CASTAWAYS OF CALIFORNIA
The Origin of Animal Life of the Channel Islands

by CHRISTOPHER D. NAGANO, SCOTT E. MILLER and CHARLES L. HOGUE

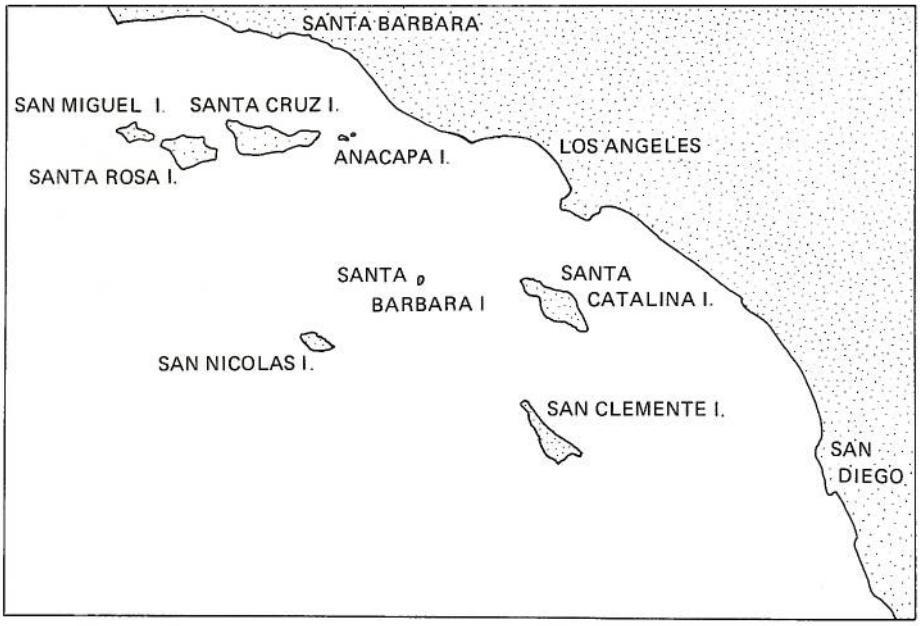
The California Channel Islands are home to a surprising variety of animals, from tiny insects to foxes and elk. Even giant mammoths lived there in the past.

The visitor asks "How did they get there?" and "How can there be so many kinds when the islands are separated from the mainland by miles of ocean?"

The answer is found in the geological history of the islands as well as in the nature of the creatures themselves.

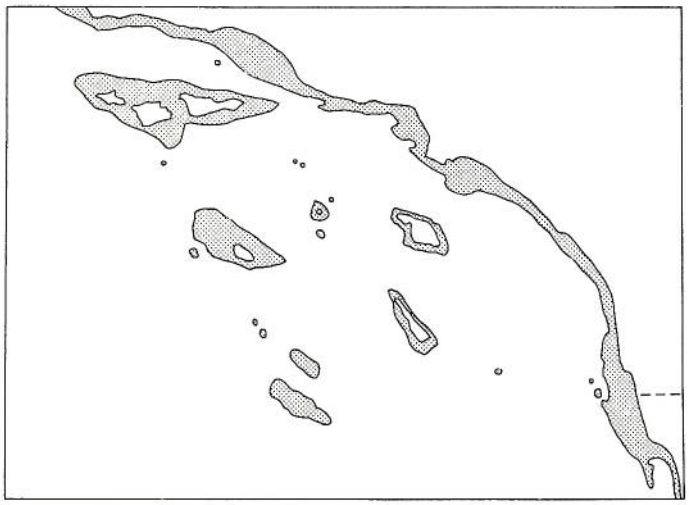
GEOGRAPHY

The Channel Island group is composed of eight islands located off the coast of southern California. The group itself is divided by a wide sea lane into a northern subgroup, consisting of four islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa) and a southern subgroup (Santa Catalina, Santa Barbara, San Nicolas and San Clemente). The islands range in size from tiny 1-square-mile Santa Barbara Island to the expansive 96-square-mile land mass of Santa Cruz Island.



Above: The California Channel Islands.

Below, left: Coastlines of the mainland and the Channel Islands at the time of highest sea level during the Pleistocene Epoch (shaded) (present day shorelines unshaded).Right: Coastlines of the mainland and the Channel Islands at the time of lowest sea level during the Pleistocene Epoch (shaded) (present day shorelines unshaded). After J.G. Vedder and D.G. Howell (in D. Powers, 1980. The California Channel Islands: Proceedings of a multidisciplinary symposium. Haagen Printing, Santa Barbara).



Channel Islands Fox (Urocyon littoralis) *on San Miguel Island. Photograph by Paul Collins, Santa Barbara Museum of Natural History, Santa Barbara.*

The existence and positions of the islands were determined millions of years ago by complex geological processes generated when two great pieces of the Earth's surface known as the Pacific and North American tectonic plates were forced together. The junction where the tectonic plates collide is still the focus of earthquakes, mountain building, vertical shifts in the land, uplifting and subsidence, the formation of ocean troughs, and the building of mountain ranges. Out of this gnashing and gnarling of the edge of southern California, the Channel Islands were born sometime during the Miocene Epoch, some 20 million years ago.

Since that period, the islands have been at times above water or submerged, either because of vertical changes in the Earth's crust or changes in sea level. The latter occurred during the beginning of the Pleistocene Ice Ages some 2 million years ago when glaciers covered immense land areas and sea levels dropped, exposing the islands. During the four interglacial periods, glaciers melted, sea levels rose and the islands were submerged, perhaps leaving only their highest peaks exposed.

Twenty thousand years ago, the four northern islands were united by glacially lowered sea levels into one super-island mass that we now refer to as "Santarosae." Subsequently, rising sea levels caused by the melting of the glaciers at the close of the Pleistocene separated Santarosae into the islands we are familiar with today.

The southern islands have always been separated from each other and the mainland. Some scientists have proposed that they were connected to other islands or to the mainland, but examination of the submarine geography and geological history provides no support for this belief.

Animal Life of the Islands

Although there is a great diversity of animal life on the Channel Islands, there are fewer species there than in areas of comparable size and habitat on the mainland. Most island species are also found on the southern California mainland, but some are endemic (found in one place and nowhere else in the world). Because of isolation, many island creatures have evolved into forms that are much larger, smaller, or differently colored than their mainland relatives.

The Dwarf Mammoth *(Mammuthus exilis)*, which was only 6 feet tall, inhabited the northern islands during the Pleistocene. Its ancestor was the 18-foot-tall Jefferson's Mammoth *(Mammuthus jeffersonii)*, which had become stranded on the islands thousands of years before. Widely fluctuating food supplies in the finite island environment dictated that smaller individuals survived. Thus, over time, through natural selection, the island mammoth became much smaller than its mainland ancestor. The Dwarf Mammoth, along with many other large mainland and island mammals, became extinct at the close of the Pleistocene Epoch, some ten thousand years ago.

The Channel Island Fox *(Urocyon littoralis)* is found on all of the islands except Santa Barbara and Anacapa. It is significantly smaller than the widespread, and probably ancestral, mainland Gray Fox *(Urocyon cinereoargentatus)*, to which it is closely related.

The extinct Giant Island Mouse *(Peromyscus nesodytes)* of Santa Rosa and San Miguel Islands and the Anacapa Mouse *(Peromyscus anyapahensis)* from

the island of the same name provide further examples of size modification as a result of isolation. These extinct mice were several times the size of modern *Peromyscus* mice (which are about house mouse size). Some Giant Island mice were as large as pack rats; the Anacapa mouse was slightly smaller, although still a respectably sized animal. Both are known from ice age fossils, but remains of the Giant Island Mouse have also been found in Indian middens, indicating that this creature coexisted with man and survived until some 2,000 years ago.

The Dwarf Mammoth, island mice and Island Fox are examples of the general trend for mammals—after introduction to islands—to become larger if small and smaller if large. Lack of predators apparently favors largeness; fluctuating availability of food sources leads to smallness.

Color patterns are also modified by insular selective forces. The Santa Cruz Island Scrub Jay *(Aphelocoma coerulescens insularis)* is closely related to mainland scrub jays, but it is a darker blue and has slightly different mating behavior. This animal is only found on Santa Cruz Island, although suitable habitats exist on some of the other islands.

A unique population of garter snake *(Thamnophis couchi hammondi)* inhabits an isolated canyon on Santa Catalina Island. Unlike other garter snakes of this species, this population lacks distinctive stripes and is a deep olive brown with a pale buff colored chin and lips. The present day snakes on the island may have descended from only one or a few individuals which had an unusual color pattern and passed it on to their offspring ("founder effect"). Because the Santa Catalina Island Garter Snake most closely resembles a population found at nearby Lompoc on the mainland, the latter may have been the source of the original island population. Sadly, the island snake is threatened with extinction because of snake collectors and adventive bullfrogs that eat the young reptiles.

The insects and other terrestrial arthropods (spiders, millipedes, centipedes, etc.) of the islands are still poorly known. However, the information that has been collected about some species or groups forms an important part of the study of Channel Island zoology. Although most of the island insects are largely identical to their mainland relatives, some are larger and/or darker colored than their southern California counterparts, and some are truly unique.

The Avalon Hairstreak Butterfly *(Strymon avalona)*, which is found only on Santa Catalina Island, has one of the most restricted ranges of any insect in the world. Its closest relative, the common Gray Hairstreak *(Strymon melinus)*, is found on all the Channel Islands and throughout North America. The Avalon Hairstreak is distinctly different from its near relative in its smaller size and lack of dark markings on the underwings. The island butterfly probably evolved into its present form from a mainland ancestor, possibly *melinus* itself, that arrived on the island millenia ago. Alternatively, but more improbably, the Avalon Hairstreak may be a "relict" species, that is, a species that was once widespread but that now exists in one or only a few places.

Grasshoppers, crickets, katydids and their cousins (Orthoptera) are the only group of island insects to be intensively studied. Entomologists David Rentz and David Weissman found that of the 52 species of Orthoptera inhabiting the Channel Islands, 12 are found nowhere else in the entire world (they are endemic). For example, of the silk-spinning crickets *(Cnemotettix)*, one species *(C. caudulus)* is found only on the northern group of islands, another *(C. miniatus)* only on Santa Catalina and in northern Baja California, a third *(C. spinulus)* on Santa Cruz, Santa Rosa, Anacapa and San Nicolas and a fourth *(C. pulvillifer)* only on San Clemente Island. It is unlikely that these endemic island Orthoptera represent relict populations of various species once widespread on the mainland. It is more probable that they had a common ancestor species and that members of this species arrived on each of the islands separately and evolved independently over time into the present day species.

ORIGIN OF THE ANIMAL LIFE

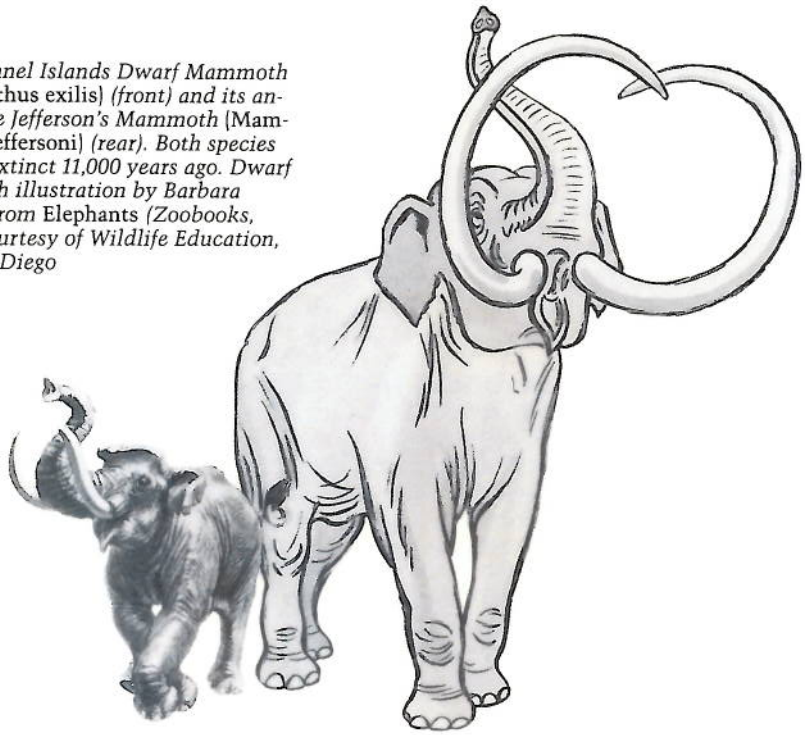
The animals of the Channel Islands are clearly related to the fauna of the mainland, but how they arrived is still the subject of debate. For many years, biologists assumed as "fact" that the wildlife of all islands—even those at great distance from the nearest continent—must have traveled to them over terrestrial connections or land bridges. The practice led the well-known biogeographer Dr. E. C. Zimmerman to comment, "So many continents and land bridges have been built in and across the Pacific by biologists that, were they all plotted together on a map, there would be little space left for water." A logical result of land bridges is that the composition of animal life on an island should approximate that of the closest adjacent mainland area to which there was a hypothetical connection, constituting a "balanced" fauna.

For a long time, because of a believed "balanced" fauna (and flora) it was thought that the northern Channel Islands were an extension of the Santa Monica Mountains and were once connected to the mainland by a land bridge that extended aross the ocean from Point Mugu. However, modern detailed geological and biotic analysis of the two regions have revealed their biotas actually to be significantly different. For example, southern California herpetologist Jay Savage found that only 16 different reptiles and amphibians inhabit the Channel Islands compared to the 36 species known from the adjacent mainland. We now know that, even during the period of lowest sea level during the Pleistocene Epoch, there was always an ocean barrier between the islands and the mainland; because many life forms that should be on the islands are absent, the fauna is actually somewhat "unbalanced."

The concept of a land bridge to the northern Channel Islands was also based on the presence of Dwarf Mammoth fossils. It was assumed the prehistoric pachyderms and their modern counterparts were unable to cross a water barrier. But modern elephants are, in fact, excellent swimmers. Recent observers in Africa have seen them often swim in lakes and rivers, and herds on the coast have been known to travel to offshore islands, snorkeling with their trunks held out of the water. Furthermore, Indian elephants have been observed swimming in water for as long as 6 hours. Biologists now believe that, because of the lowered sea level caused by the growth of glacial land masses, the ocean gap between Santarosae and the mainland was as little as three and a half miles wide. Thus, the ancestors of the Pygmy Mammoths might have easily traveled to the islands from the mainland by swimming across such a narrow channel.

The lack of a land connection to the mainland means that animals must have reached and be still reaching the islands by flying or swimming or riding out on logs and other floating debris. Chance, not logic, is the most important factor in this way an animal expands its range. This is known as "sweepstakes dispersal" and leads to an "unbalanced" fauna different in composition from that of proximate mainland.

It is easy to envision how animals such as lizards, mice and snakes could have rafted to the islands by riding on floating debris after being washed out to sea by storms. Although salamanders and frogs are intolerant of salt water, these creatures would be protected during the trip to the islands by the partially decayed logs that they normally inhabit. Direct evidence for the probability of animals traveling to the islands by rafting came in 1955 when J. H. Prescott, a mammalogist, observed a jackrabbit sitting on a kelp raft some 39 miles off the coast of California near San Clemente Island. It is highly likely that over a time span of hundreds of thousands of years, countless animals could have been washed



The Channel Islands Dwarf Mammoth (Mammuthus exilis) *(front) and its ancestor, the Jefferson's Mammoth* (Mammuthus jeffersoni) *(rear). Both species became extinct 11,000 years ago. Dwarf Mammoth illustration by Barbara Hoopes, from* Elephants *(Zoobooks, 1982). Courtesy of Wildlife Education, Ltd., San Diego*

out to sea by storm-laden creeks and rivers, and that — by riding on drifting logs or other debris — a tiny percentage could have reached the islands alive. Further support for this idea lies in the fact that the larger of the Channel Islands that are closer to the mainland have more types of animals than those that are smaller and further away: there is a greater probability of individuals reaching the bigger and closer land masses by sweepstakes dispersal.

MAN'S ROLE

Man has also played a significant part in determining the animal life of the Channel Islands. Recent anatomical studies by Paul Collins indicate that Island Foxes on the northern islands are more closely related to each other than to those on the southern islands. It would appear most likely, therefore, that the ancestral species was introduced on rafting material to Santarosae during the Pleistocene and, once there, evolved into the smaller Island Fox. When rising sea levels separated the big island into the present day four smaller islands, the fox survived on San Miguel, Santa Rosa and Santa Cruz. The final dispersal of the foxes to the southern islands occurred when Chumash Indians arrived on the scene, approximately 10,000 years ago, and carried the foxes to San Clemente, Santa Catalina and San Nicolas in their canoes.

Although the remains of Island Foxes have been found in prehistoric refuse mounds, the relationship of these animals to the Chumash people is unknown. The Indians may have used the Island Fox as a pet, as a food source, for its pelt (which could be used as clothing), or for use in religious ceremonies. Escaped foxes could easily have established feral populations on the other islands.

Twentieth century man has introduced animals to the Channel Islands deliberately for food or sport or accidentally out of sheer ignorance. Animals recently introduced include pigs, sheep, goats, rats, turkeys, cattle, cats, elk, deer, peacocks, dogs and rabbits; some have caused great damage to island ecosystems. Bison *(Bison bison)* have become almost a symbol of Santa Catalina since about a dozen were brought over from the mainland in 1920's to costar in the movie "The Vanishing Americans" and some episodes of the Tom Mix cowboy series. The small nucleus has increased to approximately 400 animals, which now roam freely over the island.

When animals are introduced for the first time into an area, they often experience enormous population explosions because of freedom from predators and the lack of other restraints that controlled their numbers in their native environments. Plant feeding types often consume all of the native vegetation in their new home in a short time; introduced carnivorous species may quickly eat all the suitable resident prey animals. These side effects on the native flora and fauna are magnified in isolated ecosystems such as islands.

Many areas on the Channel Islands have been devastated by goats and sheep. The former were placed on San Clemente sometime in the mid-1800's, thus the island has suffered goat-caused environmental damage for over 100 years. These feral creatures, with their legendary vacuum cleaner feeding habits, have denuded vast areas of the island, resulting in the near extinction of many endemic plants and animals. Overgrazing, as well as elimination of vegetation caused by trampling by countless goat hooves, also contributed to erosion of the island. Recent efforts to remove the goats by trapping have been successful, however, and the luxuriant native vegetation is now beginning to recover, hopefully reversing the destruction of the last century.

VALUE OF THE FAUNA

Even before Charles Darwin voyaged to the famed Galapagos Archipelago, where many of his ideas on natural selection became crystalized in his mind, the flora and fauna of islands had fascinated scientists. Because of their relatively small size and completely self-contained biotic systems, islands are a perfect natural laboratory for investigating evolution, ecology and other biological subjects that would be difficult, prohibitively expensive or even impossible to study in larger mainland areas.

Although the Channel Islands have suffered under the hand of man for many years, efforts to restore them by governmental agencies, such as the National Park Service, and private organizations, including The Nature Conservancy, have helped to protect the remaining natural ecosystems. Yet we are still imposing diverse threats to island wildlife through increased recreational use, newly introduced animals, passing petroleum and natural gas tanker traffic, harvest of nearby marine resources, oil drilling, sonic booms from overflights of landing space shuttles, and the various military operations in the area. Whether or not the current island wildlife populations can survive remains to be seen.

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Dr. Charles L. Hogue is Curator of Entomology at the Museum. Although his interests in insect island biogeography center mainly on the oceanic islands of the far northeastern tropical Pacific, he has visited several of the Channel Islands and encourages entomological work there among local collectors and students.