

A large school of silver fish, possibly mackerels, swimming in clear blue water. The fish are densely packed and moving in various directions, creating a dynamic and vibrant scene. The water is a deep, clear blue, and the lighting is bright, suggesting a sunny day. The fish have a silvery sheen and are seen from various angles, some swimming towards the camera and others away from it.

High Seas Gems: Hidden Treasures of Our Blue Earth

Acknowledgements

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C H A N T E C A I L L E



The largest, least-protected places on our blue planet are found in the high seas — the open ocean and deep seabed that lie seaward of individual nations' jurisdictions.

Extending from the Southern Ocean surrounding Antarctica to most of the Indian, Pacific, Atlantic and Arctic Oceans and the Mediterranean Sea, these areas cover 45% of the Earth's surface. Hidden beneath the surface of the high seas are extraordinary places that are in urgent need of our protection. Belonging to no single nation, they have been, for too long, neglected by all.

The high seas are home to great whales, sea turtles, seabirds, tunas and sharks that traverse entire ocean basins in search of food. They house deep-dwelling fishes and invertebrate animals that live long, slow-motion lives in eternal darkness. High seas ecosystems include places where great water masses meet and species congregate, as well as vast muddy plains, coral-capped seamounts, and vents that shoot hot water into the frigid depths. These places give rise to many rich and precious life forms found nowhere else on the planet.

High seas biodiversity is threatened by fishing, climate change and other human-caused impacts. These losses are also our losses, as they threaten the ability of the oceans to sustain marine life and support human societies. The global community recently decided that key high seas ecosystems should be protected, and agreed on a common set of criteria to start selecting these areas. To help them, we asked scientists from around the world to name examples of high seas sites that reflect these criteria as areas of concentrated abundance or diversity, rarity, naturalness, or vulnerability; or which function as key habitats, such as feeding and breeding grounds for long-distance migrants. The ten sites described herein illustrate just a few of the special places scientists suggested and that merit further conservation consideration.

Emperor Seamount Chain

In the frigid darkness of the deep North Pacific Ocean between the Hawaiian and Aleutian Islands is a chain of silent volcanoes that arose millions of years ago from molten rock 80 kilometers below the Earth's surface. Until the 1970s, they harbored large numbers of deep-water corals and fishes. They are the Emperor Seamounts.

Many seamounts were once underwater volcanoes, which formed many years ago from a "hotspot" of rising magma. These volcanoes were produced as tectonic plates moved over the hotspot. Some of these eventually pierced the surface, cooled and were colonized by plants, spiders and other land life. Then rain, wind and waves eroded some of the islands and they submerged again into the bosom of the sea. Again and again, volcanoes were born and moved northwest until they formed a very long chain. The ones still above water are the Hawaiian Islands. The oldest, lowest, northwestern-most Hawaiian islands were protected in 2006 by the USA as Papahānaumokuākea Marine National Monument, then the world's largest no-take marine reserve. However, the older submerged seamounts further northwest—the Emperors—are on the high seas, and remain unprotected.

Albatrosses, whales and tunas visit the nutrient-rich waters above the Emperor Seamounts to feed before continuing their ocean-spanning migrations. Kilometers below them, corals and deep-sea fishes dwelt in splendid isolation until they were discovered and plundered in the 1960s and 1970s. Large offshore trawlers invaded these undersea paradises, dragging away their deep-sea corals and fishes, including alfonosinos and pelagic armorheads. Even four decades later there is little indication of coral recovery.

Yet, harbored within the complex terrain of these seamounts are small nooks, crannies and overhangs that were too difficult to trawl. These areas have served as a refuge for the deep-sea life that once blanketed the Emperor volcanoes and may hold the seeds of promise for their recovery, if properly protected.

GOLD CORALS (*Gerardia* spp.) and some other deep-sea corals are the oldest known animals of all. Some colonies are as old as 2,700 years, which means they first formed around the time poets were putting the *Iliad*, the *Odyssey* and the *Epic of Gilgamesh* into written form.



LAYSAN ALBATROSSES (*Phoebastria immutabilis*) breed in the northwestern Hawaiian Islands, then fan out over the north Pacific to find squids and other food animals. Many die from ingesting floating six-pack rings, cigarette lighters, toothbrushes and other discarded plastic debris.



Gakkel Ridge

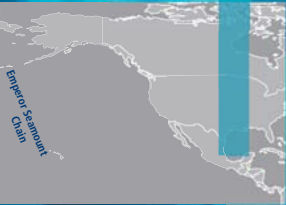
The most mysterious mountain ranges on Earth are not found on land, but far beneath the sea ice of the Arctic Ocean. Scientists know more about the waterless landscape of the "Ocean of Storms" on the Moon than the remote and inaccessible undersea landscape of the central Arctic Ocean.

The Gakkel Ridge may be one of the deepest and slowest-forming of these mid-ocean ridges, spreading less than one centimeter per year. In 1999, a scientific expedition yielded evidence that this 1,800 km mountain chain between Greenland and Siberia has very active volcanoes and hydrothermal vents. It is thought that the depths of the central Arctic Ocean may have been isolated from the Atlantic and Pacific Oceans for many millions of years. As a result, Gakkel Ridge hydrothermal vent animals could be very different from those found elsewhere on Earth.

There is no credible doubt that global warming is rapidly melting the Arctic's permanent sea ice. This will open vast areas of the Arctic seafloor—for the first time in human history—to shipping, oil drilling and bottom trawling, creating new threats that may adversely impact these as-yet untouched ecosystems.

Top: Unknown to science until 1986, EYELESS SHRIMP (*Rimicaris exoculata*) are dominant Mid-Atlantic Ridge hydrothermal vent species. Although there are no published accounts of species from the Gakkel Ridge, scientific expeditions will unveil the secrets of this site, which may include these eyeless shrimp or species currently unknown to humankind.

Bottom: The POLAR BEAR (*Ursus maritimus*) is the animal for which the Arctic Ocean was named (*arctos* is Greek for bear). The world's largest land predator, the polar bear hunts seals from the Arctic's sea ice, which is rapidly disappearing. It is the first animal listed by the USA as threatened due to global warming.



Sargasso Sea

Far from land, in the middle of the North Atlantic, is an area of the ocean famed for strange occurrences, dead calms, and disappearing planes and ships. This area, the Bermuda Triangle, lies within a far more unusual place, the Sargasso Sea, which is the world's only known shoreless sea.

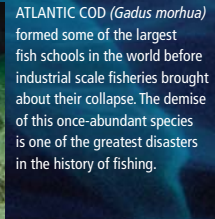
The Sargasso Sea is actually a gyre, a colossal subtropical mass of water that slowly turns clockwise. It is named for brown algae called *Sargassum*, which, uniquely among seaweeds, can grow as mats and island-like floating clumps. These provide shelter, nurseries, spawning areas, and feeding grounds for a myriad of species, some of them transoceanic travelers (such as European and American eels) and others found among *Sargassum* and nowhere else.

The small invertebrates and fishes living in the seaweed have shapes and color patterns that closely resemble *Sargassum*. This camouflage is essential for the survival of snails, shrimps, crabs, pipefishes and anglerfishes trying to avoid hungry predators. Sharp-eyed migratory predators including dolphinfish, white marlin and tunas are only too willing to make hors d'oeuvres of them.

Unfortunately, the overfishing of tunas and the removal of *Sargassum* for fertilizer and livestock feed threaten this ecosystem. The USA recognizes *Sargassum* as "essential fish habitat," and limits its exploitation, but the high seas offer no meaningful protection. In addition, ineffectual regulation of tuna fisheries is not only causing a serious decline in tuna populations, but also of marlin and sharks that are inadvertently caught in nets, and which jeopardizes the functioning of the entire ecosystem.

Newly-hatched **LOGGERHEAD SEA TURTLES** (*Caretta caretta*) scurry to leave nesting beaches and cross hundreds of kilometers of open ocean to reach the Sargasso Sea, where they can dine comfortably while finding refuge within the *Sargassum*.

SARGASSUM ANGLERFISH (*Hystrio hystrio*) is a voracious predator in the three-dimensional maze of *Sargassum*. Fortunately, the largest of these anglerfish reach only 20 cm!



Southeast Shoal of the Grand Banks

Jutting into the North Atlantic Ocean are the Grand Banks, a shallow, submerged extension of Newfoundland with a long history of fishing in a place where mammoths once walked. Located on the southern portion of the Banks is a 10,300 square kilometer sandy plateau, called the Tail or Southeast Shoal. This site, rising to within 40 to 60 meters of the surface, is one of the major areas where the cold, southward-flowing Labrador Current and the warmer, northward-flowing North Atlantic Current meet.

The confluence of these currents along the shallow plateau results in an abundance of nutrients that fuel phenomenal populations of a small fish called capelin. Their abundance provided a world-class feeding ground for Atlantic cod, Atlantic halibut, northern gannets, harbor porpoises and fin whales.

So abundant were the cod on the Grand Banks that explorers prior to Columbus voyaged from Portugal and Spain to fish them. Cod populations could have been sustained forever had they been managed wisely. Instead, intensive overfishing in the area has severely depleted this species and damaged their critical habitat.

In places such as the Southeast Shoal, where fishing remains a threat and fish populations are depleted, no-fishing areas are an important means for recovery. Under international law, most but not all of the Grand Banks is within Canada's Exclusive Economic Zone. Canada can lead the recovery process in the high seas by working with the international community to establish a network of no-take reserves, recognizing the interconnected nature of the species and ecosystems of the Grand Banks within and beyond national jurisdiction.

BUBBLEGUM CORAL (*Paragorgia arborea*) is a large branching coral that, like a tree in a forest, creates habitat used by many animal species. Young Atlantic cod are better able to escape from predators in complex seafloor ecosystems.

ATLANTIC COD (*Gadus morhua*) formed some of the largest fish schools in the world before industrial scale fisheries brought about their collapse. The demise of this once-abundant species is one of the greatest disasters in the history of fishing.



Charlie-Gibbs Fracture Zone



GLASS SPONGES (*Euplectella* spp.) are bizarre animals whose skeletons are made predominately of glass-like silicates. Also known as hexactinellid sponges, they are abundant on many deep-sea features where hard substrata are available. A recent expedition to the Charlie-Gibbs Fracture Zone discovered several new species of glass sponge in a single cruise, demonstrating how little we know about the fauna of this region.

Deep-sea fishes live life in the slow lane, but LEAFSCALE GULPER SHARKS (*Centrophorus squamosus*) are especially slow. Identified as a declining species of concern in this area, leafscale gulper sharks are slow to reach reproductive age and have very few young, making them highly vulnerable to anything that reduces their populations.

Places in the sea with the most biological activity are often ones where the seafloor is most complex and where different water masses come together. In the high seas of the North Atlantic Ocean, partway between Iceland and the Azores, the Charlie-Gibbs Fracture Zone is such a place. In it, a colossal, cold mass of subpolar water frequently collides with an even larger warm mass of subtropical water over an arrow-straight seafloor feature called a fracture zone.

Fracture zones are linear seafloor features, often caused by the geological process called faulting which creates not only the deep fracture trench found at this site but also the high mountainous ridges and isolated seamounts of the surrounding area. These zones create opportunities for high biological diversity by changing the local patterns of currents and by providing rocky substrata that serve as habitat for deep-sea corals and sponges. In the oceanographically-complex waters far above the Charlie-Gibbs Fracture Zone, deep-sea sharks, great whales, dolphins, and seabirds such as shearwaters converge, taking advantage of the phenomenal abundance of copepods, krill, squid, and octopuses that flourish in these high-nutrient waters.

The diversity of the Charlie-Gibbs Fracture Zone is not just limited to the fracture zone area itself. In surrounding waters, seamounts rise from the seafloor, providing homes for invertebrate animals and migrating fishes alike. To protect this vulnerable site from a range of human activities, the international regional seas management body for the North East Atlantic, the OSPAR Commission, is currently making this entire area part of its network of marine protected areas, which would establish an important model for other high seas regions.



Saya de Malha Banks

Rising from the deep waters of the tropical western Indian Ocean is the world's least-explored shallow marine ecosystem. Encompassing more than 40,000 square kilometers, the northern and southern portions of the Saya de Malha Banks are undersea oases capped by the world's largest seagrass community. They were first discovered more than 500 years ago by Portuguese sailors, who described them as green, billowing carpets suspended in the blue ocean.

Research expeditions in the late 1990s revealed seagrass beds interspersed with a dazzling diversity of coral reefs and slow-growing encrusting red coralline algae. These isolated coral communities may serve as crucial stepping stones for coral dispersal throughout the Indian Ocean. These shallows, which reach within 10 meters of the sea surface, host parrotfishes, surgeonfishes, rabbitfishes and green sea turtles. The nutrient-rich deep waters around these plateaus support a huge diversity of marine mammals, such as spotted dolphins and sperm, blue, and pilot whales.

As in many other reef communities around the world, corals at the Saya de Malha Banks were heavily damaged in the devastating 1998 mass coral-bleaching event. Since then, Saya de Malha corals have shown considerable recovery and the seagrass beds remain healthy. The best way to improve the resilience of these corals to future bleaching events is to safeguard the ecological integrity of this phenomenal site.

GREEN SEA TURTLES (*Chelonia mydas*) are long-distance commuters. Adults feed on the Banks' seagrasses for years then migrate up to thousands of kilometers to sandy beaches, where the females dig their nests. Protecting this globally endangered species requires international cooperation in protecting both their feeding and breeding habitats.



The SPERM WHALE (*Physeter catodon*) is the largest of all toothed whales, diving as deep as 2,200 meters to feed on squids and fishes. Because they mature slowly and reproduce infrequently, they are considered a vulnerable species.



Ross Sea



First discovered by the British explorer James Clark Ross in 1841, the triangle-shaped Ross Sea between West and East Antarctica is partly covered by the thick, permanent Ross Ice Shelf, which is roughly the size of France. The rest is covered with much thinner sea ice that forms when seawater freezes during the southern autumn and winter. During the spring and summer, when the sun climbs above the horizon, winds push the melting sea ice offshore.

As light floods the waters of the Ross Sea, phytoplankton and shrimp-like Antarctic krill become phenomenally abundant. These dense clouds of marine life are feasted upon by squids, Antarctic silverfishes, emperor penguins, Weddell seals and blue whales. Some of these, in turn, are hunted by leopard seals, sperm whales and killer whales. Few places in the world, if any, support greater numbers of large animals.

The Ross Sea is one of the world's most ecologically intact, least-polluted nearshore ecosystems and is a global treasure, a Serengeti of the Southern Ocean. Moreover, whereas most high seas areas start at 200 nautical miles from land, the Ross Sea and adjacent coastal seas are exceptional because international law treats Antarctica's waters as high seas.

The ecological integrity of the Ross Sea may be at stake with the expansion of commercial fisheries for Antarctic toothfish. This is happening in a time of growing risk from global warming, which could dislodge the vast Ross Ice Shelf and reduce essential sea ice cover.

KRILL (*Euphausia* spp.) are finger-sized crustaceans that feed on tiny phytoplankton either growing under sea ice or blooming in the water column. They are probably the most abundant animals of their size on our planet and are the foundation of the Antarctic food web.



The largest animal in the Earth's history, BLUE WHALES (*Balaenoptera musculus*) grow as long as 33 meters and can weigh in excess of 181 metric tons. Industrial whaling in the 20th Century brought them to the verge of extinction. They have been very slow to recover.



Pelagos Sanctuary for Mediterranean Marine Mammals



The northwestern shores of the Mediterranean Sea are home to the Riviera regions of France, Monaco, and Italy, a popular tourist destination boasting a mild climate, scenic coastline, and posh resorts. Further offshore, and much less famous, are waters that hold a similar attraction for the marine mammals of the Mediterranean. At this site, the strong northwesterly Mistral winds combine with narrowing currents to help create highly productive waters that attract sharks, other fishes and a diversity of marine mammals. The Pelagos Sanctuary illustrates the challenges and potential benefits of protecting ocean areas, especially on the high seas.

Recognized for its abundance of marine mammals in 1899 by Prince Albert I of Monaco, it was a non-governmental organization in Italy that suggested protection for marine mammals in this area in 1990. The Pelagos Sanctuary now comprises both territorial and high seas waters, the latter making it the world's first high seas real estate to be protected by an agreement among neighboring nations. Once its management provisions are in place and effectively enforced, the Pelagos Sanctuary will provide refuge for fin, sperm, and long-finned pilot whales and Risso's, striped and short-beaked common dolphins that visit its waters.

Other species desperately needing protection in the Mediterranean, such as bluefin tunas, swordfish and many types of sharks that reside in or visit these waters, are at historically low levels and remain unprotected. Progress made to date within the Pelagos Sanctuary provides hope that these species can also receive the protection they deserve.

The ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*) is one of the largest of all bony fishes, with some adults reaching over 3 meters long. This highly migratory species is known to traverse the oceans with great speed and efficiency to feed and breed. Severely overfished for decades, the Atlantic bluefin may be destined for extinction if we don't act now to protect it.



SHORT-BEAKED COMMON DOLPHINS (*Delphinus delphis*) were so well-known that their images frequently appeared on Minoan frescos and pottery dating back 3,500 years. Now the Mediterranean subpopulation of this dolphin is classified as Endangered on the IUCN Red List.



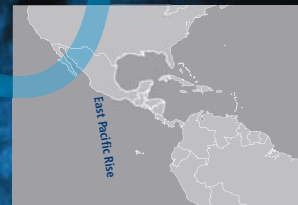
East Pacific Rise Hydrothermal Vents

The world's most unusual ecosystems—hydrothermal vents—were discovered only in 1977 in the black depths not far from the Galapagos Islands. By 1980, scientists had found more of these astounding sites, the equivalent of underwater geysers, further north off the coast of Costa Rica, in the East Pacific Rise.

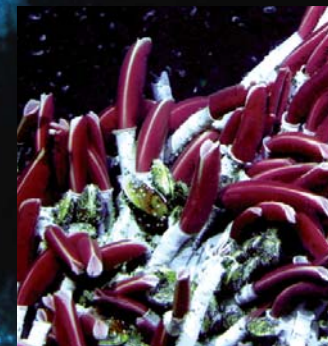
Before the discovery of hydrothermal vents, scientists thought that all food webs depended on light-driven photosynthesis. Yet at seafloor spreading centers, where the Earth's tectonic plates pull apart, there exist entire communities that thrive in conditions lethal to most life. In these areas, superheated waters rich in sulfides and heavy metals spew out from below the Earth's crust. Appearing like billowing clouds of black or white smoke, this incredibly hot water mixes with frigid bottom waters that are under high pressure due to their great depth (more than 2 kilometers below the ocean surface). Under these conditions the metals precipitate, forming large chimneys that support a remarkable variety of invertebrate animals. These species, in turn, depend on bacteria that use the sulfides in the water to produce usable food analogous to the way plants use sunlight.

Harboring more than 150 different types of animals, this hydrothermal vent field is one of the most studied ones in the world. Scientists believe this area of the East Pacific Rise may be a source of larvae, spreading life to vent communities throughout the Pacific Ocean.

Vent food webs are independent of the shallows, so impacts at the sea surface have little effect on them. However, vent communities are susceptible to activities that could occur on the seafloor bed, such as mining for rare metals. The unusual life found along the East Pacific Rise and at other hydrothermal vent sites should be protected against mining and other potentially harmful activities.



The HYDROTHERMAL VENT TUBEWORM (*Riftia pachyptila*) is a large vestimentiferan worm that builds tubes of up to 2 meters long and whose discovery at East Pacific hydrothermal vents astounded the world's scientists. *Riftia*, which grow amongst active vents, have no gut, but live off chemosynthetic bacteria that fill most of the body of the worm.



Equipped with specialized vision for sensing dim light and with an unusual ability to tolerate temperature extremes, the VENT CRAB (*Bythograea therydron*) is a top predator at the East Pacific Rise hydrothermal vents. This bizarre, ghostly white crab feeds on tubeworms, mussels and clams at the vents.




Lord Howe Rise


The mythical sunken continent of Atlantis in the North Atlantic is the subject of famous European legends, but ironically, the sunken continent of Zealandia in the South Pacific is real, yet much less famous. Located approximately 800 kilometers east of Australia, it sank into the Pacific Ocean long before humans evolved. In the northern section of Zealandia lies a 1.5 million square kilometer section known as the Lord Howe Rise.

From the depths of this site, a mountain rises above the sea surface to form Lord Howe Island, which is a terrestrial conservation hotspot, a World Heritage Site and is surrounded by shallow waters with more than 100 species found nowhere else on Earth. Further west, and far less-explored, lies a large submerged portion of the Lord Howe Rise, which is a high seas biodiversity hotspot. Recent expeditions have found hundreds of species of sponges, crabs, sea urchins, sea stars, and octopuses, many of them new to science and quite possibly occurring nowhere else.

Much of this Rise is a plateau studded with volcanic seamounts. Fishes such as orange roughy are attracted to seamounts to feed or to breed. Unfortunately, in many places this has become a fatal attraction: large offshore fishing trawlers dragging nets through aggregations of breeding orange roughy continue to deplete the population of this especially vulnerable species. Whether seamount fishes on the Lord Howe Rise escape this fate hinges on its adequate protection.



DUMBO OCTOPUSES (*Grimpoteuthis* spp.) are deep-sea bottom-dwellers reminiscent of one of Walt Disney's most beloved characters. Some of the species are pink and have fins that are remarkably similar in size and shape to Dumbo's ears.



ORANGE ROUGHY (*Hoplostethus atlanticus*) is the fishery trade name for a fish otherwise known as a "slimehead." Although they are exceptionally slow in maturing and can live for more than a century, fishermen are exploiting them to feed people who may not realize they are eating animals that could be older than their grandparents.



Photo Credits

We thank all of the photographers who contributed their outstanding images to this effort and who bring to life these remote and beautiful ocean places.

Front cover: bigeye jack school (background), Jürgen Freund, www.naturepl.com; **Emperor Seamount Chain:** yellowfin tuna (background), Mark Conlin, www.markconlin.com; Laysan albatross (inset), Kevin Schafer, www.kevinschafer.com; gold coral tree (inset), National Oceanic and Atmospheric Administration USA. **Gakkel Ridge:** Arctic ice (background), Chris Linder, Woods Hole Oceanographic Institute USA; polar bear (inset), Thomas P. Mangelsen, www.mangelsen.com; eyeless shrimp (inset), Woods Hole Oceanographic Institute USA. **Sargasso Sea:** Sargassum (background), Kip Evans, www.kipevansphotography.com; dolphinfish (inset), Don DeMaria, www.seapics.com; loggerhead sea turtle (inset), Doug Perrine, www.naturepl.com; Sargassum anglerfish (inset), David Shale, www.deepseas.co.uk. **Southeast Shoal:** fin whale (background), Hiroya Mnakuchi, www.seapics.com; bubblegum coral close-up (inset), Fisheries and Oceans Canada; Atlantic cod (inset), Florian Graner, bubblegum coral with black background (inset), National Oceanic and Atmospheric Administration/Monterey Bay Aquarium Research Institute USA. **Charlie-Gibbs Fracture Zone:** glass sponge (background), John Reed, Harbor Branch Oceanographic Institute USA; leafscale gulper shark (inset), OceanLab University of Aberdeen UK, www.oceanlab.abdn.ac.uk; sea pen and brittle star (inset), David Shale, www.deepseas.co.uk; octopus (inset), Jeff Rotman, www.jeffrotman.com; gorgonian coral (inset), David Shale, www.deepseas.co.uk.

Saya de Malha Banks: seagrass and coral (background), Peter Goreau, www.globalcoral.org; green sea turtle (inset), Caroline Rogers, United States Geological Survey USA; sperm whale (inset), Brandon Cole, www.brandoncole.com. **Ross Sea:** Ross Sea ice shelf (background), Doug Allan, www.naturepl.com; Antarctic krill (inset), Joachim Plotz, Alfred-Wegener Institute Germany; emperor penguins (inset), Sandra Crielei; leopard seals (inset), Jerzy Strzalecki; blue whale (inset), Mike Johnson, www.earthwindow.com. **Pelagos Sanctuary for Mediterranean Marine Mammals:** Risso's dolphins (background), Todd Pusser, www.naturepl.com; bluefin tuna (inset), Jeff Rotman, www.jeffrotman.com; porbeagle shark (inset), Doug Perrine, www.seapics.com; short-beaked common dolphin (inset), Jan-Michael Breider; devil rays (inset), Kevin Deacon, www.auscape.com.au. **East Pacific Rise:** black smoker (background), P. Roma, National Oceanic and Atmospheric Administration USA; white vent crab (inset), National Oceanic and Atmospheric Administration; Zoarcid vent fish (inset), Richard A. Lutz, Rutgers University, hydrothermal vent tubeworms (inset), Woods Hole Oceanographic Institute USA. **Lord Howe Rise:** Ball's pyramid (background), Jean-Paul Ferrero, www.auscape.com.au; dumbo octopus (inset), Monterey Bay Aquarium Research Institute USA; orange roughy (inset), Malcolm Clark, National Institute of Water & Atmospheric Research NZ.



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