

Grandeur and Instabilit

Trindade, a small, volcanic outcrop in the vast South Atlantic Ocean is a model of the way islands are colonized by animals and plants.

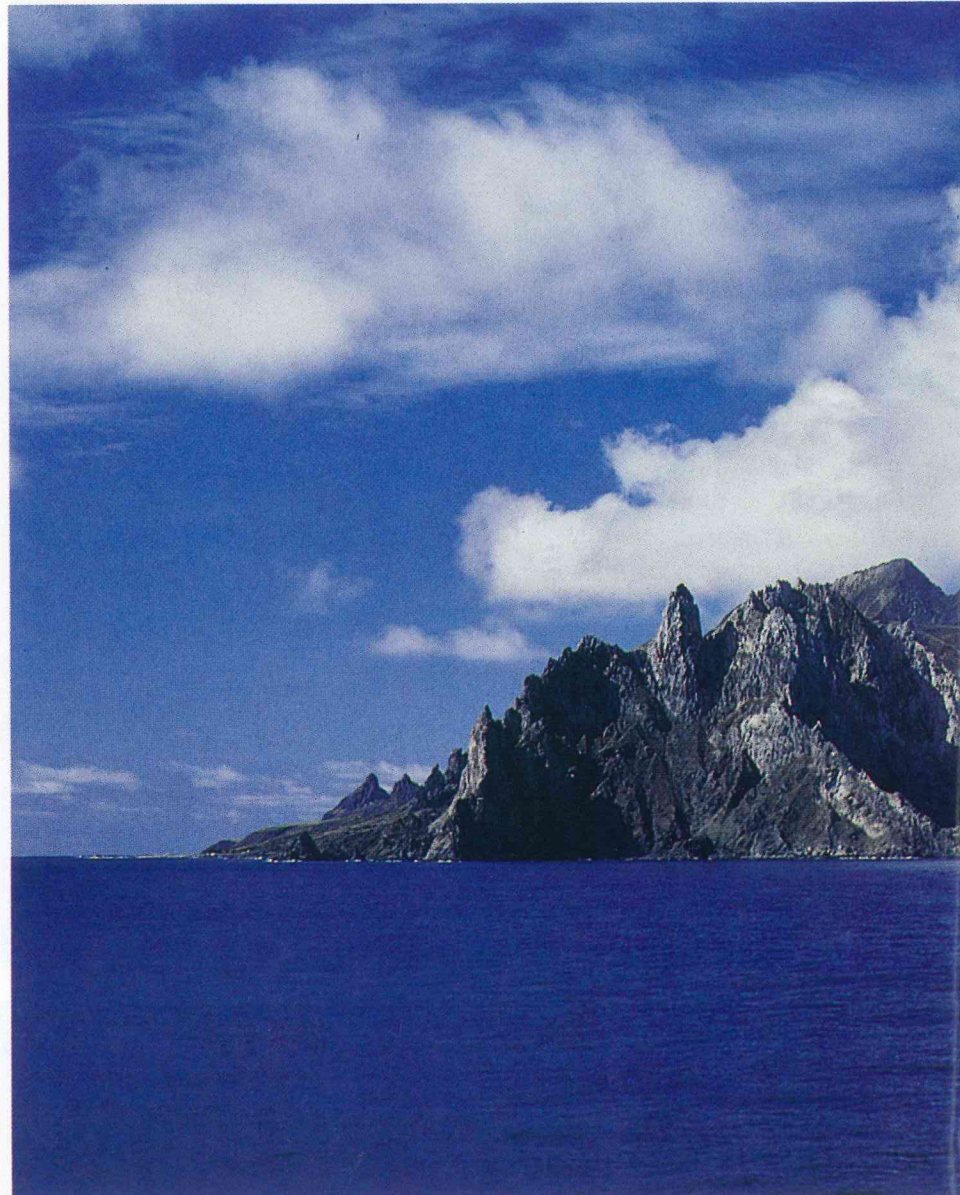
TEXT AND PHOTOGRAPHS BY JOSE H. LEAL

In the early morning, the island of Trindade appeared as a jagged silhouette backlit by the rays of the rising sun. The Brazilian supply ship *Soares Dutra*, her captain on the alert, drew slowly in toward the island, her depth recorder tracing the rapidly rising bottom. On the bridge the navigation officer took repeated bearings as they slowly approached the anchorage. Portuguese Bay and its sharp volcanic rocks had been the graveyard of many ships. The rusty wreck of the *Baependi*, another Brazilian Navy supply ship lost on the rocks and still visible at low tide, gave grim warning of the inhospitable coast.

Even as the anchor chain rumbled through the hawsepipe, the crew began the preparations for transferring the supplies to the shore. This was accomplished by reeving an endless line from ship to shore and hauling the supplies through the surf on a barge constructed of wooden timbers and oil drums. Power was furnished by one of the ship's winches. This trip the operation proceeded smoothly, occupying only two days, but often work has to be suspended due to heavy seas roaring in from the open South Atlantic.

The operation is carried out today in much the same fashion as it has been since Trindade was first settled in 1916. Every two months, the supply ship arrives. It is the island's only contact with the Brazilian mainland, bringing food, fuel, batteries, and the relief party for the garrison that operates the small meteorological and hydrographical station.

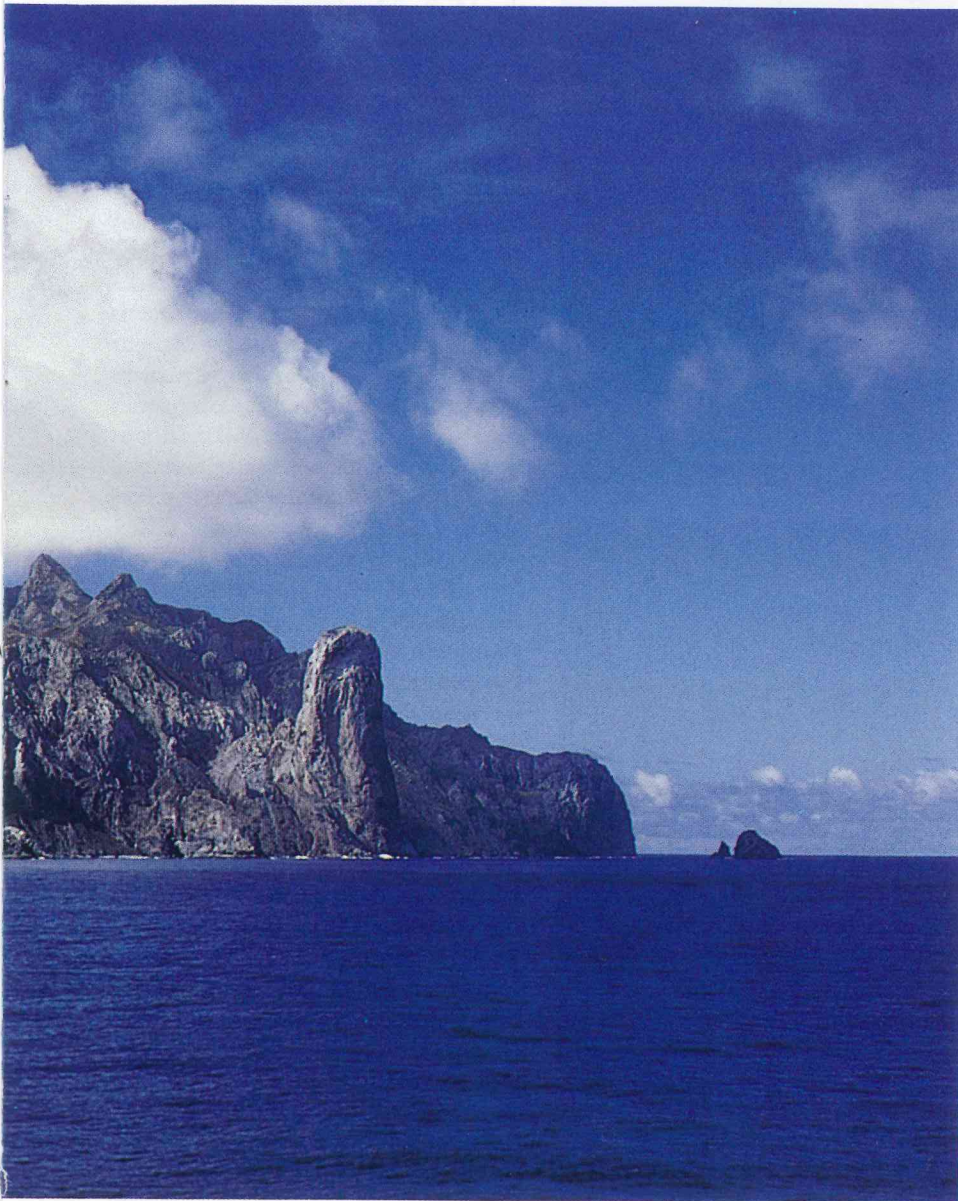
But Trindade has more to offer than just a weather station. The island's natural environment is an example of



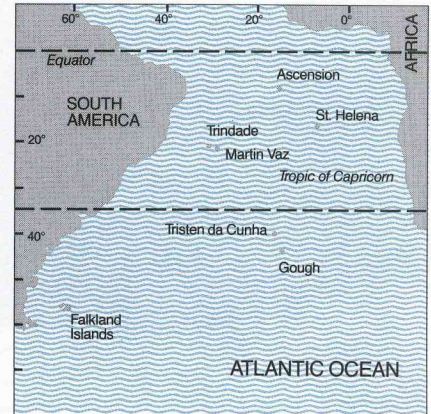
the geological and ecological evolution of an oceanic island. Plants, birds, animals, and their habitat naturally achieve a balance, or equilibrium, which can be maintained only until one of the elements changes, or a new factor is added,

such as disease, geological upheaval, or the intervention of humans. Trindade, relatively isolated and geologically active, offers a rare opportunity for scientists to study developing marine and terrestrial ecosystems in one microcosm.

y in the South Atlantic



Bulwarks of stone (above). The forbidding north coast of Trindade is permanently capped by a crown of clouds. The seemingly bellicose oceanic island, more than 600 miles from the coast of Brazil (map), is actually a primer for ecologists.



A birth on the seafloor

Trindade is one of the few, true oceanic islands in the South Atlantic. Lying 620 nautical miles from the Brazilian coast ($20^{\circ}30'S$, $29^{\circ}20'W$), it was formed by volcanic activity along the Mid-Atlantic Ridge. Because of differing tectonic processes occurring in the Atlantic and Pacific, oceanic islands are not as numerous in the Atlantic as they are in the Pacific. The Pacific has many atolls, high islands and subsided seamounts formed mainly at the highly active convergent boundaries of the Pacific Plate as a result of volcanic activity deep in Earth's mantle. In the Atlantic, the basic pattern of plate movement is caused by the opposite process, divergence, at the Mid-Atlantic Ridge, and volcanism is mainly restricted to shallow activity at fracture zones and the displacement of the diverging plates moving over "hot spots."

Trindade is the most conspicuous feature of the Martin Vaz Fracture Zone, which runs in an east-west direction, perpendicular to the Mid-Atlantic Ridge along the $20^{\circ}S$ parallel. The fracture zone includes the deso-

620 nautical miles = 1,150 kilometers

The island has given visitors the impression that ... it is fast crumbling to bits.



White and pink, Trindade's beach sands are products of the erosion of rock and skeletons of calcareous algae. The south and east coasts of the island, such as Tartarugas (top) produce mostly white carbonate sand beaches. Príncipe beach (bottom) is dark pink from oxidized iron washed from the surrounding hills.

late Martin Vaz Islands, 26 nautical miles due east of Trindade, and, to the west, the flat-topped elevations of the Vitória-Trindade Seamount Chain.

Trindade's profile is roughly conical, a characteristic of geologically young oceanic islands; its base, at a depth of about 2.5 miles, has a diameter of about 31 miles. The island's emerged surface area comprises only 3 square miles. As a result, Trindade has fairly steep slopes. The narrow insular shelf, from sea level to a depth of 328 feet, has an area equal to four times that of the island itself.

Early visitors

Although remote and uninhabited for many years, Trindade has a history of visitations by various exploratory and scientific expeditions, some of which left their marks on the ecological balance of the island. Between 1501, when Trindade was reputedly discovered by the Portuguese navigator João Alves, and the permanent occupation of the island by Brazil in 1916 with the construction of the meteorological observatory and radio station, the island was described and briefly occupied several times by Portuguese and British expeditions.

Trindade became a regular watering site for the Portuguese along their transatlantic trade routes in the late 1500s and early 1600s. In April 1700, the British astronomer and mathematician Edmond Halley, on a scientific expedition with the *Paramore*, visited Trindade and wrote that they had found "very fine and good" water from springs in the island. During five days in Trindade, Halley provided its first good description, including the contour, overall plan, and geographic coordinates. They left "Some Goats and Hogs on the Island for breed, and alsoe a pair of Guiney Hens ... carry'd from St. Helena ...," the influences of which can still be seen on the island.

Other famous explorers followed, including James Cook in 1775, and the British botanist James Dalton Hooker in 1839, the British Antarctic ("Terra Nova") Expedition in 1910, and a visit by a scientific party of the

26 nautical miles = 48 kilometers
2.5 miles = 4 kilometers
31 miles = 50 kilometers
3 square miles = 8 square kilometers
328 feet = 100 meters

tory during the *Blossom* Expedition in 1925. By the time a major survey of the island was performed by the Brazilian scientists of the João Alberto Expedition, in 1950, the reputation of Trindade had been established.

Trindade was included as one of the observation sites for the wide-ranging studies conducted as part of the International Geophysical Year (1957). One of the most important scientific results was the comprehensive work on the petrology and geological structure of the island, accomplished by the Brazilian geologist F. F. M. de Almeida. He described in detail Trindade's volcanic nature, including the phonolitic domes (fine-grained volcanic rocks primarily composed of alkali feldspar) and the distinct basaltic lavas and pyroclastic (fragmented) deposits. The latter, formed by volcanic explosion or violent aerial expulsion from volcanic vents, constitute the greater volume of the island.

Beginning with Hooker's geological observations in 1839, scientists have emphasized the local dominance of erosion over sedimentation—a consequence of seismic phenomena, strong winds, sea-level fluctuations over geological time, and a relatively recent history of volcanic activity. As American ornithologist Robert C. Murphy, who visited Trindade briefly in 1913, observed, "the island has given the visitors the impression that through erosion and landslides, it is fast crumbling to bits."

Soft rocks

The mechanically "soft" pyroclastic rocks allowed the steady and relatively fast alteration by wind and marine erosion of many geological structures on the island. An example is the extensively eroded volcano Paredão (meaning a large wall, or cliff, in Portuguese), the southernmost and youngest volcano. Its earth-colored pyroclastics are being destroyed at a fast geological pace. The resulting pink-colored sands (pink due to the oxidation of iron at high temperatures) are swept into the ocean to combine with calcareous fragments derived from algae, and are eventually accumulated at Príncipe Beach.

This accumulation is the result of long-fetch waves caused in turn by strong, winter storm winds acting

over long distances of open ocean. Arriving from great depths, these waves maintain their energy up to the shore, where they break on coastal features such as the domes and have excavated the famous 426-foot-long, 39-foot-diameter tunnel that pierces the ruins of the Paredão Volcano from east to west.

In contrast, Trindade's other beaches, mainly on the southern and eastern coasts, are formed by wind-driven accumulations of calcium carbonate sands. At Tartarugas Beach, the drifts of sand rise to 164 feet above mean sea level, and the area is now famous as a mating ground for the green turtle (*Chelonia mydas*) on its migration between Ascension Island and South America. At neighboring Andradas Beach, beach rock that includes marine organic remains, representing a subfossil marine terrace, is evidence that sea level once stood about 10 feet above its present level.

There are 16 phonolitic domes in Trindade, but by far the most impressive are those at the north-northwestern part of the island. Their regular, cylindrical shape is produced by monolithic intrusions of viscous lava during periods of intense volcanic activity. The Desejado Peak, about 2,000 feet high and the highest point on the island, is the eroded remnant of a phonolitic dome, later inserted with pyroclastic deposits.

According to Almeida, 80 percent of the exposed rock belongs to the group of pyroclastic and eruptive rocks known as the Trindade Complex. Radiometric analysis gives an age of about 2.8 to 3.5 million years for the oldest rocks, assigning the formation of the emerged part of the island to some time in the Middle-Upper Pliocene. Volcanic activity and the age of the rocks below sea level is supposedly older. The last volcanic episode in the island—the "young" activity of the Paredão Volcano—occurred about 5,000 to 7,000 years ago.

The saga of island life

Human activity has also probably contributed to the erosion on the island. S. L. Olsson, an ornithologist

Strong shelled and powerful, this South Atlantic land crab is found in habitats from beach to mountain, preying on the young of turtles and birds.



with the U.S. National Museum of Natural History, has found weathered and charred pieces of wood in the higher parts of Trindade, supposedly evidence of extensive tree die-offs caused by fires set by humans in the eighteenth century.

Since the early beginnings of oceanic crossings in the South Atlantic, hogs and goats were left on the island as an eventual food source for stranded seamen, an old practice that took place sporadically in Trindade until the dawn of this century. The rooting and digging type of feeding of these fast-reproducing, omnivorous animals can cause severe disturbances in the already sensitive balance of terrestrial ecosystems in oceanic islands with small areas, causing the uprooting of medium-sized trees and preventing the development of seedlings and young plants. It is believed that the once widespread forest of the endemic giant fern *Cyathea copelandi* had been reduced in area by these animals. Today, only a small patch of this exquisite vegetation remains in a humid depression at the summit of the always-cloudy Desejado Peak, and the prevalent type of vegetation is represented by meadows formed by the grasslike *Cyperus atlanticus*.

Supposedly, the large concentrations of feral animals has also provoked a steep decline in the natural populations of breeding oceanic birds. It has also been suggested that the low concentrations of birds on the island might be correlated with the

426 feet = 130 meters
39 feet = 12 meters; 164 feet = 50 meters
10 feet = 3 meters; 2,000 feet = 600 meters

Barren and inhospitable ... its marine life is open to change.

presence of the land crab *Gecarcinus lagostoma*. Bird eggs and fledglings are a highly valued food item for this omnivorous crab, which is known to occur only in the tropical oceanic islands of the South Atlantic. *G. lagostoma* is apparently ubiquitous in Trindade, from the intertidal region, where it browses lazily at low tides, to the 1,600-foot-high mountainous realm. I have personally witnessed the fierce, efficient predatory activity of the land crabs upon newly hatched green turtles, during the hatchlings' strenuous first and decisive march from land to sea.

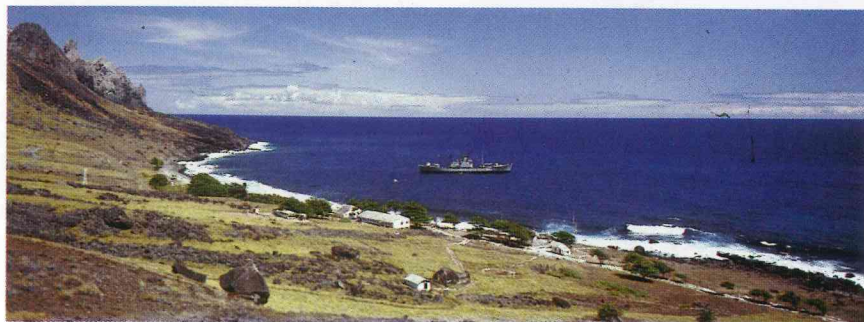
Instability means opportunity

The ubiquitous and ecologically opportunistic habits of the land crab are paralleled underwater by the

abundance and frantic behavior of a triggerfish, the black durgon (*Melichthys niger*). Usually during austral summer, huge schools of this tropical

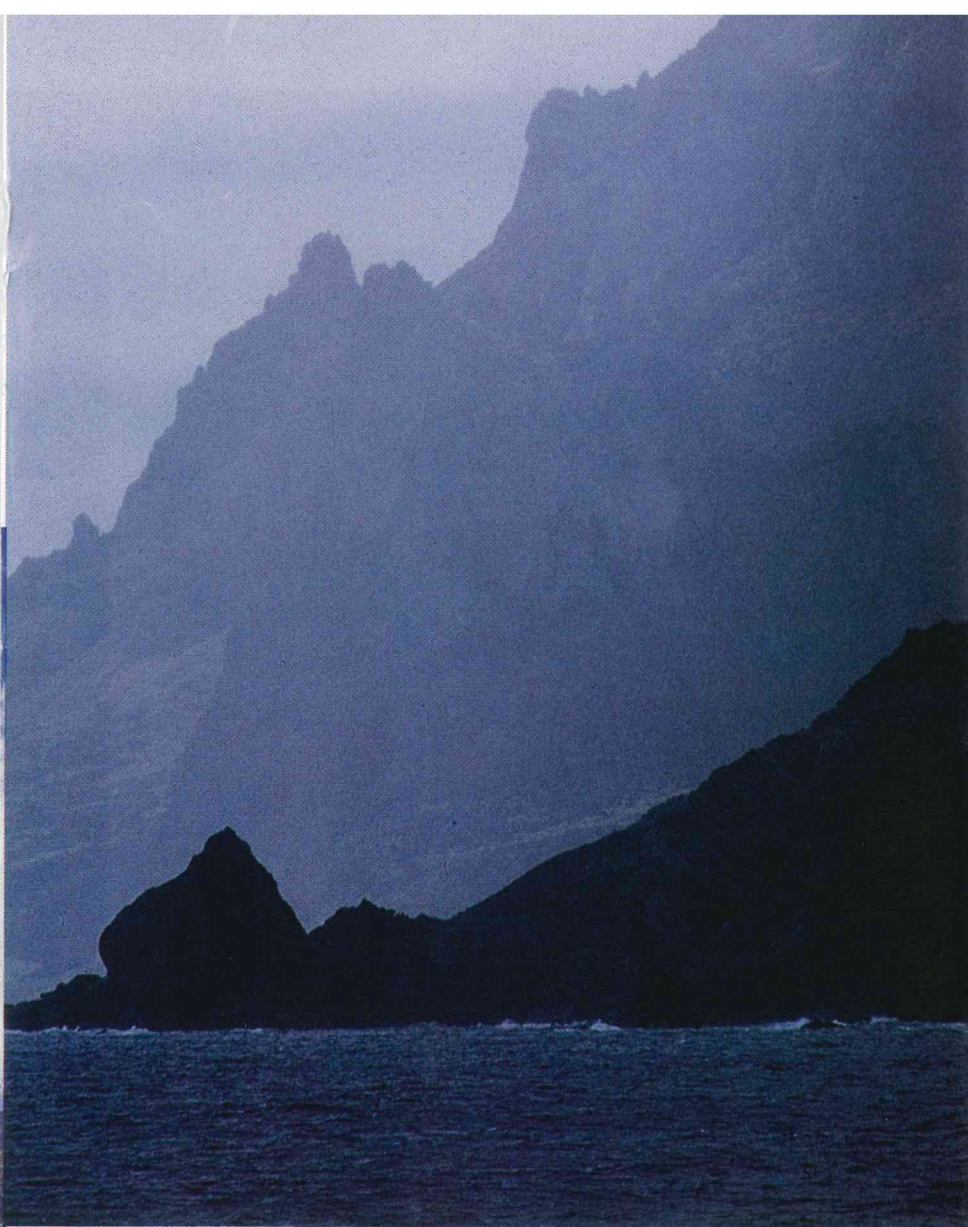
fish are found on the windward coast of Trindade, where they concentrate around moored ships, feeding on waste from the ships' galleys. They are present in large numbers from the sea surface down to the bottom of the island shelf.

The black durgon occurs in the western Atlantic from Brazil throughout the Caribbean to Florida and the Bahamas, and large populations are also found around oceanic islands of the central Atlantic Ocean. The reasons for such high numbers are unknown, but factors that may play important roles are environmental fluctuations, long duration of early life stages in the pelagic environment, and the absence of competition, allowing for fast colonization in a probably unstable benthic ecosystem. At Trindade, fluctuations of salinity and sediment input occur



A Brazilian supply vessel moors precariously in Português Bay near the small naval post. The bluff coast offers little shelter, and no good anchorage on the steep shelf.

Where the land meets the sea (top), the crumbling layers of the Paredão Volcano are pierced by a natural sea-level tunnel more than four football fields in length, a tribute to the power of nature to destroy what it creates.



during periods of heavy rain. These fluctuations can have significant effects in small populations of eventual competitors, leaving the way free for species that, as might be the case with the black durgon, have the characteristics of early colonists in new or unstable ecosystems. Dead black durgon sometimes accumulate along the high-water line of the windward beaches, possibly dying from lack of food after rapid increases in population.

From my own investigation, dealing with hard-shelled marine gastropods, it is becoming clear that species with long-lasting planktonic early-life stages and wide geographic distribution are predominant, as adults, in the sublittoral seafloor around the island.

Today, the small garrison of the Brazilian Navy not only is in charge of

this important observational outpost in the Atlantic, but is using it in the least destructive way from the conservationist viewpoint. No huge airstrips or military bases exist (although some talks about a naval base have been made, following the Falkland Islands/Malvinas war), and the impact of about 20 people on the environment is probably minimal.

Barren and inhospitable, Trindade offers scientists a concise example of the influences of an unstable environment on linked ecosystems. As an oceanic island lacking reef-building corals, its marine life is open to change, as is the geologically young island itself. Far from being a tropical "dream island" to the casual eye, Trindade in its development will continue to be a scientific showcase for distant marine and terrestrial environments with few parallels in the world ocean.

Jose H. Leal developed strong ties with the ocean and its marine organisms during his boyhood, spent along the rocky seacoast of Rio de Janeiro State, southeastern Brazil. He graduated from the Federal University at Rio de Janeiro with a B.S. in biology and earned an M.S. in invertebrate zoology at the same institution. Leal has worked for five years as a research associate in malacology at the National Museum in Rio de Janeiro. There, together with his work on systematics of gastropod mollusks, he became interested in the formation of oceanic islands and seamounts and in the processes that impinge on the colonization of these geological structures by animals and plants. He has made several field trips to different South Atlantic islands, the most recent in May-June 1987 to the Vitória-Trindade Seamount Chain, aboard the French research ship *Marion Dufresne*. Currently, Leal is a Ph.D. student at the University of Miami Rosenstiel School of Marine and Atmospheric Science, where he is working, funded by the Brazilian government, on his dissertation on the biogeography of the shelled gastropods from seamounts and oceanic island off the Brazilian coast.

Related Reading:

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1,600 feet = 490 meters