



# UNDERSEA GARDENS

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**HAWAII'S CORAL REEFS SHELTER A RAINBOW  
OF MARINE LIFE BY ERIC LUCAS**



The marvelous sealife found in and around Hawaiian coral reefs—such as raccoon butterflyfish—draws many admirers.



**T**

**HOUGH THERE ARE ALMOST 350 SQUARE MILES**

of coral reef around the Hawaiian Islands, for the moment I believe I am visiting the most marvelous of them all. A mild swell rolling in from the Southern Pacific wraps around basalt pillars along the south shore of Lānaʻi, and in 30 feet of water I venture a free dive down 15 feet to take a closer



look at a huge, minivan-size embankment of lobe coral.

It's a painterly, vivid sculpture of ocean art. Ropelike wire corals sway in the current. Fuchsia-colored corals rest atop the underlying mound of lobe

coral. Butterflyfish, polka-dotted gobies and iridescent baitfish flash past. I spy exquisitely figured reef triggerfish, the Klee-like canvases of the Pacific—they're Hawai'i's state fish, called *humuhumunukunukuāpua'a*. The sunlight slants down through the water like Hollywood searchlight beams. The rest of my group has



Red sea urchins and pennant bannerfish are among the many colorful creatures inhabiting Hawai'i's coral reefs, which surround most of the islands. Visitors delight in the sights to be found on snorkeling expeditions, such as this one at Kaua'i's Kē'ē Beach. Hawaiian green sea turtles use the reefs as places to feed and rest.





Kayakers explore coral formations off the Olowalu coast of Maui.

paddled toward the other side of this small cove, and I have this water to myself. It's all perfect.

But wait, how can this be? It seems someone has strewn cooked spaghetti on the reef. It looks incongruous—white strands flexing in the shifting water, dangling across the coral.

“Ah, yes, ‘spaghetti,’” laughs our shipboard naturalist when I call her over to point it out. “How *did* that get there?” she teases me.

OK, I urge. Tell me.

“That’s spaghetti worm. Pretty common, actually,” she explains. “People are always surprised, though.”

I dive back down for another look. On closer inspection, I see that these are, indeed, living strands of a thin worm. I find the central lobe of the multistranded animal, and measure it drifting over the reef, an inch at a time. Looking farther, I find some coral specimens that also aptly fit the



Hawaiian whitespotted toby



Pebble collector urchin



Short-bodied blenny

### CORAL REEFS

- **More than 100** species of corals inhabit Hawaiian Islands waters. Worldwide, there are just under 1,000 coral species.
- **Hawaii’s coral reefs** are home to 7,000 marine species. Worldwide, reefs host up to 9 million species. That’s 1/4 of all marine species, even though reefs encompass less than 10 percent of the world’s oceans.
- **One mound** of lobe coral in Hawaiian waters

may have up to 100 million individual polyps.

- **Scientists** have mapped more than 350 square miles of coral reef in Hawaiian waters. The global number is estimated at 110,000 square miles.
- **Officials** at the National Oceanic and Atmospheric Administration estimate the “value” of coral reefs in U.S. waters at \$34 billion. A global estimate con-

ducted by a British agency under United Nations auspices yielded a value of \$172 billion.

- **While the majority** of coral species build hard exoskeletons out of calcium, soft corals also inhabit tropical reefs, including cup corals and fan corals.
- **Cold-water corals** can be found as far below the sea surface as 9,000 feet, and as far north as Alaska’s Aleutian Islands.



A large school of yellow tangs is joined by one filefish above a reef along the Lāna'i shore. At right, growth on the cables at a shipwreck along the Hawai'i Island coastline illustrates how adept corals are at colonizing suitable surfaces, helping provide habitat for bluestripe snapper.

food theme. They look like piles of sticky, purplish rice. Exploring a bit more, I notice some smaller, crimson worms that seem ever so much like strands of sweater yarn.

To say these are just three among innumerable wonders—and surprises—in the coral reefs of Hawai'i is putting it mildly. In fact, perhaps the most enchanting aspect of this remarkable ecosystem is this: Coral reefs become even more magical as you learn ever-deeper distinctions about their delicately balanced facets.

Consider the corals themselves. They are actually small animals, called polyps, very similar to sea anemones, that may be only as big as an infant's fingernail. Most live in colonies of millions (the reef mounds) that may be genetically identical. And rather than build internal bones, as most animals do, coral polyps extract

Coral utilizes a unique partnership with tiny dinoflagellates known as zooxanthellae. The latter live within coral cells, using photosynthesis to help the polyps build their limestone exoskeletons.

minerals from the water to deposit an exoskeleton, largely made of calcium, that forms the actual reef.

The vast majority of shallow-water tropical corals, such as those in Hawai'i, rely on a symbiotic relationship with tiny, algaelike creatures known as *zooxanthellae*. The latter live inside the corals—inside their cells, actually—and use photosynthesis to produce oxygen and carbon that the corals use as energy. The corals, meanwhile, provide their zooxanthellae shelter.

**THESE UNIQUE ECOSYSTEMS** could be likened to old-growth forests in their complexity, diversity and matchless beauty. Coral reefs appear along nearly every shoreline in Hawai'i.



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Ringling most of the islands, harboring clouds of colorful tropical fish, gentling the constant onrush of ocean swells that have traveled thousands of miles, and protecting fish from predation, these unique ecosystems could be likened to old-growth forests in their complexity, diversity and matchless beauty.

Coral reefs appear along nearly every shoreline in Hawai'i, save those too exposed to heavy surf or to freshwater runoff from the islands. Even the newest land on the planet, the shores below Hawai'i Island's Kīlauea volcano, begin to show coral growth just a few years after lava has reached the ocean and cooled.

More than 100 species of corals are found in Hawaiian waters; the reefs they form provide habitat for hundreds of species of fish and arthropods, such as crabs and shrimp. Some of the limestone that coral reefs are made of eventually becomes soft white sand. Some corals form massive underwater mounds, such as the *porites lobata* (lobe coral) colonies I explored at Lāna'i. Some are graceful three-foot fans; some are two-foot wires that rise in the water like genie ropes. They are astoundingly sophisticated tiny animals that have formed an alliance with members of the plant kingdom, and learned to construct castles of rock as sturdy as any artifact that human civilization has engineered.

Polynesian peoples have valued coral reefs for millennia, considering them semi-sacred gateways to the wealth of the ocean. Today, the reefs are treasured by visitors who swim, snorkel and dive among them; by fishermen who savor the many species that coral nurtures; and by the oceanologists and ocean advocates who marvel at corals' dynamic vitality and study their seemingly infinite complexity.

**S**INCE I FIRST looked through a snorkel mask at a coral reef at the age of 14, I've spent thousands of blissful hours watching the colorful Expressionist-like portrait of life here just beneath the surface. I've looked for

Lobe coral is found throughout the islands, with millions of polyps forming huge colonies.

morays in secret passages and sought the abstract patterns of triggerfish. I've spun in amazement amid clouds of yellow butterflyfish and silvery blennies, whose shifting patterns in the water seem like rain sprayed sideways in the light of rainbows. Coral palisades reach from sea bottom toward the sun, its rays glancing past the reefs like shafts of light in a forest. These reefs are often likened to underwater butterfly gardens.

In fact, they are complicated, interwoven ecosystems in which all the hundreds of resident species play integral roles. Blennies, for example, eat algae off coral surfaces: In effect, they are the housecleaners of the reefs. It's an incredibly sophisticated system, too. Some algae are welcome,



ANTHONY TORTORIELLO / TANDEMSTOCK.COM

## RESPECT THE REEFS

### Visiting Hawai'i's

marvelous coral reefs is a great delight—and will stay that way for future generations if visitors take care of this sensitive environment.

**1. Don't stand on,** sit on or touch the coral, even if you are wearing fins or

gloves. One touch can kill a coral polyp.

**2. Don't collect anything,** especially coral, as a souvenir.

**3. Don't chase** or harass reef residents, such as blennies, moray eels and other marine life (including dolphins).

**4. Wear sun-protective clothing** rather than sunscreen, which may contain chemicals that are toxic to corals.

**5. Visit with licensed tour guides** who respect local regulations, such as not anchoring directly on the reef. —E.L.



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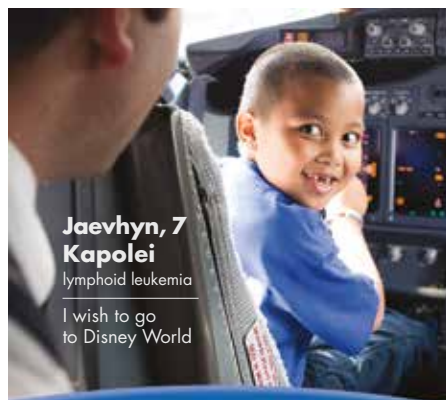
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such as zooxanthellae. Some are not, such as the algae that blennies consume.

And the whole system, hidden underwater as it is, did not experience the same level of 19th and early-20th century scientific exploration as, say, rainforests, until the modernization of scuba gear in the 1950s, which opened up undersea research significantly.

In one of the region's ancient marine protected areas in the Yap Islands of the western Pacific, islanders have preserved their coral reefs for a thousand years, and assiduously observed conservation tactics such as restricting fishing during spawning times.

"Traditional ecological knowledge from Polynesian people is highly valued, although insufficient when dealing with modern ecological issues," says Robert Richmond, director of the University of Hawai'i's Kewalo Marine Laboratory in Honolulu, and president of the International Society for Reef Studies.

Today, there are 11 Marine Life Conservation Districts in Hawai'i, some dating back to 1967, that encompass nearly 2,000 acres.

The Hawai'i coral reef ecosystem is, in fact, so rich and complicated that even scientists use shortcuts to describe its components. Technically, the creatures sharing intracellular space with coral polyps are a kind of algae called "dinoflagellates"—and these same scientists are apt to call them, rather than the mouthful zooxanthellae, just "zoox."

"The ecosystem is complex, and through decades of scientific research we have learned much about their dynamics, but there is still much to understand," says Erik Franklin, associate research director at the Hawai'i Institute of Marine Biology, in Kane'ohe Bay on O'ahu's northeast shore. Franklin is incorporating 21st century techniques such as eco-informatics: computer modeling of data that is validated with observation of the reefs.

"We use complementary methods such as studying organisms in aquaria in the lab where we can control variables," Franklin explains.



But as anthropologists will affirm, actual living societies perpetually confound scientific models. Consider the way a coral reef is like a crowded, multi-ethnic extended family, even inside the coral cells, everyone living in communal harmony. Except when things get tough.

**WHERE TO SWIM  
AMONG THE CORAL**

There are coral reefs along almost all shorelines in Hawai'i, but ocean conditions make many areas best for only experts or guided tours. Local regulations may govern boating, snorkeling and diving. Following are some good choices for visitors:

- **Kē'ē Beach, Kaua'i:** The shallow waters here are well protected from ocean swells by offshore reefs, so this is an excellent place to introduce children to the marvels of undersea life.
- **Hanauma Bay, O'ahu:** The state's oldest marine reserve is a semicircular cove east of Waikīkī, with facilities on-site, including gear rentals. A half hour north, Kāne'ohe Bay is perhaps O'ahu's most protected marine water, though there are no services on-site.
- **La Perouse Bay, Maui:** This large, protected inlet is vast enough to absorb the many snorkelers who visit. The bulk of Kaho'olawe Island, eight miles west, helps moderate ocean swells.
- **Kealakekua Bay, Hawai'i Island:** It's best, and easiest, to visit this marine reserve utilizing the many guided boat tours that depart from the Kona and Kohala resort areas.
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CYNTHIA HUNTER

**UNIVERSITY OF HAWAII** biology professor Cynthia Hunter lifts her snorkel mask for a minute and points her thumb toward the coral reef just below us. “I want you to see something right down there,” she says, then dons her mask and plunges underwater.

The top portion of this 10-foot mound of lobe coral, which is the size of a VW Bug, is a glistening ivory white. But here, a foot below the surface, is a single lobe that’s a gorgeous, delicate lavender in the refracted sunlight. I admire it, then follow Hunter’s outstretched arm farther down, where she’s indicating the wall of the coral mound about 4 feet deep. Taking a deep breath, I descend and look. More lobes, each about an inch across—this time leather-brown, like an old saddle. I return to the surface with Hunter.

“That lavender lobe sure is beautiful.”

She nods when I comment on what we’ve just seen.

“Is that healthy?” I ask. Hunter shakes her head.

Though there is much still to be learned about coral reef ecosystems, researchers such as these University of Hawai’i students are gathering data to fill the gaps.

## ISLAND LIVING AT ITS FINEST

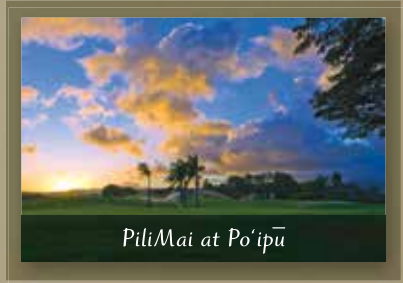
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**YOU CAN SHARE THE DREAM**



Older reef colonies provide a platform for newer corals, such as this cauliflower coral. Cup coral (right) forms no exoskeleton.

**“CORAL REEFS DO HAVE RESIDENT CRABS AND SHRIMP**  
that help keep the reefs clean and drive away natural predators, such as the crown-of-thorns starfish. ... We can capture them and check their health.”

“The coral deeper down, that brownish cast, that’s healthy coral,” Hunter says. “But most people wouldn’t know that.”

“The average visitor out here, they’d see all this lavender and yellow and ivory coral, they’d think it’s beautiful—and it is. But it’s not ordinary.”

Hunter and a UH graduate student, Tayler Massey, have brought me out in 10 feet of water on a mid-autumn morning, 100 yards off O’ahu’s windward eastern shore, at Lanikai Beach, to learn about Massey’s reef-monitoring thesis project, and to witness a unique and troubling



episode of coral bleaching in Hawai’i’s ocean waters. Near-shore ocean temperatures reached record levels in late summer and early autumn this year, and the result has been a stark reaction by the

corals that ring island shores.

“I heard an anecdotal report of a 90 degree sea temp from one researcher,” Hunter reports, about an area where 83 degrees is the usual maximum. Color

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dissipation—coral bleaching—has been observed by reef scientists in Hawai'i on only a few occasions, most notably back in 1996 during another period when ocean temperatures reached unusually high levels.

Massey's monitoring project was designed to investigate the potential for bleaching, to see what effect elevated sea temperatures have on coral health. She has six sensors attached to reefs up and down the shore, and swims out weekly to see what's happening and record her observations. The expected bleaching peaked in late September. Now, three weeks later, temperatures have cooled, aided by the passage of seasons and, ironically, the ocean churning wrought by the passage of Hurricane Ana, which brushed the islands. Now, corals that were stark white weeks ago are regaining a little color.

How all this happens is a deep and complex mystery. Scientists know that corals under heat stress literally expel the actual source of their color, their zoox.



JEFF HUNTER / GETTY IMAGES

Finger coral is one of the most common types in the Islands—seen here with threadfin butterflyfish and yellow tangs.

Among other things, the dinoflagellates' color provides a bit of "shade" from the sun. Getting rid of it seems counter-intuitive.



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"The corals just spit them out, literally," Franklin says. "But I can't tell you the exact physiological mechanism by which a coral expels an organism that is living inside its own cells."

Deepening the mystery is the indication that, once sea temperatures subside, the corals at Lanikai evidently have the ability to quickly recruit and incorporate new zoox.

How do they do that? And why do some colonies exhibit much less bleaching? If it is a heat-resistant strain of coral, what makes it resistant?

This is far from the most astounding mystery about corals. Spawning time, for instance, causes a colony to release vast clouds of sperm and eggs into the reef waters; the spawn then drift in the ocean currents until they happen upon a substrate that's suitable, both physically and chemically.

That's how corals so quickly colonize the new undersea lava surfaces below the Kilauea volcano, and the manmade structures such as derelict ships purposefully sunk to host new colonies.

Somewhat surprisingly, coral spawn are able to actually measure the chemical suitability of the waters they drift to. Scientists know, for example, that spawn will not settle in water that is carrying unusually high levels of pesticides, such as happens after storm events that wash agricultural chemicals from the land into Hawaiian bays. What are the parameters of this mechanism?

"Interestingly enough, corals have the same metabolic proteins as humans," says Robert Richmond. "But we can't get coral to pee in a bottle to do analyses."

"However, coral reefs do have resident crabs and shrimp that help keep the reefs clean and drive away natural predators, such as the crown-of-thorns starfish.

These [crabs and shrimp] are arthropods, same as cockroaches, and sensitive to the same pesticides," Richmond continues.

"We can capture them and check their health. If they're not healthy, we investigate why.

"In essence, we're asking the crabs and shrimp, What's bothering you?"

**R**ICHMOND thus describes his work as “Dr. Dolittle plus CSI.” And he expresses great admiration for the intuitive knowledge and care that Polynesian peoples have applied to marine conservation for centuries. Among the ancient *kapu* that governed fishing, for instance, was one that reserved the power to net-fish in the reefs to unmarried males. While it was part of a spiritual custom separating men and women, Richmond observes, it seems that men without families would be less likely to overharvest. And the famous fishponds found throughout all the islands were created specifically to substitute for ocean

**MORE THAN 40 PERCENT** of Hawai‘i visitors enjoy the tropical water through snorkeling, diving and just plain sightseeing, and scientists are far from immune to that sheer sense of fun.

fishing, lessening the pressure on the reefs.

“The Polynesians knew what we are still learning, that reefs can sustain themselves, even with human utilization, if those human uses are carefully managed,” Richmond concludes.

For all the scientific intensity marine biologists in Hawai‘i are now bringing to bear on coral reefs, they are also keenly aware that their profession requires them to focus on something laypeople just find magical ... and that provides marvelous recreation.

More than 40 percent of Hawai‘i visitors enjoy the tropical water through snorkeling, diving and just plain sightseeing, and scientists are far from

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immune to that sheer sense of fun.

At Lanikai, I jest with Massey about the "rigors" of her thesis work, which includes weekly swims, with snorkel and fins, to check her monitoring stations.

"Not much like the usual dry thesis topic, is it?" she grins.

It is not dry in many ways, of course. But the knowledge that researchers such as Massey gain will help preserve and enhance Hawai'i's priceless shoreline.

As Erik Franklin points out, the Hawaiian archipelago is the world's most isolated major island chain, and that magnifies the importance of fending off damage—and discovering how to do so.

"We have to protect the resources we have," Franklin says. "We can't just go next door to find replacements."

"We do know many things and what we can do," says Robert Richmond. "The good news is, given the opportunity to recover, coral reefs are dynamic systems that will do just that."

Scanning the water from onshore at Lanikai Beach, Cindy Hunter muses that, for all the alarming bleaching the corals here have shown during one hot autumn month, it's possible that by January most of the reefs will have shaken off the stress, regained their color, and be healthy once again. And scientists such as Hunter and Massey will be busy trying to figure out exactly what happened—both the crisis and the recovery.

"Clearly, there's a lot we just don't know," Hunter says. "There is so much wonder out there." ▲

*Eric Lucas is a contributing editor at Alaska Airlines Magazine and frequent visitor to Hawai'i.*

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