





# On the VERMILION SEA



*Beauty and biodiversity may be endangered in the Gulf of California*

The Gulf of California has held a growing fascination for naturalists for the past 150 years, though it wasn't until 1940 that modern marine biology entered its waters through the pioneering

expedition of Edward F. Ricketts and John Steinbeck aboard the *Western Flyer*. The biological discoveries of that amazing voyage, chronicled in *The Sea of Cortez: A Leisurely Journal of Travel*

and *Research*, launched an era of Gulf research that continues today. Compared to many of the world's coastlines, however, our knowledge of the Sea of Cortez is still young.

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# OCEANOGRAPHY



▲ An undescribed jellyfish. This is one of several dozen species of jellyfishes in the Gulf that lack formal names and descriptions.

The Sea of Cortez exceeds 700 miles in length, covers nearly 100 square miles of surface area, and spans over 9 degrees of latitude. It is composed of 3 distinct biogeographic regions: the Northern Gulf extends from the Colorado River delta southward to the Midriff Islands (the largest being the Islas Tiburón and Ángel de la Guarda); the Central Gulf ranges from the Midriff Islands to Guaymas (Sonora) and Punta Coyote (Baja California Sur); and the Southern Gulf extends southward to Cabo Corrientes, Jalisco on the mainland, and Cabo San Lucas on the Baja California Peninsula. The great East Pacific Rise runs right up the center of the Gulf, and continues to push Baja away from mainland Mexico at the rate of several inches per year.

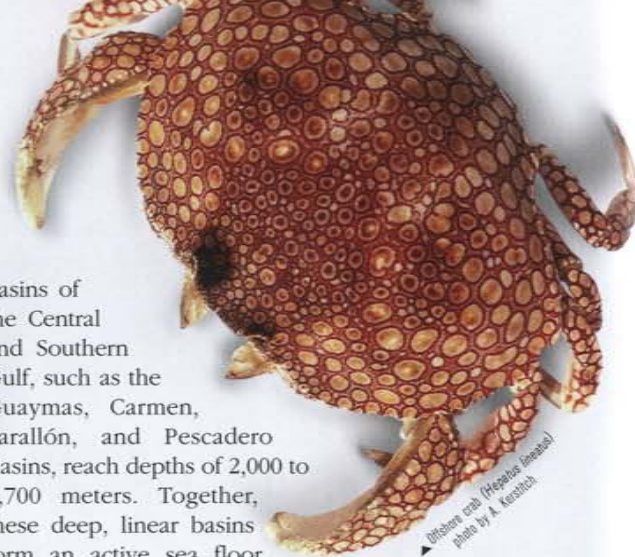
The Northern Gulf offers some of the most powerful tides in the world. The annual tidal range at San Felipe and Puerto Peñasco is about 7 meters, while on the Colorado River delta it is nearly 10 meters. The climate is very dry, with an average annual rainfall of less than 10 centimeters. Most of the Northern Gulf is shallow, less than 100 meters in depth, and because of this—and due also to its location in the heart of the Sonoran Desert—coastal seawater temperatures vary strongly with the seasons, falling to between 8 and 12°C in the winter (equivalent to the southern California shores), but rising to 30°C or more in the summer.

The Central and Southern Gulf maintain more oceanic conditions than the north, with warmer and more stable water temperatures. Rainfall is fairly high, averaging 50 to 100 centimeters per year. Tides in the Southern Gulf have much lower amplitudes than in the Northern Gulf, with maximum annual ranges of 2.3 meters (La Paz) to 2.7 meters (Mazatlán). The

basins of the Central and Southern Gulf, such as the Guaymas, Carmen, Farallón, and Pescadero Basins, reach depths of 2,000 to 3,700 meters. Together, these deep, linear basins form an active sea floor spreading center complete with hydrothermal vents and a unique community of benthic organisms.

At the mouth of the Gulf, the trough formed by this series of basins approaches Cabo Corrientes (Jalisco), the likely site where the Cape Region of Baja California was originally attached to the mainland before being torn away 5 to 10 million years ago. This area, where the Sea of Cortez begins, is a complex mix of surface waters from several sources, including warm saline Gulf waters, cold California current waters, and warm, tropical Eastern Pacific waters. Where these waters of different temperature, salinity, and density meet, hydrographic fronts develop, plankton and other sea life accumulate, and commercial and sport fisheries flourish.

The Gulf of California has exceptionally high rates of phytoplankton growth. In fact, this growth is comparable to that of the greatest fishing areas of the world, and averages three times that of the open Atlantic or Pacific at similar latitudes. The rich, pelagic waters of the Gulf are famous for supporting large numbers of fishes, marine mammals, sea turtles, marine birds—and human fisheries. Forty percent of Mexico's fishery production comes from the Sea of Cortez.



▲ Dithone crab (*Hepatus sinuata*)  
photo by A. Kerstitch

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In the Northern Gulf, nutrient and plankton levels are high year-round and show little variation by season, although in recent years the primary sources of nutrients have probably been agricultural drainage and the release of nutrients trapped in eroding Colorado River sediments. High nutrient levels, shallow waters, and strong tidal mixing combine to make the Northern Gulf one of the most productive marine regions on earth. Large fish and at least 12 species of whales and dolphins, including the critically endangered vaquita porpoise, enjoy these fertile waters.

The Central and Southern Gulf are also highly productive waters, but these regions are largely supplied by cold, nutrient-rich water from the Pacific that enters the Gulf at great depths. These waters are driven to the surface in localized areas, and when they near the surface their nutrients and high oxygen content combine with sunshine to cause phytoplankton blooms, initiating food chains of zooplankton, fish, and ultimately, marine mammals and sea birds.

This process, called “upwelling,” is especially common in the Central Gulf, where seasonal winds blow surface waters away from the coast, and where the basins turn upward and drive their deep currents to the surface. “Red tides,” localized phytoplankton blooms so dense that they discolor the water, occur daily during the spring and summer months in the Central Gulf. These waters are so rich that populations of sperm and finback whales have forsaken their ancestral migratory instinct and taken up permanent residence. Some Pacific Gray whales even enter the Central and Southern Gulf to feed during the winter. During El Niño years, when productivity in most of the Eastern Pacific plummets, the Central Gulf remains a refuge for many species, sustaining their populations until conditions improve elsewhere.

In recognition of its remarkable conditions, Francisco de Ulloa (an explorer under the command

of Hernán Cortés) first named the Gulf of California the “Vermilion Sea.” Ulloa, knowing on which side his bread was buttered, also christened the Gulf “Mar de Cortés,” the name that history has kept on the maps.

## B I O D I V E R S I T Y

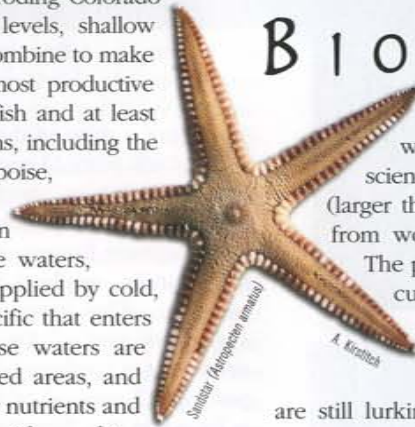
For the past eight years, I have been working with a group of Mexican and U.S. scientists to catalog every known macroscopic (larger than 2 millimeters) species of animal life, from worms to whales, in the Sea of Cortez.

The project, called “Macrofauna Golfo,” has a current tally of nearly 6,000 named species. Of course, this is probably still less than half the actual species count, as many animals yet to be described are still lurking in the rich waters of the Gulf. The cataloged fauna includes 4,857 invertebrates and 1,113 vertebrates (891 fishes; 222 non-fish vertebrates). These numbers rank the Sea of Cortez among the most diverse marine regions on Earth.

The flora and fauna that inhabit the Gulf comprise a rich mix of life derived from an array of sources: from tropical Central and South America, from the Caribbean Sea (before the uplift of Panama sealed the Caribbean-Pacific Seaway 3 to 4 million years ago), from the temperate shores of California (during past glacial periods, when coastal waters were cooler), and even across the vast stretch of the Pacific Ocean from the tropical Indo-West Pacific.

1,432 species inhabit the Upper Gulf and the Colorado River Delta Biosphere Reserve (see page 9), which adds up to 24 percent of the Gulf's total. One of the richest areas in the entire Gulf is Pulmo Reef (near La Paz), the only true coral reef in the Sea of Cortez. Other regions with notably high diversity include Cabo San Lucas, Bahía Banderas, the limited beachrock habitats of the upper Gulf, the oceanic shelf waters of Sinaloa, and all of the Gulf

▼ The Gulf sea pen (*Ptilosarcus undulatus*) is actually a colony of thousands of miniature polyps.







▲ The Gulf cleaner shrimp (*Lysmata californica*) sets up "cleaning stations" over large rocks. Fish passing by the "station" stop by to be cleaned (picked free of parasites and other skin debris) by the shrimp.

islands. Coastal lagoons are also notably diverse areas, and their habitats provide important nursery and feeding grounds for the young of many fishes and shellfish, including most commercial finfish and shrimp.

Of the 891 fishes recorded in the Gulf, 801 are bony fishes (Actinopterygii) and 90 are cartilaginous fishes (Chondrichthyes). Nearly 10 percent of the Gulf's fish fauna (87 species) is endemic, occurring nowhere else in the world. The Gulf's non-fish vertebrate fauna includes 181 sea birds, 34 marine mammals, and 7 marine reptiles.

Two aquatic bird species are essentially endemic to the Gulf, the Yellow-footed Gull and Craveri's Murrelet. These birds, as well as the Least Storm Petrel, Heerman's Gull, and Elegant Tern, rely almost wholly

on the Gulf for reproduction—90 percent of their breeding populations are found in the Gulf, mostly on a few small islands. In the case of the Heerman's Gull and Elegant Tern, 95 percent of their breeding population

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occurs on a single island, Isla Rasa, which is only a square kilometer in size. The Biosphere Reserve is further home to an extraordinary avian diversity of 131 species.

The marine mammal fauna of the Gulf is also astonishingly diverse, with 29 cetaceans (whales, dolphins, porpoises), 4 pinnipeds (sea lions, seals), and one bat (the endemic coastal fishing bat, *Myotis vivesi*).

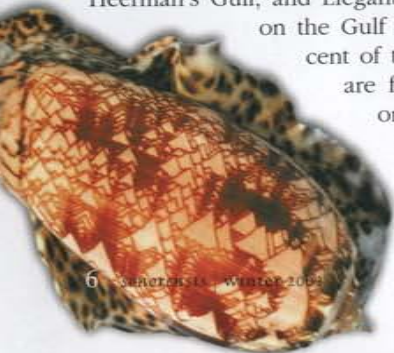


▲ Baby brown pelicans on Isla San Pedro Martir.

More than a third of the world's cetacean species occur in the Gulf, with 22 species of the Odontoceti (toothed whales, dolphins, porpoises) and 7 species of the Mysticeti (baleen whales). One of the cetaceans found in the Biosphere Reserve is the vaquita (*Phocoena sinus*), the world's smallest and most endangered marine cetacean. This rare porpoise is endemic to the uppermost part of the Gulf, where its critical habitat straddles the southern boundary of the Reserve. In all, 38 percent (13 species) of the Gulf's marine mammal fauna is found in the Biosphere Reserve, a testimony to the importance of conservation efforts in this area.

The 7 marine reptiles found in the Gulf include small populations of 5 sea turtles, a sea snake (*Pelamis platurus*), and a crocodile (*Crocodylus acutus*). Four of the turtles inhabit the Biosphere Reserve, and all are threatened or endangered due to historic—and now modern—fishing pressure. Crocodiles are present only in a few estuaries of the mainland side of the Southern Gulf. The yellowbelly sea snake (a tropical Indo-Pacific species) may be seen infrequently in the Central and Northern Gulf, but is increasingly common southward all the way to Ecuador.

There are a whopping 4,857 named species of invertebrates recorded in the Gulf, and 769 of these (16 percent) are endemic to the Sea of Cortez. The Biosphere Reserve is home to 1,053 species of invertebrates, or 22 percent of all those known in the Gulf. At the phylum-level, the highest species diversity occurs with the Mollusca (2,193 species) and Arthropoda (1,051 species). Over 1,530 species of snails (gastropods) alone have been reported in the Gulf.



◀ Gulf text olive (*Oliva porphyria*) - photo by A. Kerstitch



# THE COLORADO RIVER



◀ Gulf sunstar (*Heliaster kubiniji*) - photo by R. Brusca

The single most serious threat to the integrity of the delta's natural communities is probably Colorado River water management decisions made by U.S. politicians. Virtually all of the rivers that once reached the Gulf have been altered or destroyed by overdraft and diversion (including the Ríos Fuerte, Mayo, Yaquí, and Sonora), but the most significant is the Colorado River. Historically, more than 15 million acre-feet of Colorado River water reached the delta annually. Before the completion of Hoover Dam in 1935, fresh water from the Colorado River flowed into the Gulf throughout the year, with great seasonal floods resulting from spring snowmelt in the Rocky Mountains. By the time Glen Canyon Dam was completed in 1962, the flow of Colorado River water arriving at the Gulf had completely ceased. For 20 years after completion of Glen Canyon Dam, as Lake Powell filled, virtually no river water at all reached the sea.

Twenty dams and thousands of kilometers of canals have converted the once-mighty river to a highly controlled plumbing system, and every drop of water is measured, managed, and fought over, with only a dribble reaching the delta. Today, less than 10 percent of the delta's formerly magnificent wetlands remain. Due to the greatly reduced freshwater flow, the powerful tides of this region now overwhelm the delta and river channel. During spring tides, seawater rushes 50 to 60 kilometers upriver, a marine intrusion which has killed

most of the freshwater flora and fauna that used to live along the lower river corridor.

Prior to the construction of Hoover Dam, the annual sediment discharge from the Colorado River into the Gulf was also enormous, estimated to have ranged from 50 to 450 million metric tons a year. Indeed, the entire Northern Gulf is considered the "Colorado River Sedimentary Province." The reduction of sediment discharge, along with freshwater, since 1935 has greatly modified the delta and the Northern Gulf. Rather than receiving sediment, the entire delta is now eroding away due to the forces of tides and storms, exposing ancient river sediments and gradually exporting them out of the Northern Gulf.

▼ Close up of the Gulf sea pen (*Phyllocarpus undulatus*)



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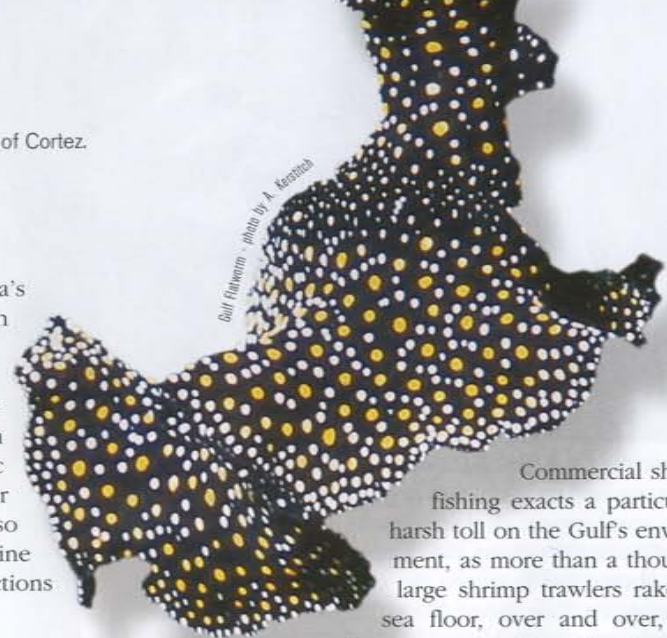
◀ This yellow & red sea fan (*Eugorgia aurantica*) is one of about 20 sea fans known from the Sea of Cortez.

Water has only reached the delta's riparian corridor in recent years when infrequent U.S. flood releases have exceeded the upstream use and diversion capacity. It is likely that the loss of freshwater in the Northern Gulf, in combination with other anthropogenic factors, has driven some species to (or nearly to) extinction. However, we have so little historical or baseline data for marine organisms of this region that most extinctions would go unnoticed.

## OTHER DANGERS

Human development has greatly reduced the rich lagoon and mangrove communities of the Gulf, which are the critical spawning and nursery grounds for shrimp and other invertebrate and fish species. Migratory birds rely heavily on the rapidly disappearing coastal wetlands along this western flyway. In the Northern Gulf, reduction of the brackish estuarine habitat, in combination with overfishing, has driven the large, corvina-like totoaba to near-extinction. Commercial shrimp catches have been falling since the 1960s, due to a combination of overfishing and loss of habitat. The young of these shrimp utilize the shallow wetlands of the region, including the tidelands of the delta, as a nursery, migrating into these areas subsequent to their offshore planktonic larval phase. When the shrimp reach a juvenile or subadult stage, they migrate offshore once again.

Today, every fishery in the Gulf is probably overfished. Commercial trawlers drag nets through the water and across the bottom, set long-lines, and use floating gill nets. Small boat (*panga*) fishers often take shrimp and finfish from coastal lagoons throughout the Gulf before they have even reached reproductive maturity.



Commercial shrimp fishing exacts a particularly harsh toll on the Gulf's environment, as more than a thousand large shrimp trawlers rake the sea floor, over and over, year after year, scraping the top few inches of life off the bottom and into their nets. This damages fragile benthic habitats and displaces 10 to 30 kilograms of bycatch for each kilogram of shrimp, depending on the location and time of year. Almost all of the bycatch is discarded. Bottom areas chronically disturbed by shrimp trawlers and the accumulation of their discarded bycatch on the sea floor experience hypoxia (depleted oxygen levels) or even anoxia (too little oxygen for "normal" life). Profound changes in

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ocean-bottom community structure appear to have taken place over the past five decades as a result of this disturbance, bringing about a decrease in the diversity and biomass of benthic life. Where bottom-



fishers used to capture hundreds of species in each trawl, today's catch is dominated by a handful of scavengers, such as skates and blue crabs.

Vaquita, living only in the northernmost area of the Gulf, are one of the species most endangered by fishing. With the most recent estimate of population size at only 567 individuals, and the fisheries' bycatch mortality at an estimated 39 to 84 deaths per year, the chances for this porpoise's survival are low. Incidental capture in gillnets is the vaquita's primary cause of death, and unless this type of fishing gear is banned in the Biosphere Reserve and critical habitat to the south, the vaquita will soon be extinct.

Many once-abundant but less visible species, such as the threatened giant brown sea cucumber (*Parastichopus fuscus*), are now practically gone from the Gulf. Sea cucumbers have vanished at the hands of Mexican and Japanese fishers who collect them for Asian food markets. Visitors from other places hand-collect these and other marine animals, and trample the fragile habitats exposed at low tide, while locals collect larger animals for sale as curios. In areas of heavy tourism, such as Puerto Peñasco, San Felipe, San Carlos, Mazatlán, and La Paz, littoral biodiversity is but a shadow of what it was just 20 years ago.



Despite these threats, there are still many coastal refugia (areas not easily accessible by road or large fishing boats) in the Sea of Cortez, which serve as important shelters for species extirpated elsewhere in the Gulf. Meanwhile, numerous Mexican, U.S., and European environmental organizations are increasing their conservation efforts. The Mexican government is tightening their fishing laws. In light of these hopeful signs, it seems almost certain that the 21st century will be one in which the rich biodiversity of the Sea of Cortez will begin to receive the protection it needs. **S**



Commercial shrimp  
(*Farfantepenaeus californiensis*)  
photo by M. Wicksten

◀ Shrimp boats, Puerto Peñasco  
photo by R. Brusca



By the late 1980s there was widespread recognition that the Northern Gulf was experiencing an economic and ecological crisis, leading to a series of workshops. In 1992, a group of environmental nonprofits and government agencies submitted a proposal to the Government of Mexico to declare the Upper Gulf of California and the Colorado River Delta a national (Mexican) biosphere reserve. The national fisheries institute of Mexico fought the reserve idea, fearing its economic impact on Northern Gulf fisheries. However, aware of the extraordinary biological and cultural importance of the Upper Gulf and Colorado Delta ecosystems, and under increased international pressure to protect the endangered vaquita and totoaba, the Mexican Government declared this region a 2,336,890-acre Biosphere Reserve in 1993. 412,000 acres of this reserve is in the Zona Núcleo (Core Zone). Except for traditional

practices by the Cucapá people living in the delta, and clam harvesting by local residents, all commercial fisheries were prohibited within the Core Zone, and regulations increased for most fisheries within the buffer zone (Zona de Amortiguamiento). In 1995, the Reserve was accepted into UNESCO's system of worldwide biosphere reserves. The Upper Gulf/Delta Biosphere Reserve has an official "sister reserve" on the Colorado River in the U.S., the Imperial National Wildlife Refuge (U.S. Forest Service). This partnership has proven highly useful in coordinating efforts at protecting wildlife, especially migratory waterfowl. Although the flora and fauna of the Northern Gulf is fairly well known, the biota of the Biosphere Reserve and delta region are largely unexplored. Fundamental biological exploration remains to be made along the coastline in the uppermost Gulf and within the delta itself.