# MARINE ATLAS

## MAXIMIZING BENEFITS FOR

# KIRIBATI

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**


www.macbio-pacific.info



Although this document has been funded by the International Climate Initiative (IKI), which is supported by the BMU in accordance with a decision of the German Bundestag, its content does not necessarily reflect the official opinion of the German Federal Government. MACBIO retains the copyright of all photographs, unless otherwise indicated.



Project director: Jan Henning Steffen

Suggested citation: Gassner, P., Westerveld, L., Abeta, R., Macmillan-Lawler, M., Davey, K., Baker, E., Clark, M., Kaitu'u, J., Wendt, H., Fernandes, L. (2019) *Marine Atlas. Maximizing Benefits for Kiribati.* MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 72 pp.

ISBN: 978-82-7701-175-2

# MARINE ATLAS
## MAXIMIZING BENEFITS FOR
# KIRIBATI

AUTHORS: **Philipp Gassner, Levi Westerveld, Riibeta Abeta, 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 Kiribati is more than 4,000 times larger than its land territory. With an exclusive economic zone (EEZ) of 3.55 million km2, Kiribati 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 more than 500 fish species, including sharks and rays, as well as whales, dolphins and sea turtles. We are committed to conserving this unique marine biodiversity.

Kiribati's marine ecosystems are worth at least AU$400 million per year, which is twice the country's gross domestic product (GDP). 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, Kiribati's coastal villages manage inshore marine resources. We are striving to work together to sustainably manage all Kiribati's outer island inshore areas for the benefit of empowered and resilient communities.

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

By strengthening global and regional partnerships, we are proudly taking leadership in climate change advocacy and global conservation initiatives, such as the Phoenix Island Protected Area, one of the largest in the world. 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 Kiribati, its people and its economy.

This is where the Kiribati 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 three chapters, the atlas sets out to illustrate:

- What values does the ocean provide to Kiribati, 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 can 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 Kiribati's 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 Kiribati.

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

# CONTENTS


4 **FOREWORD**

6 **SEA OF ISLANDS**: THE CENTRAL PACIFIC

7 **A LARGE OCEAN STATE**: ADMINISTRATION

## 8 VALUING

### – SUPPORTING VALUES

10 **STILL WATERS RUN DEEP**: OCEAN DEPTH

12 **VOYAGE TO THE BOTTOM OF THE SEA**: GEOMORPHOLOGY

14 **UNDER WATER MOUNTAINS**: SEAMOUNT MORPHOLOGY

16 **GO WITH THE FLOW**: SALINITY AND SURFACE CURRENTS

18 **STIR IT UP**: MIXED LAYER DEPTH

19 **PUMP IT**: PARTICULATE ORGANIC CARBON FLUX

20 **SOAK UP THE SUN**: PHOTOSYNTHETICALLY AVAILABLE RADIATION

### – OCEAN VALUES

22 **HOME, SWEET HOME**: COASTAL HABITATS

24 **SHAPING PACIFIC ISLANDS**: CORAL REEFS

26 **TRAVELLERS OR HOMEBODIES**: MARINE SPECIES RICHNESS

28 **HOW MUCH DO WE REALLY KNOW?** COLD WATER CORAL HABITATS

30 **NATURE'S HOTSPOTS**: KEY BIODIVERSITY AREAS

32 **BEYOND THE HOTSPOTS**: BIOREGIONS

## 34 PLANNING

### – USES

36 **FISHING IN THE DARK**: TUNA CATCH

38 **SMALL FISH, BIG IMPORTANCE**: INSHORE FISHERIES

40 **FISH FROM THE FARM**: AQUACULTURE

42 **BEYOND THE BEACH**: MARINE TOURISM

44 **UNDER WATER WILD WEST**: DEEP-SEA MINING AND UNDER WATER CABLING

46 **FULL SPEED AHEAD**: VESSEL TRAFFIC

### – THREATS

48 **PLASTIC OCEAN**: MICROPLASTICS CONCENTRATION

50 **THE DOSE MAKES THE POISON**: PHOSPHATE AND NITRATE CONCENTRATION

### – CLIMATE CHANGE THREATS

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

54 **TURNING SOUR**: OCEAN ACIDITY

56 **REEFS AT RISK**: REEF RISK LEVEL

58 **STORMY TIMES**: CYCLONES

## 60 MANAGING

62 **SPACE TO RECOVER**: MARINE MANAGEMENT

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

66 **KIRIBATI'S COMMITMENT TO MARINE CONSERVATION**

67 **A MARINE LAYER CAKE**

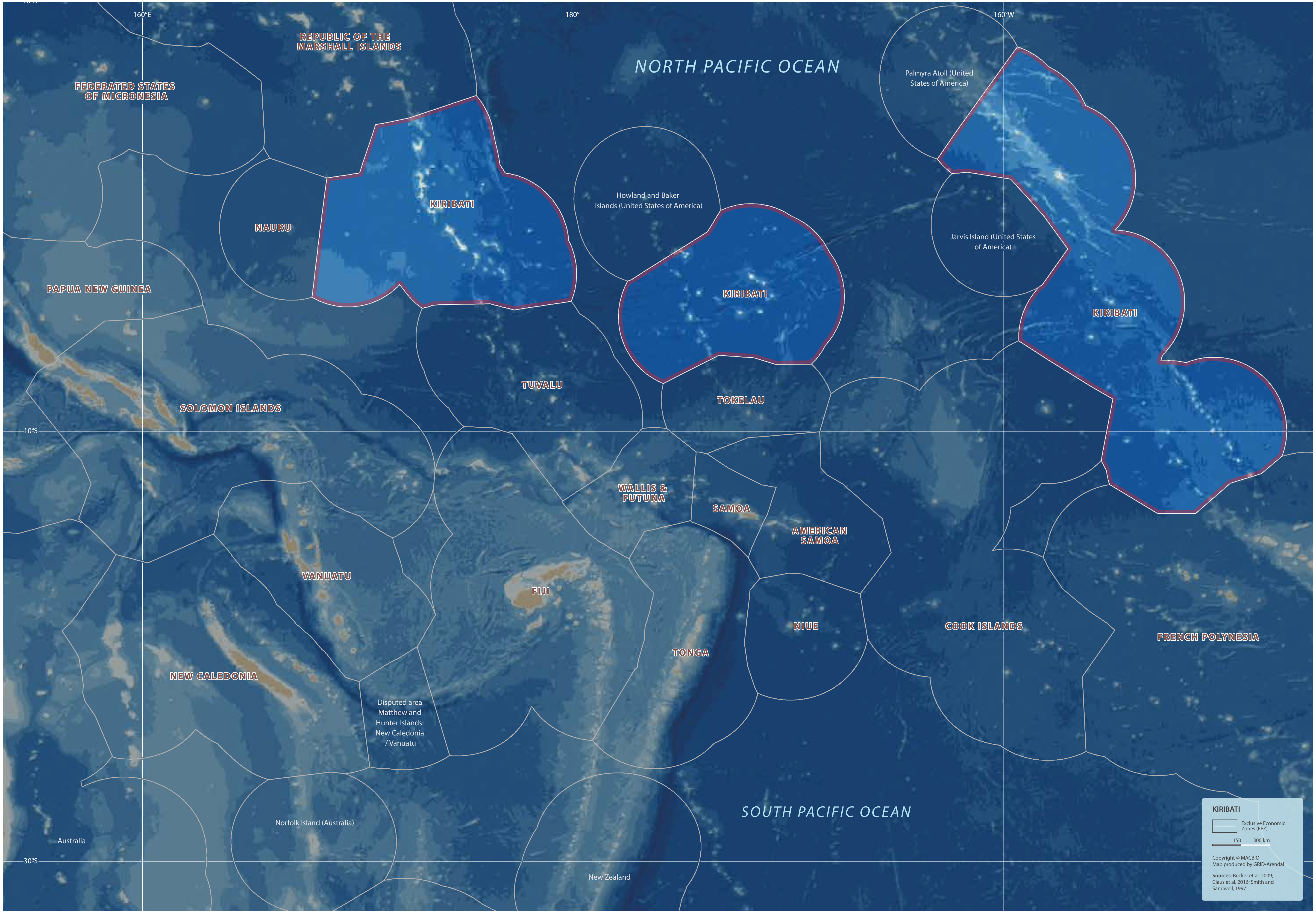
68 **CONFLICTING VERSUS COMPATIBLE USES**

70 **CONCLUSION**

71 **REFERENCES**

74 **APPENDIX 1. DATA PROVIDERS**

74 **APPENDIX 2. PHOTO PROVIDERS**


160°E
180°
160°W
10°S
30°S
NORTH PACIFIC OCEAN
SOUTH PACIFIC OCEAN
REPUBLIC OF THE MARSHALL ISLANDS
FEDERATED STATES OF MICRONESIA
NAURU
KIRIBATI
Howland and Baker Islands (United States of America)
KIRIBATI
Palmyra Atoll (United States of America)
Jarvis Island (United States of America)
KIRIBATI
PAPUA NEW GUINEA
SOLOMON ISLANDS
TUVALU
TOKELAU
WALLIS & FUTUNA
SAMOA
AMERICAN SAMOA
VANUATU
FIJI
TONGA
NIUE
COOK ISLANDS
FRENCH POLYNESIA
NEW CALEDONIA
Disputed area Matthew and Hunter Islands: New Caledonia / Vanuatu
Norfolk Island (Australia)
Australia
New Zealand
KIRIBATI
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.

# A LARGE OCEAN STATE: ADMINISTRATION

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

Taari and marawa, which translate as "brotherhood" and "deep", are the terms the early I-Kiribati people used to refer to the sea—evidence of the strong connection the they felt to the sea.

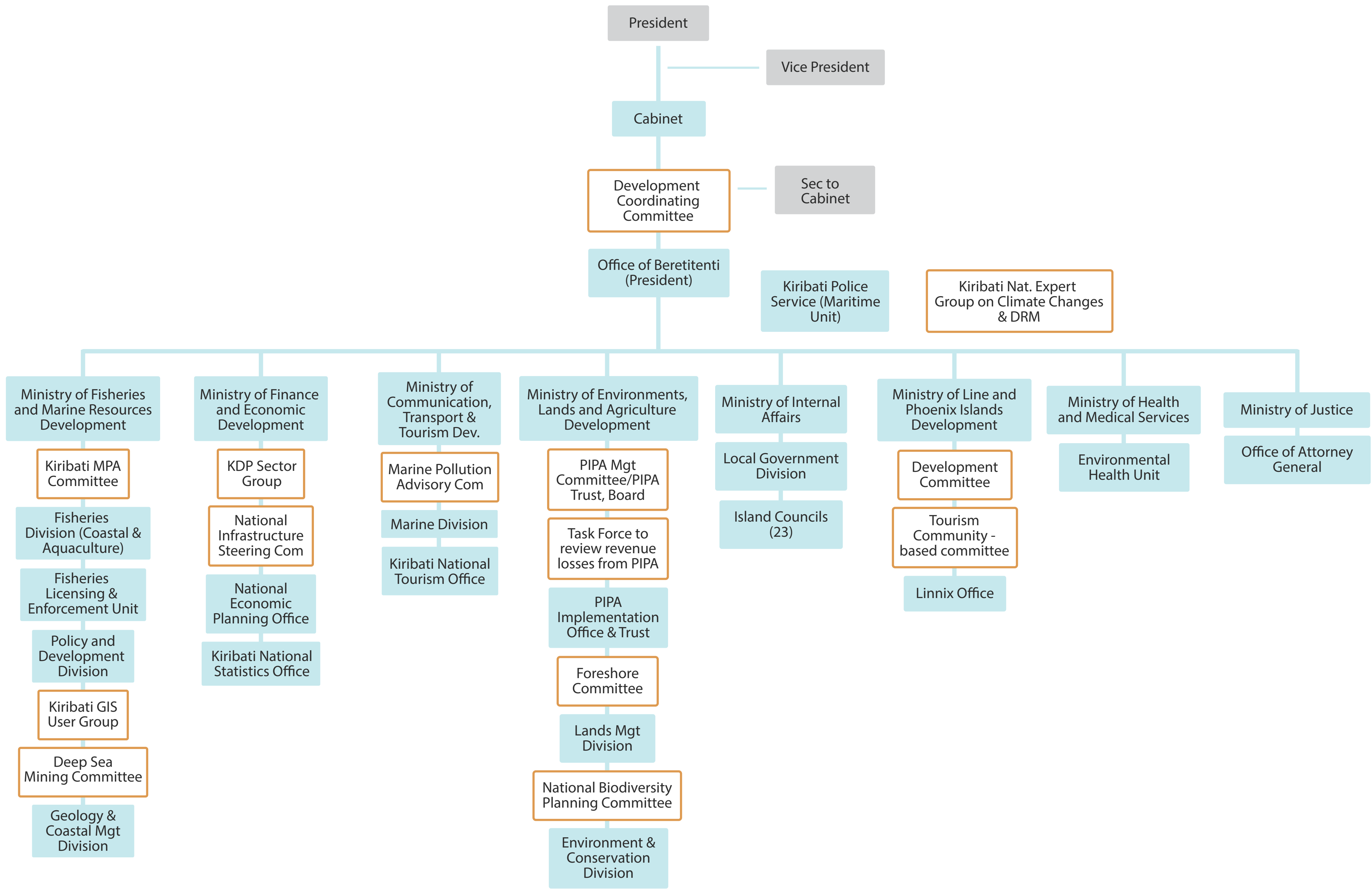
The islands of Kiribati were settled around 4,000 to 5,000 years ago. Prior to colonial times, customary tenure determined how land and marine areas were allocated and therefore determined people's access to natural resources (Lambert, 1987). Each kainga (family unit) was allocated plots of land and areas for fishing and thus had exclusive rights to fish and incentives to manage the fisheries within their designated area. During the colonization of Kiribati by the British Empire, the customary marine tenure was changed, which unfortunately, in many cases, led to the "tragedy of the commons" depleting marine resources. Only in 1979, when Kiribati gained independence, could the people of Kiribati govern and make decisions themselves through a democratic form of government, including governance of the resources in their vast exclusive economic zone (EEZ).

## Special rights

An exclusive economic zone (EEZ) is a sea zone that extends up to 200 nautical miles (nmi) from a country's baseline. Kiribati's EEZ, prescribed by the United Nations Convention on the Law of the Sea (UNCLOS), gives Kiribati sovereign 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 Kiribati, in which it has full authority.

The government comprises the President (both Head of State and Government), Vice-President and a Cabinet of appointed ministers who are elected into the Legislative House of Assembly. There are a number of domestic laws, regulations and policies that govern the management and use of marine resources through different government line ministries. The Ministry of Fisheries and Marine Resources Development is responsible for the development of marine resources, while some elements of resource management are shared with the Ministry of Environment, Lands and Agriculture Development. The hierarchy of authorities involved in marine resource management in Kiribati is depicted in the graphic below.

Kiribati has one of the largest EEZs in the world at 3.5 million km2 and heavily relies on ocean resources for its revenue and the well-being of its people. During the United Nations Ocean Conference in June 2017, the minister responsible for fisheries, Mr Tetabo Nakara, stated, "…Kiribati, often referred to as a Small Island Developing State, is actually a huge Ocean State with the second largest EEZ in the Pacific Ocean, 3.5 million square kilometres; the same size as India… The extent of our marine resources are delineated by maritime boundary, which provides long-term security, rights and status for my country…".



# VALUING

Marine ecosystems in Kiribati provide significant benefits to society, including livelihoods and nutrition for the people of Kiribati, the Pacific and around the world. Limited land resources and the dispersed and isolated nature of communities make the I-Kiribati 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.

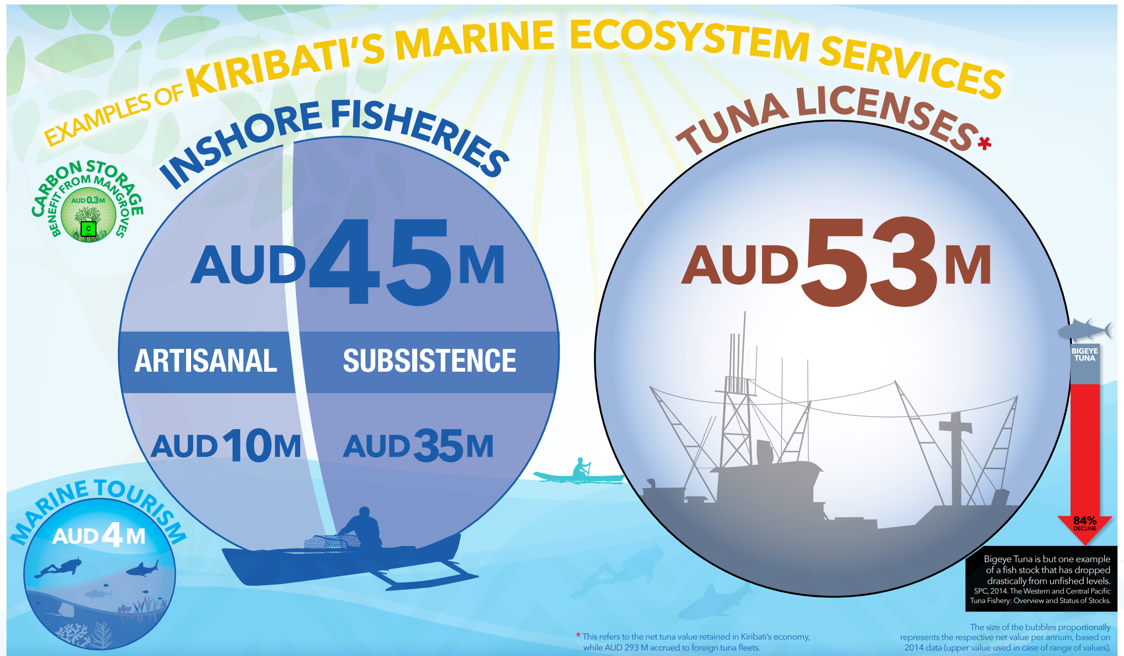
Based on the combinations of biophysical conditions, the ocean provides a home to many different species, from coral-grazing parrotfish on the reefs to the strange and mysterious animals of the deep. These and many other species and the unique marine ecosystems on which they rely are featured in the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


The **goods and services** provided by Kiribati's **marine ecosystems** are **huge**. They are worth **double** the country's **GDP**.

Appreciating the rich diversity of marine ecosystems helps in understanding their importance to Kiribati. 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.

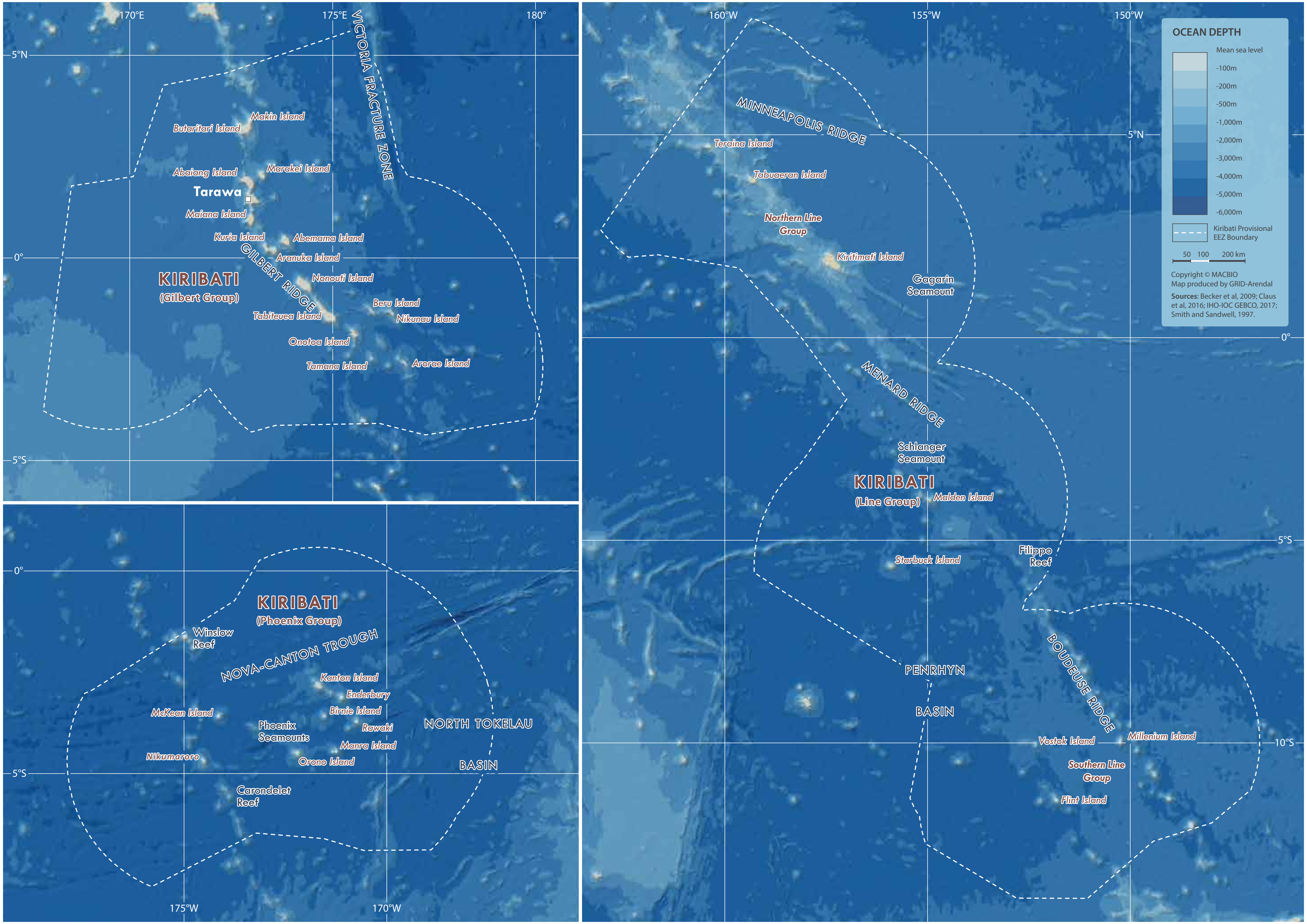
Kiribati has therefore undertaken economic assessments of its marine and coastal ecosystem services, and is working on integrating the results into national policies and development planning. These economic values are also featured in the maps of this atlas, to help maximize benefits for Kiribati.

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




Kiribati's **marine ecosystem services** are **valuable** and **diverse**, yet often **hidden**.

Kiribati's **marine ecosystem services** need to be **fully recognized** and **sustainably managed** or they **may be lost forever**.


170°E
175°E
180°
5°N
0°
5°S
VICTORIA FRACTURE ZONE
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
GILBERT RIDGE
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Winslow
Reef
NOVA-CANTON TROUGH
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orona Island
McKean Island
Phoenix
Seamounts
Nikumaroro
Carondelet
Reef
NORTH TOKELAU
BASIN
175°W
170°W
160°W
155°W
150°W
MINNEAPOLIS RIDGE
Teraina Island
Tabuaeran Island
Northern Line
Group
Kiritimati Island
Gagarin
Seamount
MENARD RIDGE
Schlanger
Seamount
KIRIBATI
(Line Group)
Malden Island
Starbuck Island
Filippo
Reef
PENRHYN
BASIN
BOUDEUSE RIDGE
Vostok Island
Millenium Island
Southern Line
Group
Flint Island
10°S
OCEAN DEPTH
Mean sea level
-100m
-200m
-500m
-1,000m
-2,000m
-3,000m
-4,000m
-5,000m
-6,000m
Kiribati Provisional
EEZ Boundary
50 100 200 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.

# SUPPORTING VALUES

# 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 Kiribati.

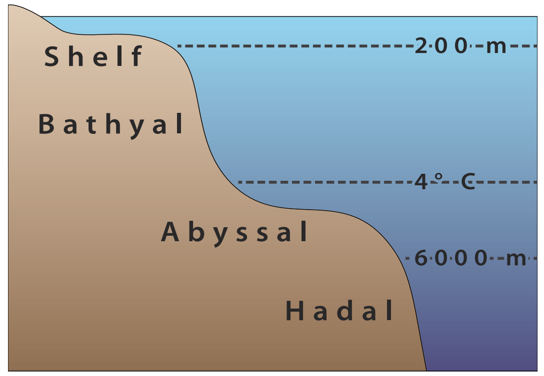
Standing on Kiribati's shore and gazing into an alluring turquoise lagoon, it is hard to imagine how deep the ocean truly is. Only 0.1 per cent of Kiribati's national waters are shallower than 200 metres, while the other 99.9 per cent are up to 8,155 metres deep in the Nova-Canton Trough. Changes in 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).

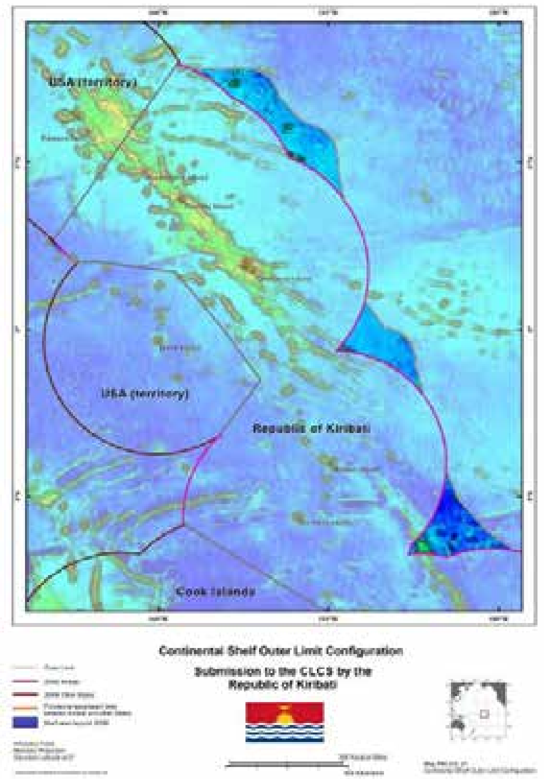
In addition, bathymetry significantly affects the path of tsunamis, which travel as shallow-water waves across the ocean. As a tsunami moves, it is influenced by the sea floor, even in the deepest parts of the ocean. Bathymetry influences the energy, direction and timing of a tsunami. As a ridge or seamount 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 minimize the risk of disaster.

Kiribati comprises three island groups: the Gilbert group, the Phoenix group and the Line group. Each of these groups is characterized by extensive areas of deep abyssal sea floor between 4,000 and 6,000 metres deep. The easternmost Gilbert group is a chain of islands rising up from the Gilbert Ridge, which runs north to south through the EEZ. This ridge is mostly between 3,000 and 4,000 metres deep. The Phoenix group consists of a number of islands and seamounts rising up from the deep ocean sea floor. The Nova-Canton Trough is the deepest part of sea floor found in Kiribati's waters and lies in the northern part of the EEZ. At its deepest point, this trough measures 8,155 metres and is the result of tectonic movement of the sea floor. The Line group are a chain of islands rising up from a series of ridges running from the south-east to the north-west, including the Boudeuse, Menard and Minneapolis Ridges. All the island groups have a significant number of seamounts rising up from the deep abyssal sea floor.

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.

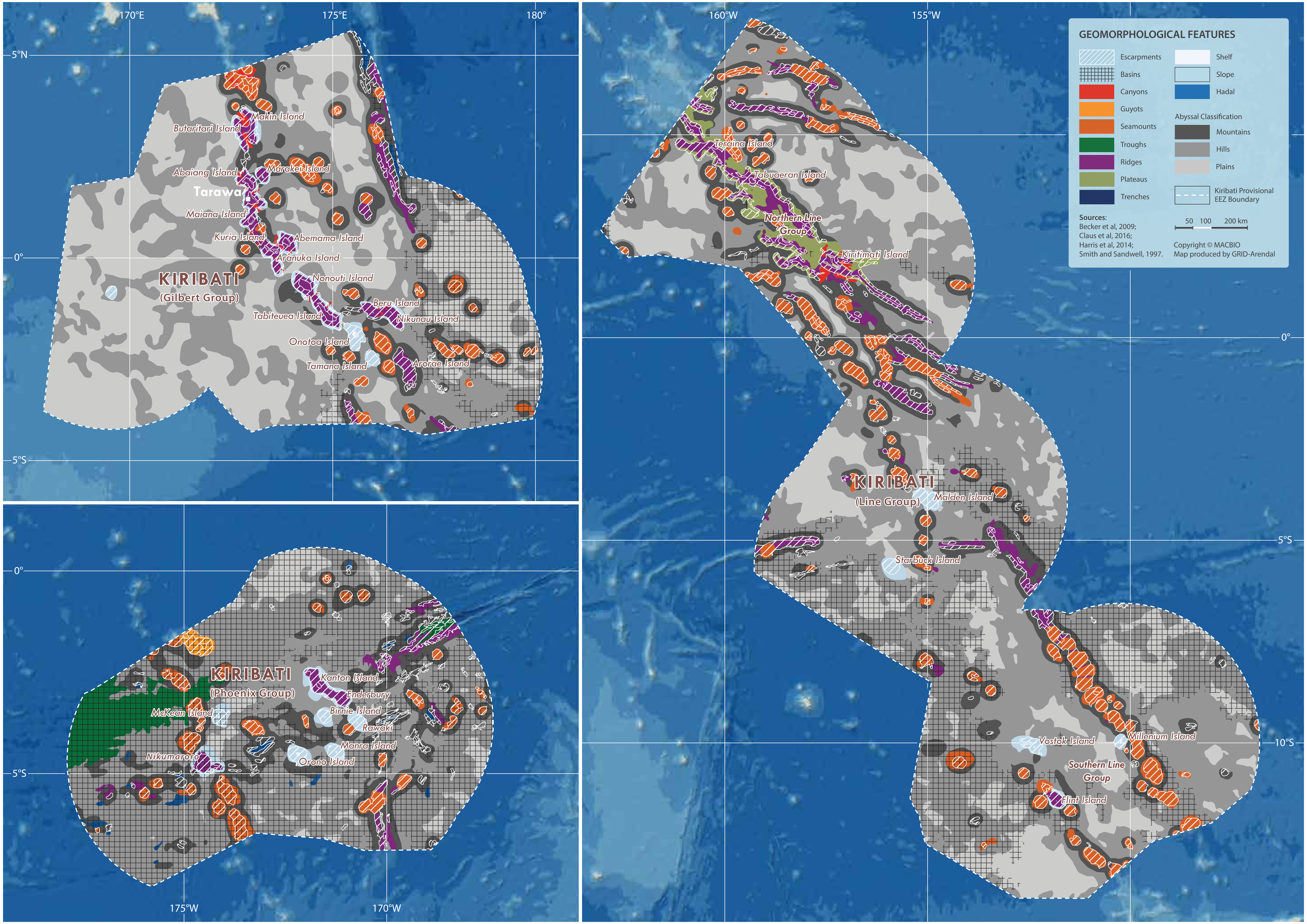



## More space for Kiribati

While Kiribati's land mass is rather small, it has sovereignty over a very large marine area. Why? Because the national area includes the exclusive economic zone (EEZ), with its boundary drawn 200 nautical miles from the coast. And this area may grow further yet.

In 2012, Kiribati applied for an extended continental shelf claim for a particular region adjacent to the Line Islands that includes the Line Islands Ridge Complex—a chain of tropical atolls, elevations, submarine ridges and seamounts. These submarine elevations do not form a simple linear chain, but rather comprise scattered volcanic constructs and therefore constitute a natural prolongation of the continental shelf.

For this reason, Kiribati's EEZ may be extended, showing just how important a good understanding of bathymetry is for establishing maritime boundaries.

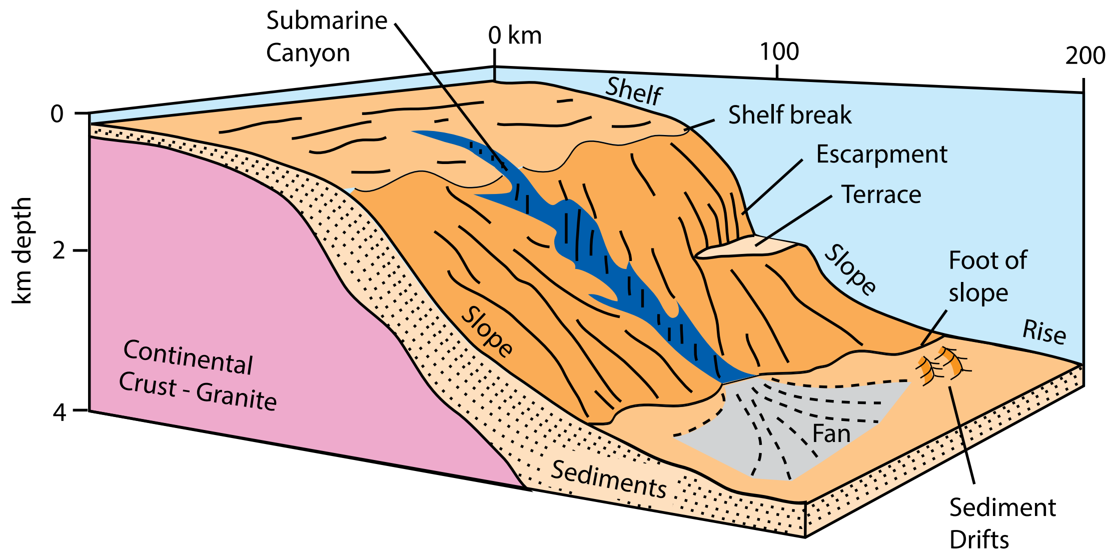

GEOMORPHOLOGICAL FEATURES
Escarpments
Basins
Canyons
Guyots
Seamounts
Troughs
Ridges
Plateaus
Trenches
Shelf
Slope
Hadal
Abyssal Classification
Mountains
Hills
Plains
Kiribati Provisional EEZ Boundary
Sources:
Becker et al, 2009;
Claus et al, 2016;
Harris et al, 2014;
Smith and Sandwell, 1997.
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Tabiteuea Island
Beru Island
Nikunau Island
Onotoa Island
Tamana Island
Arorae Island
170°E
175°E
180°
5°N
0°
5°S
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Manra Island
Orono Island
Nikumaroro
175°W
170°W
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island
160°W
155°W
10°S

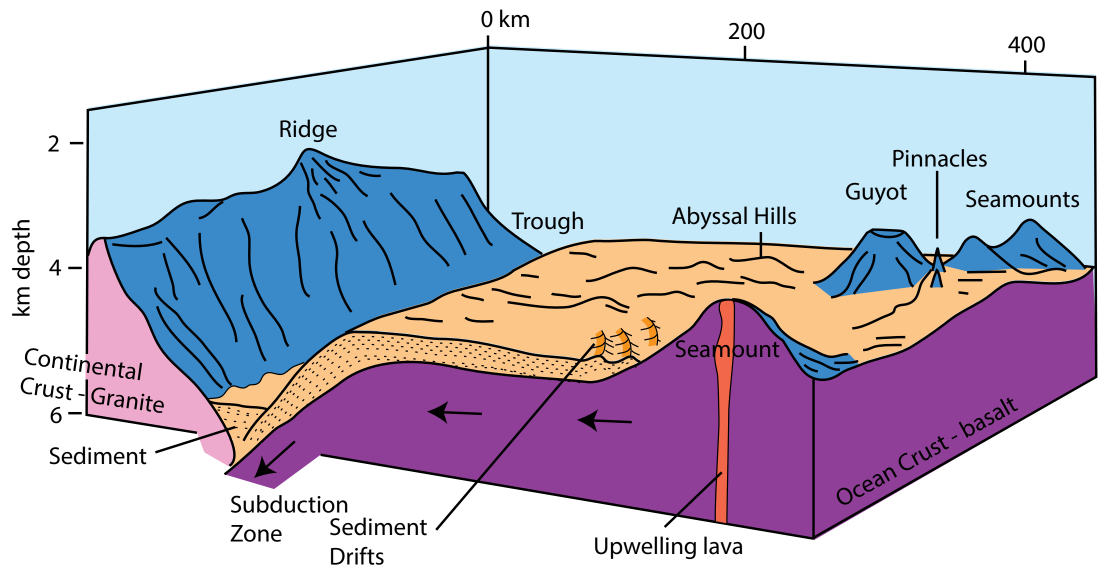
# VOYAGE TO THE BOTTOM OF THE SEA: GEOMORPHOLOGY

Kiribati's sea floor is rich in physical features of different shapes and sizes 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"), the way the wind blows and the distribution of water temperature and salinity (see also chapter "Hotter and higher"). These f actors 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 Kiribati, 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, cobalt-rich ferromanganese crusts on the flanks of seamounts and nodule deposits on some deep abyssal plains (see chapter "Underwater Wild West").

Kiribati's waters harbour 15 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. Kiribati's waters include 342 seamounts and 12 guyots. Seamounts are large—over 1,000 metres high—conical mountains of volcanic origin, while guyots are seamounts with flattened tops (see also chapter "Underwater mountains"). There are also numerous ridges and chains of abyssal mountains rising up from the sea floor. The island chains of the Gilbert and Line groups are perched along such ridges. The steep sides of all these features interact with currents and create important habitats for many species. Surrounding the islands is an area of generally narrow shelf, which supports extensive coral reefs.

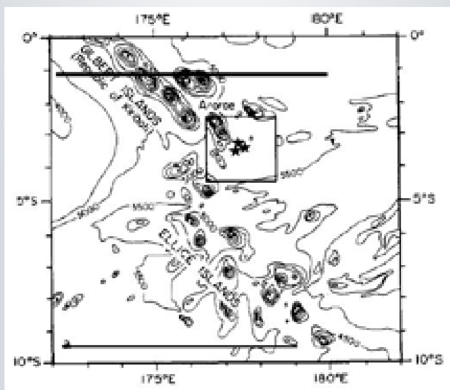
The adjacent areas of slope and the margins of the plateau are incised with numerous large, submarine canyons. These canyons are characterized as areas of high biodiversity due to their steep sides featuring rocky slopes, strong currents and enhanced access to food. They also act as a conduit between 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.

On the deep-sea floor, there are extensive areas of abyssal plains, hills and mountains. The deep Novo-Canton Trough runs to the north of the Phoenix group. This area of sea floor includes the hadal zone, where the sea floor is deeper than 6,000 metres. The mosaic of different geomorphic features likely supports a large range of different ecosystems. In the absence of detailed information on the distribution of biodiversity, geomorphology can be used to inform decisions on management of the sea floor in Kiribati.

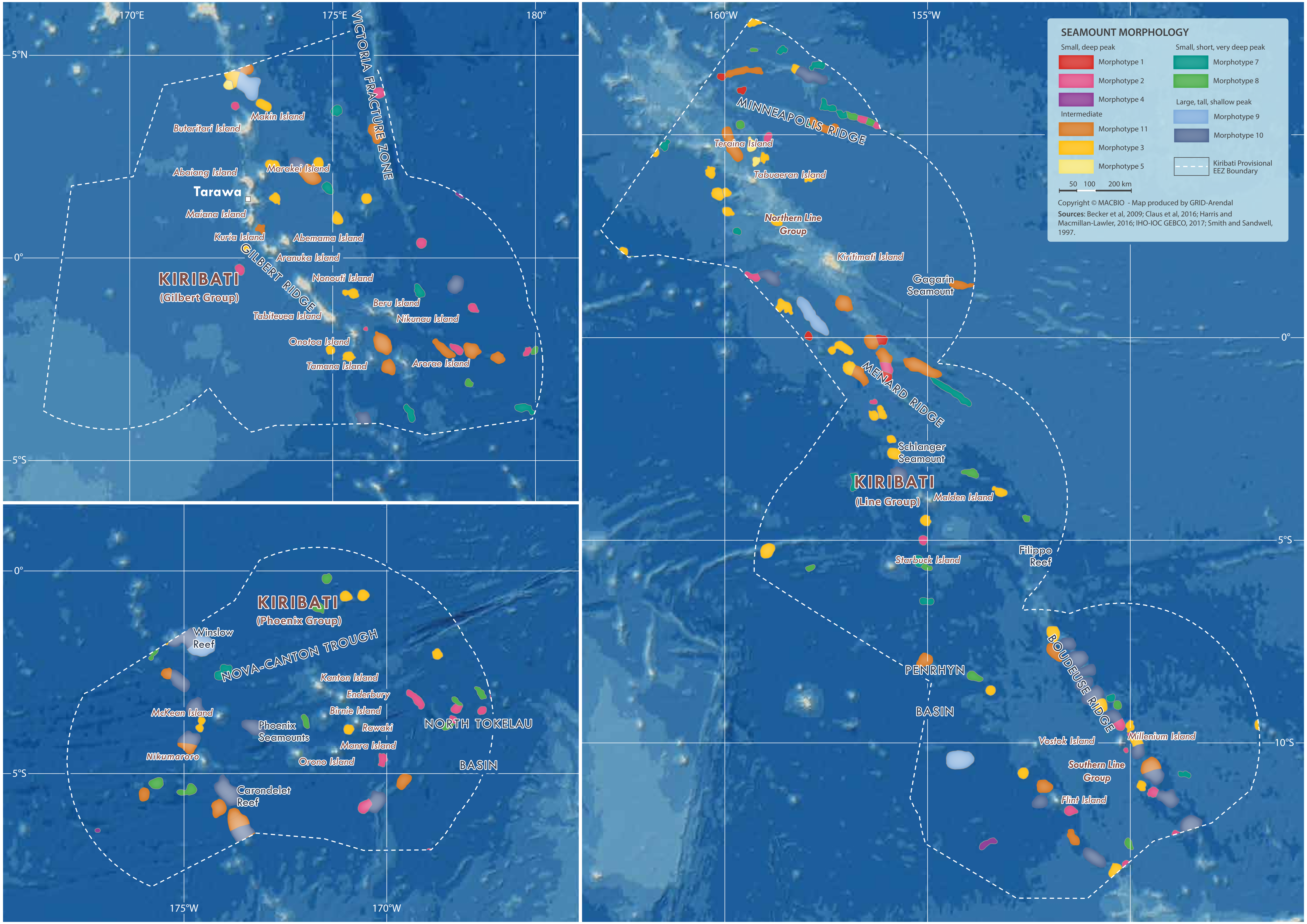
## The lost babai pit

For the longest time, Kiribati's exclusive economic zone (EEZ) was very calm. There was no active seismic activity, volcanic eruption or fracture zone on historical records. Then, in December 1981, a family in Arorae Island—the southernmost of the Gilbert Islands—awoke to a surprise. In the morning, they realized that their babai, or giant taro pit, had completely closed overnight.

This was the effect of a series of undersea earthquakes at a location about 150 kilometres south-east of Arorae. The quakes continued until March 1983. This formerly unknown zone of weakness within the lithosphere underneath the area near Arorae Island is an interesting example of the tectonic activity that ultimately shapes our ocean floor and creates the atolls and islands on top.




*Base map showing the location of the largest earthquake swarm events in the Gilbert Island group (bathymetry contours in metres).*



170°E
175°E
180°
5°N
0°
5°S
VICTORIA FRACTURE ZONE
Makin Island
Butaritari Island
Marakei Island
Abaiang Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
GILBERT RIDGE
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
0°
5°S
175°W
170°W
KIRIBATI
(Phoenix Group)
Winslow Reef
NOVA-CANTON TROUGH
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Phoenix Seamounts
Manra Island
Orona Island
Nikumaroro
NORTH TOKELAU
BASIN
Carondelet Reef
160°W
155°W
0°
5°S
10°S
MINNEAPOLIS RIDGE
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
Gagarin Seamount
MENARD RIDGE
Schlanger Seamount
KIRIBATI
(Line Group)
Malden Island
Starbuck Island
Filippo Reef
PENRHYN
BASIN
BOUDEUSE RIDGE
Vostok Island
Millenium Island
Southern Line Group
Flint Island
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
Morphotype 8
Large, tall, shallow peak
Morphotype 9
Morphotype 10
Kiribati Provisional EEZ Boundary
50 100 200 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.

# UNDER WATER MOUNTAINS: SEAMOUNT MORPHOLOGY

Kiribati has 354 submarine mountains commonly known as seamounts). 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 Kiribati. 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 mountain 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 Kiribati’s 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 342 seamounts in Kiribati’s waters represent 10 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 Kiribati’s case, this includes the large, tall and shallow peaked seamounts (morphotypes 9 and 10), the majority of which are found in the Phoenix group and in the southern part of the Line group. Almost half the seamounts in Kiribati’s waters 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, seamounts—with their associated cobalt-rich crusts—are likely to come under increasing pressure.

## Mysterious Maiana Bank

On te kai, meaning “on the log”, is the subject of endless myths, dances and old song lyrics in Kiribati. On te kai is a particular seamount in the middle of the ocean between the islands of Tarawa and Maiana. It was later named the Maiana Bank and has become known as the main tuna-trolling spot for fishing communities from Tarawa and Maiana. In this way, it has provided tuna for the residents of Tarawa and Maiana for millenniums.

The Secretariat of the Pacific Community (SPC) Tuna Tagging Programme conducted several tuna surveys around the Maiana Bank area, reaffirming local claims that this area is indeed the aggregation site for skipjack and other species of tuna. In March 2017, partners of the Phoenix Islands Protected Area (PIPA) project conducted detailed bathymetric surveys and mapping around the Phoenix Islands archipelago and found more than 14 communities of seamounts with untouched deepwater coral biodiversity comparable to the shallow-water coral diversity of the coral triangle region—Western Pacific (see map on the right).

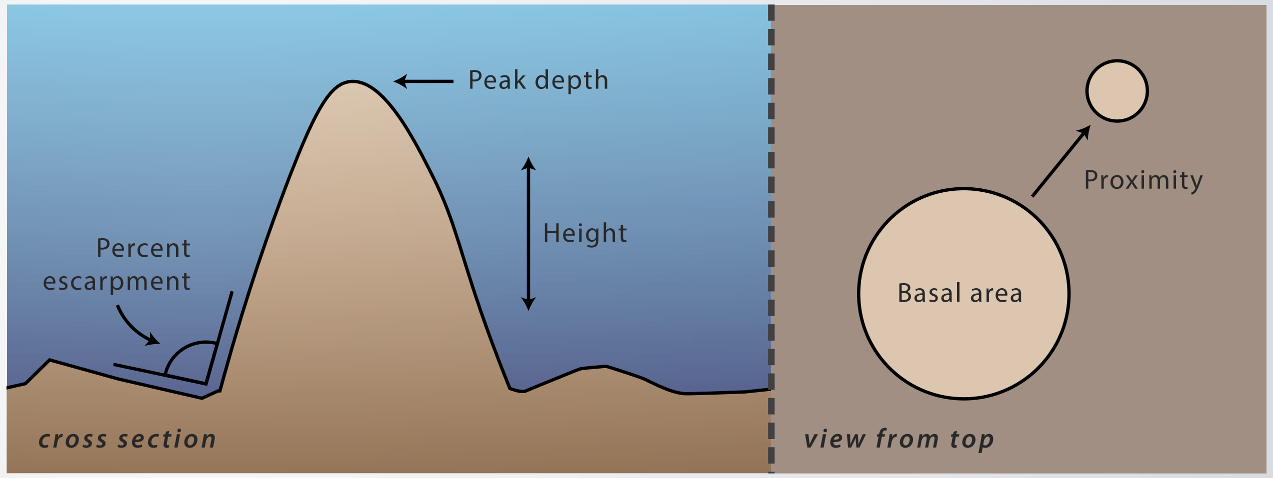

## Seamount morphotypes found in Kiribati waters

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*.

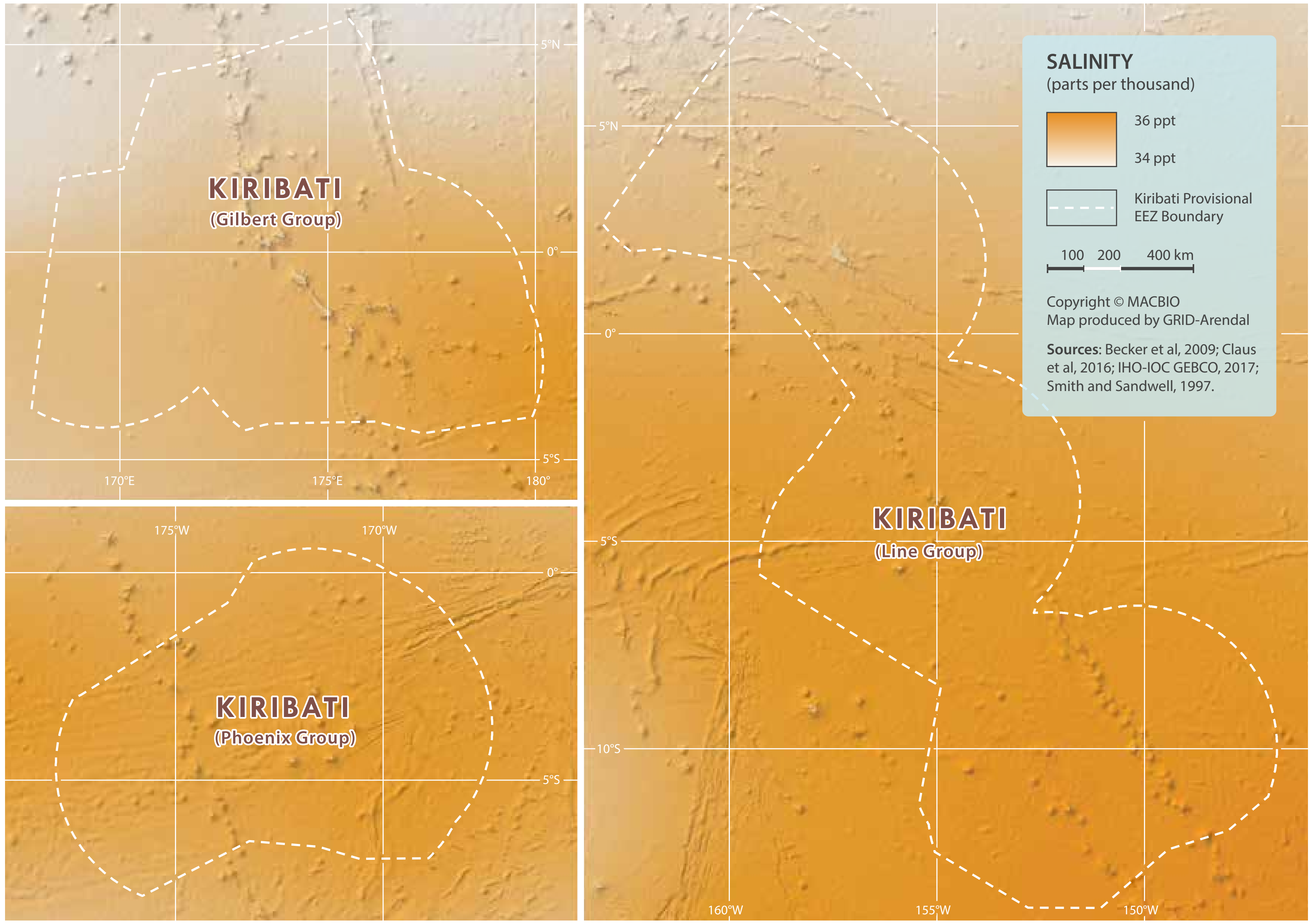


# GO WITH THE FLOW: SALINITY AND SURFACE CURRENTS

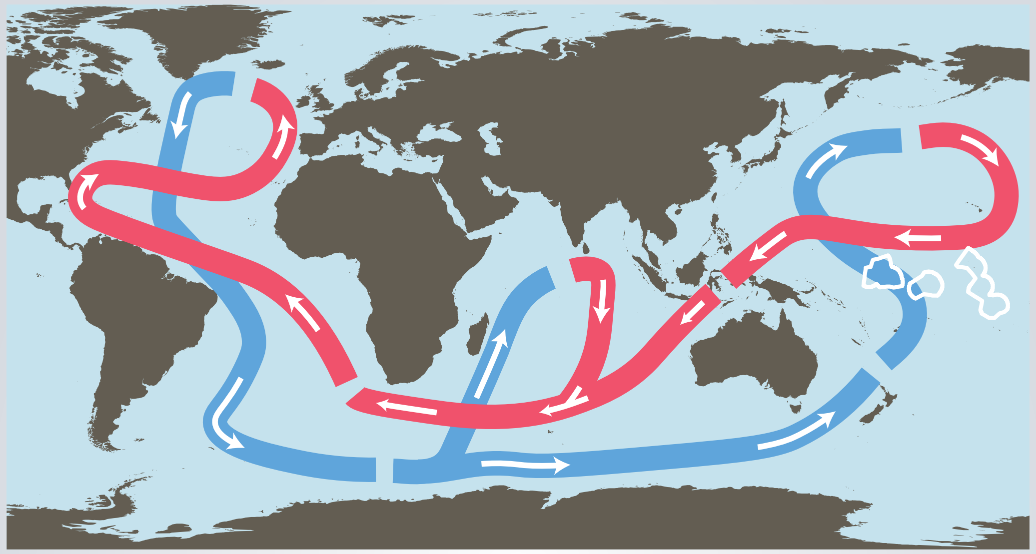
Ocean currents are driven by a combination of thermohaline currents (thermo = temperature; haline = salinity) in the deep ocean and wind-driven currents on the surface. Ocean currents affect climate, the distribution of biodiversity and the productivity of the seas, particularly during extreme El Niño 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 Kiribati's waters has a narrow range—between 34.2 and 35.7. Salinity is highest in the southern parts of the Line Islands, slowly decreasing towards the east, and also in the northern parts of the Line Islands and Gilbert Islands. 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, Kiribati's 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 in the central part of the Line Islands and the Phoenix 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). In the northern part of the Gilbert Islands and the Line Islands, the easterly flowing Equatorial Current is dominant.




## 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 water 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.

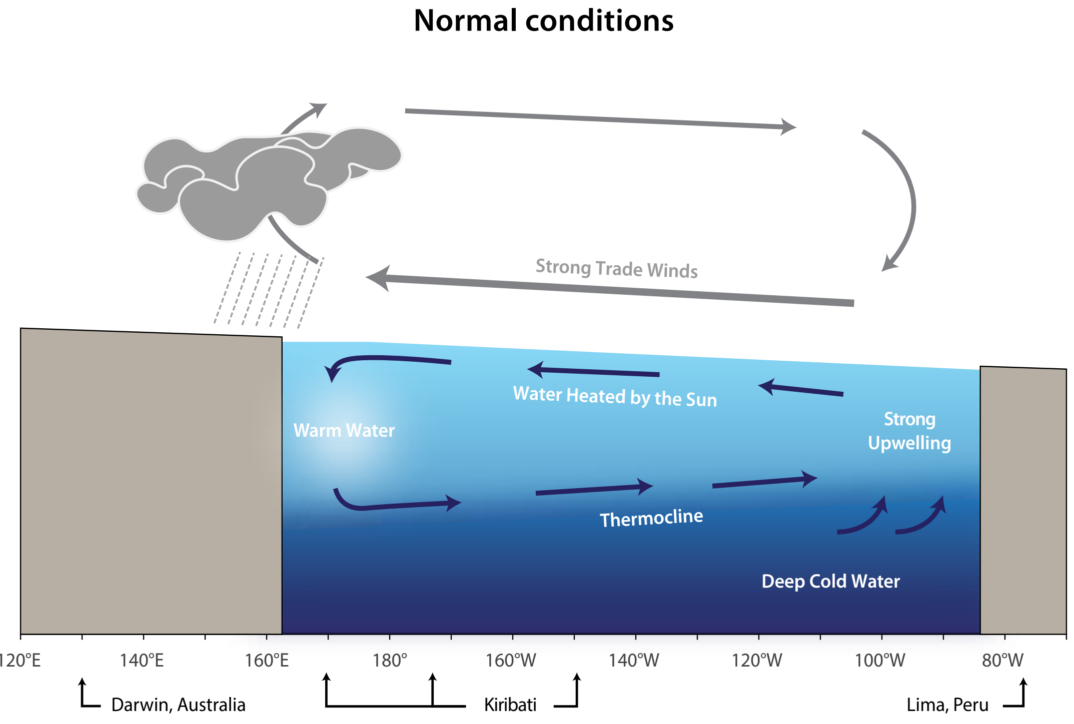
A full circle takes about 1,000 years. No rush at all!

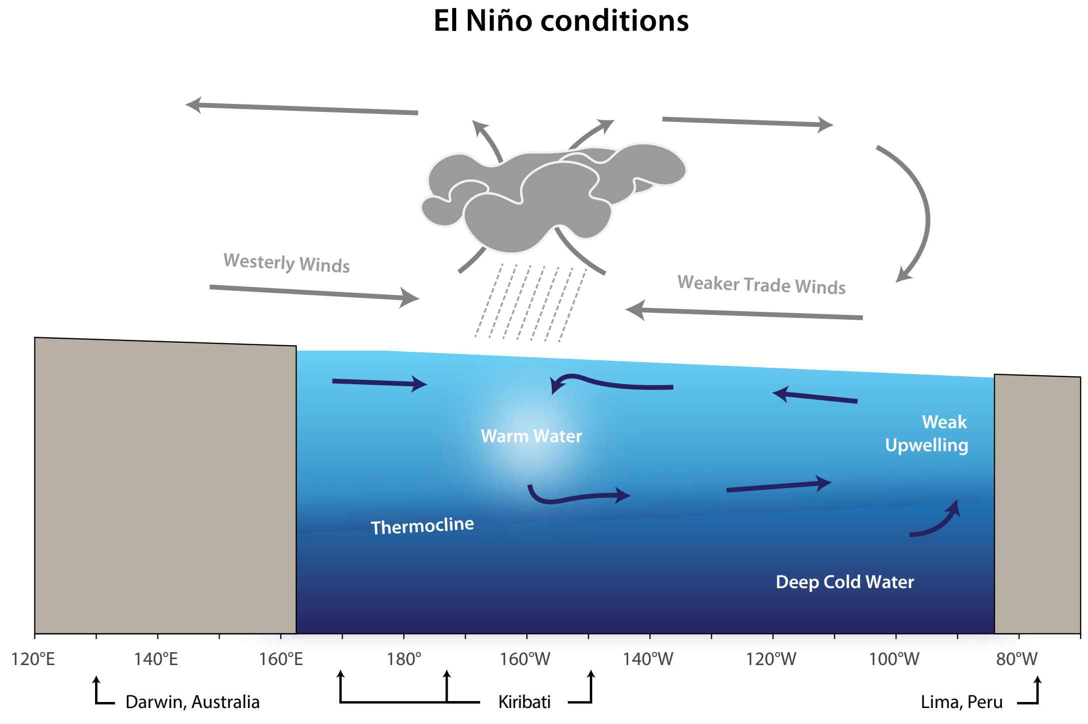
Both kinds of currents—the thermohaline ones in the deep water and the wind-driven one on the surface—are very important to Kiribati. On their journey, water masses transport two things around the globe and through Kiribati's waters. Firstly, matter such as solids, dissolved substances and gases are 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 Kiribati (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).

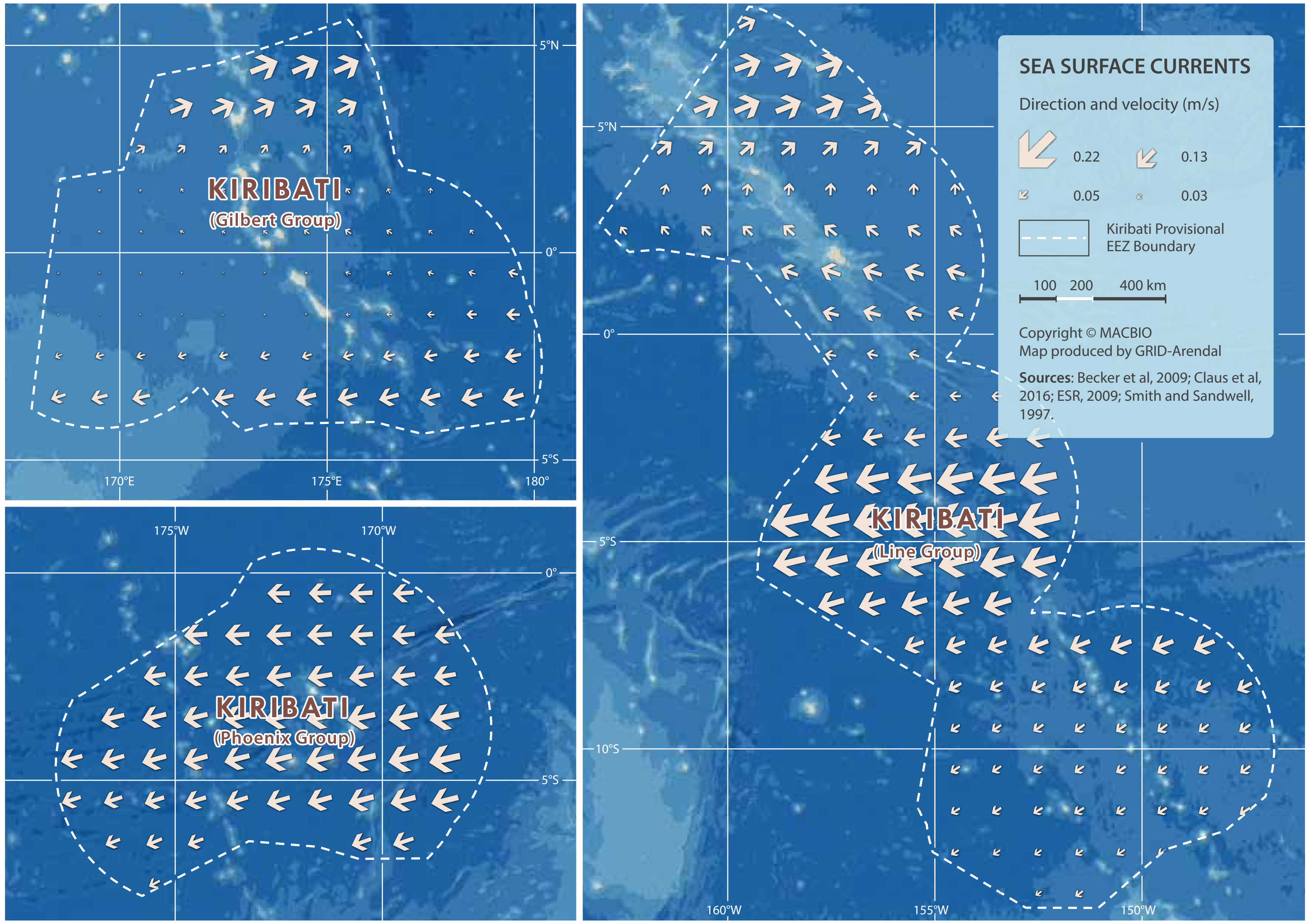
On the other side, the Western Pacific experiences particularly dry conditions.




The periods 1997–1998 and 2014–2016 witnessed some of the most extreme events on record in the region. Average annual rainfall in Kiribati is approximately 2,100 millimetres, with just over 900 millimetres received between May and October. From July 1988 to December 1989, only 205 millimetres of rain fell, while from August 1998 to February 1999, total rainfall was 95 millimetres. However, under climate models, the prevalence of drought is projected to decrease in the future (Australian Bureau of Meteorology and CSIRO, 2014). 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 Kiribati, temperatures are predicted to increase, as is the occurrence of extreme rainfall events (Australian Bureau of Meteorology and CSIRO, 2014).

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



# STIR IT UP: MIXED LAYER DEPTH

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

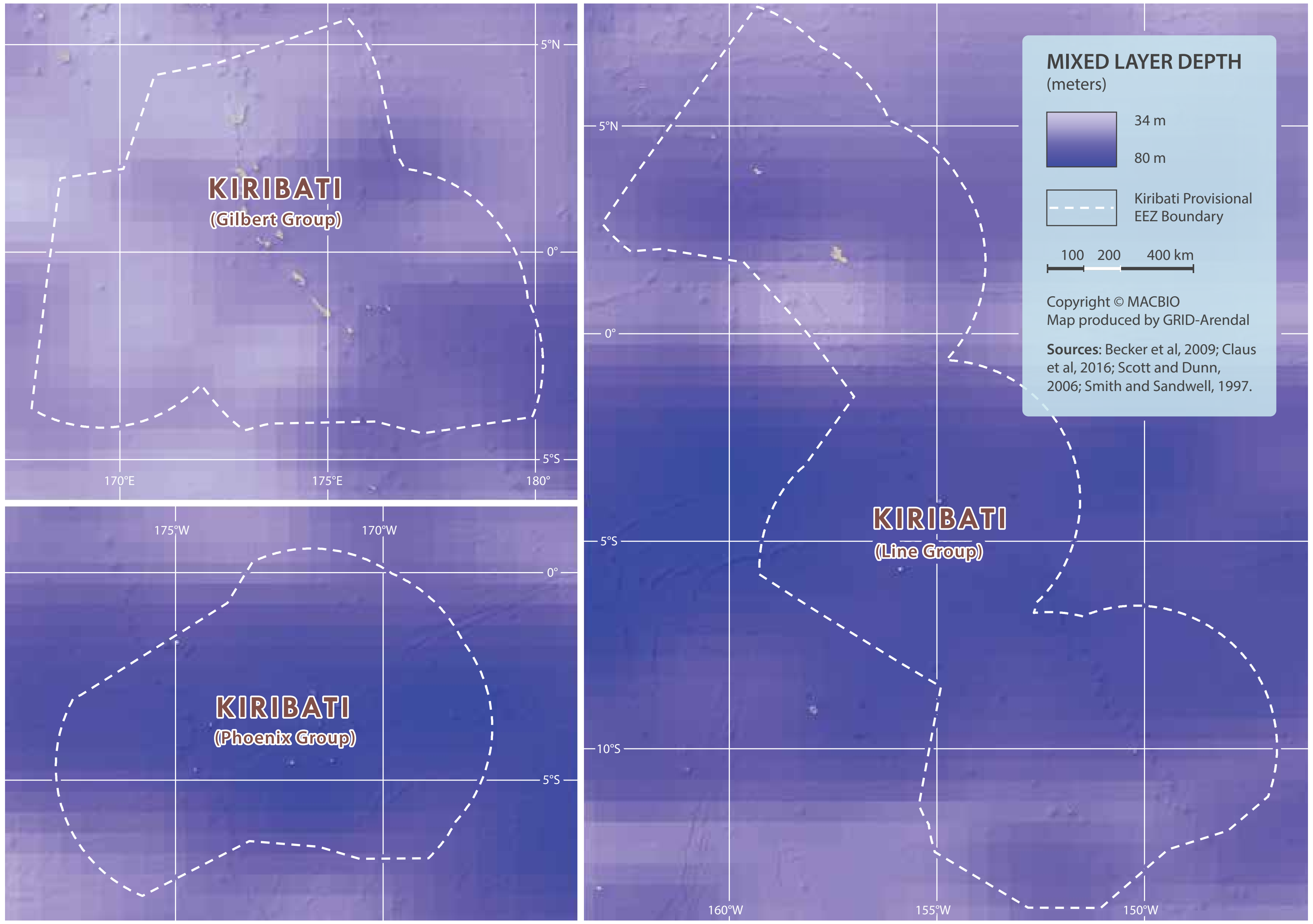
The waters surrounding Kiribati are often choppy and turbulent, creating a 'mixed layer' in the upper portion of sea surface where active air–sea exchanges cause the water to mix and become vertically uniform in temperature and salinity, and thus density.

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 Kiribati's 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").

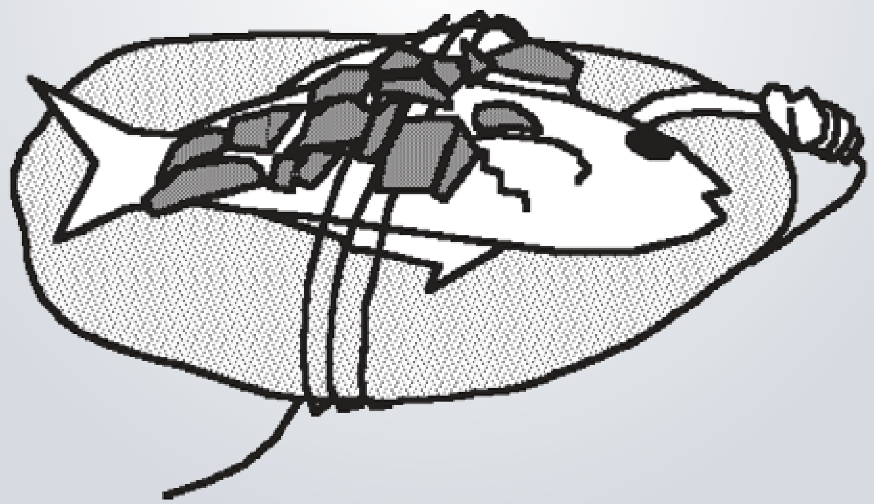
The mixed layer also has a strong influence on marine life, as it determines the average level of light available to marine organisms. In Kiribati and elsewhere in the tropics, the shallow mixed layer tends to be nutrient-poor, with nanoplankton and picoplankton supported by the rapid recycling of nutrients (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 Kiribati's 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 Kiribati's waters ranges from 37 metres to 79 metres, and there is a considerable difference between the three island groups. The shallowest mixed layer depths are found in the Gilbert Islands and the northern part of the Line Islands. The deepest mixed layer depths are found through the centre of the Line Islands and Phoenix Islands. This area corresponds to the strongest sea surface currents from the South Equatorial Current. Globally, mixed layer depths range from 4 metres to nearly 200 metres depth. The deepest mixed layer depths are generally found in the sub-Antarctic regions and the high latitudes of the North Atlantic.

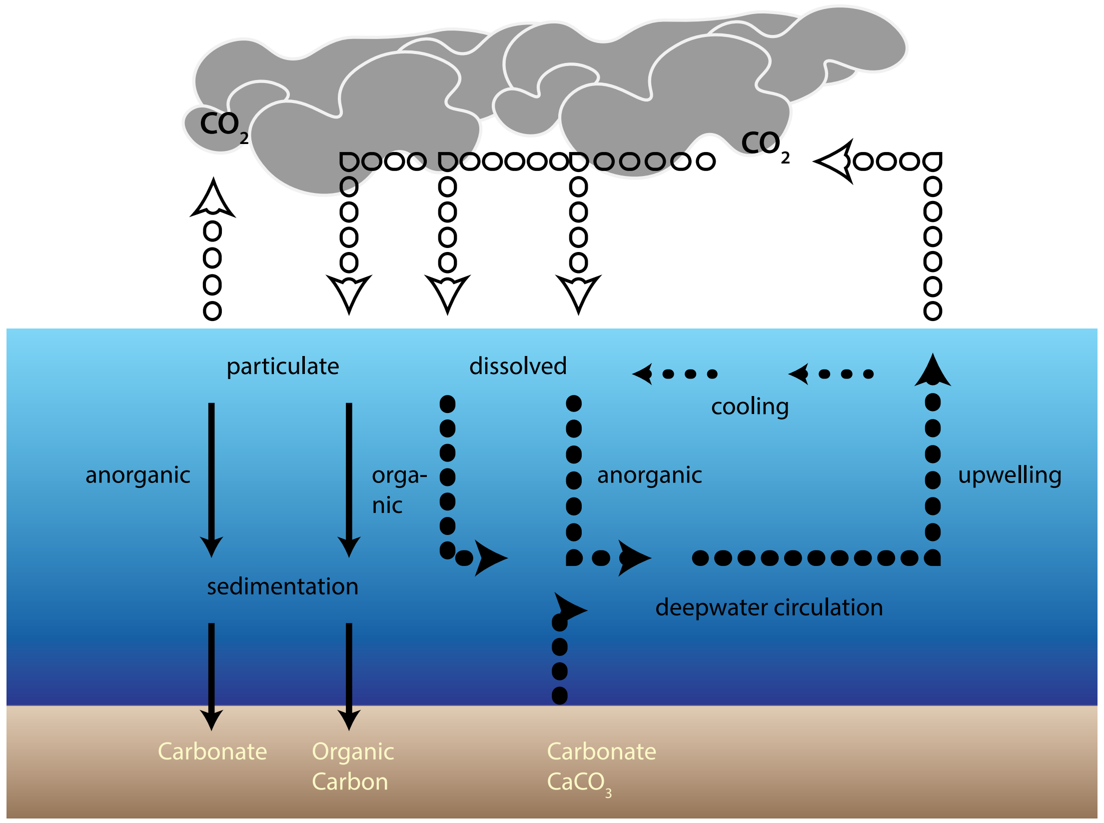



## Getting to the lower layers

Local fishermen in the southern islands are well known for the type of vertical tuna longlining known as drop-stone fishing, or Te kabwara, in Kiribati. With their small canoes, they travel to the outer reef where they employ this technique to catch tuna in the deep ocean. The technique involves a long, flattish stone weighing 1–2 kilograms, around which a wire trace with baited hook is wrapped several times and tied with a quick-release knot. This allows the fishermen to get the baited hook down to the required depth and then release the stone, so that the hook hangs free. This method often uses chum, or finely chopped bait, to attract tuna at specific depths. The ingenuity of this technique is not only in the manufacturing of the gear itself, but in the very sophisticated understanding of the depths of the ocean as well as the mixed layer depth on any given day. Only in this way can fishermen find the right depth for specific species of tuna, be it yellowfin, skipjack or albacore.



# PUMP IT: PARTICULATE ORGANIC CARBON FLUX




Kiribati's 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.

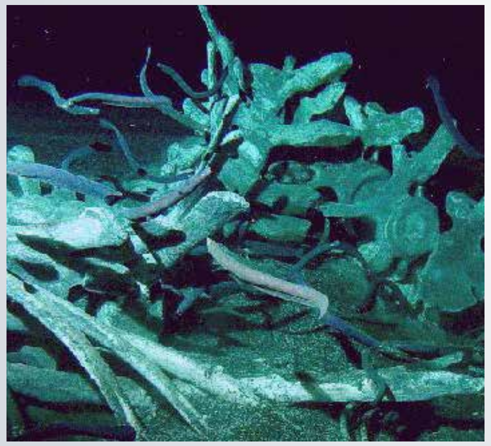
Kiribati's ocean pumps are measured by particulate organic flux (the total amount of organic carbon reaching the sea floor) as seen on the map. Organic detritus passing from the sea surface through the water column to the sea floor controls nutrient regeneration, fuels benthic life and affects the burial 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.

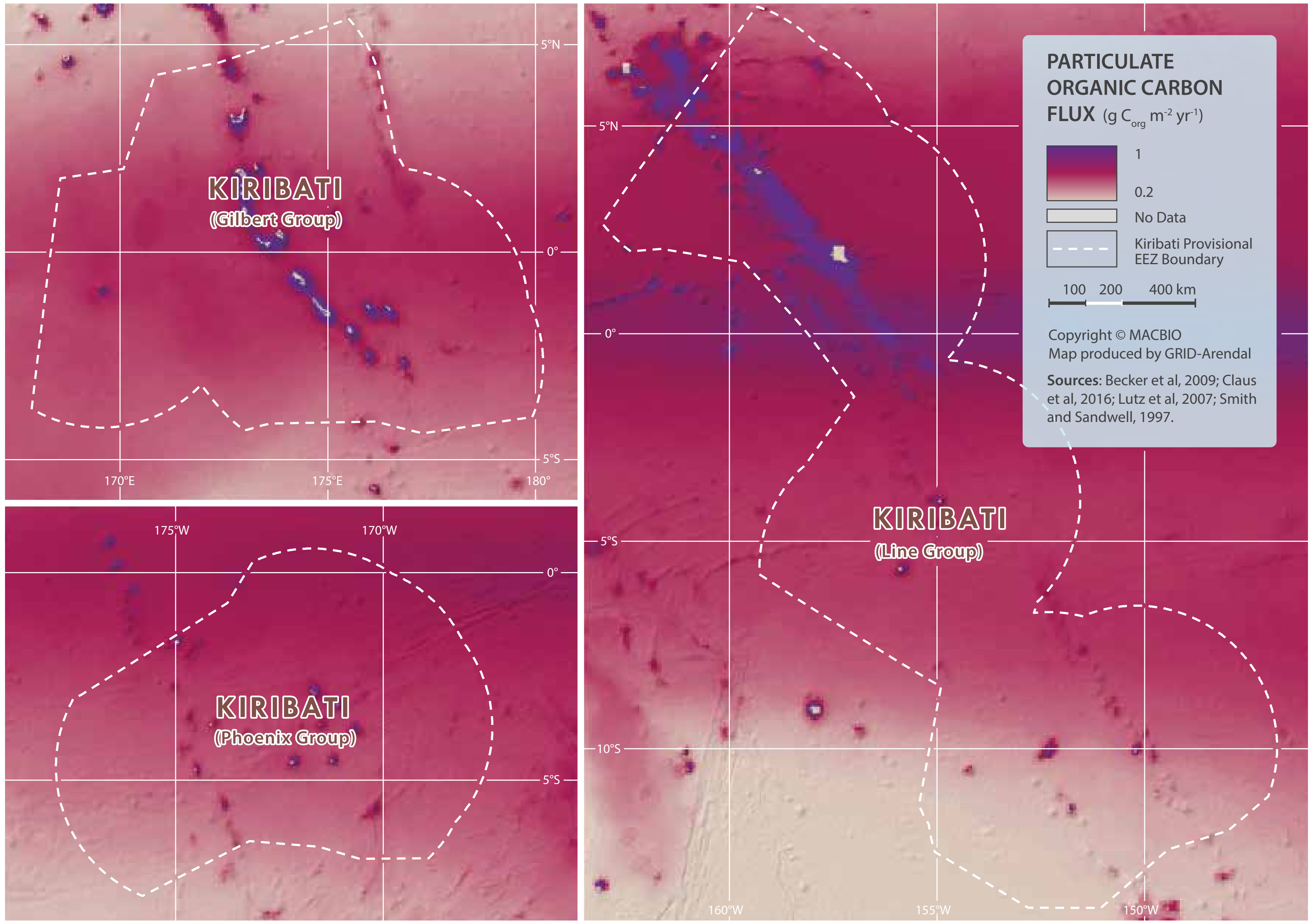
In fact, Kiribati's ocean pumps are a key part of blue carbon—the carbon captured by the world's oceans and coastal ecosystems. The carbon captured by living organisms in the oceans is stored as biomass and can be trapped in sediment. Key carbon-capturing ecosystems include mangroves, salt marshes, seagrasses and potentially algae (see also chapter "Home, sweet home"). The social benefit of carbon sequestration, plus the avoided emissions in the oceanic waters of Kiribati's EEZ, is very high.

The patterns of particulate organic carbon flux in Kiribati's waters closely reflect the depth of the sea floor, with higher rates in the shallow water compared with the deep. There is also a trend for slightly higher particulate organic carbon flux in the northern part of the Line Islands. Particulate organic carbon flux is low throughout the majority of Kiribati's 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 generally above 10 grams/m2/year and up to a maximum of 22 grams/m2/year.

## Whale falls

Whales cross Kiribati's waters and have an important role in the marine food chain. This is true even after they have died. 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).





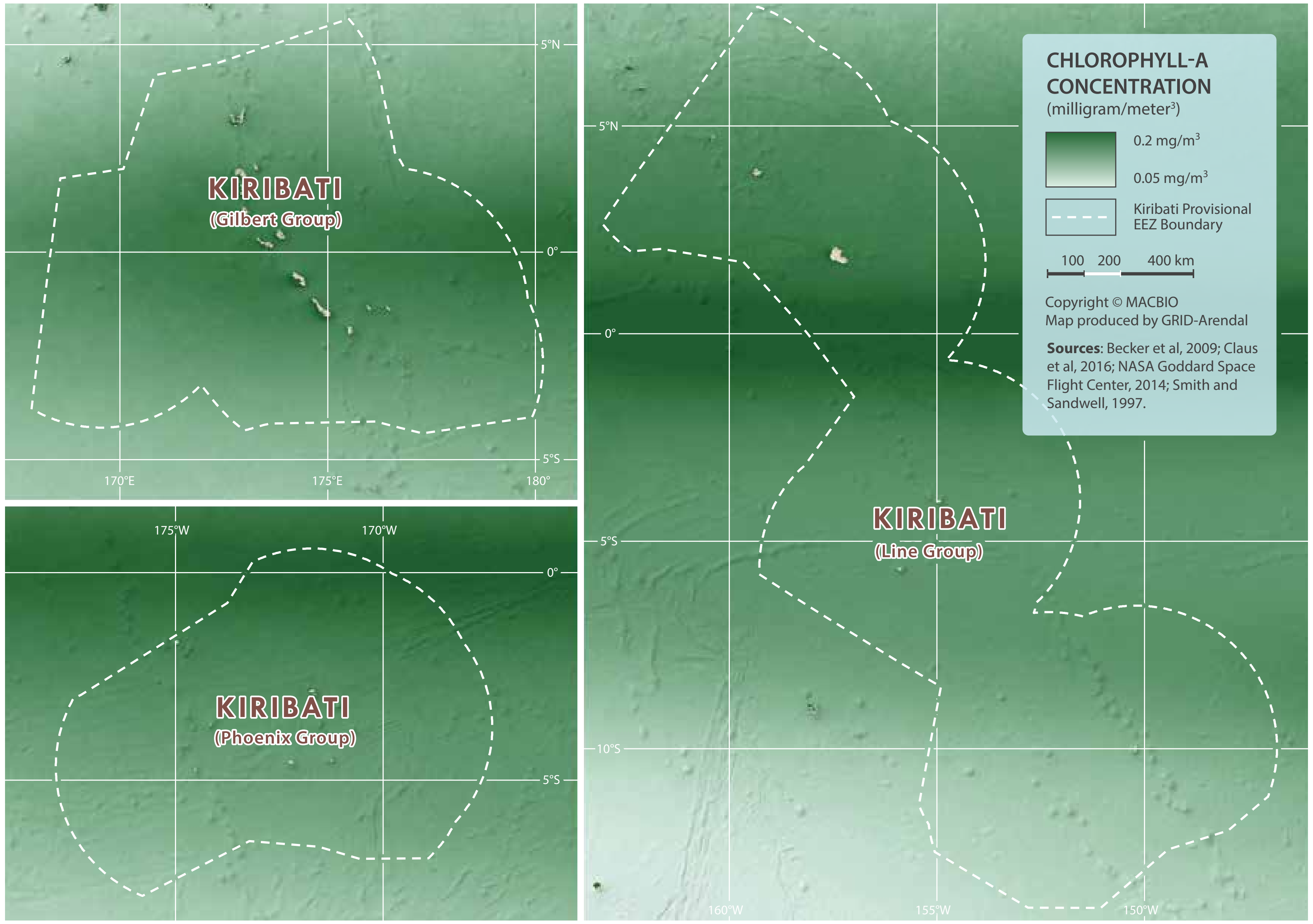
# SOAK UP THE SUN: PHOTOSYNTHETICALLY AVAILABLE RADIATION

The amount of light available in Kiribati's 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 Kiribati's 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 Kiribati's 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, photosynthetically available radiation is moderately high in Kiribati's waters and mirrors the global pattern, with higher amounts in parts of Kiribati's waters along the equator (0 degrees), and decreases to the north and south. Within this overall trend, there are other variations: for example, photosynthetically available radiation is higher in the easterly islands of




## Ocean gardens

For plants to thrive, they need three things: water, sunlight and nutrients. In Kiribati's sea, the first is obviously not an issue. The second is also not a problem, with the sun shining on Kiribati's 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 Kiribati.

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 Kiribati's 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 Kiribati's 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).

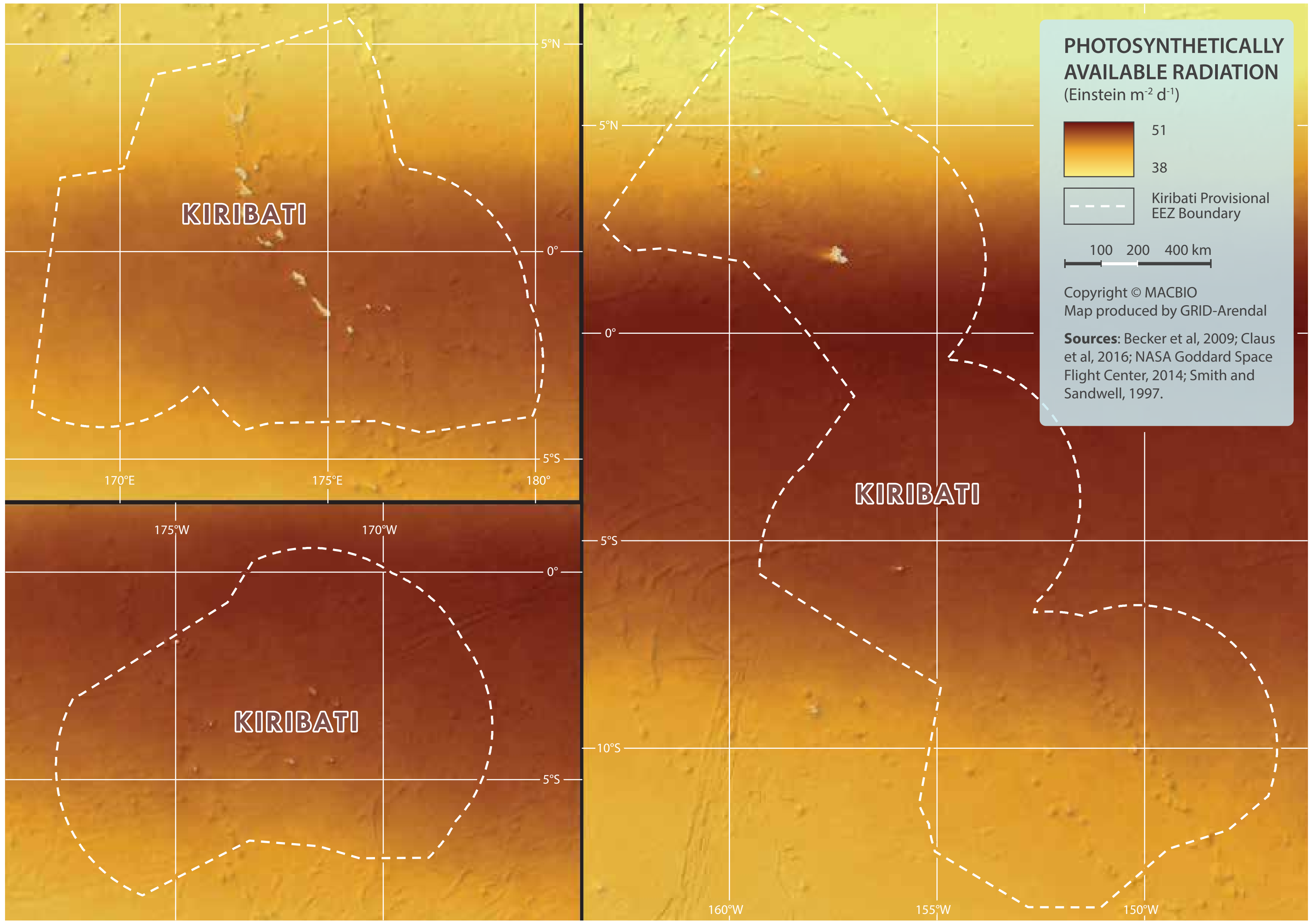
the Line group, and decreases to the west, with lower maximum values in the Gilbert Islands. This is a reflection of the local climatic conditions, with the predominantly easterly trade winds (see also chapter “Go with the flow”) resulting in changes in increasing cloud cover from east to west.

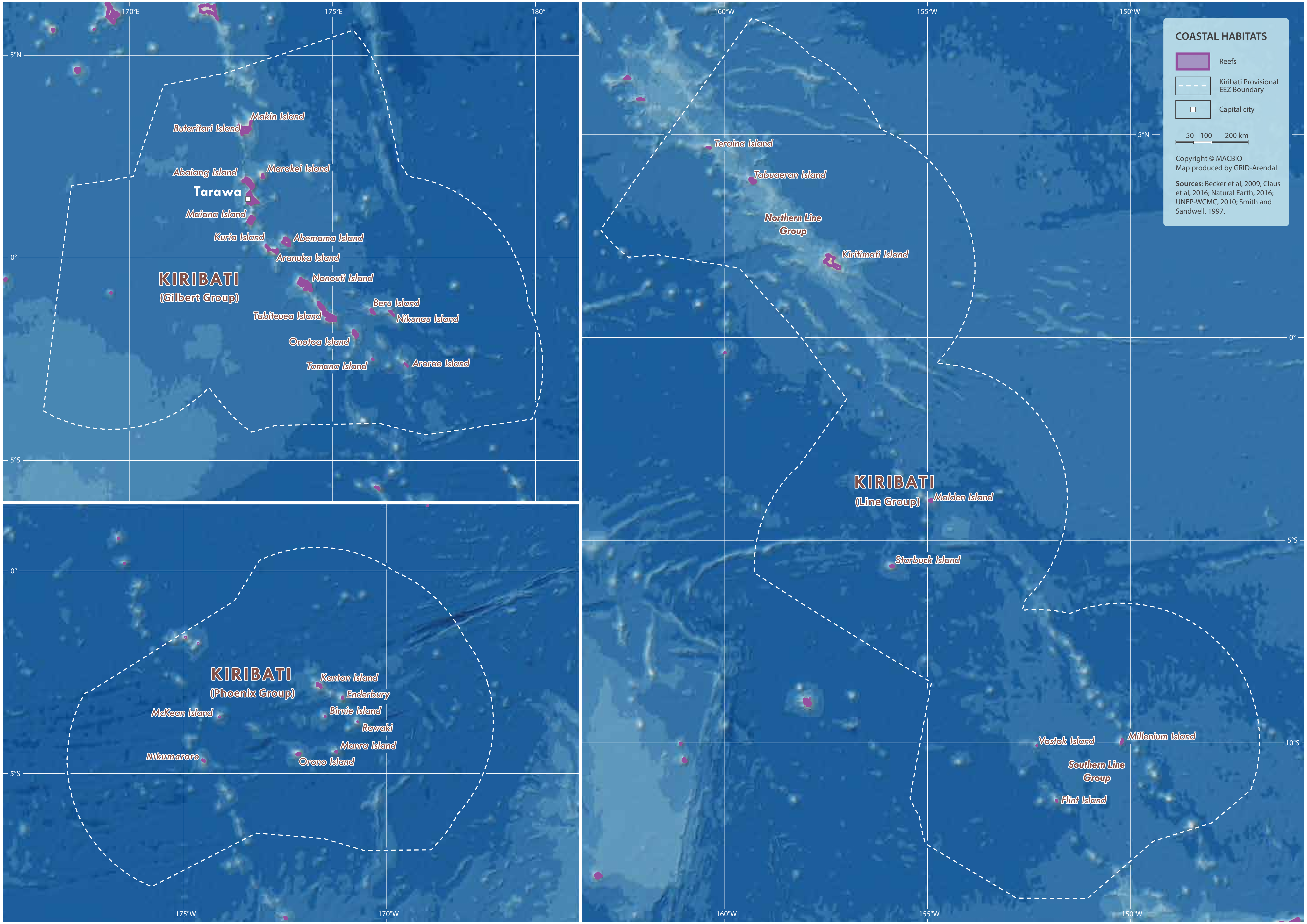
There is seasonal variation in photosynthetically available radiation in Kiribati. The greatest variation occurs away from the equator, in the southern areas of the three island groups. There is also greater variability in photosynthetically available radiation in the Gilbert group compared with the other two island groups. This is in part due to changes in atmospheric conditions, such as cloud cover. In Tarawa, the average percentage of the sky covered by clouds experiences significant seasonal variation, with the cloudiest days occurring from December to March and the least cloudy days occurring from April to November.

The chlorophyll-a concentration in Kiribati’s waters is generally very low, with concentrations in the offshore waters less than 0.15 grams 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 Tonga have increased chlorophyll-a concentrations, with up to 3–5 grams per m3 of seawater in some of the coastal areas of the Gilbert Islands. 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 Kiribati’s waters reflect the low availability of key nutrients. Compared to large continental landmasses, with large river discharges that can carry nutrients into the sea, Kiribati 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.

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 Kiribati or Tonga. The annual variation in chlorophyll-a around Kiribati up to 5 grams per m3 of seawater in some coastal areas.

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




170°E
175°E
180°
5°N
0°
5°S
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Tabiteuea Island
Nikunau Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Manra Island
Nikumaroro
Orono Island
175°W
170°W
160°W
155°W
150°W
Teraina Island
Tabuaeran Island
Northern Line
Group
Kiritimati Island
KIRIBATI
(Line Group)
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line
Group
Flint Island
10°S
COASTAL HABITATS
Reefs
Kiribati Provisional EEZ Boundary
Capital city
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Natural Earth, 2016; UNEP-WCMC, 2010; Smith and Sandwell, 1997.

# OCEAN VALUES

# HOME, SWEET HOME: COASTAL HABITATS

Kiribati's 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 Kiribati's 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 Kiribati's 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 Kiribati's coastal habitats.

Marine and coastal ecosystems provide a number of valuable services to Kiribati, a key one of these being coastal protection, which has two components: the prevention of erosion and the mitigation of storm surges. Healthy coastal ecosystems prevent coastal erosion by reducing the effects of waves and currents and they also help regulate the removal and deposition of sediment (erosion and accretion). They also 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.

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.

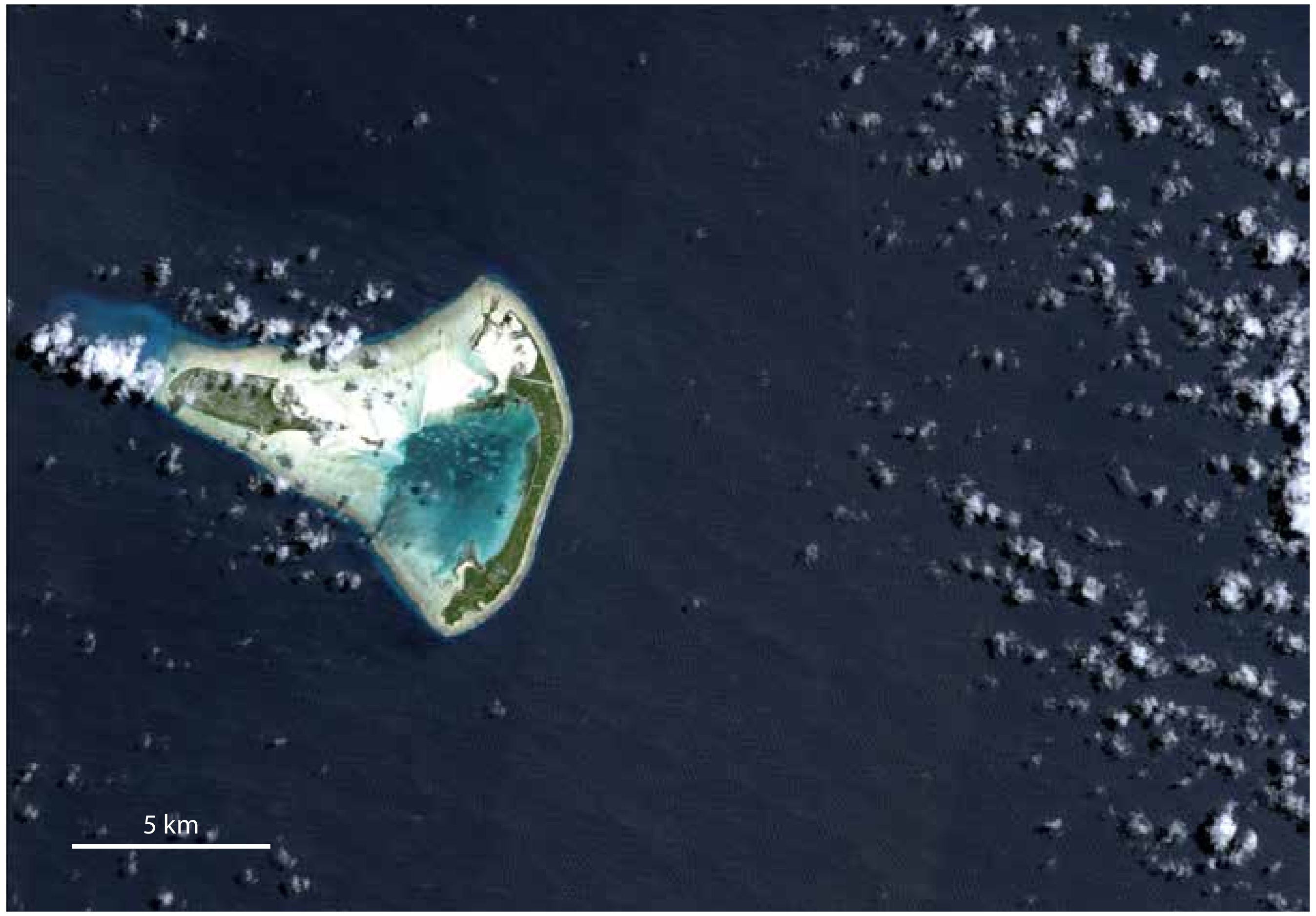
The role of mangroves in coastal stabilization is well known. They protect coastal areas from erosion, storm surges (especially during cyclones) and tsunamis. Their massive root systems are efficient at dissipating wave energy and slow down tidal water so that suspended sediment is deposited as the tide 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, Kiribati's coastal habitats also act as nursery areas for fish and support food security, livelihoods, tourism and other human activities. Seagrass meadows and mangroves are also recognized as important carbon stores, with the preservation of healthy mangrove systems contributing to climate change action. There are around 258 hectares of mangroves in Kiribati (Ellison, 2009), with four types of mangroves, namely Te Nikabubuti (white mangrove), Te Aitoa (black mangrove), Te Tongo Buangi (oriental mangrove) and Te Tongo (red mangrove). Mangroves are found on many of Kiribati's islands, however, there is limited detailed information on their distribution. They are being planted as part of the Environment and Conservation Division and the Kiribati Adaptation Program – Phase III to enhance coastal protection. But while coastal habitats are some of the most productive and valuable marine habitats, they are by the same token some of the most vulnerable to human activities (see also chapters "Reefs at risk" and "Turning sour").

As described, three of the key coastal habitats in Kiribati are coral reefs (see also chapter "Shaping Pacific Islands"), seagrasses and mangroves. 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. And Kiribati is a nation of corals—the islands are either surrounded by fringing reefs or built as coral atolls, making reefs an important coastal habitat.

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. There is limited information on the distribution of seagrass beds in Kiribati, with one to two species present in the country (Brodies and N'Yeurt, 2018). Seagrass has been documented from Abaiang, Abemama, Kuria and Kiritimati (Awira et al., 2004). Seagrass maps have not been presented in the map of coastal habitats as there are currently no publicly available data that adequately capture the distribution of seagrass in Kiribati.



*Fringing reef of Aranuka*

*Barrier reef south of Abaiang Island*

*Atoll Abemama*

*Patch reef west of Kiritimati*

# SHAPING PACIFIC ISLANDS: CORAL REEFS

Kiribati's reefs are not only important coastal habitats; they are also transforming and shaping Kiribati's coastlines, islands and atolls.

Corals play a fundamental role in the development of island nations such as Kiribati, with coral reefs having helped transform and shape the very outline of Kiribati's 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. 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).

Kiribati consists of 33 islands or island systems that straddle a vast swathe of the Pacific from east to west. These islands and island systems are typically atolls with coral reefs encircling lagoons, although there are also examples of fringing and submerged coral reefs in Kiribati (Spalding et al., 2001). In total, Kiribati has around 2,940 km2 of coral reef, which is nearly three times its total land area of 1,050 km2 (Spalding et al., 2001). There are trends in coral diversity in the island groups of Kiribati from east to west that reflect the broader regional trends in coral diversity. For example, there is diminishing species diversity from west to east, with 115 species of hard corals recorded from Tarawa and Abiang Atolls in the west and only 71 at Tabuaeran in the east (Spalding et al., 2001).

The maps show examples of the four prevailing reef types in Kiribati:

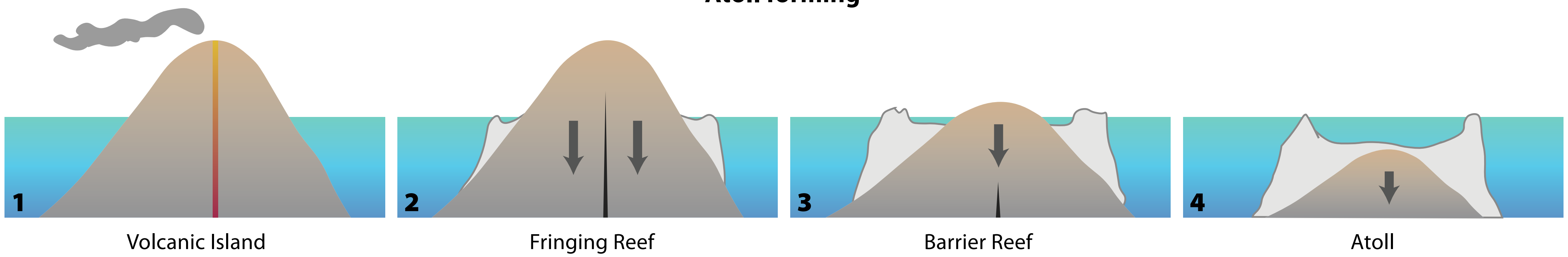
- *Fringing reef* (e.g. east of Buariki): Directly attached to a shore or borders it with an intervening shallow channel or lagoon.
- *Barrier reef* (e.g. south of Abaiang Island): Separated from a mainland or island shore by a deep channel or lagoon.
- *Atoll reef* (e.g. Atoll Binoinano): More or less circular or continuous barrier reef that extends all the way around a lagoon without a central island.
- *Patch reef* (e.g. west of Kiritami): Common, isolated, comparatively small reef outcrop, usually within a lagoon or embayment, often circular and surrounded by sand or seagrass.

The major reef types are atoll reefs, which have created many of the islands of Kiribati, and fringing reefs along the coast of some of the larger raised islands.

## Underwater rainforests

Kiribati's sea features the proverbial "rainforests of the sea", coral reefs. These reefs are rich in biodiversity and harbour many more plants and animals than Kiribati's forests above sea level. Such a diverse ecosystem is very valuable to Kiribati, providing habitat, shelter and tourism opportunities (see also chapters "Home, sweet home" and "Beyond the beach").

**Atoll forming**



# TRAVELLERS OR HOMEBODIES: MARINE SPECIES RICHNESS

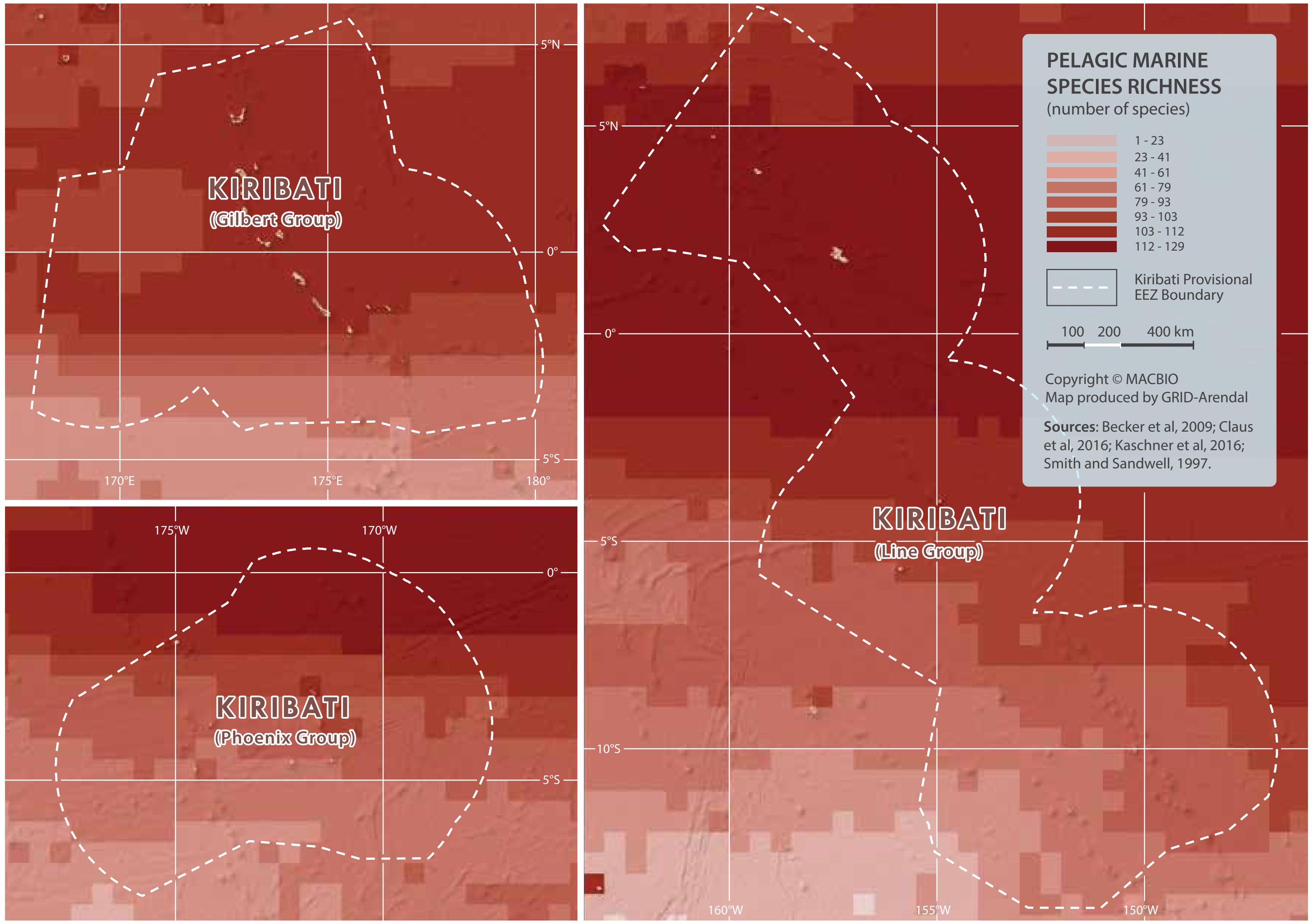
Kiribati's marine environment hosts two types of animals: pelagic species and benthic species, both of which are important and biologically interconnected.

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 are either attached to the substrate or very site-specific.

Both pelagic and benthic species contribute to Kiribati's rich marine biodiversity, are part of complex food chains, and form important habitats. Furthermore, many commercially important species of both types are found in Kiribati's waters. Commercially important pelagic species include several species of tuna, such as albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) tuna, and several important commercial billfish species, such as blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*) and swordfish (*Xiphias gladius*). There are also some pelagic shark species, which are now protected by the world's second largest shark sanctuary and a ban on commercial shark fishing within the entire Kiribati EEZ. 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.

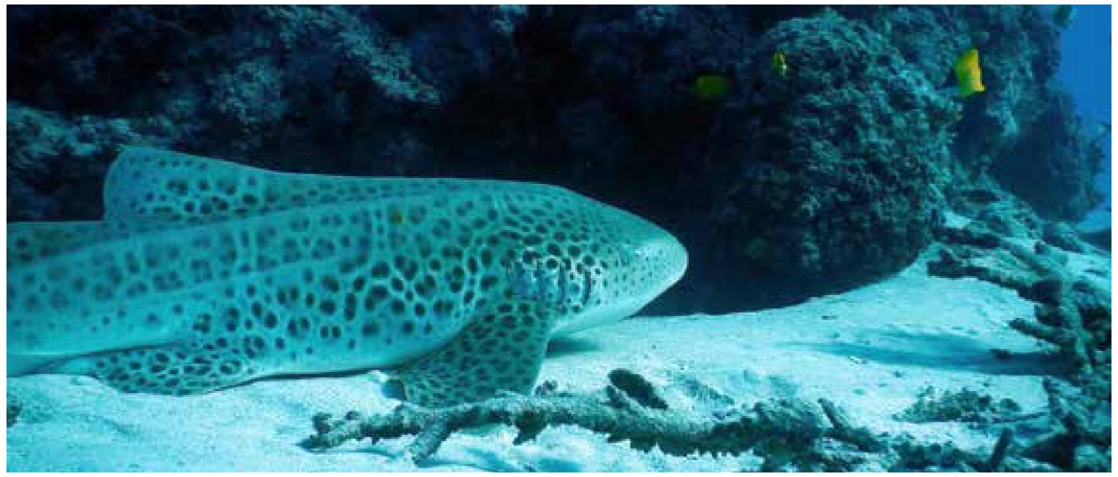
As for Kiribati's numerous benthic species, many invertebrates (those without a backbone) are found in soft sediment habitats. According to the Ocean Biogeographic Information System, Kiribati has at least 84 species of corals, 68 species of bivalves (such as oysters and mussels) and 261 species of gastropods (such as snails and slugs), 300 species of crustaceans (such as crabs, lobsters and shrimps) and 68 species of echinoderms (including starfish, sea urchins and sea cucumbers). Many benthic species form habitats in Kiribati's 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 species composition, nor does it identify whether there are rare or priority species in an area. Further, areas with similar species richness may have very different species present, which would affect the conservation and management measures required.

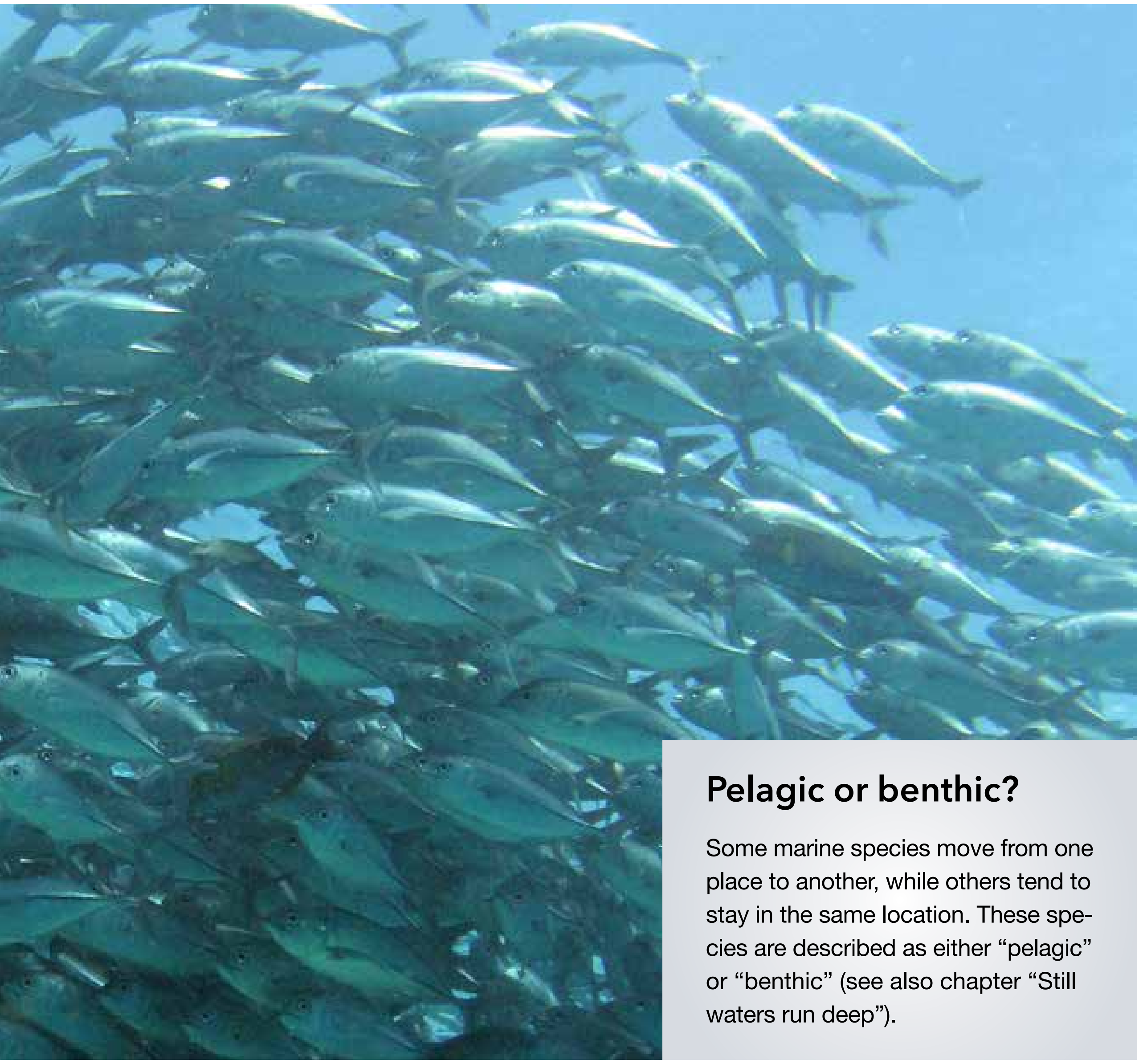



Globally, pelagic fish are generally more abundant in tropical waters and decrease as latitude increases. As the map shows, within Kiribati's waters, the highest species richness is along the equator, with lower species richness to the north and south of the equator (see also chapter "Voyage to the bottom of the sea"). Generally, large geographic features that rise off the sea floor interact with currents (see also chapter "Go with the flow"). Pelagic fish abundance and biomass can, therefore, peak deep in the water column in association with abrupt bathymetric features such as seamounts and mid-ocean ridges (Sutton et al., 2010). Furthermore, migrating species, including whales, frequently pause over seamounts and other shallow geographical features (Garrigue et al., 2015). However, there is likely to be a lower density of sampling in Kiribati than many other areas of the world due to its remoteness, which may result in an underestimation of distribution of species richness.

Similarly, tropical waters tend to have a higher benthic species richness than waters at higher latitudes. Again, in Kiribati's waters, there is a trend for higher benthic species richness close to the equator, decreasing to the north and south. Benthic species richness is usually higher in shallow water compared with deep water; however, this trend is less apparent in Kiribati due to the lack of sample data.

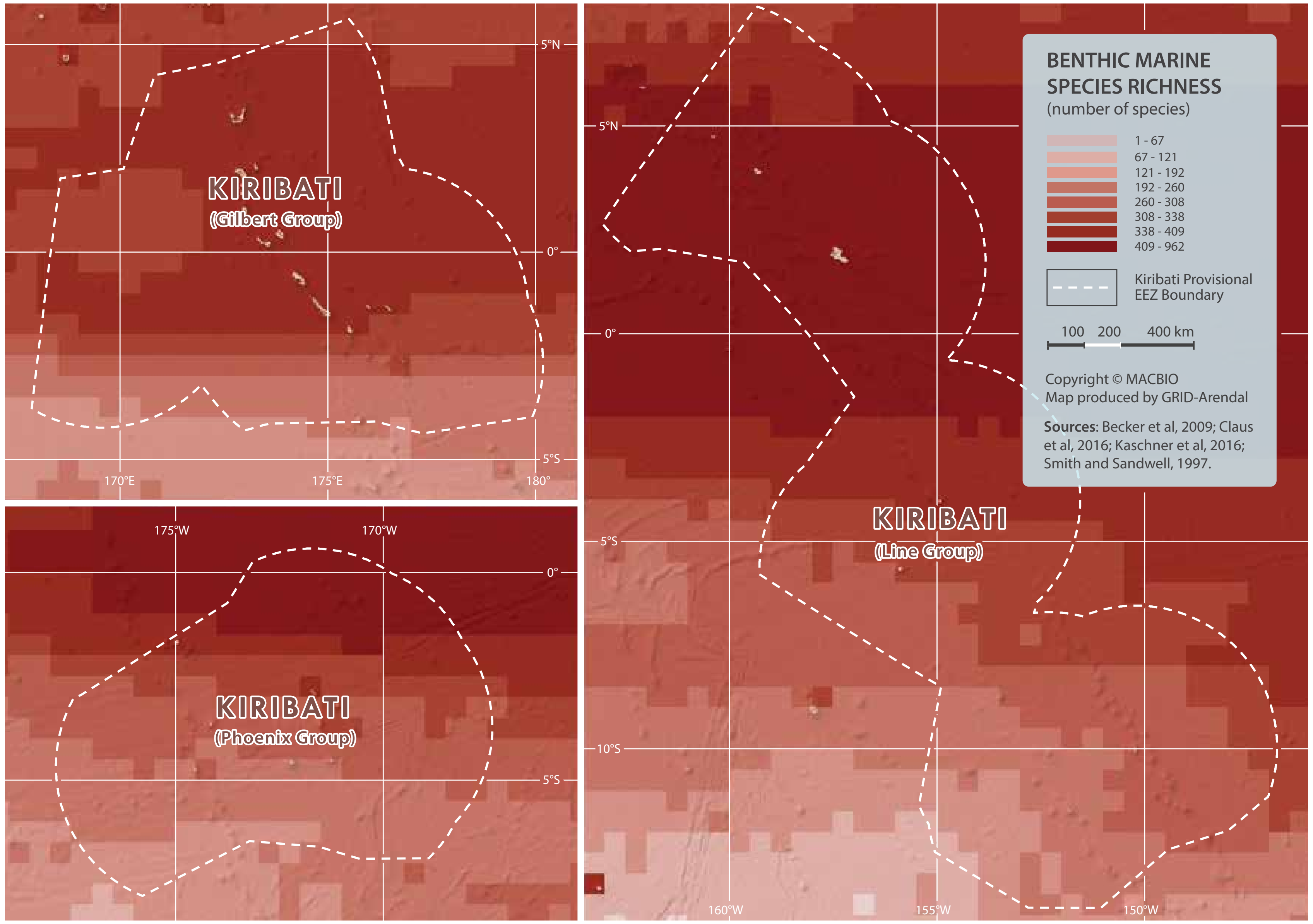


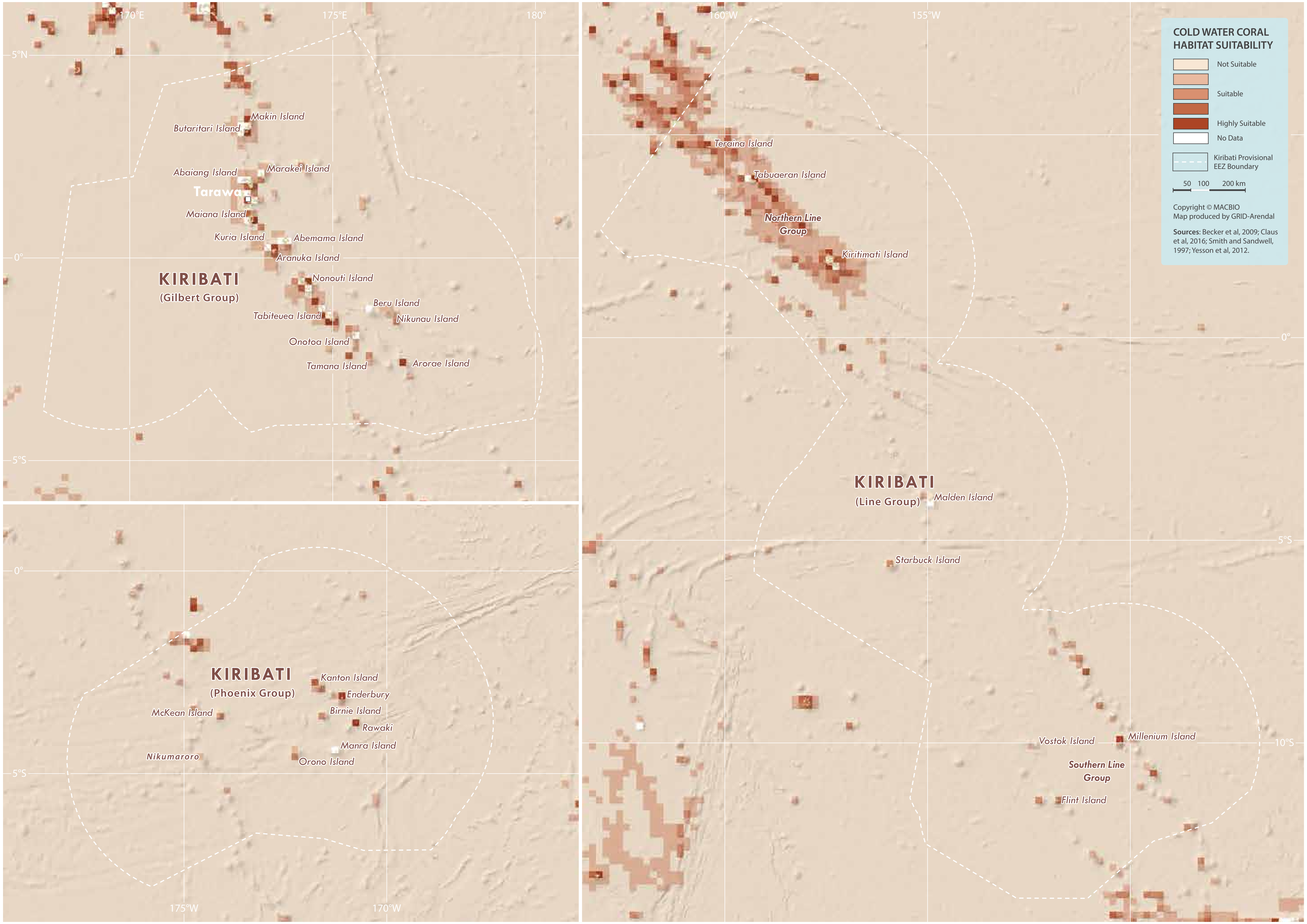
*The Zebra shark is found throughout the tropical Pacific, but listed as endangered species.*



## 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
Kiribati Provisional EEZ Boundary
50 100 200 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.
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orono Island
McKean Island
Nikumaroro
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island
170°E
175°E
180°
160°W
155°W
175°W
170°W
5°N
0°
5°S
10°S

# HOW MUCH DO WE REALLY KNOW? COLD WATER CORAL HABITATS

Although cold-water corals can be common and important deep-sea species, little is known about their distribution and abundance in much of Kiribati's waters, except for the PIPA. 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 Kiribati's 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. Deepwater or 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 Kiribati, although some coral species have a value for 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.

The map shows the predicted suitability of habitat where octocoral species could occur. Octocorals are a highly diverse group, with soft corals, gorgonians, sea fans, sea whips, sea feathers, precious corals, pink coral, red coral, golden corals, bamboo corals, leather corals, horny corals and sea pens among their estimated 2,000-plus species (Roberts et al., 2009). Globally accessible data for offshore corals are sparse in many Pacific Islands, including a large proportion of Kiribati's waters. The Phoenix Islands area has been relatively well studied. A number of recent voyages by the National Oceanic and Atmospheric Administration (NOAA) vessel Okeanus Explorer (as part of the CAPSTONE programme) and the Schmidt Ocean Institute's RV Falkor (Raineault et al., 2018) set out to survey new seamounts and have taken extensive video footage and several hundred samples of cold-water corals. When fully processed and analysed, these data will hugely boost the knowledge of corals in the region. However, at present, owing to the limited data, habitat suitability modelling has been used to predict the likely occurrence of corals in the area.

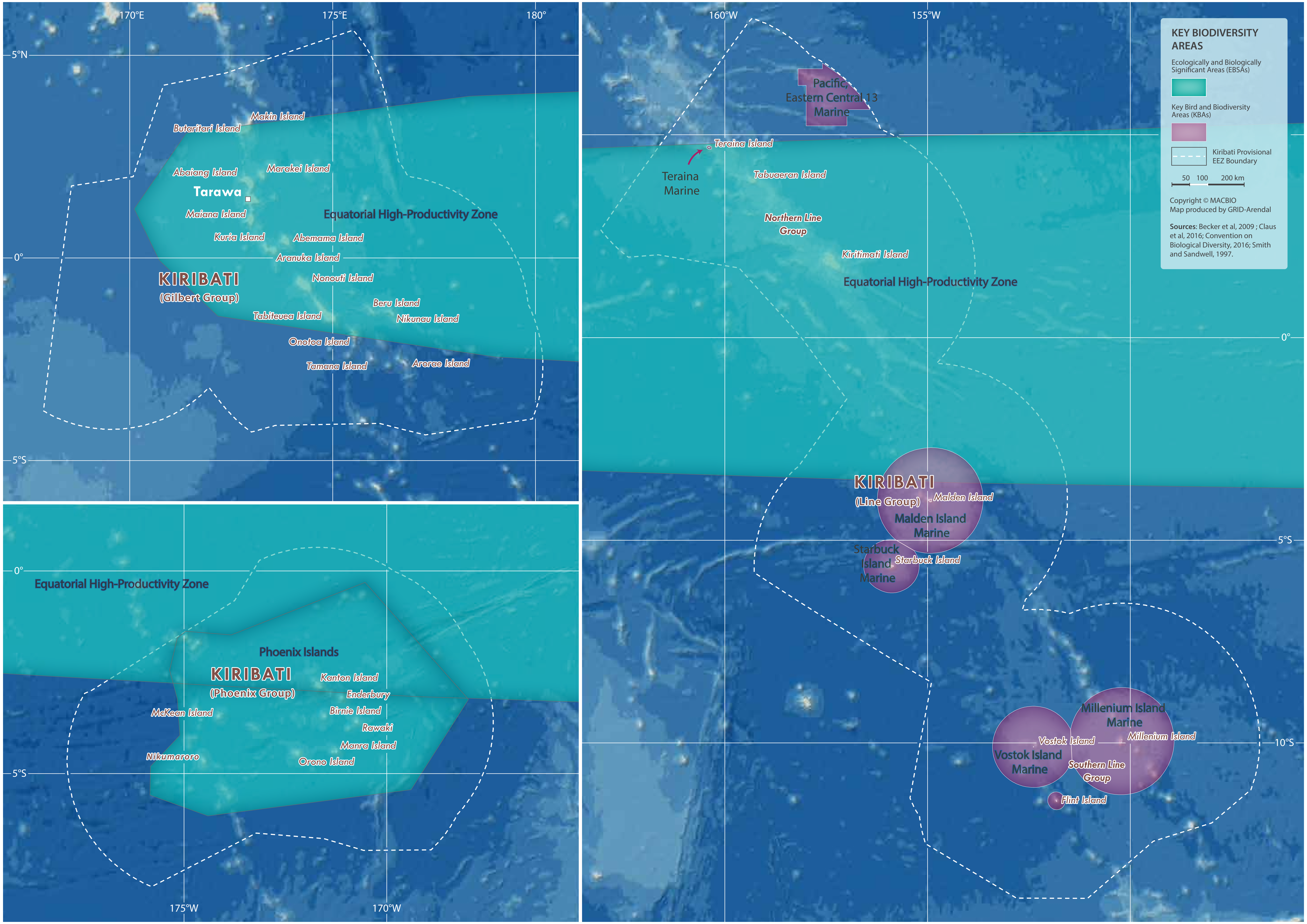
Habitat suitability was highest along the major island slopes in each sector of Kiribati. The northern Line Islands, as well as the Gilbert group, had high habitat suitability close to the islands. There were also high predicted occurrences on seamounts in the Line Islands and Phoenix Islands EEZs. However, bathymetry is poorly known in this region; following recent work in the PIPA, new seamount features were located in 2017. The distribution shown in the maps largely reflects the depth of the seafloor, with topography also a factor. These deeper slope and seamount features are shallower than much of the abyssal plains, with higher food availability for the corals. The steep topography provides hard rocky substrate, which the corals need for attachment; it also elevates them from surrounding sediment for feeding.

*The bamboo coral Keratoisis grandiflora, which has been recorded in Kiribati's waters.*

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 in Kiribati's waters.

Cold-water corals are widely regarded as being susceptible to damage from human activities, such as direct effects from fishing and deep-sea mining (with potential for cobalt-rich ferromanganese crust in Kiribati) as well as more indirect impacts from pollution and climate change. 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, or changing environmental conditions, is slow. This could have long-term effects on deep-sea ecosystems. Octocorals are one of the groups that the Food and Agriculture Organization of the United Nations (FAO) lists as potentially Vulnerable Marine Ecosystems (FAO, 2009), and which are required under United Nations resolutions to be protected from deep-sea fishing.

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.


170°E
175°E
180°
5°N
0°
5°S
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Equatorial High-Productivity Zone
Kuria Island
Abemama Island
Aranuka Island
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Tabiteuea Island
Nikunau Island
Onotoa Island
Tamana Island
Arorae Island
0°
5°S
Equatorial High-Productivity Zone
Phoenix Islands
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
McKean Island
Birnie Island
Rawaki
Manra Island
Nikumaroro
Orona Island
175°W
170°W
160°W
155°W
Pacific Eastern Central 13 Marine
Teraina Island
Teraina Marine
Tabuaeran Island
Northern Line Group
Kiritimati Island
Equatorial High-Productivity Zone
0°
KIRIBATI
(Line Group)
Malden Island
Malden Island Marine
5°S
Starbuck Island Marine
Starbuck Island
Millenium Island Marine
Vostok Island
Millenium Island
10°S
Vostok Island Marine
Southern Line Group
Flint Island
KEY BIODIVERSITY AREAS
Ecologically and Biologically Significant Areas (EBSAs)
Key Bird and Biodiversity Areas (KBAs)
Kiribati Provisional EEZ Boundary
50 100 200 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.

# NATURE'S HOTSPOTS: KEY BIODIVERSITY AREAS

Kiribati's waters host a large variety of habitats, which are important breeding or feeding grounds for a number of marine and seabird species. There are already many protected areas in place, most notably the PIPA, but the characteristics of Key Biodiversity Areas (KBAs) mapped here can support the further development of management options to balance human needs and protection of vulnerable species and ecosystems.

The previous maps show Kiribati's impressive richness of natural wonders and their value to Kiribati. 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 Kiribati's waters also have international significance. It is therefore essential for Kiribati 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 Kiribati is guided by the goals and objectives laid out in its Environment Act (1999) and Amendment (2007), as well as the Kiribati Integrated Environment Policy (2012). These link national actions to promote conservation and sustainable use of biological diversity with regional and international conventions and obligations, including the CBD process for designating EBSAs, the International Union for Conservation of Nature's (IUCN) KBAs and Birdlife International's IBAs. These areas 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.

There is growing recognition worldwide that marine ecosystems need to be managed

*Kiribati's Key Biodiversity Areas are important habitats, e.g. for bird nesting, benthic and pelagic species.*

to prevent or minimize harm from human activities. Conservation areas or plans can benefit a country's tourism potential, as well as improving consumer acceptance of products if they are proven to be sustainable. As knowledge of the characteristics of such prospective areas develops, they can become critical elements of an integrated protected area network that ensures key ecological sites are protected, while still allowing human activities to occur in an environmentally sustainable way. The importance of this for Kiribati was borne out by the declaration of the PIPA in 2008—at the time, one of the largest marine protected areas (MPAs) in the world.

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

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). Two EBSAs were subsequently approved by the CBD:

1. *Phoenix Islands:* This large EBSA encompasses diverse bathymetry, including shallow seamounts, a productive upwelling zone and high biodiversity of fish species. The islands are breeding sites for numerous bird species, and their isolation is important for localized species distributions contributing to biogeographic patterns in the region. Isolation also gives the area a very high naturalness, with relatively limited human impacts, although whale and tuna fisheries have appeared.

2. *Equatorial High Productivity Zone:* This EBSA is based on a large oceanographic feature—an upwelling tongue of nutrient-rich water supporting high primary production over a large section of the equatorial Pacific Ocean. It covers areas of all three sectors of Kiribati.

There are 28 KBAs in Kiribati's waters (Birdlife International, 2018a). These include 25 IBAs (Birdlife International, 2018b), among which are a number of marine areas around islands, which have been recommended primarily to protect foraging or migration routes of rare or endangered seabirds. Examples include Flint Island Marine (a 22 kilometre extension around the island to encompass the foraging range of the lesser frigatebird); Malden Island Marine (a 140 kilometre extension for the foraging range of the lesser frigatebird, greater frigatebird, masked booby and red-footed booby); Millennium (Caroline) Island Marine (a 140 kilometre seaward extension from the island for the foraging range of the greater frigatebird, black noddy, common white tern and red-footed booby—plus it is a high-use/transit area for the red-tailed tropicbird); Pacific; Eastern Central 13 Marine (an area revealed from tracking data to be important for Gould's petrel); Starbuck Island Marine (a 70 kilometre extension to protect foraging grounds for a number of birds from Starbuck Island); and Teraina Marine (a 3 kilometre extension around Teraina Island to encompass the foraging range of the common white tern).

EBSAs and KBAs have no official management status, but are components of efforts by the CBD and the 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 IUCN Red List) and to describe the marine habitats in which these species are likely to be found, and which may therefore need protection.

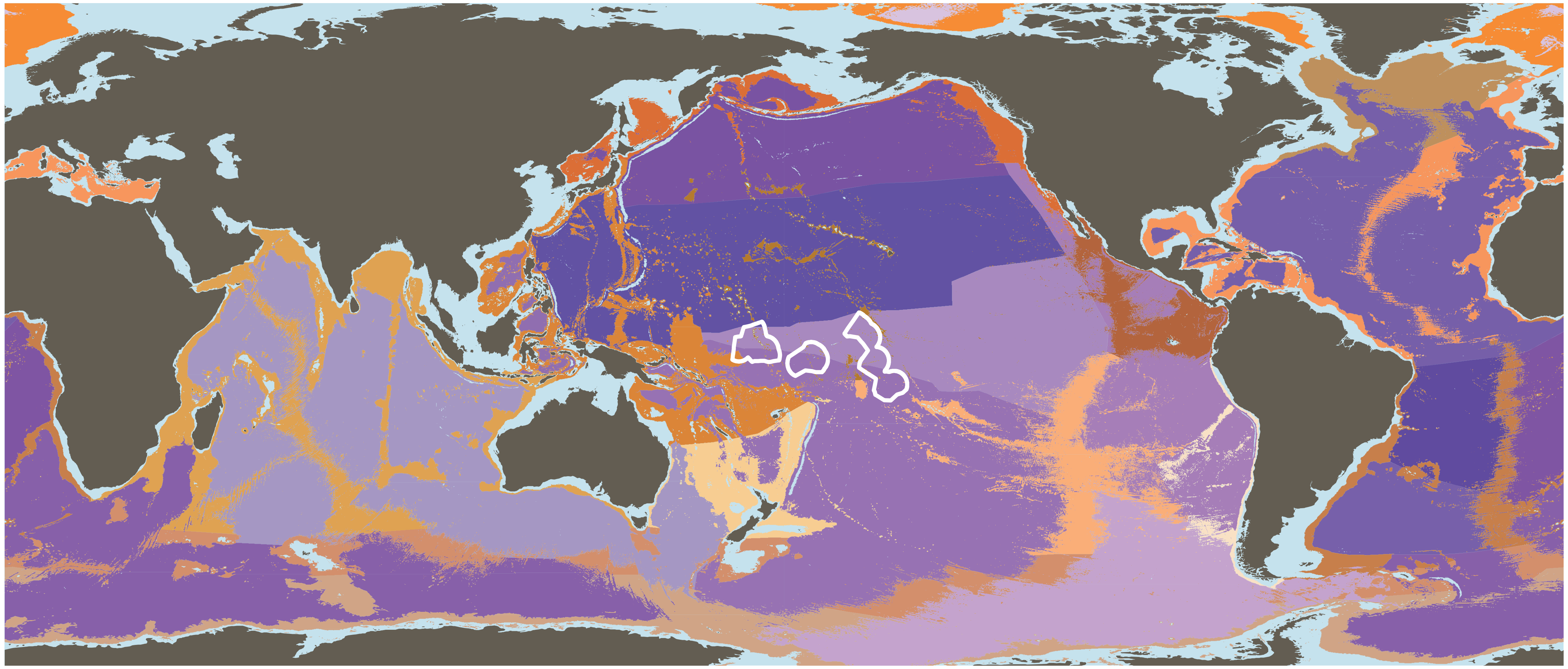
The PIPA covers the island archipelago and surrounding waters over an area of 408,250 km2. This area includes island and reef ecosystems, as well as deepwater habitats and several offshore seamounts. It is a UNESCO World Heritage site.

In conjunction with the 27 official marine reserves and protected areas (Marine Conservation Institute, 2018), KBAs and EBSAs can help develop an appropriate network of multiple-use managed areas.


170°E
175°E
180°
5°N
0°
5°S
Seamounts of Micronesia
Victoria Fracture Zone
Makin Island
Butaritari Island
Nauru Marshall and Gilbert Abyssal
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Kiribati - Howard and Baker Island Abyssal Range
Central Gilbert
Nonouti Island
KIRIBATI
(Gilbert Group)
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Rungata, Tamana and Arorae Deep
South (Banaba) Ocean Island
Tamana Island
Arorae Island
South Nauru and Gilbert Boarder
South Gilbert Boarder
Gilbert, Tuvalu High Seas
0°
5°S
Dolmah
Nova Trough and Celestial Seamount
KIRIBATI
(Phoenix Group)
Kanton Island
Northeast Phoenix and High Seas
Enderbury
Birnie Island
McKean Island
Phoenix Seamounts
Rawaki
Rungata, Tamana and Arorae DeeP
Manra Island
Nikumaroro
Orono Island
Cook Island - Kiribati Abyssal Range
Gardner Island and North Cooks Boarder
Northeast Tuvalu to Southern Phoenix Boarder
Cook Island - Kiribati Abyssal Range
Lakina to Northern Tokelau Submerged Seamounts
175°W
170°W
160°W
155°W
North Kingman Reef
East West Kingman and Palmyra
Teraina Island
Washington Island and Christmas Ridge
Tabuaeran Island
North East Christmas Boarder
Tabuaeran Fanning Deep
East West Christmas Islands Boarders
Northern Line Group
East West Christmas Islands Boarders
Kiritimati Deep
Kiritimati Island
High Seas Line Island Group & Menard Ridge
South Christmas Island
Jarvis Deep
East Line Islands and French Polynesia Northern Tip
Malden and Schlanger
KIRIBATI
(Line Group)
Malden Island
Boudeuse Ridge
5°S
Starbuck Island
Starbuck and high seas
Penrhyn Basin
Penrhyn Basin
Cook Island - Kiribati Abyssal Range
Vostok Island
Millenium Island
10°S
Southern Line Group
Flint and Vostok Islands Deep
Flint Island
Line, Cooks and French Polynesia High Seas
KIRIBATI BIOREGIONS
Deepwater bioregions
Reef associated bioregions
Butaritari associated reefs
Washington Island
Fanning and Tautua Islands
North Gibert Atolls
Christmas Islands and nearby Atolls
Nonouti and South Gibert Atolls
Winslow Reef
Ocean Island
Canton to Phoenix Islands Chain
McKean to Manra Cluster
Flint and South Islands
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Smith and Sandwell, 1997. Wendt H, et al, (in prep).

# BEYOND THE HOTSPOTS: BIOREGIONS

Ideally ecosystem-based marine planning should be based on comprehensive data that represents all of Kiribati's 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.*

Kiribati joined many other countries in signing and ratifying the international Convention on Biological Diversity. In so doing, Kiribati 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."*

To address this, in 2006, Kiribati established the PIPA, one of the largest large-scale MPAs in the world, which constitutes around 11 per cent of Kiribati's EEZ. Furthermore, the government of Kiribati is aiming to scale up national efforts towards creating community- and island-based MPAs throughout the country.

While a lot of data are accessible—as the maps in this atlas show—comprehensive data are not available for any country, including Kiribati. 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 Kiribati 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. 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, Kiribati's 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 Kiribati. This calls for more detailed bioregions to inform marine planning.

The MACBIO project has thus developed draft marine bioregions across the South-West Pacific for use by Pacific Island countries, including Kiribati, in their national planning processes for MSP and MPAs.

Using these bioregions as substitutes to describe the suite of marine biodiversity in Kiribati, 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"). The bioregional approach assists planners with the fact that not all habitats and ecosystems are known and mapped.

Bonefish Flats
Village
Kiritimati Tourist Office
Path
Paved Road
Secondary Road
Sand Track
North West Point
Cape Manning
Tabwakea
Wilkes Lagoon
Motu Upou
Cassidy Intl Airport (CXI)
Banana
Bridges Point
Ronton (London)
Cook Island Passage
Motu Tabu
North East Point
Cook Is.
Norman's Lagoon
South Passage
Benson Point
Bay of Wrecks
St. Stanislas Lagoon
Old Wharf
South West Point
Poland
Cecile Peninsula
Vaskess Bay
Pacific Ocean
Aeon Point
Aeon Airfield
Teraaka Lagoon
Pelican Lagoon
Forward Zone (Ruins)
South East Point
Korean Wreck
Hawaiian Is. (U.S)
Johnston Atoll (U.S.)
North Pacific
Kingman Reef (U.S.)
Line Islands
Howland Is. (U.S.)
Baker Is. (U.S.)
Equator
Jarvis Is. (U.S.)
Kiritimati (Christmas Is.)
Phoenix Islands
South Pacific
Tokelau (N.Z.)
Cook Is. (N.Z.)
Marquesas (Fr.)
Kiritimati (Christmas Island)
Republic of Kiribati
N
S
E
W
Key to the Bonefish Flats
1. Paris 1
2. Paris 2
3. Paris 3
4. Eddie's Flat
5. Texas Flat
6. Whisper Flat
7. Fred's Flat
8. Bareaka Flat
9. Poland Flat
10. Perry's Wharf
11. Smoky Flat
12. Nine Mile Flat
13. Koito Flat
14. Te Ren Flat
15. Submarine Flat
16. Huff Dam
17. Trailer Wreck Y-Site
18. Lone Palm Y-Site
19. London Channel
20. Helen Flat
22. Arthur Flat
23. Tereke Flat
24. Taura Flat
25. Cat Island Flat
26. Go-Like-Hell Flat
27. Little Plantation
28. Te Baura Flat
29. Bathing Lagoon
30. Banana Flat
31. Boating Lagoon
32. Eriete Flat
33. Orvis Flat
34. Bob Delemos Flat
35. Lone Palm Close-By
36. Motu Upua Flat
37. Rick's Flat
38. Canada Flat
39. Navy Flat
40. Worm Flat
41. Pan Cakes
42. Clam Flats
Kimaere Flat
Scale 1:100,000
Coordinate System WGS 84 UTM Zone 4N
Prepared For: Jeff McDonald
Prepared By: Erica McCormick, Cascade GIS

# PLANNING

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

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

Despite the high value of the ocean to I-Kiribati, 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 Kiribati 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 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 Kiribati 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: **www. macbio-pacific.info/marine-spatial-planning**

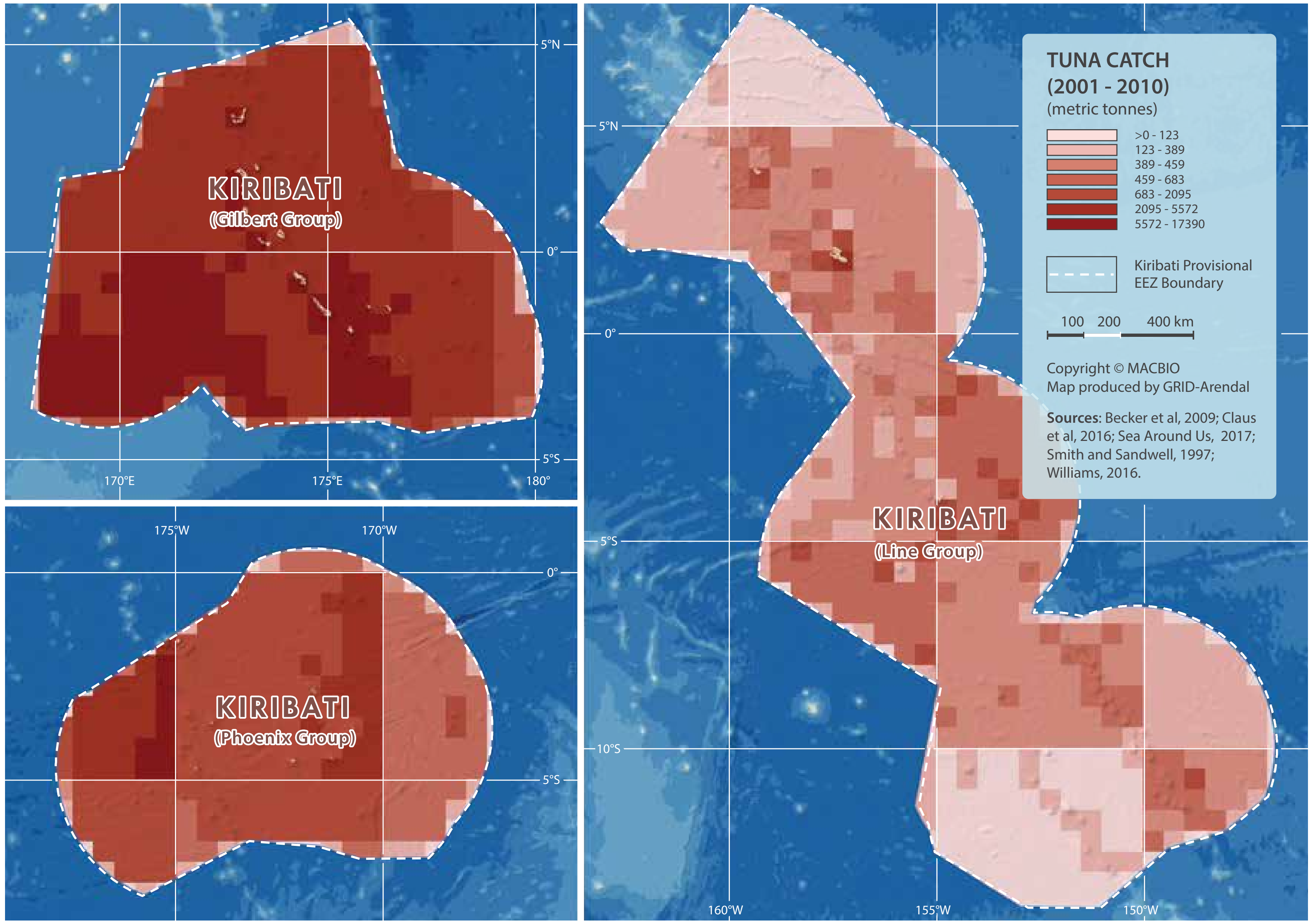
# FISHING IN THE DARK: TUNA CATCH

Tuna fisheries are an important resource for Kiribati in terms of income, employment and providing food for locals. Knowledge of the distribution and catch is crucial for the regional scale of management required to ensure such fisheries are sustainable.

A very important use of the ocean that immediately comes to the mind of every I-Kiribati is fishing. There are two different types of fisheries in Kiribati: those close to the shore (see also chapter “Small fish, big importance”) and those offshore (see also chapter “Travellers or homebodies”). While offshore fish often live in the deep ocean, there’s no need to fish in the dark.

Commercial offshore fisheries are primarily based on tuna harvest and produced a total of AU$293 million in 2015, which accrued to foreign tuna fleets. However, in the same year, the direct benefits to Kiribati’s economy only amounted to AU$53 million (net value – Rouatu, 2015). Interestingly, inshore fisheries yielded a similar amount in 2015, with a total of AU$45 million. Since then, revenues from access fees to tuna have increased, highlighting its importance to Kiribati’s economy.

Tuna are the basis of important commercial fisheries for many island nations in the South-West Pacific. Typically, there are four main species taken: skipjack (*Katsuwonus pelamis*), albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), and yellowfin (*Thunnus albacares*). The abundance of these species varies throughout the region. Tuna are caught using purse seine, longline and pole-and-line methods. The tuna fishery is associated with the capture of a number of valuable non-target species as well as numerous by-catch species including sharks, turtles and birds. 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. Typically, there are 3,000–4,000 vessels operating each year, and the total tuna catch exceeds 2 million tons per year.




Tuna provide both an important local food source, through small-scale local fishing, and a major source of income to the country, through the licencing of foreign vessels to catch tuna within Kiribati’s EEZ. Kiribati fishers also form an important component of the crew on the larger foreign-flagged tuna vessels, which operate throughout the Western Pacific region. 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 three maps show the distribution of all tuna catches from 2001 to 2010 in the Phoenix Islands, Gilbert Islands and Lines Islands areas.

Longline fisheries over this period were small, with between one and three vessels per year targeting albacore, bigeye and yellowfin tuna. These species comprised 51 per cent, 37 per cent and 12 per cent, respectively, of the total catch by this method over the 10-year period, which only amounted to 130 tons. The number of vessels increased to 14 in 2015 and to 17 in 2016. Catches of albacore, bigeye and yellowfin during this period amounted to 870 tons, 1,150 tons and 1,015 tons, respectively (WCPFC, 2017).

The pole-and-line fishery is much smaller, with only one vessel active in 2009 and 2010, catching a total of 320 tons of tuna—mainly skipjack tuna (280 tons), with small catches of yellowfin tuna (20 tons) and bigeye (16 tons). As with longline fishing, catches have increased in recent years. Only one vessel has been active each year, but catches of skipjack have often been between 100 and 300 tons per year.

The largest tuna fishery covered by vessels registered to Kiribati is the purse seine fishery. For much of the 2001–2010 period, there was only a single vessel reported to be active, but the number of vessels increased to four in 2009 and five in 2010. In 2016, there were 27 active vessels. The catch also started to increase dramatically in the last two years of the period plotted here. For the majority of this period, catches of skipjack were 3,000–4,000 tons per year, although they increased to almost 16,000 tons in 2009 and more than 19,000 tons in 2010. The purse seine fleet catches over 100,000 tons (based on 2015 and 2016 figures). Skipjack is the main species caught by purse seine (65,000 tons, i.e. 73 per cent of the total catch for 2001–2010), with yellowfin next (18,500 tons, i.e. 21 per cent), followed by bigeye (almost 6,000 tons, i.e. 6 per cent).

Most of the fishery has occurred in the Gilbert Islands region of Kiribati, but the offshore fishery has also occurred over extensive areas of the Phoenix Islands region and fishing still occurs in the PIPA MPA. Catches in the Line Islands region of Kiribati are much lower and more scattered along the chain of islands. Although catches are generally dominated by the large offshore vessels, there is also a small-scale local tuna fishery that is estimated to catch

10,000–12,000 tons per year (Gillet, 2002; Zylich et al., 2014).

The distribution of tuna catch around seamounts can be important. Yellowfin and, to a lesser extent, bigeye tuna catches are often higher on seamounts (Morato et al., 2010) and these are relatively common throughout Kiribati's waters. Seamounts and similar topographic features can, in some situations, enhance localized productivity, which can help support higher densities of fish species. As such, the management of such habitat is important for fisheries.

All the tuna species are widely distributed, although the stock or sub-stock structure is poorly known. Skipjack is a surface species that is short-lived (2–3 years), matures young and is highly fecund. Spawning occurs throughout the year in the central Pacific, near the equator. Hence some skipjack can migrate long distances, but their movement patterns are not well understood. Fishery catches therefore need to be managed on a regional, rather than national, basis, so as to better account for these migration patterns.

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 is not expected to greatly affect Kiribati at the large spatial scale of the modelling to date. However, it is a factor that should be considered in longer-term management scenarios.

Deepwater snapper inhabit reef slopes and shallow seamounts that rise to 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. More than 20 west-central Pacific countries and territories either have active deepwater snapper fisheries, have historically participated in deepwater snapper fishing or have expressed some interest in developing this capacity (Williams and Nicol, 2014). The fish caught in these fisheries are mainly from the families Serranidae, Lutjanidae, and Lethrinidae (McCoy, 2010). However, a range of more than 100 species is landed, including those in the families Gempylidae and, more recently, Centrolophidae (SPC, 2013b).

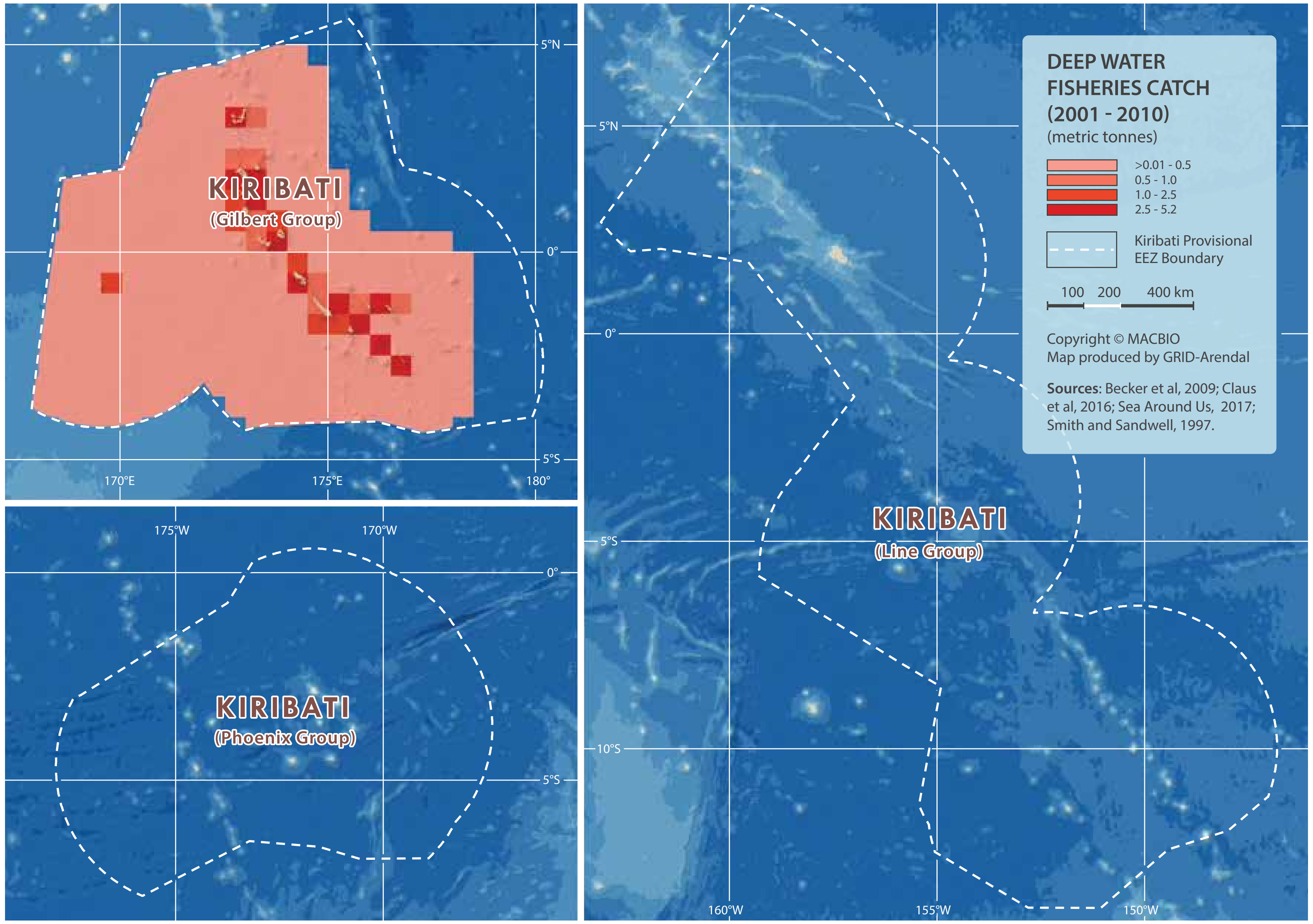
The map shows historical catches over the 2001–2010 period for deepwater fisheries in Kiribati's waters, based on FAO data and national reports. There are issues with the reported data (Zylich et al., 2014), with much of the catch reported at family rather than species level. This makes it difficult to assign catch by depth. The reported deepwater species are mainly from the family Serranidae (groupers of the genus *Epinephlus*), but small catches also from the Lutjanidae (snappers, primarily the genera *Etelis* and *Pristipomoides*) and Lethrinidae (emperors of the genera *Gymnocranius, Lethrinus* and *Wattsia*) (McCoy, 2010; SPC, 2013b). The estimated catch over the 10 years is dominated by unspecified Serranidae. Species of deepwater snapper common in other waters of the South-West Pacific (*Etelis coruscans, E. carbunculus* and *Pristipomoides filamentosus*) are reported, but in very small quantities. Annual catches over the period were generally less than 20 tons. The deep catch is taken largely in coastal waters around the main islands of the Gilbert Islands.

Line fishing is the main method used for these species. Deepwater snapper fishing was promoted in the 1970s and 1980s by the SPC, and the Gilbert Islands were fished (Dalzell and Preston, 1992), with indications of a potential annual yield of 15–150 tons. However, the fishery in the early 2000s was recorded as being carried out on an ad hoc basis by small private vessels, with no development or management plan in place (Adams and Chapman, 2004). Such fisheries in the region as a whole have struggled due to low catch rates following an initial fishing-down phase, variable export markets and prices, shipping costs, and limited habitat area (McCoy, 2010).

The data set on all known deepwater snapper location records, compiled by Gomez et al. (2015), includes data for the three main genera (*Etelis, Pristipomoides* and *Aphareus*) from Kiribati. 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 extensive suitable habitat and a potential unexploited biomass of more than 2,000 tons. However, there are currently no reliable estimates of sustainable levels of catch and effort, and there is a poor understanding of stock structure. Deepwater snapper stocks are considered vulnerable to overfishing due to their seamount distribution, high longevity, late maturity and slow growth (Williams et al., 2013). 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 that occurs when the fishery can move from one place to the next if total catch limits are set for a large area.

Deepwater fisheries over the period considered were a very small resource for Kiribati, and catches were only reported from the Gilbert Islands region. Although some estimates of suitable habitat suggest a fishery could exist for deepwater snappers, little is known about stock structure, stock size and productivity, thereby making the long-term sustainability of historic catch levels uncertain.

It is evident that Kiribati's offshore fisheries are important and provide economic benefit, employment and a source of food to supplement its valuable inshore fisheries. In order to maintain these values for generations of I-Kiribati to come, MSP and evidence-based, sustainable fishery management is all the more important to prevent us from fishing in the dark.



# SMALL FISH, BIG IMPORTANCE: INSHORE FISHERIES

Catch from Kiribati's inshore fisheries is eaten locally and sold on the market. While inshore fisheries are relatively small, they have a similar value to Kiribati as its offshore fisheries. However, to maintain these benefits, sustainable management of dwindling inshore resources is key.

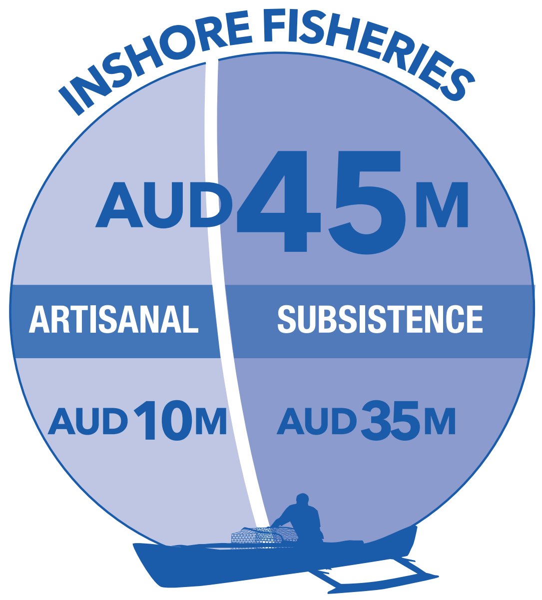
Inshore fisheries in Kiribati are important to coastal communities as a source of food and income. The inshore fisheries target the coastal lagoons, reefs and shallow waters close to the islands. Kiribati's inshore fisheries can be divided into two broad categories: subsistence fishing and commercial fishing. Subsistence fishing is the use of marine and coastal resources by local populations directly for food or trade, rather than for profit. It typically occurs when these products are consumed by the fisher or their family, given as a gift or bartered locally. In Pacific Island countries, coral reef fisheries are characterized by a strong predominance of subsistence fishing, with an estimated 80 per cent of coastal fisheries' catch consumed directly by the fisher and their communities. Seafood is a key source of nutrition for the Kiribati population, accounting for around three quarters of animal protein in the national diet (FAO, 2002).

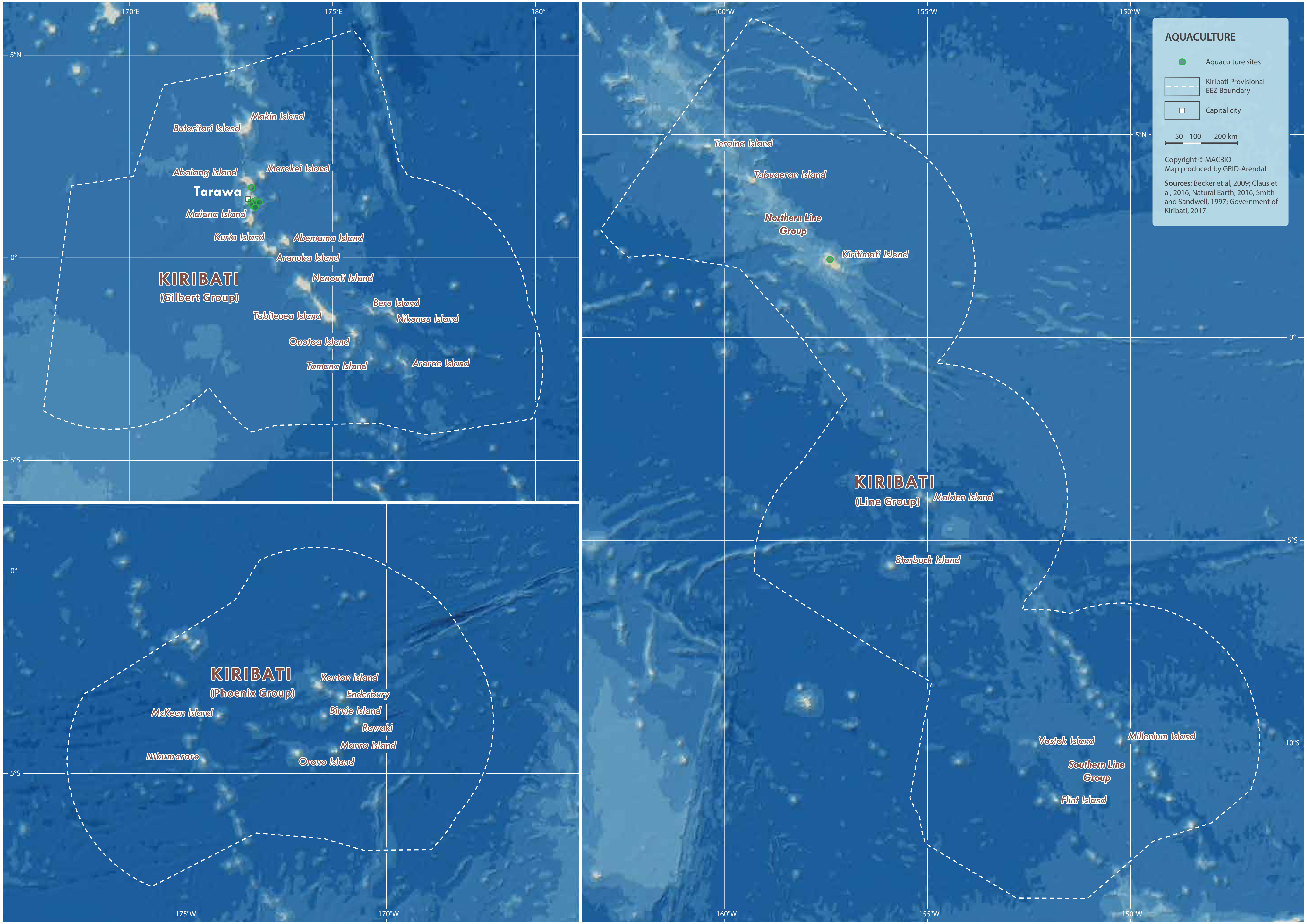
The total value of inshore fisheries in Kiribati is estimated at $AU45 million (Rouatu et al., 2017). Of this, subsistence fishing makes up the majority of the value, at approximately $AU35 million, with the remaining $AU10 million coming from artisanal fishing. The distribution of inshore fishing reflects the populations of the different islands, with the highest number of households engaged in South Tarawa (see table). However, the proportion of households compared to population size is higher in many of the smaller islands, and an indication of the relative importance of fishing.

Maintaining productive inshore fisheries is a key challenge for Kiribati in order to ensure food security and provide for livelihoods for coastal populations. This requires maintaining healthy and productive coastal ecosystems (see also chapter "Home, sweet home").

**Number of households engaged in different types of inshore fishing on the different islands of Kiribati (2010 Population Survey)**

| Island | Lagoon reef | Collect on ocean | Ocean fishing | Reef fishing | Total population |
|---|---|---|---|---|---|
| Banaba | 24 | 20 | 50 | 36 | 295 |
| Kuria | 28 | 116 | 29 | 104 | 993 |
| Aranuka | 144 | 199 | 143 | 168 | 1057 |
| Nonouti | 325 | 437 | 110 | 384 | 2683 |
| Tabiteuea.Nth | 273 | 429 | 145 | 380 | 3689 |
| Tabiteuea.Sth | 100 | 194 | 50 | 189 | 1290 |
| Beru | 156 | 303 | 177 | 342 | 2099 |
| Nikunau | 194 | 96 | 129 | 261 | 1907 |
| Onotoa | 138 | 237 | 142 | 235 | 1519 |
| Tamana | 118 | 2 | 130 | 122 | 951 |
| Arorae | 58 | 51 | 138 | 85 | 1279 |
| Makin | 152 | 139 | 173 | 244 | 1798 |
| Teeraina | 79 | 83 | 162 | 135 | 1690 |
| Tabuaeran | 128 | 299 | 194 | 201 | 1960 |
| Kiritimati | 248 | 628 | 372 | 374 | 5586 |
| Kanton | 3 | 5 | 3 | 5 | 31 |
| Butaritari | 237 | 474 | 239 | 450 | 4346 |
| Marakei | 247 | 390 | 207 | 383 | 2872 |
| Abaiang | 317 | 734 | 193 | 578 | 5502 |
| Nth.Tarawa | 414 | 690 | 245 | 660 | 6102 |
| Sth.Tarawa | 1976 | 3065 | 1581 | 2925 | 50182 |
| Maiana | 91 | 241 | 53 | 136 | 2027 |
| Abemama | 206 | 428 | 89 | 347 | 3200 |




AQUACULTURE
Aquaculture sites
Kiribati Provisional EEZ Boundary
Capital city
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Natural Earth, 2016; Smith and Sandwell, 1997; Government of Kiribati, 2017.
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orona Island
McKean Island
Nikumaroro
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island
170°E
175°E
180°
160°W
155°W
150°W
175°W
170°W
5°N
0°
5°S
10°S

# FISH FROM THE FARM: AQUACULTURE

Aquaculture has faced many challenges in Kiribati over the years. Although successful fish farms do exist, Kiribati's aquaculture is declining and the true costs and benefits need to be carefully assessed.

Half of the seafood eaten globally does not come from the sea. It is not wild caught fish from inshore or offshore fisheries (see also chapters "Small fish, big importance" and "Fishing in the dark"), but rather farmed. The farming of seafood, known as aquaculture, can be practised in either fresh water or salt water, the latter of which is also known as mariculture (see map).

Aquaculture is a small but important industry in Kiribati for both subsistence consumption and as a potential commercial industry. One of the main species cultivated in aquaculture in Kiribati is milkfish (Chanos chanos). Milkfish culture has been a traditional practice in the Gilbert group. Small fry are collected from the lagoon, reared in ponds and grown to a size suitable for subsistence consumption. There have also been several projects to culture milkfish for use as bait and food in Tarawa, Temwaiku, Ambo fish farm and Kiritimati (SPC Aquaculture Portal, 2018). However, there has been little commercial success for milkfish as an export industry, mainly due to competition on the international market.

Efforts are being made to develop a sustainable black pearl industry, with government-supported operations established on Abaiang Atoll. After 10 years of planning, research and development, the first pearl harvest was produced in September 2003 (SPC Aquaculture Portal, 2018). Similarly, efforts are being made to establish aquaculture for giant clam for the aquarium trade, with at least one site in Tarawa Lagoon.

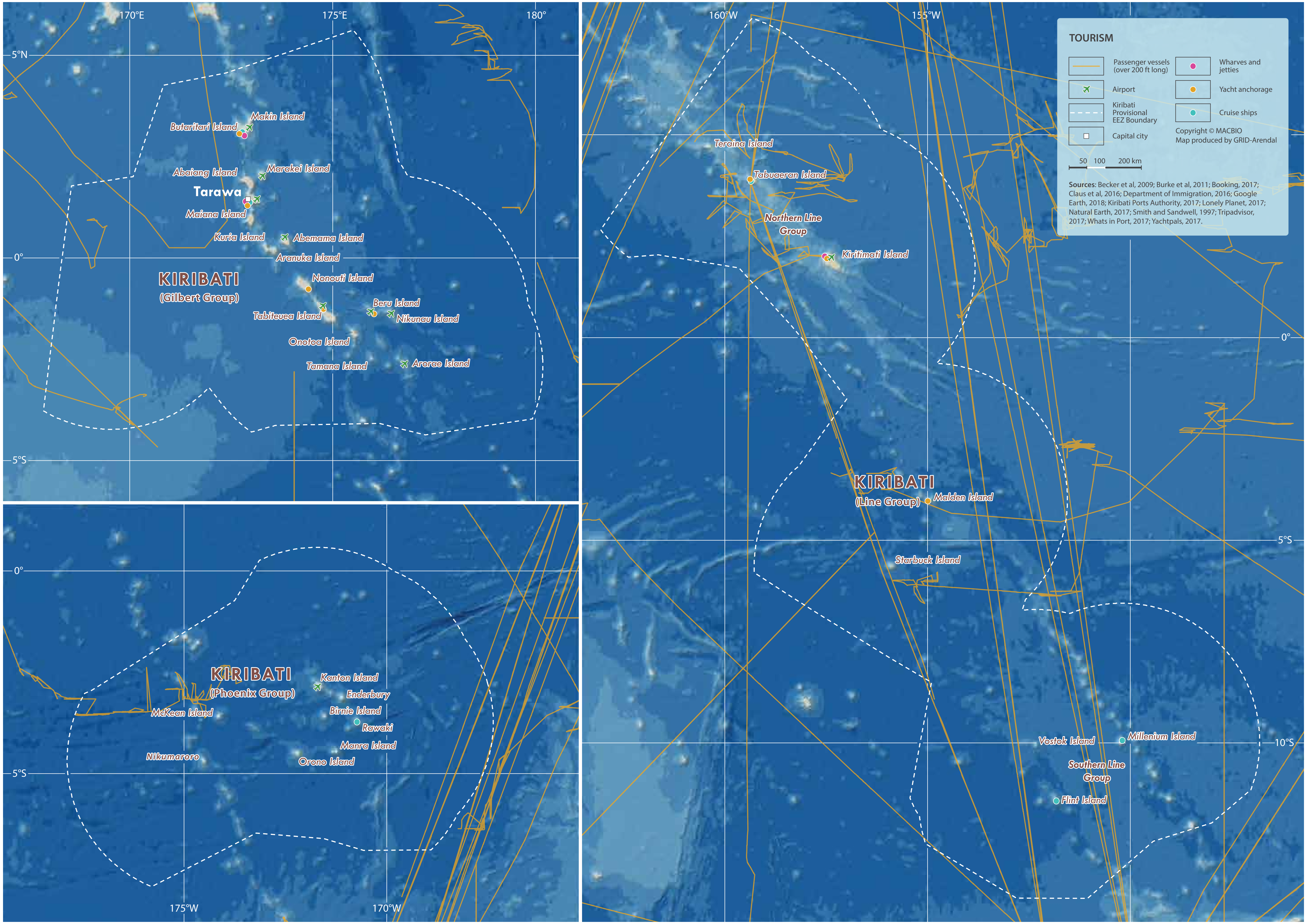
Historically, there were attempts to develop aquaculture for tilapia (Oreochromis mossambicus), which was introduced in 1963 as a food and bait source. However, this species reproduced prolifically and affected milkfish aquaculture ponds. Attempts were made to eradicate the species, but these were unsuccessful. Currently, tilapia is utilized for alternative purposes such as livestock feed, fish meal and fertilizer (SPC Aquaculture Portal, 2018). In terms of other types of aquaculture, seaweed aquaculture was initially started on Kiritimati in the 1970s and after initial success, was expanded to the Gilbert group. Currently, seaweed aquaculture is overseen by the Atoll Seaweed Company Limited, a national company responsible for development and trade of seaweed aquaculture products.

The map shows the location of aquaculture activities in Kiribati, the majority of which are concentrated in the Gilbert group and on Kiritimati. Milkfish ponds are common in many areas for subsistence (see box on babai pits).

## Babai pits

Traditionally, I-Kiribati families keep one or two babai pits and turn them into small ponds to culture milkfish. Almost all islands have practised small-scale aquaculture for milkfish for more than century. Milkfish reared in the pits are popular to eat and an alternative source of fish when the sea is rough and conditions are unconducive to fishing. Some of the larger islands such as Nukunau usually have a large lake where they practise communal milkfish farming and seasonally harvest the milkfish to provide food for the entire village.

Aquaculture can have negative impacts on Kiribati's marine ecosystem, including pressure on wild fish used for fish feed, 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
Passenger vessels (over 200 ft long)
Wharves and jetties
Airport
Yacht anchorage
Kiribati Provisional EEZ Boundary
Cruise ships
Capital city
Copyright © MACBIO
Map produced by GRID-Arendal
50 100 200 km
Sources: Becker et al, 2009; Burke et al, 2011; Booking, 2017; Claus et al, 2016; Department of Immigration, 2016; Google Earth, 2018; Kiribati Ports Authority, 2017; Lonely Planet, 2017; Natural Earth, 2017; Smith and Sandwell, 1997; Tripadvisor, 2017; Whats in Port, 2017; Yachtpals, 2017.
170°E
175°E
180°
5°N
0°
5°S
Makin Island
Butaritari Island
Marakei Island
Abaiang Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
175°W
170°W
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Manra Island
Nikumaroro
Orona Island
160°W
155°W
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
KIRIBATI
(Line Group)
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island
10°S

# BEYOND THE BEACH: MARINE TOURISM

Kiribati's diverse and growing marine tourism sector is worth millions to the economy, but needs to be carefully managed so as not to endanger the very ecosystems it relies on.

The capital Tarawa and Kiritimati (Christmas Island) are the two main tourism destinations. Kiribati's marine environment, including its beaches and historical sites, is ideal for game fishing, diving, snorkelling, seabird watching and surfing. It goes without saying that the health of coral reefs, the sustainability of fish stocks and the beaches are crucial for the tourism industry in Kiribati.

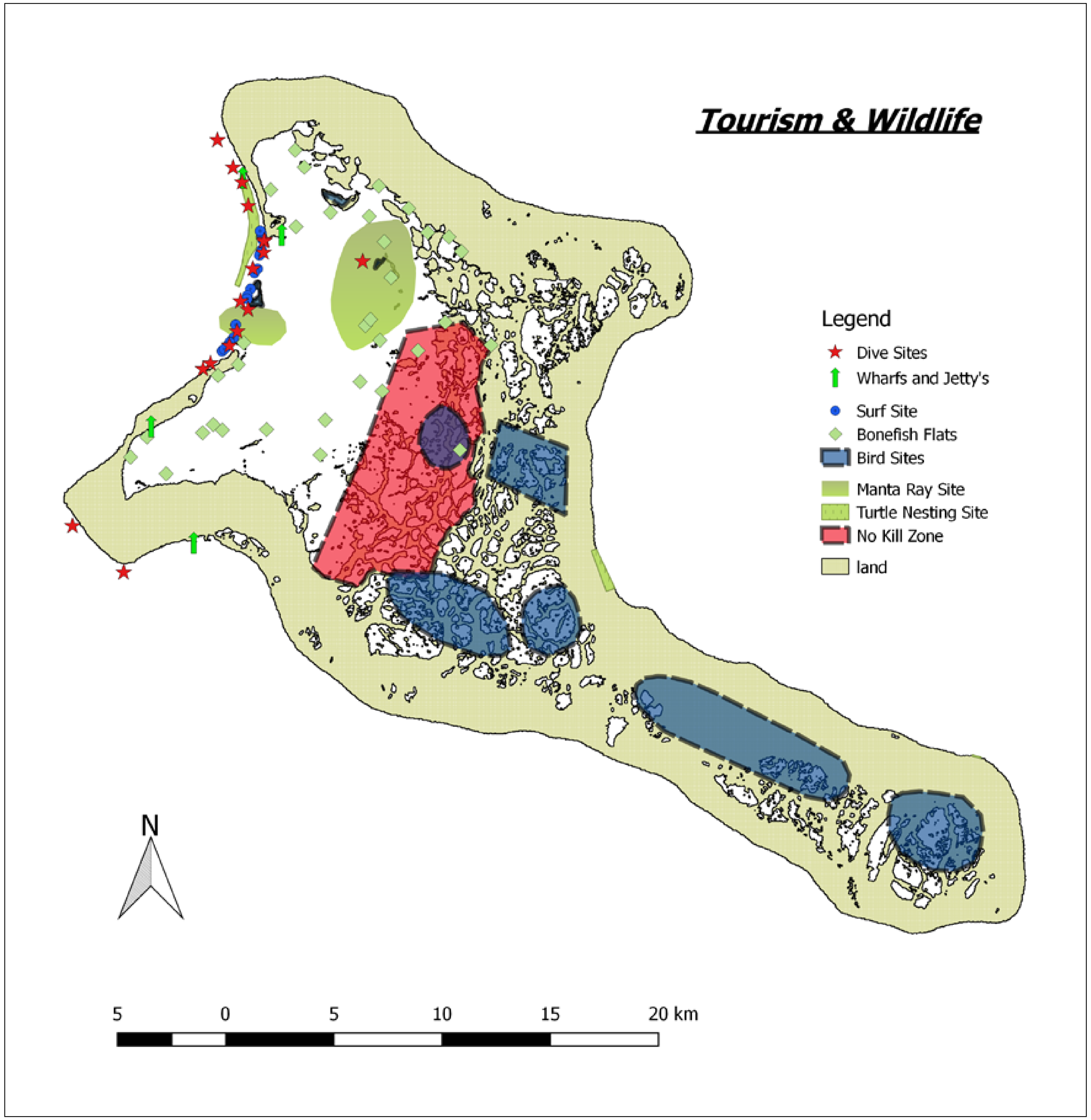
Due to its remoteness and infrastructural barriers, tourism is relatively small scale, with an average 6,000 visitors per year contributing a portion (10 per cent in 2014) to the overall GDP. According to Rouatu (2015), the estimated value of marine tourism in Kiribati is around AU$4.3 million per year, although this is expected to increase in the future. In light of this, in 2017 the government of Kiribati introduced a policy (Kiribati 20-year Vision – KV20) that advocates tourism and fisheries as the focus sectors for further development and investment. This same policy prioritizes tourism development in the Line and Phoenix Islands groups—the islands with pristine conditions ideal for tourism opportunities.

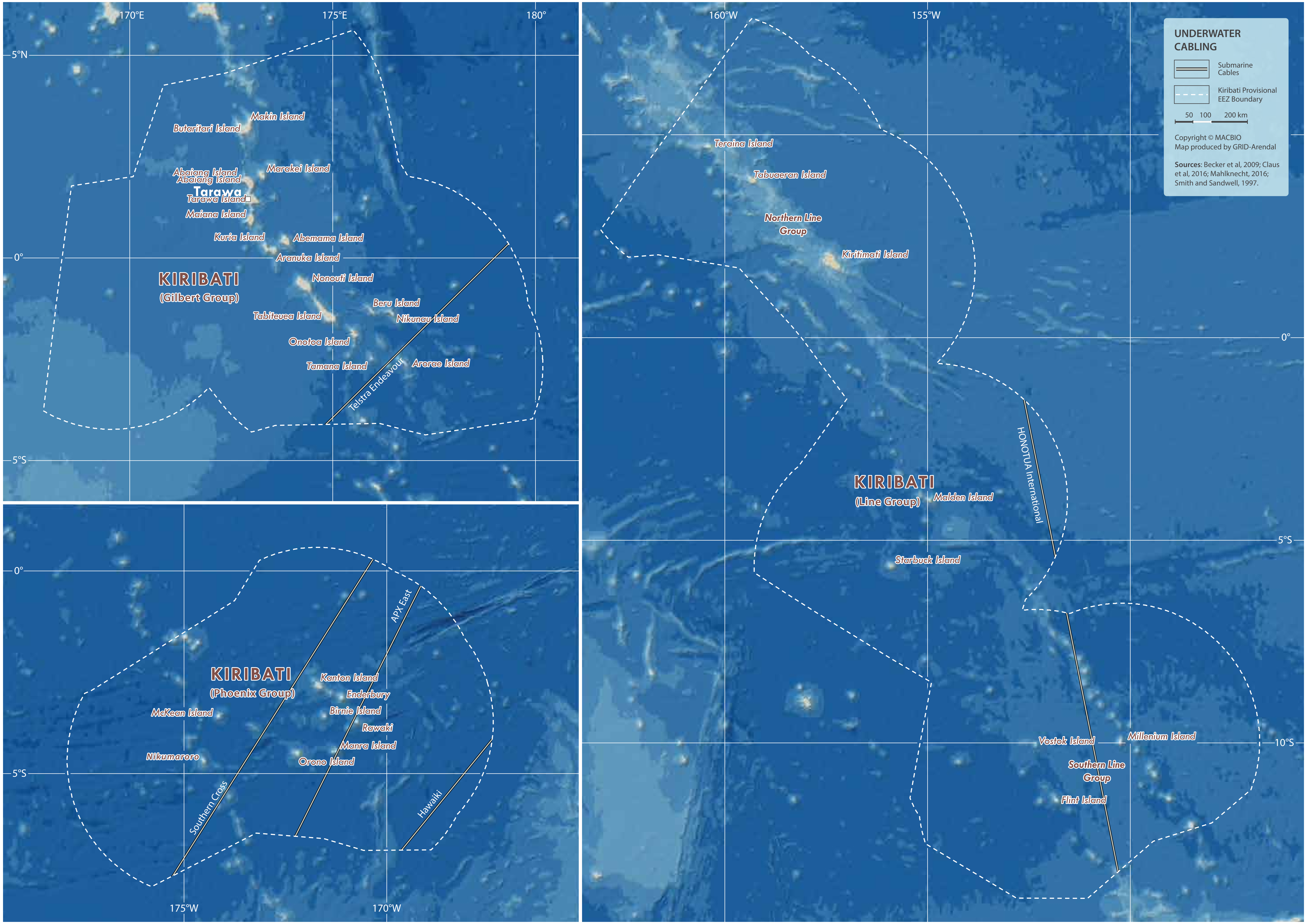
To plan effective and sustainable marine tourism, one of the fundamental tasks is to take stock of the various existing uses of the marine environment that may be affected by tourism. In 2018, the MACBIO project mapped around 50 different types of uses in the marine environment of Kiritimati Island, showing current and potential overlapping uses in some places. To address this and avoid conflicts, an MSP process can be undertaken to inform the overall planning of tourism and other development activities in the marine environment.


Kiribati is serviced by international airports at Tarawa and Kiritimati, with links to Hawaii, Australia and neighbouring countries including Narau, the Solomon Islands and Fiji. There are also a number of small domestic airports servicing the various islands in the three major island groups. The number of tourists visiting Kiribati is low, with around 5,000 people arriving per year, compared with over 500,000 per year to Fiji. The number of tourists arriving each year is similar to the number of arrivals visiting family and friends.

Cruise tourism is also a small sector in Kiribati, although Tabuaeran (Fanning Island) was regularly visited by the Norwegian Cruise Line between 2001 and 2008, which generated significant tourism income. The island is still a stop for cruise ships en route to the Pacific Islands to the south and Hawaii to the north. Kiribati's many islands also serve as a stop for cruising yachts sailing across the Pacific Ocean.

Lack of investment, both in terms of infrastructure and promotion, is the limiting factor in the growth of Kiribati's tourism sector. Kiribati has some of the most pristine coral reefs in the world, so the development of the tourism sector must be balanced with ensuring the health of the ecosystems on which it relies.



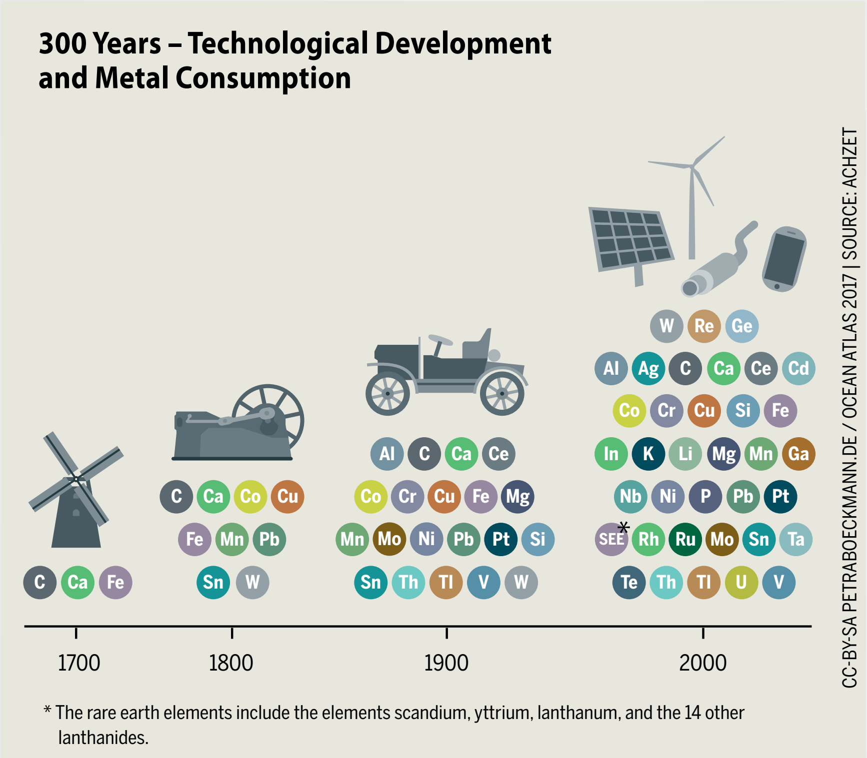

UNDERWATER CABLING
Submarine Cables
Kiribati Provisional EEZ Boundary
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
Sources: Becker et al, 2009; Claus et al, 2016; Mahlknecht, 2016; Smith and Sandwell, 1997.
170°E
175°E
180°
5°N
0°
5°S
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Marakei Island
Abaiang Island
Tarawa
Tarawa Island
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Tabiteuea Island
Nikunau Island
Onotoa Island
Tamana Island
Arorae Island
Telstra Endeavour
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orono Island
McKean Island
Nikumaroro
Southern Cross
APX East
Hawaiki
175°W
170°W
160°W
155°W
0°
5°S
10°S
Teraina Island
Tabuaeran Island
Northern Line Group
Kiritimati Island
KIRIBATI
(Line Group)
Malden Island
HONOTUA International
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island

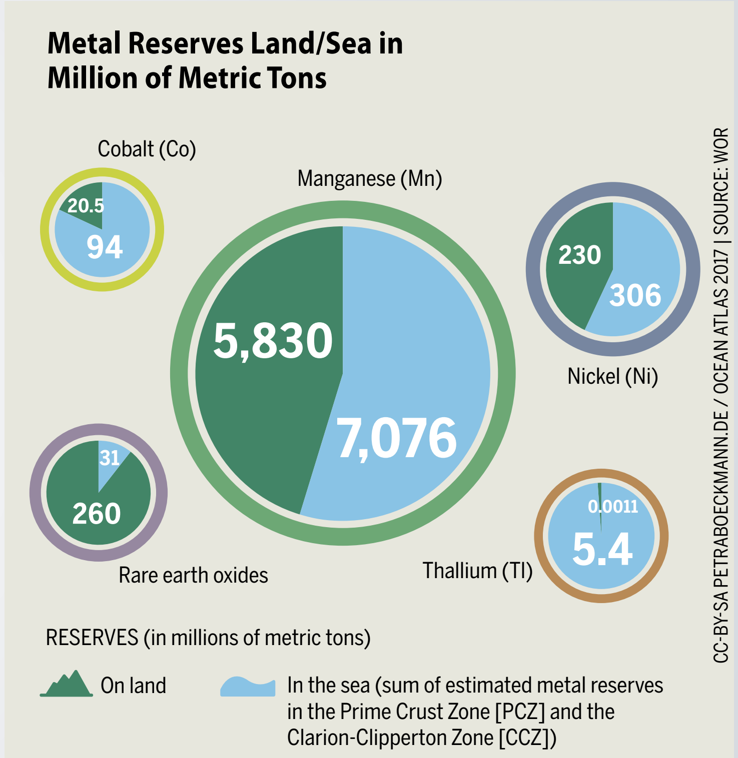
# UNDER WATER WILD WEST: DEEP-SEA MINING AND UNDER WATER CABLING

Kiribati's sea and coasts are rich with deep-sea minerals, petroleum, sand and gravel. Its ocean floor also supports underwater cabling. As such, these important resources and uses need to be sustainably managed and a balance found with other overlapping values and uses.

## Gold rush

Is Kiribati 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 Kiribati's land may be rich in many ways, gold is much scarcer. Instead, Kiribati's 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 found throughout the Pacific Ocean basin, including in maritime jurisdictions of many Pacific Islands countries: sea-floor massive sulfides, polymetallic manganese nodules and cobalt manganese crusts (rich in platinum and rare earth elements). 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, deep-sea mineral mining still entails significant uncertainty and knowledge gaps with regard to resource potential, technology, economic viability and social, cultural and environmental impact (World Bank, 2017).

Kiribati is known to have abundant deposits of polymetallic manganese nodules and cobalt crusts in its EEZ. The President of Kiribati, HE Taneti Maamau, alluded to this when mentioning deep-sea mining in his Policy Statement delivered on 25 April 2016:

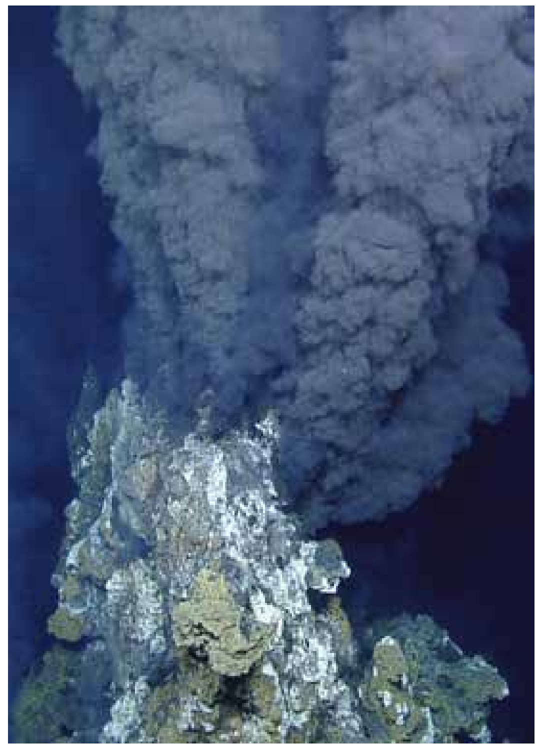
> *"…fisheries is not only the potential source of revenue and our Government is committed to exploring deep sea mining with a view to not only expand our revenue base but also as a means of easing the pressure on overharvesting of our fisheries sector."*

Although studies have identified the existence of minerals in Kiribati's waters, no study has confirmed the viability of the principal economic minerals (nickel, cobalt and copper) for exploitation, suggesting that more exploration, studies and assessments are required. According to the SPC cost–benefit analysis report completed in 2016, deep-sea mining could possibly generate annual revenues (reference to Marshall Island's Deep-Sea Mining study) of US$82 million from cobalt, US$48 million from nickel and US$4 million from copper. In an attempt to pursue this industry, several Pacific Island countries have embarked on efforts to prospect, explore the minerals and put in place national regulatory measures for deep-sea mining industry. Kiribati undertook public consultation on a draft Deep-Sea Mining Policy in 2015. Given the longevity of the deep-sea mining development process, it is highly likely that this issue will continue to be relevant in the context of future ocean resource use or the ocean governance agenda.

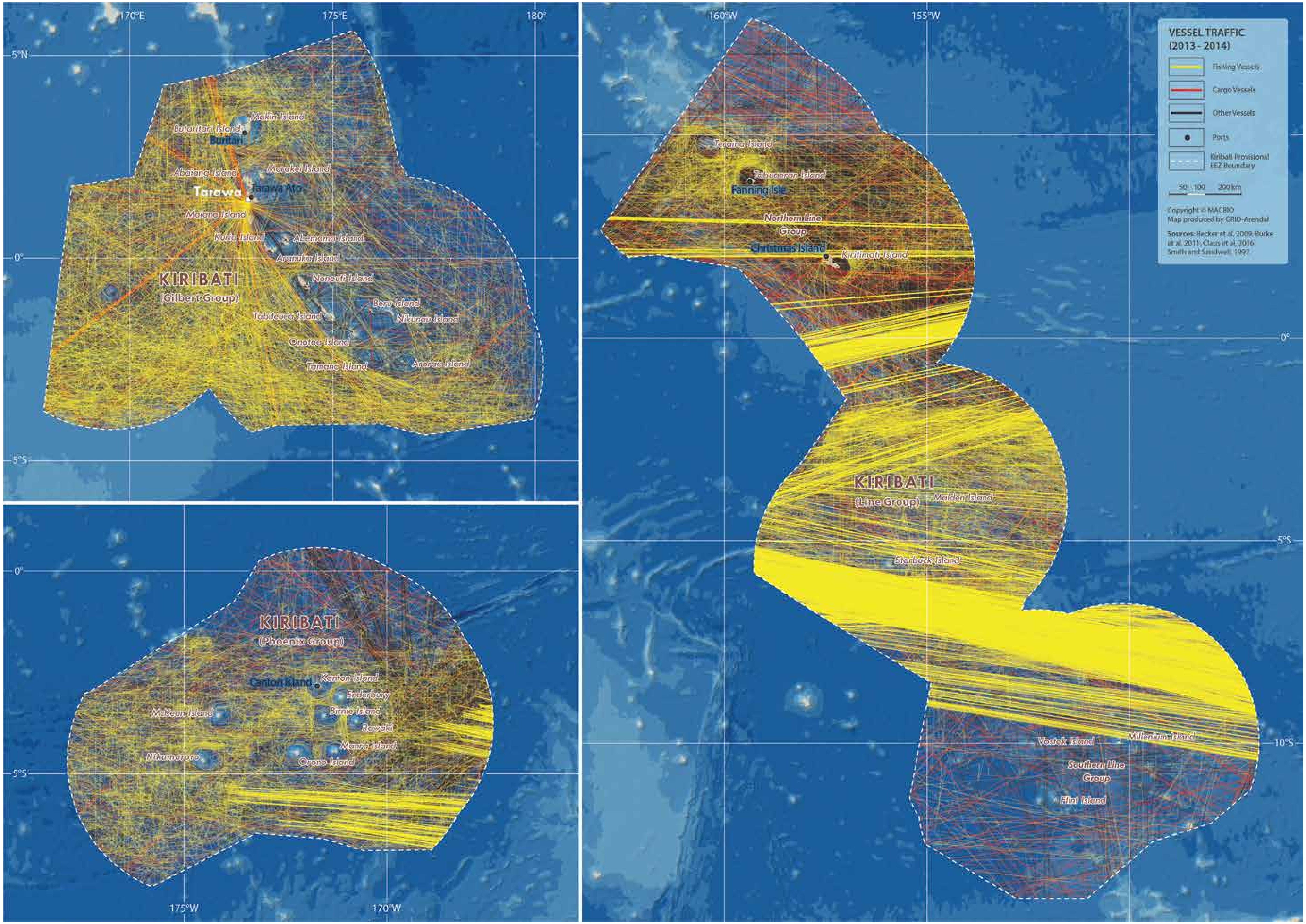
Kiribati is thus still waiting for its gold rush, as the mining companies are still undertaking exploration and collecting samples to estimate the magnitude of seabed mineral deposits. The state-owned mining company, Marawa Research and Exploration Ltd., has signed a contract with the International Seabed Authority for an exploration licence in the Clarion-Clipperton Fracture Zones in the east Pacific. In addition to deep-sea minerals, there are also aggregate resources found in the lagoons.

Aside from resource exploration, Kiribati's ocean floor has a number of submarine cables that form part of a trans-Pacific cable network. The Telstra Endeavour cable crosses the south-eastern part of the Gilbert group EEZ; the Southern Cross, APX-East and Hawaiki cables cross the Phoenix group EEZ; and the Honotua cable crosses the Line group EEZ. While all these cables cross Kiribati's EEZ, none directly services Kiribati. However, the new Southern Cross NEXT cable system, due to go live in late 2019, will connect Kiribati to Australia, New Zealand and the US, as well as a number of other Pacific Islands.

These different and overlapping uses clearly need to be well planned and managed. For example, direct risks from sea-floor mining 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.



*Hydrothermal vent deposits*



VESSEL TRAFFIC (2013 - 2014)
Fishing Vessels
Cargo Vessels
Other Vessels
Ports
Kiribati Provisional EEZ Boundary
50 100 200 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
170°E
175°E
180°
5°N
0°
5°S
Makin Island
Butaritari Island
Butitari
Abaiang Island
Marakei Island
Tarawa
Tarawa Atoll
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
KIRIBATI
(Gilbert Group)
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
175°W
170°W
KIRIBATI
(Phoenix Group)
Canton Island
Kanton Island
Enderbury
Birnie Island
McKean Island
Rawaki
Manra Island
Nikumaroro
Orona Island
160°W
155°W
10°S
Teraina Island
Tabuaeran Island
Fanning Isle
Northern Line Group
Christmas Island
Kiritimati Island
KIRIBATI
(Line Group)
Malden Island
Starbuck Island
Vostok Island
Millennium Island
Southern Line Group
Flint Island

# FULL SPEED AHEAD: VESSEL TRAFFIC

Kiribati's waters are a highway for thousands of domestic and international vessels that are lifelines for many I-Kiribati, who rely on the regular delivery of important goods and food items. Minimizing potential environmental and safety risk is therefore a high priority for all.

Ships coming in and out of Kiribati ports, from fishing vessels, to cargo vessels, cruise ships and ferries, serve many different purposes. Being an island nation, shipping is a very important means of transport for both goods and people from one island to another. The map only reflects the larger registered vessel traffic and does not capture much of the 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 Kiribati's waters. Fishing vessel activity is highest to the west of the Gilbert group, throughout most of the Phoenix group and around the islands of the Line group. There is also a significant amount of fishing vessel transit through the Line group, as seen by the straight lines crossing east to west.

Kiribati has two main international cargo ports: one located on the edge of Betio Lagoon on Tarawa and the other at Ronton on Kiritimati (Christmas Island). These ports are managed by the Kiribati Ports Authority and service the freight vessel traffic, which brings much of the food and goods to Kiribati. As Kiribati's land area is very small, the people are reliant on imports for much of their food, fuel and other consumable goods. In terms of exports, Kiribati exports the coconut product copra, which accounts for approximately two thirds of its export revenue.

From the map of different types of vessels crisscrossing Kiribati's waters, it is clear that MSP is key not only for navigational safety, but also to minimize conflicts with Kiribati's 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 Kiribati's fossil fuel dependence, more sustainable forms of sea transport are being explored. As a seafaring nation, the I-Kiribati can look to their ancestors, who were advanced sailors following the stars in their traditional, wind-powered Te wa.

### *Te wa*

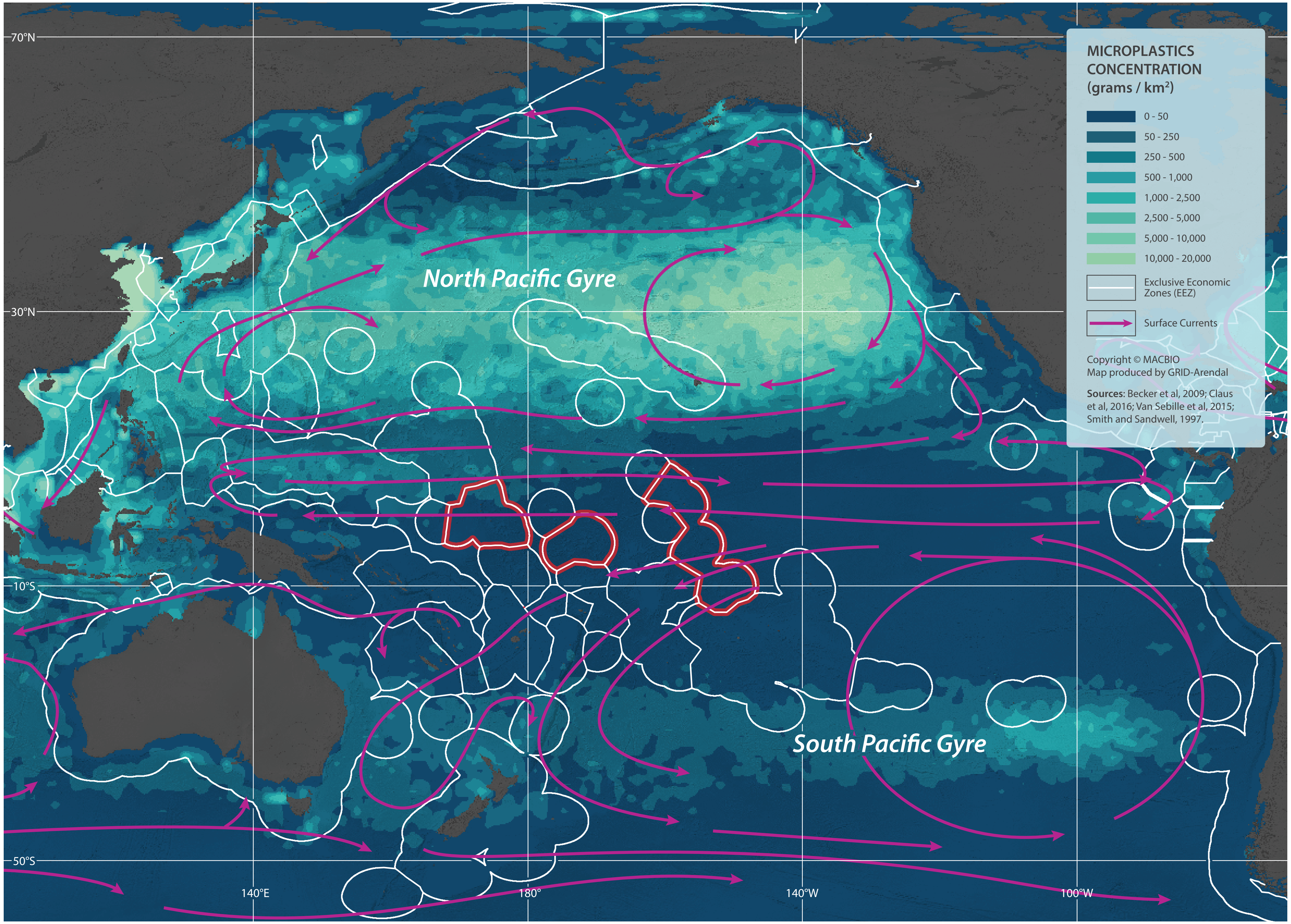
In Kiribati's vast ocean space, you don't want to get lost. Unfortunately, this can happen quite easily. In 1992, two fishermen involuntarily extended their fishing trip in their tiny boat and ended up in Samoa 175 days later, some 3,000 kilometres away—in modern terms, a 12-hour flight. To avoid this world record of being lost at sea, they should have listened to their forefathers who, with their carefully constructed canoes (known as te wa) and navigational skills, created routes and voyaging traditions to successfully reach their destinations without getting lost. The knowledge of these regular voyages across the ocean is preserved by the I-Kiribati in their language, which is still used in all 16 islands in the Gilbert group.

Today, the focus of maritime transportation has shifted from safeguarding inter-island movements and traditional navigational skills to securing routes and building infrastructure for inbound vessels such as container ships and fishing fleets. This shift was necessary not only to ensure Kiribati's growth and secure its economic trade with the rest of world, but more importantly, to maintain a stable import of food commodities and other material demands to the country.

# THREATS

# PLASTIC OCEAN: MICROPLASTICS CONCENTRATION

Like the rest of the world's oceans, Kiribati's 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.

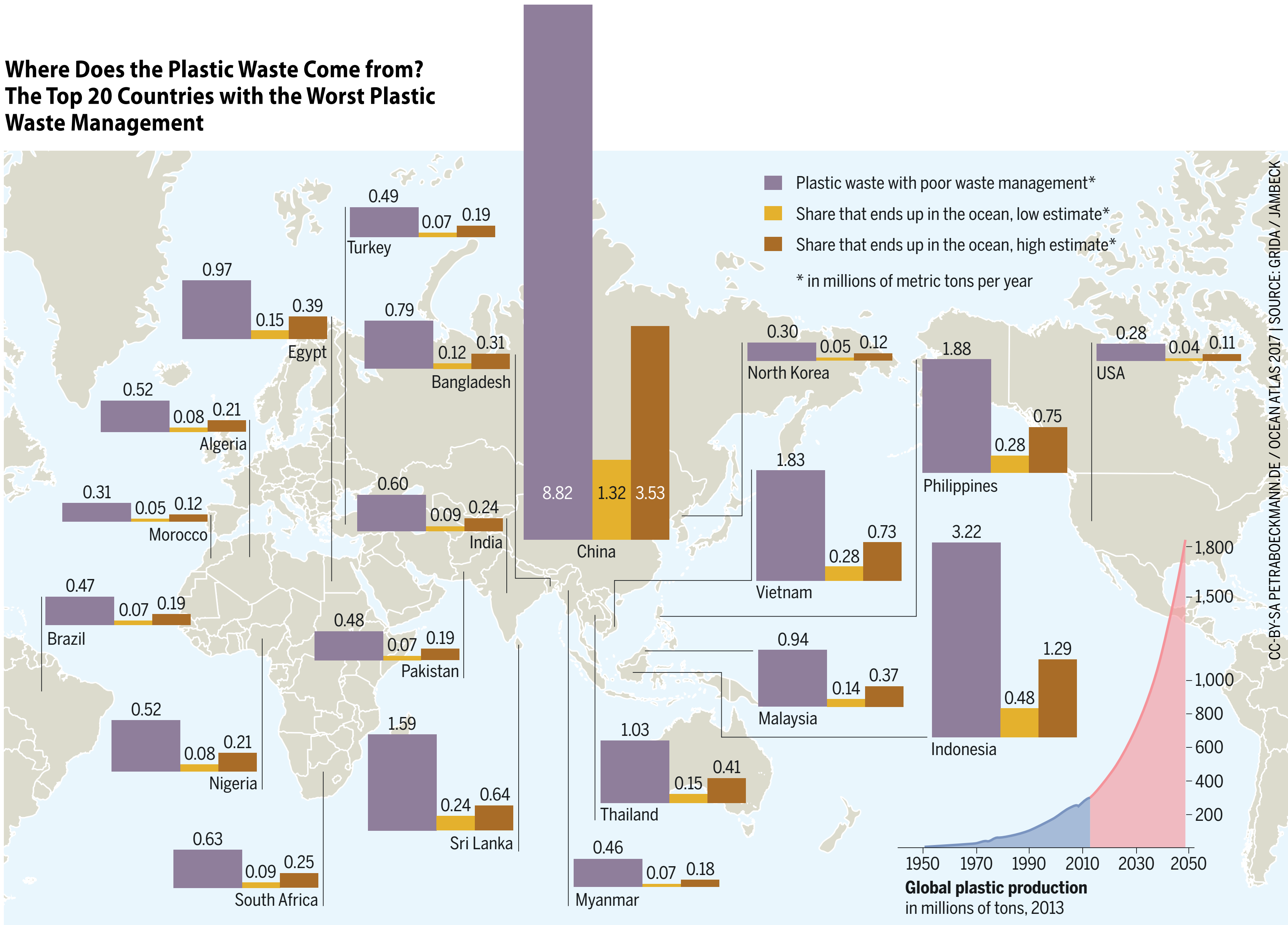



The world produces 300 million tons of plastic each year. About 2 per cent of it—around 8 million metric tons—ends up in the ocean. It is a staggering amount, yet only 1 per cent of this plastic is actually found on the surface of the ocean. Half of this 1 per cent becomes caught in large gyres (see 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.

## 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.*

In light of this, Kiribati's 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. The Kiribati government indicates that 111 tons of plastic is generated annually on its islands. Without a good waste infrastructure and management system in place to properly contain waste in Kiribati, about 50 per cent of this plastic waste makes its way to the ocean every year.

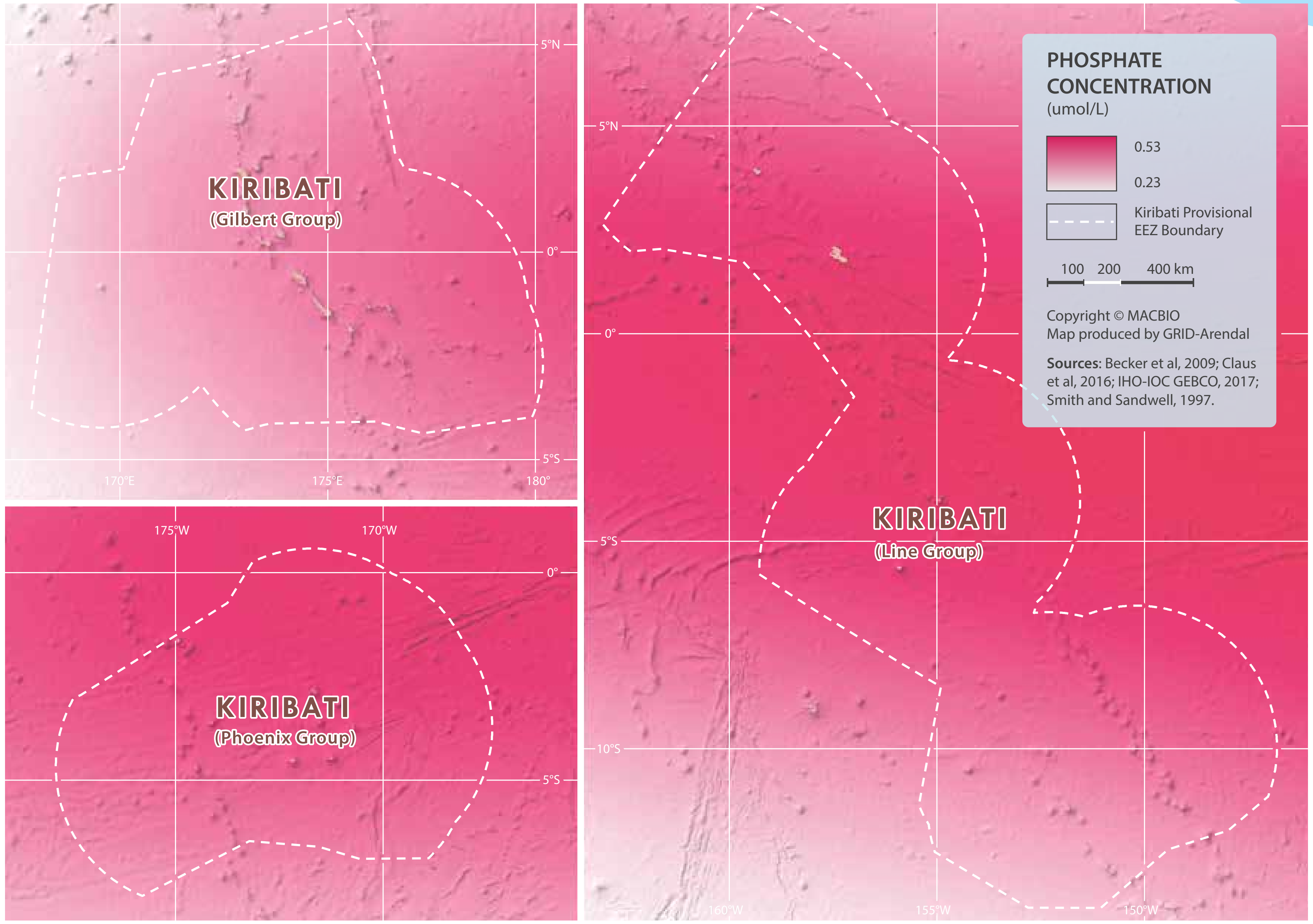
Political engagement is a powerful lever for setting the right incentives for change, and developing a circular economy is just a matter of political will. Kiribati's government has recognized the importance of this. Early in 2017, UN Environment launched the global Clean Seas campaign to eliminate microplastic in cosmetics and drastically reduce single-use plastic by 2022. Kiribati joined the campaign in September of the same year. As a first step, many I-Kiribati are participating in coastal clean-up activities, helping to keep Kiribati's 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 Kiribati's coastal ecosystems.

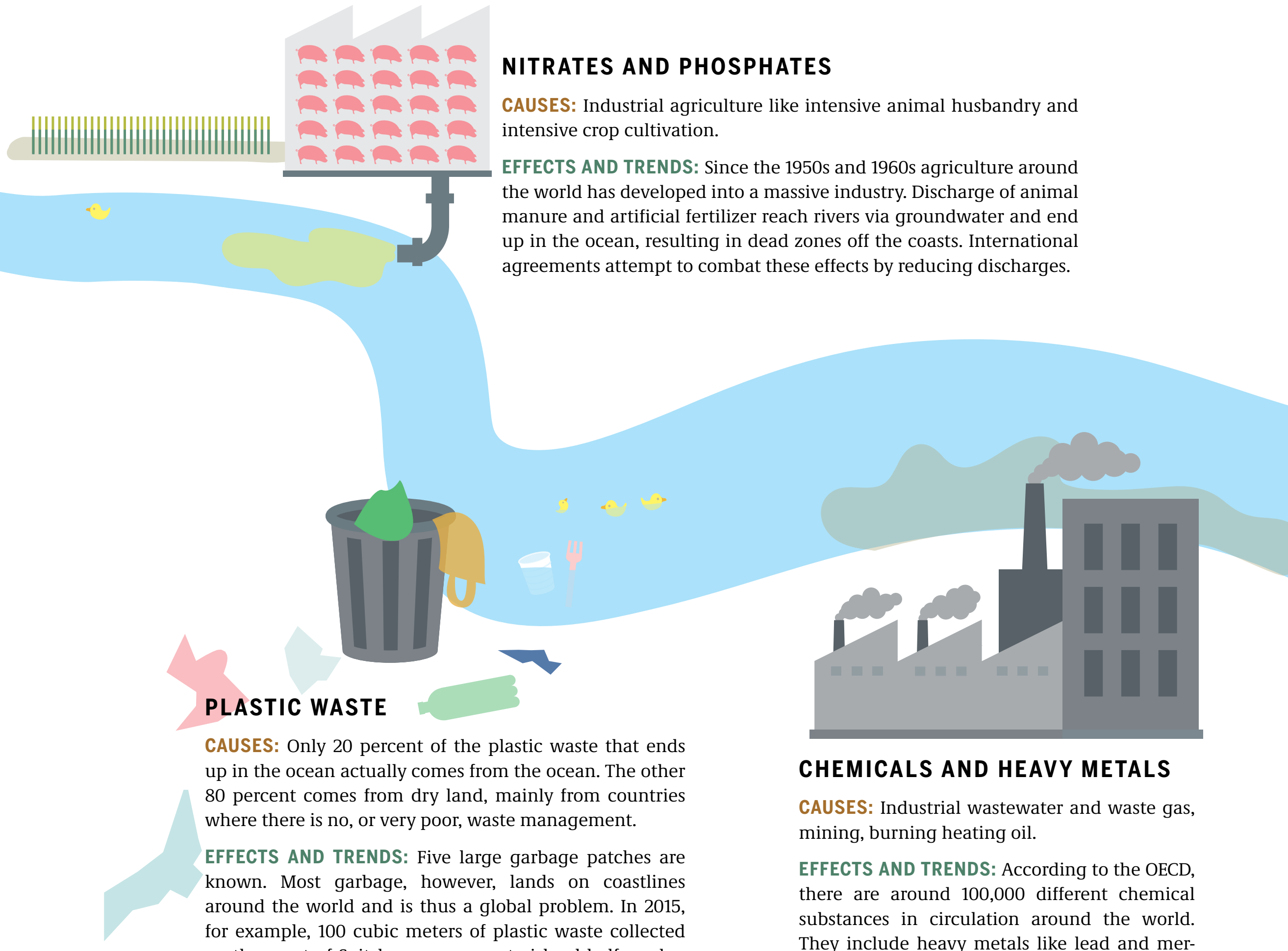
On a global scale, Kiribati's waters have a moderately low phosphate concentration, ranging from 0.28 to 0.51 umol/L. Higher concentrations are observed in the eastern island groups (Line and Phoenix), particularly along the equator. Generally, the highest phosphate concentrations are found in high latitudes and in areas of coastal upwelling. A similar pattern can be seen in global nitrate concentrations, which are generally low, with the highest concentrations found in high latitudes and some areas of coastal upwelling. Within Kiribati's waters, the nitrate concentration ranges from 0.6 to 3.2 mmol m-3, with the highest concentrations again in the eastern island groups, particularly along the equator, but the South-West Tropical Pacific (SWTP) is generally considered a nitrogen-limited area.

Although not shown on the map, localized concentrations of both phosphate and nitrate are often higher around dense populations due to land and coastal inputs, which can include inorganic fertilizers, wastewater treatment from municipal sources, 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 Kiribati's 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 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, such as enclosed lagoons, where increased nutrients can result in algal blooms. 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).




## 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

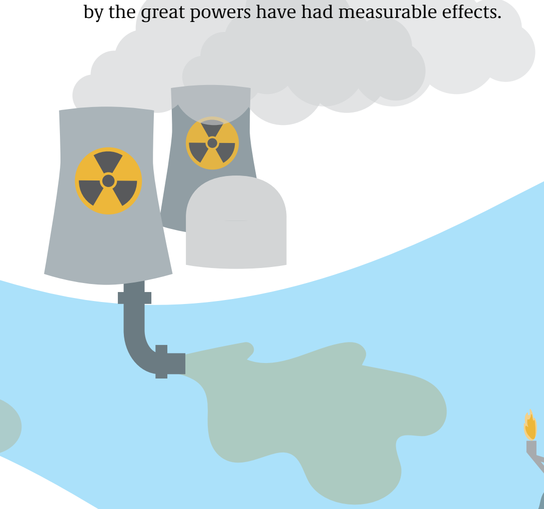
**CAUSES:** Industrial wastewater and waste gas, mining, burning heating oil.

**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.

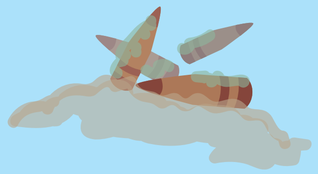
**EFFECTS AND TRENDS:** Starting in the 1950s, countries began legally dumping barrels of radioactive waste from nuclear power plants into the ocean. Barrels in the English Channel that should have remained sealed for hundreds of years have already begun leaking. The marine dumping of atomic waste was 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.



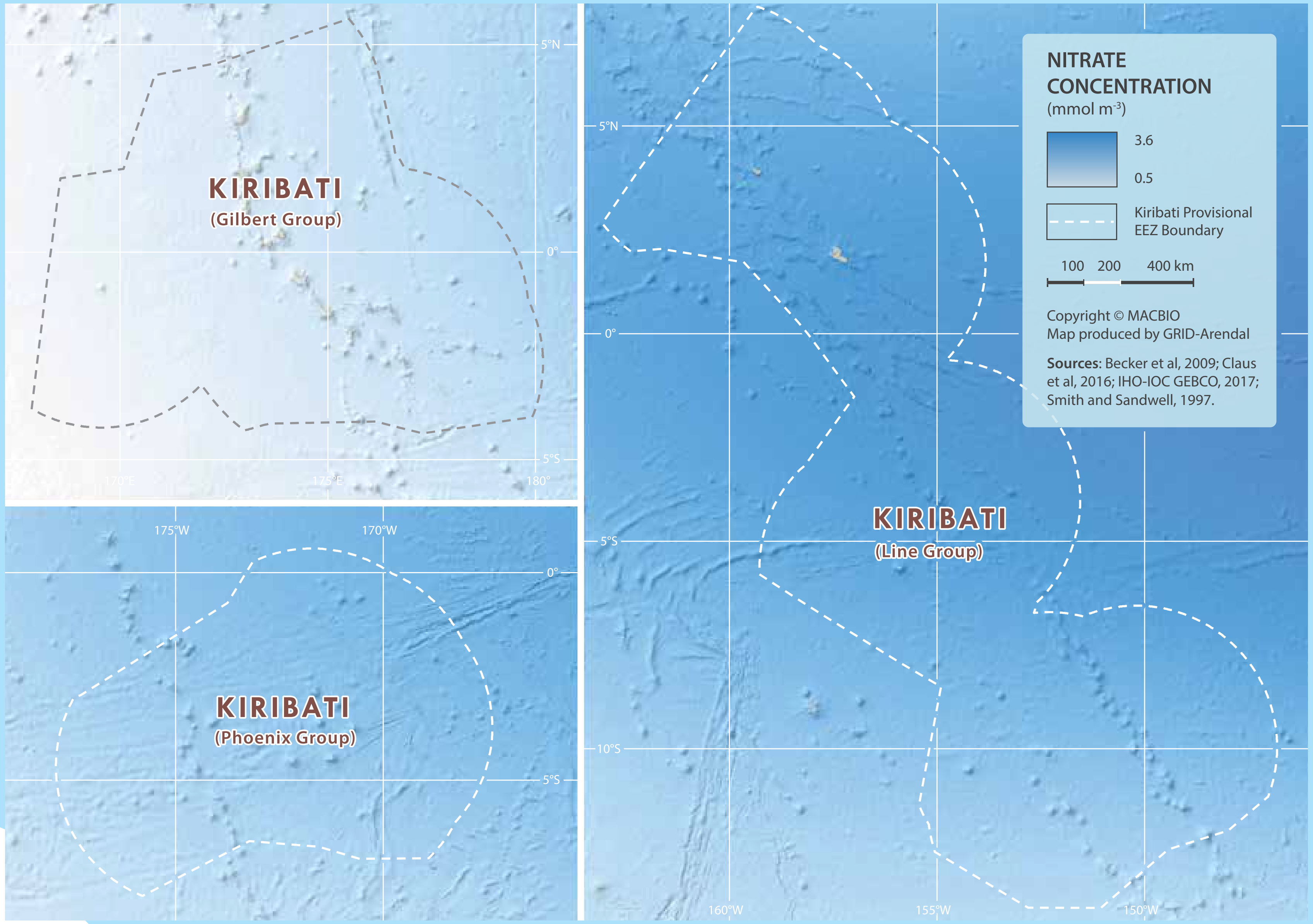
## Sea food

“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. We need to eat food, but too much food is evidently bad for us.

Marine organisms need food and nutrients as well. Phosphate (see map) is one of the important nutrients that supports biological activity and is important for the growth of tiny plants known as phytoplankton, which form the basis of many marine food chains (see also chapter “Soak up the sun”).

Another food source is nitrogen (see map), which is present in the marine environment in various forms, with nitrate being the principal form used by organisms. 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.

As the chapters “Plastic oceans” and the graphic below show, excess nutrients are only one type of pollution and threat to Kiribati’s marine values. To keep Kiribati’s coastal habitats healthy (see also chapter “Home, sweet home”), it is important to manage 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.



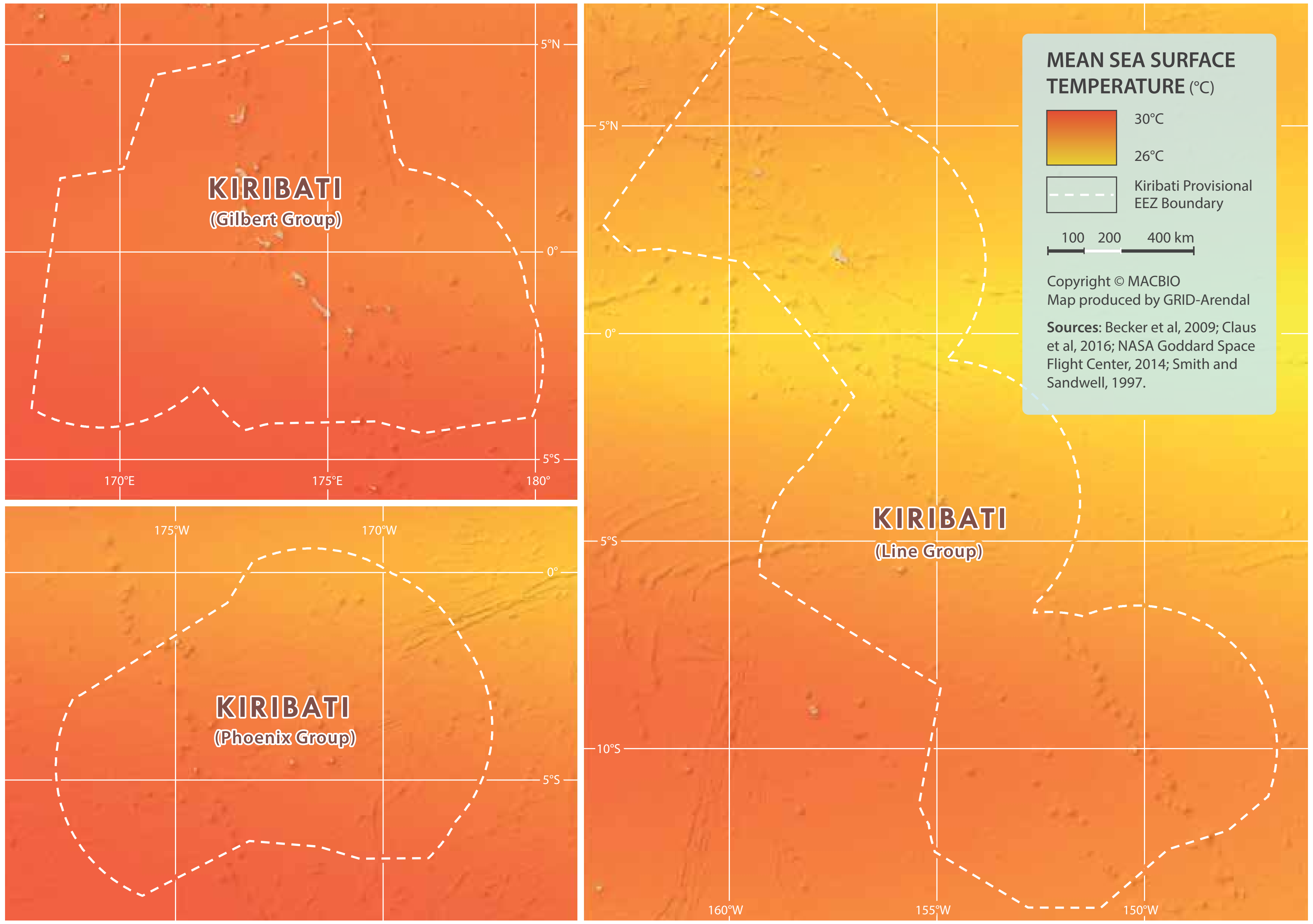
# CLIMATE CHANGE THREATS

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

Sea surface temperature (SST) is a limiting factor for much of Kiribati's marine life. Climate change is leading to higher sea temperatures, as well as sea levels, compromising Kiribati's marine biodiversity.

The following chapters explain how observed and predicted climate change will affect Kiribati's marine values, starting with SST, which is the water temperature close to the ocean's surface. 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 breezy 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 Kiribati's waters ranges from 25°C to 29°C. The warmest water temperatures occur in the Gilbert group and the southern parts of the Phoenix group, and to a lesser extent, the Line group. The central part of the Line group has the coolest temperatures. Across the year there is variation in the SST, with the largest seasonal variation of ±3.5°C in the central part of the Line group and the smallest seasonal variation of ±1.5°C in the Gilbert and Phoenix groups. The southern parts of Kiribati's waters are strongly

## Blame it on the weatherman?

Water in Kiribati can get poisonously hot. Tiny dinoflagellates, such as Gambierdiscus toxicus, like it warm and produce a certain poison that adheres to algae, which is eaten by reef fish. These fish are, in turn, eaten by humans. In warm periods, this so-called Ciguatera poisoning can become a serious problem for I-Kiribati, who rely on reef fish as their main source of food and nutrition.

But is it just a few hot, sunny days or global warming that is warming the water to a poisonous temperature?

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").

influenced by the South Equatorial Current (see also chapter "Go with the flow"), 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 Kiribati, 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 sea level rise are necessary in order to plan effectively for these changes.

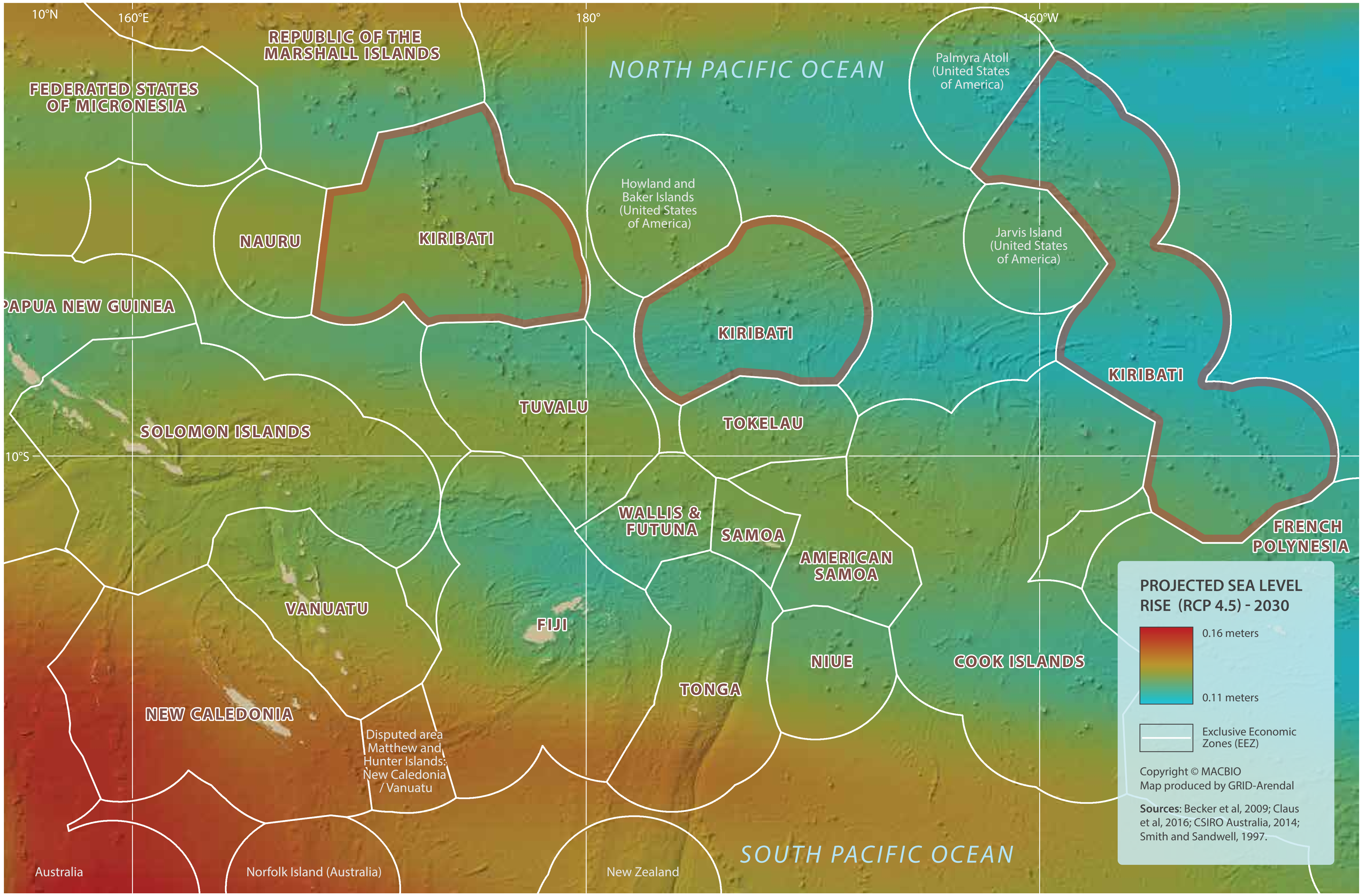
Sea level rise, as a consequence of global warming, threatens many low-lying regions of the world. The Fifth International Panel on Climate Change assessment projects a global rise in mean sea level for 2081–2100 relative to 1986–2005 of between 0.2 and 0.98 metres, depending on different emissions scenarios. 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).

With its low-lying coral atolls, Kiribati is particularly vulnerable to sea level rise. Vulnerability to sea level rise is influenced by coastal geography and prevailing ocean currents. 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 Kiribati 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, Kiribati will experience a minimum rise in sea level of between 0.13 and 0.15 metres. The Gilbert group will experience the lowest sea level rise, while the Line group will experience the highest. In general, the map shows that the main islands of Kiribati are in a zone of lower sea level rise, when compared with the South-West Pacific. However, when combined with weather events, even these small sea level increases can have significant coastal impacts. There is already an increasing level of flooding and wave inundation in some coastal areas of Kiribati. Pacific island nations are therefore focused on developing adaptation strategies to address the predicted continued rise in sea level.

In the past, atolls and islands, which often rise a mere metre above the waves, were only flooded by the ocean every couple of decades. That trend has since changed, with an increased frequency in these flooding events. When these events become too frequent, it makes it difficult for islands to recover. The land becomes too salty, the freshwater reserves in the lagoons become undrinkable and the islands themselves can no longer support human habitation. Given the limited amount of land in Kiribati, this is a particular issue, since there is no higher ground to move communities and infrastructure to. Kiribati is investigating various options for addressing sea level rise, including physical defences on islands. It has also purchased 5,000 acres of land in neighbouring Fiji in case it loses the fight against the rising sea.

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



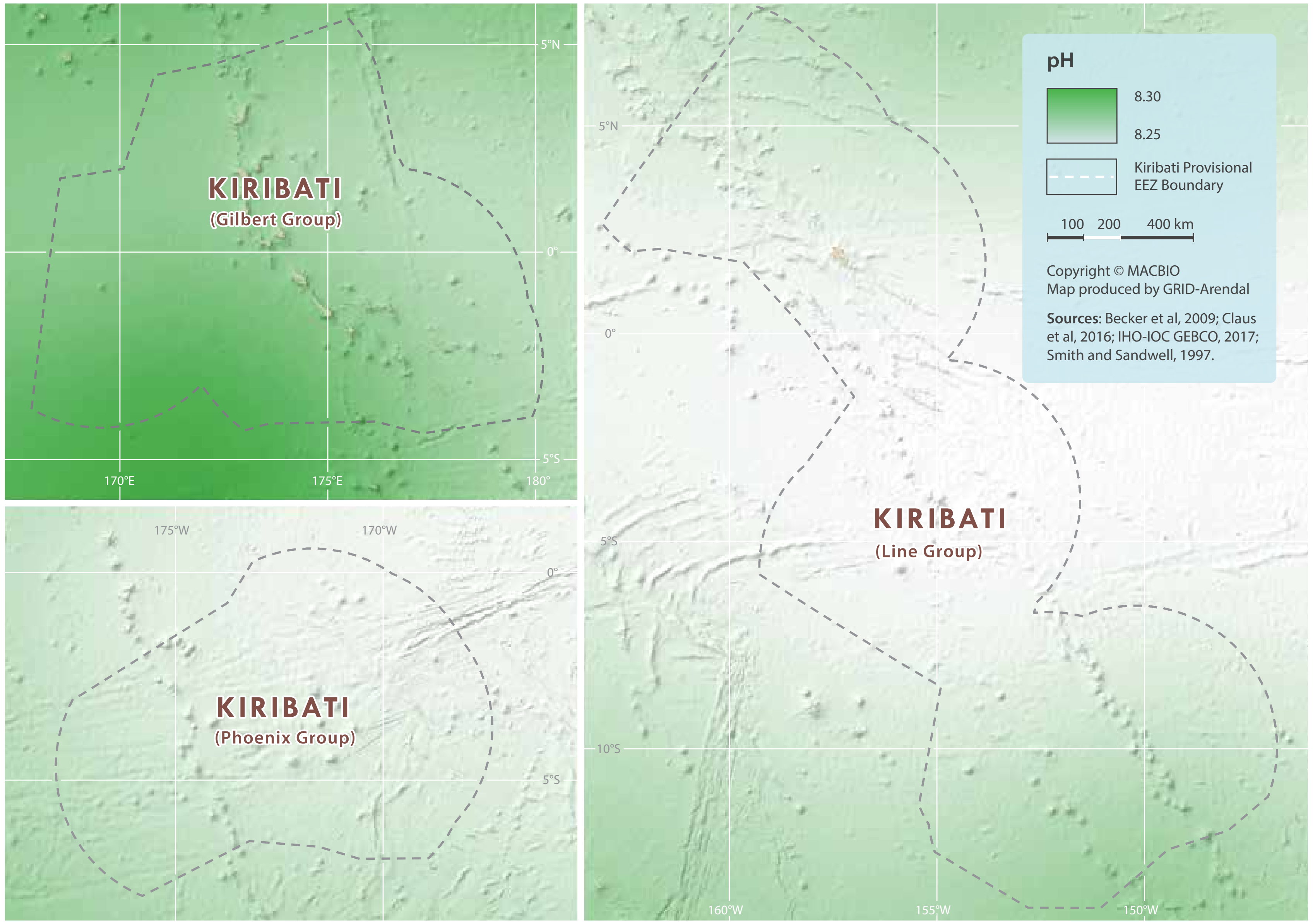
# TURNING SOUR: OCEAN ACIDITY

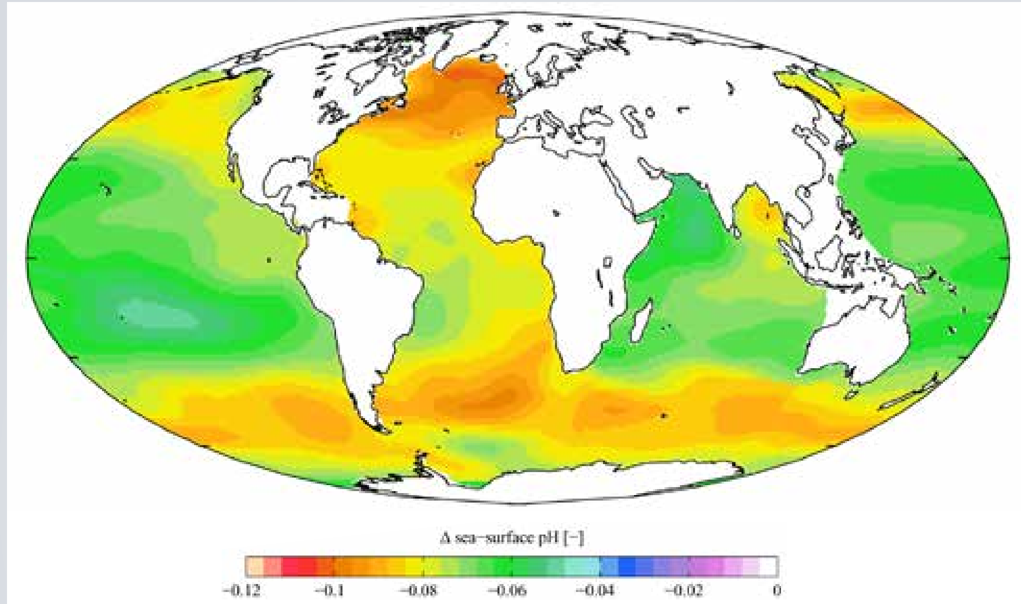
Climate change is not only causing sea temperatures and levels to rise but also its acidity, which causes serious problems for many marine organisms.

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. Kiribati's waters are at the higher end of this range, with pH between 8.26 and 8.30. 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 on the right), 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 Kiribati's 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 marine 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 Southern Ocean has noticeably



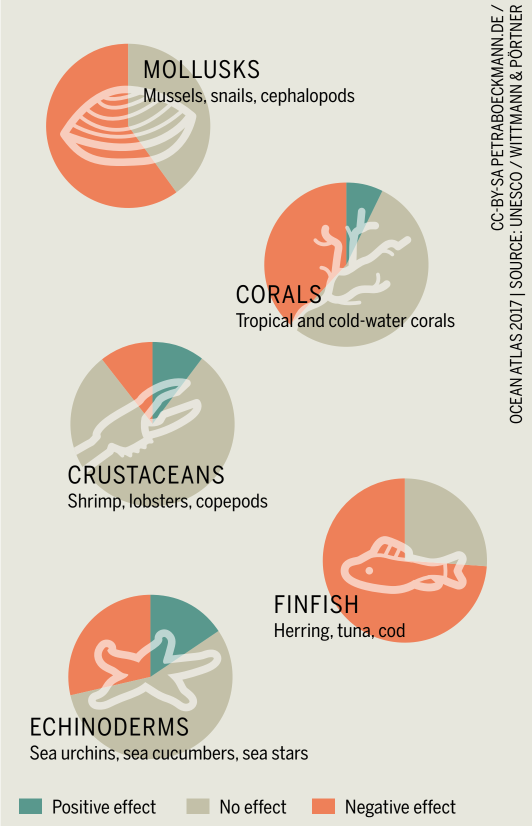




## Ocean acidification

Kiribati 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.

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,

### 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.*

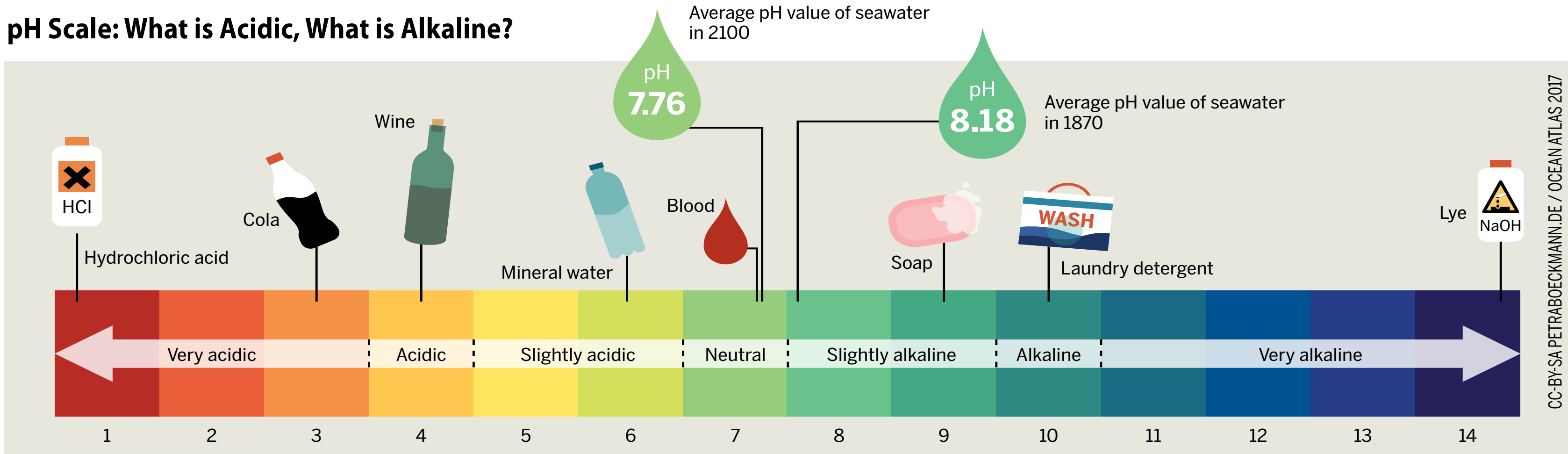
but only because they invest so much energy into shell production that it stunts their overall growth. This makes them easier prey for predators, such as murex snails.

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.

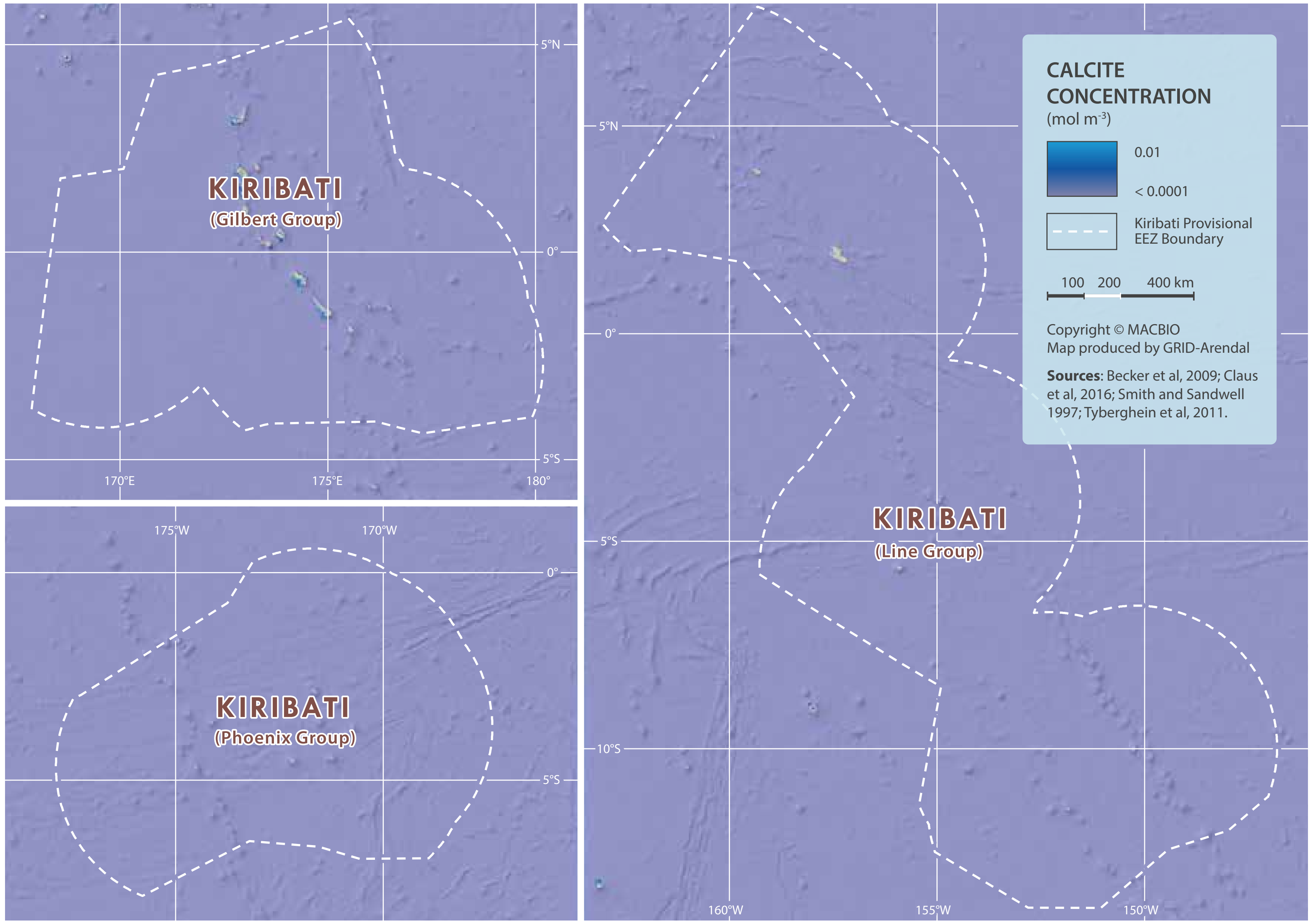
Kiribati's shallow-water corals are also likely to be affected if acidity continues to increase. For example, it has been predicted that ocean acidity will decrease from a current pH of around 8.3 to a pH of 7.9 by 2100. This level of decrease has been shown to result in a 50 per cent reduction in coral 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.

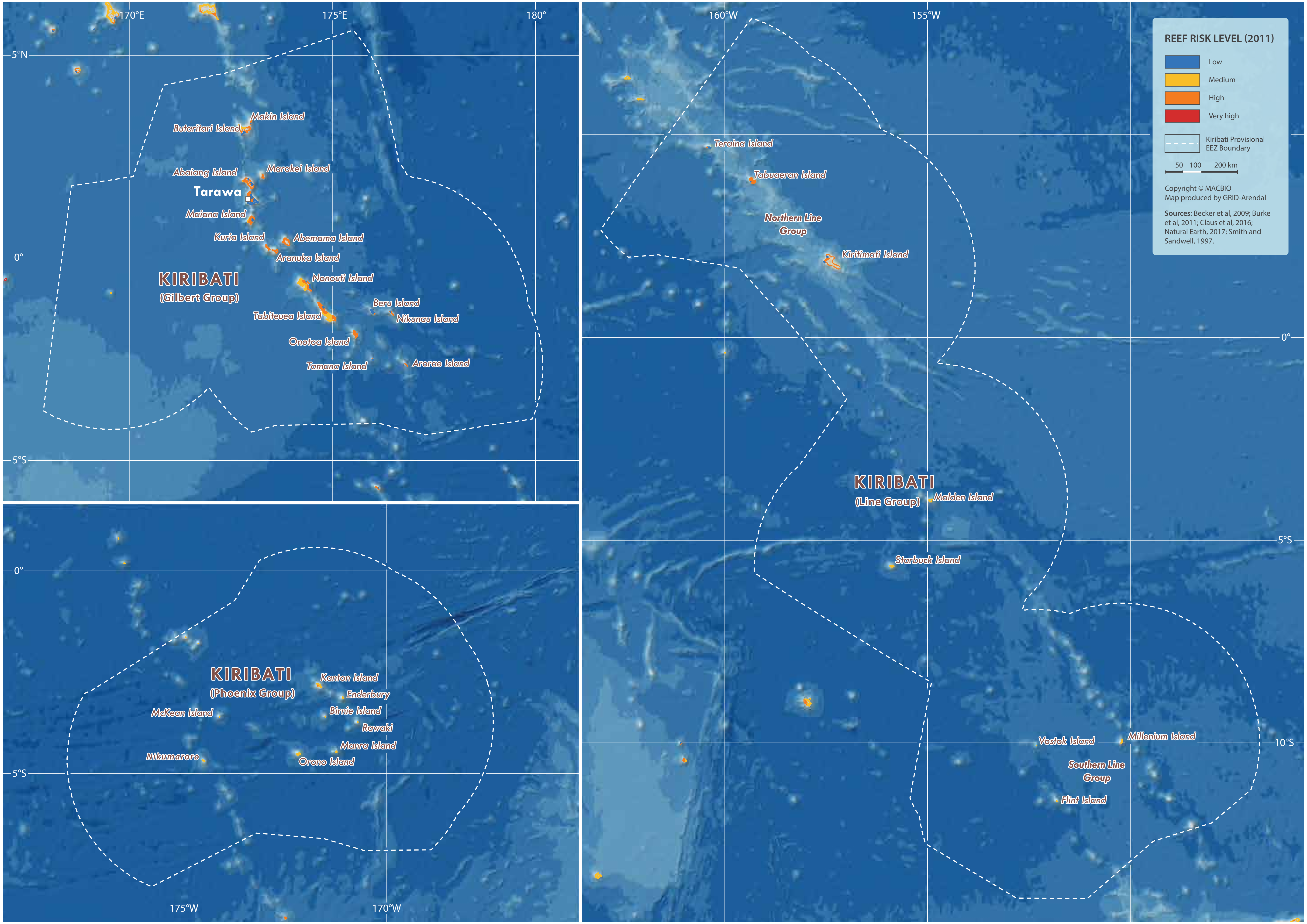
It seems that in the face of global warming's "evil twin" (ocean acidification), Kiribati's sea is turning sour.

### 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.*




REEF RISK LEVEL (2011)
Low
Medium
High
Very high
Kiribati Provisional EEZ Boundary
50 100 200 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.
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orona Island
McKean Island
Nikumaroro
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Northern Line
Group
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line
Group
Flint Island
170°E
175°E
180°
160°W
155°W
175°W
170°W
5°N
0°
5°S
10°S

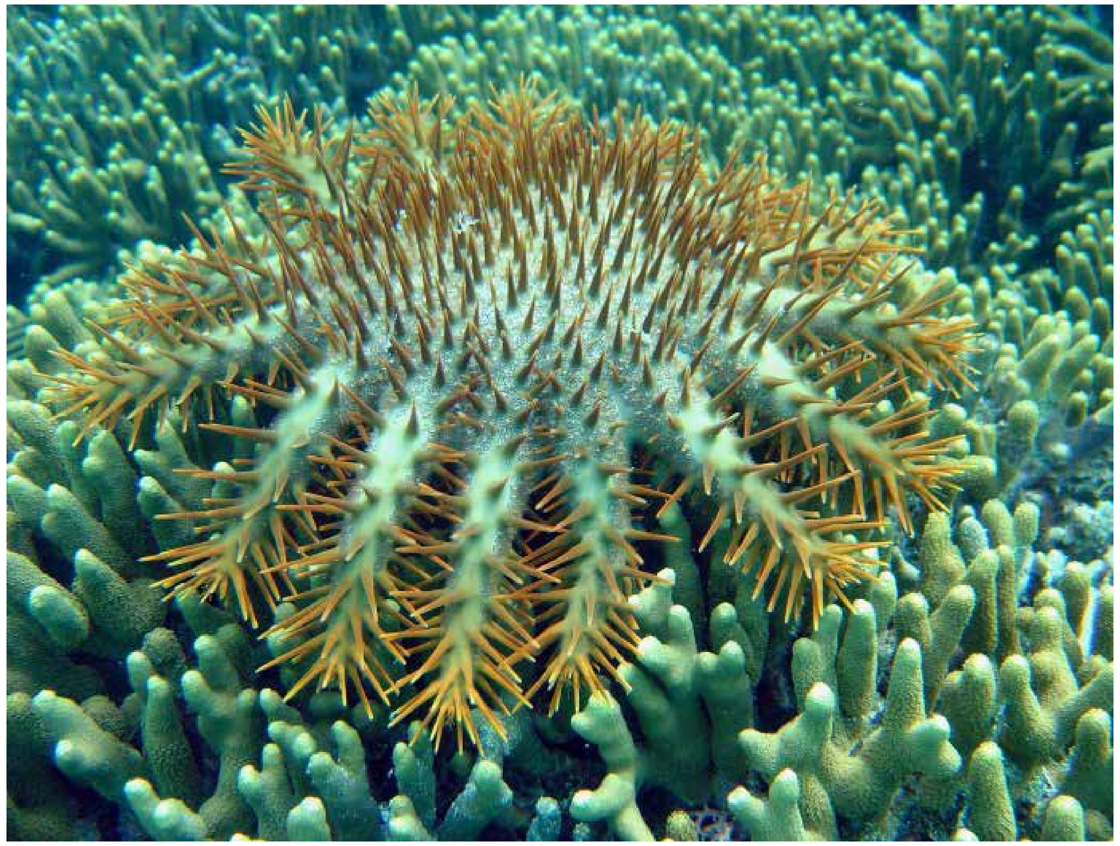
# REEFS AT RISK: REEF RISK LEVEL

Kiribati's reefs are at risk and the direct and indirect impacts of climate change are exacerbating a system already under threat, jeopardizing marine values worth billions of dollars.

As seen in the previous maps, coral bleaching is the silent reef killer, caused by rising sea levels and ocean acidification. Kiribati's reefs are remote and often pristine; however, even they are not immune from the threat of coral bleaching. In 2015–2016, persistent elevated ocean temperatures as high as 31.4°C affected the northern Line Islands. This resulted in widespread coral bleaching, with more than 80 per cent coral mortality in some locations, particularly around Kiritimati (NOAA Coral Reef Watch). This event was linked to a very strong El Niño event that affected much of the Pacific reefs.

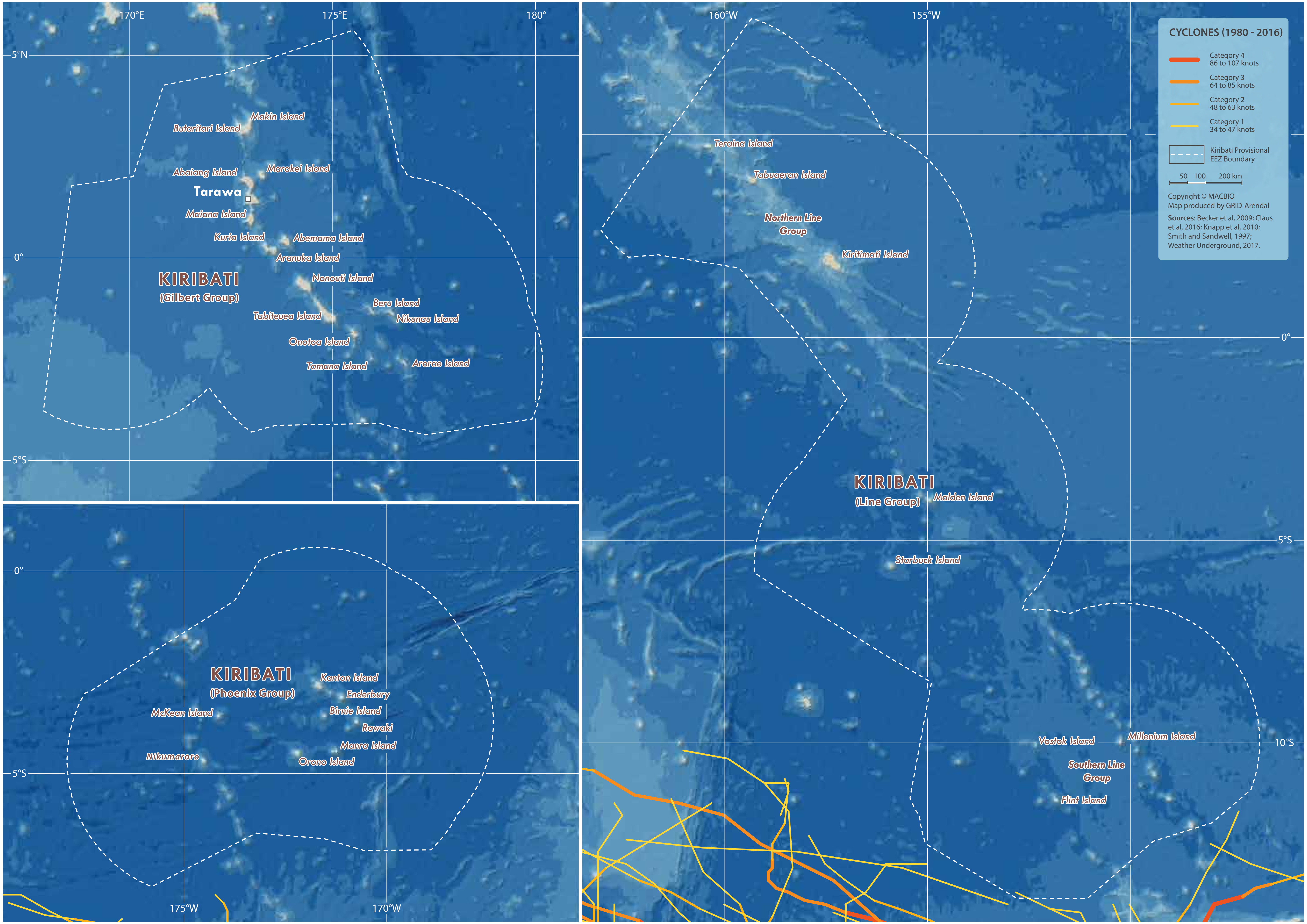
However, climate change is not the only threat to coral reefs; local human activities are also posing a threat to Kiribati's reefs. The cumulative risk of these threats is shown on the map of Kiribati's reefs, classified by estimated present threat from local human activities, according to the Reefs 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").

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



*Crown-of-thorns starfish damage Kiribati's reefs. Outbreaks often occur when their natural predators are overfished.*

This multitude of man-made threats leaves Kiribati's reefs at risk. Analysis of the threat index indicates that 28.1 per cent of the reef area is classified as facing a low risk, 56.0 per cent a medium risk and 15.9 per cent a high risk, with no reefs facing a very high risk at the time of assessment (2011). The areas of increased risk to reefs correspond to the main population centres, particularly in the Gilbert group and around Kiritimati (Christmas Island). Kiribati has also been identified as one of the nine countries most vulnerable to coral reef degradation, due to a combination of high dependence on the reefs, high threat exposure and low adaptive capacity (Burke et al., 2011). The reefs are important to the economies of local communities, for subsistence and for coastal protection. The islands of Kiribati are built entirely of coral reefs and would not exist if it were not for their protective fringe (Burke et al., 2011).



CYCLONES (1980 - 2016)
Category 4
86 to 107 knots
Category 3
64 to 85 knots
Category 2
48 to 63 knots
Category 1
34 to 47 knots
Kiribati Provisional
EEZ Boundary
50 100 200 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.
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
Manra Island
Orono Island
McKean Island
Nikumaroro
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Northern Line
Group
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line
Group
Flint Island
170°E
175°E
180°
5°N
0°
5°S
175°W
170°W
160°W
155°W
10°S

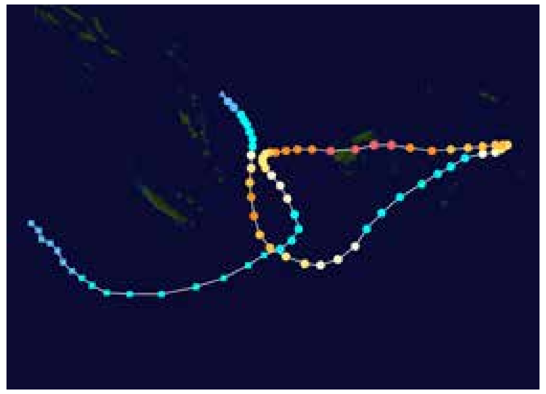
# STORMY TIMES: CYCLONES

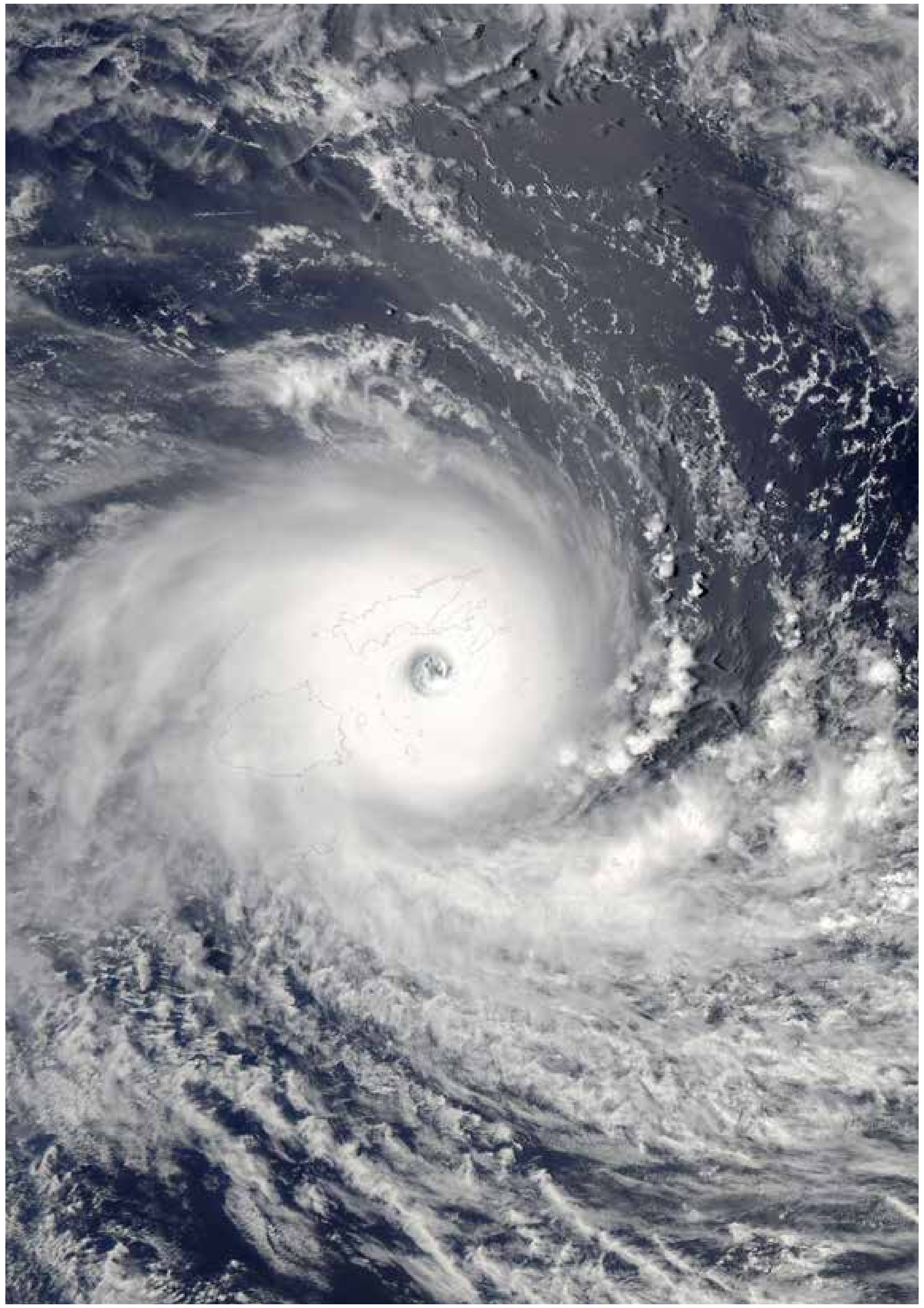
Tropical cyclones pose direct threats to Kiribati, its people and its marine life. Marine and coastal habitats including mangroves, seagrasses and coral reefs play an important role in offering effective protection and therefore need to be sustainably managed and conserved.

Kiribati's geographical location in the central Pacific puts it a safe distance from the cyclone and hurricane belts. Despite this, Kiribati is still susceptible to occasional spill-over effects of category 5 cyclones. In 2005, as Tropical Cyclone Pam strengthened in her path around Vanuatu, flooding and storm surge destroyed homes in Kiribati's southern islands, such as Arorae, Tamana and some parts of the main capital, Tarawa. The government spent significant sums on money, including donations from development partners, to aid recovery efforts following this event.

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 1991–2010 period compared with the 1970–1990 period. Rising SSTs are fuelling cyclones (see also chapters "Hotter and higher") that are resulting in increasing damage, including to Kiribati's valuable coastal habitats and infrastructure (see small map).

At the same time, conserving habitats such as coral reefs and mangroves offers a very effective form of protection against storms.





# MANAGING

The marine and coastal ecosystems of Kiribati's waters provide benefits for people in and beyond Kiribati. To better understand and improve the effective management of these values on the ground, Pacific Island countries, including Kiribati, 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 Kiribati that starts at the local level, based on traditional fishing grounds. In addition, Kiribati 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, through understanding and harmonizing the many different layers of values and uses in Kiribati's waters.

To maximize benefits from these marine values for Kiribati, 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.

For further reading, please see **http://macbio-pacific.info/effective-management**

# SPACE TO RECOVER: MARINE MANAGEMENT

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

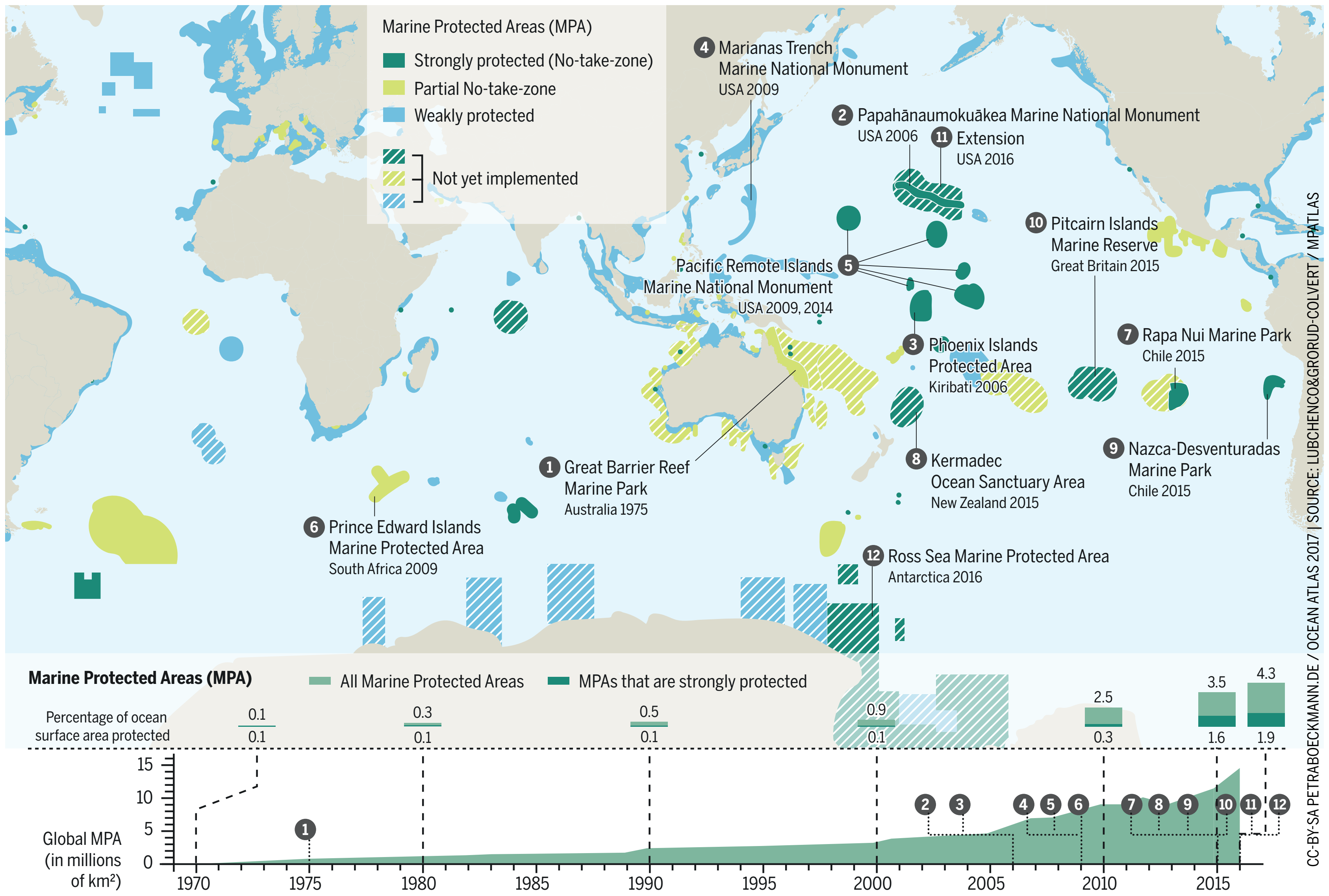
Taking into account every type and category of protected area globally, only 3.5 per cent of the ocean is currently protected. Environmental organizations and scientists recommend that between 20 and 50 per cent of the ocean should be protected. The goal is not to preserve things as they are—even protected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

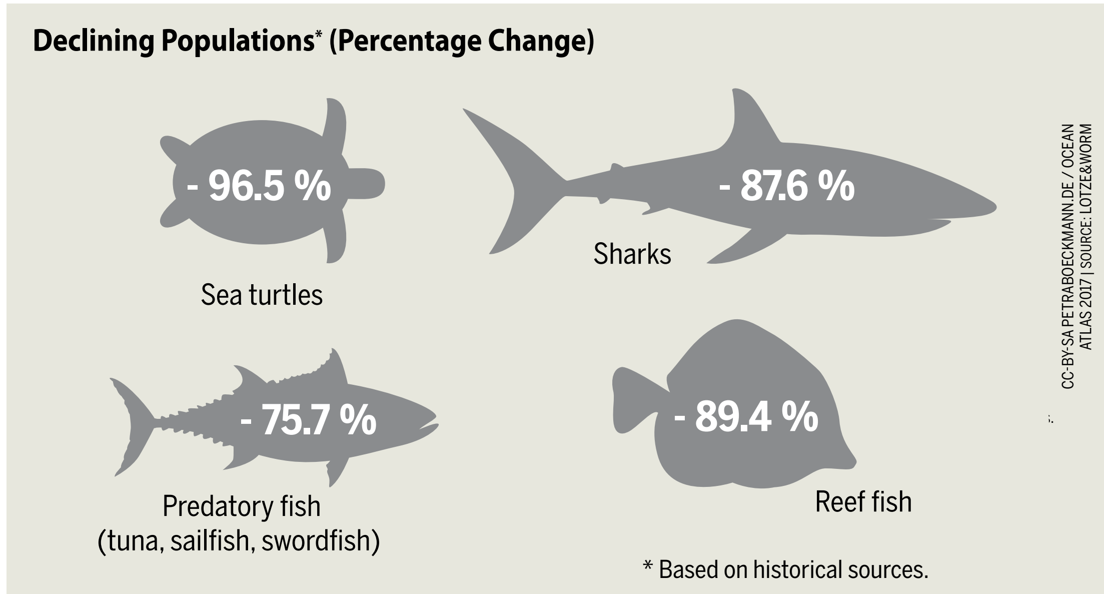
This is crucial, given the decline of global marine populations (see graphic). For this reason, the world wants to protect at least 10 per cent of coastal and marine areas by 2020, as formulated in an international CBD target (see also chapter "Kiribati's commitment to marine conservation"). Indeed,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

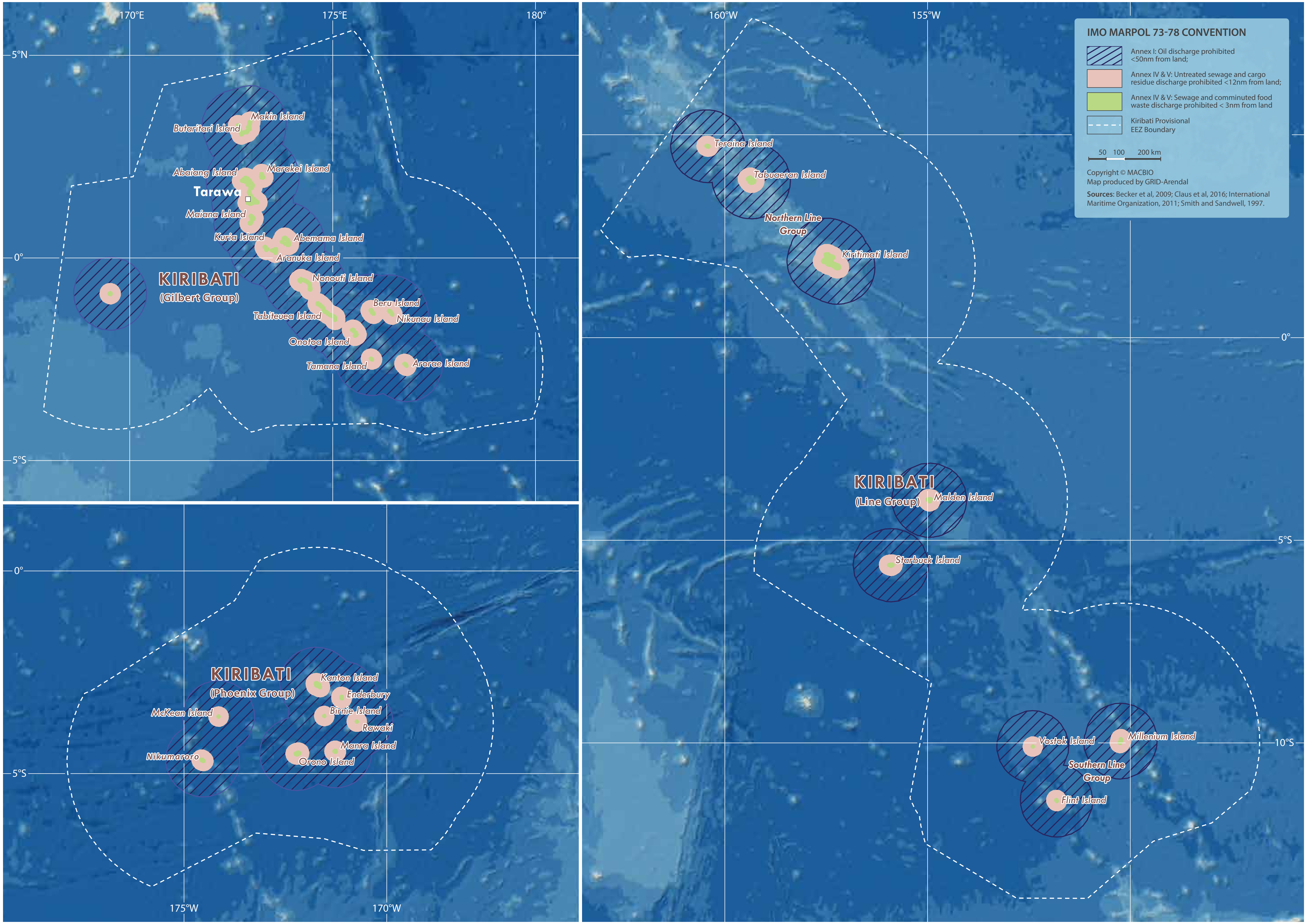
Marine managed areas are areas of the ocean that are managed for specific purposes, which can include protection of biodiversity or sustainable use of the resources. These areas are summarized in the World Database on Protected Areas (WDPA), which is a global compilation of both terrestrial and marine 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 importance of designating areas for marine life to recover, in 2016, Kiribati declared its whole ocean area—all 3.5 million km2 of the EEZ—as a shark sanctuary, banning all commercial fishing of sharks. As a gift to humanity, Kiribati created the PIPA in 2006, an MPA that covers more than 11 per cent of the country's total EEZ and serves as a spawning ground for tuna. The government is currently scaling up these efforts towards the creation of community- and village-based MPAs throughout the country.

**Marine Protected Areas – Space to Recover**




170°E
175°E
180°
5°N
0°
5°S
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
KIRIBATI
(Gilbert Group)
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
160°W
155°W
Teraina Island
Tabuaeran Island
Northern Line
Group
Kiritimati Island
0°
KIRIBATI
(Line Group)
Malden Island
5°S
Starbuck Island
Vostok Island
Millenium Island
Southern Line
Group
Flint Island
10°S
IMO MARPOL 73-78 CONVENTION
Annex I: Oil discharge prohibited <50nm from land;
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
Kiribati Provisional EEZ Boundary
50 100 200 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.
0°
5°S
KIRIBATI
(Phoenix Group)
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Manra Island
Nikumaroro
Orona Island
175°W
170°W

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

Kiribati's marine values do not stop at national borders. This makes international cooperation increasingly important for effective management of Kiribati's marine estate, especially for fisheries, mining, shipping and conservation.

Kiribati has sovereign rights over a vast marine area of 3.55 million km2. 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 Kiribati (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.

Kiribati 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 Kiribati's 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.*

- 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, Kiribati is in the process of declaring Particularly Sensitive Sea Areas (PSSAs), which are areas that need special protection through IMO action because of their ecological, socioeconomic or scientific significance, and which may be at risk from maritime activities. As an example, a PSSA can be protected by routing measures, meaning that ships avoid these areas.

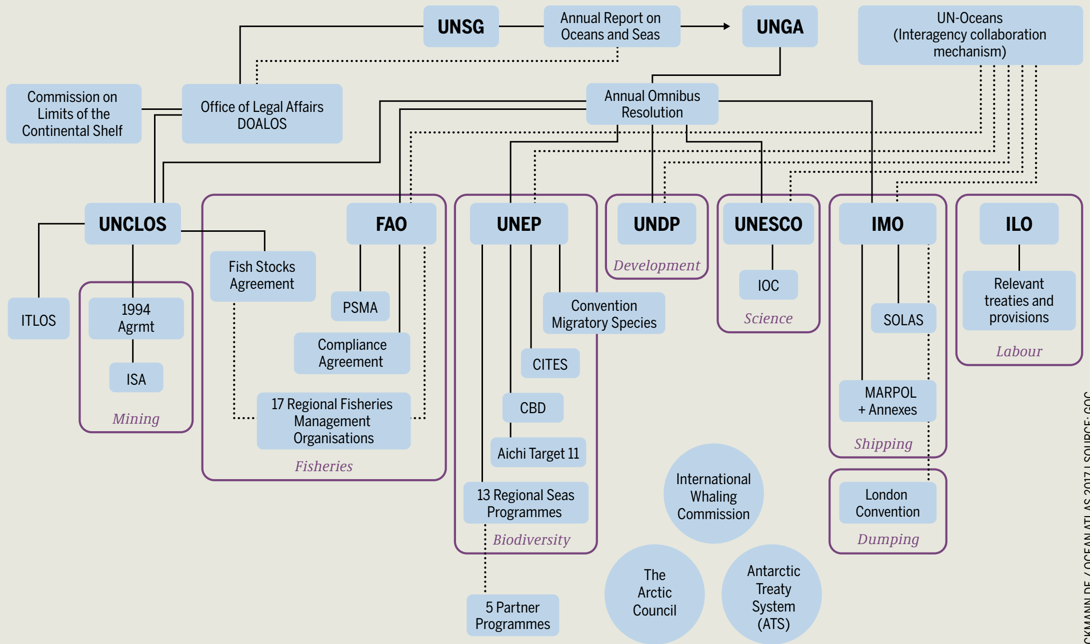
Beyond addressing pollution and invasive species, the Pacific Oceanscape Framework provides orientation at the regional level for sustainable marine management.

Ultimately, Kiribati and other Pacific Island countries are heavily reliant on their marine values, which are not delimited by national borders. Thus, regional and international cooperation and agreements are becoming increasingly important. We only have one world, and one ocean!

## Under invasion

In addition to pollution, international shipping routes pose another threat to Kiribati's 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.

**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

# KIRIBATI'S COMMITMENT TO MARINE CONSERVATION

Kiribati is committed to sustainably managing and conserving its marine values. By creating the PIPA, it fulfilled its international obligation of conserving 10 per cent of its waters, but Kiribati is going further still.

Kiribati has long realized the many values it derives from the sea, and the importance of sustainably managing and planning it uses (see also previous chapter). Thus, Kiribati joined many other countries in signing and ratifying the international Convention on Biological Diversity (CBD), under which Kiribati 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."*

To address this, in 2006, Kiribati established the PIPA, one of the largest large-scale MPAs in the world, which constitutes around 11 per cent of Kiribati's EEZ. Furthermore, the government of Kiribati aims to scale up national efforts towards creating community- and island-based MPAs throughout the country.

In 2017, the interim Interministerial Ocean Committee was formed through the Ministry of Fisheries and Marine Resources Development and the Ministry of Environment, Lands and Agricultural Development, to prepare for the United Nations Ocean Conference and discuss Marine Spatial Planning efforts in the islands of Tarawa and Kiritimati.

The members of this committee include technical experts from government ministries, which include:

- Ministry of Fisheries and Marine Resources Development
- Ministry of Environment, Lands and Agricultural Development
- Office of the President (Te Beretitenti)
- Ministry of Finance and Economic Development
- Ministry of Foreign Affairs and Immigration
- Ministry of Justice
- Kiribati Police Service and Maritime Surveillance
- Ministry of Information, Communication, Transport and Tourism Development
- Ministry of Health and Medical Services
- Kiribati Ports Authority
- Ministry of Line and Phoenix Islands Development
- Phoenix Islands Protected Area Implementation Office
- Ministry of Internal and Social Affairs

This interim Interministerial Ocean Committee, led by the Ministry of Fisheries and Marine Resources Development, sought cabinet approval to institutionalize ocean governance-related committees within government, which include the national overarching steering committee for Kiribati's EEZ, its technical geographic information system (GIS) support committee and the relevant policy instruments required.

The government is now moving towards initiating MSP processes in Tarawa, Kiritimati and other Line Islands, as well as finalizing steps for institutionalizing functional ocean governance committees and policy instruments to oversee a broad range of issues concerning Kiribati's EEZ.

This shows that Kiribati is committed to sustainably managing and conserving its marine values. In this spirit, Kiribati submitted three Voluntary Commitments (VCs) to the United Nations Ocean Conference in June 2017. Two of these VCs were commitments by the PIPA Scientific Advisory Committee and its partners to collaborate further on research in the PIPA. These efforts will include focusing on the impacts of ocean acidification, tuna dynamics , and exploring models for community MPAs that could be applied in other inhabited islands of Kiribati.

"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".

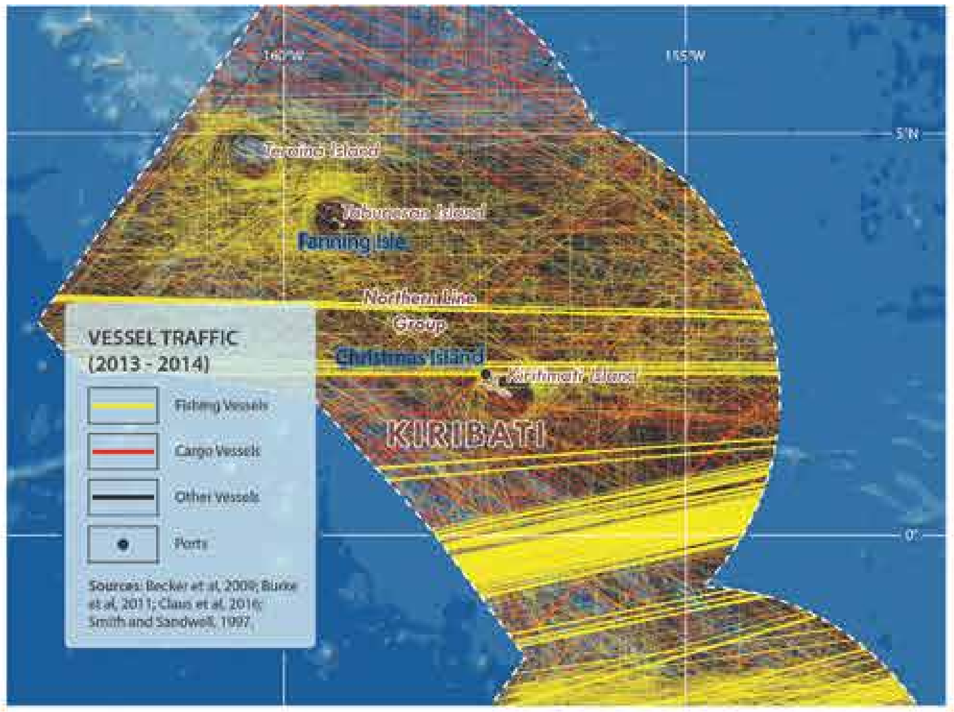
The second highest number of commitments come from the South Pacific, highlighting not only the importance of the ocean to Pacific Island countries, but also their commitment to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (SDG 14).

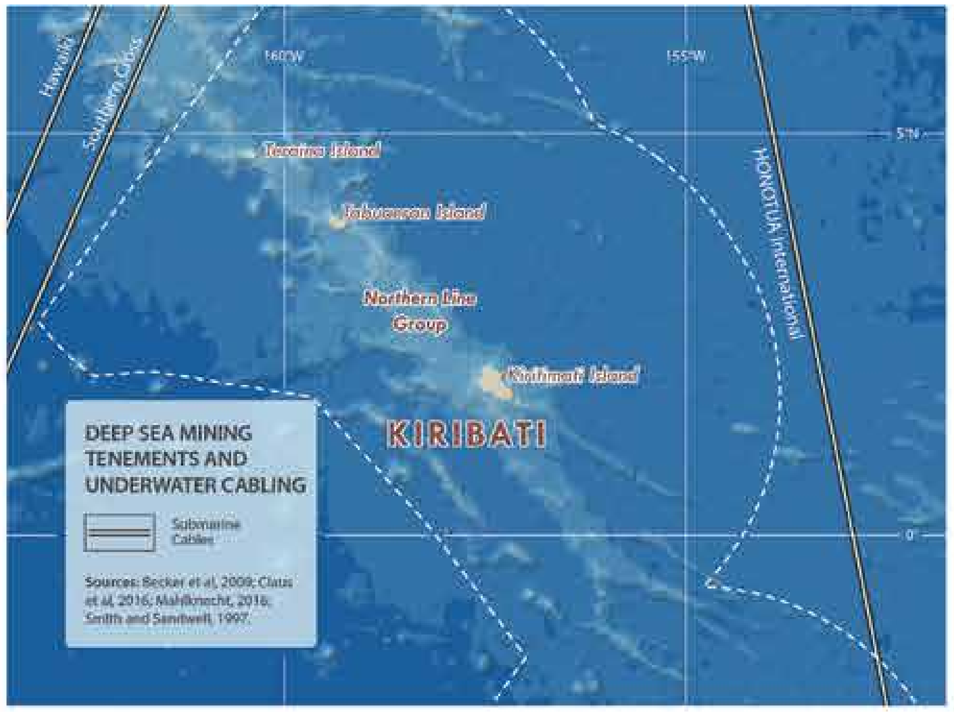
Kiribati is calling for action to conserve valuable life below the surface, within its own waters and beyond.

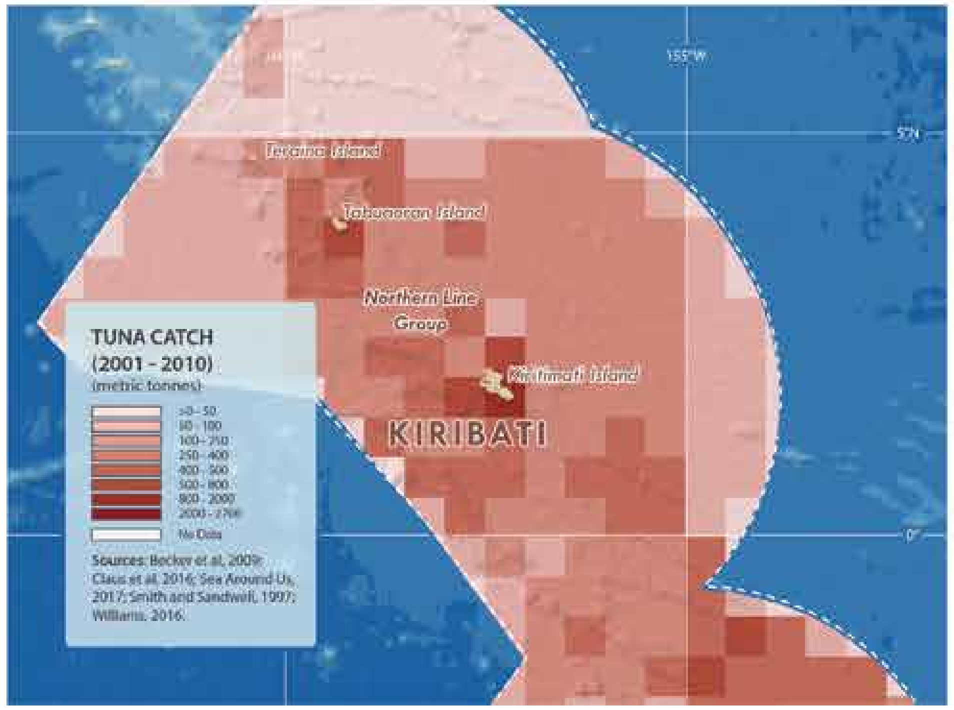
## Voluntary Commitments

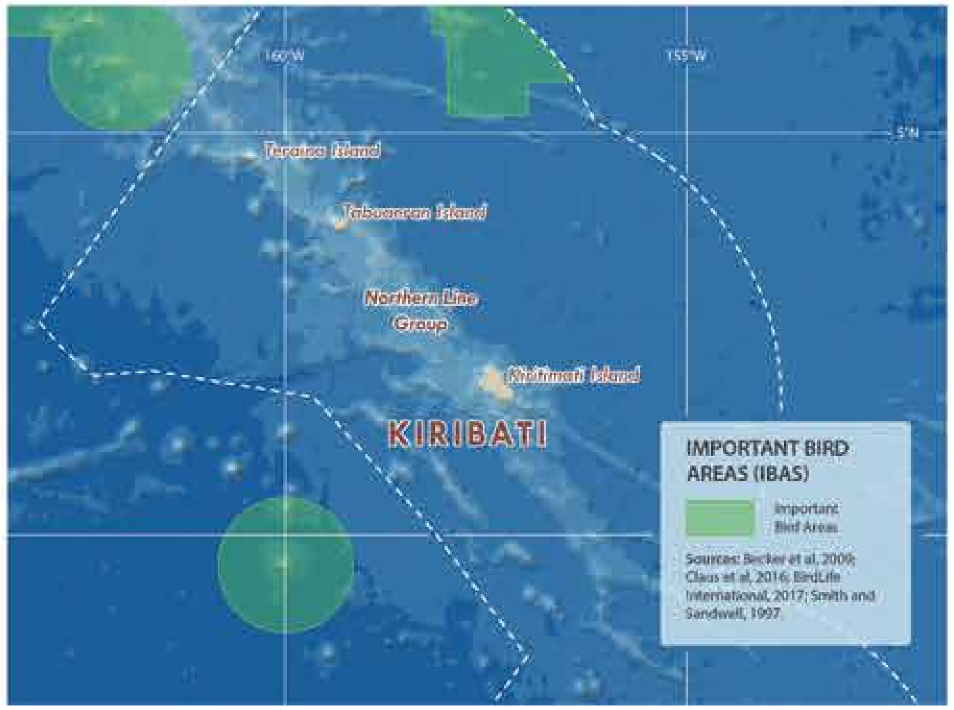
Voluntary Commitments (VCs) for The Ocean Conference are initiatives voluntarily undertaken by governments, the United Nations system, other intergovernmental organizations, international and regional financial institutions, non-governmental organizations and civil society organizations, academic and research institutions, the scientific community, the private sector, philanthropic organizations and other actors—whether individually or in partnership—that aim to help implement Sustainable Development Goal 14.

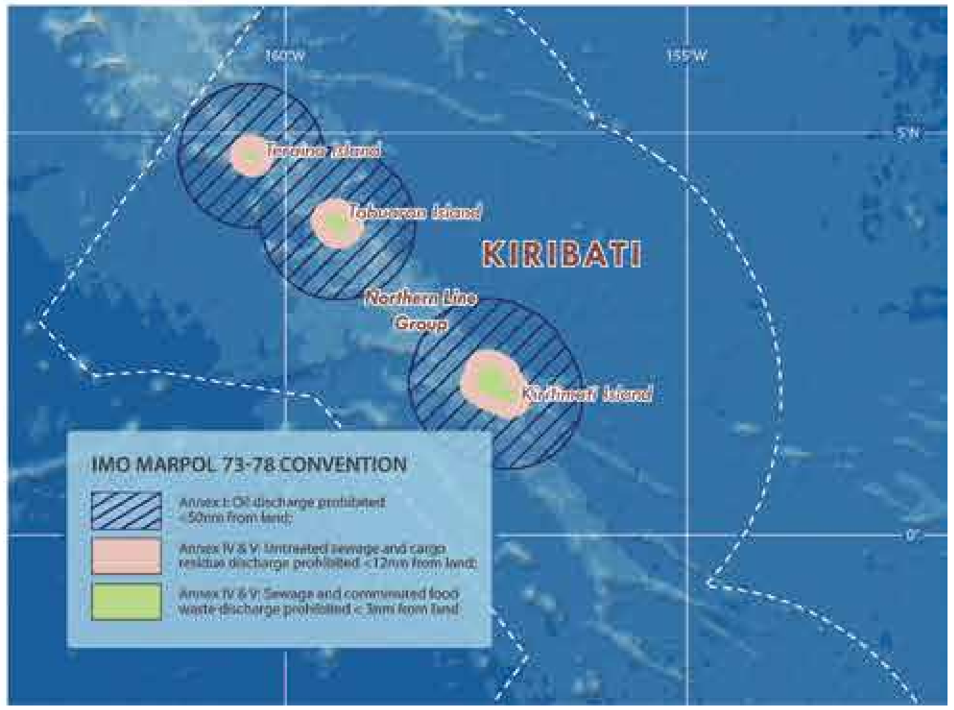
# A MARINE LAYER CAKE

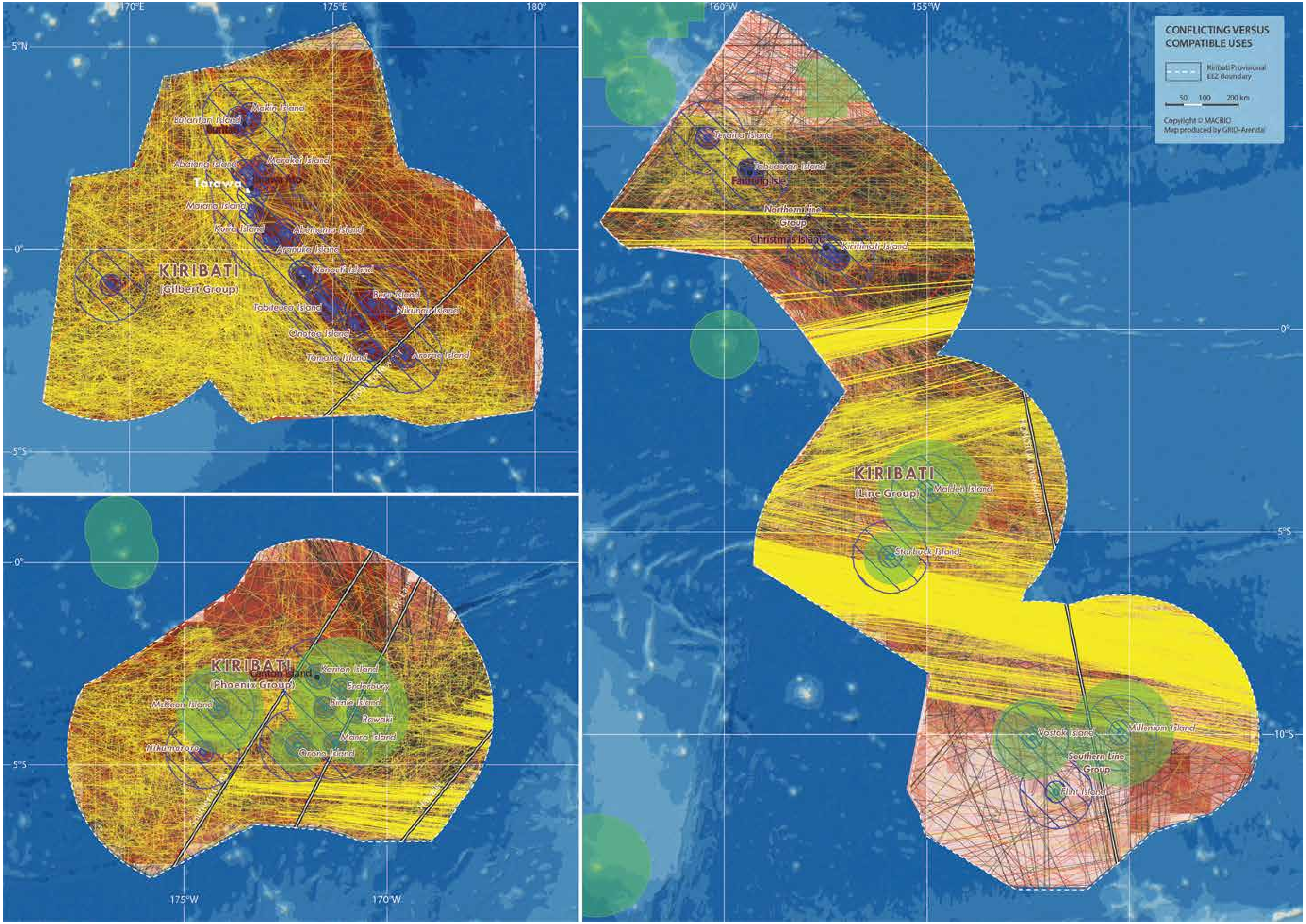




CONFLICTING VERSUS COMPATIBLE USES
Kiribati Provisional EEZ Boundary
50 100 200 km
Copyright © MACBIO
Map produced by GRID-Arendal
KIRIBATI
(Gilbert Group)
Makin Island
Butaritari Island
Abaiang Island
Marakei Island
Tarawa
Maiana Island
Kuria Island
Abemama Island
Aranuka Island
Nonouti Island
Beru Island
Nikunau Island
Tabiteuea Island
Onotoa Island
Tamana Island
Arorae Island
KIRIBATI
(Phoenix Group)
Canton Island
Kanton Island
Enderbury
Birnie Island
Rawaki
McKean Island
Manra Island
Orona Island
Nikumaroro
KIRIBATI
(Line Group)
Teraina Island
Tabuaeran Island
Fanning Isle
Northern Line Group
Christmas Island
Kiritimati Island
Malden Island
Starbuck Island
Vostok Island
Millenium Island
Southern Line Group
Flint Island
170°E
175°E
180°
160°W
155°W
175°W
170°W
5°N
0°
5°S
10°S

# 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 Kiribati address these conflicts?

MSP (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
- 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 Kiribati’s waters is not a new concept and there are already 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 locally managed marine areas (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.

## 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, 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*

Photos © Stuart Chape, © Carlo Iacovino and © Niue Tourism Office. Others are public domain images. Symbols: courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

# Marine Spatial Planning

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

## 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.

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 Kiribati 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 Kiribati’s rich and complex marine environment in a fair and sustainable manner, while maximizing benefits.

# CONCLUSION

Kiribati's vast ocean supports a myriad of marine values. To successfully conserve and manage these values, the island nation is committed to holistic planning and effective management to maximize the benefits from its marine resources.

Through valuing, planning and managing the values and benefits of its coastal and marine systems, Kiribati can achieve this. Nevertheless, the experience with MSP shows that only a truly participatory and inclusive process can generate nationwide ownership across sectors. Stakeholders across Kiribati are working together to secure a healthy, productive, 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 would like to thank the Kiribati Department of the Environment of the Ministry of Local Government, Housing and Environment, the Fisheries Department of the Ministry of Fisheries and Forests, the Kiribati Bureau of Statistics and other relevant ministries for providing data and support to the project.

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 for their support: Jasha Dehm, Marian Gauna, Eileen Motua, Jimaima Le Grand, Jan Steffen, Jonah Sullivan, Vatu Molisa, Hans Wendt, Lysa Wini, Naushad Yakub; 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 Kiribati's 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 Kiribati Marine Atlas are available here: **http://macbio-pacific.info/marine-atlas**

## Timeline of Kiribati Marine Spatial Planning Process

**2014**

In-country workshop on marine ecosystems services valuation with key stakeholders to raise awareness among government stakeholders of the relevance of resource and ocean economic values.

Discussion with government stakeholders on the MSP process and its living and non-living resources.

**2015**

Existing area-based management tools reviewed.

Follow-up discussions on the MSP process with Kiribati government.

Open-source GIS software training conducted.

More than 100 open data sets on marine aspects disseminated, and customized national maps for Kiribati shared with key government stakeholders (Departments of Environment, Fisheries, Mineral and Lands and the Phoenix Islands Protected Area Office)

**2016**

Marine Ecosystem Services Valuation report finalized.

Marine Atlas introduced to Kiribati, covering its living and non-living resources.

**2017**

Dialogue among government agencies on ocean governance, MSP and Voluntary Commitments, prior to the United Nations Ocean Conference.

Government of Kiribati endorse an atoll-scale MSP to be formulated for Tarawa and Kiritimati island.

First MSP workshop held and GIS capacity-building provided to key government officials in Tarawa, resulting in preliminary spatial maps and information to serve as the basis for Tarawa MSP.

Cabinet memorandum on officiating the MSP process for Tarawa and Kiritimati islands drafted, submitted by the Ministry of Fisheries and Marine Resources Development and approved by Cabinet.

Marine Ecosystem Services Valuation soft launched by Ministry of Environment, Lands and Agriculture Development and featured front page in the local newspaper Uekera.

**2018**

Scoping exercise for the initiation of MSP process in Kiritimati.

# 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

UN Oceans Conference Kiribati Statement, Government of Kiribati Website. (2017). Accessed at: https://www.mfmrd.gov.ki/?p=518.

Lambert, B. (1987). Chapter 8, Kiribati – micro-individualism. In Land Tenure in the Pacific. Edited by R. G. Crocombe. Pages 164-189

## 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.

**Underwater 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.

**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

Australian Bureau of Meteorology and CSIRO. (2014). "Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports." Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

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.

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

Awira, R. Friedman, K., Sauni, S. Kronen, M, Pinca, S., Chapman, L. and Magron, F. (2008). "Kiribati Country Report: Profiles and Results from Survey Work at Abaiang, Abemama, Kuria and Kiritimati (May to November 2004)". SPC FAME Digital Library, 2008. 313 pp.

Ellison, J. (2009). Wetlands of the Pacific Island region. Wetlands Ecology Management. 17:169-206.

Brodie, G. and N'Yeurt, A. (2018). "Effects of Climate Change on Seagrasses and Seagrass Habitats Relevant to the Pacific Islands." Pacific Marine Climate Change Report Card. Science Review 2018: pp 112-131.

Rouatu I., Leport G., Pascal N., Wendt H., Abeta R., Brander L., Fernandes L., Seidl A., Salcone J. (2017) "National marine ecosystem service valuation: Kiribati." MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 83 pp.

**Shaping Pacific Islands: Coral Reefs**

MAPS

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

TEXT

Spalding, M., Ravilious, C., and Green, E. (2001). "World Atlas of Coral Reefs. Berkeley, CA: University of California Press and UNEP/WCMC ISBN 0520232550.

**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.

Raineault, N.A, J. Flanders, and A. Bowman (2018). "New frontiers in ocean exploration: The E/V Nautilus, NOAA Ship Okeanos Explorer, and R/V Falkor 2017 field season." Oceanography 31(1), supplement, 126 pp.. Accessed at: https://doi.org 10.5670/ oceanog.2018. supplement.01.

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.


### 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.


### 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., and Fernandes L. (2018). Draft marine bioregions of the Southwest Pacific. GIZ, IUCN, SPREP: Suva.


## PLANNING

### Fishing In The Dark: Tuna Catch

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

Adams, T., Chapman, L. (2004). "Overview of deepwater snapper fisheries in the SPC region." Information paper No. 5, 4th SPC Heads of Fisheries meeting. SPC. 8 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 p.

Gillett, R (2002). "Pacific island fisheries: regional and country information." FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. 168 p.

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 in: Bell, J.D., Johnson, J.E., Hobday, A.J. (eds). Vulnerability of tropical Pacific fisheries and aquaculture to climate change. Secretariat of the Pacific Community, Noumea, New Caledonia.

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.

Rouatu I., Leport G., Pascal N., Wendt H., Abeta R., Brander L., Fernandes L., Seidl A., Salcone J. (2017). "National marine ecosystem service valuation: Kiribati." MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 83 pp.

SPC (2013a). "Improving the management of deepwater snapper resources in Pacific Island Countries and Territories." Available 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 p. Available 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.

Zylich, K., Harper, S., Zeller, D. (2014). "Reconstruction of marine fisheries catches for the Republic of Kiribati (1950-2010)." pp. 89-106. In: Zylich, K., Zeller, D., Ang, M. and Pauly, D. (eds.) Fisheries catch reconstructions: Islands, Part IV. Fisheries Centre Research Reports 22(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].


### Small Fish Big Importance: Inshore Fisheries

MAP

Center for International Earth Science Information Network - CIESIN - Columbia University. (2017). "Gridded Population of the World, Version 4 (GPWv4): Population Density Adjusted to Match 2015 Revision UN WPP Country Totals, Revision 10." Accessed at: http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-adjusted-to-2015-unwpp-country-totals-rev10

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

TEXT

FAO. (2002). "FAO Fishery Profile - Kiribati." Accessed at: http://www.fao.org/fi/oldsite/FCP/en/KIR/profile.htm

Rouatu I., Leport G., Pascal N., Wendt H., Abeta R., Brander L., Fernandes L., Seidl A., Salcone J. (2017). "National marine ecosystem service valuation: Kiribati." MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 83 pp.


### Fish From The Farm: Aquaculture

MAP

Government of Kiribati. (2015).

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

TEXT

SPC Aquaculture Portal. (2018) Accessed at: http://aquaculture.spc.int/index.php?option=com_countries&view=country&id=18&Itemid=49


### Beyond The Beach: Marine Tourism

MAP

Department of Immigration. (2016). Kiribati Cruise Ship Data

Whats in Port. (2017). Cruise Data Kiribati https://www.whatsinport.com/Kiribati.html

Kiribati Ports Authority. (2017). Wharf and jetties www.kiribatiportsauthority.com/

Lonely Planet. (2017). Kiribati https://www.lonelyplanet.com/Kiribati

Tripadvisor. (2017). Kiribati https://www.tripadvisor.com/kiribati

Booking. (2017). Kiribati www.booking.com/Hotel_Kiribati/Maresias

Yachtpals. (2017). Kiribati Cruising www.yachtpals.com/cruising/kiribati-islands

TEXT

Rouatu I., Leport G., Pascal N., Wendt H., Abeta R., Brander L., Fernandes L., Seidl A., Salcone J. (2017). "National marine ecosystem service valuation: Kiribati." MACBIO (GIZ/IUCN/SPREP): Suva, Fiji. 83 pp.


### Underwater 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

Policy Statement. (2016). Government of Kiribati, Tarawa, Kiribati.

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


### 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."


### 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.

### Hotter And Higher: Mean Sea Surface Temperature And Projected Sea Level Rise

**MAP**

CSIRO Australia. (2015). "IPCC AR4 Sea Level Projections". Accessed at: https://research.csiro.au/slrwavescoast/sea-level/measurements-and-data/sea-level-data/.

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.

NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. (2014). "Moderate-resolution Imaging Spectroradiometer (MODIS) Aqua Sea Surface Temperature Data." NASA PO.DAAC. Accessed on 01/13/2017.

**TEXT**

Australian Bureau of Meteorology and CSIRO. (2011). "Climate Change in the Pacific: Scientific Assessment and New Research." Volume 1: Regional Overview. Volume 2: Country Reports.

Becker, M., Meyssignac, B., Letetrel, C., Llovel, W., Cazenave, A. and Delcroix, T., (2012). "Sea level variations at tropical Pacific islands since 1950." Global and Planetary Change, 80, pp.85-98.

Beetham, E., Kench, P.S. and Popinet, S. (2017). "Future Reef Growth Can Mitigate Physical Impacts of Sea-Level Rise on Atoll Islands." Earth's Future, 5(10), pp.1002-1014.

Garschagen, M., Hagenlocher, M., Comes, M., Dubbert, M., Sabelfeld, R., Lee, Y.J., Grunewald, L., Lanzendörfer, M., Mucke, P., Neuschäfer, O., Pott, S., Post, J., Schramm, S., Schumann-Bölsche, D., Vandemeulebroecke, B., Welle, T.and Birkmann, J. (2016). "World Risk Report 2016." World Risk Report. Bündnis Entwicklung Hilft and UNU-EHS.

Kench P. S., Thompson D., Ford M. R., Ogawa H. and McLean R. F. (2015). "Coral islands defy sea-level rise over the past century: records from a central Pacific atoll". Geology 43 515–8.

Nicholls, R. J. and Cazenave, A. (2010). "Sea-Level Rise and Its Impacts on Coastal Zones." Science 1517-1520.

### Turning Sour: Ocean Acidity

**MAP**

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**

Sabine, C.L., R.A. Feely, N. Gruber, R.M., Key, K. Lee, J.L. Bullister, R. Wanninkhof, C.S. Wong, D.W.R. Wallace, B. Tilbrook, F.J. Millero, T.H. Peng, A. Kozyr, T. Ono, and A.F. Rios. (2004). "The oceanic sink for anthropogenic $CO_2$." Science, 305(5682), pp. 367-371.

### 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**

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

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.

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.

## 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

### Kiribati's 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."

### 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."

**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 |
|---|---|
| 8 | MACBIO |
| 11 | iStock/CaraMaria |
| 19 | NOAA |
| 20 | iStock/HenrikAMeyer |
| 21 | iStock/Michael Zeigler |
| 23 | iStock/Velvetfish |
| 23 | iStock/Michael Zeigler |
| 25 | iStock/ZeynepOzturk |
| 26 | MACBIO |
| 27 | MACBIO |
| 31 | MACBIO |
| 32 | MACBIO |
| 38 | iStock/nicolesy |
| 41 | MACBIO |
| 45 | University of Bremen & NOAA |
| 47 | MACBIO |
| 47 | iStock/tedpagel |
| 54 | iStock/Velvetfish |
| 55 | iStock/djgunner |
| 57 | NOAA |
| 59 | Wikipedia |
| 62 | iStock/Юлия Моисеенко |
| 66 | MACBIO |
| 69 | MACBIO |

MACBIO

Marine and Coastal Biodiversity Management
in Pacific Island Countries