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Ecologically or Biologically Significant Marine Areas (EBSAs)

Special places in the world's oceans

WESTERN SOUTH PACIFIC

Areas described as meeting the EBSA criteria at the CBD Western South Pacific Regional Workshop in Nadi, Fiji, 22 to 25 November 2011

UNEP

Convention on Biological Diversity

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Cover photo: Orange roughy, a long-lived, deep-sea fish of the western South Pacific.
Photo courtesy of The National Institute of Water and Atmospheric Research (NIWA), New Zealand

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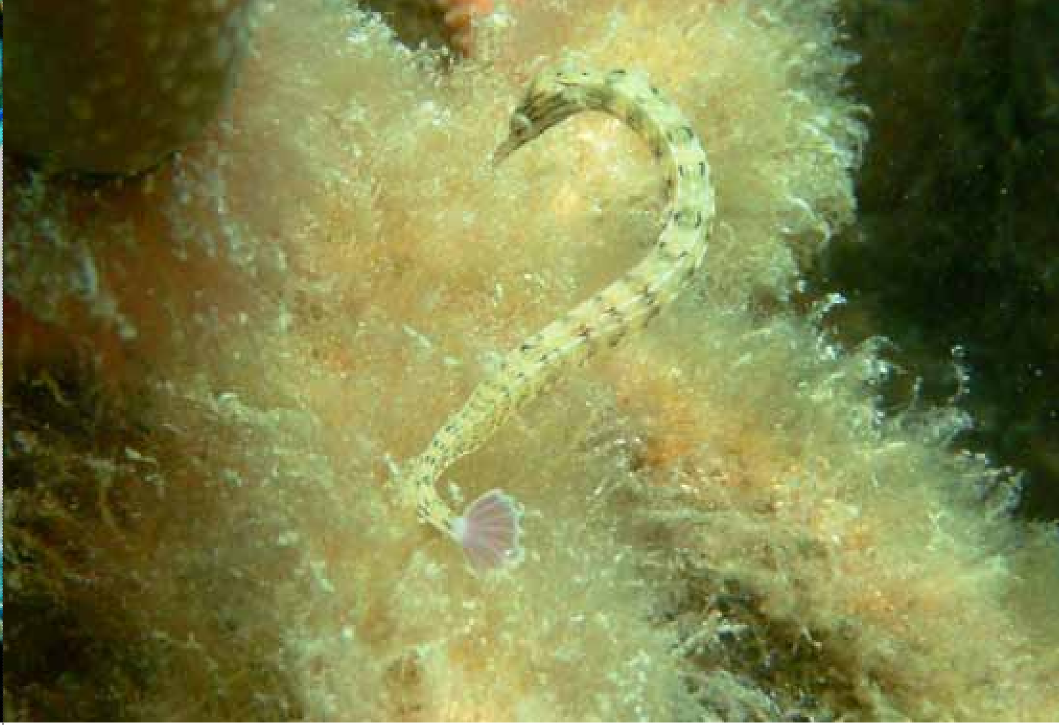

Photos courtesy of Mike McCaffrey

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FOREWORD

Activities related to ecologically or biologically significant marine areas (or EBSAs) have been an important part of the CBD's programme of work on marine and coastal biodiversity since 2008. This work has significantly contributed to global, regional and national efforts to expand scientific knowledge on marine biodiversity and improve conservation and sustainable use in support of the achievement of the Aichi Biodiversity Targets in marine and coastal areas.

The CBD's work on EBSAs began with the development of the EBSA criteria, which were adopted in 2008 at the ninth meeting of the Conference of the Parties (COP) to the CBD. At this meeting, the COP urged Parties, and invited other Governments and relevant organizations to apply, as appropriate, the EBSA criteria to identify ecologically or biologically significant marine areas, with a view to assist the relevant processes within the United Nations General Assembly and further enhance conservation and management measures, in accordance with international law, including the United Nations Convention on the Law of the Sea.

At its tenth meeting, in 2010, COP requested the CBD Secretariat to convene a series of regional workshops to facilitate the description of EBSAs. Since then, the CBD Secretariat has embarked on a remarkable collaborative effort, working with many global, regional and national partners around the world, to describe areas meeting the CBD's scientific criteria for EBSAs (decision XI/20, annex 1) through a series of regional EBSA workshops that started in the Western South Pacific region in November 2011.

The regional EBSA workshop process has facilitated the sharing of scientific information and the networking of experts across disciplines at the regional scale, and has enhanced collaboration between various initiatives for marine conservation and sustainable use by providing a global platform for scientific assessment of the ecological or biological significance of marine areas.

The reports of the regional EBSA workshops are the product of expert scientific discussions, and therefore, often contain very detailed and technical descriptions of various features of the marine ecosystems and species. This booklet, which was produced with the kind support of the Government of Germany, is part of a series of booklets that aims to present the information compiled at each regional EBSA workshop in a concise, engaging and easily understandable way. The purpose of this publication is to expand the recognition and understanding of these important marine areas across a broad range of stakeholders and the general public.

I encourage you to read this booklet and gain a greater appreciation of the breadth, depth and complexity of the unique features of the marine environment and their important role in a healthy functioning planet.

Braulio Ferreira de Souza Dias
Executive Secretary, Convention on Biological Diversity

Coral, New Caledonia. Photo courtesy of Julien Baudat-Franceschi

EBSAs: AN INTRODUCTION

The ocean encompasses 71 per cent of the planet's surface and a large portion of its habitable space. Whereas life on land is almost exclusively contained within a thin strip of breathable atmosphere overhead, in the ocean it is found from the waves that wash against the shore to the deepest canyons that plunge thousands of metres beneath the sea floor.

Life is found throughout the ocean, from coastal zones to the open sea, from coral reefs to kelp beds, in forms as varied as algae that cling to the underside of polar ice floes, humpback whales that migrate from the Antarctic to the equator and back, and multitudes of marine viruses that, if laid end to end, would span farther than the nearest 60 galaxies.[1]

But the distribution of life in the ocean is varied. Whether caressed by currents, sheltered by the shore, nurtured by nutrients, or heated by hydrothermal vents on the sea floor, some areas boast life that is more plentiful, diverse or unique than others. For example, scientists with the Census of Marine Life found that white sharks congregate in an area off Hawaii that they dubbed the "white shark café", and that several species of whales, turtles, seabirds, seals and sharks all congregate at "hotspots", such as the California Current.

The top 100 metres (m) of the open ocean hosts the great majority of the sea life with which we are more familiar—turtles, fish and marine mammals—as well as the microscopic plankton that form an integral part of the ocean food web and provide so much of the oxygen that we breathe. Far below the surface, in the dark depths, seamounts—underwater mountains that rise 1,000 m or more from the ocean floor—provide habitat for rich and diverse communities. Hydrothermal vents and cold-water seeps form the basis of unique ecosystems and species that might seem to belong more comfortably in a science fiction movie than the real world.

Yet, much of this unique and special biodiversity is facing major threats related to such factors as habitat destruction, overfishing, pollution and climate change. The global community has recognized the need to address these threats and to take measures to support the health and well-being of marine and coastal biodiversity.

In 2010, at its tenth meeting, the Conference of Parties to the Convention on Biological Diversity (CBD) adopted a new 10-year Strategic Plan for Biodiversity, including 20 "Aichi Biodiversity Targets". A number of these targets focus specifically on marine and coastal biodiversity, including

targets to achieve sustainable fisheries and protect at least 10 per cent of the world's marine and coastal areas by 2020.[2]

But in order to protect and preserve marine biodiversity effectively, we need to know where to focus and prioritize conservation and management. We must have a good understanding of the many different types of marine ecosystems in different regions, including which areas are the richest in life, which boast the greatest diversity and abundance of species, and which possess the rarest species and the most unique communities of marine flora and fauna.

It is in this respect that the CBD's work on ecologically or biologically significant marine areas (EBSAs) plays a key role. In 2008, the Parties to the CBD adopted a set of seven scientific criteria to be used in identifying EBSAs. The EBSA criteria are as follows:

1	Uniqueness or rarity
2	Special importance for life history stages of species
3	Importance for threatened, endangered or declining species and/or habitats
4	Vulnerability, fragility, sensitivity, or slow recovery
5	Biological productivity
6	Biological diversity
7	Naturalness

These criteria provide guidance on the key types of features to be considered when identifying areas that are critically important to the functioning of marine ecosystems.

In 2010, the Parties to the CBD requested the CBD Secretariat to collaborate with Parties, other Governments and a range of partners in different regions in convening regional workshops to facilitate the description of EBSAs using the EBSA criteria. Through an inclusive and science-driven process involving experts from all over the world and an enormous amount of scientific data, these regional EBSA workshops have described the areas of the oceans that are the most crucial to the healthy functioning of the global marine ecosystem.

EBSAs can be as varied as the life within them. They can address large ocean areas or individual features. They can be static or move with seasonal variations in certain oceanographic features. But they all, in one way or another, have been described as important in the context of one or more of the seven EBSA criteria.

Furthermore, there are many different types of measures that can be used in regard to the EBSAs, and include, but are not limited to, marine protected areas and other area-based management tools, impact assessments and fisheries management measures.

The description of an area as meeting the EBSA criteria is a scientific exercise aimed at supporting the prioritization of management efforts of governments and relevant authorities. It does not necessarily mean that new management measures will be put in place, and it does not prescribe what types of management measures should be used.

These booklets, one of which is being produced for each region in which an EBSA workshop has taken place, provide snapshot summaries of the pages upon pages of data compiled by participating experts, to provide a guide to some of the most biologically or ecologically significant ocean areas in the world.

This booklet provides summaries of the areas described during the Western South Pacific Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, held in Nadi, Fiji, from 22 to 25 November 2011. The workshop was held in collaboration with the Secretariat of the Pacific Regional Environment Programme (SPREP) and with financial support from the Government of Japan through the Japan Biodiversity Fund. The Government of Australia, through the Commonwealth Scientific and Industrial Research Organisation (CSIRO), provided scientific and technical support. To find out more about this and other EBSA workshops see www.cbd.int/ebsa.

Opposite page: Gorgonian, New Caledonia. Photo courtesy of Julien Baudat-Franceschi

THE WESTERN SOUTH PACIFIC REGION

The Pacific Ocean is both the largest and the oldest ocean basin on Earth. It was named in the 16th century by Portuguese explorer Ferdinand Magellan in an expression of relief after navigating the tempestuous strait north of Tierra del Fuego that now bears his name. But if the southern part of the ocean in particular conjures up images of tranquil blue seas and sun-drenched atolls, those images are inevitably incomplete.

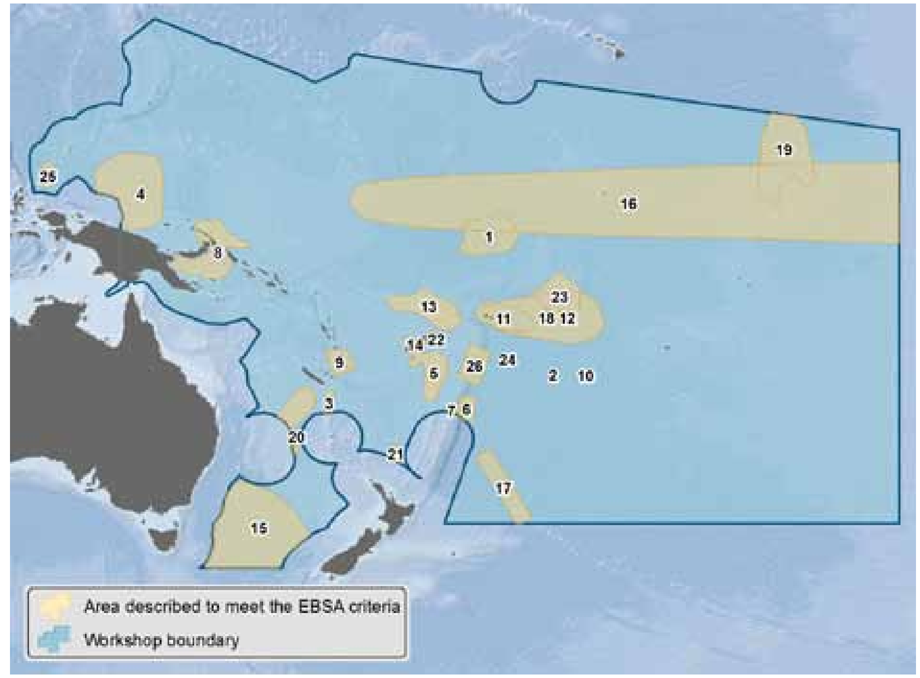
Certainly, the western South Pacific is dotted with atolls and coral islands, but as the profiles in this booklet underline, there is much more to the marine environment of this region, from its coastal surface waters to its deepest depths. Here, there are trenches and canyons, the deepest parts of the planet, giant gashes torn into Earth's crust by tectonic activity. So, too, are a multitude of super-heated hydrothermal vents that support species that would have been considered the stuff of science fiction, had they been conjured up a mere 40 years ago.

The relief of the sea floor is also punctuated by rising seamounts—the total number of which is unknown, but is certainly in the tens of thousands and likely in excess of 100,000. While some are comparatively small, others reach up to almost brush the surface or poke their heads through the waves; all of them support a mosaic of diverse communities.

Several themes occur at multiple sites: humpback whale populations battling back from decades of overhunting, tuna that migrate across vast distances and take advantage of pockets of nourishment and productivity along the way, seabirds that use islands and atolls as refuges and nesting sites on which they gather in the thousands, and high levels of endemism as a consequence of isolated environments.

In some of those environments, just how high those rates of endemism truly are, or how many species are likely to be discovered, remains unknown. Much of the region is remote, and some deep-sea environments in particular are yielding their secrets slowly, with even the most thorough and best-equipped research expeditions barely able to scratch the surface.

Yet, such caveats are footnotes to the broader picture: a vast region of islands and ocean, seamounts and trenches, whales and turtles, a region of abundance and rarity, of immense biological and ecological richness and variety.



Marine Geospatial Ecology Lab, Duke University / CSIRO, Austalia (2014)

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Giant clam. Photo courtesy of Keith A. Ellenbogen / New England Aquarium

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PHOENIX ISLANDS

This EBSA—encompassing one of the world's largest pristine atoll archipelagos—is located in the central Pacific, slightly south of the equator and north of Samoa. It includes all the Kiribati islands of the Phoenix Archipelago and covers some 408,250 km^2 of ocean. Within its boundaries are eight atoll islands, two submerged reefs and perhaps as many as 30 or more seamounts. The area includes breeding sites for numerous nomadic, migratory and pelagic species, and provides key habitat for endemic and/or endangered species of seabirds, fish and marine turtles.

"I've made it my goal to find Earth's last pockets of primal ocean, those underwater havens that have remained unspoiled as long as the ocean can remember. Here … we had discovered such a place.

What they lack in human population, the islands make up for in animal life, much of it revolving around magnificent coral reefs that keep marine biologists like me awake at night thinking of undiscovered species they shelter."

—Gregory Stone, *National Geographic Magazine*, February 2004 [3]

The biological density of the Phoenix Islands has been described as "nothing short of extraordinary."[4] The waters of these eight atoll and low-reef islands are home to at least 120 types of coral and host over 500 species of fish, including those of economic importance such as billfishes, sharks and tuna. The islands host five Important Bird Areas, as defined by BirdLife International; these islands cover globally important colonies of 19 seabird species (such as petrels, storm-petrels, frigatebirds, boobies, tropicbirds and terns)—including the endemic and endangered Phoenix petrel—and serve as crucial breeding and resting areas for a number of threatened migratory birds, including 20 per cent of the world population of the endangered white-throated storm petrel. Other types of wildlife found on reefs and in surrounding waters include green and hawksbill sea turtles, bottlenose and spinner dolphins, giant clams and bumphead parrotfish. The Phoenix Islands region was also the site of a high concentration of sperm whale catches in the early 1900s, suggesting that this EBSA may be important to any recovery in this historically whaled population.

The Phoenix Islands, which are a part of the Republic of Kiribati, are largely uninhabited; the only current residents are approximately 50 individuals on the island of Kanton. The bulk of the population of Kiribati lives about a thousand km to the west on the Gilbert Islands or more than 1,600 km to the east on the Line Islands. The Phoenix Islands' remoteness and near-pristine condition mean that they can serve as a benchmark for understanding and potentially restoring degraded coral reefs found elsewhere. The islands are considered critical sites for the study of global climate change and sea-level rise, the growth and evolution of reef systems, and reef species diversity, among other research areas.

Because of its isolation, the Phoenix Islands archipelago occupies a unique position in the biogeography of the Pacific. It is a critical stepping stone for species from migratory birds to the planktonic life that is carried on any of the ocean currents that converge on the region. The islands encompass a range of marine habitats that support high levels of species abundance and diversity across spectrums of size and age—something that is of increasing rarity in the tropics, especially in the case of apex predator fish, sea turtles, seabirds, corals, giant clams and coconut crabs, most of which have been depleted elsewhere. The overall marine trophic dynamics for these communities across this archipelago are relatively intact compared with other island systems where human habitation and exploitation have greatly altered the environment.

Yet to focus entirely on the coral atolls and islands of the archipelago would be to, almost literally, only scratch the surface. The region has a huge bathymetric range with waters reaching to a maximum depth of 6,147 m and an average depth of around 4,500 m. The islands, atolls and submerged reefs in this site are all the peaks of long-extinct volcanoes that rise more than 5,000 m from the seabed to lightly brush against uppermost boundaries of the ocean. Here, too, is an outstanding array of seamounts, perhaps 30 or more, which form part of the Tokelau seamount chain. [5]

Seamount systems provide a diverse range of habitats for deep-sea species,[6] generate hotspots of pelagic diversity[7] and can support substantial benthic biomass.[8] [9] Furthermore, their role in shaping the dispersal, evolution and biodiversity of deep-sea life is being increasingly understood and appreciated.[10] Though there has been limited exploration of the seamounts around the Phoenix Islands they are considered to be in pristine condition and hence clearly deserving of scientific monitoring and effective management.

This EBSA is also a marine protected area—one of the largest in the world. Kiribati first declared the creation of the Phoenix Islands Protected Area (PIPA) at the eighth meeting of the Conference of the Parties to the CBD (2006), and two years later more than doubled its original size. In 2010 PIPA was added to the list of UNESCO World Heritage sites.

Opposite page, top: Phoenix petrel. Photo courtesy of Ray Pierce. Bottom: Coconut crab. Photo courtesy of Keith A. Ellenbogen / New England Aquarum

School of tuna. Photo courtesy of Hemera/Thinkstock/Tatiana Belova

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UA PUAKAOA SEAMOUNTS

Located some 400 km almost due east of Rarotonga, Southern Cook Islands, this seamount system is virtually unknown and therefore likely to be in pristine condition. Some evidence has indicated that the summit of one seamount may be less than 300 m from the ocean surface which would make it one of the very few shallow seamounts in the vast region of the Cook Islands.

Seamounts often have complex surfaces of terraces, pinnacles, ridges, crevices and craters, and their presence diverts and alters the currents that swirl about them; along with unique combinations of various factors along the depth gradient, such as pressure, temperature and food resources, the net effect is a variety of living conditions, supporting a mosaic of diverse communities. Deep-sea corals adhere to their rocky substrate, where they feed on the detritus of marine organisms, quite unlike their tropical warm-water cousins, which photosynthesize in the available sunlight. Some seamounts appear to act as "aggregating locations" for highly migratory pelagic species, such as sharks, which appear to congregate within 30 km of seamount summits.[11] A 2011 study used global bathymetric data to identify 33,452, with the caveat that "the seamounts and knolls identified herein are significantly geographically biased towards areas surveyed with ship-based soundings. As only 6.5% of the ocean floor has been surveyed with soundings it is likely that new seamounts will be uncovered as surveying improves."[12]

The great majority of seamounts that have been discovered and described do not come close to breaking the surface of the ocean; they are considered deep-sea habitats, and the ecosystems they support, possibly containing high degrees of endemism, are readily identifiable as deep sea in nature. But those that do approach the surface, "shallow seamounts", are particularly notable for the way in which their presence diverts ocean currents, resulting in the upwelling of nutrients and often comparatively high concentrations of marine life near their peaks.[13] Whales and dolphins, sharks, tuna and cephalopods (mollusks such as octopus, cuttlefish or squid) all congregate over seamounts to feed, and some seabirds have been shown to be more abundant in the vicinity of shallow seamounts.[14] This phenomenon has been exploited by commercial fisheries; finding shallow seamounts that apparently have been undiscovered and unfished is a valuable achievement.

The details of the Ua Puakaoa seamounts are being inferred from satellite imagery—which indicate that these seamounts may be shallow seamounts, although further research is required to confirm this. That same satellite imagery identified an isolated area of sea surface turbulence that provided additional evidence in support of the existence of a seamount system. The several million km_2 of ocean surrounding the Cook Islands have very few shallow seamounts or reefs. Therefore, if this area was confirmed to contain shallow seamounts, this would surely make this a likely habitat for a variety of animals that would otherwise be quite rare in the area.

3

Neogymnocrinus richeri, found at depths between 400 and 550m.
Photo courtesy of Bertrand Richer de Forges

SEAMOUNTS OF WEST NORFOLK RIDGE

This EBSA consists of a series of seamounts beginning near the southern tip of New Caledonia and extending southward along the Norfolk Ridge to just south of Norfolk Island at about 30°S. Highlights include high biological and habitat diversity, rare and unique species, high endemism, and some unique associations between specific habitats and wildlife populations, including a seamount that is important for humpback whales.

In the 20th century, humpback whales of the southern hemisphere were among the species most devastated in numbers by commercial whaling. Some populations appear to be recovering. Off the coast of eastern Australia, for example, humpback numbers are estimated to be close to 10,000, with an annual rate of increase of 10 per cent. Humpback whales off New Caledonia, however, apparently number only between the mid-300s and 500, and that number does not seem to be increasing. Curious as to why this should be, a team of researchers recently attached satellite tags to a dozen whales in the area, to study their movements and establish definitively whether they comprised a discrete population. What they found surprised them.[15]

The tagging study reinforced the existing understanding that the New Caledonian humpback whales are separate from those of eastern Australia and connected to those off New Zealand and Norfolk Island. An unexpected revelation, however, was that at least seven of the whales swam directly to Antigonia Seamount in New Caledonian waters, one of a number of seamounts on the Norfolk Ridge, a prominent underwater feature extending over 1,000 km from southern New Caledonia towards the north of New Zealand, and appeared to spend several days in its vicinity, sometimes visiting it several times before resuming their migration.[16]

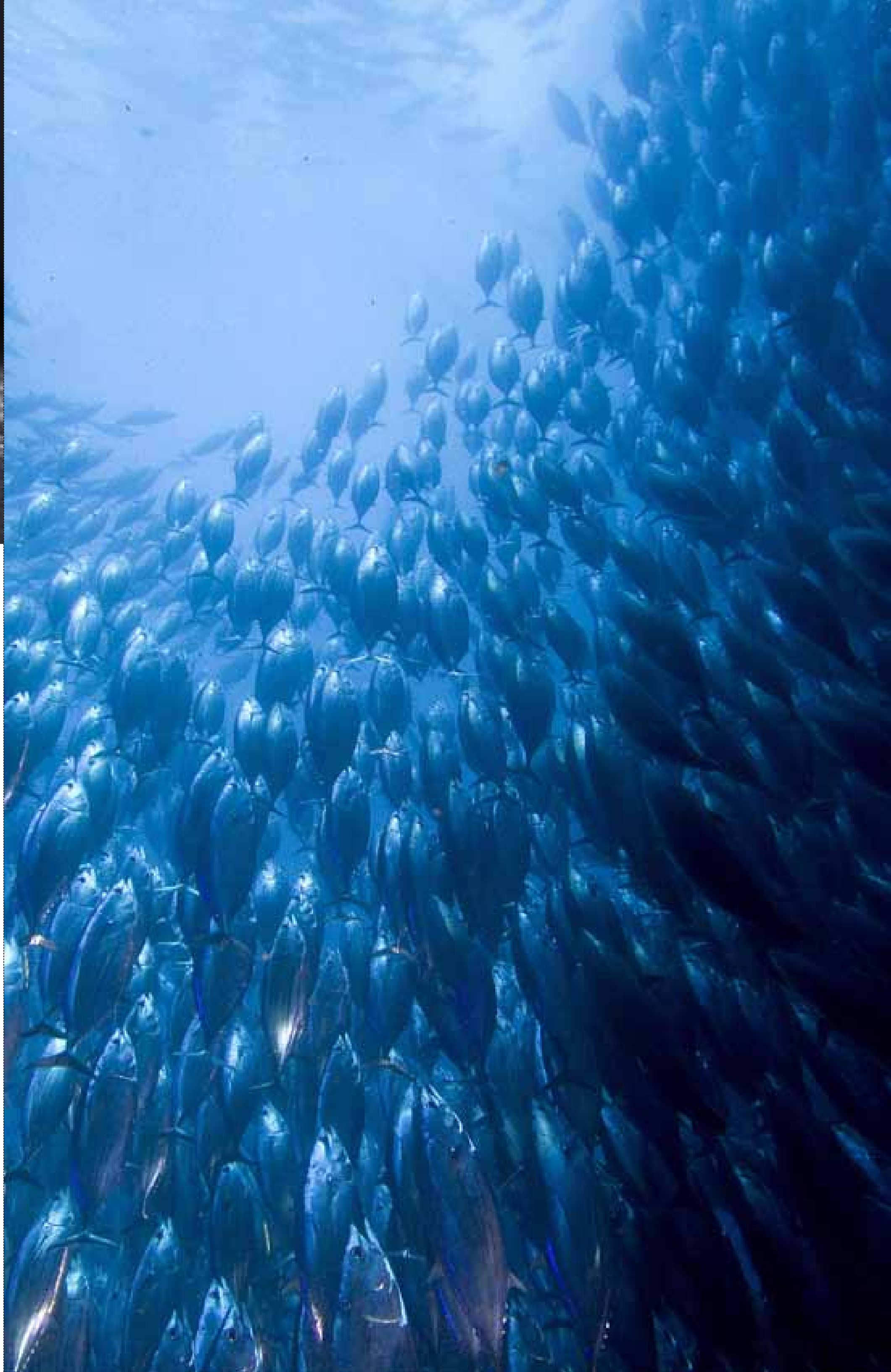
Intrigued by the observations, the research team set out the following year to see for themselves. Over the course of just six days, they observed more than 100 humpbacks at Antigonia Seamount. Exactly what compels the whales to spend time here, and whether they do so throughout the season or only during migration, remains uncertain. Given that the whales bypassed other seamounts en route to Antigonia, however, hints at the possible distinctiveness of individual seamounts even within the same region and that of the biotic communities associated with them.

The extent of the various life forms on and around seamounts in the Tasman and southern Coral seas is gradually being revealed. Samples taken from six seamounts within this site (i.e., on the Norfolk Ridge in New Caledonian waters) by a French research programme during the 1980s and 90s revealed 516 species of fish and macro-invertebrates, of which 36 per cent were new to science. Given sampling limitations, scientists involved in this lengthy study[17] considered that the actual number of species living on these seamounts, however, would be "far greater".

Psychrolutes microporos, also known as "Mr. Blobby". Photo courtesy of NORFANZ Founding Parties 2003

The 2003 "NORFANZ" deep sea survey covered additional areas, including seamounts on the Norfolk Ridge just south of the exclusive economic zone (EEZ) of New Caledonia (i.e., within the EEZ of Norfolk Island, Australia), also with staggering results. In total, that expedition found 348 demersal fish species, of which 25 per cent were potentially new, and 1,313 benthic macro-invertebrate species, of which 78 per cent had not been named, suggesting that most were likely new to science.[18 19] Some of those species are effectively "living fossils" or "archaics": of 14 genera of crinoids (i.e., sea lilies and feather stars) discovered in the region, for example, eight were closely related to fauna from the Mesozoic Era, relict species believed extinct for up to 300 million years.[20]

An additional series of exploratory surveys conducted between 2001 and 2007 included sampling of 10 seamounts and the continental slope within New Caledonian waters of this EBSA and found evidence of a higher number of endemic seamount species than had been reported previously, along with a tiny geographic distribution for most of the species analysed.[21] The scientists involved in these surveys point out that this "micro-endemism" means that current estimates of the global number of marine species may be significantly underestimated and, further, that the biodiversity of at least the New Caledonian seamounts is likely to be quite vulnerable to disturbance.



4

Coral reef, Micronesia. Photo courtesy of Suchana Chavanich/Marine Photobank.
Previous page: Tuna, Papua New Guinea. Photo courtesy of Alex Hofford, Greenpeace/Marine Photobank

REMETAU GROUP: SOUTH-WEST CAROLINE ISLANDS AND NORTHERN NEW GUINEA

This EBSA, covering 813,331 km², overlaps with the EEZ of the Federated States of Micronesia (FSM) (also known as the Caroline Islands) in its northern section, while to the south, the majority of the site coincides with the Papua New Guinean EEZ, with partial overlap of the Indonesian EEZ. The central portion of the site spans the high-seas pocket between the EEZs of FSM and Papua New Guinea. The area covers the Eaupirik Rise and areas of both the west and east Caroline Basins, intersects with the southern extent of the Caroline seamounts and includes the Manaus Trench. The region is particularly important for streaked shearwaters and up to 25 per cent of the global population—close to one million individual seabirds—can be found here during their non-breeding season.

There are perhaps three million streaked shearwaters in the world, breeding on the coast and on offshore islands of Japan and Russia, and on islands off the coasts of China, North Korea and South Korea, before flying south to spend winter off Vietnam, New Guinea, the Philippines and northern Australia. Though numbers of streaked shearwaters are substantial they may be in decline, partly as a result of fisheries by-catch but more significantly likely due to introduced rats predating on eggs and chicks.[22] During the non-breeding season, fully one quarter of the global population alights on the waters north of New Guinea and south-west of the Caroline Islands.[23]

The importance of this region to streaked shearwaters is a primary rationale for its recognition as an EBSA. But it is not by any means the only one. The area includes a number of seamounts and, as with other seamount systems, could be expected to exhibit a rich biodiversity of deep-sea life with high levels of endemism. The waters here support high catches of tuna while the coral reefs of the region are among the most biologically productive in the world.

The proximity of Micronesia to the Indo-Malay region, and the proximity of the islands themselves, enables the high islands and reefs to act as passages for the migration of marine species—including, for example, green turtles, which forage in the area during their post-nesting migration, and the critically endangered leatherback sea turtle, which migrate to foraging grounds in the Northern Hemisphere from beaches in Papua, Indonesia and the Solomon Islands.

Humphead wrasse. Photo courtesy of NOAA

5

KADAVU AND THE SOUTHERN LAU REGION

Located in the southern and far south-eastern regions of Fiji, and straddling the borders of the Tongan EEZ, this area includes seagrass beds, patch and fringing reefs, atolls, barrier reef systems such as the Great Astrolobe Reef, seamounts, deep upwelling slopes, submarine canyons and the Lau Ridge, among other features. It is an important foraging area for the endangered Fiji petrel and provides important breeding areas for a number of seabirds, including one of the last remaining colonies of sooty tern in Fiji. Using the area as a migratory corridor are humpback, minke, sei and sperm whales, and a number of smaller whale and dolphin species.

Few areas of the world can compare, in terms of diversity and endemism, to the Fiji islands; but even among this archipelago, Kadavu and the Southern Lau islands merit recognition. The waters around Kadavu and the Southern Lau region include important marine foraging areas for Fiji's sole species of endemic seabird, the critically endangered Fiji petrel, which are believed to number less than 50 individuals.[24] Naevo Island—also known as "Seabird Island"—hosts between 6,000 and 10,000 breeding seabird pairs, including one of the last remaining colonies of sooty tern in Fiji. [25]

The Southern Lau region features raised coralline islands that support endemic palm trees and barrier reef systems boasting a number of endemic fish species. The area supports high catch rates for tuna—particularly bigeye and albacore—and associated pelagic species. The waters offshore comprise an important migration corridor for great whales such as humpback, sei, minke and sperm, as well as smaller whale and dolphin species. Nearshore and onshore, the islands provide important feeding and nesting areas for hawksbill and green turtles.

Fiji petrel. Photo courtesy of The Tubenoses Project © Hadoram Shirihai

Giant grouper, Fiji. Photo courtesy of Dave Weeks/Marine Photobank

Three species of sea snakes are found in the region: the yellow-lipped sea krait, black-banded robust sea snake, and the yellow-bellied sea snake.[26] [27] The sea snakes are all found within fringing and barrier reef systems, but easily migrate across the deeper waters between one island and the next.

The Southern Lau islands are also important for such reef fishes as the endangered humphead wrasse, bumphead parrotfish and giant grouper, listed as vulnerable by the IUCN, and giant sweetlips, and important breeding areas for inshore shark species (including IUCN Red-listed species such as common hammerhead, scalloped hammerhead, giant hammerhead) and the oceanic whitetip, blue and silky sharks. They are also home to four giant clam species,[28] including two classified as Vunerable on the IUCN Red List: the rare "devil giant" or tevoro clam; and the smooth or southern giant clam.

Black-banded robust sea snake. Photo courtesy of Mike McCaffrey.

Over 80 species of shallow-water amphipods (shrimp-like crustaceans) have been described across the Fiji island groups, including the Kadavu and Southern Lau region, 41 per cent of which are endemic.[29]

Kadavu and the Southern Lau region are very biologically diverse with high productivity and feature seagrass beds, raised coralline atoll islands, seamounts, deep upwelling slopes, submarine canyons and the Lau Ridge, which connects into the New Hebrides Trench. The seamounts south of Kadavu and the Southern Lau islands are relatively intact and are currently not exploited by fisheries or mining interests. Along with canyons and slopes, the seamounts are associated with upwelling and downwelling activities, which support primary productivity within these deep-water areas.

6

Snailfish, *Notoliparis kermadecensis*, endemic to the Kermadec Trench.
Photo courtesy of University of Aberdeen (UK) – NIWA (NZ)

KERMADEC-TONGA-LOUISVILLE JUNCTION

The site covers a triple conjunction area, where the Louisville Seamount Chain subducts into the Kermadec and Tonga trench region. The northern boundary sits inside the Tongan EEZ, while its southern boundary is in the area of New Zealand's extended continental shelf but outside of its EEZ. Seamounts and trenches—along with their specialized fauna—are featured here, as is the world's deepest-living fish species.

While the ecological and biological value of some areas is evident from even comparatively cursory examination, for others—those which are the most remote and inaccessible—the value must be inferred. But even that inference, particularly when placed in the context of similar environments, is sufficient to highlight the likely uniqueness of this particular EBSA.

Plunging to depths as far as 10 km below the surface, the area where the Louisville Seamount Chain subducts into the Kermadec and Tonga Trench region features both seamount and trench habitat. There has been no sampling of the Louisville seamounts in this area of their range; however, although each seamount is likely to have its own community of species, and while endemic and novel species likely remain to be discovered, several decades of studies and sampling from nearby seamounts and elsewhere in the region paint a picture of probability.[30]

Amphipod, Kermadec Trench. Photo courtesy of University of Aberdeen, UK.

It is highly likely, for example, that they are dominated by cold-water corals, in particular stony coral species such as *Solenosmilia variabilis*, easily distinguishable by its thick, bushy branches.[31] As depth increases, soft octocorals almost certainly become more prominent. Sponges and echinoderms are likely common. As with similar organisms elsewhere, these species will have slow growth rates and long lifespans, making them highly vulnerable to disturbance.

The trenches have been better studied, in the form of biological sampling using towed gear and baited landers. A 2006 study reported eight species of amphipods, five of which had been previously undescribed, and one of which—*Hirondella dubia*, which is endemic—was found in such high densities that thousands or even tens of thousands would be recovered each time sampling gear was deployed.[32] Subsequent studies have described scavenging fish in the Kermadec Trench from depths of 4,329 m to 6000 m, an unidentified species of synaphobranchid eel at depths of up to 5,172 m, and the endemic snailfish *Notoliparis kermadecensis* at depths as great as 7,561 m.[33]

The very first observations of a living *N. kermadecensis* were not described until 2009, with the study's authors ruminating "as to how, in the darkness of the hadal zone, these fishes can effectively target individual prey," and speculating that the positioning of their eyes allows for a binocular focus on potential prey's bioluminescence, unwittingly sending a signal through the gloom to would-be predators.[34] Other fauna that has been recovered includes very poorly known aphyonid fish, very rare stephanoberycids, and the deepest-living fish in the world, *Abyssosbrotula galathea*, which in the 1950s was discovered in the Puerto Rich trench at a depth of 8,370 m.[35] The waters over the trenches also seem to be popular habitats for both humpback and sperm whales, and possibly other great whale species.

Because trenches are isolated, the Kermadec-Tonga Trench faunal communities will not be found anywhere else, although some of their component species may well be. There is at present no known commercial activity (i.e., fisheries, seabed mining) within this region.

Opposite page: *Solenosmilia variabilis*. Photo courtesy of NIWA (NZ).

7

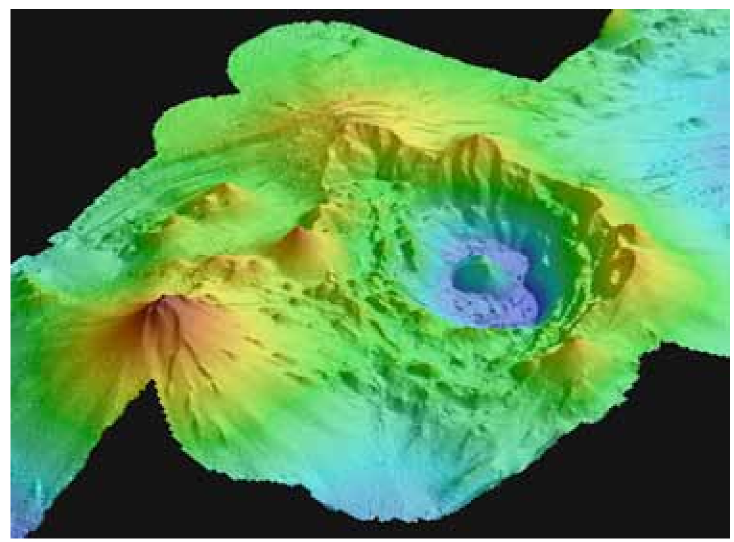
A basketball-sized jellyfish. Photo courtesy of 2005 Ring of Fire Expedition (NOAA-GNS-NIWA)

MONOWAI SEAMOUNT

The Monowai Seamount lies north of New Zealand on the Tonga-Kermadec Arc about half way between the Kermadec and and Tonga island groups. The site consists of a seamount structure, with a cone in the south and a caldera feature on its northern side. The site is active, with hydrothermal venting on the caldera floor and the cone undergoing frequent activity, which has resulted in substantial changes to its shape and size. Hydrothermal vents are distributed over a substantial section of the caldera floor. The venting sites support high densities of chemosynthetic organisms, including mussels, shrimps and crabs.

In 2011, a team led by the University of Oxford was conducting a seafloor mapping expedition in the South Pacific near Monowai seamount, which lies at the intersection of the Pacific and Indo-Australian tectonic plates at the Tonga-Kermadec subduction zone, when they noticed yellow-green water and gas bubbles at the surface, and a strong smell of sulfur. They suspected that the volcano was venting gases. In fact, it was erupting, adding about 9 million m^3 of rock to its summit in just five days, even as a large part of its flank collapsed.[36] The encounter was all the more fortuitous given that, although Monowai has been continually active since its discovery by airplane in 1944,[37] it has not been continuously so; its activity "seems to be short-lived and interspersed by long periods of quiescence."[38] Yet even during periods when the volcano itself is in slumber, its immediate surroundings are anything but, as Monowai's cone and caldera boast at least three major systems of hydrothermal vents.[39]

The existence of hydrothermal vents has only been known since 1977,[40] and their discovery turned preconceived notions of life on their head.[41] They occur in volcanically active areas of the seafloor, like mid-ocean ridges, where tectonic plates are pushing and pulling above magma hotspots in Earth's crust and where super-heated gases and chemically-rich water can erupt from the ground at temperatures of well over 400°C.[42] Microbial organisms are able to withstand these extreme temperatures



Monowai bathymetry. Photo courtesy of NIWA to create energy from the chemical compounds being forced up through the vents—particularly hydrogen sulfide, which is highly toxic to most known organisms—via a process called “chemosynthesis”. Some of these microbes live symbiotically inside tubeworms, while others form large mats, which attract progressively larger organisms that graze on them.

The vents on Monowai, known as “Mussel Ridge”, are no exception. Here, in what might appear the most improbable circumstances and inhospitable surroundings, an active volcano and hydrothermal vents support dense communities of tubeworms, mussels, crabs, shrimps and eels. The entire assemblage was described by Bob Embley, chief scientist of the expedition that discovered Mussel Ridge, in 2005: “The seafloor was colonized by dense beds of mussels, in some places so thick that they completely covered the seafloor. Swarms of shrimp, crabs and pale white eel-like fish compete for ‘feeding space’ on this living seafloor. This oasis extended for at least 300 meters along the crest of the ridge.”[43]

Each individual vent appears to support a unique community, although those communities are constantly having to adapt as venting, eruptions and caldera collapse cause the chemical composition and even location of vents to change, sometimes rapidly.

The region’s water column does not appear to be especially bountiful. Based only on its pelagic properties, the area would likely be overlooked for consideration as an EBSA (although it is worth noting that recent studies have highlighted the extent to which minerals from hydrothermal vents can be distributed by ocean currents into surrounding waters).[44] But on the seafloor, where gases vent and occasionally roil the sea surface, chemical-based communities of life make this a productive and significant system.

Monowai vent community. Photo courtesy of 2005 Ring of Fire Expedition (NOAA-GNS-NIWA)

Mussels competing for space on a rocky outcrop, where warm hot-spring water discharges from the seafloor. Photo courtesy of New Zealand-American Submarine Ring of Fire 2005 Exploration, NOAA Vents Program.

Some of the fauna found on the remains of sunken vegetation in the New Britain Trench. Photos courtesy of Pante, E. et al.[47]

8

NEW BRITAIN TRENCH REGION

The New Britain Trench region lies almost wholly within the EEZ of the north-east sector of Papua New Guinea and includes St. George's Channel (the passage between New Ireland and New Britain) and the area extending 50 km from the western side of the trench itself. This region includes clusters of fishable seamounts and hydrothermal vent aggregations and is notably characterized by highly productive tuna fisheries and an array of seabird species, including the critically endangered Beck's petrel, which appears to breed only in this area.

The otherworldly species revealed themselves in the inquiring lights of the submersible-mounted cameras that probed the dark depths: stalked anemones growing on pillow lavas; spoon worms, burrowing animals that lick organic matter off the surrounding sediment with a tongue-like proboscis; sea cucumbers. Then, further down, surprisingly familiar sights: palm fronds, leaves, sticks and coconuts, descended from the shores of New Guinea far, far above, to become a part of a colder, darker, deeper ecosystem.[45]

The submersibles had been dispatched as part of 2012 expedition to investigate a trio of trenches in the Pacific Ocean; the highlights above were of the New Britain Trench, a scar in the seabed to the north-east of Papua New Guinea that plunges down almost 8,000 m.

The assumption might be that, so far removed from the sun's warming rays, deep seabed trenches must be relatively lifeless affairs. However, trenches are not ecological barrens fenced-off from the rest of the ocean. Nutrients from the Southern Ocean, for example, are deposited by currents that flow through the West Pacific while hydrothermal vents provide localized energy and nutrition, as does organic matter—in particulate and carcass form—that descends from surface waters far above. And the pressure, darkness and cold have produced a potpourri of uniquely adapted life so that these deepest places on the planet "host active and diverse biological communities."[46]

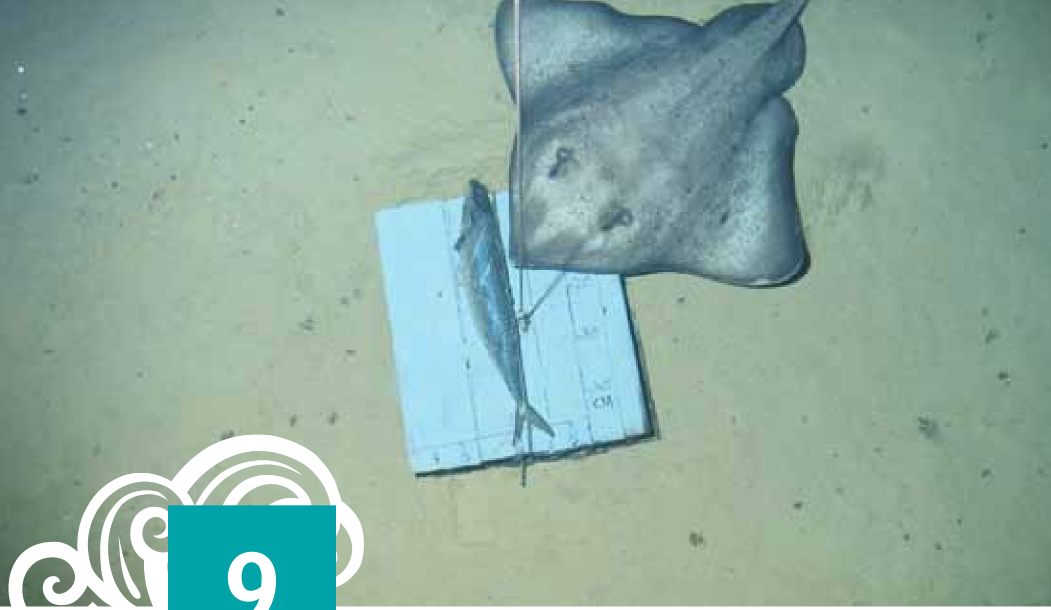



The deep-sea region around New Guinea, including the New Britain Trench, appears to provide testimony in support of that assessment, even though information in some areas remains relatively sparse. Writing in the journal *Oceanography* in 2012, Eric Pante of the University of La Rochelle and colleagues noted that, "Preliminary data suggest that deep New Guinean fauna is highly diversified. As an example, a rapid assessment of decapod crustacean biodiversity revealed more than 500 species collected, including four new genera and about 15 per cent new species." Sampling of one seamount in particular "revealed a wealth of filter-feeding invertebrates, such as hydroids, sea pens, octocorals, and sea anemones, as well as a rich crustacean fauna." [47]

The location of the New Britain Trench in an area of strong tectonic activity leads to substantial hydrothermal venting. There are likely to be high levels of biological diversity and endemism around the vents, as well as around the seamounts that erupt from the sea floor south of the trench. Catches of tuna around the seamounts have historically been significant, suggesting strong upwellings and high levels of local productivity. If the presence of coconuts and sticks at the base of the New Britain Trench signifies the degree to which coastal, surface life can influence even the deepest depths—and studies have shown that deep-sea fauna has evolved expressly to feed on such sunken wood[48]—then the high tuna catches, and the presence of sperm whales in the southern part of the trench, are indications of how deep-sea ecosystems can influence those in shallower waters. Indeed, one recent study notes that, while vent communities are known primarily for being localized hotspots of productivity, at the right depths they can release iron into the ocean mixing zone, which currents can then transport into surrounding waters, potentially increasing surface ocean productivity.[49]

Certainly, the waters of the New Britain Trench region are rich in life, boasting endangered leatherback turtles as well as the aforementioned sperm whales and abundant tuna, and an array of seabirds. There are extensive, isolated islands and atolls in the region that support a number of shearwaters and petrels, with new information continuing to come to light; a 2010 study, for example, noted that, between 1985 and 2007, research cruises documented numerous species—including the herald petrel, Bulwer's petrel, Christmas shearwater, white-faced storm petrel, Leach's storm-petrel and Matsudaira's storm-petrel—that had not previously been recorded in the area.[50]

One species of particular interest is the critically endangered and localized Beck's petrel. Until recently, the species was known only from two specimens, caught in 1928 and 1929, but it was definitively rediscovered in 2007. This petrel is believed to breed in the montane forests of southern New Ireland; its numbers are unknown, but could range between 50 and 249 mature individuals, or 75 to 400 birds in total.[51]



As-yet-unidentified species of ray at a depth of 2583m. Photo courtesy of AJ Jamieson, University of Aberdeen, UK

Bassozetus, at a depth of 7000m. Photo courtesy of AJ Jamieson, University of Aberdeen, UK

9

NEW HEBRIDES TRENCH REGION

The New Hebrides Trench region lies between Vanuatu and New Caledonia and includes a substantial portion of the trench itself. This site encompasses three major islands at the southern end of Vanuatu, water depths reaching 7,600 m, hydrothermal vents and seamounts. High numbers of tuna are found in the region, and recent research has revealed unusual deep-sea communities within the trench.

The deep seabed is not one flat, featureless plain. It undulates, here rising in the form of seamounts or ridges, there plunging into submarine canyons or hadal trenches. As it changes, so too do the species and communities that live and even thrive there; seamount communities are frequently greatly different from those in canyons and trenches. Similar and even proximate formations can also host life that is in such variance from one location to the next that even the most seasoned observers can be amazed.

The New Hebrides Trench is a case in point.

There is much about the region that is superficially familiar to students of the ocean's deepest depths, even if the details are far from pedestrian. Not only, for example, does it contain hydrothermal vents, but fully one half of the known hydrothermal vents in the western Pacific are within the New Hebrides Trench area. There are a number of seamounts, indicating the likely presence of deep-sea corals. High catches of tuna and marlin in the northern part of the trench area are testament to the localized productivity that surrounds seamounts. The area also includes the likely spawning grounds of three species of freshwater eel that undertake the long migration from either New Zealand or Australia.[52]

But the appearance of familiarity does not preclude unpredictability, as a research team from University of Aberdeen's Oceanlab and New Zealand's National Institute of Water and Atmospheric Research discovered during a 2014 research expedition.

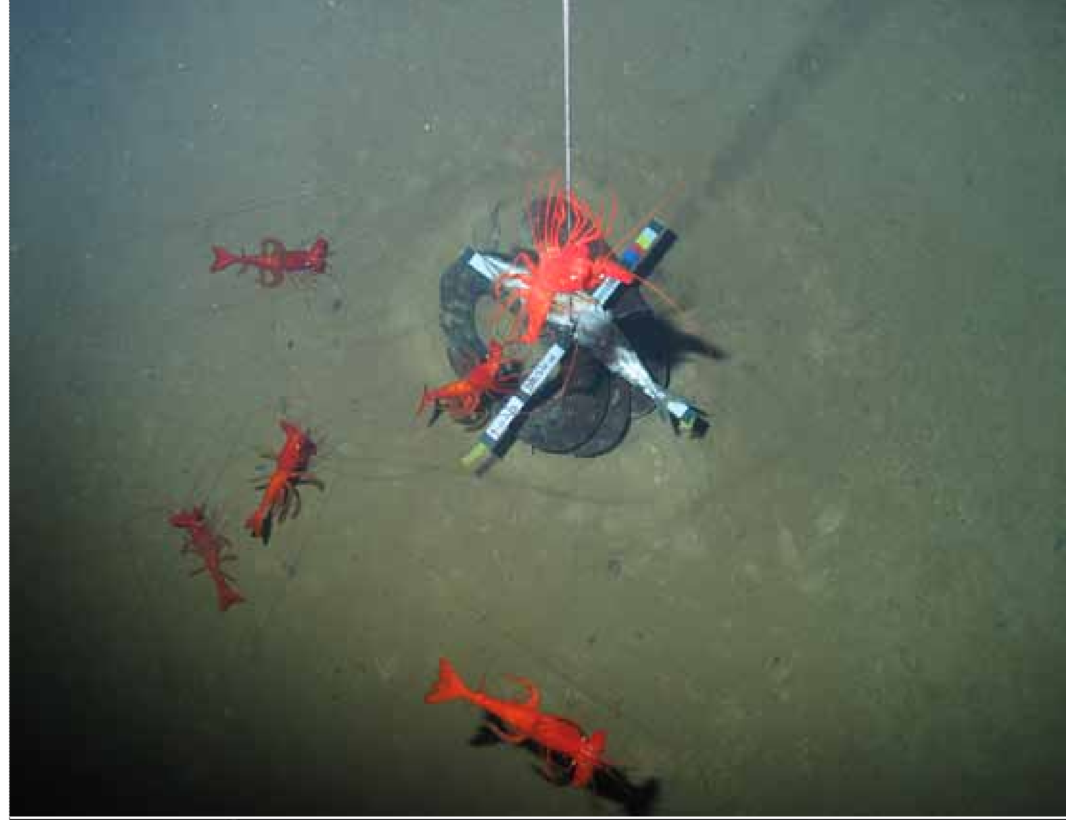
"What we found was an entirely different deepwater fish community [than in other Pacific Rim trenches]," said expedition leader Alan Jamieson. "The fish we would always expect to see, the grenadiers, were completely absent. The fish that dominated the area were a group called cusk eels which are far less conspicuous elsewhere. As well as the difference in biodiversity we also stumbled across another surprise—the area in and around the New Hebrides Trench was swarming with large bright red prawns which are typically seen in very low numbers in other areas."[53]

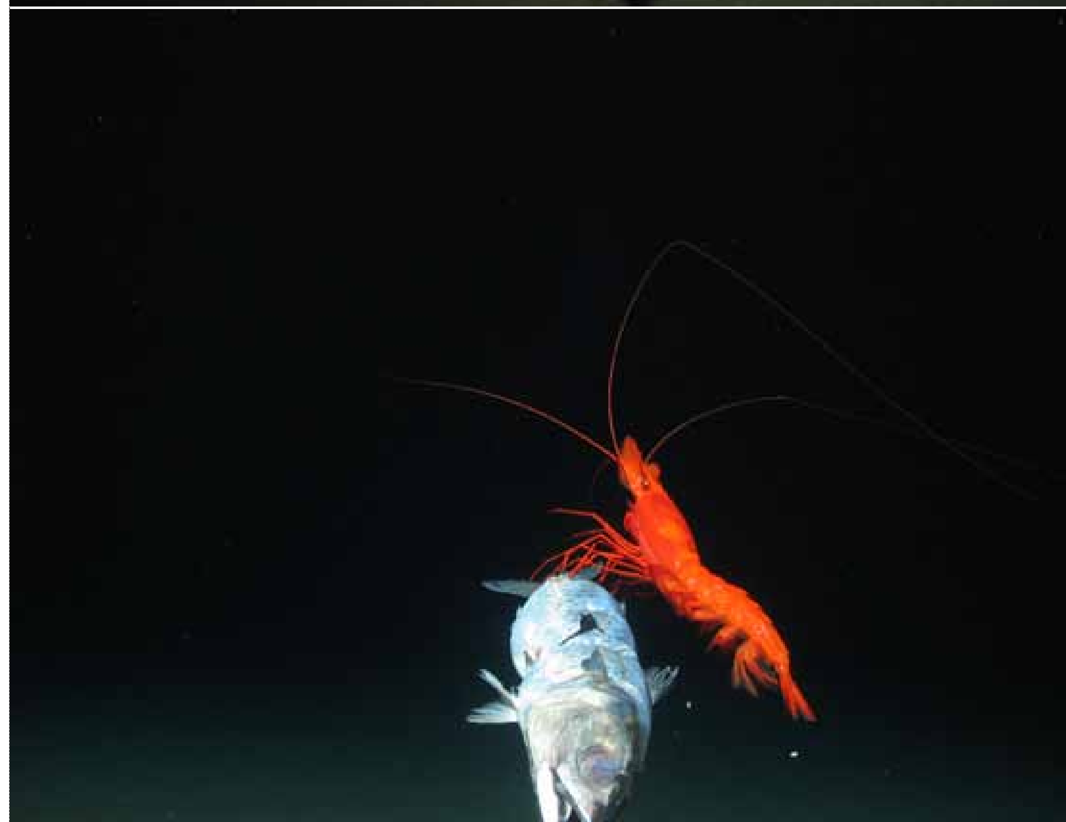
The waters over a deep-sea trench "feed" the deep-sea community with organic matter and detritus that descend from waters at and near the surface. Because the waters above the New Hebrides Trench are tropical, they are inherently less productive than colder, more nutrient-rich waters further south, and the abundance of prawns and cusk eels suggests that they have adapted to survive in an environment where food is at a premium. It also suggests that they, or similar forms of life, are likely to be relatively widespread in trench environments throughout the tropical Pacific.

The discovery, added Jamieson, was "a stark reminder that even the deepest parts of the world are intrinsically linked to the productivity of the surface waters."[54]

Meanwhile, the expedition obtained extremely rare samples of cusk eels, eel pouts, arrow-tooth eels and thousands of small crustaceans, which were sent for study in Australia. Ultimately, their identities and secrets will be revealed; for now, the mysteries of the New Hebrides trench endure.

Opposite page, top: *Plesiopenaeus armatus*, at a depth of 4200m. Bottom: *Plesiopenaeus armatus*, at a depth of 4835m. Both photos courtesy of AJ Jamieson, University of Aberdeen, UK.





Orange spotted soapfish (*Belonoperca pylei*). Photo courtesy of Richard Pyle

Blue ribbon eel. Photo courtesy of Malcolm Francis

10

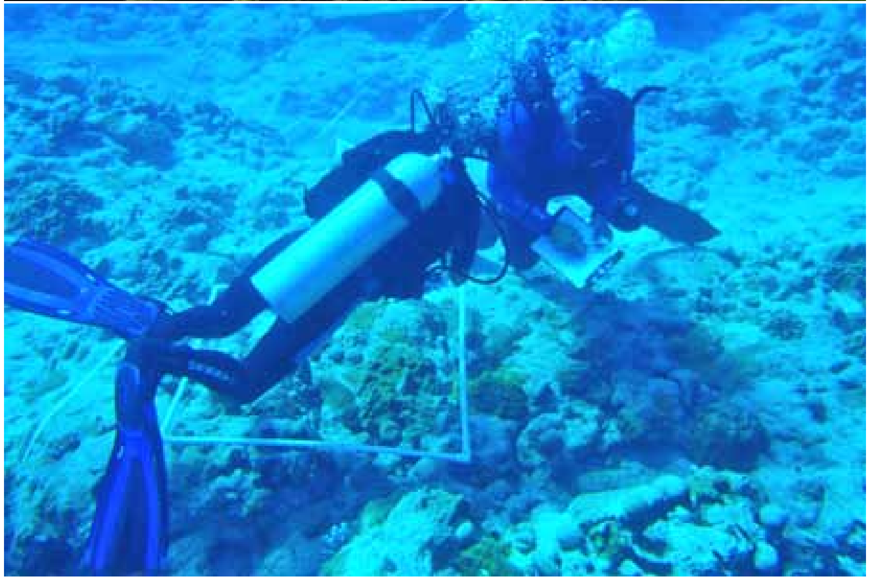
RAROTONGA OUTER REEF SLOPES

Rarotonga is one of nine islands making up the southern group of the Cook Islands. The Cook Islands are particularly remote and are located 1,130 km west of Tahiti and some 3,000 km north-east of Auckland, New Zealand. This site encompasses approximately 8,000 km², extending 50 km out to sea from Rarotonga's reef edge, with depths ranging from 80 to 300 m. The outer reef contains at least 12 endemic fish species and is a notable feeding and resting area for two species of sea turtle, including the critically endangered hawksbill.

The island of Rarotonga is the largest and most populous in the Cook Islands and a nexus of tourism. A frequent port of call for cruise ships, this volcanic high island is surrounded by a fringing barrier reef, which protects the beaches and shallow coastal waters from severe weather and makes it a haven for snorkelers and divers.

As with reef slopes elsewhere, coral life here grows in greater abundance and diversity, supporting species from blue ribbon-eels to spotted eagle rays to several reef sharks.[55] And it is here in deeper waters—even to depths of 300 m or more—that the true biological uniqueness and value of this area come to the fore. At least 12 species of fish have been discovered that live in the deep waters of Rarotonga's outer reef slope, and nowhere else. They include the Powell's false-moray; the Cook Islands flashlight fish—so named for the bioluminescence beneath its eyes; the fairy-basslet; the beautiful red-and-white striped peppermint angelfish; the orange-spotted soapfish with its jaguar-like camouflage; the narcosis angelfish, named for the dangerous condition known as nitrogen narcosis that can afflict humans who dare to dive to the fish's depth; the two-toned Claire wrasse; the stunning, multi-coloured mystery, or white-barred, wrasse; the latticed goby; and several other species yet to be fully described.

Critically endangered hawksbill sea turtles and endangered green sea turtles are found throughout the year in the outer reef waters of Rarotonga, an area they use almost exclusively for feeding and resting.[56] Also found here are humpback whales, although overall numbers of this genetically distinct population remain unknown.



Top: Peppermint angelfish. Photo courtesy of Richard Pyle. Bottom: Surveying Rarotonga. Photo courtesy of Kelvin Passfield. Opposite page: Narcosis angelfish. Photo courtesy of Richard Pyle.

Humpback whale, flickr/panachart

11

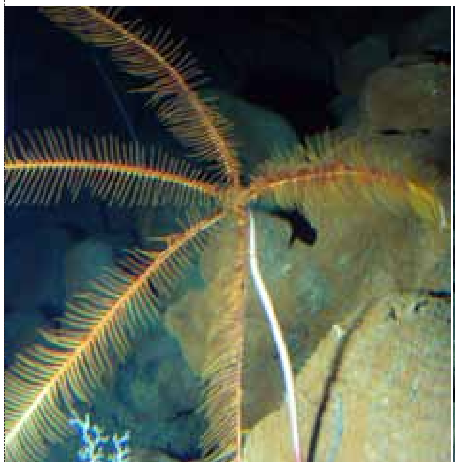
SAMOAN ARCHIPELAGO

This area is centred on the islands and surrounding waters of the Samoan archipelago, a biodiversity "hotspot" within the western South Pacific. It is also characterized by numerous seamounts to the east and west of the main islands, including the seismically and hydrothermally active Vailulu'u Seamount, with its remarkable diversity. Found here, as well, is one of the world's oldest and largest hermatypic coral colonies known.

Stretching roughly west to east above the Pacific Tectonic Plate, the islands and waters of the Samoan archipelago constitute the "Samoan hotspot", one of some 70 geological hotspots so far identified [57]. The term has a very specific meaning in geology: areas where upwelling plumes of magma have forced their way through Earth's crust to form volcanic islands. From an ecological standpoint, it is also a valid description for the ecology of Samoa's waters, a hotspot of endemism, diversity and abundance: the Samoan archipelago is one of very few EBSAs to score "high" on all seven criteria.

The only specimen of the delightfully named musical furry lobster was recovered from deep below the sea surface in Samoa (The only other record of the species is a photograph taken off the Tuamotu Archipelago). Similarly, the deepwater snapper *Lutjanus mizenkoi* is known only from Samoa and Indonesia. One of the ocean's largest and oldest single hermatypic coral colonies known, a massive *Porites* coral, is located in 17 m of water off of Ta'u island. This remarkable structure of living coral is 7 m tall and 41 m in circumference, with a skeleton weighing in at an estimated 129 t (dry weight) and an age of between 360 and 800 years old, although it could be much older. The fact that other very large *Porites* colonies thrive around Ta'u and nearby islands suggests that the area has been especially conducive to coral growth for quite some time.[58] Meanwhile, the longest-known mammalian migration begins in Samoa, where two humpback whales breeding in the near-shore waters of Tutuila—members of the endangered sub-population of the central South Pacific—were subsequently photo-identified on three occasions at feeding grounds off the Antarctic Peninsula. One of the whales was again identified after its return, a round-trip journey of 18,840 km.[59]

A large stalked crinoid on the outer SW flank of Vailulu'u Seamount. Photo courtesy of NOAA



Large hexactinellid sponge, probably family Pheronemidae, attached with large spicules to the broken pillows off Ta'u. Photo courtesy of NOAA

Swarms of small synaphobranchid eels, *Dysommina rugosa*, live in the crevices on the summit of Nafanua. Scientists dubbed this site “Eel City”. Photo courtesy of NOAA

The seismically and hydrothermally active Vailulu’u Seamount, located 45 km east of the easternmost island of the archipelago, has been described as “an incredibly diverse and dynamic marine environment where volcanic, hydrothermal, oceanographic, and biological processes are closely interlinked” by deep-sea researchers.[60] Found, for example, are cutthroat eels at low-temperature vents, stalked demosponges on crater walls, octocorals, brittle stars, sponges and sea lilies and feather stars on nonhydrothermal rocky bottoms, and bright-red worms in the “Moat of Death”, a highly turbid and acidic region displaying “the most hostile conditions to life”.[61]

Porites coral. Photo courtesy of National Parks Service

Crinoid. Photo courtesy of National Park Service

Rose Atoll, which lies at the eastern end of the archipelago, is an important nesting site for the threatened green sea turtle and habitat for 17 species of protected migratory seabirds and shorebirds. The largest population of giant clams in American Samoa is found here, as are as many rare species of reef fish.[62] Humpback whales are present, and catches of albacore tuna and marlin are among the highest in the region, probably due to the abundance of seamounts creating localized upwellings.

Politically, the archipelago is divided between the six islands and one atoll of American Samoa and the two islands and one islet of the Independent State of Samoa, although the archipelago’s marine life unsurprisingly shows considerable connectivity. That connectivity extends far beyond those borders, as the archipelago, and particularly Savai’i, is a potential source of coral reef larvae and associated organisms for colonization and replenishment of other South Pacific areas.

The Government of American Samoa has declared Rose Atoll a National Monument, and the EEZs of both jurisdictions have been declared sanctuaries for whales and turtles (with the EEZ of Samoa also being a sanctuary for sharks). Rose Atoll and Vailulu’u Seamount were included within the United States National Marine Sanctuary system in 2012[63], while Aleipata and Safat are marine protected areas in Samoa. The Samoan Archipelago has been recognized in the Pacific Oceanscape framework (endorsed by all governments in the Pacific Island region) as a key Ocean Arc, and both governments support the Two Samoas Initiative,[64] which is supported by Conservation International and the Secretariat of the Pacific Regional Environment Programme.

12

Bristle-thighed curlew. Photo courtesy of Cook Islands Natural Heritage Trust/Gerald McCormack

SUWARROW NATIONAL PARK

Suwarrow is a remote atoll in the northern Cook Islands, located some 800 km north-west of the main island of Rarotonga and a similar distance to the east of American Samoa. The site covers approximately 8,700 km², encompassing an area that extends 50 km from the reef edge around the coast, and to depths as great as 3,000 m below the sea surface. Data from the Ocean Biogeographic Information System (OBIS) show that there are several seamounts surrounding the atoll that could contribute to foraging resources for the region's marine wildlife. Suwarrow is an important breeding and foraging area for numerous seabird species. The area also supports sea turtles, coconut crabs and humpback whales.

The coral atoll of Suwarrow is something of an isolated oasis in the western South Pacific. The atoll comprises islets and cays surrounding a lagoon 80 km in circumference and 80 m deep, with one navigable entrance on its north-east perimeter. The four largest islets are densely wooded; there are approximately 23 smaller islets and cays, although this number varies, depending on the impact of occasional cyclones. A tropical climate moderated by south-easterly trade winds prevails for most of the year.[65]

In 1890, the wife of Robert Louis Stevenson described Suwarrow as "the most romantic island in the world", and at least two individuals have been sufficiently charmed by its beauty to live on the atoll that is the living embodiment of her husband's most famous literary creation, *Treasure Island*. At least two others have reportedly found great bounties of buried treasure there, too. One of them, a New Zealander by the name of Henry Mair, discovered gold and silver necklaces, brooches and coins in a rusty box that a turtle uncovered while laying its eggs in 1876. Unable to carry the booty away with him, he marked its location for later retrieval; alas, he was later killed on the New Hebrides, and his find has never been relocated.[66]

Suwarrow National Park. Photo courtesy of Ewan Smith.

Today, Suwarrow is valued for its natural treasures, and in particular for its abundant bird life.

Eleven seabird species breed here, and it supports the only large colonies of sooty tern, brown booby and lesser frigatebird in the Cook Islands, with the sooty tern population numbering fully 240,000 individuals. The atoll is a breeding and foraging site for 13 per cent of the world's lesser frigatebirds and four per cent of red-tailed tropicbirds. Migratory birds such as the bristle-thighed curlew and wandering tattler overwinter here, and the atoll's birdlife is recognized as being important for maintaining seabird populations on the other islands. The most significant seabird nesting and foraging area in the Cook Islands, Suwarrow is recognized as an Important Bird Area by BirdLife International.

The atoll also provides habitat for coconut crabs as well as two species of sea turtle—the endangered green and the critically endangered hawksbill—that nest on the island before migrating to feeding grounds, possibly off Fiji. Humpback whales calve and breed in the area and represent a genetically distinct population from other Pacific humpback populations, all of which are vulnerable as a result of historical catches.

Above: Giant clams. Photo courtesy of Kelvin Passfield, Opposite page, top: Lesser frigatebird. Bottom: Lesser frigatebird colony, Suwarrow. Both photos courtesy of Nick Hayward.

Green sea turtle. Photo courtesy of Comstock Images

13

SOUTH OF TUVALU/ WALLIS AND FUTUNA/ NORTH OF FIJI PLATEAU

This EBSA encompasses an estimated total area of more than 325,000 km² and falls within three national jurisdictions (Tuvalu, Fiji, Wallis and Futuna—France). It features a number of distinct topographic features, such as seamounts, knolls, large submarine canyons, trenches, basins, plateaus, ridges, volcanic islands and fringing reefs.

This region includes "one of the most favourable tuna fishing areas in the world."[67] Catches are primarily of skipjack and yellowfin, though bigeye and albacore are caught here as well. Other highly migratory fish species in the region include blue marlin, listed as vulnerable on the IUCN Red List;[68] black marlin, one of the world's largest boney fishes, listed as data deficient (recent tagging studies have tracked black marlin originating from a Great Barrier Reef spawning aggregation to within Tuvalu waters of this EBSA);[69] striped marlin, listed as near threatened; and swordfish, classified as a species of least concern.[70]

A wide range of other charismatic species occur throughout this region, including four species of sea turtle (hawksbill, green, loggerhead and leatherback),[71] humpback whales, and possibly sperm whales, purportedly seen in these waters historically,[72] and a number of smaller cetacean species, including Frazer's and spinner dolphins, Ginkgo-toothed and Blainville's beaked whales, and pygmy killer whale.[73] There are at least 20 species of seabirds with distributions known to occur within this region, including a number of threatened petrel species. Ten species have been recorded as breeding on Wallis and Futuna islands.[74]

Of note, also, is the high number of submarine topographic features, including canyons, seamounts, basins and ridges, with water depths plunging to approximately 5,500 m in Allice Basin. Deepwater sampling in this region has been sporadic, though cruises during the 1990s collected 83 species of cold-water coral across various environments around Wallis and Futuna, suggesting high levels of species richness throughout much of this area.[75]

Of particular interest are the numbers of submarine canyons located here. Submarine canyons are common features incised into continental and ocean island margins, where they connect continental shelves and slopes to the much deeper ocean basins. Using satellite altimetry, a 2011 study delineated 5,849 separate large submarine canyons in the world ocean, the first global inventory to be compiled.[76]

The few studies that have been undertaken of these canyons suggest that they can contain extraordinary benthic biomass and that at least some are likely to be among the most productive habitats in the deep sea. Kaikoura Canyon on the eastern New Zealand margin, for example, was found to have benthic biomass values 100-fold higher than any previously reported (non-chemosynthetic) ocean habitat below 500 m.[77] Numbers of benthic-feeding fishes were also dramatically higher than those found on the adjacent slopes. Recent studies have discovered that canyons contain highly unique habitats and communities and that they can be frequented by giant squid, deep-sea coral, glass sponges, sharks, tunas and sperm whales, among other species.[78]

14

Spinner dolphin. Photo courtesy of Stacy Jupiter

VATU-I-RA/LOMAIVITI

Located entirely within Fiji, this area contains a diverse benthic geomorphology, including channels, submarine canyons and seamounts. Extremely high coral reef biomass, multiple significant seabird colonies, including the only breeding site for the endemic and critically endangered Fiji petrel, and a hotspot for humpback whales and other cetaceans, sea turtles and sharks are just a few of the features included within this EBSA.

Black noddy. Photo courtesy of Stacy Jupiter

In 2010, researchers led by the Fiji Department of Fisheries set up station at two sites—in the town of Levuka on the east coast of Ovalau, and on Magokai island to the north-east—and looked out to sea. They were looking for humpback whales.

More than 50 years previously, a survey led by William Dawbin in the same region had counted a total of 1,648 humpbacks over three years, with a maximum of 238 in one week; the 2010 study, though shorter in nature, yielded but a fraction of that. But in the years after Dawbin's work, illegal whaling had decimated humpback whale numbers in the region, and the fact that the new research not only saw whales—60, in fact, during 120 hours of observation from Makogai—was in itself a reason for encouragement. Even more encouraging, however, was the fact that the sightings included several mother-calf pairs on consecutive survey days, suggesting that the site just may be an important breeding and calving area for this endangered but recovering sub-population.[79]

The whales were spotted in the Vatu-i-Ra Passage, the waterway that runs between the main Fijian islands of Viti Levu and Vanua Levu, and which

Grey reef shark. Photo courtesy of Stacy Jupiter. Opposite page: Red-footed booby. Photo courtesy of Steve Cranwell

has long been identified as a migratory corridor for the Oceanis humpback whale sub-population. The area includes a channel, more than 700 m deep, and the resulting fast currents and potential upwelling support some of the highest levels of coral reef biomass in the western Pacific.[80] As well as whales, those waters support two resident spinner dolphin pods that rest at Moon Reef during the day and feed at depth during the night. There are important turtle nesting and foraging areas around the shallow and coastal margins, including at Namenalala Island, which is thought to be the last remaining nesting area in Fiji for hawksbill turtles;[81] a grey reef shark breeding ground at Nigali Passage off Gau Island; and no fewer than five species of sharks from three families in the waters around Namenalala Island.[82]

There are at least two shallow seamounts within proximity of the channel, and the islands host several globally significant bird colonies: black noddies on Vatu-i-Ra and Mabualau islands, red-footed boobies on Namenalala Island, and collared petrels on Koro and Gau islands. Furthermore, this area is home to the endemic and critically endangered Fiji petrel, which breeds on Gau Island. This petrel species is considered to be exceptionally rare and, according to researchers, is likely to number a few tens of individuals. Virtually nothing is known about the species, not even its breeding habitat on Gau.[83]

Because the deep waters of the channel support such productive adjacent shallow ecosystems, it is likely—though unconfirmed—that the deeper ecosystems are also productive. Provincial administrators and other government representatives have indicated interest in protecting this important area.

Antipodean albatross. Photo courtesy of Ben Lascelles

15

SOUTH TASMAN SEA

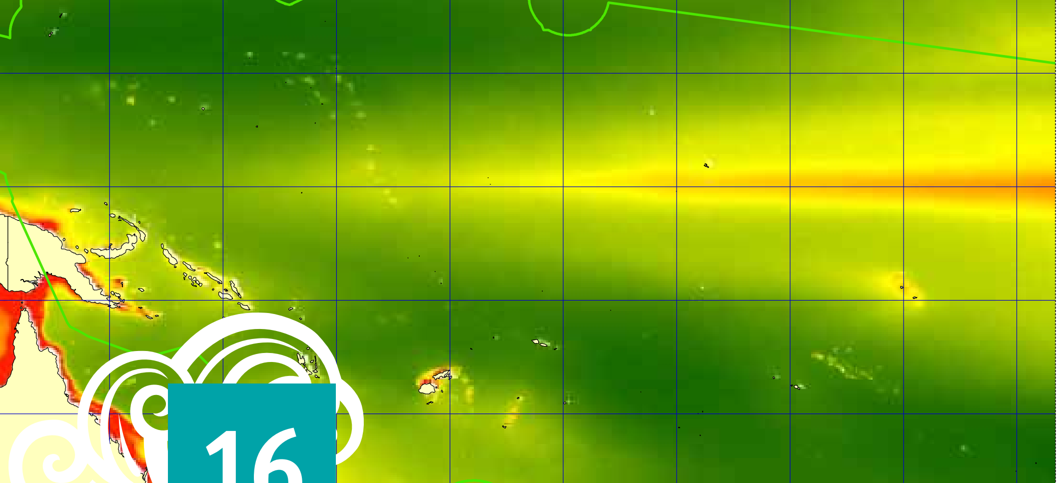
Lying below the sub-tropical front between Australia and New Zealand, this site covers a large portion of the Tasman Sea. It is bordered to the north by Lord Howe Island and has an average depth of 4,962 m, but contains seven seamounts on its eastern border with the Tasman Abyssal Plain and two shallow seamounts in its north-west corner, one of which, the Gascoyne Seamount, rises from a depth of around 4,500 m to just 25 m below the surface. The region is characterized by very high densities of seabirds, and foraging areas for numerous breeding and non-breeding birds.

The East Australia Current begins life in the tropical Coral Sea, travels south along the entirety of the eastern coast of Australia deep into the Tasman Sea, and collides with the sub-polar waters in the northernmost reaches of the Antarctic Circumpolar Current, an encounter that causes it to angle counterclockwise to the east toward New Zealand.

Quite likely the most famous current in the ocean, courtesy of its starring role in the animated movie *Finding Nemo*—in which it was portrayed as an aquatic highway for the region's marine life—the East Australia Current functions as both the western boundary of the South Pacific Gyre and the linking element between the Pacific and Indian Ocean gyres, but is less of a steady stream than a series of mesoscale eddies that produce highly variable patterns of current strength and direction.[84]

Where it clashes with the cooler waters further south, the surface mixing creates an extremely dynamic and productive environment, resulting in frequent chlorophyll-*a* "blooms" across the site, especially in the southern and central areas. The associated high levels of primary productivity support a bountiful ecosystem that includes the highest seabird densities throughout the entire Pacific islands region. The area is important for Buller's and Antipodean albatross, Cook's petrel, white-capped albatross, which transits to forage off the coast of Tasmania, and, outside of breeding season, white-capped, wandering and Antipodean albatross, the latter two of which are classified as vulnerable on the IUCN Red List.

The meeting between sub-tropical and sub-polar waters also has an impact far beneath the waves, as the cooler, heavier water from the south drives beneath the warmer waters of the East Australian Current, ultimately spreading out across the abyssal plan, delivering nutrients that sustain a thriving seabed community. Samples collected during a 1982 survey revealed the presence of several rare species, including black coral, brittlestars, gastropods and crustaceans. The north-east corner of the plain is characterized by seven seamounts at summit depths of around 3,000 to 3,500 m, while to the north-west, two shallower seamounts rise to within 1,200 m of the sea surface. These latter seamounts have not been sampled, but seem likely, based on inference from similar seamounts, to support cold-water coral communities.



16

Global ocean productivity, showing an area of high productivity (orange) in the equatorial central Pacific Ocean. Map courtesy of CSIRO (Australia)

EQUATORIAL HIGH-PRODUCTIVITY ZONE

This is primarily a pelagic feature in the equatorial central Pacific Ocean. The feature includes the western extreme of the Pacific south equatorial current, and as such is a component of a much larger ocean feature that extends across the Pacific to the Americas. A high-nutrient cold water "tongue" intersects with a warmer "pool" of seawater in the central Pacific Ocean, leading to high levels of primary productivity at the surface and secondary productivity on the seabed.

Efforts to proclaim and protect the value of the ocean tend to do so in the context of some form of terrestrial or geographical feature. An area of ocean may be deemed valuable for the coral atolls it contains, for the turtle-nesting beaches on its islands, for the respite that isolated islets provide for migratory birds. Even beneath the waves, it is

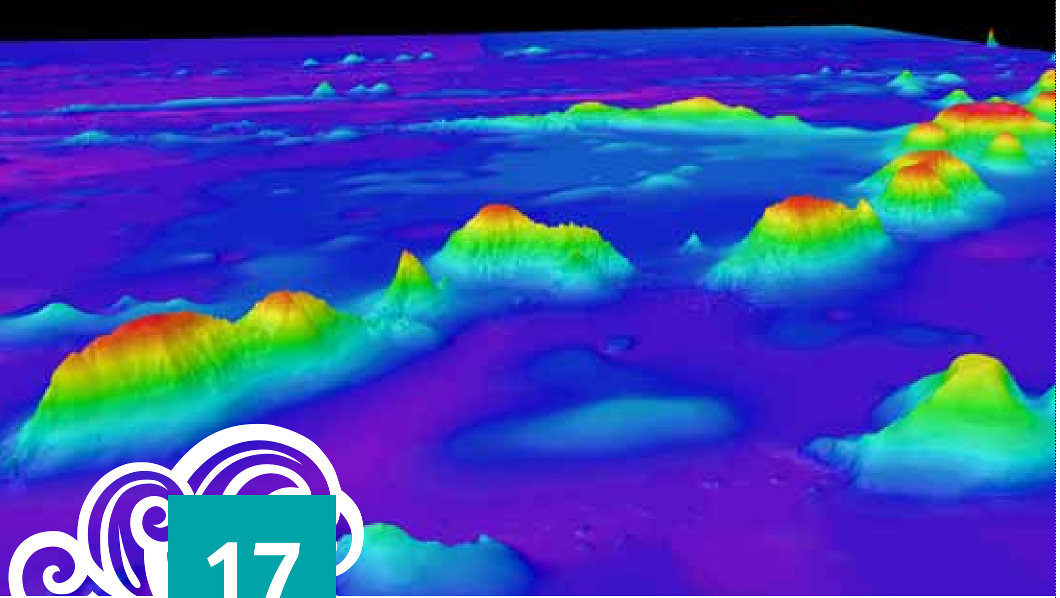
geology—deep-sea trenches that carve into the seabed, or seamounts that rise from it—that is often the focus, for the way in which they divert currents, enhance productivity or shelter unique communities.

This EBSA, however, is different. This region is not renowned for its endemism, or its high rates of biodiversity. It does not boast a critically endangered petrel, or habitat for a rare crab. This area of the ocean contains … ocean. But due to its size and oceanographic properties, it is a major source of the planktonic organisms that are so vital for marine life throughout the ocean.

The roots of the EBSA begin far to the south, off the Pacific tip of South America, in the form of a current that brings cool water up the coast of the continent, toward the equator, before being driven by trade winds to the west and toward the central Pacific Ocean, where it forms the South Equatorial Current.[85] This "cool tongue" of water is high in nutrients, particularly nitrate, phosphate and silicate, resulting in high primary productivity.[86] That planktonic life sinks to the bottom as it dies and decays, bringing with it nutrients to the abyssal plains and deep-water trenches far below, resulting in high levels of benthic secondary production at depths as much as 5,000 m.[87]

As they drive west, the cool waters of the South Equatorial Current meet the eastern edge of the western Pacific "warm pool", which is formed as a result of high rainfall causing lower salinity and warmer conditions. The area where the two meet—in a frontal zone that shifts back and forth from east to west and back again—is known as the Eastern Warm Pool Convergence Zone. It is possible that the nutrient input from the "cold tongue" may help explain why the comparatively nutrient-poor waters of the warm pool are able to sustain high levels of tuna, as reflected in the fact that the area contributes approximately 40 per cent of the world's tuna catch.[88] Historically, also, this same region has seen very high levels of sperm whaling, greatly reducing their numbers.

This area is highly unique—it features the westerly extreme of a major oceanographic feature of the Pacific Ocean, as well as the interaction of this upwelling zone with a major surface area of the western central Pacific. It is highly influenced by El Nino/Southern Oscillation (ENSO) events, and as a result, is potentially highly vulnerable to the oceanographic changes to such events that will result from climate change.



17

Central Louisville Seamount Chain—bathymetry. Photo courtesy of NIWA (NZ)

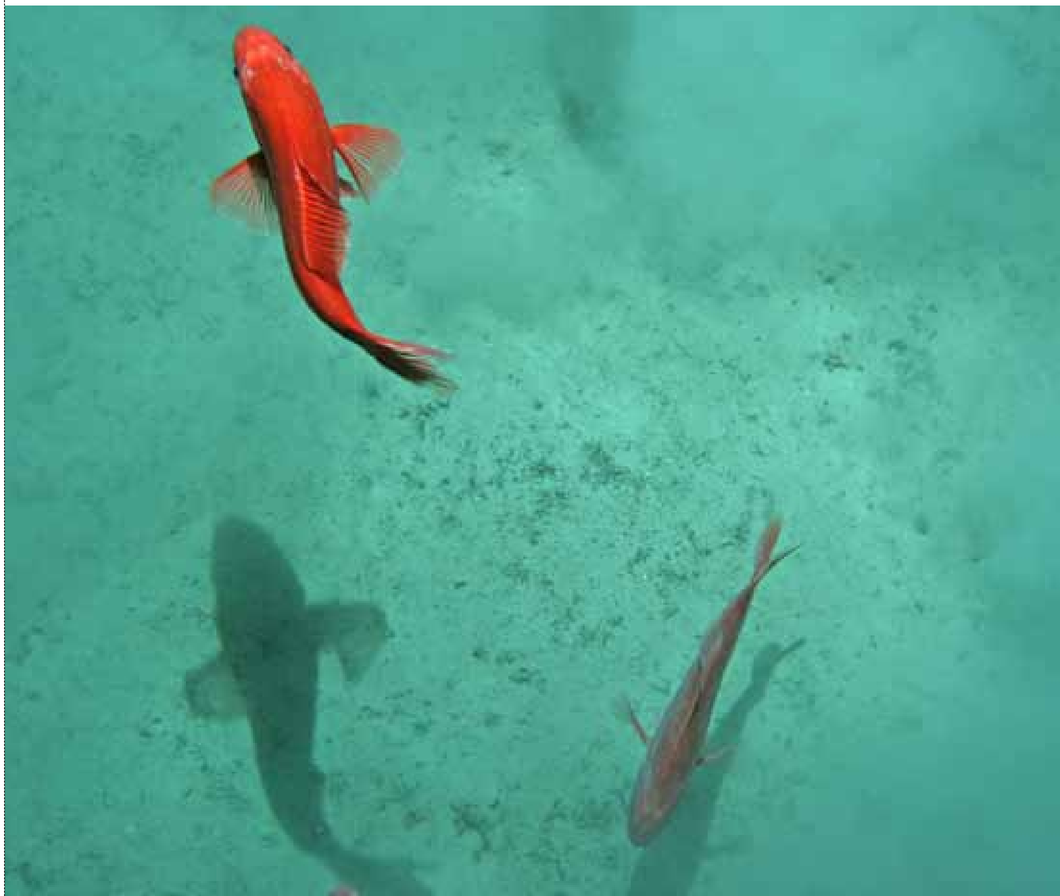
CENTRAL LOUISVILLE SEAMOUNT CHAIN

Located south-east of New Zealand on the high seas (i.e., beyond EEZ boundaries), this area contains 13 seamounts (several with multiple peaks) spanning a distance of about 1,000 km and a range of summit depths from 250 m to over 4,000 m. These are likely to have productive and diverse benthic invertebrate communities, providing "oases" for animals that can't survive at abyssal depths or requiring hard rocky substrates for attachment. The seamounts host a variety of deep-water fish species and are spawning grounds for orange roughy.

Over 4,300 km in length, the Louisville Seamount Chain extends from the Tonga-Kermadec Trench in the north-west to the Pacific-Antarctic Ridge in the south-east. Dating back 80 million years, likely when the Pacific plate slid across a centre of upwelling magma called the Louisville Hotspot, the chain was first detected in 1972 using depth soundings collected along random ship crossings of the South Pacific, and its full extent was revealed six years later by a radar altimeter aboard the Seasat (NASA) spacecraft.[89]

The entire chain comprises about 80 seamounts rising from the abyssal seafloor 4,000 m deep to peaks between 500 and 1,000 m below the sea surface, forming a rift in the mantle similar to the Hawaiian Islands.[90] Oceanographic conditions at the surface range from subtropical in the north to temperate in the south. This EBSA focuses on 13 seamounts in multiple forms: large, single conical seamounts, seamounts with multiple peaks (as many as four in the case of the Forde-Danseur seamount complex)

Orange roughy, Central Louisville Seamount Chain. Photo courtesy of NIWA (NZ)



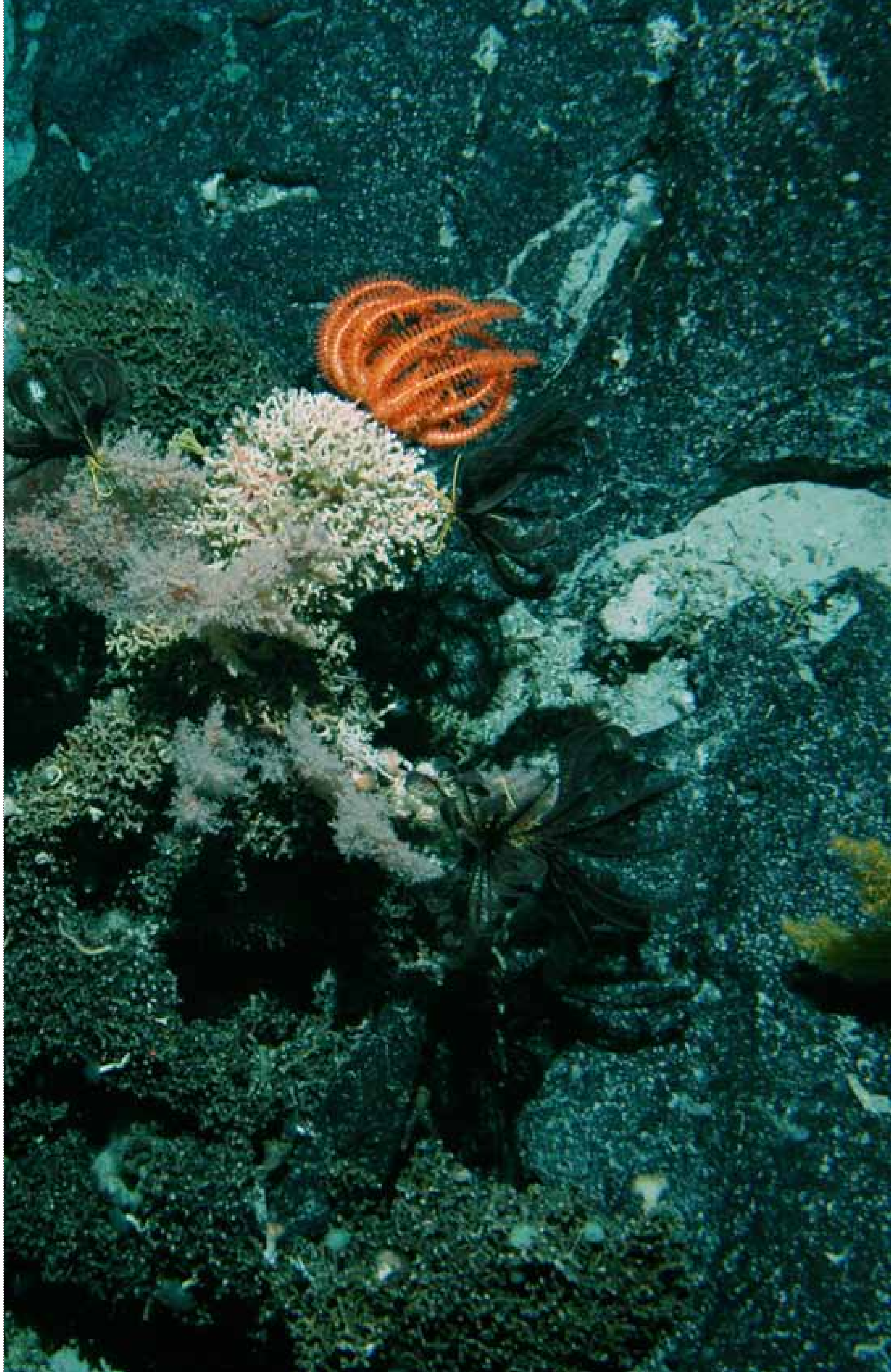
and guyot structures (flat-topped seamounts that are often sediment-covered in contrast to small-summit seamounts). The depths of the peaks range from 250 m to the peaks on Burton seamount, which are typically over 2,000 m.

The seamounts are perhaps most renowned as spawning grounds for orange roughy, a demersal fish that is a member of the Trachichthyidae—a family more colloquially known as slimeheads, in recognition of the network of muciferous canals that run through its members' heads. All slimeheads are slow to mature, low in fecundity and exceptionally long-lived, and the orange roughy is no exception, not reaching maturity until approximately 32 years of age and possibly capable of reaching almost 150 years in age.[91]

Orange roughy has been heavily fished in the region, and much of the information about the biology and ecology of these seamounts has been derived from studies of species that have been incidentally caught in those fisheries, including stony, black and bamboo corals (including very long-lived stony corals that have been declared protected inside New Zealand's EEZ), sponges, deep-water urchins, numerous invertebrate species, and slow-reproducing deep-water dogfish.

The fact that the topography of the seamounts is so varied, and that the range is geographically widespread, means the fauna will almost certainly differ from one end of the chain to the other. The seamounts to the north, for example, are in deeper, warmer water, making them less suitable as habitat for cold-water stony corals.[92] But the presence of the seamounts, rising from the deep seabed, grants life a toehold and an opportunity to thrive at elevations that would otherwise be unavailable to them. It seems likely also that each seamount, while offering its own unique assemblage of fauna, functions not just as an oasis but as a stepping-stone, a way-station that enables species to disperse, expanding their distribution from one seamount to the next and beyond.[93]

Opposite page: Coral community, central Louisville Seamount Chain. Photo courtesy of NIWA (NZ).



18

Starfish, *Fromia monilis*, American Samoa.
Photo courtesy of National Park Service

Spiny lobster, *Panulirus sp.*, American Samoa.
Photo courtesy of National Park Service

WESTERN SOUTH PACIFIC HIGH ARAGONITE SATURATION STATE ZONE

This area includes the surface waters (i.e., down to about 100 m) within the South Equatorial Current in the tropical Pacific from an area slightly west of American Samoa and extending eastward. It is characterized by a distinct oceanographic feature in which the aragonite saturation state of the surface layer is the highest in the Pacific Ocean and is projected to remain so under a range of future ocean chemistry scenarios. This area has special biological and ecological value as an area where the impact of ocean acidification will be slowest and from which recovery may potentially be the quickest.

"Ocean acidification" refers to the change in ocean chemistry in surface ocean waters due to increasing concentrations of carbon dioxide (CO_2) absorbed from the atmosphere. The dissolution of carbon dioxide in seawater results in a chemical reaction that forms carbonic acid, which 1) ultimately lowers seawater pH (i.e., increases acidity); and 2) decreases the concentration of calcium carbonate ions and thus the carbonate saturation state (Ω), notably with respect to aragonite and calcite, the two main forms of calcium carbonate.

Globally, the uptake of CO_2 has reduced the pH of surface seawater by 0.1 units, a seemingly small amount until one considers that this means that current pH levels are very likely lower today than at any point over the last two million years. If current trends continue then the reduction in pH level projected for the end of this century would be unprecedented over the last 40 million years.[94]

The most profound impacts will likely be felt on calcifying organisms—those requiring calcium carbonate to produce shells or skeletons—such as coral, gastropods, bivalve molluscs and crustaceans, via reduced calcification rates.[95] Increasing CO_2 concentrations and acidity can also bring about physiological changes in at least some marine organisms; if those impacts hamper the survival, growth, or overall fitness of keystone species, such as corals, pteropods, or coccolithophores, then severe alterations to ecosystems or foodwebs could follow.[96 97]

In pre-industrial times, the aragonite saturation state (Ω_{arag}) of surface waters throughout most of the sub-tropical and tropical Pacific Island region was around 4.5; by the mid-1990s the highest values had declined to slightly over 4—still considered optimal for corals, for example[98]—but such high levels could only be found in the western Pacific and the South Equatorial Current region. As a result of increased atmospheric CO_2 since then, only one Pacific region, the South Equatorial Current and the location of this EBSA, now has a current Ω_{arag} that has not dropped below 4.[99]

Meanwhile, data from long-term monitoring of surface waters along sections of the equatorial Pacific, a band of ocean running along the equator between the coasts of South America and Southeast Asia, and slightly north of this EBSA, have recently shown a wholly unexpected rate of increase in CO_2 concentrations. Researchers affiliated with the study surmised that the combination of ocean acidification and decadal variability has created conditions for high rates of pH change.[100]

Recent measurements show that areas within the South Equatorial Current to the east of American Samoa have the highest Ω_{arag} in Pacific surface waters. These areas can be assumed to be the least affected for the longest period under increased atmospheric CO_2 concentrations.

Oyster, American Samoa. Photo courtesy of National Park Service

19

Black-winged petrel. Photo courtesy of Steve Cranwell.

CLIPPERTON FRACTURE ZONE PETREL FORAGING AREA

The area is equatorial and lies north-east of the western South Pacific region and to the north of the Pacific Equatorial Upwelling Zone, well beyond any national jurisdiction. It is situated over the abyssal plain, with an average depth of 4,624 m, although several seamounts rise to minimum depths of 1,060 m below the ocean surface. This area has been identified as the core foraging area for Pycroft's petrel, listed as vulnerable by the IUCN. Approximately 50 per cent of the species' global population is estimated to use this area, with a number of other migratory seabird species also passing through on their way to more distant non-breeding areas.

Each October, on the forested slopes of a dozen small islands off the north-eastern coast of New Zealand, adult Pycroft's petrels return to breed. They clear out burrows that they dug earlier in the year, lining the rear with twigs and leaves to make a nest, and sometime during November or December, each fertilized female adult will lay a single white egg.[101] Approximately 45 days later, all being well, a chick emerges; within 80 days, it will have fledged, taking wing until it returns years later to begin breeding itself.[102]

Much about the behaviour of Pycroft's petrels when they are at sea remains unknown. As with other seabirds, they presumably feed primarily at the surface or the upper water column, and it is known that they eat squid and crustaceans.[103]

Satellite tracking of Pycroft's petrels in 2009 showed that some 50 per cent of the global population spends the months following fledging, from July to October, foraging in the waters within this EBSA. They are not the only birds to take advantage of the region: sooty shearwaters, Gould's petrels and Cook's petrels, among others, transit through here during migration to distant non-breeding sites; and satellite tracking has shown that black-winged petrels, too, forage intently in one part of the area.

This site is the core foraging area for the birds from Red Mercury Island, New Zealand, the breeding site for some 80 per cent of the entire global population of Pycroft's petrels. The island supported 1,000 to 2,000 pairs in 1991 and 2,000 to 3,000 pairs in 1998; surveys in 2010 indicated that, following efforts to eradicate rats from the island, the petrel population had climbed to 5,000 to 10,000 pairs, making it the dominant bird on the island. There are likely at most 500 pairs on the nearby Hen and Chicken islands; other populations are tiny.[104]

The fact that Pycroft's petrels and black-winged petrels were tracked in separate years, with high numbers using the area in each year, suggests that the site is relatively static, although this might be disrupted by El Niño Southern Oscillation events, which send warm waters west through the area. The site is inherently linked to processes occurring across the Pacific basin: continued eradication of rats from New Zealand islands will likely further increase numbers of Pycroft's petrels using this foraging area during the non-breeding season.

Great-winged petrel. Photo courtesy of Ben Lascelles.

20

NORTHERN LORD HOWE RIDGE PETREL FORAGING AREA

This site extends along the Lord Howe Ridge, south-west from New Caledonia's EEZ, through an area beyond national jurisdiction to the Australian EEZ north-east of Lord Howe Island. It has been identified as the core foraging area for the endemic New Caledonian subspecies of Gould's petrel.

There are two subspecies of Gould's petrel, breeding 2,000 km apart. To the south, *Peterodroma leucoptera leucoptera* breeds mainly in two steep gullies on the western side of Cabbage Tree Island, a 30-ha nature reserve that lies offshore of the entrance to Port Stephens, New South Wales, Australia, on the doorstep of that country's largest city, Sydney.[105] In 1992, the total population—of breeders and non-breeders—was estimated at 1,500 birds, a decline of 26 per cent since 1970, and the breeding population was estimated to fledge fewer than 50 young a year. Since then, however, stringent conservation measures have seen the population increase and stabilize at around 1,000 breeding pairs.[106]

Far to the north-east, there are at least three main breeding sites of other subspecies of Gould's petrel, *Peterodroma leucoptera caledonica,* between mounts Dzumac and Poya on the island of New Caledonia. Each site, 350 to 650 m above sea level, contains as many as 2,000 breeding pairs, flitting over the colonies with bat-like weaving flight and emitting a staccato *ti-ti-ti-ti* .[107]

Recent tracking studies have revealed that during the non-breeding season, both subspecies migrate across the Pacific, but use different migration routes and over-winter in different regions of the ocean: *leucoptera* in the central Pacific south of Hawaii, and *caledonica* in the eastern Pacific west of Ecuador. During the breeding season (October-April), *caledonica* forages primarily in the area contained within this EBSA, with between 50 and 65 per cent of the global population spending the bulk of its time feeding—primarily on fish, cephalopods and crustaceans—in these waters to the south-west of New Caledonia.[108]

Other species for which the area is known to be important, and which breed in New Zealand, include northern populations of Cook's petrel, breeding on Little Barrier Island; great-winged petrel, breeding on the Alderman (Ruamaahua) Islands; and Parkinson's petrel, breeding on Great and Little Barrier islands.

The endemic *caledonica* subspecies of Gould's petrel is thought to number up to 10,000 pairs in total, although some breeding colonies may yet be discovered in isolated massifs of New Caledonia. IUCN lists the species as vulnerable because it has a small breeding range and a small number of breeding locations, and because the *caledonica* subspecies appears to be undergoing a sharp decline.[109]

Parkinson's petrel. Photo courtesy of Ben Lascelles.

21

NORTHERN NEW ZEALAND/SOUTH FIJI BASIN

The site encompasses key foraging areas used by breeding Parkinson's petrel, a threatened seabird that breeds on Great Barrier and Little Barrier islands in northern New Zealand. Situated over the southern portion of the south Fiji Basin, the site is predominately deep-water, with an average depth of 3,973 m. However, there are several seamounts that rise to 1,343 m below the sea surface. This area has been identified as the core foraging area for the Parkinson's petrel, a species listed as vulnerable on the IUCN Red List, during its breeding season (October to June). Data show that the area is likely especially important from November to May, when more than 40 per cent of the approximately 5,000 individuals making up the total population may be present.

In November 1769, British explorer Captain James Cook was completing the first full year of the first of three expeditions on board the *Endeavour* and, later, the *Resolution*, expeditions that would take him to Alaska, Japan, New Guinea, Australia, the islands of the South Pacific and even the edge of the Antarctic continent before culminating in his death at Kealakekua Bay on the island of Hawaii in January 1779.[110] He spent much of the month around New Zealand's Hauraki Gulf, the vicinity of which expedition naturalist Joseph Banks deemed to be "the properest place we have yet seen for establishing a colony" and which indeed today is the maritime gateway to Auckland, New Zealand's largest city.[111]

At the mouth of the gulf, 100 km or so north-east of Auckland, sits an island, approximately 285 km^2 in area, which Cook dubbed Great Barrier Island, and which the area's existing inhabitants referred to as MotuAotea, or Island of the White Cloud. Like many of New Zealand's islands, this island and its smaller neighbour—an extinct volcanic island known as Little Barrier Island, or TeHauturu-o-Toi (resting place of the wind)[112]—contain a number of rare and endemic populations and species. Among them is the black petrel (*Procellaria parkinsoni*), the smallest member of the *Procellaria*, also called Parkinson's petrel after the artist who carefully illustrated the specimens Banks collected, Sydney Parkinson.

At the time of Cook's arrival, Parkinson's petrels were found on much of New Zealand's North Island, but were extirpated following the introduction of cats, rats, pigs and mustelids.[113] Now, two breeding colonies remain: of approximately 1,300 breeding pairs on Great Barrier Island, and a further 100 pairs on Little Barrier Island. The species was abundant on Little Barrier during the 1800s, but the population was decimated, mostly by feral cats, until introduced predators were eradicated in 1980; the population now seems to be increasing slightly.

The species is difficult to study, and hence little understood, as it breeds underground in burrows, only returning to the colony at night. During the breeding season, Parkinson's petrels occur in subtropical waters around New Zealand, eastern Australia and the Pacific Islands. At the season's height, likely more than 40 per cent of the population concentrates its foraging in the waters contained within this EBSA.[114] The species is most often seen in the outer Hauraki Gulf or in pelagic waters near the continental shelf break, though its foraging range during chick-rearing season can extend beyond a thousand km over much deeper waters.[115] During the non-breeding season, they migrate to South American waters, congregating in offshore and pelagic waters off Ecuador, and have been reported off the coasts of Panama, Costa Rica, Guatemala, Mexico and Galapagos.

Monogamous birds that breed in colonies, Parkinson's petrels are generally solitary at sea, but will congregate in flocks following fishing vessels or in association with feeding cetaceans. They generally feed at night on bioluminescent squid, supplemented with fish and crustaceans.[116] Due to its importance for the species, the area is recognized as an Important Bird Area by BirdLife International.

These waters are also used by Antipodean albatross, which breed on New Zealand's Antipodes Islands. In addition, Cook's petrel, white-chinned petrel, Pycroft's petrel and sooty shearwater have all been tracked to the site.

Bumphead parrotfish. Photo courtesy of Flickr/Jenny Huang

22

TAVEUNI AND RINGGOLD ISLANDS

This area, located among the north-eastern Fiji Islands, supports a diverse array of communities and habitats within a compact area. It encompasses deep-water areas to the east of Taveuni and a productive channel between Taveuni and Vanua Levu. The Ringgold Islands are either sand cays or raised coral atolls that support key turtle and seabird nesting habitat. The site is home to globally and regionally significant populations of marine turtles, humpback whales, seabirds and semi-nomadic reef fish and may hold concentrations of cold-water corals.

The waters surrounding Taveuni and the Ringgold Islands in north-eastern Fiji are, by and large, light on human occupation and activity. This is particularly true of the Ringgold Islands, whose only notable settlement is a village on the island of Qelelvu. This low population density is likely to some degree responsible for the flourishing of numerous biological communities. One key aspect of this site is that it combines a number of habitats, important communities and priority species in a compact area that includes deep channels, sheltered areas, small islands and sand cays. The area supports globally and regionally significant populations of marine turtles, humpback whales, seabirds and semi-nomadic reef fish, and may hold concentrations of cold-water corals.

It is a key breeding and foraging area for hawksbill and green turtles that are considered to be resident in Fiji, and the last remaining nesting location in Fiji for the latter.[117] The area supports migratory movements of humpback whales and resident spinner dolphins and nationally (and regionally) significant populations of humphead wrasse and green bumphead parrotfish, which, although associated with reef areas, have been shown to move between sites through deeper ocean habitats.

The region supports the largest seabird colonies in Fiji, encompassing four marine Important Bird Areas (IBAs), as identified by BirdLife International, that include globally and regionally significant populations of seabird species such as black noddy and red-footed booby. These populations spend a large proportion of their time within a 20 km radius of their breeding colonies, making large parts of this area important for maintaining the breeding life-history stage for these species in Fiji and the Pacific.[118]

Taveuni is believed to be the only site in Fiji where the Tahiti petrel breeds. The area supports a globally significant population of this species, with comparatively high densities recorded during at-sea surveys.

Finally, the area is predicted to support high cold-water coral diversity and has comparatively high deep-water species diversity.[119]

Hawksbill turtle. Photo courtesy of Stephan Kerkhofs, Hemera/Thinkstock

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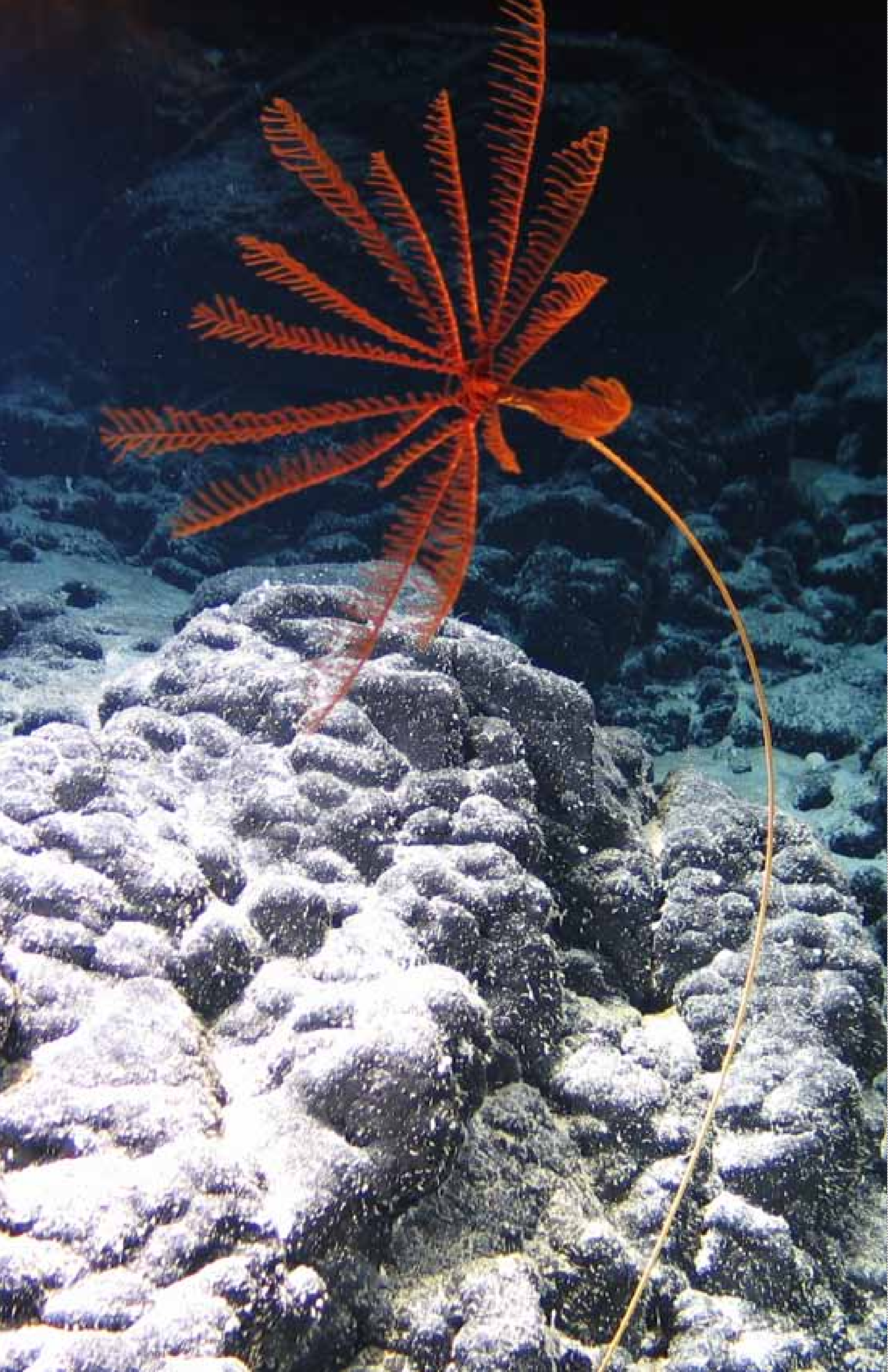
Brittle star on lava block. Photo courtesy of ROV Team, GEOMAR Kiel, Germany.

MANIHIKI PLATEAU

The Manihiki Plateau is a very large oceanic plateau located between Kiribati and the Cook Islands with an elevation of some 2,000 m above the surrounding ocean basins. The area is home to some unusual and possibly rare species of, for example, sponges, sea cucumbers, starfish and unknown sediment-eating organisms.



Formed 125 to 200 million years ago by volcanic activity at the boundary between three tectonic plates known as the Tongarev triple junction, the Manihiki Plateau rises approximately 2,000 m from the surrounding oceanic basins. The water depth of the plateau is at approximately 2,500 m to 3,000 m. Numerous seamounts, and a couple of small islands and atolls, extend farther upward as far as the sea surface.[120] The Manhiki Plateau has been divided into three regions: the High Plateau, the shallowest and flattest, in the south-eastern section; the Western Plateau with ridges and seamounts north-west of the High Plateau and; the small North Plateau at the northern end of the region.[121]

Because of its elevation above the surrounding seabed, the plateau and its environs have likely undergone a variety of changes in response to climatic shifts. As sea levels dropped during ice ages, coral may have been able to grow on top of the seamounts. When the climate warmed 10,000 or so years ago, the seas rose far above the seamounts' summits, killing the light-dependent reefs, which subsequently eroded down the slopes, creating carbonate layers that are ideal habitat for benthic communities.[122]

Exactly what kind of life might live on the plateau, however, remains uncertain; some of it appears to be quite unusual and unique. Much of what is known about its biological communities comes from a 1986 New Zealand expedition on board the research vessel *Tui* and a 2001 cruise by a Japanese research vessel looking for seabed minerals—and many of their results remain inconclusive.

It was the *Tui* voyage that discovered that the plateau's margins turn into deep slopes, and it was *Tui*'s dredges that brought up the debris of reef-building corals and other invertebrates. But both the New Zealand and Japanese expeditions made some intriguing discoveries about the life that lives on and around the plateau now, as well as that which lived there in millennia past.

Isopods, a common type of crustacean, appear to be the most prevalent form of large benthic fauna; there are in comparison relatively few polychaetes (segmented worms). There are sponges, sea cucumbers and sea stars. The reef slope of Pukapuka Atoll boasts an endemic species of brittle star. A species of cowrie was found in 1,000 m of water, well outside its previously recorded depth range. There is an unidentified, seemingly endemic species of *Malacanthus* tilefish. Shrimps and jellyfish swim and float in the water column.[123] [124]

Crinoid on pillow breccia, consisting of fragments of a nearby pillow lava cliff. Photo courtesy of ROV Team, GEOMAR Kiel, Germany

One unusual feature of the plateau is that its surface is in places covered with dense concentrations of manganese nodules, of potential interest for deep-sea mining; the richness of such mineral deposits prompted some of the expeditionary investigations of the area. And, in many cases, amid the nodules are small mounds of feces.

The organisms that left the feces have not been identified. The report of the *Tui* cruise assumed that those responsible were sea cucumbers, but sea cucumbers do not form such mounds. Something else is presumably feeding on the rich sediment, and whatever it is, the particular nature of those sediments means that it is highly unlikely to exist anywhere else.

Sea cucumber cf. *Psychropotes sp.* in front of lava block. Photo courtesy of ROV Team, GEOMAR Kiel, Germany

24

Black-banded sea krait, Niue. Photo courtesy of Flickr/fearlessRich

NIUE ISLAND AND BEVERIDGE REEF

Almost 2,500 km north-west of New Zealand, Niue is an isolated speck in the Pacific Ocean, surrounded by a huge expanse of water bounded by a triangle formed by Tonga, Samoa and the Cook Islands. Beveridge Reef is located 125 nautical miles south-east of Niue. In addition to harbouring the endemic black-banded sea krait and other endemic species, Niue's waters are part of an important migratory route for endangered humpback whales.

Niue is truly a land apart. With a population of fewer than 1,300 and an area of 260 km², Niue is the world's smallest independent nation. It is also the world's single largest coral island.[125]

Raised above the sea by long-past tectonic activity, much of Niue's coast comprises an ancient reef platform that rises to around 60 m above sea level. Cliffs dominate the coastline, and the drop to the shallow seabed is precipitous: the outer reef descends to 1000 m below the surface within 5 km of the shore.

Niue's waters are part of an important migratory route for endangered humpback whales. From June to October each year, humpbacks take advantage of the deep but sheltered waters just offshore to calve and nurse their young, before continuing south to their feeding grounds in the Southern Ocean. There are some reports of whales with calves in the area in January as well, suggesting that some Northern Hemisphere whales also winter in the area, but these have not been confirmed.

The fact that humpbacks are able to approach so close to shore makes Niue an almost unparalleled site for whale-watching tourism, one of the very few places where visitors and residents alike can, as one observer has put it, "enjoy their dinner while watching the whales." At times, whale sightings are so plentiful that the island's more hyperbolic boosters refer to its surrounding waters as a "whale soup."[126]

In addition to humpbacks, sperm and sei whales also visit the waters around Niue, the latter doing so at the very northern end of their Southern Hemisphere range. While some of Niue's endemic species—such as the Niue rail and the Niue night heron—apparently disappeared even before Polynesian settlement of the island, others remain.

Notably, an endemic species of sea snake, the black-banded sea krait, has been found from near-shore areas out to approximately 100 km from the island's fringing reef. The species is classified as vulnerable on the IUCN Red List. *Ecsenius niue*, a recently discovered species of comb-tooth blenny[127] and a sea snail *Tectarius (Echinopsis) niuensi*,[128] are likely endemic as well. However, relatively little is known about the diversity of the coral reefs here, though by the beginning of this century, over 240 marine fish and over 43 coral genera had been recorded at Niue.[129]

The reef area of Niue has been estimated to measure about 620 ha, and the island's EEZ extends over an area of 390,000 km². Within this zone, about 125 nautical miles to Niue's south-east, is the semi-exposed Beveridge Reef. According to Elsdon Best, the celebrated chronicler of Maori and Polynesian traditions, Raratongans asserted that the reef "was once a fine isle, with many coconut-palms growing thereon, but that it

Humpback whale mother and calf, Tonga. Photo courtesy of Glenn Edney, www.grida.no/photolib/detail/humpback-whale-mother-and-calf-haapai-islands-tonga_57d4

was swept bare by a fierce hurricane, which carried away both trees and soil, leaving nothing but the bare rock."[130]

The reef is an undersea mountain capped by a lagoon about 7 km long and 3.5 km wide. It is a pinnacle rising steeply from a depth of around 5,500 m; because of its isolation, it is likely to host some endemic species of its own. Additionally, Niue and Beveridge Reef likely experience upwellings that make their waters considerably more productive than others in the immediate vicinity, particularly as there are no other reefs or islands for hundreds of kilometres.

Niue is both a product of tectonic activity and a future victim of it. Situated east of the Kermadec Trench, it is moving slowly toward it; millions of years from now, it will be subsumed into it, and this shining oasis in the South Pacific will be gone forever.

Great crested terns. Photo courtesy of Steve Cranwell.

25

PALAU SOUTHWEST

This region, located from 270 to 600 km south-west of the main Palauan archipelago, encompasses a series of seamounts, spectacular seabird colonies, including what may be the largest colony of great crested tern in the whole Pacific region, and a remarkably rich nearshore fish fauna. It is situated in a zone of strong oceanic currents and covers a number of geomorphic features with diverse topography.

Dynamism and contrast frequently stimulate diversity and productivity. Clashes between cold water and warm, and boundaries between seabed and slopes, cause upwelling and downwelling of currents that carry nutrients from the depths to the surface and vice versa. Seamounts erupting from the abyssal plain interrupt the currents' flow, causing swirling eddies that concentrate those nutrients and promote a water flow in which they and the microorganisms that feed on them are "trapped", in the process leading to localized hotspots of productivity. The effect is magnified in the presence of diverse topography in close proximity, providing a variety of habitats and substrates for different species at multiple depths. This EBSA, an area of approximately 80 km^2 located south-west of Palau, is just such a place.

The area encompasses Palau's Southwest Islands region, which includes the large atoll Helen Reef (about 25 km long and 10 km wide) and five small raised coral islands that are surrounded by narrow fringing reefs before dropping off steeply into deep ocean depths. One of the small islands, Fanna Island, is noted for its spectacular seabird colonies and is listed as an Important Bird Area by BirdLife International.[131] The island harbours large colonies of red-footed booby, black noddy and great frigatebirds. Sooty and white terns are also abundant, and the only nesting site in Palau for giant frigatebirds is likely located here.[132] Helen Reef and surrounding waters, meanwhile, are thought to support the largest colony of great crested terns in the Pacific region, among a host of other seabird species.[133]

Green and hawksbill turtles are common on the islands' reef slopes and in the lagoon at Helen Reef, though only green turtles appear to nest in the region. Green turtles in Palau (along with those nesting in Micronesia and the Northern Mariana Islands) are of one genetic stock and thus distinct from other Pacific populations.[134] Found here as well are a remarkable number of nearshore fish species. One study counted over 600 species just in waters less than 25 m—thought to be a conservative estimate.[135]

The site is situated in a zone of strong oceanic currents and covers a number of diverse geomorphic features, including a tightly packed cluster of 13 seamounts, at least one of which is considered a high-catch area for tuna that aggregate there. A recent analysis identified Palau's waters around seamounts (which include the area within 30 to 40 km surrounding each summit) as one of four areas in the north-western Pacific with a particularly rich pelagic biodiversity.[136] The study provided further evidence that seamounts are a hotspot for pelagic diversity and can be important aggregation locations for a range of highly migratory pelagic species, such as swordfish, blue marlin, albacore and yellowfin tuna, and blue shark. The presence of seamounts also suggests the presence of deep-water corals, which are among the foremost species to take advantage of the substrate and elevation from the seabed that seamounts provide.

The convergence of seamounts, high-energy eddies, and various deep-water benthic communities suggests that this is an area of rich interaction between deep-sea, pelagic marine and oceanic-going avian species.

Masked booby. Photo courtesy of Steve Cranwell.

26

TONGAN ARCHIPELAGO

Located just south of Samoa, the Tongan Archipelago includes the Tonga Trench, the second-deepest trench on the planet, a number of seamounts, active hydrothermal venting sites, 174 islands (37 of which are uninhabited), and at least 400,000 km² of ocean. The archipelago is the most important breeding location for Oceania's humpback whales, supports globally significant populations of eight seabird species, and hosts highly unique and diverse hydrothermal vent barnacle species.

It is perhaps fitting that our tour of the EBSAs of the Western South Pacific should end in this sprawling archipelago, because this site contains such a high number of the qualities that characterize many of those featured beforehand.

Not only, for example, does this site have a deep-sea trench, but that trench—the Tonga Trench—is the second-deepest on Earth. At its deepest point, the Horizon Deep, it is 10,882 m below the sea-surface and yet even here organisms such as scavenging amphipods and elasipod sea cucumbers are found.[137 138] Meanwhile, the exceedingly rare "supergiant" hadal amphipod, *Alicella gigantea*, was seen for the first time in the Tonga Trench during a 2013 Japanese research expedition.[139] This enigmatic deep-sea crustacean can reach a length of at least 34 cm, some 10 times longer than any other known amphipod.

The Tonga Trench extends north-northeast from the Kermadec Islands and turns west, north of the Tonga Plate and becomes a transform fault zone. Tectonic plates at the trench are coming together at an approximate rate of 15 cm per year; however, recent Global Positioning Satellite measurements indicate that in places the rate approaches 24 cm per year, which is the fastest plate velocity recorded on the planet. Consequently, this is one of Earth's most seismically active zones, and the seabed here is heavily populated with hydrothermal vents.

Vent fauna in this region includes a newly discovered species of prehistoric sessile barnacle, *Neobrachylepas relica*, which was collected from vents in the Lau Basin, west of Tonga. The barnacle is the only known living member of what is the oldest and most primitive suborder of sessile barnacles, Brachylepadomorpha, whose representative species first appeared in the Jurassic; until its discovery here it was thought to have died out in the Miocene.[140] The hydrothermal vent barnacles in the basin also include three other "living fossils" and relics of the Mesozoic, each of which is similarly considered to be the most primitive living member of its suborder. Indeed, the vent barnacle fauna of the Lau Basin has been described as the most unusual and diverse known.[141]

The archipelago also includes a number of seamounts, notably the Capricorn Seamount, which rises from a depth of 5,450 m to within 360 m of the surface. This has been an extremely productive seamount in terms of fisheries, with catch rates six times greater than those yielded

by other regional long-line fisheries. Where there are seamounts, there are likely to be cold-water stony corals, and the area has been identified as a likely location for them.[142, 143]

'Ata island, one of the 174 islands in this area, is thought to have the greatest diversity of seabird species in Tonga, mainly due to its isolation and absence of human inhabitants, and is the only Tongan island where the masked booby breeds. Maninita Island is dominated by the vegetation preferred by nesting noddies and terns. The islands of 'Ata and Late are considered important breeding sites for the great and lesser frigatebirds and have large populations of the wedge-tailed shearwater and blue noddy. HungaHa'apai has over 350,000 burrows of wedge-tailed shearwater and a colony of red-tailed tropicbirds, while Fonualei Island is considered a sanctuary for more than 100,000 breeding sooty terns.[144]

The archipelago is also an important migratory corridor for green turtles, though arguably the most obvious sign of the vibrancy of the marine environment is the annual presence of humpback whales offshore. Once hunted to near-extirpation in Oceania, they are showing signs of strong recovery. Whereas once money was to be made from hunting humpback whales, today it is to be found from enabling people to watch them. With the largest breeding population of humpbacks in Oceania, Tonga is poised to benefit from an increasing ethic of environmental protection in the region and across the world.

Above: Swimming elasipod sea cucumber, *Paleopatides*. Photo courtesy of NOAA. Opposite page, top: Wedge-tailed shearwater. Photo courtesy of Ben Lascelles. Bottom: Red gorgonian fan with brittle star, Tonga. Photo courtesy of Glenn Edney www.grida.no/photolib/detail/red-gorgonian-fan-with-brittle-star-haapai-tonga_d3c9.

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