other billfish species caught by longline fishing include blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*). Pole-and-line fishing has much larger results, with 1 to 12 vessels operating per year between 2001 and 2008 (no vessels reported fishing in 2009 and 2010). During this period, the total catch was roughly 47,000 tones and was mainly skipjack (93 per cent) and yellowfin (7 per cent) tuna. Catch levels and fishing efforts have decreased in recent years.

The largest tuna fishery is the purse seine fishery. Between 2001 and 2010 there were two to seven purse seine vessels in operation each year, with the reported catch for the period totalling 83,000 tons of skipjack and 70,000 tons of yellowfin tuna. The catch of these two species is generally similar each year, though since 2010 they have increased by 56–76 per cent, with over 55,000 tons reported in 2016 (WCPFC, 2017). Most of the catch occurs in the northern part of the EEZ, particularly in the north-western areas off the islands of Choiseul, Santa Isabel and New Georgia, north of latitude

Vessel Day Scheme

Solomon Islands is part of the Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest. The eight signatories collectively control 25–30 per cent of the world’s tuna supply and approximately 60 per cent of the western and central Pacific tuna supply. Part of the agreement is a Vessel Day Scheme that sets an overall total allowable effort (TAE) limit on the number of days fishing vessels can be licensed to fish in the respective EEZs per year. Each country is allocated a share of the TAE for use in its zone each year. This agreement has helped the signatories to increasingly keep the benefits of offshore fishing within their economies.

10° S. Although large offshore fisheries tend to dominate catch totals, there are also local small-scale fisheries; however, their catch estimates are not available and are likely very small (Doyle et al., 2012).

The map shows the distribution of all tuna catches from 2001 to 2010 in the Solomon Islands' EEZ. The commercial tuna industry's catches are predominantly skipjack and yellowfin tuna, though it also has significant catches of albacore and bigeye tuna. Tuna fisheries are also associated with the capture of valuable non-target species, such as marlin, sailfish and shark (Gillett, 2005).

The distribution of tuna catch around seamounts can be significant. Catches of yellowfin tuna, and to a lesser extent bigeye tuna, are often larger (Morato et al., 2010). Seamounts and similar topographic features, in some situations, can enhance localized productivity, helping to support higher densities of fish species. Managing such habitats is therefore important for these fisheries.

All the tuna species are widely distributed, though little is known about their stock or substock structures. Skipjack is a more productive species than yellowfin, matures earlier and has a shorter lifespan (2–3 years). Spawning occurs in the central Pacific throughout the year. Skipjack can swim long distances, but their migration patterns are not well understood. Yellowfin matures at two years, and can live up to seven years. Adults migrate over distances up to 1,800 kilometres. There may be several stocks of these tuna species in the Pacific area (Grewe et al., 2015). Fishery catches should be managed on a regional, rather than national, basis.

The distribution of tuna and their fisheries is influenced by oceanographic events, particularly the El Niño–Southern Oscillation (ENSO) period. Fish distribution is also expected to shift with climate change, potentially moving to the east and to higher latitudes (Lehodey et al., 2011). This may affect fish stocks in the Solomon Islands' EEZ and have a greater impact on the distribution of bigeye tuna than skipjack or yellowfin. This is a factor that should be considered in longer-term management scenarios. With much of the fish catch being taken by large foreign vessels, national and regional efforts are needed to ensure that fisheries remain sustainable in the long term.

While tuna is the main large-scale fishery resource in Solomon Islands' waters, deepwater fisheries are a small but important resource for Solomon Islands in terms of export income, employment and local food. However, deepwater species are often vulnerable to overfishing and thus require careful management to ensure the sustainability of these fisheries.

Deepwater snapper is an important resource for many Pacific Island countries, supporting domestic and some small export markets (SPC, 2013a). These fish inhabit reef slopes and shallow seamounts that rise between 100 metres and 400 metres below the surface. Commercial line fishing for these species has been undertaken around the Pacific Islands for several decades.

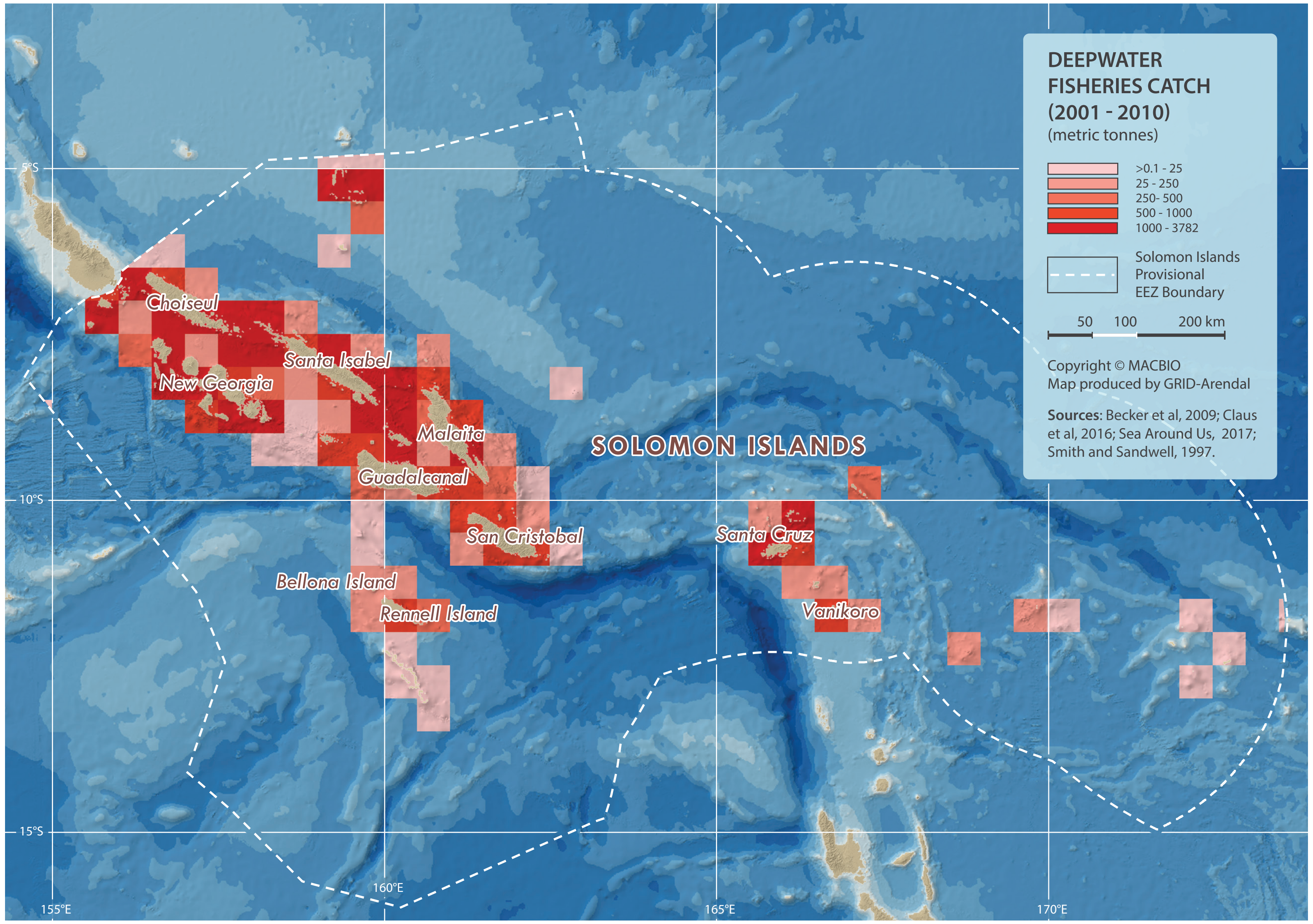
The map shows historical catches over the 2001–2010 period for deepwater fisheries around the islands of Solomon Islands, based on FAO data and national reports. Of the 100-plus species caught in these deepwater demersal fisheries, the majority are snappers from the Lutjanidae family (primarily of the genus *Pristipomoides*), Lethrinidae family (emperors of the genera *Gymnocranius, Lethrinus* and *Wattsia*), and Serranidae family (groupers of the genera *Epinephelus* and *Variola*), (McCoy, 2010; SPC 2013b). The catches are dominated by the Pristipomoides snapper, which accounts for 99 per cent of the total deepwater catches mapped here, averaging between 700 and 900 tons per year.

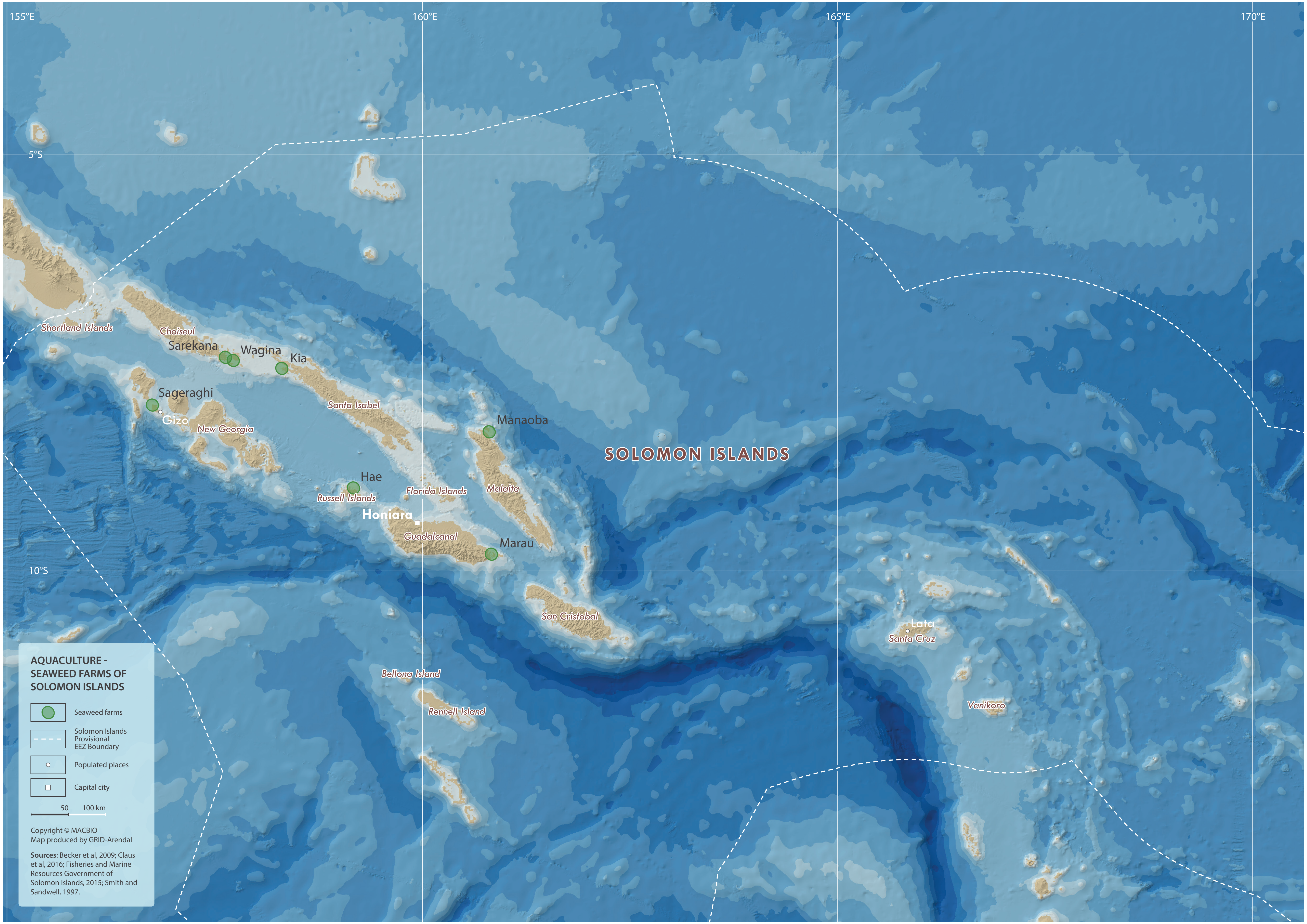
Line fishing is the main method used for these species. The gear used includes hand-reels and powered reels, with some commercial bottom longlining and trotlining. Deepwater snapper fishing was promoted in the 1980s by the SPC, (Dalzell and Preston, 1992), with several snapper-targeting vessels working out of Honiara. A regional assessment of fisheries potential was made in 1992, largely based on sea-floor area with around a 200-metre depth. This resulted in an estimate of sustainable yield per year for Solomon Islands' waters of between 200 and 500 tons (Dalzell and Preston, 1992). In the mid-1990s, the islands exported nearly 50 tons of deepwater species annually (FAO, 2010). However, in general, such fisheries in the region have struggled, due to low catch rates after an initial fishing-down phase, variable export markets and prices, shipping costs, and limited habitat areas (McCoy, 2010).

The data set on all known deepwater snapper locations compiled by Gomez et al. (2015) has very few records from around the Solomon Islands. The modelled distribution of 14 deepwater snapper species, using available fisheries and oceanographic data, was based largely on depth (Gomez et al., 2015) and indicated a potential biomass of 1,700 tons. However, at present, there are no reliable estimates of sustainable levels of catch and fishing effort and understanding of stock structure is limited. Deepwater snapper stocks are considered vulnerable to fishing due to their seamount distribution, high longevity, late maturity and slow growth (Williams et al., 2013).

Seamount features are recognized as an important habitat for deepwater snappers, though these fish are mostly caught on island slopes around the Solomon Islands. Snapper populations may be localized on slopes or on seamounts, which can make them vulnerable to overfishing, as well as impacts from potential deep-sea mining for sea-floor massive sulfides (Clark et al., 2017). Improved knowledge of stock structure, and the degree of seamount-affinity, are issues of major relevance to management. The likelihood of restricted distributions of these deepwater species means there is a need to consider regulations specific to seamounts or to localized areas of suitable fish habitat, in order to reduce the risk of serial depletion.

Deepwater fisheries over the period considered were a small but important resource for Solomon Islands. However, little is known about stock structure, stock size, and productivity, thereby making the long-term sustainability of historic catch levels uncertain.




155°E
160°E
165°E
170°E
5°S
10°S
Shortland Islands
Choiseul
Sarekana
Wagina
Kia
Sageraghi
Gizo
New Georgia
Santa Isabel
Manaoba
SOLOMON ISLANDS
Hae
Russell Islands
Florida Islands
Malaita
Honiara
Guadalcanal
Marau
San Cristobal
Lata
Santa Cruz
Bellona Island
Rennell Island
Vanikoro
AQUACULTURE - SEAWEED FARMS OF SOLOMON ISLANDS
Seaweed farms
Solomon Islands Provisional EEZ Boundary
Populated places
Capital city
50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Fisheries and Marine Resources Government of Solomon Islands, 2015; Smith and Sandwell, 1997.

FISH FROM THE FARM: AQUACULTURE

Aquaculture has become a developing sector in Solomon Islands over the years. While this sector has great potential to provide people with food and livelihoods, its development should be balanced against other coastal and ocean uses.

The farming of seafood, known as aquaculture, can be practised in either fresh water or saltwater, the latter of which is also known as mariculture (see map).

The further development of aquaculture in Solomon Islands could contribute to food security, sustainable livelihoods and economic growth for current and future generations. At present, the gap between the sustainable supply of seafood from wild fisheries and food security demands is growing.

Aquaculture in Solomon Islands is still in its infancy, but it is being actively promoted as a means of supplying food and livelihoods, especially in rural communities. It is also seen as a means to build the country's economic growth through the development of an export industry. At present, marine aquaculture development in Solomon Islands is focused on two main areas: seaweed aquaculture and sea cucumbers for stock enhancement. There is also low-scale farming of the non-native Mozambique tilapia (*Oreochromis mossambicus*) in freshwater ponds, particularly in Malaita and Guadalcanal.

The main target species of seaweed aquaculture is elkhorn sea moss (*Kappaphycus alvarezii*). This tropical red alga can grow up to 2 metres in length and can double its biomass in 15 days under ideal growing conditions. Carrageenans are extracted from the harvested algae, which are used as gelling, thickening and stabilizing agents in foods. They are also used in the cosmetic industry and even mining. The Ministry of Fisheries and Marine Resources first assessed the aquaculture feasibility of this species in 1998, continuing such work with subsequent projects until 2012. There are currently seven active seaweed farms in

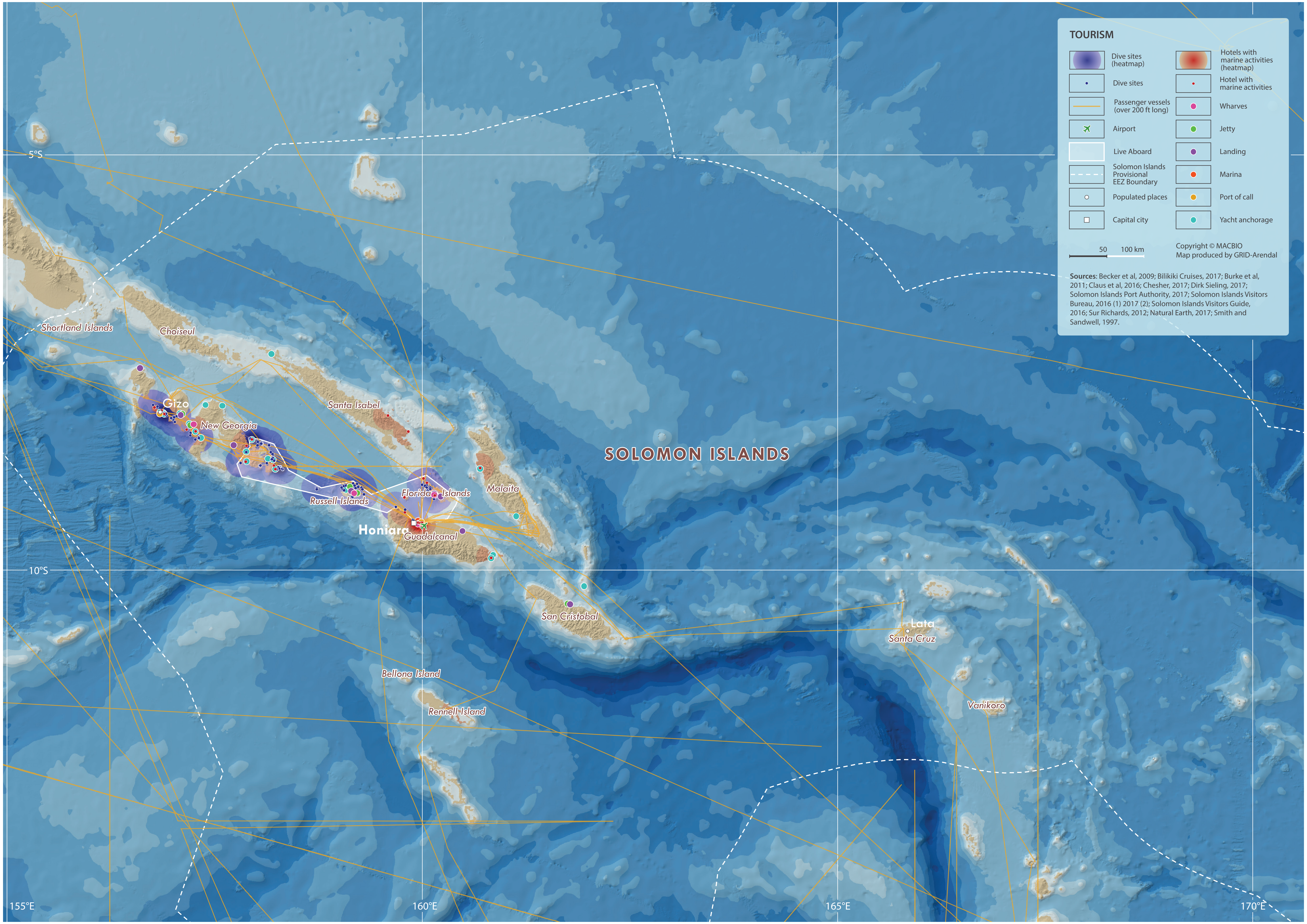
Solomon Islands (see map), making the country the largest seaweed producing nation in the Pacific (Ministry of Fisheries and Marine Resources, 2015). The largest seaweed production comes from Wagina, with more than 50 tons produced per month. In 2014, Solomon Islands' annual seaweed production was over 1,500 tons, which was worth over SI$5 million (Ministry of Fisheries and Marine Resources, 2015).

Sea cucumbers and tilapia—the other two main target species for aquaculture—are produced at a smaller scale than seaweed aquaculture. The Overseas Fishing Cooperation Foundation supported the establishment of a marine hatchery to research the biology of a type of sea cucumber locally known as peanutfish (*Stichopus horrens*). Juvenile peanutfish have been used in a trial restocking at Marau in north-eastern Guadalcanal. As is the case in other Pacific Islands, there is growing interest in commercial sea cucumber aquaculture in Solomon Islands. However, there are challenges with developing a profitable model for this industry (Pakoa et al., 2014).

Tilapia aquaculture is produced as a food source, directly consumed by the farmers or sold at local markets. The main target species is the non-native Mozambique tilapia (*Oreochromis mossambicus*). This aquaculture is produced in land-based freshwater ponds, mainly in rural areas on the islands of Malaita and Guadalcanal.

Due to this species' slow growth rates, the Ministry of Fisheries and Marine Resources is looking at options to farm the faster growing Nile tilapia (*Oreochromis niloticus*), also known as Genetically Improved Farmed Tilapia (GIFT) (Ministry of Fisheries and Aquatic Resources, 2015).

Although aquaculture offers Solomon Islands several benefits, it also has some negative impacts on the country's marine ecosystem. These include pressure on wild fish used for fish feed, escape of introduced aquaculture species, interbreeding of farmed fish with wild fish, pollution and habitat loss. For example, mangroves are cut to develop shrimp farms, resulting in loss of this key coastal habitat (see also chapter "Home, sweet home"). There is therefore a need for clear priorities when expanding aquaculture to minimize any adverse environmental impacts.



TOURISM
Dive sites (heatmap)
Hotels with marine activities (heatmap)
Dive sites
Hotel with marine activities
Passenger vessels (over 200 ft long)
Wharves
Airport
Jetty
Live Aboard
Landing
Solomon Islands Provisional EEZ Boundary
Marina
Populated places
Port of call
Capital city
Yacht anchorage
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Bilikiki Cruises, 2017; Burke et al, 2011; Claus et al, 2016; Chesher, 2017; Dirk Sieling, 2017; Solomon Islands Port Authority, 2017; Solomon Islands Visitors Bureau, 2016 (1) 2017 (2); Solomon Islands Visitors Guide, 2016; Sur Richards, 2012; Natural Earth, 2017; Smith and Sandwell, 1997.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
Gizo
New Georgia
Russell Islands
Florida Islands
Malaita
Honiara
Guadalcanal
San Cristobal
Lata
Santa Cruz
Vanikoro
Bellona Island
Rennell Island
5°S
10°S
155°E
160°E
165°E
170°E

BEYOND THE BEACH: MARINE TOURISM

"Seek the unexplored" is Solomon Islands' tourism slogan. For many years, tourism has been identified as a sector with potential for major economic development in Solomon Islands, though there are challenges in developing this potential.

Solomon Islands is blessed with natural beauty, rich culture and historic World War II sites, all of which are key ingredients for a thriving tourism industry. Tourism has long been considered an important sector for building Solomon Islands' economy. As early as 1973, the Board of the Solomon Islands Tourism Authority had a five-year plan to increase visitor numbers tenfold. Similarly, in 1990, it predicted 70,000 tourist visitors by 2000. However, in both these cases, the growth in tourism did not match the country's ambition (Kaczan and Tuhanuku, 2008). This has been attributed to a combination of poor infrastructure, limited access to capital to drive investment, limited air services and the civil unrest in 1999 (Douglas, 2004; Kaczan and Tuhanuku, 2008). At present, Solomon Islands is ranked ninth out of 15 South Pacific countries in terms of visitor arrivals and is well behind its neighbours, Vanuatu and Papua New Guinea (TRIP Consultants, 2015).

However, things are slowly improving for the tourism sector in Solomon Islands, with marine tourism an important and growing part of this sector. Total visitor numbers were 24,400 in 2013, the majority of which were business visitors. It was estimated that around only 5,000 of these were holiday arrivals (TRIP Consultants, 2015). Solomon Islands has set itself the goal of growing its holiday market to 12,500 arrivals by 2019. In 2016, the tourism sector was estimated to be worth SI$427.7 million (BOP data), with the marine sector accounting for approximately SI$119 million. Some key marine tourism activities include cruise ship visits (see also chapter "Full speed ahead") and diving.

Solomon Islands has a limited cruise industry, with just 47 port calls in 2015, contributing an estimated $A 900,000 in direct benefits to Solomon Islands' economy (ICF, 2016). The country's main port in Honiara received most of these benefits from its 13 port calls, which accounted for two-thirds of the direct benefits. Cruise ships also visit the islands of Ghizo and Tavanipupu, as well as provinces around Honiara. Despite the low number of cruise ship visits, there is an upward growth projection, with the country's proximity to Australia and New Zealand likely to increase demand. The National Tourism Development Strategy 2015–2019, aims to increase ship visits by 20 per cent per annum (TRIP Consulting, 2015).

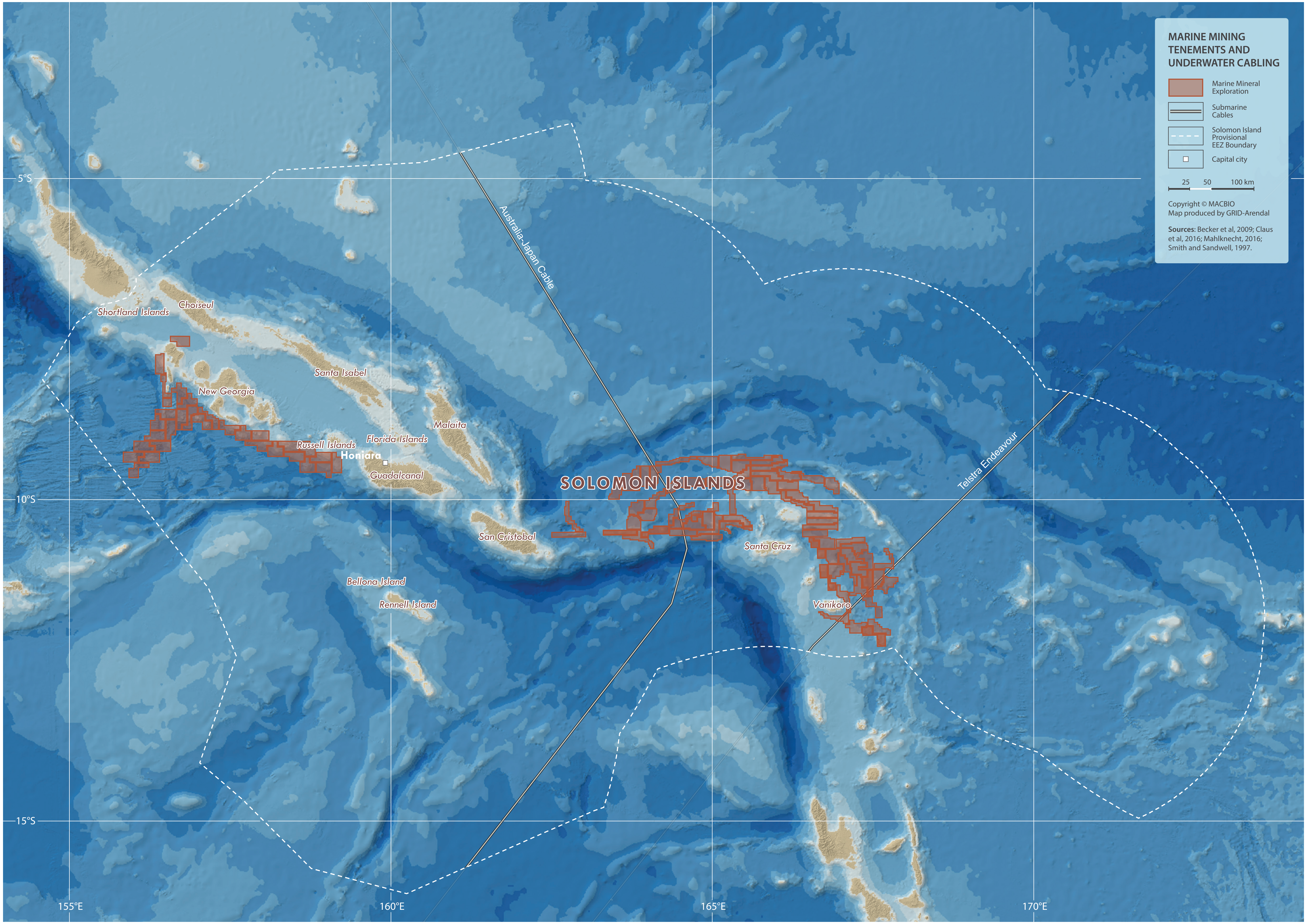
Diving is also an important part of Solomon Islands' tourism industry, accounting for an estimated 1,000–2,000 visitors per year (TRIP Consulting, 2015). Solomon Islands has world class dive sites, with some of the most diverse coral reefs in the world (see also chapter "Home, sweet home" and "Shaping Pacific Islands"). There are also a large number of wrecks from World War II. These sites are a great attraction to dive tourists and have the potential to draw more tourists than Papua New Guinea or Vanuatu due to the historical importance of the engagements, high number of sites and equipment and broad geographical coverage across the country (TRIP Consulting, 2015). However, these sites are often poorly conserved and have limited information and documentation.

Dolphin hunting

In Solomon Islands, various communities (e.g. Fanalei village on Malaita Island) have hunted dolphins for hundreds of years. Dolphin teeth are a significant cultural currency used in bridal dowries, while dolphin meat is also consumed. Nowadays, Solomon Islands' communities are working closely with international conservation partners to transition this practice into a luxury community-based marine tourism activity, thus providing these communities with an alternative livelihood. Under the Fisheries Management Regulations 2017, the government prohibits the capture of dolphins.

The map shows the distribution of major tourism infrastructure in Solomon Islands. The main international airport is located in Honiara on Guadalcanal Island and receives most visitors to Solomon Islands. There are also a several small regional airports throughout the islands (not shown on map) that service domestic connections. The main cruise ship routes are shown on the map. Honiara is the main gateway for cruise ship visitors, with cruise ships also calling at the Port of Gizo. There are various other marine facilities, including wharves, jetties, landings, marinas and yacht anchorages, which service smaller vessels, including ferries and cruising sailboats. The majority of these are concentrated on the New Georgia Islands, the Russell Islands, Guadalcanal Island and Central Island, as are most hotels with marine activities. A small number of hotels with marine activities can also be found on the islands of Santa Isabel and Malaita. Diving, a key marine activity, largely occurs off the New Georgia Islands, especially around Gizo and the eastern part of the islands, as well as around the Russell Islands, which are a destination for liveaboard dive charters, and Central Island.

With its wealth of natural beauty, cultural richness and World War II historical sites, Solomon Islands can develop a strong marine tourism sector that could drive sustainable and economic development, offering many benefits to its people.



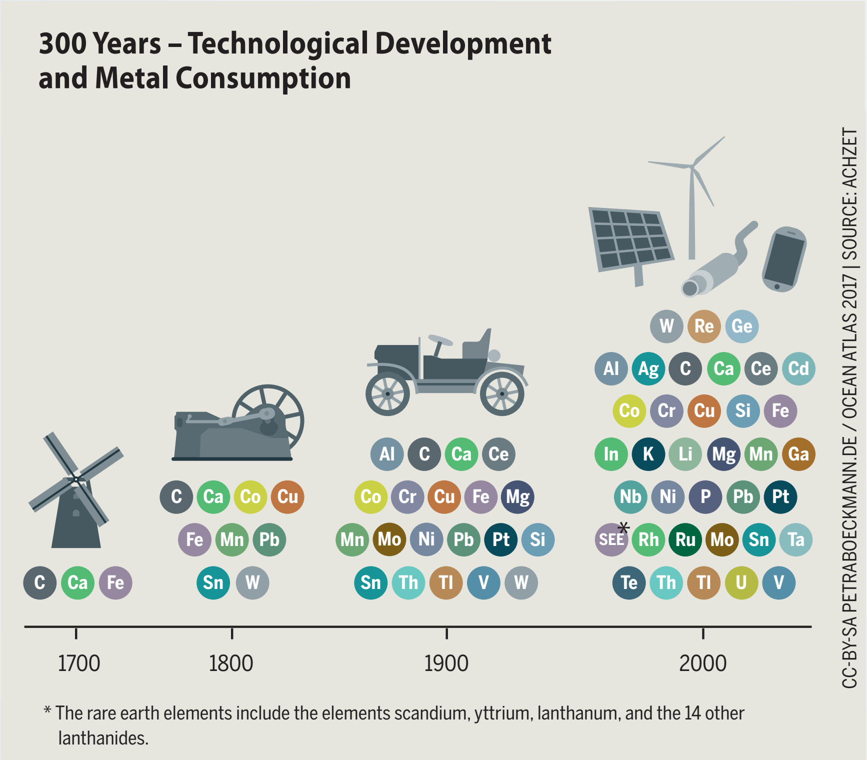
MARINE MINING TENEMENTS AND UNDERWATER CABLING
Marine Mineral Exploration
Submarine Cables
Solomon Island Provisional EEZ Boundary
Capital city
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Mahlknecht, 2016; Smith and Sandwell, 1997.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Malaita
Florida Islands
Russell Islands
Honiara
Guadalcanal
San Cristobal
Santa Cruz
Vanikoro
Bellona Island
Rennell Island
Australia-Japan Cable
Telstra Endeavour
5°S
10°S
15°S
155°E
160°E
165°E
170°E

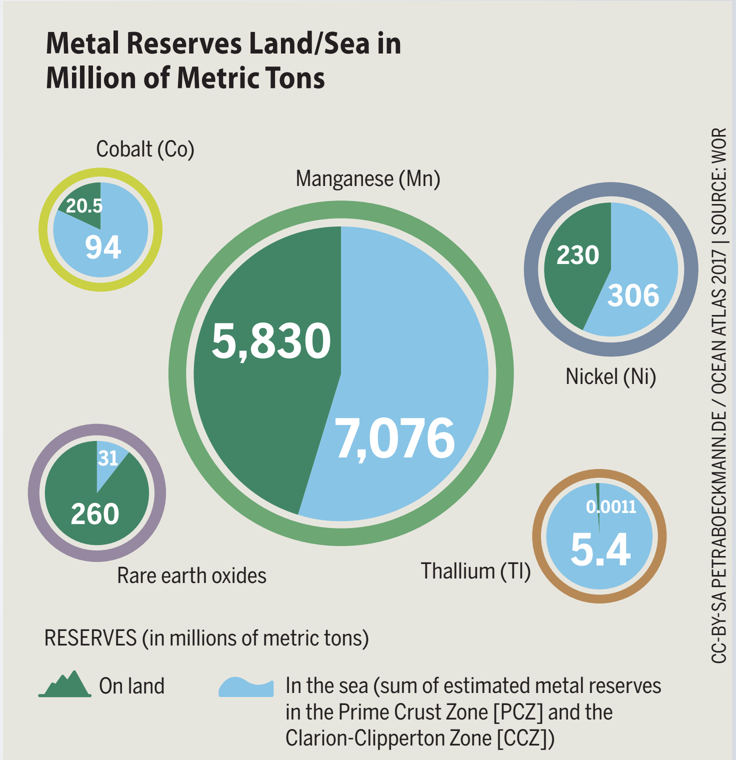
UNDER WATER WILD WEST: DEEP SEA MINING AND UNDER WATER CABLING

Solomon Islands' sea and coasts are rich with deep-sea minerals, petroleum, sand and gravel. These all need to be sustainably managed and a balance found between their overlapping uses.

Gold rush

Is Solomon Islands about to experience a gold rush, like California did in the 1850s, when over 300,000 people rushed to the Wild West with dollars signs in their eyes? While Solomon Islands' land may be rich in many ways, gold is much scarcer. Instead, Solomon Islands' gold rush could take place underwater to satisfy the world's hunger for minerals, given that many metal reserves are found in the sea (see graphic).





There are three main types of deep seabed mineral deposits: sea-floor massive sulfides, polymetallic manganese nodules and cobalt manganese crusts (rich in platinum and rare earth elements) found throughout the Pacific Ocean basin, including in the maritime jurisdictions of many Pacific Islands countries. Due to limited opportunities for economic growth in these countries, there is considerable interest from the leaders of these nations to develop this as a potential new industry to boost their economic development.

However, there are still significant gaps in knowledge of deep-sea mineral mining, particularly in terms of resource potential, technology, economic viability, and social, cultural and environmental impacts (World Bank, 2017).

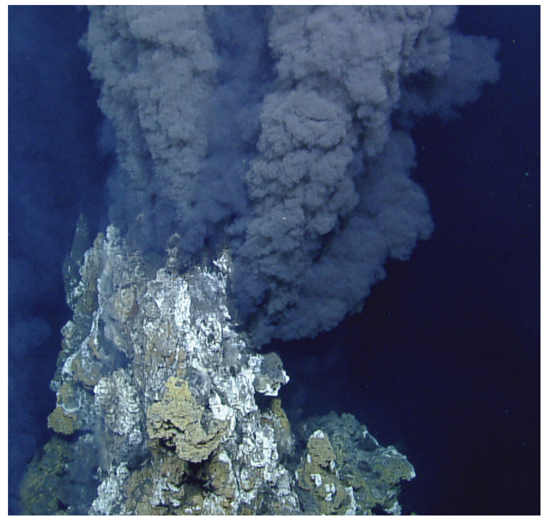
As yet, Solomon Islands has not experienced a gold rush, and mining companies are therefore still undertaking exploration activities and collecting samples to estimate the extent of seabed mineral deposits. Extraction costs for deep-sea mineral resources are still unknown. At present, there are 264 mining tenements in Solomon Islands: 146 onshore and 118 offshore. Several different companies operate the offshore tenements. In 2015, more than 20 companies submitted 129 applications for exploration and mining licences to the Ministry of Mines, Energy and Rural Electrification (PNG Mine Watch, 2015). One company, Bluewater Minerals (SI) Ltd, has submitted applications for 81 of the offshore tenements. Most offshore tenements are in Western Province, east of Makira-Ulawa Province and around the Temotu Province. Of the three types of marine minerals, Solomon Islands is known to contain sea-floor massive sulfides, which are associated with hydrothermal vents (see also chapter "Smoke underwater, fire in the sea") (World Bank, 2017).

There are no exploited sources of natural gas or oil in Solomon Islands, meaning the country currently depends on imports of petroleum products. Due to this reliance of imported energy, Solomon Islands, like many Pacific Island countries, is considering alternative energy sources, including renewable energy.

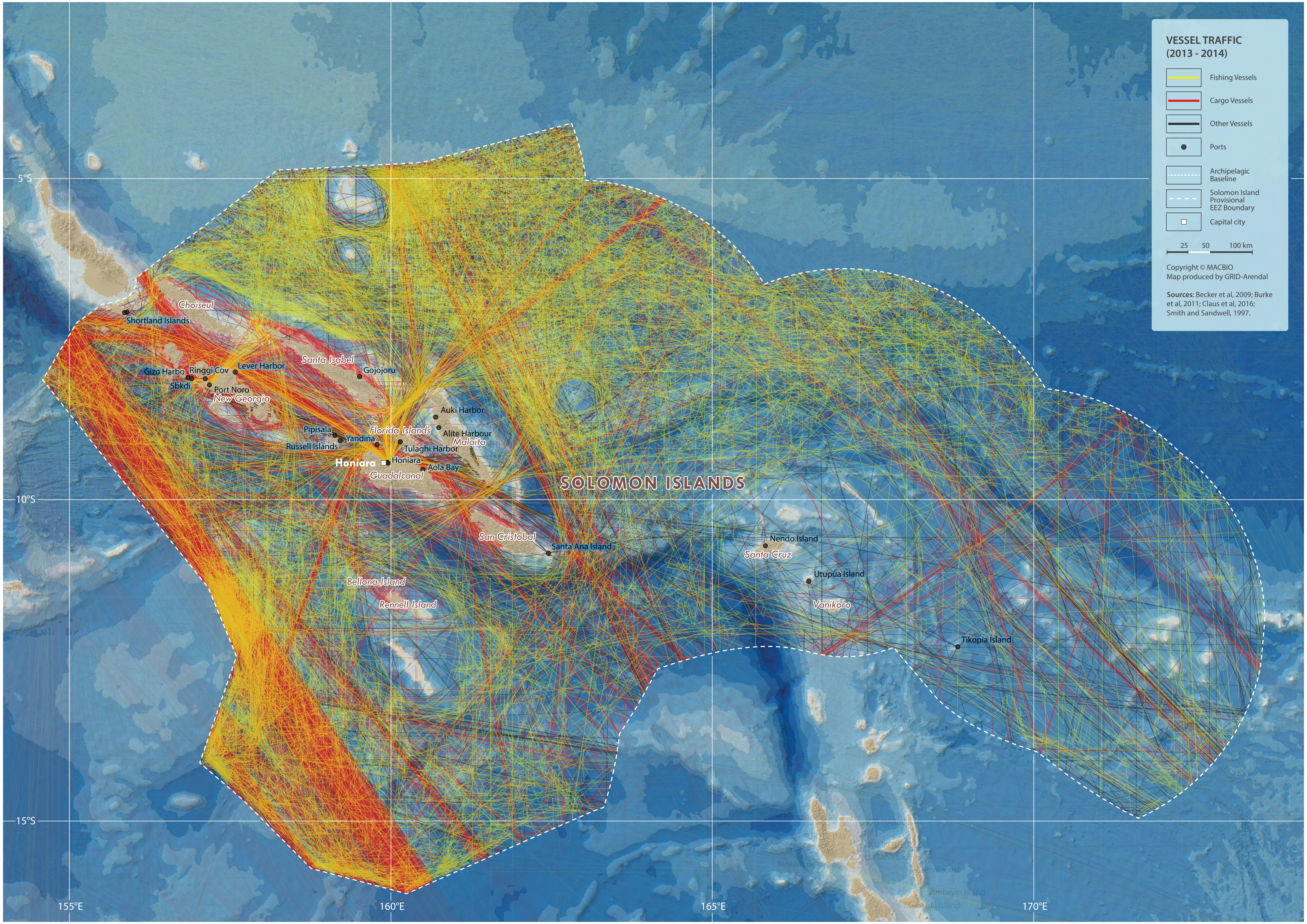
In addition to resource exploration, Solomon Islands' sea floor has been used to build communications structure, with several submarine cables laid across it. The Australia-Japan Cable passes between Makira and Temotu Provinces and has cable stations in Australia, Guam and Japan. The Telstra Endeavour cable passes through the eastern part of Solomon Islands' waters, connecting Australia and Hawaii. Despite both these cables transiting the Solomon Islands, neither service Solomon Islands. Plans for a cable between Australia and Solomon Islands have been drawn up and a contract for the work has been signed with a Chinese company. However, the work has not yet been completed due to various delays. In shallow waters, the fibre-optic cables are generally thicker and laid beneath the sea floor for protection. At the shoreward end of the cables, where they cross the intertidal zone, the cables are protected by piping and are bolted to the substrate. In deeper water, the thinner cables are laid on the sea floor.

These different and overlapping uses clearly need to be well planned and managed. For example, as the map shows, sea-floor massive sulfides are found on or close to hydrothermal vents, which are biodiversity hotspots (see also chapter "Smoke underwater, fire in the sea"). Deep-sea mining has the potential to impact these important ecosystems. However, because deep-sea mining is a relatively new field, the complete consequences of full-scale mining operations on this ecosystem are unknown. Direct risks include disturbances to the benthic layer, increased toxicity of the water column and sediment plumes from tailings with unknown long-term effects, while indirect risks are leakage, spills and corrosion. As mining involves the extraction of a non-renewable resource, it should be managed using the precautionary approach and, technically, cannot be considered sustainable. Given the limited scientific knowledge and high demand for technology in exploring and mining deep-sea areas, marine-based mineral extraction should be treated with caution. Equally, sand and gravel mining, as well as petroleum exploitation, comes with risks that need to be managed. Finally, cable routes have to avoid hazardous conditions and sensitive marine areas, such as deep-sea vents and seamounts.

In short, mining, cabling and their potential risks are a good example of the need to spatially plan overlapping uses well in order to maximize benefits for Solomon Islands.



Hydrothermal vent deposits.


VESSEL TRAFFIC
(2013 - 2014)
Fishing Vessels
Cargo Vessels
Other Vessels
Ports
Archipelagic Baseline
Solomon Island Provisional EEZ Boundary
Capital city
25
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Burke et al, 2011; Claus et al, 2016; Smith and Sandwell, 1997.
SOLOMON ISLANDS
Choiseul
Shortland Islands
Santa Isabel
Gojojoru
Lever Harbor
Gizo Harbo
Ringgi Cov
Sbkdi
Port Noro
New Georgia
Auki Harbor
Florida Islands
Alite Harbour
Malaita
Pipisala
Yandina
Russell Islands
Tulaghi Harbor
Honiara
Aola Bay
Guadalcanal
San Cristobal
Santa Ana Island
Nendo Island
Santa Cruz
Utupua Island
Vanikoro
Tikopia Island
Bellona Island
Rennell Island
5°S
10°S
15°S
155°E
160°E
165°E
170°E

FULL SPEED AHEAD: VESSEL TRAFFIC

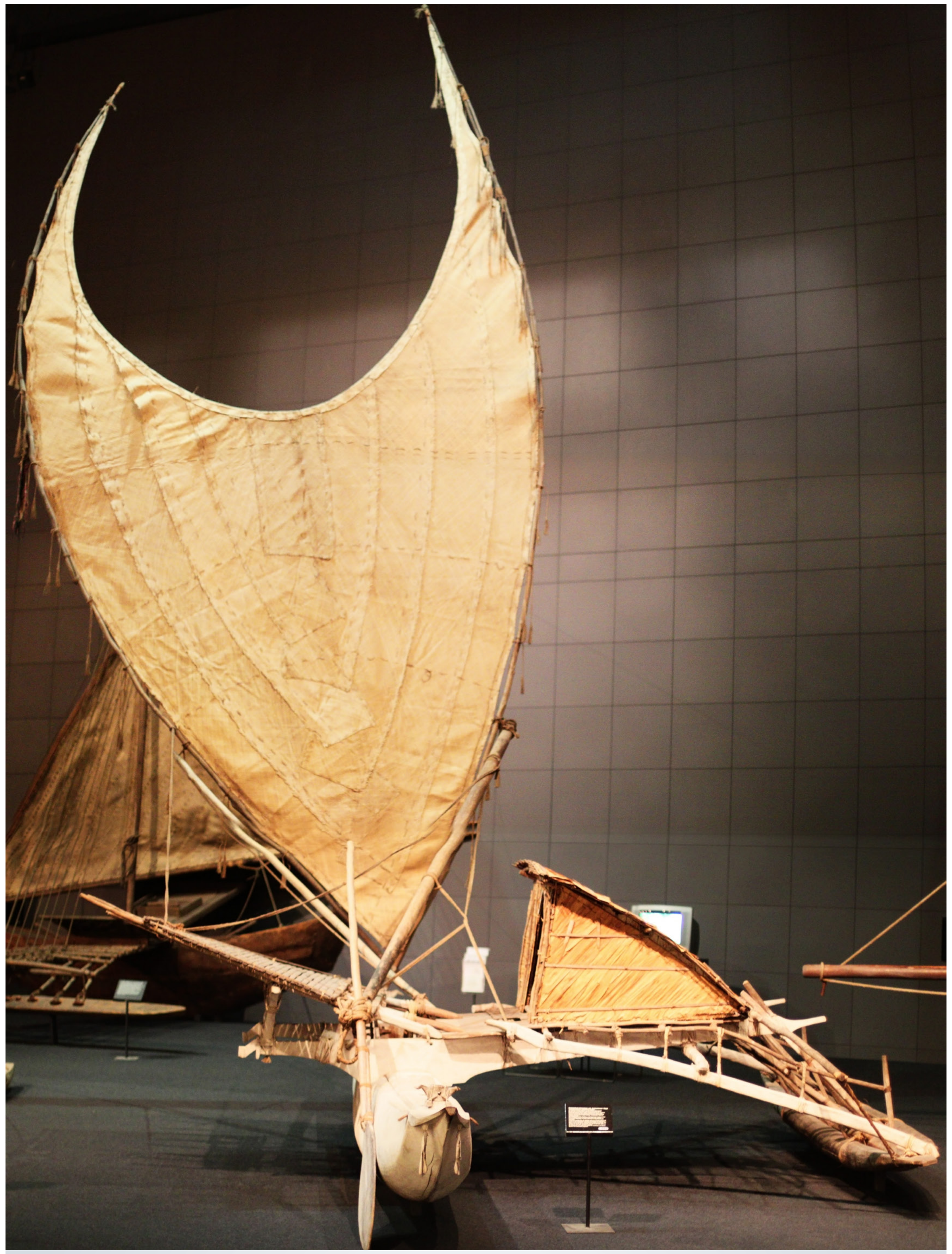
Solomon Islands' waters are a highway for thousands of domestic and international vessels that are lifelines for many Solomon Islanders who rely on the regular delivery of important goods and food items. Minimizing potential environmental and safety risks is a high priority for all.

Ships coming in and out of Solomon Islands, from fishing vessels to cargo vessels, cruise ships and ferries, serve many different purposes. As a nation of islands, shipping is an important method for moving goods and people between islands. The map reflects large registered vessel traffic and does not capture small local boat traffic.

Fishing vessels operate in a range of fisheries, including artisanal and subsistence inshore fisheries and commercial offshore fisheries for tuna and billfish (see also chapters "Fishing in the dark" and "Small fish, big importance"). Fishing vessel activity is one of the main shipping activities occurring in Solomon Islands' waters and is highest north and south-west of the main islands, where vessels use the Port of Honiara and several smaller ports in Western Province. The main cargo shipped out of Solomon Islands includes log exports, palm oil, cocoa and fish (Mizusawa et al., 2012).

The government manages the major ports in Solomon Islands, including the two largest international ports in Honiara and Noro. The port in Yandina was previously the country's third largest international port, but stopped being used in this capacity in 2012 (Mizusawa et al., 2012). There are numerous smaller ports in Solomon Islands that are used to connect a network of inter-island shipping routes, linking all the main islands.

From the map of different types of vessels crisscrossing Solomon Islands' waters, it is clear that MSP is key not only for navigational safety, but also to minimize conflicts with Solomon Islands' many other marine values that are threatened, be it by fishing or oil spills. In order to avoid the negative impacts of oil transporters and shipping emissions in general, and to decrease Solomon Islands' fossil fuel dependence, more sustainable forms of sea transport are being explored. As a seafaring nation, Solomon Islanders can look to their ancestors, who were advanced sailors following the stars in their traditional canoes, for inspiration.

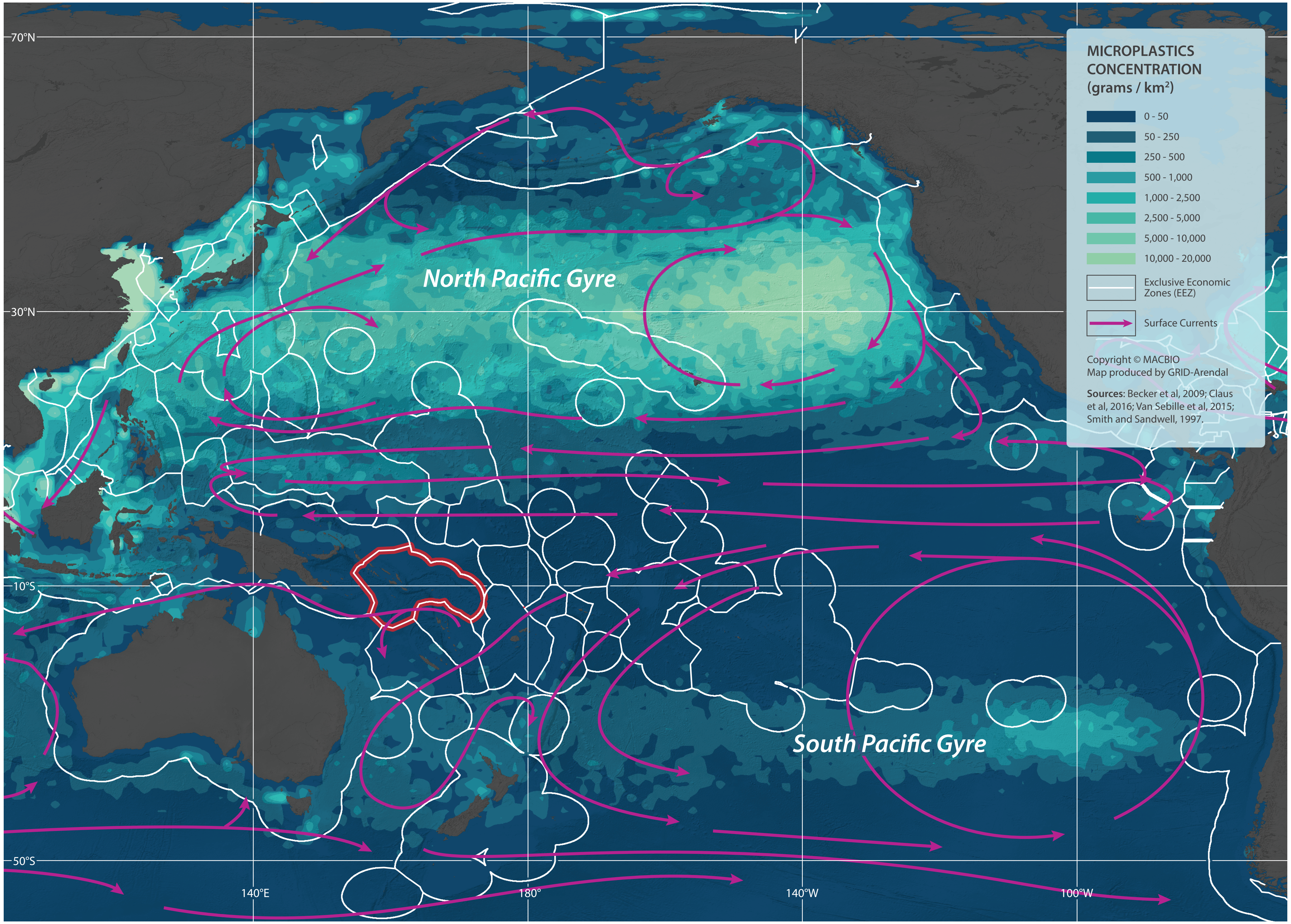


Te puke

People have been living on Taumako—the largest of the Duff Islands—as early as 900 B.C. Those who made pottery, known as the Lapita, made the island their home. Over 2,500 years later, Spanish explorer Álvaro de Mendaña visited the Santa Cruz Islands and was first to report the people's impressive tradition in 1595—a tradition that still survives. Full traditional Polynesian navigational techniques have been preserved by the people of Taumako, who are the builders of one of one of the oldest documented proa sailing canoe, named the te puke or tepuki, which means "ocean-going canoe". The te puke is a very old Melanesian and Polynesian type of boat; it has a similar appearance to an outrigger canoe and has a crab claw sail. This highly sophisticated sailing ship shows the deep connection between Solomon Islanders, sailing and the ocean.

PLASTIC OCEAN: MICROPLASTICS CONCENTRATION

Like the rest of the world's oceans, Solomon Islands' waters are overflowing with plastic. Only 5 per cent of plastics are recycled effectively and forecasts expect that by 2050 there will be more plastic than fish in the world's ocean.

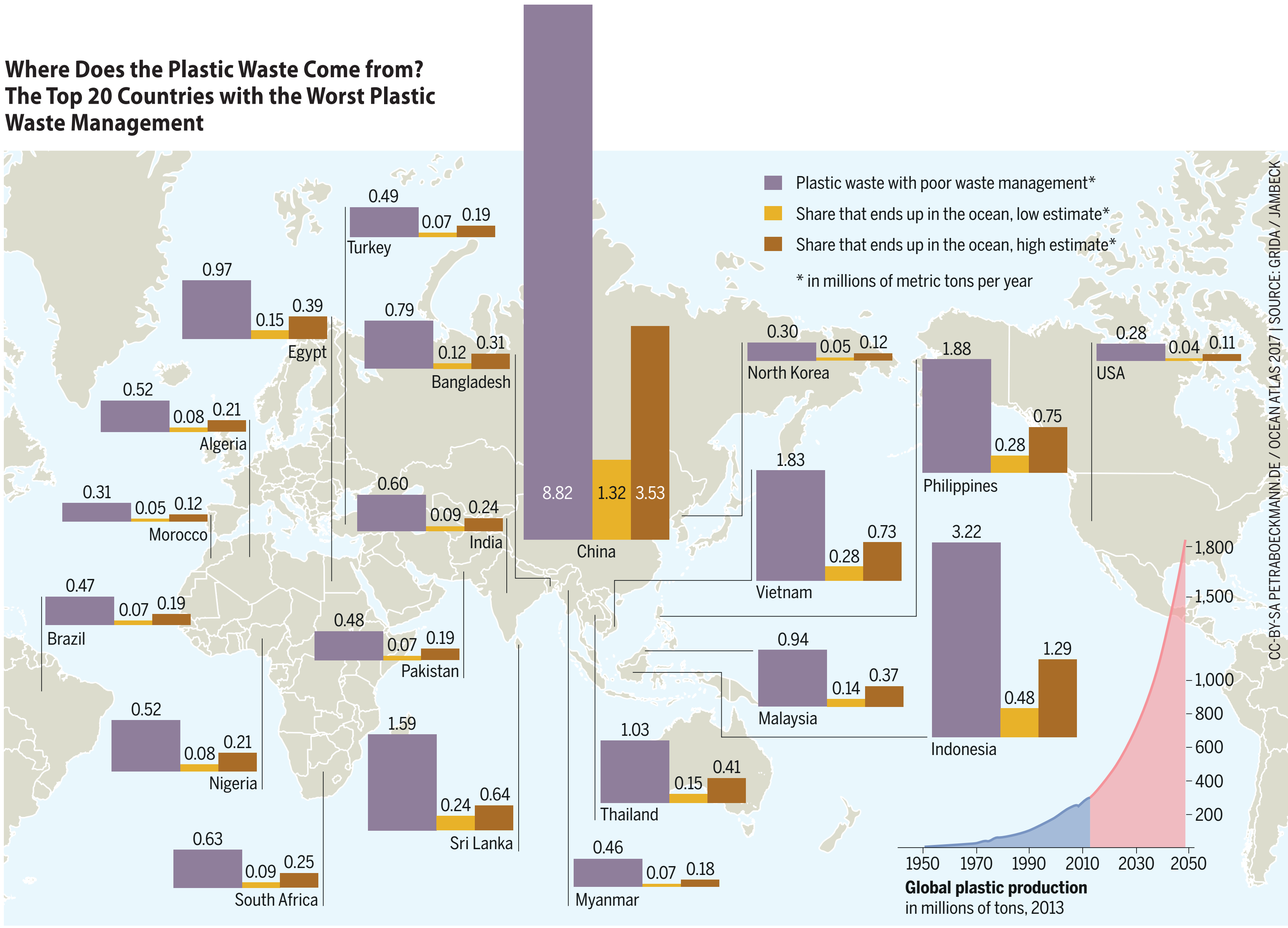


The world produces 300 million tons of plastic each year. About 2 per cent of it—around 8 million metric tons—ends up in the ocean. It is a staggering amount, yet only 1 per cent of this plastic is actually found on the surface of the ocean. Half of this 1 per cent becomes caught in large gyres (see map); the other half is more widely dispersed. The other 99 per cent (7.92 million metric tons) of plastics in the ocean worldwide are unaccounted for each year.

Science has only just begun to unravel the riddle of where this unaccounted-for plastic ends up. At the turn of the millennium, scientists uncovered a previously unknown phenomenon: microplastic. Eighty per cent of plastic waste enters the ocean via rivers and the other 20 per cent is tossed overboard from ships (see graphic). A portion of the plastic waste is carried great distances by ocean currents and gathers in large trash vortices such as the Great Pacific Garbage Patch in the North Pacific Gyre. On this journey, which can take up to 10 years, large pieces of plastic are progressively eroded, broken down by sunlight and eaten by bacteria, fragmenting into many smaller pieces. The result is microplastic—plastic particles that are smaller than 5 millimetres.

Thus the Great Pacific Garbage Patch is not the massive islands of trash that one might first imagine. Large bits of plastic are relatively rare, and one could actually swim through a gyre without noticing the microplastic that composes it. The remaining 99 per cent of the waste that begins its journey on the coasts never reaches garbage patches. It also breaks down into microplastic and disperses through the ocean, before finally sinking into the depths. In fact, the plastic concentration on the ocean floor is 1,000 times greater than on the surface. In

Where Does the Plastic Waste Come from? The Top 20 Countries with the Worst Plastic Waste Management



How Does All That Plastic Get Into the Ocean?

1. *A poor waste management/recycling system (or none at all) is the leading cause.*
2. *Plastic garbage from cities and industrial centers flows directly into rivers and seas with untreated wastewater.*
3. *Microplastic used as additives in cosmetic products is not filtered out by water treatment plants.*
4. *Fishing nets and lines lost or intentionally abandoned at sea.*
5. *Lost loads and ship materials.*
6. *Garbage illegally dumped at sea.*
7. *Catastrophic waste: wreckage and garbage swept out to sea by hurricanes, floods, and tsunamis.*

light of this, Solomon Islands' comparably low concentration of microplastic at the ocean surface (see the map) is not necessarily good news.

The microplastic is trapped on the ocean floor, embedded in the sediment. It is gradually forming a new geological layer, the "plastic horizon", which researchers of the future will attribute to our era. The sad truth is that we use the deep sea as a gigantic dustbin and benefit from the fact that the majority of the waste seemingly disappears forever, rather than washing up at our feet again.

While the portion of microplastic that remains afloat may seem small, it is the cause of a large problem with far-reaching effects. It is no wonder that fish mistake microplastic for plankton and eat it, since there is six times as much plastic as plankton in some parts of the ocean. Very small pieces of plastic can penetrate the fish's intestinal walls and become trapped in the surrounding tissue. The microplastic then enters the food chain and eventually winds up on our plates and in our own stomachs. The consequences of consuming microplastic have yet to be studied—after all, microplastic itself has only been a research topic since 2007. One finding is already cause for concern: the surface of microplastic acts like a sponge that soaks up toxins, including environmental poisons such as PCB and disease-causing germs, helping them spread and threatening entire fish populations.

Once plastic gets into the ocean, there is currently no way to retrieve it. Most becomes microplastic, which is so small that filtering it out of the water would filter out the aquatic life as well and would still leave larger pieces of plastic that are dangerous to larger animals. Many technical solutions aimed at ocean cleanup are under development and must consider the ecological consequences as well as the benefits. For instance, plans to scoop rubbish out of large areas of the sea could unintentionally catch fish and other organisms. The benefits must therefore be compared with the resulting damages.

The solution to the problem actually lies on dry land: on coasts and river deltas, at markets and in households. The good news is, it is within our grasp. As a significant portion of the plastic waste in the ocean comes from the packaging and products we use, we can have a direct influence by changing our consumption patterns. Governments can also ban the use of microplastics in cosmetics. But the most effective step that we can take is to build a globally functioning recycling economy, or circular economy, so that fewer new plastics are created and fewer are disposed of in an uncontrolled manner. Political engagement is a powerful lever for setting the right incentives for change, and developing a circular economy is just a matter of political will.

As a first step, Solomon Islands was involved in the 2018 World Environment Day, World Ocean Day and Coral Triangle Day campaigns, which focused on beating plastics pollution. Many Solomon Islanders are involved in coastal cleanup activities, helping to keep Solomon Islands' waters from turning into a plastic ocean.

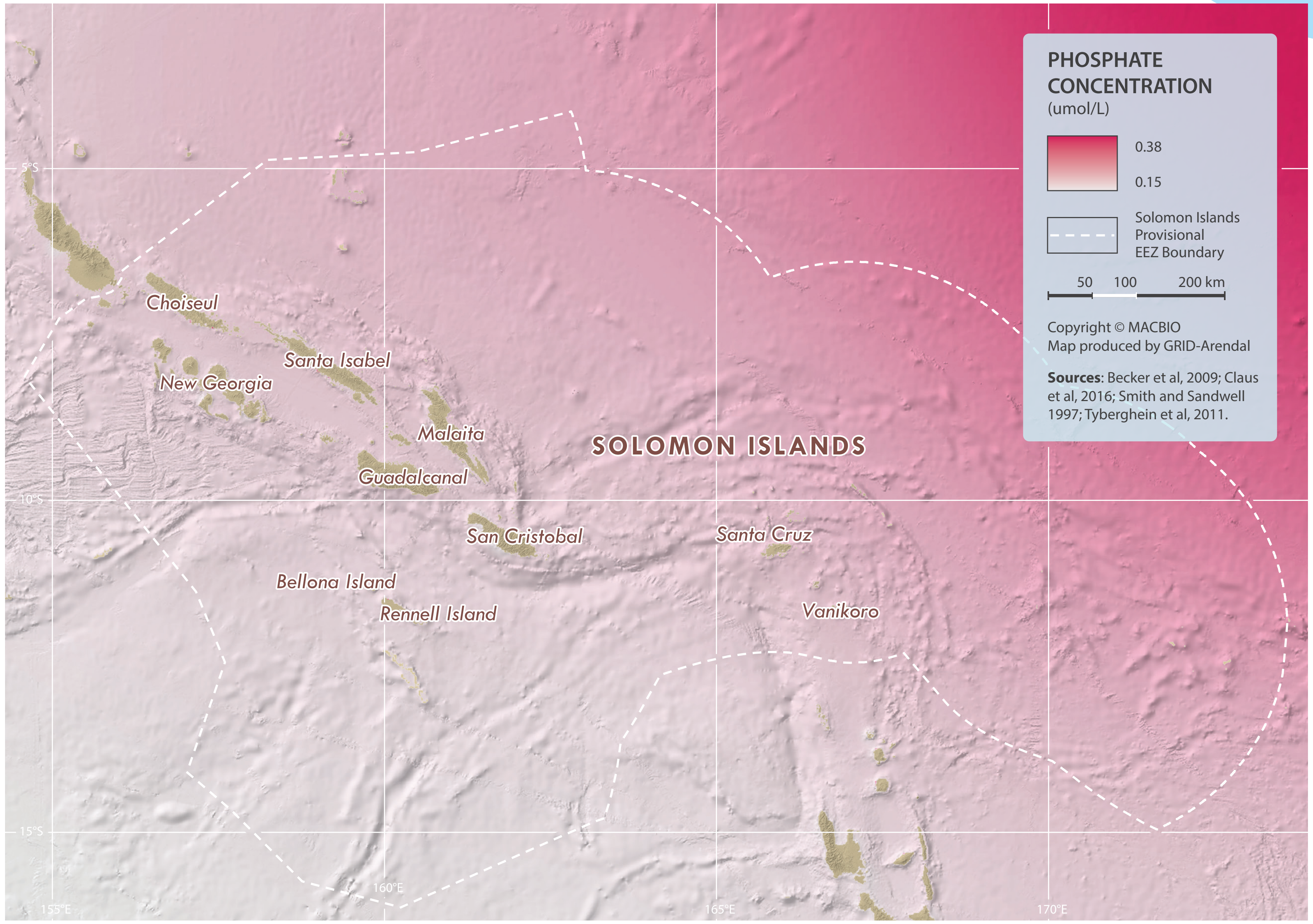
THE DOSE MAKES THE POISON: PHOSPHATE AND NITRATE CONCENTRATION

While nutrients including phosphate and nitrate provide much-needed nutrients for the marine food chain, too much from agricultural run-off and other sources negatively affect Solomon Islands' coastal ecosystems.

On a global scale, Solomon Islands' waters have a moderately low phosphate concentration, ranging from 0.16 to 0.27 umol/L. The highest concentrations are observed in the eastern waters and gradually decrease to the west. At the global level, nitrate concentrations in seawater are generally low, with the highest concentrations found in high latitudes and some areas of coastal upwelling. Within Solomon Islands' waters, the nitrate concentration ranges from 0.3 to 0.7 mmol m3. The highest concentrations of nitrate in Solomon Islands occur in the east, but the South-West Tropical Pacific (SWTP) is generally considered a nitrogen-limited area.

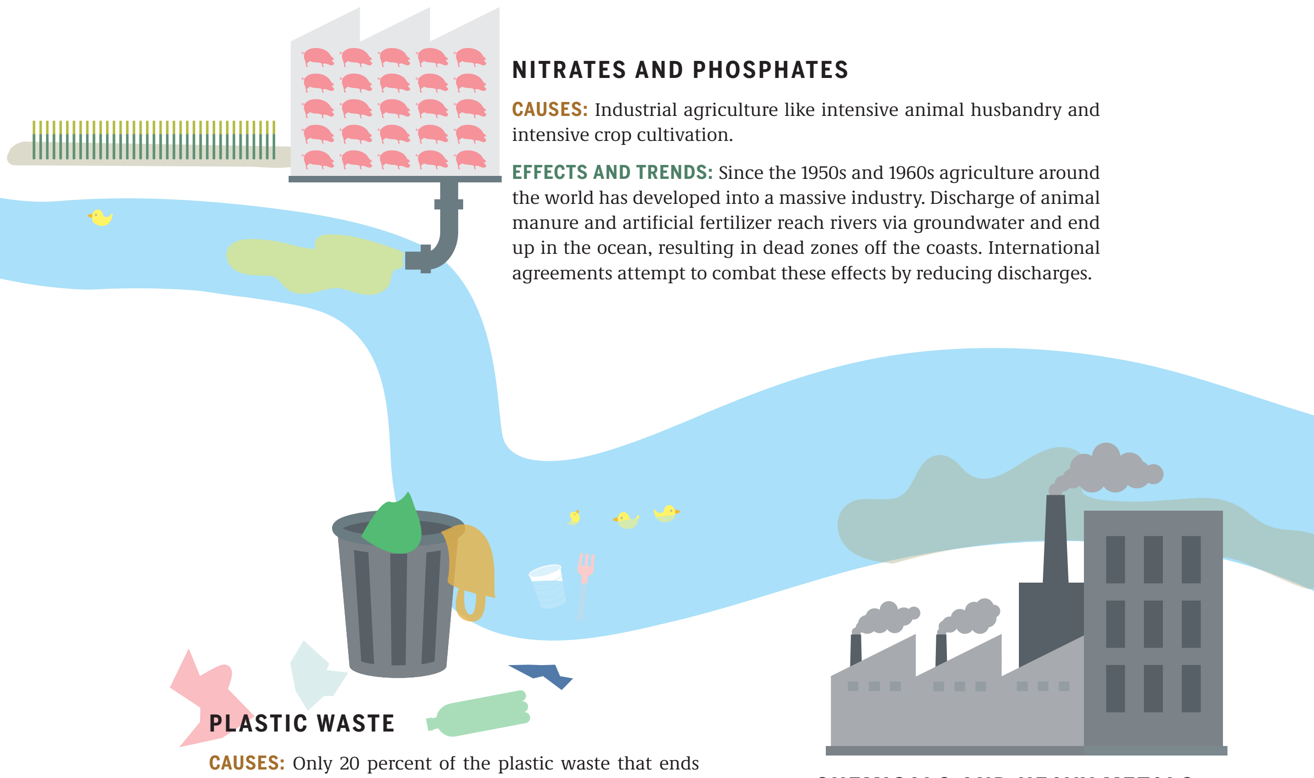
Phosphate and nitrate concentrations can be higher in the waters close to the main islands due to land and coastal inputs, which can include inorganic fertilizers, wastewater treatment from municipal sources, and soaps and detergents. This is where the dose makes the poison: while phosphate and nitrate are important nutrients, too much of them can be bad for marine and coastal ecosystems. In Solomon Islands' waters, there is certainly no shortage of sun, and thus photosynthetically available radiation, but there is a general limit of phosphate and nitrate. Once these nutrients are added from the land-based activities such as farming and wastewater treatment, primary productivity increases dramatically. The impact of too many nutrients (eutrophication) is especially significant in coastal waters, where increased nutrients can result in algal blooms (see satellite picture). These blooms can affect coastal habitats such as coral reefs by smothering, in the case of macro-algae, or limiting light availability, which can lead to rapid declines in reef biodiversity (Fabricius, 2005).

As the chapters "Plastic oceans" and "From ridge to reef" as well as the graphic show,



TRASH IN THE SURF, POISON IN THE SEA

The mounds of garbage on some coasts pose clearly visible problems. Other types of pollution are less visible – but every bit as serious.



NITRATES AND PHOSPHATES

CAUSES: Industrial agriculture like intensive animal husbandry and intensive crop cultivation.

EFFECTS AND TRENDS: Since the 1950s and 1960s agriculture around the world has developed into a massive industry. Discharge of animal manure and artificial fertilizer reach rivers via groundwater and end up in the ocean, resulting in dead zones off the coasts. International agreements attempt to combat these effects by reducing discharges.

PLASTIC WASTE

CAUSES: Only 20 percent of the plastic waste that ends up in the ocean actually comes from the ocean. The other 80 percent comes from dry land, mainly from countries where there is no, or very poor, waste management.

EFFECTS AND TRENDS: Five large garbage patches are known. Most garbage, however, lands on coastlines around the world and is thus a global problem. In 2015, for example, 100 cubic meters of plastic waste collected on the coast of Spitsbergen, a remote island halfway between Norway and the North Pole. The mounds of trash grow larger each year.

CHEMICALS AND HEAVY METALS

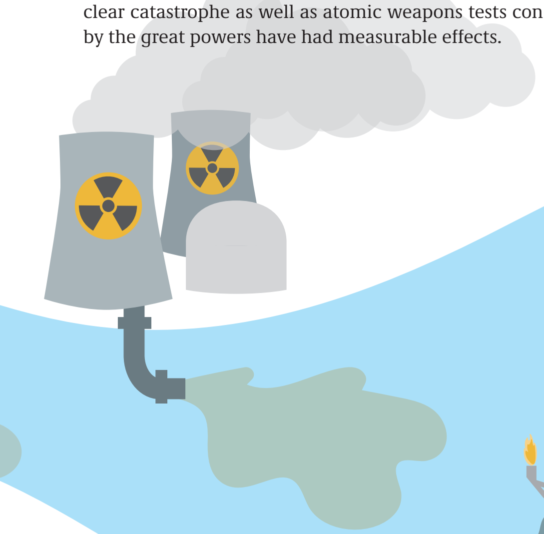
CAUSES: Industrial wastewater and waste gas, mining, burning heating oil.

EFFECTS AND TRENDS: According to the OECD, there are around 100,000 different chemical substances in circulation around the world. They include heavy metals like lead and mercury but also persistent organic pollutants (POP). Many of these substances are highly problematic because they accumulate in the bodies of marine organisms, entering the food chain where they pose a risk to human health.

RADIOACTIVITY

CAUSES: Atomic powers and countries that operate atomic power plants like the USA, Russia, Japan, and several European countries.

EFFECTS AND TRENDS: Starting in the 1950s, countries began legally dumping barrels of radioactive waste from nuclear power plants into the ocean. Barrels in the English Channel that should have remained sealed for hundreds of years have already begun leaking. The marine dumping of atomic waste was finally forbidden in 1993. However, the ban only applies to radioactive solids. Expelling radioactive wastewater into the ocean is still permitted and practiced. The Fukushima nuclear catastrophe as well as atomic weapons tests conducted by the great powers have had measurable effects.



MUNITIONS IN THE OCEAN

CAUSES: World wars and other conflicts. Many countries around the world have dumped chemical as well as conventional weapons in the ocean.

EFFECTS AND TRENDS: The experts agree that recovering the munitions would be too expensive and possibly too risky. However, leaving them is risky as well, though: for example, 70 years after the Second World War, clumps of white phosphorous from firebombs still wash up on beaches. They look like amber and children like to collect them. Phosphorous bursts into flames if it comes in contact with oxygen and warmth. At 1,300 degrees Celsius, it can burn all the way to the bone. This military waste will continue to pose a threat long into the future.

OIL POLLUTION

CAUSES: Wastewater, leaks during oil drilling, regular shipping, illegal tank cleaning, oil spills, and drilling accidents.

EFFECTS AND TRENDS: It takes exposed rocky and sandy coasts anywhere from a few months to five years to recover, while sheltered rocky coasts and coral reefs need from two to more than ten years.

Although the rate of extraction is higher than ever, pollution from oil spills has decreased due to stricter maritime transport regulations. On the other hand, the risk of drilling accidents increases the farther we penetrate into the depths.

NOISE

CAUSES: Shipping, deep-sea mining, military activities, driving sheet piling for harbors and offshore plants into the seabed, searching for oil and gas reserves with long-range acoustic devices (LRADs), and oil and natural gas extraction.

EFFECTS AND TRENDS: The amount of noise in the ocean is increasing due to the continually increasing usage of the ocean. Fish and especially marine mammals like whales and dolphins that communicate and navigate with sound are affected. The animals get confused, beach themselves, and perish in shallow water.

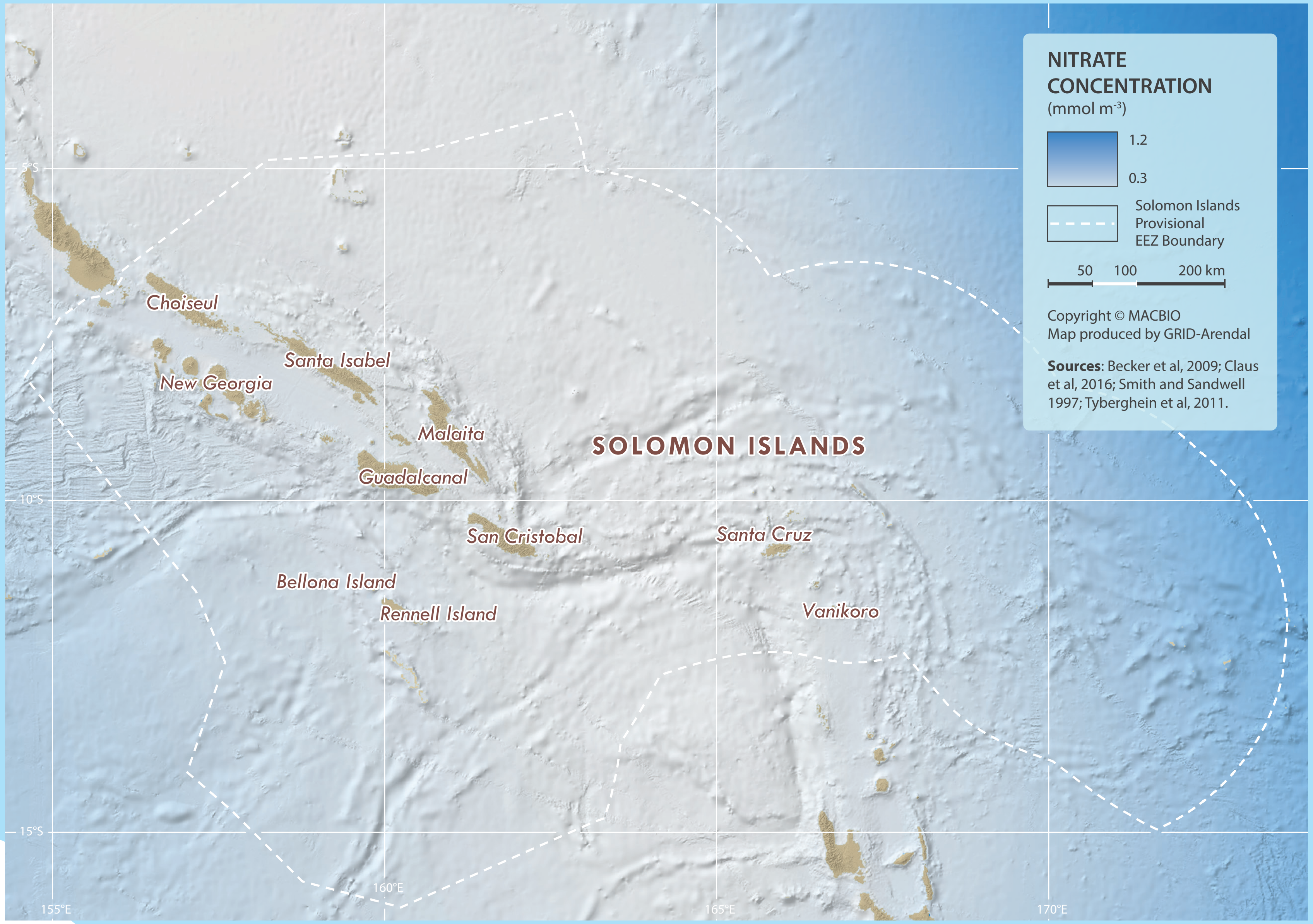
Sea food

“All things are poison and nothing is without poison; only the dose makes a thing not a poison”, stated the Swiss physician Paracelsus 500 years ago. And indeed, the dose makes the poison.

Marine organisms need food and nutrients, with tiny plants known as phytoplankton forming the basis of many marine food chains (see also chapter “Soak up the sun”). These phytoplankton rely on the nutrients phosphate and nitrogen, principally in the form of nitrate (see map).

Phytoplankton productivity at the surface of the ocean is often limited by the amount of available fixed inorganic nitrogen (Falkowski et al., 2009). However, where there is too much of these nutrients, algal blooms can occur, which can have negative impacts on the environment.

excess nutrients are only one type of pollution and threat to Solomon Islands’ marine values. To keep Solomon Islands’ coastal habitats healthy (see also chapter “Home, sweet home”), it is important to manage both point-source pollution, which comes from a single identifiable source such as a factory, as well as non-point pollution, for example from agricultural run-off. The MARPOL Convention (see also chapter “One world, one ocean”) is one international instrument to regulate pollution. MSP can help spatially identify sources and areas of pollution to guide sustainable ecosystem management, ensuring the dose does not make the poison.



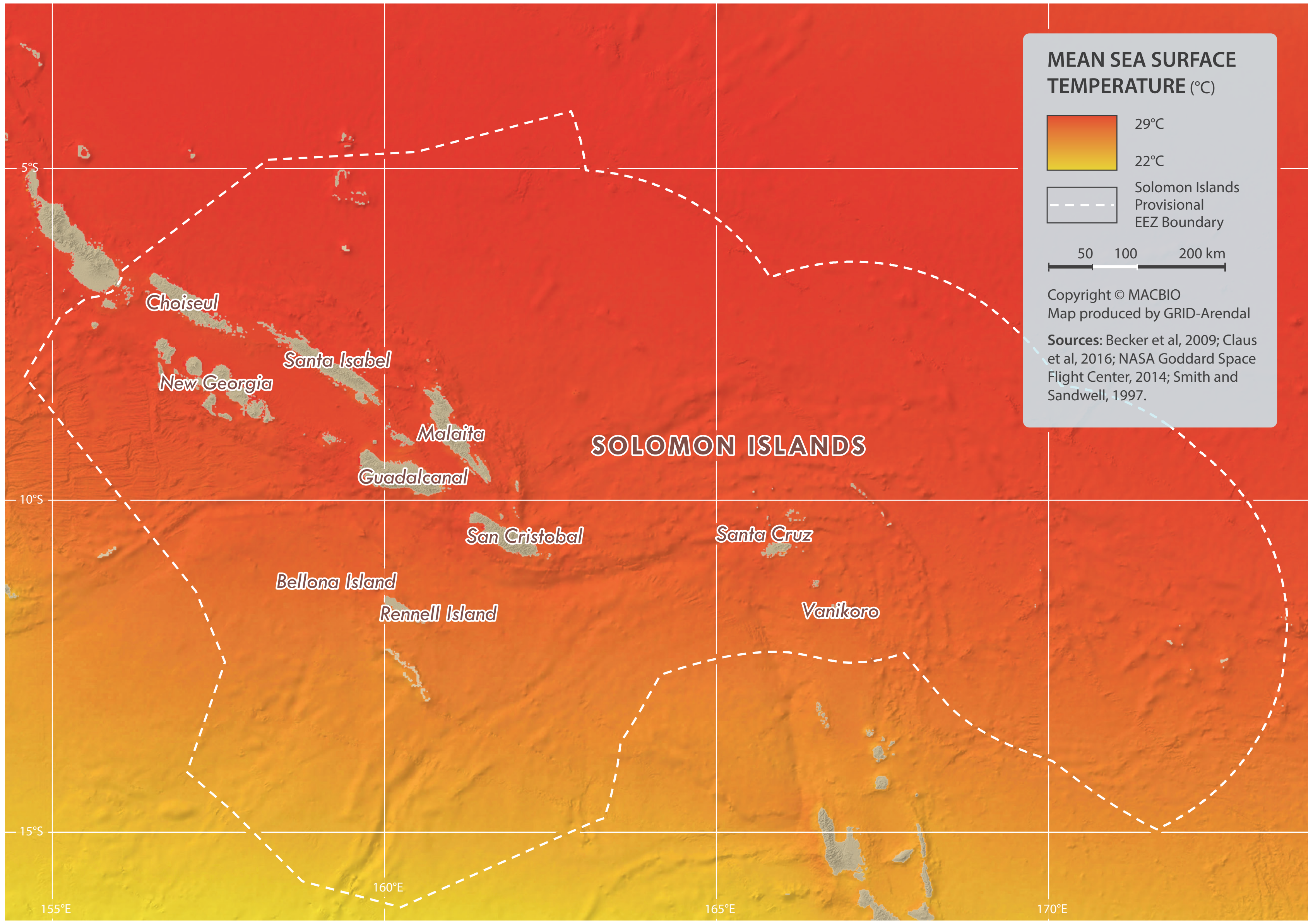
CLIMATE CHANGE THREATS

HOTTER AND HIGHER: MEAN SEA SURFACE TEMPERATURE AND PROJECTED SEA LEVEL RISE

Sea surface temperature (SST) is a limiting factor for much marine life. Climate change is leading to higher sea temperatures, as well as sea levels, thus compromising Solomon Islands' marine values.

The following chapters explain how observed and predicted climate change will affect Solomon Islands' marine values, starting with SST which is the water temperature close to the ocean's surface. The very hot temperatures in 2012 were not only uncomfortable for people, but for the ocean's inhabitants too. Warm water holds less dissolved oxygen than cooler water and once the level of dissolved oxygen drops below a critical threshold, fish and invertebrates suffocate. This is especially bad in shallow-water habitats, which can rapidly heat up and lose dissolved oxygen, resulting in thousands of dead fish.

Corals also find hot water uncomfortable. Shallow-water corals grow optimally between 23°C and 29°C, hence they are confined to tropical regions of the globe. When the water temperature falls outside this range, they can become stressed and expel their symbiotic algae (see also chapter "Home, sweet home") in a process known as bleaching. Coral bleaching is an increasing threat to coral reefs in tropical regions and can have a negative impact on ecosystems, fisheries and tourism. An increase in SST of only 1°C for four weeks can trigger a bleaching event. When increased temperatures last for longer periods (eight weeks or more), corals begin to die. This shows how SST is an important factor in the distribution of ocean life, with many species confined to specific temperature ranges.



Moreover, air masses in the Earth's atmosphere are highly modified by SST. Warm SST is known to be a cause of tropical cyclones over the Earth's oceans, with a threshold temperature of 26.5°C being a trigger mechanism (see also chapter "Stormy times"). At the same time, tropical cyclones can also cause a cool wake, due to turbulent mixing of the upper 30 metres of the ocean. SST changes diurnally, like the air above it, but to a lesser degree due to its higher specific heat. There is less SST variation on windy days than on calm days. In addition, ocean currents can affect SST on multi-decadal timescales. Coastal SST can cause offshore winds to generate upwelling, which can significantly cool or warm nearby land masses, and additionally shallower waters over a continental shelf are often warmer. Onshore winds can cause a considerable warm-up even in areas where upwelling is fairly constant.

The annual mean SST in Solomon Islands' waters ranges from 24°C in the south to nearly 29°C in the north, as the map shows. Across the year there is relatively little variation in the SST, with up to ±2.5°C in the south and less than ±1°C in the north. Solomon Islands is strongly influenced by the South Equatorial Current, which brings warm water from the eastern tropical Pacific Ocean.

Sea level rise has the potential to negatively impact the low-lying coastal areas of Solomon Islands, through flooding and wave inundation, with consequent shoreline erosion and groundwater salinization. These impacts could lead to a loss of infrastructure and productive land, thereby posing a challenge to livelihoods in the region. Improved data and information on

Blame it on the weatherman?

When Solomon Islands' coastal waters warm way above their average temperature during summer, is it due to a few hot sunny days or global warming?

To understand this, we need to look at two different things.

On one hand climate variability, which refers to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with El Niño (dry) or La Niña (wet) events (see also chapter "Go with the flow"). On the other hand climate change, which refers to long-term (decades or longer) trends in climate averages such as the global warming that has been observed over the past century, and long-term changes in variability (e.g. in the frequency, severity and duration of extreme events) (see also chapter "Stormy times"). There may always be particularly rainy weather, or a particularly hot week. Only by observing trends in the long term can we show how the climate is changing.

sea level rise are necessary in order to plan effectively for these changes.

Sea level rise, as a consequence of global warming, threatens many low-lying regions of the world. The Fifth International Panel on Climate Change assessment projects a global rise in mean sea level for 2081–2100 relative to 1986–2005 of between 0.2 and 0.98 metres, depending on different emissions scenarios. Furthermore, the western tropical Pacific Island region is considered one of the most vulnerable regions under future sea level rise (Nicholls and Cazenave, 2010). Sea level rise is not uniform across the western Pacific and is affected by ENSO events. These have a strong modulating effect on inter-annual sea level variability, with lower than average sea level during El Niño and higher than average during La Niña events (of ±20–30 cm). In addition, there is also an observed low-frequency (multi-decadal) variability, which in some areas adds to the current global mean sea level rise due to ocean warming and ice melting (Becker et al., 2012).

Solomon Islands is a mix of predominantly high volcanic islands and several low-lying coral atolls. Vulnerability to sea level rise is influenced by coastal geography and prevailing ocean currents. High volcanic islands with significant infrastructure along the coastal zone are also vulnerable to rising sea levels.

Visualizing rising sea levels

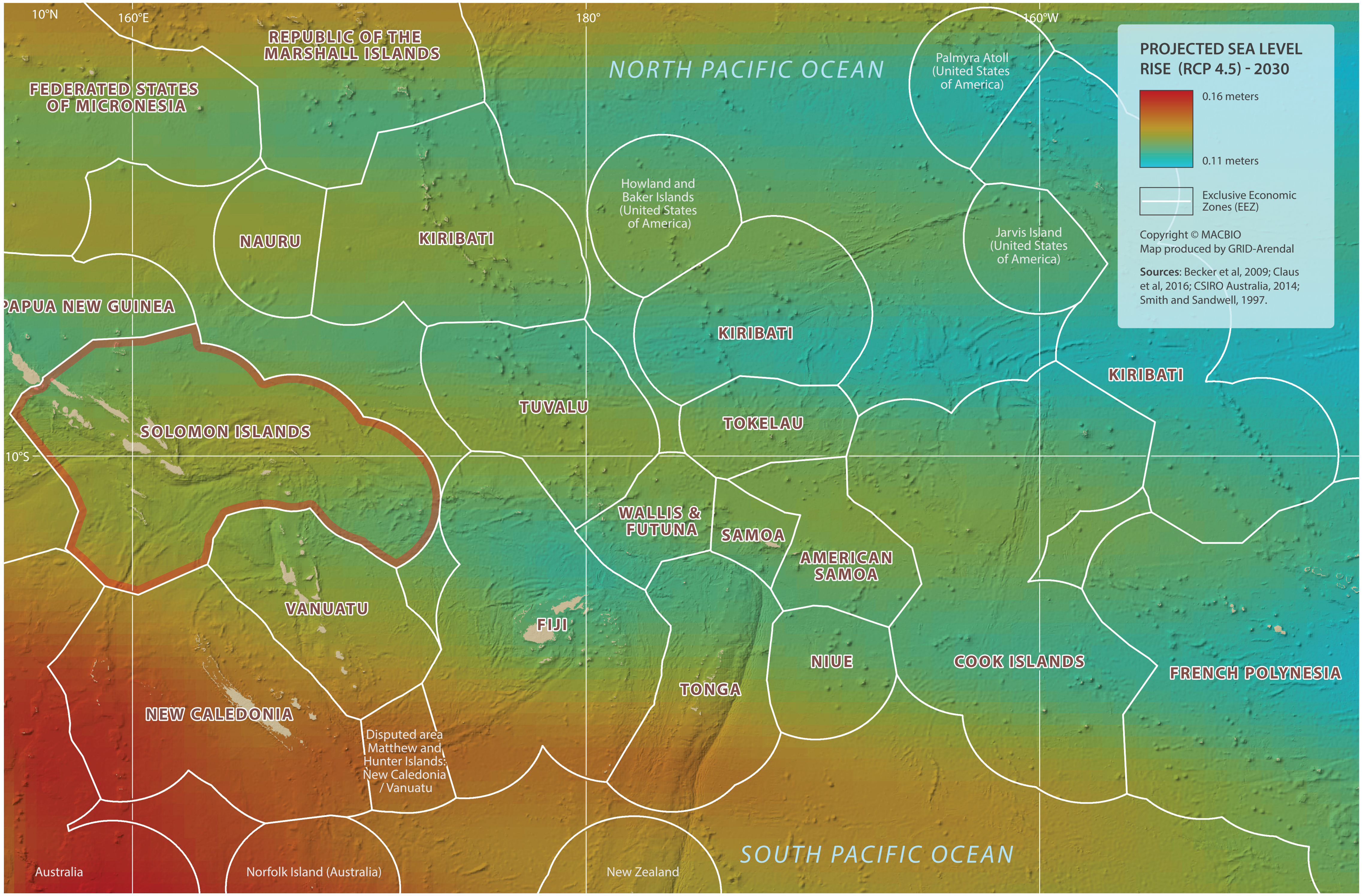
Five islands have already disappeared in Solomon Islands due to coastal erosion and rising sea levels. A further six reef islands have been severely eroded with 10 houses being swept from one island into the sea between 2011 and 2014. Solomon Islands is considered a sea-level hotspot, as its waters are rising three times higher than the global average. As a result, some villages have already been relocated, with more to follow.

Islands exposed to higher wave energy in addition to sea level rise can experience higher rates of erosion than their more sheltered counterparts. However, the coral atolls of Solomon Islands may be able to adjust their size, shape and position in response to sea level rise, as has been suggested for other reef islands such as Funafuti Atoll in Tuvalu (Kench et al., 2015). Vertical reef accretion that occurs in response to sea level rise may be able to prevent the significant increases in shoreline wave energy and wave-driven flooding that are predicted in the absence of reef growth (Beetham et al., 2017).

The map indicates that by 2030, Solomon Islands will experience a minimum rise in sea level of 0.14–0.16 metres. This is likely to be accompanied by increases in episodes of flooding and wave inundation in some coastal areas. In general, the main islands of Solomon Islands are in a zone of lower sea level rise, with sea levels increasingly rising in the south. Pacific Island nations are therefore focused on developing adaptation strategies to address the predicted continued rise in sea level.

In the past, ocean waves only flooded atolls and islands (often just one metre above the waves) every couple of decades. This trend has since changed, with flooding now beginning to occur more frequently. When these flooding events become too frequent, it will be difficult for the islands to recover. The land becomes too salty, freshwater reserves in lagoons become undrinkable and the islands themselves are no longer able to support human habitation.

It is becoming clear that in a warming world, Solomon Islands' sea will become hotter and higher, with drastic consequences for coastal habitats and their inhabitants.



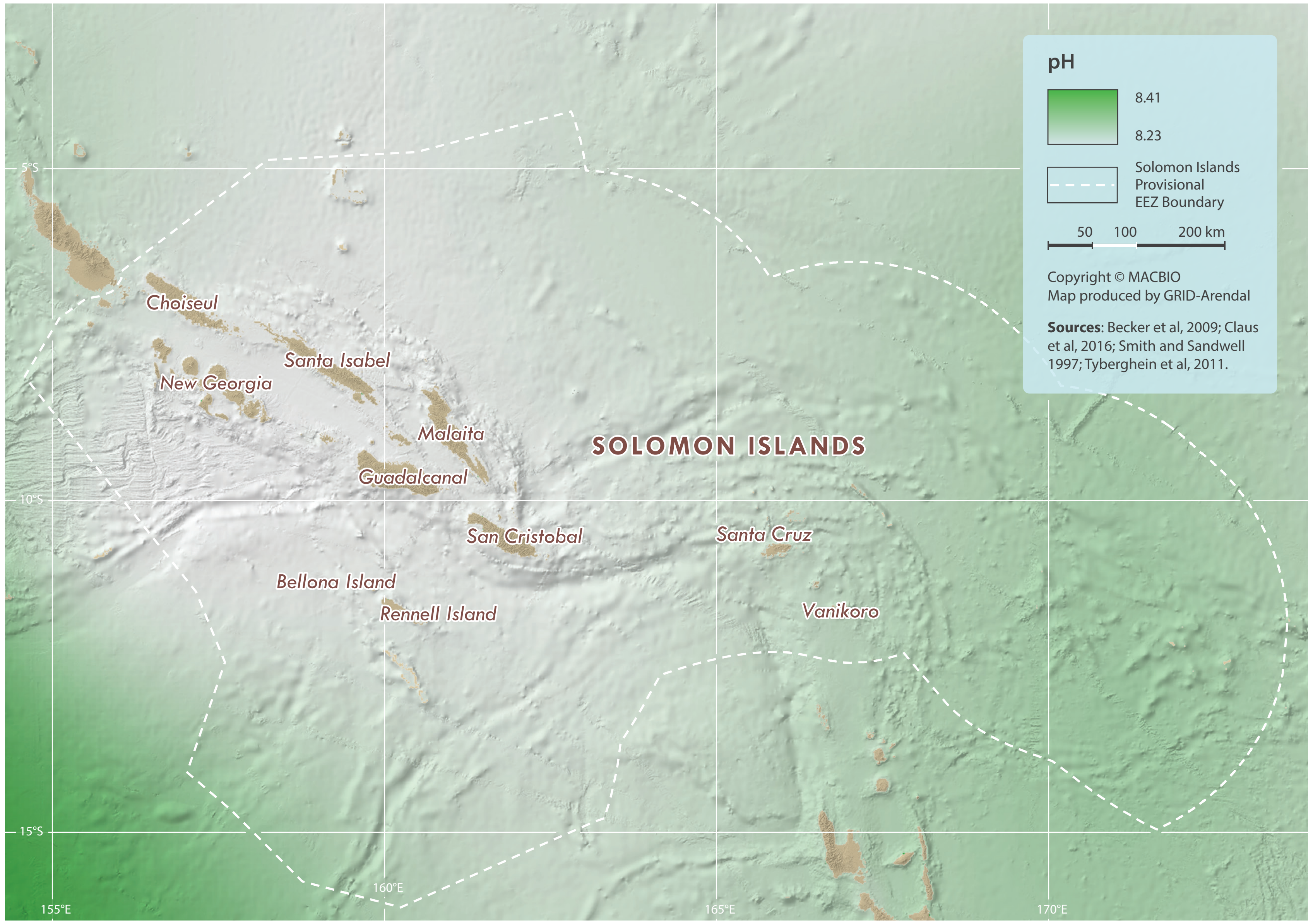
TURNING SOUR: OCEAN ACIDITY

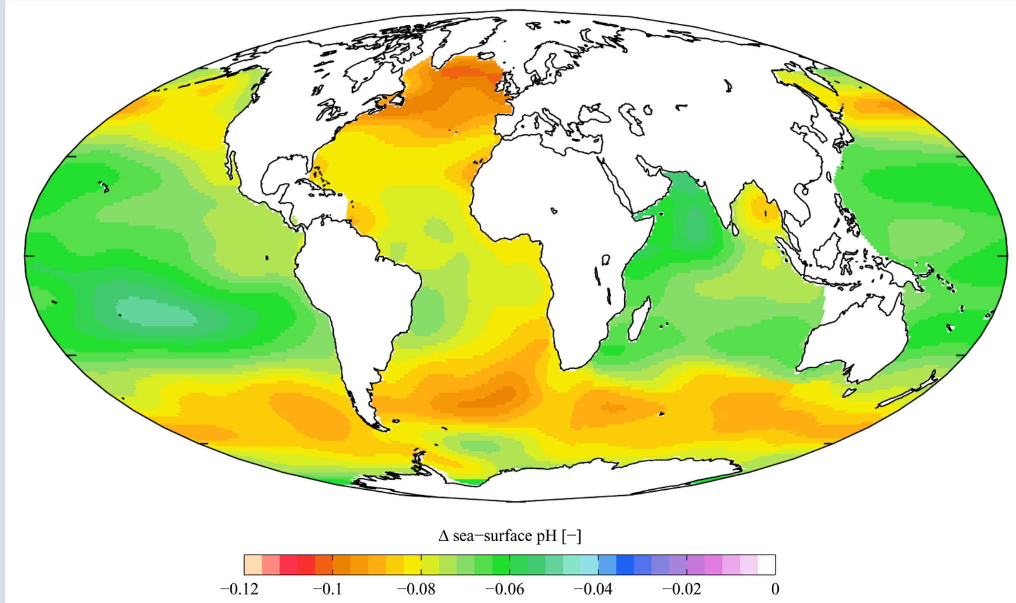
CO_2 emissions are not only causing the temperature and level Solomon Islands' waters to rise, but also its acidity, which causes serious problems for many marine organisms.

Seawater acidity can be measured using the pH, a numeric scale to specify the acidity or basicity of a solution; a pH of 7 is neutral—neither acidic nor basic. A decrease in pH by one means a solution is twice as acidic, whereas an increase by one means a solution twice as basic (see graphic). The pH of the global oceans ranges from around 7.5 to 8.4. Solomon Islands' waters are at the higher end of this range, with pH between 8.23 and 8.31. Increasing CO_2 in the surface water leads to increased acidification (lower pH). Already, CO_2 emissions have resulted in a 26 per cent increase in the acid content in the ocean (see small map).

In this context, it is important to look at calcite, which is another vital element found in seawater (see map), as calcium carbonate is a building block of the skeletons of most marine organisms, including corals. Globally, calcite concentrations are highest in the high latitudes and in coastal areas. The calcite concentrations in Solomon Islands' oceanic waters are low, with the coastal areas around the islands having a higher concentration (see calcite map).

How does acidification affect calcite levels? Firstly, CO_2 in the water transforms into carbonic acid and the carbonate saturation decreases. This is problematic for all animals that use carbonate to make their shells, such as mussels, snails, corals and sea urchins, among many others (see also chapter "Travellers or homebodies"). The less carbonate there is in the water, the more difficult it is for them to make suitable shells. The effects can already be seen among foraminifera: tiny calcifying creatures that make up an important part of the plankton. The shell-thickness of animals in the

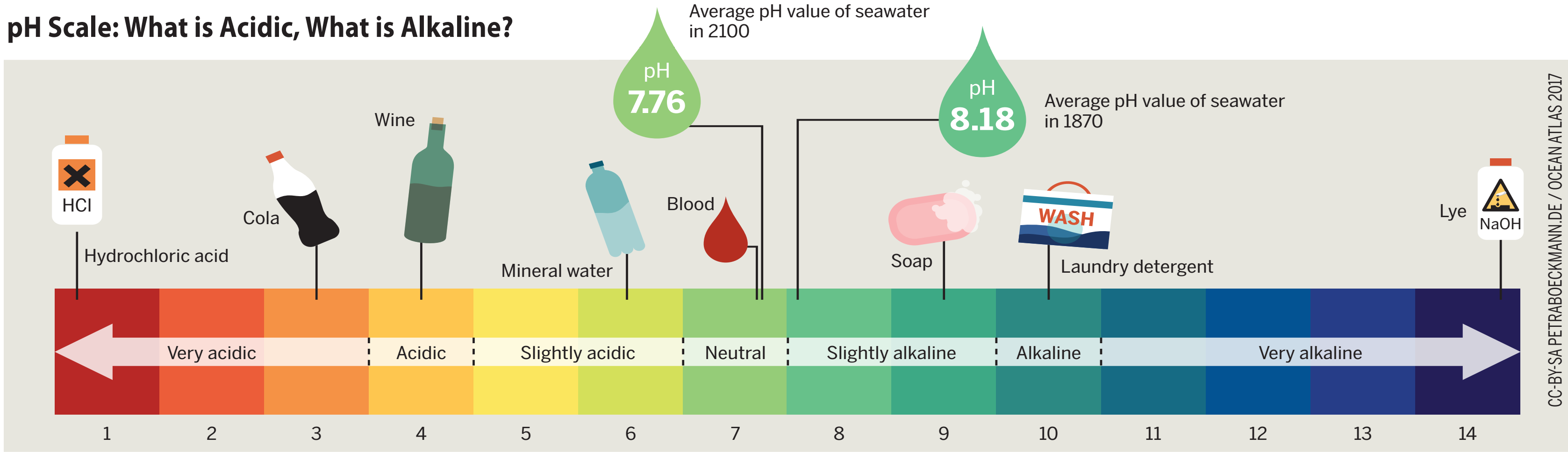




Ocean acidification

Solomon Islands is suffering the effects of global warming, with greenhouse gas emissions not only heating the nation's sea, but also ending up in it. In fact, worldwide the oceans have absorbed about one third of the carbon dioxide (CO_2) produced by human activities since 1800 and about half of the CO_2 produced by burning fossil fuels (Sabine et al., 2004). As CO_2 in the ocean increases, ocean pH decreases, resulting in the water becoming more acidic. This is called ocean acidification, the "evil twin" of sea temperature and sea level rise, described in the previous maps.

pH Scale: What is Acidic, What is Alkaline?



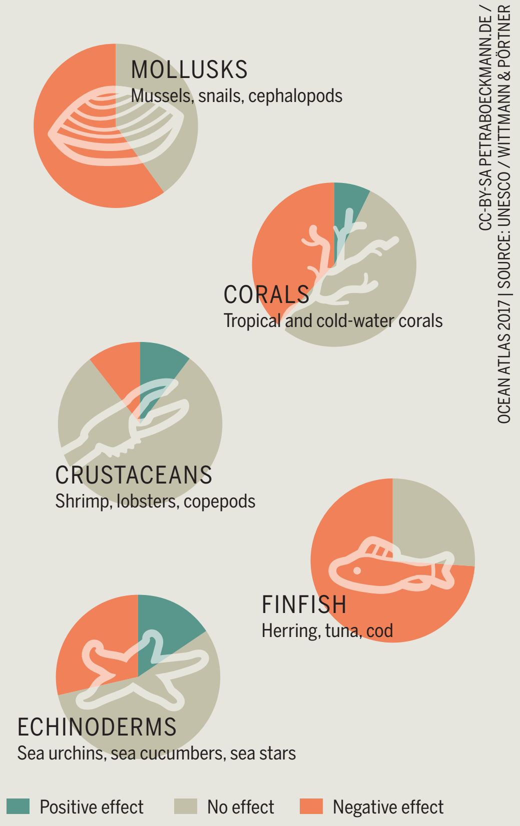
The difference may seem small, but the decline in the pH value from the year 1870 (pH 8.25) to 2100 (pH of 7.9) would mean a 170 per cent increase in acidity. Much smaller changes already pose problems for many sea creatures.

Southern Ocean has noticeably decreased compared to specimens from the pre-industrial period. The effect on oysters is slightly different: it has been observed that the thickness of their shells does not decrease, but only because they invest so much energy into shell production that it stunts their overall growth. This makes them easier prey for predators, such as murex snails.

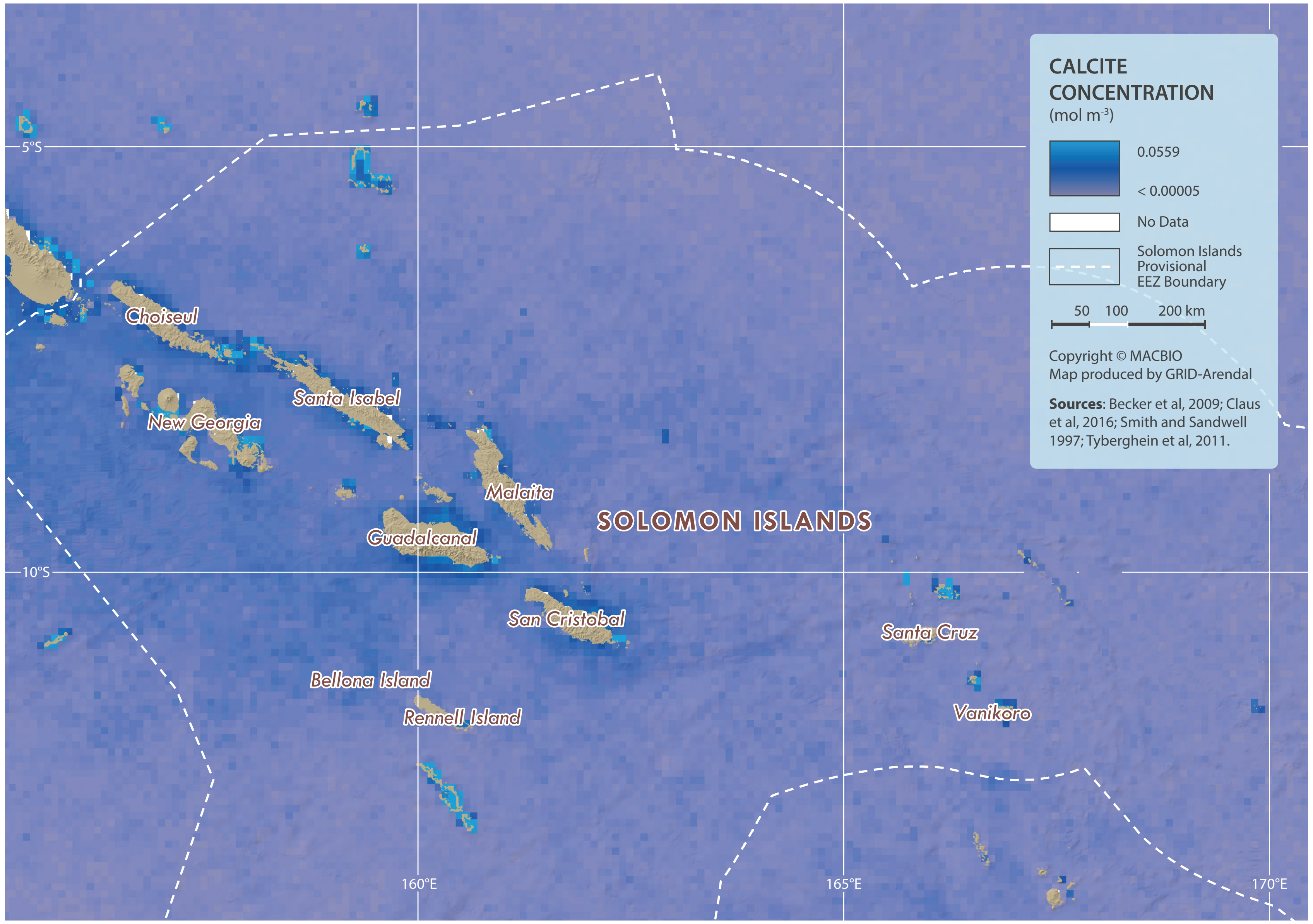
The situation is particularly critical for calcifying species in zones in which carbonate saturation drops too far. In that case, the water actually begins to draw carbonate out of their shells and corrodes them. This is already happening in some regions in Antarctica and in the North Atlantic. The cold-water corals that live there cannot maintain their skeletons and will eventually collapse.

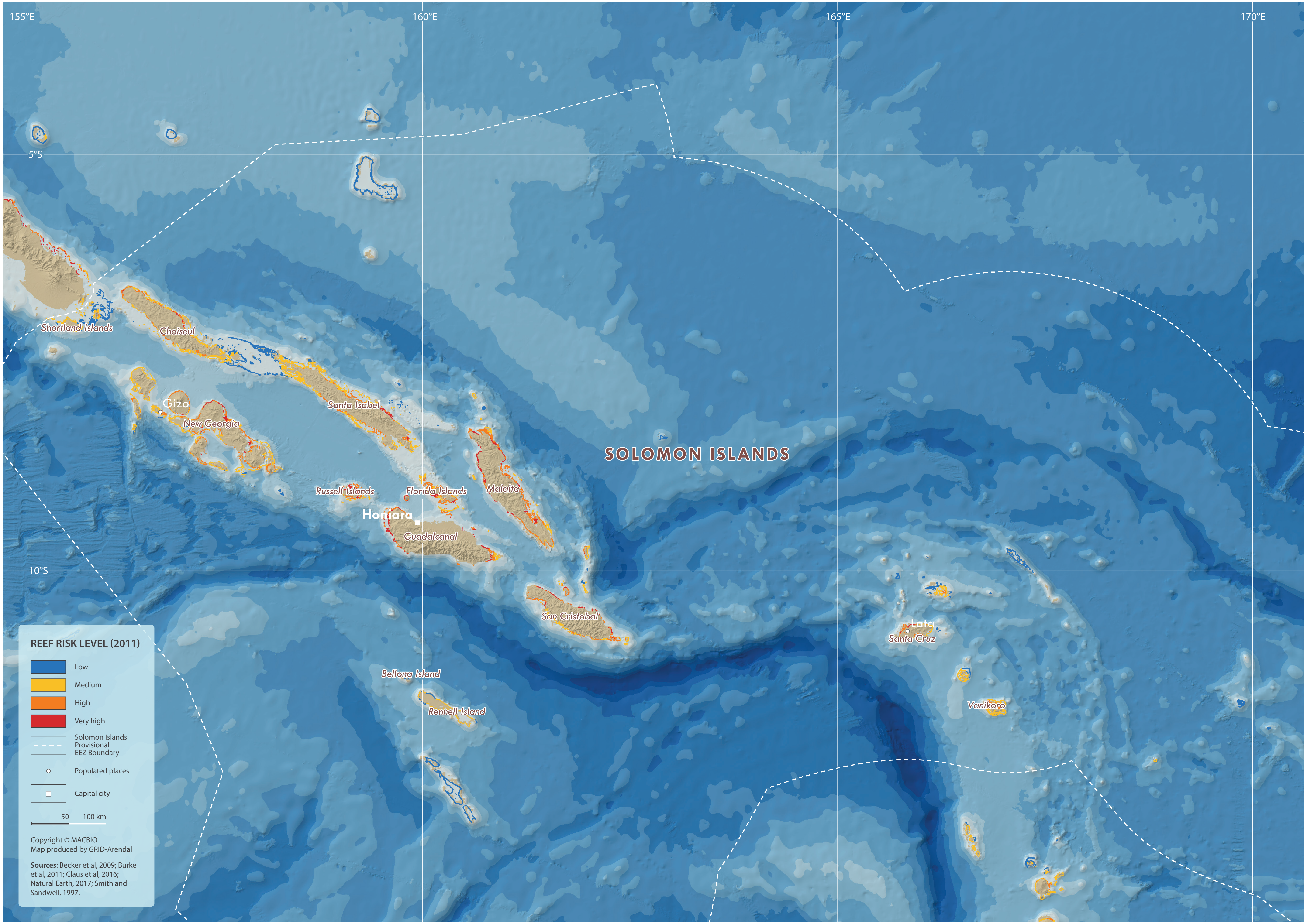
Solomon Islands' shallow-water corals are also at risk from increasing acidity. For example, it has been predicted that ocean acidity will decrease from a current pH of around 8.3 to a pH of 7.9 by 2100. This level of decrease has been shown to result in a 50 per cent reduction in coral productivity, and increased acidity makes coral bleaching more likely.Moreover, other non-calcium carbonate-skeleton-producing species, such as fish, are threatened, as their eggs can be corroded in more acidic water.

Acidification: Some Species Adapt – Others Don't



Many animals, including fish and snails, are negatively affected by acidification. Only a few actually benefit from it.





155°E
160°E
165°E
170°E
5°S
10°S
Shortland Islands
Choiseul
Gizo
New Georgia
Santa Isabel
Russell Islands
Florida Islands
Malaita
Honiara
Guadalcanal
SOLOMON ISLANDS
San Cristobal
Lata
Santa Cruz
Bellona Island
Rennell Island
Vanikoro
REEF RISK LEVEL (2011)
Low
Medium
High
Very high
Solomon Islands Provisional EEZ Boundary
Populated places
Capital city
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Burke et al, 2011; Claus et al, 2016; Natural Earth, 2017; Smith and Sandwell, 1997.

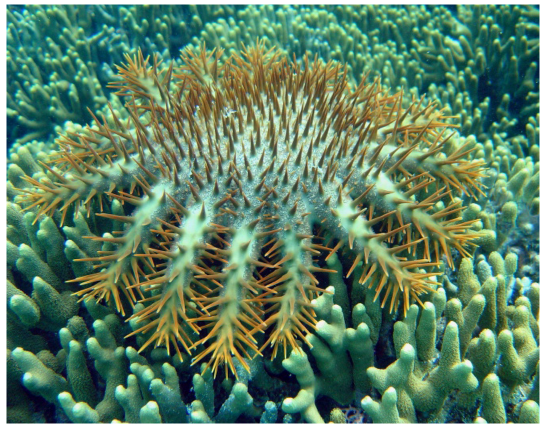
REEFS AT RISK: REEF RISK LEVEL

Solomon Islands' reefs are at risk. The direct and indirect impacts of climate change are exacerbating the pressures reefs face, jeopardizing marine values worth billions of dollars.

As shown in the previous maps, coral bleaching is the silent reef killer, caused by rising sea levels as well as ocean acidification. There is little information on coral bleaching in Solomon Islands, with the earliest coral bleaching recorded during a 1965 Royal Society expedition, which found dead coral in the shallow waters of several locations around Honiara, Tete Island and the Sandfly Passage of the Nggela Islands (Reefbase). This mortality is thought to have been the result of a bleaching event, due to high SSTs several months before the expedition. Confirmed coral bleaching was observed in 2000 around Ghizo Island and by 2002 had spread around much of the Solomon Islands (Sulu et al., 2002).

In addition to bleaching, coral reefs face several other natural threats, including cyclones, tsunamis and earthquakes. In April 2007, an earthquake and subsequent tsunami damaged Solomon Islands' coral reefs. In one case, reef flats were uplifted, exposing the coral to the air (Wilkinson, 2008). Maintaining healthy coral communities helps build their resilience against many natural threats.

Human disturbances are another threat to coral reefs in Solomon Islands and include overfishing, pollution, sedimentation,



Crown-of-thorns starfish damage Solomon Islands' reefs. Outbreaks often occur when their natural predators are overfished.

eutrophication and coastal development (Wilkinson, 2008). Prevalent widespread logging is also having a major impact on lagoons and coral reefs, such as the Marovo Lagoon, by causing huge sediment discharges from rivers draining the logged catchments (Sulu et al., 2002). Plans for land-based human activities, such as forestry, agriculture, aquaculture and mining, must therefore take into account their downstream impacts on coastal habitats in order to maintain the resilience of coral reef communities.

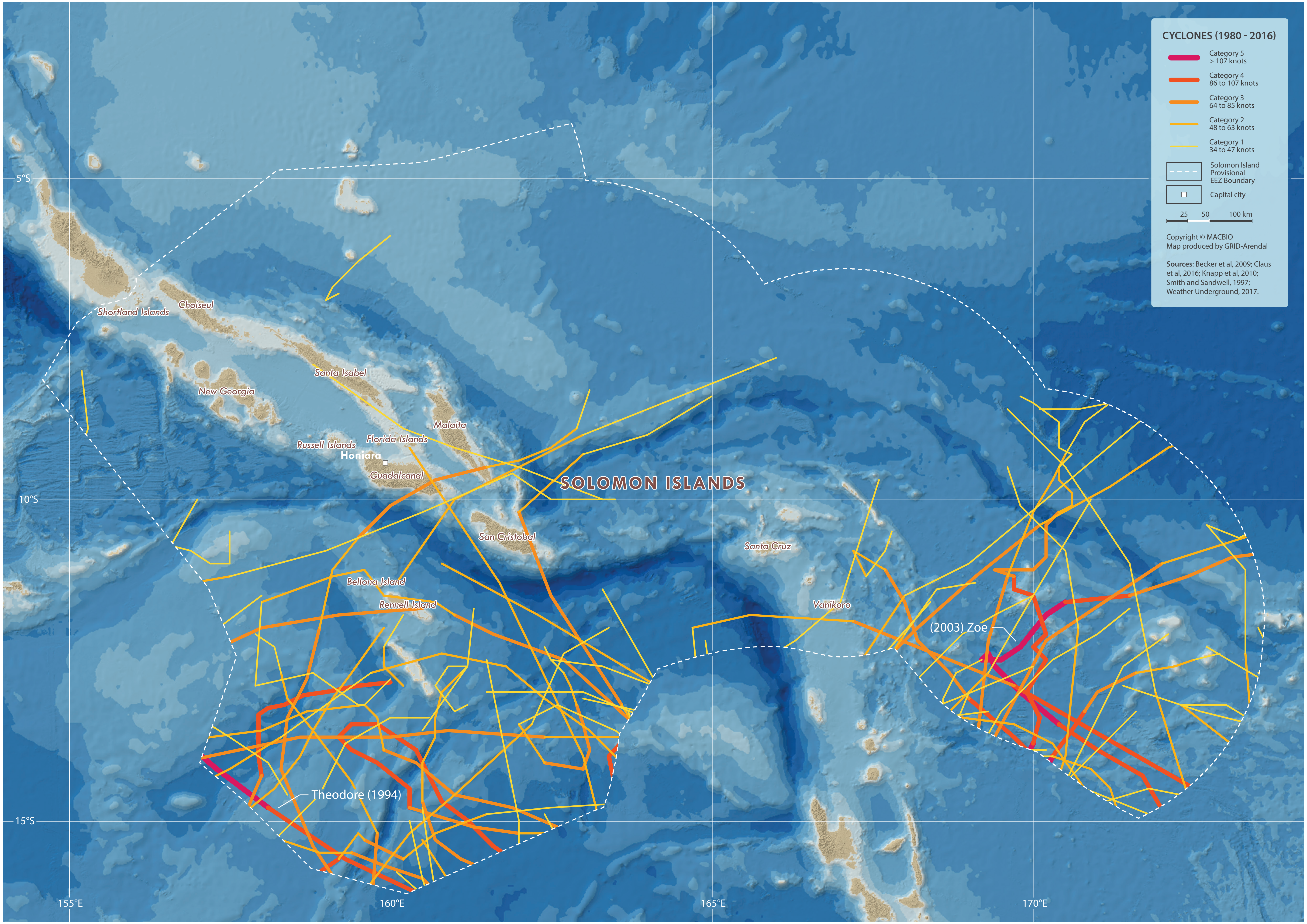
This interaction shows the cumulative impact of climate change and local human activities on Solomon Islands reefs; threats that will increase over time. The risk of these threats is shown on the map of Solomon Islands' reefs, classified by estimated present threat from local human activities, according to the Reefs at Risk integrated local threat index. Threats considered in the index include coastal development, including coastal engineering, landfilling, run-off from coastal construction, sewage discharge (see also chapter "The dose makes the poison"), and impacts from unsustainable tourism (see also chapter "Beyond the beach"); watershed-based pollution, focusing on erosion and nutrient fertilizer run-off from agriculture entering coastal waters via rivers; marine-based pollution and damage, including solid waste, nutrients, toxins from oil and gas installations and shipping, and physical damage from anchors and ship groundings (see also chapter "Full speed ahead"); and overfishing and destructive fishing, including unsustainable harvesting of fish or invertebrates, and damaging fishing practices such as the use of explosives or poisons (see also chapters "Fishing in the dark" and "Small fish, big importance").

This multitude of man-made threats leaves Solomon Islands' reefs at risk. Analysis of

Acropora coral field in Solomon Islands exposed to multiple impacts, including a crown-of-thorns outbreak and cyclone damage.

the threat index indicates that 31.3 per cent of the reef area is classified as facing a low level of risk, 40.3 per cent a medium risk, 22.8 per cent a high risk and 5.6 per cent a very high risk. The areas of very high risk (red) are found on many of the main islands' coasts, particularly around populated locations, such as Guadalcanal. The reefs are important to the local communities' economies, especially for subsistence and coastal protection. Land-based activities, including logging, farming and aquaculture, can affect coastal habitats, such as coral reefs, due to the release of increased sediment and nutrient loads into coastal waters. Certain types of fishing practices can also damage coral reefs, which will subsequently affect the productivity of these fisheries.

Luckily, there are many initiatives aiming to facilitate the changes needed. The Coral Triangle Initiative is helping Solomon Islands develop its capacity to manage coral reefs. Integrated approaches to coral reef conservation should consider land–sea connections and require an understanding of how and where terrestrial conservation actions influence reefs. Klein et al. (2012) examined the impact and cost effectiveness of protecting forests as a reef conservation measure. Their analysis found that relative coral reef condition could be improved by between 8 and 58 per cent if all remnant forest was protected rather than deforested (Klein et al., 2012).



CYCLONES (1980 - 2016)
Category 5
> 107 knots
Category 4
86 to 107 knots
Category 3
64 to 85 knots
Category 2
48 to 63 knots
Category 1
34 to 47 knots
Solomon Island Provisional EEZ Boundary
Capital city
25
50
100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Knapp et al, 2010; Smith and Sandwell, 1997; Weather Underground, 2017.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Malaita
Florida Islands
Russell Islands
Honiara
Guadalcanal
San Cristobal
Santa Cruz
Vanikoro
Bellona Island
Rennell Island
(2003) Zoe
Theodore (1994)
5°S
10°S
15°S
155°E
160°E
165°E
170°E

STORMY TIMES: CYCLONES

Tropical cyclones pose direct and indirect threats to Solomon Islands, its people and its marine life. Marine and coastal habitats including mangroves, seagrasses and coral reefs play an important role in offering effective protection and therefore need to be sustainably managed and conserved.

Solomon Islands is less prone to cyclones than several of its Pacific Island neighbours to the east. However, the country still has a significant risk of cyclones, particularly in the east and south. On average, Solomon Islands receives 1–2 cyclones per season. The cyclones that affect Solomon Islands are often in the early stage of their life cycle, meaning they are usually relatively small. Nevertheless, they can cause serious damage to structures, crops, forests and local water supplies, and have caused loss of life in the past (Solomon Islands Government Meteorological Services Division, n.d.).

Cyclones are monitored by the Solomon Islands Government Meteorological Services Division in Honiara and categorized according to the Australian and South Pacific Category System from category 1 (90 km/h gusts) to category 5 (280 km/h gusts). The cyclone season is considered to run from the beginning of November to the end of April, but destructive cyclones can occur outside this period. The formation of cyclones in the region is strongly influenced by the El Niño–Southern Oscillation (ENSO; see also chapters "Go with the flow" and "Hotter and higher"). During El Niño years, cyclones are more likely to form between 6°S and 18°S and 170°E and 170°W. The highest density is centred over the southern and eastern part of Solomon Islands' waters, where low-level relative vorticity, an upper-level divergent atmosphere and weak environmental wind shear are very conducive to genesis. During La Niña years, slightly fewer tropical cyclones form and the origin moves to the south of Solomon Islands (Chand and Walsh, 2009). El Niño brings a heightened risk of cyclones.

In the past decade, there has been increasing attention on the relationship between climate change and the frequency and intensity of cyclones in the region. Diamond et al. (2013) found a statistically significant increase in the number and intensity of cyclones in the period 1991–2010 compared with the period 1970–1990 in the tropical South-West Pacific. In Solomon Islands, it is estimated that the number of tropical cyclones will decrease by the end of the twenty-first century. However, those that do occur are expected to be more intense or severe (MECDM, 2012). Rising SSTs are fuelling cyclones (see also chapters "Hotter and higher") that are resulting in increasing damage, including to Solomon Islands' valuable coastal habitats.

At the same time, conserving habitats such as coral reefs and mangroves offers a very effective form of protection against storms. In this way, Solomon Islands can strengthen its defences against cyclones.

Cyclone Namu

On May 15, 1986, a tropical depression formed within the monsoon trough. Located north of Solomon Islands, the storm steadily intensified while meandering. After briefly moving west, the storm attained category 2 intensity on May 18, moving through the country's island chain the following day. Cyclone Namu had a peak intensity of 120 km/h. Although its wind speed was not particularly high, the storm's slow movements allowed for prolonged periods of heavy rainfall, resulting in significant flooding throughout Solomon Islands. The islands of Malaita and Guadalcanal experienced the worst damage. Rough seas and strong winds severely damaged Malaita Island's coastal areas, especially along the island's eastern side where entire villages were destroyed. On Guadalcanal Island, a village of 43 people had only five survivors and more than 75 per cent of the island's plains were flooded. In addition, 22 per cent of homes on the island were either damaged or destroyed. Villages throughout the entire island group sustained severe damage. Overall, approximately 90,000 people—one third of the country's population—were reported homeless. Cyclone Namu was responsible for at least 150 deaths, largely from flooding and landslides. Property damage and economic losses across Solomon Islands totalled US$25 million and US$100 million (1986 USD) respectively.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MANAGING

The marine and coastal ecosystems of Solomon Islands' waters provide benefits for people in and beyond Solomon Islands. To better understand and improve the effective management of these values on the ground, Pacific Island countries, including Solomon Islands, are increasingly building institutional and personal capacities for planning and management.

However, there is no need to reinvent the wheel, as Pacific Islanders possess centuries of traditional management knowledge. Coupled with scientific approaches and lessons learned, this knowledge can strengthen effective management of the region's rich natural capital.

The maps in this chapter showcase marine management in Solomon Islands that starts at the local level, based on the management of traditional fishing grounds. In addition, Solomon Islands has made strong national commitments to effectively manage its marine resources, which are embedded in regional and international efforts and commitments, such as the Aichi Biodiversity Targets, the United Nations Oceans Conference in support of the 2030 Agenda for Sustainable Development and the Pacific Oceanscape Framework. These management efforts can be effectively supported by marine planning efforts.

To maximize benefits from these marine values for Solomon Islands, national and regional stakeholders are working together to document effective approaches to sustainable marine resource management and conservation. This chapter encourages stakeholders to share tried and tested concepts and instruments more widely throughout the Oceania region.

Further reading, please see **http://macbio-pacific.info/marine-ecosystem-service-valuation/**

SPACE TO RECOVER: MARINE MANAGEMENT

Marine managed and protected areas are key to maintaining Solomon Islands' valuable marine resources. To effectively implement these areas, it is important to combine traditional marine management with national and international efforts.

Taking into account every type and category of protected area globally, only 3.5 per cent of the ocean is currently protected, with only 1.6 per cent strictly or fully protected (see small map). Environmental organizations and scientists recommend that between 20 and 50 per cent of the ocean should be protected. The goal is not to preserve things as they are—even protected areas harbour only a tiny fraction of the biodiversity that once existed—but to allow life to recover.

This is crucial, given the decline of global marine populations (see graphic). For this reason, the world wants to protect at least 10 per cent of coastal and marine areas by 2020, as formulated in an international CBD target (see also chapter "Solomon Islands' commitment to marine conservation"). Indeed, marine managed areas are steadily increasing.

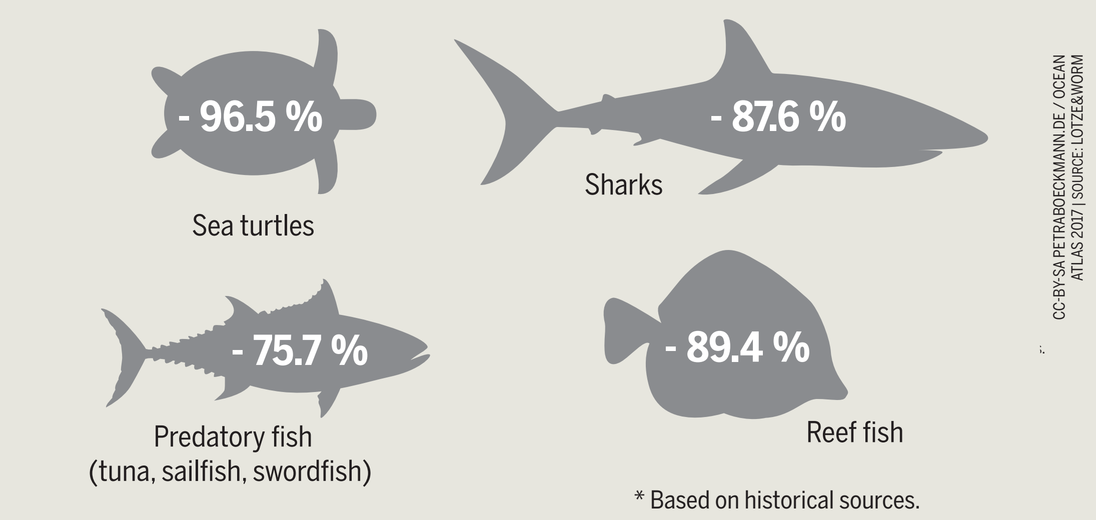
Marine managed areas are areas of the ocean that are managed for specific purposes, which can include protection of biodiversity or sustainable use of the resources. These areas are summarized in the World Database on Protected Areas (WDPA), which is a global compilation of both terrestrial and marine protected areas produced by IUCN and UNEP-WCMC (Protected Planet, 2016). For protected areas to be included in this database, they must align with one of six IUCN protected area management categories, which provide international standards for defining protected areas and encourage conservation planning according to their management aims. Only one of these categories is "no take", and they are often placed at the core of a protected area. However, holistic, sustainable marine management on a large scale is key to conserving the marine values.

Recognizing the role that these areas play in allowing marine life to recover, Solomon Islands has committed to protecting and sustainably managing 10 per cent of its sea (see also chapter "Solomon Islands' commitment to marine conservation") by 2020, using Solomon Islands-specific categories of protection. While this is an ambitious goal, Solomon Islands has a rich tradition of marine management upon which to build. The country has many community marine managed areas which practice traditional management methods. The Ministry of Fisheries and Marine Resources helps these communities develop community fisheries management plans, with a focus on the participation of customary rights holders.

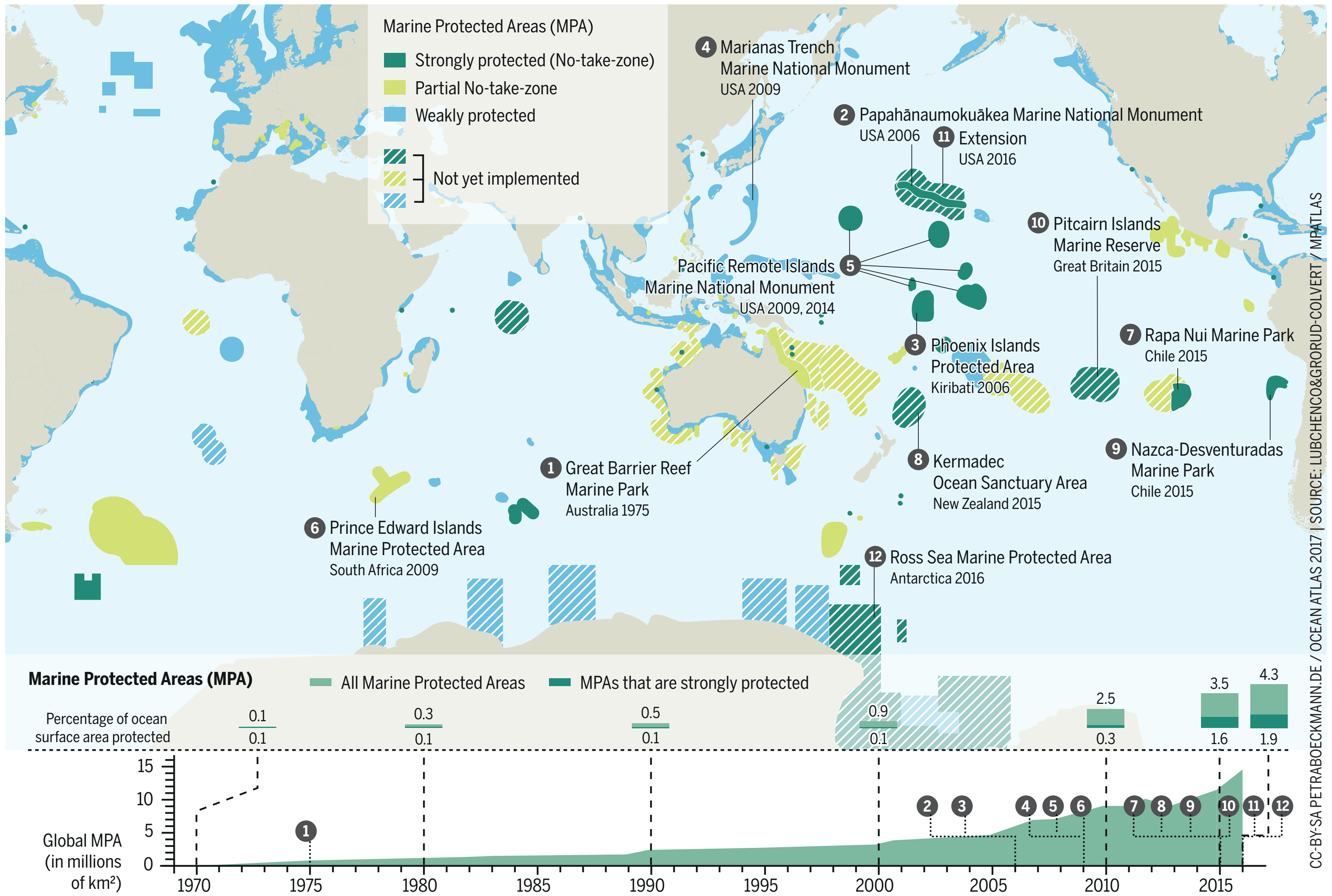
There are more than 80 MPAs in Solomon Islands, 50 of which are shown on the map. These include community conservation, marine conservation, marine protection and tabu (no-fishing) areas, many of which are LMMAs. MPAs and LMMAs can improve human well-being by increasing human resilience to short and long-term threats (thus supporting objectives for community resilience under the National Climate Change Policy) and protecting ecosystems and vulnerable species from ridge to reef, thereby assisting Solomon Islands in meeting its commitments under the CBD.

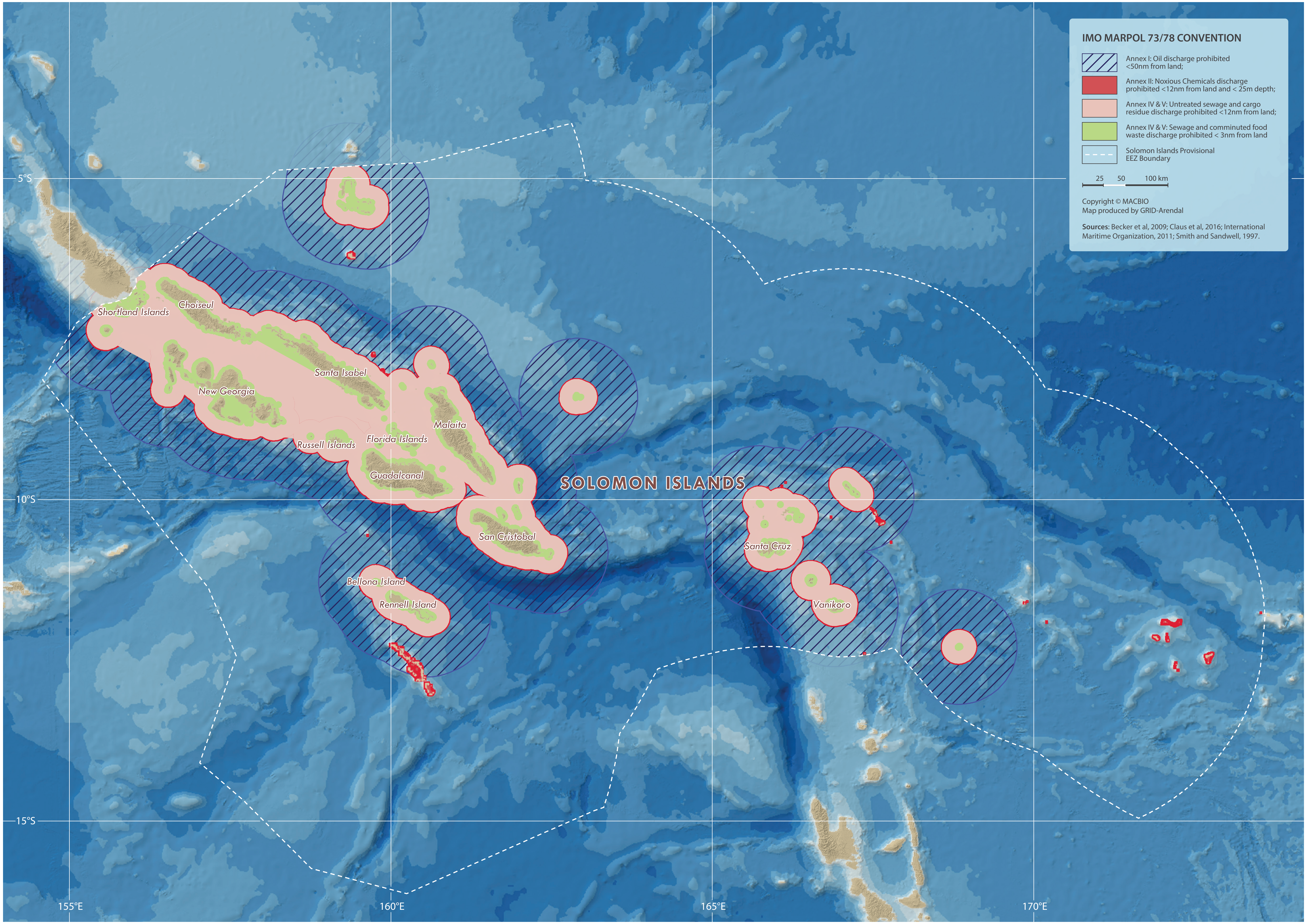
All the MPAs and LMMAs in Solomon Islands are found in the shallow coastal zone, which is the area of greatest human use, from commercial and artisanal fishing to tourism and transport. The marine managed areas in this area contribute to sustainable local livelihoods.

Declining Populations* (Percentage Change)



Marine Protected Areas – Space to Recover





IMO MARPOL 73/78 CONVENTION
Annex I: Oil discharge prohibited <50nm from land;
Annex II: Noxious Chemicals discharge prohibited <12nm from land and < 25m depth;
Annex IV & V: Untreated sewage and cargo residue discharge prohibited <12nm from land;
Annex IV & V: Sewage and comminuted food waste discharge prohibited < 3nm from land
Solomon Islands Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; International Maritime Organization, 2011; Smith and Sandwell, 1997.
SOLOMON ISLANDS
Shortland Islands
Choiseul
Santa Isabel
New Georgia
Malaita
Florida Islands
Russell Islands
Guadalcanal
San Cristobal
Bellona Island
Rennell Island
Santa Cruz
Vanikoro
5°S
10°S
15°S
155°E
160°E
165°E
170°E

ONE WORLD, ONE OCEAN: INTERNATIONAL MARITIME ORGANIZATION (IMO) MARPOL CONVENTION

Solomon Islands' marine values do not stop at national borders. This makes international cooperation increasingly important for effective management of values and their uses, such as mining, fisheries and shipping.

Solomon Islands has sovereign rights over a vast marine area of 680,000 km^2. This area is rich in marine values and managed through various local, national and international instruments (see also chapter "Space to recover"). However, nearly half the Earth is covered by areas of the ocean that lie beyond national jurisdictions. Marine Areas Beyond National Jurisdiction (ABNJ), commonly called the high seas, are those areas of ocean for which no one nation has sole managerial responsibility. In the Pacific and around Solomon Islands (see map "A sea of islands"), there are many high sea pockets that are connected to very important ecosystems and fisheries. Yet, marine species and ecosystems do not abide by the country borders shown on the map, as everything is connected in the ocean (see also chapter "Go with the flow" and "Travellers or homebodies"). Similarly, threats to marine values go beyond national boundaries. Hence, holistic, sustainable and effective marine management calls for appropriate international instruments.

Solomon Islands is therefore part of the international governance structures for the ocean, which follow a multisectoral approach and involve a plethora of organizations (see graphic) dedicated to different uses, be it mining (see also chapter "Underwater Wild West"), fisheries (see also chapter "Fishing in the dark") or shipping (see also chapter "Full speed ahead").

Addressing the latter, the Convention for the Prevention of Pollution from Ships (MARPOL 73/78; see map) is an important international instrument that applies to Solomon Islands' waters. Developed by the IMO in an effort to preserve the marine environment, it attempts to completely eliminate pollution by oil and other harmful substances, to minimize accidental spillages of such substances and to prevent air pollution from ships. The MARPOL 73/78 Convention contains six technical annexes, most of which include Special Areas with strict controls on operational discharges:

- Annex I Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)

  Covers prevention of pollution by oil from operational measures as well as from accidental discharges.

Under invasion

In addition to pollution, international shipping routes pose another threat to Solomon Islands' marine values in the form of invasive species. Since the arrival of humans on the Pacific Islands, they have deliberately brought with them species that are useful for their survival, yet unwanted species have also been accidentally introduced. One of the major vectors for introduced species is the ballast water of ships. Some of the unwanted species get out of control and can cause enormous ecological, economic or health problems. These "invasive" species are also known as "pest" species. In response, the Pacific has developed the Pacific Invasives Partnership (PIP) as a coordinating body for international agencies that provide services to Pacific countries and territories.

- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)

  Details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. No discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)

  Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.

- Annex IV Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)

  Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.

- Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)

  Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the annex is the complete ban imposed on the disposal into the sea of all forms of plastics.

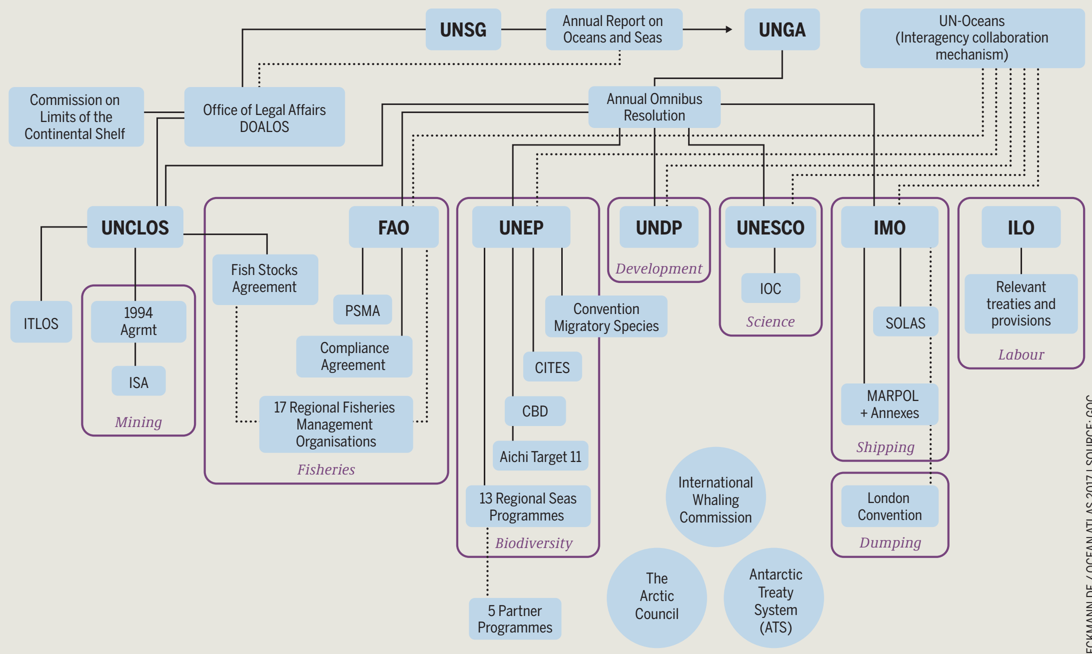
- Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005)

  Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set more stringent standards for SOx, NOx and particulate matter.

In addition, Solomon Islands is in the process of declaring Particularly Sensitive Sea Areas (PSSA), which due to their ecological, socioeconomic or scientific significance, or vulnerability to harm from maritime activities, require special protection from IMO. A PSSA can be protected, for example, by implementing routing measures, which prevent ships from entering the area.

Beyond addressing pollution and invasive species, the Pacific Oceanscape Framework provides orientation at the regional level for sustainable marine management.

International Governance Structures for the Ocean – Multi-sectoral Approach and a Plethora of Organizations



CBD Convention on Biological Diversity; **CITES** The Convention on International Trade in Endangered Species of Wild Fauna and Flora; **DOALOS** Division for Ocean Affairs and the Law of the Sea; **FAO** Food and Agriculture Organization [of the United Nations]; **ILO** International Labour Organization; **IMO** International Maritime Organization; **IOC** Intergovernmental Oceanographic Commission; **ISA** International Seabed Authority; **ITLOS** International Tribunal for the Law of the Sea; **MARPOL** International Convention for the Prevention of Pollution from Ships; **PSMA** Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing; **RFMOs** Regional Fisheries Management Organisations; **SOLAS** International Convention for the Safety of Life at Sea; **UNDP** United Nations Development Programme; **UNEP** United Nations Environment Programme; **UNESCO** United Nations Educational, Scientific and Cultural Organization; **UNGA** United Nations General Assembly; **UNSG** United Nations Secretary-General

SOLOMON ISLANDS' COMMITMENT TO MARINE CONSERVATION

Solomon Islands is committed to sustainably managing and conserving its marine values, so much so that its efforts in this respect extend beyond its international obligation of conserving 10 per cent of its waters by 2020.

Spatial distribution of Solomon Islands' voluntary commitments (VC)

Voluntary Commitment title	ID	Url	Description and focus	Geographical coverage
Improving fisheries management using a Vessel Day Scheme (VDS), Solomon Islands	20314	https://oceanconference.un.org/commitments/?id=20314	To support the framework of the Parties to the Naru Agreement (PNA) by using a Vessel Day Scheme for all Solomon Islands' purse seine fishing vessels fishing within its EEZ and national waters (territorial, archipelagic and EEZ).	Solomon Islands' entire EEZ
Support community-based resource management in Solomon Islands	20324	https://oceanconference.un.org/commitments/?id=20324	To expand the application and use of community-based resource management within Solomon Islands' coastal communities to improve resource conservation, resource management, resilience to climate change and disaster impacts, livelihood and food security.	Solomon Islands' inshore (territorial) waters
Maritime boundaries and zones finalized for Solomon Islands	20299	https://oceanconference.un.org/commitments/?id=20299	To commit to finalizing Solomon Islands' maritime boundaries and zones in order to put the country in an ideal position to secure rights over its ocean space.	Solomon Islands' entire EEZ
Review pollution control component of the Environment Act by 2018	20289	https://oceanconference.un.org/commitments/?id=20289	To commit to reviewing the Environment Act 1998 to ensure a broader and coordinated approach to waste management and marine pollution responses by 2018.	Solomon Islands' inshore (territorial) waters
Integrated National Oceans Policy and Marine Spatial Plan for Solomon Islands	19754	https://oceanconference.un.org/commitments/?id=19754	To develop and implement the following priority policies: Integrated National Oceans Policy and Marine Spatial Plan for Solomon Islands by 2018.	Solomon Islands' entire EEZ

Solomon Islands has long realized the many values it derives from its ocean, and the importance of sustainably managing and planning its uses (see also previous chapter). Thus, in 1995, Solomon Islands joined many other countries in signing and ratifying the international Convention on Biological Diversity (CBD), under which Solomon Islands has accepted international responsibilities and obligations, including Aichi Target 11:

"By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent 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 landscape and seascape."

However, the great importance of its marine resources, Solomon Islands has gone even further. In 2015, the Government of Solomon Islands through the Office of the Prime Minister and Cabinet hosted the inaugural National Ocean Summit. The summit was attended by 12 ministries that have a vested interest in the ocean and its resources.

The summit resulted in a joint communiqué recognizing the critical importance of the goods and services that coastal and marine ecosystems provide in Solomon Islands, as well as overlaps and gaps in marine resource use and management. All ministries pledged their commitment to combine efforts and resources in order to work jointly towards better management and sustainable use of national marine resources.

This shows that Solomon Islands is committed to sustainably managing and conserving its marine values. In this spirit, Solomon Islands submitted five Voluntary Commitments to the United Nations Ocean Conference in June 2017. One of these Voluntary Commitments highlighted Solomon Islands' need to establish an integrated National Ocean Policy that will guide its efforts to maximize benefits from its ocean and continue managing its ocean resources. The other Voluntary Commitments emphasized the need to strengthen national efforts to implement community-based resource management approaches for inshore marine resources, establish a Vessel Day Scheme and finalize national maritime boundaries to ensure security and rights over Solomon Islands' ocean resources.

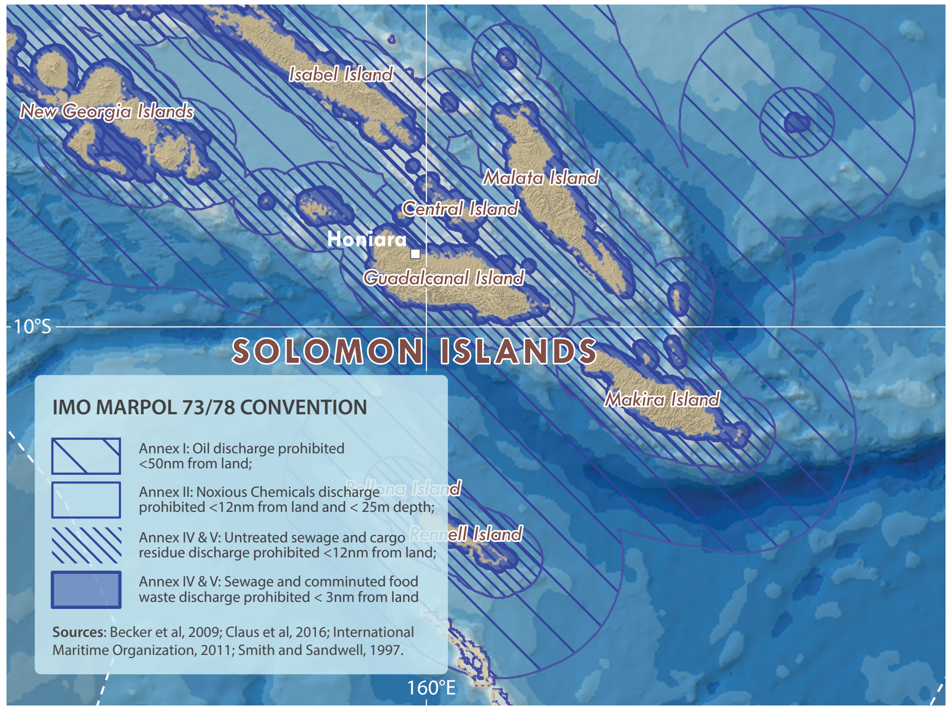
"The Ocean Conference has changed our relationship with the ocean. Henceforth none can say they were not aware of the harm humanity has done to the ocean's health. We are now working around the world to restore a relationship of balance and respect towards the ocean" said the President of the United Nations General Assembly Peter Thomson, from Fiji, at the closing of the United Nations Ocean Conference.

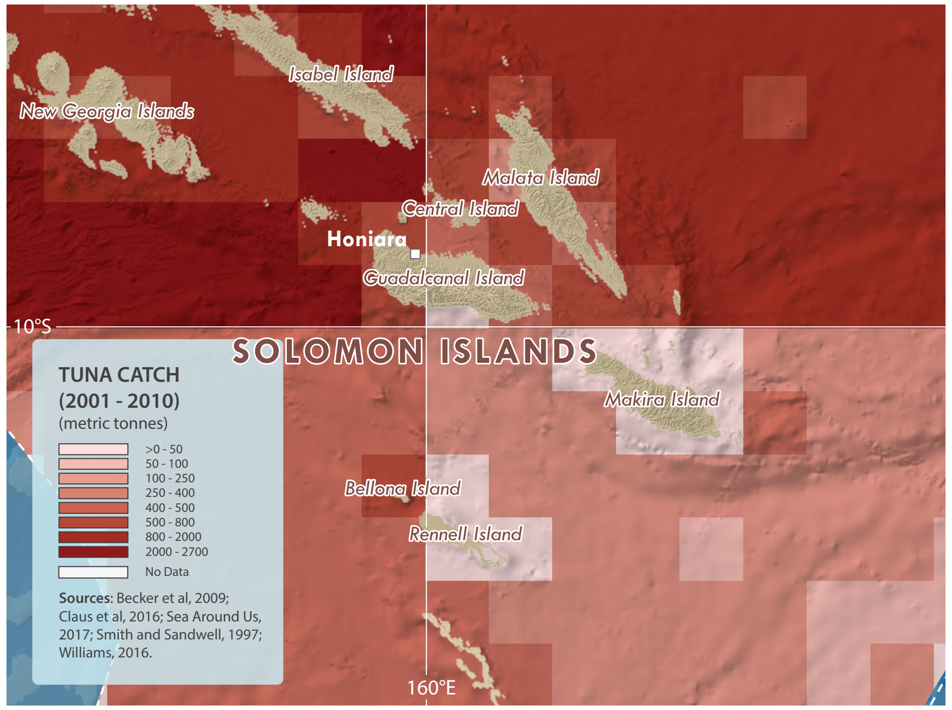
The 193 Member States of the United Nations unanimously agreed to a set of measures that aim to reverse the decline of the ocean's health. The "Call for Action" outcome document, together with more than 1,300 commitments to action, marks a breakthrough in the global approach to the management and conservation of the ocean. Recognizing that the well-being of present and future generations is inextricably linked to the health and productivity of the ocean, countries collectively agreed in the Call to Action "to act decisively and urgently, convinced that our collective action will make a meaningful difference to our people, to our planet and to our prosperity."

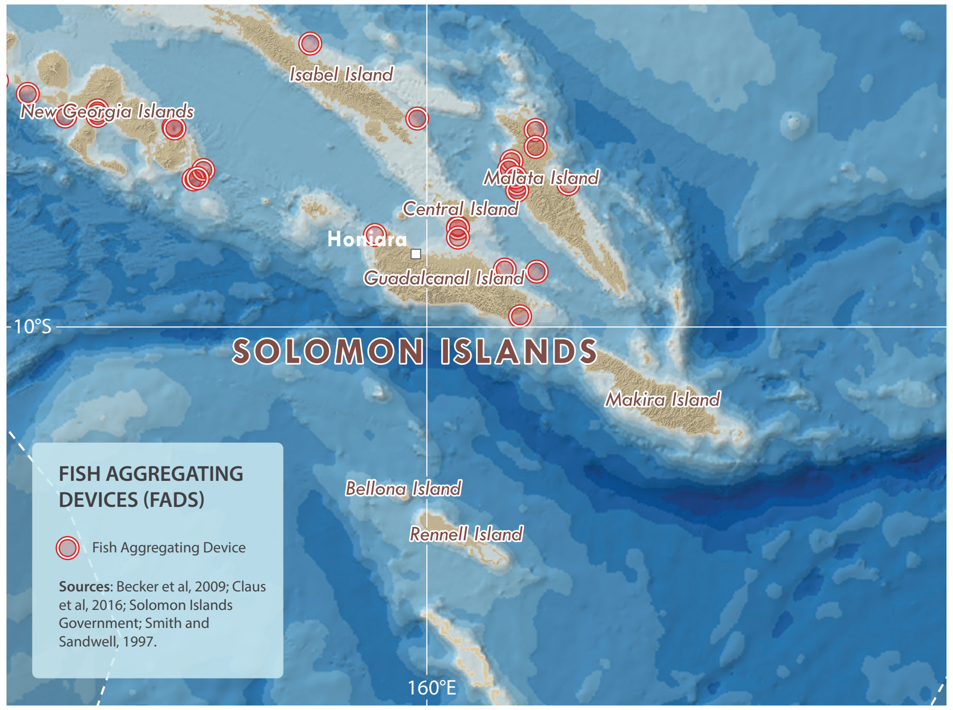
The second highest number of commitments comes from the South Pacific, highlighting not only the importance of the ocean to Pacific Island countries, but also their commitment to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (SDG14).

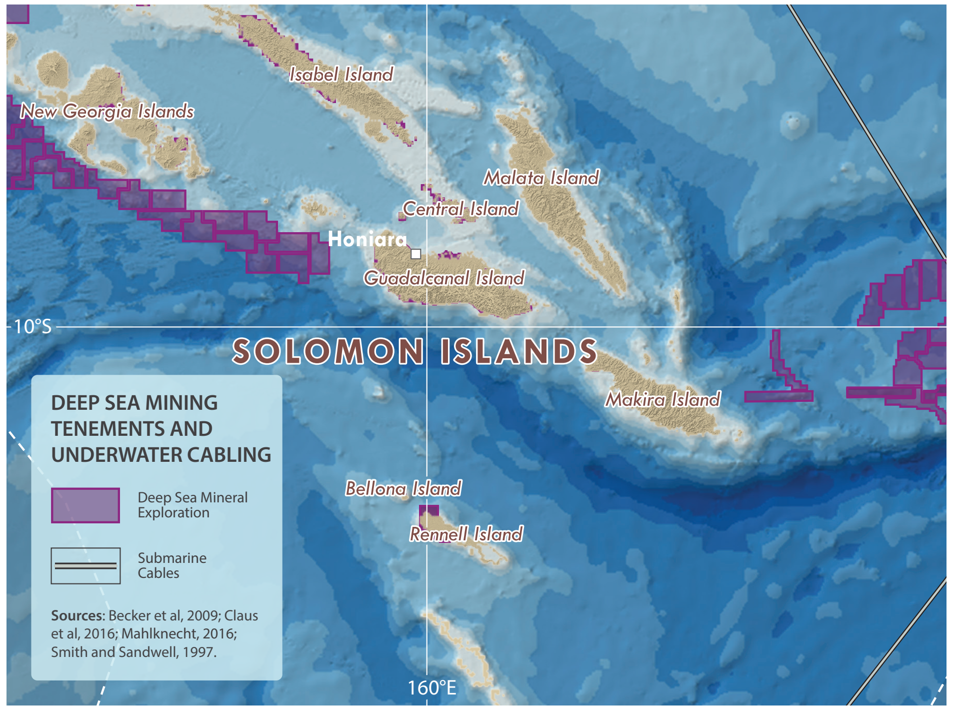
Solomon Islands is calling for action to conserve valuable life below the surface, within its own waters and beyond.

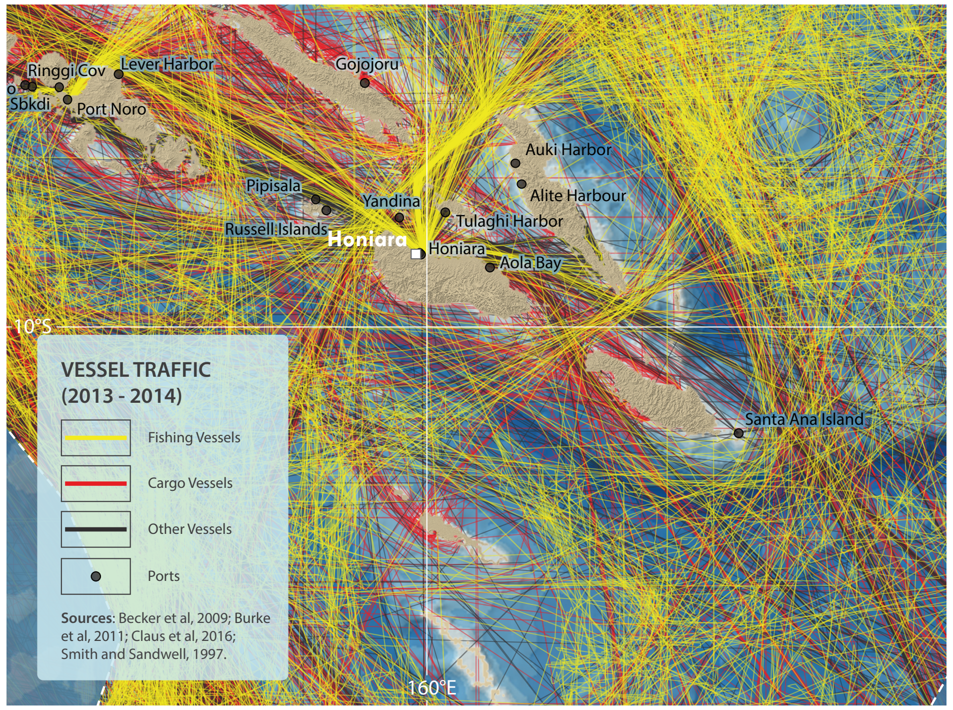
A MARINE LAYER CAKE

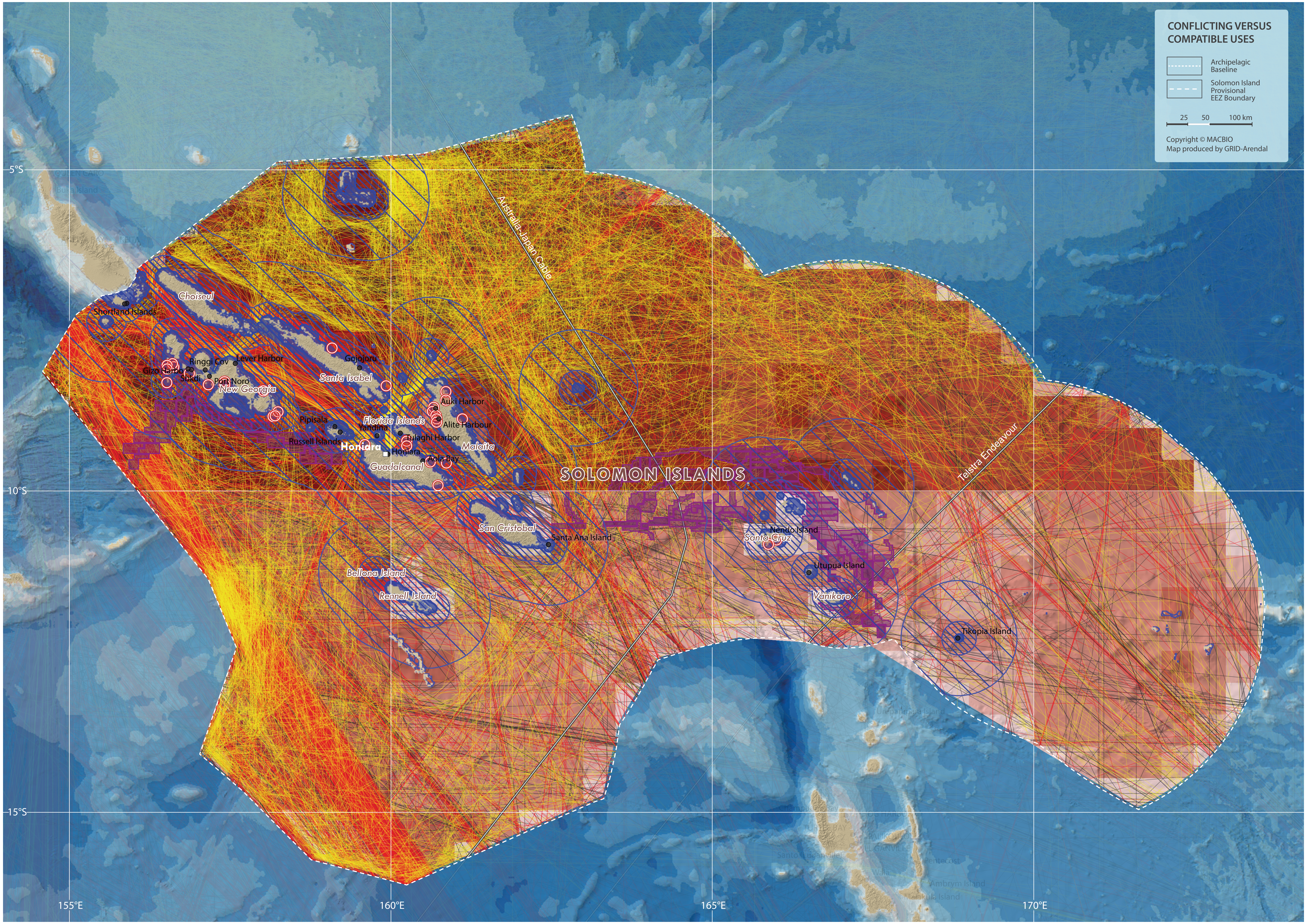












CONFLICTING VERSUS COMPATIBLE USES
Archipelagic Baseline
Solomon Island Provisional EEZ Boundary
25 50 100 km
Copyright © MACBIO
Map produced by GRID-Arendal
SOLOMON ISLANDS
Choiseul
Shortland Islands
Santa Isabel
New Georgia
Florida Islands
Malaita
Guadalcanal
Honiara
San Cristobal
Santa Ana Island
Bellona Island
Rennell Island
Russell Islands
Pipisala
Ringgi Cov
Lever Harbor
Gizo Harbor
Noro
Goijoru
Auki Harbor
Alite Harbour
Tulaghi Harbor
Aola Bay
Nendo Island
Santa Cruz
Utupua Island
Vanikoro
Tikopia Island
Australia-Japan Cable
Telstra Endeavour
5°S
10°S
15°S
155°E
160°E
165°E
170°E

CONFLICTING VERSUS COMPATIBLE USES

In an increasingly crowded seascape, MSP helps avoid conflict and maximize benefit between overlapping uses.

The six map close-ups on vessel traffic (see also chapter "Full speed ahead"), mining (see also chapter "Underwater Wild West"), fisheries (see also chapter "Fishing in the dark") and management (see also chapter "Space to recover") show snapshots of the many marine uses detailed in the previous chapters. On its own, each looks manageable. However, zooming out and looking at the big picture of all uses, it is clear that many overlap. Some of these may be complementary, such as conservation and tourism, while other uses impact each other and may lead to conflicts, such as pollution from shipping in an important fishery, or deep-sea mining on a biologically diverse seamount.

How can Solomon Islands address these conflicts?

Marine Spatial Planning (see text box) holds the key to sharing marine uses fairly, and one of the key tools used to implement MSP is a zoning plan. This is a tool that divides the ocean into zones, where each zone includes different activities that are or are not permitted.

The main purpose of a zoning plan (Ehler and Douvere, 2009) is to:

- separate conflicting human activities or to combine compatible human activities

Marine Spatial Planning

Marine Spatial Planning (MSP) is an intersectoral and participatory planning process and tool that seeks to balance ecological, economic, and social objectives, aiming for sustainable marine resource use and prosperous blue economies.

What is Marine Spatial Planning?

Marine Spatial Planning provides us with a framework and consultative process to gain a better understanding of how marine areas are used and valued by different groups of people to facilitate informed planning and decision-making.

How can the Pacific benefit?

Marine Spatial Planning allows for effective stakeholder discussion and negotiation on how marine and coastal spaces can be used more effectively and sustainably.

This directly assists Pacific island countries and territories in achieving sustainable economic development and environmental objectives.

Importantly, the approach ensures that Pacific island countries and territories are able to balance social, cultural, environmental, economic and political objectives in a sustainable way.

This can help to prevent future conflict over resources and achieve Multilateral Environmental Agreement obligations, such as the Aichi Targets laid out under the Convention on Biological Diversity. The strategic importance of integrated ocean management and Marine Spatial Planning is outlined in the Framework for a Pacific Oceanscape - a Forum Leaders' endorsed plan for implementing marine management in the Pacific Ocean.

How does it work?

From local shorelines to the high seas, maps with areas for different uses are developed through incorporation of scientific, social and traditional knowledge along with environmental and sustainable economic development priorities. This is achieved through a consultative process called Marine Spatial Planning (see examples overleaf).

This process creates a mechanism for engagement and discussion between country national representatives, relevant agencies, communities, all resource users and owners and other stakeholders.

Local capacity is built and expert support provided so that data collected can be effectively analysed. Pacific island countries and territories can then use this crucial information to move towards sustainable development of natural resources, develop Marine Protected Area networks and facilitate effective management and monitoring.

Can we do it?

Marine Spatial Planning does not necessarily require a big budget, but it does require effective engagement, cross-sector access to data, and the participation of all decision-makers and resource users to be successful.

How do we get started?

A number of initiatives have been established to support Pacific island countries and territories to better manage their marine resources using tools such as Marine Spatial Planning. These include the following projects:

PACIOCEA Pacific Ocean Ecosystem Analysis contact: paciocea@aires-marines.fr

MACBIO Marine and Coastal Biodiversity Management in Pacific Island Countries contact: jan.steffen@giz.de

Australian Aid Enhancing Pacific Ocean Governance contact: epog@environment.gov.au

Project partners: SPREP, giz, European Union, Australian Aid, IUCN, Agence des aires marines protégées

For more information, please contact: msp@sprep.org

SPREP - Secretariat of the Pacific Regional Environment Programme

PO Box 240, Apia, Samoa Tel: +685 21929 Fax: +685 20231

Our Vision: The Pacific environment, sustaining our livelihoods and natural heritage in harmony with our cultures

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Marine Spatial Planning

- Integrating planning for sustainable resource use
- Achieving sustainable economic development and environmental objectives

- protect the natural values of the marine management area while allowing reasonable human uses of the area
- allocate areas for reasonable human uses while minimizing the effects of these human uses on each other and nature
- provide protection for biologically and ecologically important habitats, ecosystems, and ecological processes and
- preserve some areas of the marine managed area in their natural state, undisturbed by humans except for scientific or educational purposes

There is no need to reinvent the wheel, as zoning of Solomon Islands' waters is not a new concept. For example, the Fisheries Management Act 2015 recognizes the need to establish MPAs for fishing management objectives. Solomon Islands already has a large number of different types of zones—although they may not be called zones. These include shipping lanes, IMO regulations regarding pollution at sea (see also chapter "One world, one ocean"), fisheries closures, and marine protected or managed areas, including LMMAs (see also chapter "Space to recover"). Each of these different zones stipulate different areas within which particular activities are permitted or not permitted.

In the past, however, these zones have been largely designated within single sectors, with little consideration of other human uses in the same area. Instead, a zoning plan that is derived through comprehensive MSP process takes into account how human uses impact each other and the environment. MSP can occur at a site level (such as a bay), across an entire marine managed area, within an EEZ, or between neighbouring countries (transboundary). It should aim to achieve clear ecological, economic and social goals and objectives.

Each marine zone should have an assigned objective that permits a range of activities to occur, provided that each activity complies with the relevant zone objective. All zones should contribute to the overall goals and objectives of the Marine Spatial Plan. For example, if the objective of a zone is to protect the sea floor habitat, then activities such as trawling, mining or dredging should not be permitted, while other zones where the objective is to allow for a broad range of industrial uses may allow industrial tuna, shipping or even mining to occur.

Preparing a zoning plan is not an easy task, and is best achieved through considerable consultation, including across government departments at all levels, users, other stakeholders and the community. Zoning plans must accommodate and balance the cultural, economic, social and biological needs of the community.

MPAs are primarily established to meet biodiversity objectives, but can also have sociocultural and economic objectives that are consistent with national, regional and local needs. To meet these different objectives, MPAs can contain one or more zones to provide for different levels of protection.

The IUCN Protected Area Categories classify protected areas according to their management objectives. The categories are recognized by international bodies, such as the United Nations, and by many national governments as the global standard for defining and recording protected areas, and as such are increasingly being incorporated into government legislation.

However, the process of aligning standardized categories to individual MPAs is not an easy one and not without a degree of controversy. For example, protected areas that are culturally appropriate for Solomon Islands may not always fit neatly into any one of the seven IUCN categories. If they are to be applied effectively, therefore, any categories used by a nation must be interpreted and adapted to meet the country's biophysical, sociocultural and economic needs.

This is a very promising way to share and manage Solomon Islands' rich and complex marine environment in a fair and sustainable manner, while maximizing benefits.

CONCLUSION

Solomon Islands' vast ocean is blessed with a myriad of valuable marine resources. The Government of Solomon Islands is strongly committed to successfully conserving and managing these resources through holistic planning and effective management, which will enable the country to maximize the resources' benefits.

Through identifying, planning and managing the values and benefits of its coastal and marine systems, Solomon Islands can achieve its vision for "a healthy, secure, clean and productive ocean which benefits the people of the Solomon Islands and beyond". As part of its integrated ocean governance, Solomon Islands is aiming to develop a national Marine Spatial Plan using a participatory and inclusive approach to ensure nationwide ownership of the final plan. Stakeholders throughout the Solomon Islands are therefore working together to achieve a healthy, resilient and biodiverse ocean for all.

We thank everyone who participated in meetings regarding this atlas and who, through their involvement, contributed input, guidance, data and/or information to this atlas and identified its utility to policy and decision-making (see list of data providers listed in the References).

In particular we thank the Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology and the Ministry of Fisheries and Marine Resources, Solomon Islands Bureau of Statistics and other relevant ministries for providing data and support to the project.

Solomon Islands' work on integrated ocean governance has been guided by the Ocean12 and the Ocean12 Technical Working Group of the Government of Solomon Islands, with particular support from the committee's chairs: the Ministry of Fisheries and Marine Resources, the Ministry of Environment, Climate Change, Disaster Management and Meteorology and the Office of the Prime Minister and Cabinet.

We are grateful for the contributions of text and graphical elements from the Ocean Atlas 2017 of the Heinrich Böll Foundation to this atlas.

We also thank the professionals of the MACBIO team, in alphabetical order, Riibeta Abeta, Jasha Dehm, Marian Gauna, Jimaima Le Grand, Vatu Molisa, Eileen Motua, Jan Steffen, Jonah Sullivan and Naushad Yakub for their support, as well as the GRID-Arendal team: Kaja Lønne Fjærtoft, Georgios Fylakis, Elsa Lindeval, Petter Sevaldsen and Janet Fernandez Skaalvik.

While the atlas provides the best data currently publicly available, the information about Solomon Islands' waters is constantly increasing. In this way, the atlas is an open invitation to use, modify, combine and update the maps and underlying data.

The e-copy and interactive version of the Solomon Islands Marine Atlas are available here: **http://macbio-pacific.info/marine-atlas**

Timeline of the Solomon Islands Marine Spatial Planning Process

2015

The Government of Solomon Islands through the Office of the Prime Minister and Cabinet hosted the inaugural Ocean Summit. The summit was attended by 12 ministries with a vested interest in the ocean and its living and non-living resources.

2016

The Ministry of Fisheries and Marine Resources submitted a Cabinet paper based on the communiqué arising from the Ocean Summit, proposing the establishment of the Ocean12 and the Ocean12 TWG to progress outcomes of the communiqué.

The Cabinet endorsed the formal establishment of the Ocean12 Steering Committee, now referred to as the Ocean12, co-chaired by the Ministry of Fisheries and Marine Resources and the Ministry of Environment, Climate Change, Disaster Management and Meteorology. The Ocean12 comprises permanent secretaries representing the 12 ministries that were present at the inaugural Ocean Summit.

Four months later, the Ocean12 convened its first meeting. Key outcomes included:

- The establishment of the Ocean12 TWG, tasked with carrying out actions under the guidance of the Ocean12. The TWG comprises technical officials from the 12 ministries.
- An interministerial commitment to promote and implement integrated ocean governance.

2017

During three meetings held by the Ocean12 TWG, the terms of reference were specified, a national approach to integrated ocean governance was developed, and 11 key aspects of integrated ocean governance were identified. Five key aspects were prioritized: the joint formulation of a National Ocean Policy, the use of a participatory Marine Spatial Planning process, and the resulting adaptation of national legislation, capacity-building and sustainable financing efforts.

The Ocean12 TWG supported the Solomon Islands delegation to the United Nations Oceans Conference, along with the country's submission of its Voluntary Commitments focused on establishing a National Ocean Policy and Marine Spatial Plan by 2020.

2018

The Ocean12 chairs (Ministry of Fisheries and Marine Resources and Ministry of Environment, Climate Change, Disaster Management and Meteorology) endorsed the identified priorities for integrated ocean government as identified by the Ocean12 TWG and committed to formulating and launching a National Ocean Policy by the end of 2018.

2015–2018

The regional MACBIO project supported the country's integrated ocean governance efforts through a review of relevant legislation and a national valuation of marine ecosystem services. MACBIO assisted the Ocean12 and its Technical Working Group in their efforts to identify SUMAs, potential ocean zones, a national consultation strategy and marine bioregions for Solomon Islands.

REFERENCES

All maps contain the following data layers:

Becker, J. J., Sandwell, D. T., Smith, W. H. F., Braud, J., Binder, B. J. Depner, D. Fabre, J. Factor, S. Ingalls, S-H. Kim, R. Ladner, K. Marks, S. Nelson, A. Pharaoh, Sharman, G., Trimmer, R., vonRosenburg, J., Wallace, G., and Weatherall, P. (2009). Global Bathymetry and Elevation Data at 30 Arc Seconds Resolution: SRTM30_PLUS, Marine Geodesy, 32:4, 355-371.

Claus S., N. De Hauwere, B. Vanhoorne, F. Souza Dias, P. Oset García, F. Hernandez, and J. Mees (Flanders Marine Institute) (2016). Accessed at http://www.marineregions.org on 2016-10-21.

Smith, W. H. F., and Sandwell, D. T. (1997). Global seafloor topography from satellite altimetry and ship depth soundings, Science, v. 277, p. 1957-1962.

Sources for maps and narratives containing additional data are available below:

A Large Ocean State: Administration

MAP

Natural Earth. (2017). "Populated Places." Accessed at: www.naturalearthdata.com.

TEXT

CIA (2017) "Solomon Islands". The World Factbook. CIA. Accessed at:
https://www.cia.gov/library/publications/the-world-factbook/geos/bp.html

VALUING

Still Waters Run Deep: Ocean Depth

MAP

IHO-IOC GEBCO. (2017). "Gazetteer of Undersea Feature Names". Accessed at www.gebco.net.

Voyage To The Bottom Of The Sea: Geomorphology

MAP

Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K. (2014). Geomorphology of the oceans. Marine Geology, 352: 4-24.

Under Water Mountains: Seamount Morphology

MAP

Macmillan-Lawler, M. and Harris, P.T. (2016) Chapter 17: Multivariate Classification of Seamount Morphology: Assessing Seamount Morphotypes in Relation to Marine Jurisdictions and Bioregions in Ocean Solutions – Earth Solutions, Editor Wright, D.J. ESRI Press.

IHO-IOC GEBCO. (2017). "Gazetteer of Undersea Feature Names". Accessed at www.gebco.net.

TEXT

Clark, M.R. et al., (2010). The ecology of seamounts: structure, function, and human impacts. Annual review of marine science, 2, pp.253–278.

Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K. (2014). Geomorphology of the oceans. Marine Geology, 352: 4-24.

Macmillan-Lawler, M. and Harris, P.T. (2015). Chapter 17: Multivariate Classification of Seamount orphology: Assessing Seamount Morphotypes in Relation to Marine Jurisdictions and Bioregions. p329 – 356. In Ocean Solutions, Earth Solutions, second edition. Editor: Wright, D. ESRI Press.

Rex, M.A., Etter, R.J., Clain, A.J., et al. (1999). Bathymetric patterns of body size in deep-sea gastropods.
Evolution 53, 1298–1301.

Smoke Under Water, Fire In The Sea: Tectonic Activity

MAP

Beaulieu, S.E. (2015). InterRidge Global Database of Active Submarine Hydrothermal Vent Fields: prepared for InterRidge, Version 3.3. World Wide Web electronic publication. Version 3.4. Accessed at http://vents-data.interridge.org on 2017-01-13.

Earthquake Hazards Program. (2017). Earthquake epicenters 1980-2016. U.S. Geological Survey. Accessed at http://earthquake.usgs.gov/earthquakes/search/ on 14 Feb 2017.

Global Volcanism Program. (2013). Volcanoes of the World, v. 4.5.3. Venzke, E (ed.). Smithsonian Institution. Accessed at http://dx.doi.org/10.5479/si.GVP.VOTW4-2013.

IHO-IOC GEBCO. (2017). "Gazetteer of Undersea Feature Names". Accessed at www.gebco.net.

TEXT

Petterson, M. G. et al. (1999). "Geological-tectonic framework of Solomon Islands, SW Pacific: crustal accretion and growth within an intra-oceanic setting." Tectonophysics 301. pp.35–60.

Go With The Flow: Salinity and Surface Currents

MAPS

ESR. (2009). OSCAR third degree resolution ocean surface currents. Ver. 1. PO. DAAC, CA, USA. Accessed [2017-01-13] at http://dx.doi.org/10.5067/OSCAR-03D01 on 2017-01-13.

Tyberghein L., Verbruggen H., Pauly K., Troupin C., Mineur F. & De Clerck O. (2012). "Bio-ORACLE: a global environmental dataset for marine species distribution modeling." Global Ecology and Biogeography.

TEXT

Cai, W., Borlace, S., Lengaigne, M., Van Rensch, P., Collins, M., Vecchi, G., Timmermann, A., Santoso, A., McPhaden, M. J., Wu, L., England, M. H., Wang, G., Guilyardi, E. and Jin, F. (2014). "Increasing frequency of extreme El Nino events due to greenhouse warming." Nature Climate Change. Accessed at https://www.nature.com/articles/nclimate2100.epdf.

Climate Prediction Center. (2005). "Frequently Asked Questions about El Niño and La Niña". National Centers for Environmental Prediction. Retrieved 17 July 2009.

Gogina, M. & Zettler, M.L. (2010) Diversity and distribution of benthic macrofauna in the Baltic Sea. Data inventory and its use for species distribution modelling and prediction. Journal of Sea Research, 64, 313–321.

Kessler, W.S. and Gourdeau, L., (2006). Wind-driven zonal jets in the South Pacific Ocean. Geophysical Research Letters, 33(3).

Lüning, K. (1990) Seaweeds: their environment, biogeography, and ecophysiology. John Wiley and Sons, New York.

Rahmstorf, S. (2003). "The concept of the thermohaline circulation". Nature. 421 (6924): 699.

Webb, D. (2000). "Evidence for shallow zonal jets in the South Equatorial Current region of the southwest Pacific". J. Phys. Oceanogr., 30, 706–720.

Stir It Up: Mixed Layer Depth

MAP

Scott A. Condie and Jeff R. Dunn (2006). Seasonal characteristics of the surface mixed layer in the Australasian region: implications for primary production regimes and biogeography. Marine and Freshwater Research, 2006, 57, 1-22.

TEXT

Jeffrey, S.W., and Hallegraeff, G. M. (1990). "Phytoplankton ecology of Australian waters". Biology of Marine Plants. pp. 310–348.

Pump It: Particulate Organic Carbon Flux

MAP

Lutz, M., Caldeira, K., Dunbar, R. and Behrenfeld, M. (2007). Seasonal rhythms of net primary production and particulate organic carbon flux to depth describe the efficiency of biological pump in the global ocean. Journal of Geophysical Research, 112 (C10).

TEXT

Higgs, N. D.; Gates, A. R.; Jones, D. O. B.; Valentine, J. F. (2014). "Fish Food in the Deep Sea: Revisiting the Role of Large Food-Falls". PLOS ONE. 9 (5): e96016.

Pascal N. (2015). "Economic valuation of marine and coastal ecosystem services : ecosystem service of coastal protection — Fiji, Kiribati, Tonga, Vanuatu and the Solomon Islands." Report to the MACBIO project. GIZ/IUCN/SPREP, Suva, Fiji.

Russo, J. Z. (2004). "This Whale's (After) Life". NOAA's Undersea Research Program. NOAA. Retrieved 13 November 2010.

Suess, E. (1980). Particulate organic carbon flux in the oceans—surface productivity and oxygen utilization. Nature 288, 260 – 263.

Soak Up The Sun: Photosynthetically Available Radiation

MAPS

NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. (2014). "Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Photosynthetically Available Radiation Data" NASA OB.DAAC.

TEXT

Dupouy, C., Dirberg, G., Tenório, M. Jacques, N., Le Bouteiller, A. (2004). "Surveillance des Trichodesmium autour de la Nouvelle-Calédonie, du Vanuatu, de Fidji et de Tonga (1998-2004)."

Fabricius, K.E. (2005). "Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis". Mar Pollut Bull. 50, 125 – 146.

Solomon Islands Meteorological Service. (2016). Accessed at http://www.met.gov.sb/.

Matear, R. J. and B. Elliott. (2004). "Enhancement of oceanic uptake of anthropogenic CO_2 by macronutrient fertilization". J. Geophys. Res. 109 (C4): C04001.

Home, Sweet Home: Coastal Habitats

MAP

Andréfouët, S., F. E. Muller-Karger, J. A. Robinson, C. J. Kranenburg, D. Torres-Pulliza, S. A. Spraggins, and B. Murch. (2005). "Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space." 10th International Coral Reef Symposium. Japanese Coral Reef Society, Okinawa, Japan.

Natural Earth. (2017). Populated Places. Accessed at: www.naturalearthdata.com.

Spalding M.D., Blasco F. and Field C.D. (1997). "World Mangrove Atlas". Okinawa (Japan): International Society for Mangrove Ecosystems. 178 pp. Compiled by UNEP-WCMC, in collaboration with the International Society for Mangrove Ecosystems (ISME). (version 3).

TEXT

Arena M, Wini L, Salcone J, Leport G, Pascal N, Fernandes L, Brander L, Wendt H, Seidl A. (2015). "National Marine Ecosystem Service Valuation: Solomon Islands." MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 86 pp.

Bani, E & Esrom, D. (1993). 'Republic of Vanuatu', In Scott, DA, IUCN Directory of Wetlands in Oceania, Ramsar Bureau, International Waterfowl and Wetlands Research Bureau (IWRB), Asian Wetland Bureau (AWB) and the South Pacific Regional Environment Programme (SPREP).

Pascal N. (2015). "Economic valuation of marine and coastal ecosystem services: ecosystem service of coastal protection — Fiji, Kiribati, Tonga, Vanuatu and the Solomon Islands."

Report to the MACBIO project. GIZ/IUCN/SPREP, Suva, Fiji.
The Nature Conservancy (TNC). (2004). “Solomon Islands Marine Assessment Key Findings.” Accessed at: http://www.seagrasswatch.org/Monitoring_reports/Solomons/solomons_key_findings.pdf
Warren-Rhodes, K., Schwarz, A., Boyle, L., Albert, J., Agalo, S., Warren, R., Bana, A., Paul, C., Kodosiku, R., Bosam, W., Yee, D., Ronnback, P., Crona, B., and Duke, N. (2011). “Mangrove ecosystem services and the potential for carbon revenue programmes in Solomon Islands.” Environmental Conservation 38(4), 485-496.

Shaping Pacific Islands: Coral Reefs

MAPS

Copernicus Sentinel 2 Data. (2018). Accessed at: https://remotepixel.ca/

TEXT

Morris, C., and Mackay, K. (EDs). (2008). “Status of the Coral Reefs in the South West Pacific: Fiji, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu.” In Status of Coral Reefs of the World: 2008, Edited by Clive Wilkinson. Pages 177 - 188.
Spalding, M., Ravilious, C., and Green, E. (2001). “World Atlas of Coral Reefs. Berkeley, CA: University of California Press and UNEP/WCMC ISBN 0520232550.
Sulu, Reuben & C, Hay & Ramohia, P & Lam, M. (2003). “The status of Solomon Islands coral reefs.in Coral Reefs in the Pacific: Status and monitoring, Resources and management.” IRD. pages 249 - 302.

Travellers or Homebodies: Marine Species Richness

MAPS

Kaschner, K., K. Kesner-Reyes, C. Garilao, J. Rius-Barile, T. Rees, and R. Froese. (2016). “AquaMaps: Predicted range maps for aquatic species.” version 08/2016. Accessed at www.aquamaps.org.

TEXT

Garrigue, C., Clapham, P. J., Geyer, Y., Kennedy, A. S., & Zerbini, A. N. (2015). “Satellite tracking reveals novel migratory patterns and the importance of seamounts for endangered South Pacific humpback whales.” Royal Society Open Science, 2(11).
Sutton, T.T., Porteiro, F., Anderson, C.I.H., and Bergstad, O.A. (2010). “Deep-pelagic fish interactions with seamounts and mid-ocean ridges.” Proceedings of an International Symposium - Into the Unknown, Researching Mysterious Deep-Sea Animals. February 2007, Okinawa, Japan.

How much Do We Really Know? Cold Water Coral Habitats

MAP

Yesson, C., Taylor, M. L., Tittensor, D. P., Davies, A. J., Guinotte, J., Baco, A., Black, J., Hall-Spencer, J. M. and Rogers, A. D. (2012). “Global habitat suitability of cold-water octocorals.” Journal of Biogeography, 39: 1278–1292.

TEXT

Davies A.J., Guinotte J.M. (2011). “Global habitat suitability for framework-forming cold-water corals”. PLoS ONE 6.
FAO. (2009). “Management of Deep-Sea Fisheries in the High Seas.” FAO, Rome, Italy.
Roberts, J.M., Wheeler, A.J., Freiwald, A., Cairns, S.D. (2009). “Cold-water corals: the biology and geology of deep-sea coral habitats”. Cambridge University Press, Cambridge UK. 334 p.
Sandwell, D. T., Müller, R. D., Smith, H. F., Garcia, E., Francis, R. (2014). “New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure”. Science 345, 65–67 (2014). http://science.sciencemag.org/content/346/6205/65.
Yesson, C., Taylor, M. L., Tittensor, D. P., Davies, A. J., Guinotte, J., Baco, A., Black, J., Hall-Spencer, J. M. and Rogers, A. D. (2012). “Global habitat suitability of cold-water octocorals.” Journal of Biogeography, 39: 1278–1292.

Nature’s Hotspots: Key Biodiversity Areas

MAP

The Convention on Biological Diversity (CBD). (2016). “Ecologically or Biologically Significant Marine Areas.”

TEXT

BirdLife International. (2018a). “The World Database of Key Biodiversity Areas.” Developed by the Key Biodiversity Areas Partnership. Accessed at: http://www.keybiodiversityareas.org
Birdlife International. (2018b). Marine IBA e-atlas. Accessed at: “https://maps.birdlife.org/marineIBAs/default.html”
Convention on Biological Diversity (CBD). (2012). “Report of the western South Pacific regional workshop to facilitate the description of Ecologically or Biologically Significant Marine Areas.” UNEP/CBD/SBSTTA/16/INF/6.

Special and Unique Marine Areas

MAPS

Sykes H., LeGrand J., Davey K., Fernandes L., Mangubhai S., Yakub N., Wendt H., Kirmani S., Gauna M. (in prep) “Special, unique marine areas of Solomon Islands.” GIZ, IUCN, SPREP: Suva.

TEXT

Daniela M. Ceccarelli, Lysa Wini-Simeon, Jonah Sullivan, Anja Hokamp, Hans Wendt, Leanne Fernandes. (2018). “Special, unique marine areas of Solomon Islands.” GIZ, IUCN, SPREP: Suva.

Beyond the Hotspots: Bioregions

MAP

Wendt H., Beger M., Sullivan J., LeGrand J., Davey K., Yakub N., Fernandes L. (2018). “Draft preliminary marine bioregions of the Southwest Pacific.” GIZ, IUCN, SPREP: Suva.

TEXT

Wendt H., Beger M., Sullivan J., LeGrand J., Davey K., Yakub N., Fernandes L. (2018). “Draft preliminary marine bioregions of the Southwest Pacific.” GIZ, IUCN, SPREP: Suva.

PLANNING

Fishing In The Dark: Offshore Fisheries

MAPS

Pauly D. and Zeller D. (2016). “Sea Around Us Concepts, Design and Data”. Accessed at www.seaaroundus.org
Williams, P. (2016). “Tuna Fishery Yearbook 2015.” Western and Central Pacific Fisheries Commission. Accessed at: https://www.wcpfc.int/system/files/YB_2015.pdf on 13 Jan. 2017

TEXT

Arena M, Wini L, Salcone J, Leport G, Pascal N, Fernandes L, Brander L, Wendt H, Seidl A. (2015). “National Marine Ecosystem Service Valuation: Solomon Islands.” MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 86 pp.
Clark, M., Horn, P., Tracey, D., Hoyle, S., Goetz, K., Pinkerton, M., Sutton, P., Paul, V. (2017). “Assessment of the potential impacts of deep seabed mining on Pacific Island fisheries. Pacific Community.” Suva. 90 p.
Dalzell, P., Preston, G.L. (1992). “Deep reef slope fishery resources of the South Pacific: a summary and analysis of the dropline fishing survey data generated by the activities of the SPC Fisheries Programme between 1974 and 1988.” SPC Inshore Fisheries Research Project technical document No. 2. 285 pp.
Doyle, B., Harper, S., Jacquet, J., Zeller, D. (2012). “Reconstructing marine fisheries catches in the Solomon Islands: 1950-2009.” pp. 119-134. Fisheries catch reconstructions: Islands, Part III. Fisheries Centre Research Reports 20(5).
Gillett, R. (2005). “Pacific Islands Region. Review of the state of world marine fishery resources.” Food and Agricultural Organization, Rome. 235 p.
Grewe, P.M., Feutry, P., Hill, P.L., Gunasekera, R.M., Schaefer, K.M., Itano, D.G., Fuller, D.W., Foster, S.D., Davies, C.R. (2015). “Evidence of discrete yellowfin tuna (Thunnus albacares) populations demands rethink of management for this globally important resource.” Nature Science Reports. 5, 16916.
Gomez, C.; Williams, A.J.; Nicol, S.J.; Mellin, C.; Loeun, K.L.; Bradshaw C.J.A. (2015). “Species Distribution Models of Tropical Deep-Sea Snappers”. Plos One 10. DOI: 10.1371/journal.pone.0127395.
Lehodey, P., Hampton, J., Brill, R.W., Nicol, S., Senina, I., Calmettes, B., Portner, H.O., Bopp, L., Ilyina, T., Bell, J.D., Sibert, J. (2011). “Vulnerability of oceanic fisheries in the tropical Pacific to climate change”. pp. 433-492.
McCoy M.A. (2010). “Overview of deepwater bottomfish fisheries and current management activities in Pacific Island Countries and Territories.” SPC Fisheries Newsletter: 26-31.
Morato T., Hoyle S.D., Allain V., Nicol S.J. (2010). “Tuna longline fishing around west and central Pacific seamounts.” PLoS ONE 5.
SPC. (2013a). “Improving the management of deepwater snapper resources in Pacific Island Countries and Territories.” Accessed at http://www.spc.int/Oceanfish/en/ofpsection/ema/389-improving-the-management-of-deep-water-snapper-resources-in-pacific-island-countries-and-territories
SPC (2013b). “Status report: Pacific Islands reef and nearshore fisheries and aquaculture.” Report compiled by members of the SciCOFish Project Team. 46 p
WCPFC (Western and Central Pacific Fisheries Commission). (2017). “Tuna fishery yearbook 2016.” 147 p. [http://www.wcpfc.int]
Williams, A.; Nicol, S. (2014). “Predicting the distribution of deepwater snapper in the Western Central Pacific Ocean [Fact Sheet].” SPC, Noumea. 4 pp. Accessed at: https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/Williams_14_PredictingDeepSnapper.html
Williams A.J., Loeun K., Nicol S.J., Chavance P., Ducrocq M., Harley S.J., Pilling G.M., Allain V., Mellin C., Bradshaw C.J.A. (2013). “Population biology and vulnerability to fishing of deep-water Eteline snappers.” Journal of Applied Ichthyology 29:395-403.

Fish From The Farm: Aquaculture

MAP

Fisheries and Marine Resources Government of Solomon Islands. (2015).
Natural Earth. (2017). “Populated Places.” Accessed at: www.naturalearthdata.com.

TEXT

Ministry of Fisheries and Marine Resources. (2015). Accessed at: http://www.fisheries.gov.sb/aquaculture
Pakoa, K., Masu, R., Teri, J., Leqata, J., Tua, P., Fisk, D., and Bertram, I. (2014). “Solomon Islands sea cucumber resource status and recommendations for management.” Secretariat of the Pacific Community. 60 pages.

Beyond The Beach: Marine Tourism

MAP

Natural Earth. (2017). Populated Places. Accessed at: www.naturalearthdata.com.

TEXT

Douglas, N. (2004). "Towards a history of tourism in Solomon Islands." The Journal of Pacific Studies. vol. 26, no.1-2, pp. 29–49.(PRTCBP)

ICF. (2016). "Assessment of the Economic Impact of Cruise Tourism in Papua New Guinea & Solomon Islands." Report by ICF Consulting Services Hong Kong Ltd. 114 pages.

Kaczan, D., and Tuhanuku, D. (2008). "Tourism in the Solomon Islands: A survey of community and operator attitudes." Solomon Islands Chamber of Commerce and Industry. 36 pages.

TRIP Consultants. (2015). "The Solomon Islands National Tourism Development Strategy 2015 - 2019." Pacific Regional Tourism Capacity Building Programme (PRTCBP). FInal Report. 33 pages.

Under Water Wild West: Deep Sea Mining And Under Water Cabling

MAP

Gràcia, E., Ondréas, H., Bendel, V., STARMER Group. (1994). "Multiscale morphologic variability of the North Fiji Basin ridge (Southwest Pacific)." Marine Geology. 116, pp. 133–151.

Mahlknecht, G. (2016). "Greg's Cable Map." Accessed at: http://www.cablemap.info/.

Natural Earth. (2017). "Populated Places." Accessed at: www.naturalearthdata.com.

TEXT

The World Bank. (2017). "Pacific Possible: Long-term Economic Opportunities and Challenges for Pacific Island Countries." 132 pages. Accessed at: www.worldbank.org/pacificpossible.

PNG Mine Watch. (2015). "More than 20 mineral firms in Solomon Islands to operate." Accessed at: https://ramumine.wordpress.com/2015/04/21/more-than-20-mineral-firms-in-solomon-islands-to-operate/.

Full Speed Ahead: Vessel Traffic

MAP

Burke, L., Reytar, K., Spalding, M. and Perry, A. (2011). "Reefs at Risk Revisited." World Resources Institute. Accessed at: http://www.wri.org/publication/reefs-risk-revisited.

Secretariat of the Pacific Regional Environment Programme (SPREP). (2013 - 2014). "Exact AIS vessel tracks."

TEXT

Mizusawa, D., Guild, R., Adhar, R., and Ling, D. (2012). "Strengthening Maritime Transport Sector in Solomon Islands." Paper to Transportation Research Board 2012 Annual Meeting. 13 pages.

ICF. (2016). "Assessment of the Economic Impact of Cruise Tourism in Papua New Guinea & Solomon Islands." Report by ICF Consulting Services Hong Kong Ltd. 114 pages.

Plastic Ocean: Microplastics Concentration

MAP

Sebille E. V., Wilcox C., Lebreton L., Maximenko N., Hardesty B. D., Van Franeker J. A., Eriksen M., Siegel D., Galgani F., and Law, K. L. (2015). "A global inventory of small floating plastic debris." 10:12.

TEXT

Heinrich Böll Foundation. (2017). "OCEAN ATLAS 2017". Accessed at: https://www.boell.de/en/oceanatlas

The Dose Makes The Poison: Phosphate and Nitrate Concentration

MAPS

Claus S., N. De Hauwere, B. Vanhoorne, F. Souza Dias, P. Oset García, F. Hernandez, and J. Mees (Flanders Marine Institute). (2016). Accessed at http://www.marineregions.org on 2016-10-21.

Tyberghein L., Verbruggen H., Pauly K., Troupin C., Mineur F. & De Clerck O. (2012). "Bio-ORACLE: a global environmental dataset for marine species distribution modeling." Global Ecology and Biogeography.

TEXT

Fabricius, K.E. (2005). "Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis". Mar Pollut Bull. 50, 125 – 146.

Falkowski, P.G., R.T. Barber, V. Smetacek, (1998). "Biogeochemical controls and feedbacks on ocean primary production." Science (Washington, D. C.), 281 (1998), pp. 200.

Reefs At Risk: Reef Risk Level

MAP

Burke, L., Reytar, K., Spalding, M. and Perry, A. (2011). "Reefs at Risk Revisited." World Resources Institute. Accessed at: http://www.wri.org/publication/reefs-risk-revisited

Natural Earth. (2017). "Populated Places." Accessed at: www.naturalearthdata.com.

TEXT

Klein, C. J., Jupiter, S. D., Selig, E. R., Watts, M. E., Halpern, B. S., Kamal, M. , Roelfsema, C. and Possingham, H. P. (2012). "Forest conservation delivers highly variable coral reef conservation outcomes." Ecological Applications, 22: 1246-1256.

Sulu, R., R. Cumming, L. Wantiez, L. Kumar, A. Mulipola, M. Lober, S. Sauni, T. Poulasi and K. Pakoa , (2002). "Status of Coral Reefs in the Southwest Pacific Region to 2002: Fiji, Nauru, New Caledonia, Samoa, Solomon Islands, Tuvalu and Vanuatu."

Wilkinson C. (2008). "Status of Coral Reefs of the World: 2008." Global Coral Reef Monitoring Network & Reef and Rainforest Research Centre, Townsville. 304 pp.

Stormy Times: Cyclones

MAP

Knapp, K. R., M. C. Kruk, D. H. Levinson, H. J. Diamond, and C. J. Neumann. (2010). "The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data." Bulletin of the American Meteorological Society, 91, 363-376.

TEXT

Chand, S.S. and Walsh, K.J. (2009). "Tropical cyclone activity in the Fiji region: Spatial patterns and relationship to large-scale circulation." Journal of Climate, 22(14), pp.3877-3893.

Diamond, H.J., Lorrey, A.M. and Renwick, J.A. (2013). "A southwest Pacific tropical cyclone climatology and linkages to the El Niño–Southern Oscillation." Journal of Climate, 26(1), pp.3-25.

MEDCM. (2012). "National Climate Change Policy. 2012 - 2017." Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM). 45 pages.

Solomon Islands Government Meteorological Services Division. (n.d.). Accessed at: http://www.met.gov.sb/.

MANAGING

Space To Recover: Marine Management

MAP

IUCN and UNEP-WCMC. (2016). "The World Database on Protected Areas (WDPA)." Accessed at: www.protectedplanet.net.

Natural Earth. (2017). "Populated Places." Accessed at: www.naturalearthdata.com.

TEXT

CBD (Convention on Biological Diversity). (2018). Accessed at: https://www.cbd.int/

IUCN and UNEP-WCMC. (2016). "The World Database on Protected Areas (WDPA)." Accessed at: www.protectedplanet.net.

One World, One Ocean: International Maritime Organization (IMO) MARPOL Convention

MAP

International Maritime Organization. (2011). "MARPOL Consolidated edition 2011: articles, protocols, annexes and unified interpretations of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the 1978 and 1997 protocols".

TEXT

International Maritime Organization. (n.d.). "Particularly Sensitive Sea Areas." Accessed at: http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx

Solomon Islands Commitment To Marine Conservation

TEXT

CBD (Convention on Biological Diversity). (2018). Accessed at: https://www.cbd.int/

United Nations. (2017). "The Ocean Conference. Registry of Voluntary Commitments." Accessed at: https://oceanconference.un.org/commitments/

United Nations. (2017). "Our ocean, our future: call for action" A/RES/71/312. Accessed at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/71/312&Lang=E.

A Marine Layer Cake

MAPS

For map data, please check references for chapters: "Fishing In The Dark – Offshore Fisheries", "Full Speed Ahead – Vessel Traffic", "One World, One Ocean – IMO MARPOL Convention", "Underwater Wild West – Deep Sea Mining And Underwater Cabling."

Fish Aggregating Devices data courtesy to Solomon Islands government.

Conflicting Versus Compatible Uses

MAP

For map data, please check references for chapters: "Fishing In The Dark – Tuna Catch", "Full Speed Ahead – Vessel Traffic", "One World, One Ocean – IMO MARPOL Convention", "Underwater Wild West – Deep Sea Mining And Underwater Cabling."

Fish Aggregating Devices data courtesy to Solomon Islands government.

TEXT

Ehler, C. and Douvere, F. (2009). "Marine Spatial Planning: a step-by-step approach toward ecosystem-based management. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme." IOC Manual and Guides No. 53, ICAM Dossier No. 6. Paris: UNESCO.

APPENDIX 1. DATA PROVIDERS

Organisation Name	Organisation Website
AquaMaps	http://www.aquamaps.org/search.php
Commonwealth Scientific and Industrial Research Organisation	http://www.csiro.au/
Convention on Biological Diversity	https://www.cbd.int/
Earth & Space Research (ESR)	http://www.esr.org/
Ecologically or Biologically Significant marine Areas	https://www.cbd.int/ebsa/
exactEarth	http://www.exactearth.com/
Government of The Kingdom of Tonga	http://www.gov.to/
Government of Vanuatu	http://governmentofvanuatu.gov.vu/
GRID-Arendal	http://www.grida.no/
Institute for Marine Remote Sensing	http://imars.marine.usf.edu/
Interridge	http://www.interridge.org/
Khaled bin Sultan Living Oceans Foundation	https://www.livingoceansfoundation.org/
Marine Ecology Consulting	http://marineecologyfiji.com/
National Aeronautics and Space Administration	http://www.nasa.gov/
National Oceanic and Atmospheric Administration	http://www.noaa.gov/
Oregon State University	http://oregonstate.edu/
Pacific community	http://gsd.spc.int/
Ports Authority Tonga	http://portsauthoritytonga.com/
Reef Life Survey	http://reeflifesurvey.com/
Republic of Kiribati	http://www.pso.gov.ki/
Sea Around Us is a research initiative at The University of British Columbia	http://www.seaaroundus.org/
Secretariat of the Pacific Regional Environment Program	http://www.sprep.org/
Solomon Islands Government	
The University of Queensland	http://www.uq.edu.au/
The Fijian Government	http://www.fiji.gov.fj/
The General Bathymetric Chart of the Oceans (GEBCO)	http://www.gebco.net/
The Nature Conservancy	http://www.nature.org/
Tonga Cable Limited	http://tongacable.to/
Tourism Tonga	https://plus.google.com/110982421797787387797
U.S. Geological Survey	https://www.usgs.gov/
University of South Florida	http://www.usf.edu/
Vava'u Environmental Protection Association	http://www.vavauenvironment.org/
Vlaams Instituut voor de Zee	http://www.vliz.be/
Western & Central Pacific Fisheries Commission	https://www.wcpfc.int/
Wildlife Conservation Society	https://www.wcs.org/
World Wildlife Fund	http://www.worldwildlife.org/
Zoological Society of London	https://www.zsl.org/

APPENDIX 2. PHOTO PROVIDERS

Page	Copyright
6	MACBIO
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10	MACBIO
13	Wikipedia/AusAID
17	Jesse Allen
19	NOAA
19	Wikipedia/A.D. Rogers et al.
22	NOAA
24	iStock/HenrikAMeyer
25	iStock/Michael Zeigler
27	iStock/Velvetfish
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35	MACBIO
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49	University of Bremen & NOAA
51	iStock/Lapis-lazuli
51	Wikipedia/Bin im Garten
58	iStock/Velvetfish
59	iStock/djgunner
61	NOAA
63	Wikipedia/Australian Emergency Management Knowledge Hub
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