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## CAPE VERDE ISLANDS

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Cape Verde's natural heritage is unique. The physical environment of these islands creates a multiplicity of habitats with a great wealth of fauna and flora. Nevertheless, this biodiversity is naturally restricted to the narrow geographical limits of the islands and is extremely vulnerable to disturbances caused by human activities. The threatened island endemics are thus likely to benefit from conservation management programs that are urgently needed if Cape Verde's natural levels of diversity are to be maintained.

### PHYSICAL ENVIRONMENT

#### Geography and Geomorphology

The Cape Verde archipelago is grouped together with the Azores, Madeira, the Selvagens, and the Canary Islands in the Macaronesian region, which is situated in the North Atlantic Ocean, close to the West African coast and the West Mediterranean region. The Cape Verde archipelago consists of ten volcanic islands and several islets situated between 14°45'–17°10' N and 22°40'–25°20' W (Fig. 1). It lies 1500 km south of the Canary Islands, and a mere 570 km separate Boavista Island from the African mainland (the coast of Senegal). The archipelago is spread over 58,000 km<sup>2</sup> of ocean and has about 1050 km of coastline.

The Cape Verde Islands are usually classified in three groups: Northern Islands, Eastern Islands, and Southern Islands (Table 1). However, other classification groups are also considered: the Windward Islands (Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal, and Boavista), and the Leeward Islands (Maio, Santiago, Fogo, and Brava).

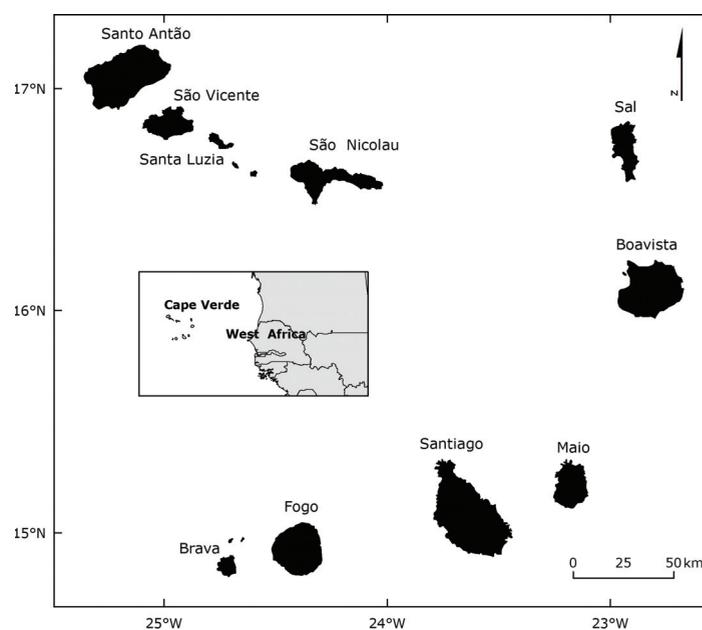


FIGURE 1 Cape Verde Islands: geographic location.

Santiago is the largest island and is home to more than half of Cape Verde's total population (434,625 inhabitants as of the 2000 census), whereas the smallest island—Santa Luzia—is uninhabited.

The northern and southern groups are characterized by high mountains and offer a wide range of habitats in relatively small areas. Slopes can be extraordinarily steep (average gradients of 25° to 41°), with active fluvial erosion. The eastern group is composed of flat islands, and such peaks as do exist reach only a few hundred meters in height and are surrounded by relatively broad extents of plain land, where deposition is dominant. Fogo Island contains Cape Verde's tallest mountain—Pico do Fogo—which rises to 2829 m (Table 1).

TABLE 1  
Some Geophysical Features of the Cape Verde Islands

Island Group	Island Names	Area (km <sup>2</sup> )	Max. Altitude (m)	Population (as of 2000)
Northern	Santo Antão	779	1979	47,170
	São Vicente	227	725	67,163
	Santa Luzia	35	395	0
	São Nicolau	343	1304	13,661
Eastern	Sal	216	406	14,816
	Boavista	620	387	4209
	Maio	269	436	6754
Southern	Santiago	991	1392	236,627
	Fogo	476	2829	37,421
	Brava	64	976	6804

## Geology and Soils

All the Cape Verde Islands are volcanic in origin. The archipelago's oceanic basement formed during the Late Jurassic and it is generally assumed that the islands originated with the development of hotspot activity above a mantle plume.

Cape Verde appears to be composed of the oldest rocks in Macaronesia. The subaerial volcanism probably began during the Miocene (the age of the oldest rocks found in the archipelago—on Sal Island—to date is about  $25.6 \pm 1.1$  million years) or pre-Miocene. There is a general progression of the oldest volcanism, which is thought to have been induced by the slow movement of the African tectonic plate. The islands of Santo Antão and Brava thus present the youngest subaerial Tertiary volcanism, which can be dated to  $7.57 \pm 0.56$  million years ago, and  $5.9 \pm 0.1$  million years ago, respectively. Moving east, Santiago Island dates to  $10.3 \pm 0.6$  million years ago, and Maio Island  $21.1 \pm 6.3$ . Quaternary igneous activity is concentrated at the western end of the archipelago, whereas Fogo is the only island with recent volcanic activity—the latest eruptions occurred in 1951 and 1995.

Soils are mainly of volcanic origin. They originated from volcanic rocks like basalts, phonolites, trachytes, andesites, tuffs, scorias, and sedimentary rocks—mainly limestone. Despite the small size of the archipelago and the similarity of the parent material, a wide variety of soils are present in Cape Verde and reflect its microclimatic and topographic diversity. They possess good physical and chemical properties, especially on the northeastern slopes of the higher mountains. At lower altitudes, the arid climate means that soils are either incipient or not developed, with low organic matter and nitrogen contents. In the Cape Verde archipelago, active dunes display maximum development on the Eastern Islands—namely Sal and Boavista—whereas there are substantial fossil dunes on Maio Island.

## Climate

Cape Verde is included in the African Sahelian arid and semi-arid climatic region, which presents a wet season of one to three months. The archipelago experiences climates ranging from tropical dry to semi-desertic, and potential evaporation exceeds precipitation throughout the year.

The climate is mainly governed by the Azores anticyclone, the Intertropical Convergence Zone (ITCZ), and the mid-Atlantic air mass movements induced by their seasonal changes of location. The annual movement of

the ITCZ around the equator, and its migration to  $10^\circ \pm 20^\circ$  northern latitudes, brings a temporary southwest monsoon climate to the islands during the months of July to October (the rainy season). However, as a result of the high- and low-pressure zone oscillations, the summer months can be completely dry in some years. Both annual and monthly precipitations are usually low, although daily or storm precipitation can be very high, and the erosion resulting from this pluvial regime can be severe. Annual precipitation ranges from 80–300 mm in the arid coastal zones to 1200–1600 mm in the highlands of the mountain islands.

The Cape Verde archipelago is subject to the northeast trade winds throughout the year, and they especially affect northeastern slopes above 300–400 m in the mountain islands. Another important wind mass is the Harmattan. This dust- or sand-laden, hot, dry wind occasionally blows from the southern Sahara Desert and is more common between November and May. Despite its relatively short duration, it has a devastating effect on agriculture. Mean annual temperatures range from  $23\text{--}27^\circ\text{C}$  at sea level to  $18\text{--}20^\circ\text{C}$  at high altitude, but temperatures as high as  $35\text{--}40^\circ\text{C}$  can occur in inner regions of the arid Eastern Islands.

## CAPE VERDE'S BIODIVERSITY

### Fauna

On the Cape Verde Islands, the vertebrate terrestrial fauna is poor, and there are few endemic species. Particularly, the terrestrial mammals are only represented in this archipelago by five bats (Chiroptera) and the introduced green monkey (*Cercopithecus aethiops*).

Similar to other Macaronesian Islands, the Cape Verde Islands are home to some endemic birds, which are estimated to include six species and 16 subspecies (e.g., the Cape Verde swift *Apus alexandri*, the Raso lark *Alauda razae*, the Cape Verde warbler *Acrocephalus brevipennis*, and the Cape Verde sparrow *Passer iagoensis*). Moreover, this archipelago offers important breeding habitats for 36 breeding species, nine of which are seabirds. Several ocean-related bird species occur in the region, especially during the winter months (about 130 species of migrants), and come mainly from Palearctic region.

Concerning the terrestrial reptile species, there are 28 taxa, 90% of which are accepted as being endemic in the Cape Verde archipelago. The largest genera are the gekkonid lizards (*Tarentola* spp.; Gekkonidae) and the scincid lizards (*Mabuya* spp.; Scincidae).

In contrast to the poor terrestrial vertebrate diversity, there is an enormous wealth of invertebrate spe-

cies, in particular arthropods, many of them introduced, whose distribution ranges from the sea to the mountain peaks of the Cape Verde Islands. Although many arthropod species remain undiscovered, and accurate studies are lacking, a considerable number of endemic species are accepted (e.g., 111 species of spiders, 41% endemic; 470 species of Coleoptera, 33% endemic; 251 species of Hymenoptera, 26% endemic; 204 species of Diptera, 26% endemic).

The marine fauna of the Cape Verde archipelago ecosystem is essentially tropical. It includes a large number of species, namely invertebrates (e.g., molluscs such as cone shells and sea slugs; corals; crustaceans such as lobsters, shrimps, and crabs) and vertebrates (such as sharks and other fishes, and mammals such as dolphins and whales). Within the marine realm, invertebrates of interest include corals (e.g., *Porites astreoides*, *P. porites*, *Favia fragum*, and *Sclerastrea radians*), especially between Boavista and Maio Islands, and they represent a unique marine environment that hosts a high concentration of fish and other species.

The marine crustacean group has permanent populations of lobsters (Decapoda) along the coast of the Cape Verde Islands, namely the green lobster *Panulirus regius*, the pink lobster *Palinurus charlestoni*, the brown lobster *Panulirus echinatus* (Palinuridae), and *Scyllarides latus* (Scyllaridae). Because of their high economic value, the lobster populations have been depleted over the past few decades and now are considered to be threatened species. Crustaceans, cephalopods (e.g., *Sepia officinalis*, *Loliolopsis chiroctes*, and *Octopus vulgaris*), and fishes (e.g., *Thunnus albacares*, *Katsuwonus pelamis* [Scombridae]; *Decapterus macarellus*, *D. punctatus*, *Selar crumenophthalmus* [Carangidae]; *Epinephelus guaza*, *Cephalopholis taeniops* [Serranidae]) are common along the coast, and most of them constitute economically important resources.

In the deep water around the Cape Verde Islands, squaliform sharks of the genus *Centrophorus*, *Mustelus mustelus* (Triakidae), are commonly found, together with one of the largest species—the tiger shark (*Galeocerdo cuvier*). In addition, this archipelago is the only area in the North Atlantic outside the West Indies where the existence of humpback whales *Megaptera novaeangliae* (Cetacea, Mysticeti) is recognized. Humpback whales migrate thousands of kilometers each year, from summer feeding grounds at high latitudes to winter breeding grounds at low ones, and they traditionally congregate during the winter months to calve, to nurse their offspring, and presumably to breed near this archipelago.

Five species of marine turtles (Reptilia) have been reported for Cape Verde: the leatherback (*Dermochelys coriacea*), the hawksbill (*Eretmochelys imbricata*), the olive ridley (*Leidochelys olivacea*), the green (*Chelonia mydas*), and the loggerhead (*Caretta caretta*). Every year, from late May to September, more than 3000 loggerhead turtles come ashore on Cape Verde's beaches, particularly Ervatão beach on Boavista Island. This island was recently described as the third most important loggerhead nesting site in the world.

## Flora

Cape Verde hosts a high level of endemic plant diversity. It presents a total of 320 lichen species, including a monospecific genus (*Gorgadesia*) and seven species which are accepted as endemic to the archipelago. In the archipelago, there are 36 liverwort species and 110 moss species, six of which are endemic. They can mostly be found on moist rocks, over the soil surface, or as epiphytes. The vascular flora comprises about 750 taxa, including more than a hundred families, of which the Asteraceae, Euphorbiaceae, Fabaceae, Malvaceae, Solanaceae, Cyperaceae, and Poaceae are the best represented.

When they were discovered in the fifteenth century, the Cape Verde Islands were uninhabited. Particularly as a result of human colonization and trading routes during the sixteenth and seventeenth centuries, most of the archipelago's flora is presently composed of exotic naturalized species. Despite the low number of native species (33 pteridophytes and 240 angiosperms), Cape Verde is rich in endemic taxa, including one fern (*Dryopteris gorgonea*) and 85 flowering plants from 42 genera, one of them endemic (*Tornabenea*: family Apiaceae). Among the native flora, annual and perennial herbaceous plants and some shrubs prevail. There are few trees, most of which are threatened: They include the endemics marmulan (*Sideroxylon marginata*) and date palm (*Phoenix atlantica*); the dragon's blood tree (*Dracaena draco*); the fig tree (*Ficus sycomorus* ssp. *gnaphalocarpa*, and *F. sur*); and the tamarisk (*Tamarix senegalensis*), fossilized stalks and roots of which are found in sand dunes on Boavista, S. Vicente, Sal, and Maio.

Hypotheses about the origin of the Macaronesian flora were first formulated about 180 years ago. Recent molecular studies suggest that the origins of the majority of the endemic species are in the western Mediterranean region, though other origins (e.g., North America, Euro-Siberia and northeast and southern Africa) are also reported. Furthermore, the insular woodiness characteristic of some endemic groups, especially those from Madeira,

the Canary Islands, and the Cape Verde Islands, is more recent than the herbaceous ones in terms of evolution (e.g., *Echium* [Boraginaceae]; *Sonchus* [Asteraceae]).

Intense speciation processes have led to the large number of endemic species that presently exist in Cape Verde, approximately one-third of which are single-island endemics (e.g., *Conyza schlechtendalii* on S. Nicolau; *Diplotaxis vogelli* on S. Vicente; *D. gracilis* on S. Nicolau; *Echium vulcanorum* on Fogo; *Tornabenea annua* on Santiago; and *T. bischoffii* on Santo Antão).

Climatic factors related to altitude and aspect, as well as to soil characteristics, are responsible for the different plant communities found on Cape Verde. In the arid and semi-arid zones (up to 300–400 m) herbaceous formations like savannah are dominant and can extend up to 700–800 m on leeward slopes or be restricted to coastal zones in areas exposed to trade winds. The native flora in arid and semi-arid zones presents Saharo-Arabian affinities. Humid and sub-humid grasslands and scrub vegetation occur with increasing altitude, and some of the species of native flora display Canarian-Madeiran (and Mediterranean) or Sudano-Zambesian-Sindian affinities.

Unlike along other tropical and subtropical coasts, marine flora and particularly seagrasses (i.e. marine flowering plants) are not common in the Cape Verde archipelago, and only some doubtful records are known. Seaweed flora includes 330 species: 57 green algae (*Chlorophyceae*), 53 brown algae (*Phaeophyceae*), and 220 red algae (*Rhodophyceae*); this tropical region of the eastern Atlantic is considered one of the poorest in terms of seaweed diversity.

### CONSERVING CAPE VERDE'S NATURAL HERITAGE

Cape Verde's biodiversity is of enormous scientific value. Many endemic and native species, some of which are economically valuable, are at risk of extinction and make conserving the archipelago's biodiversity a world concern.

The first Cape Verde *Red List* shows that most of the native fauna are endangered. Some of the main threats are due to small population sizes and restricted distributions; the arid climate, which presents long periods of drought; the introduction of invasive species such as the wild rabbit (*Oryctolagus cuniculus*) and rats (*Rattus rattus* and *R. norvegicus*); and the human impact on natural habitats.

The *Red List* considers a significant number of taxa to be threatened: 59% of terrestrial mollusc species (Actophilia, Stylommatophora: Gastropoda); 64% of

arachnid species (Arachnida: Araneida); 64% of beetle species (Insecta: Coleoptera); 25% of terrestrial reptile species (Reptilia); and 47% of bird species. Some of these taxa require urgent conservation measures, as do the small number of Caenogastropoda species (Basommatophora: Gastropoda). Others are already extinct. These include the endemic *Ancylus milleri* (Basommatophora); the three species of the Crustaceae group Decapoda (Natantia) (*Atya sulcatipes*, *Macrobrachium chevalieri*, and *M. vollenhovenii*), which are considered to have been extinct since 1954; and the giant scincid *Macrosincus coctei* (Reptilia), which has been extinct since the beginning of the twentieth century. Some endemic birds are classified as "critically endangered," including *Buteo bannermani*, *Milvus fasciicauda* (Accipitridae), and *Ardea purpurea* ssp. *bournei* (Ardeidae), which is restricted to Santiago Island. Furthermore, the emblematic marine turtles (Reptilia) are all threatened species, namely *Dermochelys coriacea* and *Eretmochelys imbricata*, which are classified as critically endangered, and *Leidochelys olivacea*, *Chelonia myda*, and *Caretta caretta*, which are classified as endangered. The major threat to turtle survival is the degradation of nesting habitats, namely Boavista beaches, as a result of the great increase in tourism in the archipelago.

Concerning the native flora, the prevalence of human activities, especially extensive agriculture, livestock herding (especially goats), and firewood collection, has led to a major destruction of the archipelago's natural habitats. Moreover, the uncontrolled spread of some exotic species like *Lantana camara*, *Furcraea foetida*, *Leucaena leucocephala*, and *Prosopis* spp., which are widely used for for-estation or land conservation, has led to an invasion of the habitats of the native vegetation and in some cases, as with *Prosopis* in temporary river beds, to the depletion of the already inadequate water resources.

According to the *Red List*, 26% of the angiosperms and 65% of the pteridophytes are threatened; moreover, it is estimated that 30% of the lichens are extinct or threatened, as are 41% of Cape Verde's bryophytes. Overexploitation (e.g., folk medicine, woody fuel, alimentation, fodder, etc.), agricultural practices, and the historical cyclic droughts have a negative effect on the islands' flora. Three species are presently considered extinct (*Fumaria montana*, *Eulophia guineensis*, *Nervilia crocifformis*), four critically endangered (*Carex antoniensis*, *C. paniculata* ssp. *hansenii*, *Conyza schlechtendalii*, *Ficus sycomorus* ssp. *gnaphalocarpa*), and 13 endangered. About 100 taxa are referred to as medicinal (e.g., *Artemisia gorgonum*, *Campylanthus glaber*, *Sarcostemma daltonii*, *Satureja forbesii*), woody fuel (e.g., *Echium vulcanorum*, *Periploca chevalieri*, *Sideroxylon*

*marginata*), fodder (e.g., *Lotus purpureus*, *Sonchus daltonii*, *Tornabenea bischoffii*), or are of use for tanning (e.g., *Euphorbia tuckeyana*), and this is responsible for the high rates of threat to the endemic flora (about 54%).

Even though the natural landscape has mainly been altered by human activity, there are still natural communities which remain relatively undisturbed. They include the cliffs at high altitudes, which are rich in endemic species such as *Campylanthus glaber* ssp. *glaber*, *Conyza feae*, *Euphorbia tuckeyana*, *Globularia amygdalifolia*, *Lavandula rotundifolia*, *Lobularia canariensis* ssp. *fruticosa*, *Nauplius daltonii* ssp. *vogelii*, *Periploca chevalieri*, *Satureja forbesii*, *Sideroxylon marginata*, *Sonchus daltonii*, and *Tolpis farinulosa*; the ancient lava flows on Fogo Island, with *Artemisia gorgonum*, *Echium vulcanorum*, *Euphorbia tuckeyana*, *Erysimum caboverdeanum*, *Globularia amygdalifolia*, and *Verbascum cystolithicum*; the litoral halophilous communities, with *Arthrocnemum macrostachyum*, *Suaeda vermiculata*, and *Zygophyllum waterlotii*; and the coastal sand dunes, with *Sporobolus spicatus*, *Cyperus crassipes*, *Cistanche brunneri*, *Lotus brunneri*, *Limonium brunneri*, and *Zygophyllum waterlotii*, among others.

The Cape Verde authorities have recognized several natural areas that are to be included in the National Network of Protected Areas, and special conservation measures will guarantee the safeguarding of the islands' biological heritage. A large number of protected areas have been established to preserve plant species. Most are at high altitudes, where the mildest climate permits a richer flora and fauna, and where many endemic species—albeit with small population sizes—have their preferential habitats (e.g., Fajã de Cima on São Nicolau Island, which is the main area of occurrence of *Dracaena draco*, and Ribeira da Vinha on São Vicente, which is designed to preserve *Tamarix senegalensis*, which is presently threatened by the spread of *Prosopis*).

Several islets are particularly suited to conservation because they offer important breeding habitats for birds. They include Branco, Raso, Rombo, and Curral Velho, which are home to important colonies of seabird species and their respective breeding areas; Lagoa de Rabil (Boavista), with wintering migrant waders, herons, and terns; some coastal cliffs on Santiago; the central mountain range of São Nicolau; and the volcano crater on Fogo. The archipelago is included in the Endemic Bird Areas of the World and contains 12 “important bird areas,” some of which are on the Ramsar List of Wetlands of International Importance. Furthermore, a proposal to classify some continental shelves, coastal areas, dune systems, and lagoons on Sal, Boavista, and Maio Islands as biosphere reserves is being considered in light of the importance of



FIGURE 2 Fogo Island. Endemic species of *Echium vulcanorum* from high elevations (about 1800 m) on Pico do Fogo.

their marine biodiversity, which includes marine turtles, corals, and halieutic resources.

The Conservation International considered the “Mediterranean Basin,” where the Macaronesian archipelagos were included as one of the “2005 Hotspots.”

Finally, a word about the natural and humanmade landscapes—for example, the impressive orography of the mountainous regions, the volcano on Fogo (Fig. 2), the bays and the long sand beaches, and the dunes and the inland salt explorations, each of which possesses a distinctive natural heritage and a particular cultural legacy that results from the combined works of nature and man and gives rise to landscapes with an outstanding value from the point of view of science, conservation, and natural beauty.

#### SEE ALSO THE FOLLOWING ARTICLES

Atlantic Region / Azores / Canary Islands / Madeira / Volcanic Islands

#### FURTHER READING

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## CAROLINE ISLANDS

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The Caroline Islands form an archipelago just north of the equator in Micronesia, western Pacific. At various times in the past, the Caroline Islands encompassed all the islands that now comprise the Federated States of Micronesia (FSM), the Republic of Palau (Palau), Guam and the southern Mariana Islands, and the southwestern islands of the Republic of the Marshall Islands (Fig. 1). Today, the name Caroline Islands refers to only the islands of the FSM and Palau (sometimes referred to as Belau).

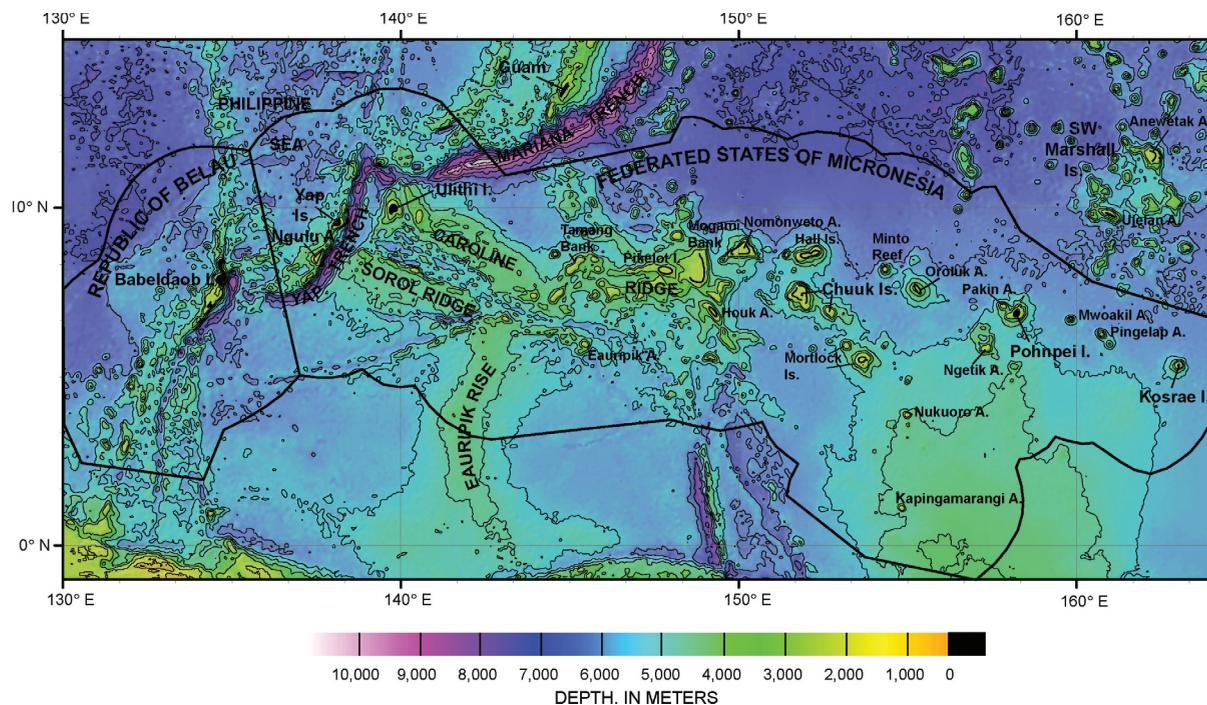
### HISTORY OF DISCOVERY

The earliest settlement of Micronesia is thought to have occurred about 2000 years ago, when immigrants from

the south arrived on the western mountainous islands. In 1525, Portuguese explorers landed on Yap and Ulithi Islands (FSM) during their search for the Spice Islands (Indonesia). Subsequent Spanish expeditions made the first European contacts with the rest of the Caroline Islands, which were named the Carolinas in 1526 by Toribio Alonso de Salazar. Although visited many times through the years, Spain did not formally occupy the Carolinas until 1886. In 1899, Spain sold the islands to Germany, and then they were taken over by Japan in 1914 and mandated to Japan by the League of Nations in 1920. The United States occupied the islands in 1944–1945, and the United Nations placed them under U.S. administration as Trust Territories in 1947. The FSM gained independence in 1986, as did Belau in 1994; both have Compacts of Free Association with the United States.

### GEOGRAPHY

The Caroline Islands have a tropical climate, and crops include taro, yams, breadfruit, coconuts, sugarcane, tapioca, and pepper. Copra and tapioca are important exports, as are handicrafts and fish, mostly dried bonito. The cultures of the FSM are as varied as the islands. Eight different languages are spoken, and nine Micronesian and Polynesian ethnic groups inhabit the FSM. Populations on Nukuoro and Kapingamarangi Atolls are mostly



**FIGURE 1** Bathymetry of the Caroline Islands, which includes islands in the Federated States of Micronesia (FSM) and the Republic of Belau (Palau); black lines show the 370-km Exclusive Economic Zones of FSM and Palau; I = island, Is = islands, A = atoll; contour interval is 500 m.