CONSERVATION SCIENCE IN MEXICO'S NORTHWEST

ECOSYSTEM STATUS AND TRENDS IN THE GULF OF CALIFORNIA

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INTRODUCTION

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The history of Baja California and the Gulf of California is one of evolution in isolation. It is a natural account of the deep causes of the diversity of life on Earth. All along the Gulf the driving theme is insularity: During the last six million years the Gulf of California has kept the long and dry peninsula separated from the Mexican mainland, and the Peninsula of Baja California has maintained the Gulf literally submerged in its own depths, sequestering it from the Pacific Ocean. On this landscape of sea and land that mutually embrace each other, keeping in solitude the genetic secrets of their founding life forms, smaller patches of insularity are superimposed at even smaller scales. Marine islands surround the Peninsula on all sides, and high mountains, true sky islands in a desert sea, imprint the landscape all the way from the U.S. border down to Los Cabos. Palm oases in deep, disjunct canyons form yet again thousands of wetland islands within the rocky matrix of the peninsular ranges. The seacoast is fringed by coastal lagoons that repeat in a fractal manner the isolation theme in smaller and smaller bodies of water.

These patches of segregation are the driving force of biological speciation, of adaptation to local conditions and specialization to particular isolated environments. After millions of years, fragmentation yields unique life forms. It also yields unique cultures. Quite separated from the rest of Mesoamerica, the Cochimí Indians developed here one of the most incredible assemblages of cave paintings in the world. Later, during the Spanish colony, the Jesuit fathers founded here their own Utopia in a system of missions that evolved in complete independence from the hard and cruel rules of the mainland *conquistadores*. True to the etymology of the word, the Peninsula has been indeed almost an island. Even in recent decades, the remarkable Mexican journalist Fernando Jordán referred to Baja California as "the other

Mexico" (*el otro México*). It has always been a land of fantasy and adventure, a territory of surprising, often bizarre growth-forms, and of immense natural beauty.

At present, however, modern transportation, population growth, urban sprawl, agricultural technology, and modern fishing techniques, among other causes, seem to be putting stress on the fragile peninsular environment. This book is an attempt at discussing some of the issues related to environmental degradation and natural resource conservation in the region within a regional perspective.

BIOLOGICAL UNIQUENESS

Few places show the extraordinary environmental heterogeneity of the Peninsula of Baja California and of the Gulf of California. The regional climates vary from mediterranean-type winter rains in the north, to monsoon-type summer rains in the south. The steep slopes of the mountain ranges generate some of the most dramatic environmental gradients on Earth. The northern part of the Peninsula extends from a coastal sclerophyllous scrub in the west, to a dry subtropical desert in the east, with a sequence of mediterranean scrubs (chaparral) and temperate pine-oak forests covering, respectively, the intermediate and the highest altitudes of the central mountain ranges. A rare form of tropical deciduous forest occupies the lowlands of the Cape Region, in the southern part of the Peninsula. Also in the Cape region, but in higher elevations, temperate pine-oak forests are found in the mountains of the Sierra La Laguna. This unique temperate ecosystem—a relictual memory of past glaciations—has evolved in extreme isolation, and is composed mostly of rare, highly endemic species. Similar areas of geographic isolation and biological rarity are found in the central mountain ranges (San Francisco, Guadalupe, and La Giganta), and in the oceanic islands of the Gulf of California and of the Pacific coast.

The flora of Baja California contains an extraordinarily high proportion (almost 30%) of endemic species. Endemism (*i.e.*, the property of being uniquely restricted to a small area) is particularly high in the island ecosystems of the region, both in the Pacific and the Gulf of California, and in the isolated *sierras* such as San Pedro Martir, Juárez, La Libertad, San Francisco, Guadalupe, and La Laguna. Similar levels of endemism are found in reptiles and land mammals, 22% of which are endemic.

Even in the case of birds, which by their volant nature are more cosmopolitan, the region of Southern California and Baja California harbors 11 strictly endemic species and 114 endemic subspecies: 2% of the avian species richness is endemic, and a remarkable 22% of the diversity at the subspecies level is unique to the region. Extinction is already a major threat for many avian species. The Guadalupe storm

petrel (*Oceanodroma macrodactyla*), a rare and highly endemic marine bird, has already become extinct, and so have some seven other local, very restricted subspecies.

In the same way as the Peninsula is isolated from the Mexican mainland by the Gulf of California, the Sea itself is also a sort of "marine peninsula", isolated from the rest of the Pacific by the 1,500 km of land of Baja California. Biologically, the Gulf of California –also known as Mar de Cortés– is one of the most productive and diverse seas in the world, harboring some 4,900 known invertebrate species (excluding the single-celled protozoans), with a very high level of endemism (Brusca 2010). Some authors estimate that a similar amount of invertebrate species remains undescribed in this extraordinarily rich environment. A similar situation of exceptionally high diversity is found in marine fishes. Around 911 species have been recorded in the Gulf, 86 (10%) of which are endemic to the region. Of these, teleostean fishes comprise some 750 species. Reef fishes, in general, have more restricted distributions than deep-sea, pelagic, or sandy shore species. Of 271 known reef fishes in the Gulf of California, some 52 species (19%) are endemic to the region. The Gulf is also extremely rich in marine mammals, harboring 36 species. Of these, 31 are cetaceans, including the highly endemic *vaquita* porpoise (*Phocoena sinus*) that is only found in the Upper Gulf (Brusca 2010).

The high diversity of the Gulf of California is largely due to two phenomena: (a) the great variety of general habitats that are found in the Gulf, including mangrove swamps, coastal lagoons, coral reefs, shallow and deep sea basins, hydrothermal vents, and a diverse array of shore and subtidal substrates; and, (b) the complex geological and oceanographic history of the Gulf, including past invasions of animal immigrants from Tropical South America, the Caribbean Sea (before Earth's tectonic forces sealed the Panama seaway), the cold shores of California (during past glacial periods), and across the vast stretch of the Pacific Ocean from the Tropical West Pacific. The Gulf is important both biologically and economically. It houses an inordinately high proportion of the marine species richness of Mexico, and yields some 30% (*ca.* 600,000 tons) of the catch of national fisheries. The sustainable use and the conservation of the Gulf of California are critical issues under both points of view.

THE SOCIOECONOMIC BACKGROUND

The region is not only one of Mexico's richest areas in terms of natural resources; it also holds one of Mexico's fastest growing regional economies. The *maquiladora* industries in Tijuana, the high-input crops and associated agro-industries in the

agricultural valleys (Mexicali, Valle de Guadalupe, San Quintín), and the growing tourism industry, are all powerful driving forces of economic and demographic growth. Indicators of economic development show values that suggest a relatively high economic development compared to the rest of Mexico. Globally, the Peninsula of Baja California has levels of illiteracy of less than 4%, the number of houses with electricity approaches 90%, and the mean number of live children per woman over 12 years is around 2.4 (for comparison purposes, the State of Oaxaca in southern Mexico has 17% of illiteracy, only 73% of its houses have access to electricity, and the mean number of live children per woman above 12 years of age is 3.1). The *per capita* contribution of the peninsular inhabitants to the GDP is more than 20% above the national average. However, the success of the peninsular economy has brought a large demographic increase to the region, mostly derived from internal migration within Mexico, from the impoverished southern States into the more dynamic economy of Baja California.

This fast demographic and economic growth poses some pressing environmental problems to the region: On the one hand, it is extremely difficult to keep adequately supplying services such as running water and sewage to cities that double in size every ten years. Rapid demographic growth means, almost by definition, an increasing lag in water and electricity supply, and in sanitary infrastructure, including poor drainage and lack of water-treatment facilities, with the concomitant results of pollution and environmental degradation. On the other hand, rapid growth means an ever-increasing demand for freshwater, fisheries, and other natural resources, many of which are scarce in the Peninsula, chiefly due to the aridity of the region. Thus, the rapid expansion of the peninsular population is mostly done at the expense of depleting underground aquifers, degrading coastal wetlands, and of destroying the natural ecosystems and the watersheds that surround the large urban conglomerates.

AIMS AND SYNTHESIS

Both the Mexican government and the conservationist non-governmental organizations (NGOs) have developed actions to protect the incredibly rich and increasingly endangered ecosystems of Baja California. The region harbors now a large number of protected natural areas. Since 1993 there has been an immense effort to decree and protect new areas. Significant efforts have been also developed to promote the sustainable use of fisheries and ocean natural resources in general. Many of these advances are discussed in detail in different chapters of this book.

However, and despite the progress achieved, it is difficult to say at this time if the increasing pace of conservation efforts in Mexico is being able to stall the

environmental degradation that the region is suffering. The optimistic note is that there seems to be in the Peninsula of Baja California and in the Gulf of California a growing awareness, as never was observed before, of the importance to take urgent action to protect the environment. The swelling number of conservation actions that have been taking place is not the sole merit of any sector. Local communities, conservation groups, research institutions, federal and state governments, NGOs, and conscientious businesspersons and eco-tourism operators have all been contributing to the growing appreciation of the environment, and to the attendant conservation actions.

It is the right moment to bring academic institutions into joint cooperative efforts to protect this land and this sea, to bring robust science into the discussion about the region's environmental future. This drives the objective of this book, to bring the academic community together in order to develop a synthesis and a vision for the Gulf of California region.

We want to thank, first and foremost, all our colleagues that made an effort to contribute to this synthesis. The edition of this book was partially funded by the David and Lucile Packard Foundation and by the Pew Fellows Program in Marine Conservation.

The Gulf of California region is part of a large ecological continuum, a large basin that involves both Mexico and the United States, with shared watersheds, species, and natural resources. The protection of these unique environments is of the uttermost importance for the survival and wellbeing of all of us, for generations to come. We hope the publication of this book may bring the perspective of science into the rich, and urgently necessary, debate about the environmental future of this extraordinary region.

REFERENCE

Brusca R. (ed.). 2010. *The Gulf of California: Biodiversity and Conservation*. Arizona-Sonora Desert Museum Studies in Natural History. The University of Arizona Press and ASDM, Tucson.

Exploring Mexico's northwest, the Baja California Peninsula, its surrounding oceans, its islands, its rugged mountains, and rich seamounds, one feels diminished by the vastness and the greatness of the landscape while consumed by a sense of curiosity and awe. In a great natural paradox, we see the region's harsh arid nature molded by water through deep time, and we feel that its unique lifeforms have been linked to this desert and sea for thousands of years, as they are now.

These landscapes of fantasy and adventure, this territory of surprising, often bizarre growth-forms and of immense natural beauty, has inspired a wide array of research for over two centuries and continues to inspire the search for a deeper knowledge on the functioning, trends, and conservation status of these ecosystems in both land and ocean.

This book offers a compilation of research efforts aimed at understanding this extraordinary region and preserving its complex richness. It is a synthesis of work done by some exceptional researchers, mostly from Mexico, who indefatigably explore, record, and analyze these deserts and these seas to understand their ecological processes and the role of humans in their ever-changing dynamics.

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