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ECOSYSTEM STATUS AND TRENDS IN THE GULF OF CALIFORNIA

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THE BAJA CALIFORNIA PENINSULA WEST COAST: A TRANSITIONAL ZONE BETWEEN BREEDING AND FEEDING GROUNDS FOR MIGRATING WHALES AND SEASONAL FEEDING HABITAT FOR OTHER CETACEANS

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The coastal area of the Baja California west coast is known as an important area for all migrating whales since the early whaling period. This area represents a migrating corridor and also serves as breeding and feeding area for several species of cetaceans. While the coastal habitat is relatively non developed and still provides a good quality habitat for cetaceans, it should be protected from gillnet fishing at least seasonally. A seasonal rhythm of cetacean stranding was associated with natural processes occurring within the ecosystem with higher incidences in the late spring and early summer months, coinciding with the seasonality of the highest rates of net primary production in the area. Regulation of whale-watching should be promoted particularly in non-protected coastal areas along the Baja California Peninsula.

Keywords: Baja California west coast, cetaceans, whaling, distribution, cetacean stranding, anthropological impact.

1. INTRODUCTION

South of the vastly developed coast of California, lays the Baja California Peninsula (see Figure 1). With few human settlements, this dry and desert land, long considered a Mexican territory, was untouched until recently, when coastal developments and marine traffic have increased very fast, principally at both extremities. Along more than 2,000 km of coastline, there are very few shelters to anchor for protection and no marinas to purchase supplies, so most of vessels sail in transit between California or Ensenada to Cabo San Lucas.

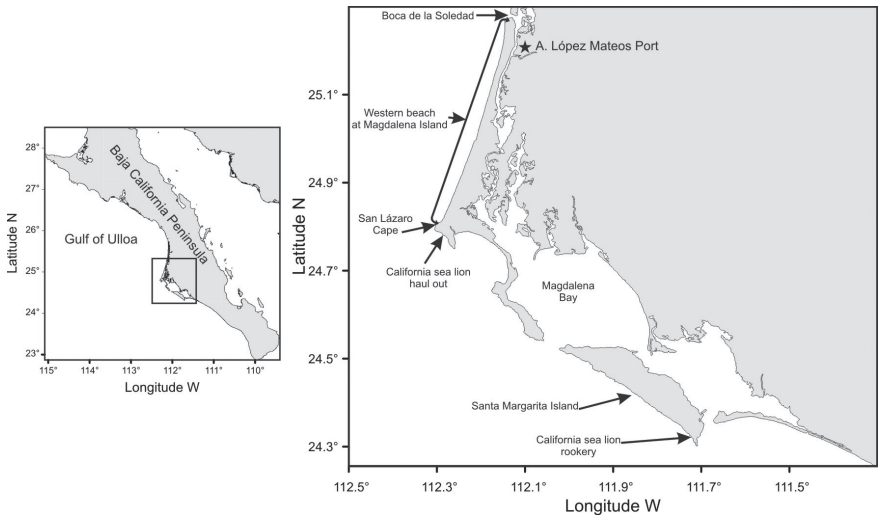

FIGURE 1. The Baja California Peninsula showing the study site at Magdalena Island.

The ocean along this coast is where the southern limit of the California Current joint with the northern limit of the North Equatorial Current and is characterized by the high biological productivity generated by seasonal upwellings and frontal systems (Lluch-Belda *et al.* 2003). The pelagic area off the southern portion is recognized as one of the Northeastern pelagic hotspot for conservation of marine species (Etnoyer *et al.* 2004). The area has never been intensively studied. Since 1997 CICESE initiated the Mexican program IMECOCAL (Programa de Investigaciones Mexicanas en la Corriente de California http://imecocal.cicese.mx/) to monitor the area north of Bahía Magdalena following the CALCOFI (California Cooperative Fisheries Investigations, www.calcofi.org) oceanographic cruises made in the past. Unfortunately due to the high cost to sustain these oceanographic cruises, in addition to the intense research activities onboard on a relatively small ship, cetacean assessments has not been part of these surveys.

Along this coast, several cetacean species are using the area partially or throughout the year, but the knowledge of their habitats, movements and feeding habits along the coastal and pelagic areas remain poorly known. It is therefore the objective of this chapter to gather the past and present information to highlight the significance of this area as an important migratory corridor for several whales and also as a seasonal feeding area for other cetaceans. A special section will illustrate the use of cetacean stranding surveys in a portion of the coastal area of the Peninsula to gather knowledge on the temporal use of the habitat by these populations.

The first piece of information on cetaceans along this coast was revealed by the detailed mapping of the whales caught around the world from 1761 to 1920 by Townsend (1935). These included the slow moving whales, such as the sperm whales, the humpback whales, and the North Pacific right whales. Another source of information on several cetacean descriptions and distributions along this coast comes from Scammon's book (1874 reprinted in 1968), the famous captain of a whaling ship that discovered the gray whales breeding lagoons. Information on other whales, is available from the period between 1924 and 1929 when the Norwegians whalers revealed the seasonal presence of faster rorquals such as blue, Bryde's and sei whales based on their reports of each species captured in the area (Tønnessen and Johnsen 1982). While several species were being protected in the 60's, scientific cruises were made to assess these reduced populations due to whaling (Rice 1966, 1974). Thereafter, more cruises conducted by different institutions: the Universidad Autonoma de Mexico (Urbán and Aguayo 1985), the Southwest Fisheries Science Center (Mangels and Gerrodette 1994), and CICIMAR (Gendron 2002, unpublished data), will help to describe the seasonal distribution of large whales in this particular area.

2. GRAY WHALE (*ESCHRICHTIUS ROBUSTUS*)

One of the most important aspects that favored the fast recovering of the gray whales is perhaps due to the relatively intact coastal area of the Peninsula including their well known breeding lagoons: Laguna Ojo de Liebre (Scammon's lagoon), Laguna San Ignacio and Bahía Magdalena (Scammon 1968). These have remained essentially unchanged since the end of the whaling of this species during the 30's. Except Bahía Magdalena, the other lagoons are protected areas that are included in the El Vizcaíno Biosphere Reserve, which is also listed internationally as a UNESCO World Heritage Site and a Ramsar protected wetland (Hoyt 2005).

The most important change that occurred since these whales were protected, was the start of the salt exploiting by the Compañía Exportadora de Sal, S.A. in Guerrero Negro in the 50's and the start of the whale-watching activities mostly in San Ignacio lagoon in the 70's and expanding south to Bahía Magdalena (Gardner and Chávez-Rosales 2000) and to Los Cabos, and north to Scammon's lagoon and off Ensenada.

An excellent review and summary on gray whales whaling history, conservation and research in Mexico is documented by Urbán *et al.* (2003). Their coastal migration is well known from the Bering Sea passing different coastal points at precise dates along the north American coast reaching the Baja California breeding lagoons mostly in January (Rice and Wolman 1971, Rugh *et al.* 2001). Pregnant females arrive first and use the most intern and protected areas to give birth to their young and

to nurse them (Rice and Wolman 1971), and will spend in general more time in the lagoons than the males or non pregnant females (Jones and Swartz 1984, Gómez-Gallardo Unzueta 2004). These single whales gathered at the entrances to reproduce, stay for shorter periods in the lagoons and may move from one breeding lagoon to another (Jones and Swartz 1984). South of the Bahía Magdalena they are scattered along the coast down to Los Cabos, and during El Niño years they extend their range south and are found well inside the Gulf of California (Urbán *et al.* 2003). Although gray whales mainly feed in the northern areas (Kim and Oliver 1989) they have been observed with sand coming out of their mouth while surfacing near the entrance of the lagoons (S. Lanham, pers. com.) and also observed chasing sardines at surface in Magdalena Bay (Gendron, not published).

Single whales are the first to initiate the northbound migration while the females accompanied by their calf are the last to leave the lagoons with a difference of one month observed for whales in San Ignacio lagoon (Jones and Swartz 1984). A single gray whale radio tagged revealed a clear coastal northern route at a mean distance of 7.3 km in water less than 100m deep, except when crossing the Vizcaíno Bay (Mate and Urbán 2003).

3. HUMPBACK WHALE (*MEGAPTERA NOVAEANGLIAE*)

Another species that principally uses the Baja California west coast seasonally is the humpback whale. This species is also well known to aggregate in breeding areas, but prefers islands or specific areas along the coast instead of lagoons. The Mexican humpback breeding areas include the southern coasts of Baja California Peninsula, mainland coast of central Mexico and the Revillagigedo Islands (Rice 1974). A fourth area where humpback whales are sighted mostly in winter is the Gulf of California (Urbán and Aguayo 1987, Urbán *et al.* 2000). As for the west coast of the Baja Peninsula, Townsend (1935) indicated aggregation of humpback whales captured in this area and along the central Mexican coast. It is interesting to note that Scammon (1968) mentioned the area off Bahía Magdalena as one of the three best areas to capture them, and coincide with the reported of 1,568 humpback whales caught there between 1924 and 1929 by the Norwegian whalers (Tønnessen and Johnsen 1982). The aggregations of humpback whales along the coast may indicate they feed during their movement north, but aside feeding behavior described in the Gulf of California (Gendron and Urbán 1993), no other feeding observation have been reported.

There are two migration routes for the humpback whales wintering in Mexico, the whales wintering in the coastal mainland and Baja California region migrate along

the coast to reach California-Oregon-Washington and British Columbia, while the ones wintering around the Revillagigedo islands are separate from the American stock and probably migrate to the Aleutian islands and or the Bering Sea (Urbán *et al.* 2000, Calambokidis *et al.* 2001).

4. BLUE WHALE (*BALAENOPTERA MUSCULUS*)

During the mid 19th century, Scammon (1968) described aggregations of blue whales along the coast of Baja California, close to Cedros Island "it was the month of July and the sea, as far as the eye could discern, was marked with their huge forms and towering spouts". Despite their velocity, some were captured in the inshore areas by Tortuga bay, Asuncion Island, and San Quintin (Scammon 1968). At the start of modern whaling (1913–1914), the Norwegians caught eighty-three blue whales off Bahía Magdalena (Tønnessen and Johnsen 1982). They returned a decade later with two floating factories and captured about 870 blue whales between the months of March and June during the 1924–1929 period (Tønnessen and Johnsen 1982), which represent almost half of the blue whales caught along the shore of the North American west coast. A last expedition was made, in conjunction with Mexico under the company named Esperanza in 1935, but no blue whales were observed.

About 40 years later, the Baja West coast area was declared by Rice (1966, 1974) as one of the world's last remaining blue whale sizable stocks. From these cruises, he reported the same general distribution, with large aggregations of blue whales from February to July relatively close to shore. Between 1994 and 1996 two coastal cruises and several aerial surveys made along the whole west coast of Baja California showed blue whales in February and March off the southern portion of the west coast and by June, they were distributed along the entire coastal area of western Baja California (Gendron 2002). In addition, blue whales apparently follow the shift in seasonal productivity around the Peninsula, from the Gulf of California during winter and early spring to the west coast between April and July (Santamaría-Del Ángel and Álvarez-Borrego 1994) where and when surface feeding is also observed (Gendron 2002). Furthermore, a two months interval between a whale photo-recapture off Bahía Magdalena and San Quintín coincides with the slow movement of blue whales along the west coast of Baja California during their movement north (Gendron 2002).

Thus the current blue whale spatio-temporal distribution has apparently not changed much since Scammon's report in 1858. The similarity of past and present distributions off Bahía Magdalena and along the west coast suggests that this area

might serve as stable spring and early summer feeding zones, in agreement with Reilly and Thayer (1990).

Blue whales are also found during all seasons in the offshore area of the Baja California west coast. They are observed during the spring, summer, and fall (Mangels and Gerrodette 1994, Gendron 2002). The same general area, offshore of the southern portion of the Peninsula, was characterized as a persistent concentration of temperature fronts called "hotspot" (Etnoyer *et al.* 2004) and where blue whales residence time, monitored through satellite tag, have permitted to identify presumed foraging area (Etnoyer *et al.* 2006).

5. FIN WHALE (*BALAENOPTERA PHYSALUS*), BRYDE'S WHALE (*BALAENOPTERA EDENI*), SEI WHALE (*BALAENOPTERA BOREALIS*), MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*)

Except for fin whales that appear to be rare off the west coast of Baja California (Scammon 1968, Rice 1974, Tønnessen and Johnsen 1982, Urbán and Aguayo 1985), the rest of the rorquals, the sei, Bryde's and minke whales have been reported (Rice 1974, Urbán and Aguayo 1985) or captured (Tønnessen and Johnsen 1982). For all species however, no winter ground has been described and very little is known about their movement, aside the information of whale marking- recovering effort made in the 60's by Rice (1974). The presence of Bryde's whales from Bahía Magdalena south, along the west coast appears to be more notorious (Rice 1974) especially during fall (Gendron unpublished data), and could be associated with whales moving off the Gulf of California following sardines (Chávez-Rosales 1995, Urbán and Flores 1996).

6. NORTH PACIFIC RIGHT WHALE (*EUBALAENA GLACIALIS*)[1]

In contrast with the other species of baleen whales previously considered here, the Northeastern Pacific right whale is the most endangered population of large whales. Although this species has been intensively harvested, their breeding area has never been identified (Scammon 1968). It is believed that the number is probably in the tens and that the western coasts of the United States and Mexico were ever highly frequented habitat for this species (Brownell *et al.* 2001, Clapham *et al.* 2004). However, three of the very few reported sightings during the past century were made off the Baja California coast, including a recent sighting off San Jose del Cabo in February 1996 (Gendron *et al.* 1999). Historically, some were captured as far south

[1] Now considered a separate species *Eubalaena japonica* http://www.iucnredlist.org

as Bahía San Vizcaíno between February and April (Scammon 1968). An extensive research on historical distribution based on the Maury charts concluded that the north Pacific right probably did not breed in coastal areas (Scarff 1986, 1991). However, the absence of searching effort along the Baja California west coast indicated by the Maury charts (Gendron *et al.* 1999) does not allow clarifying if right whales were using or not this area during winter.

7. SPERM WHALE (*PHYSETER MACROCEPHALUS*)

The largest tooth whale, the sperm whale, was perhaps the first species of whales to have been captured along this coast. During the sperm whales whaling era, the southern half of the Baja California west and south of the Peninsula were known as good whaling sites (Townsend 1935). More research would precise the importance of the area through the reviewing of the whaling log books from voyages accounts, such as the one made by Mitchell (1983) who showed that the area was visited. An interesting seasonal movement is observed in the Townsend maps by the presence of the whales in different areas in different seasons. Scammon (1968) also cited that sperm whales were found and captured in water depth as shallow as 60 fathom in the area between San Bartolome (now called Bahía Tortuga) and Point Abreojos (now called Punta Abreojos). Rice (1974) report only one sighting of 2 large male sperm whales along the coast. In the offshore areas of southern part of the Peninsula, sperm whales are reported there from June to October (Mangels and Gerrodette 1994, Gendron, unpublished data). Not much is known about the movement of these sperm whales there, although we suspect they might also visit the Gulf of California where they have been seen year round (Gendron 2000) and where several studies based on distribution, stable isotopes analysis and acoustic scattering layers suggest they feed on the jumbo squid (Jaquet and Gendron 2002, Ruiz-Cooley *et al.* 2004, Gallo-Reynoso *et al.* 2009). They also show high percentage of calves and mature males which suggest the area as a breeding, calving, and nursing ground (Jaquet *et al.* 2003).

In accordance with the IUCN Red List of Threatened species (http://www.iucnredlist.org) due to the poor information on most of the rorquals, Bryde's and minke whales are categorized as data deficient, but the sei whale as endangered. The gray and humpback whales have been re-categorized from vulnerable to the category least concern, the sperm whale as vulnerable, and the blue whale has been download from vulnerable to endangered, principally due to the very slow recovering of the overall species. However, the northeastern Pacific population is apparently increasing (Baskin 1993, Barlow 1994) and it is clearly considered the most recuperated of

all populations. So aside the endangered North Pacific right whale, it come into view that several species are showing signs of recovery compared to the western north Pacific subpopulation/population and also from population from other oceans such as the North Atlantic with the extinct gray whale population (Barnes and McLeod 1984), and slow recovering blue whale population (Sears and Calambokidis 2002).

8. SUMMARY AND ANALYSIS OF THE AREA

The coastal area of the Baja California west coast, is used by all the migrating species of large whales and represent, 1) a breeding area for the gray whales, 2) a corridor between feeding and breeding areas for the mainland and Baja California humpback whales, 3) a seasonal feeding area for blue whales, and 4) an area of distribution of the North Pacific right whales, the Bryde's, sei, and minke whales. While this relatively non developed coast still provides a good quality habitat for these species, it should be protected from gillnet fishing at least seasonally during the migrating period (December to July). Although there are no database records of whale entanglement in the Mexican Pacific, it appears that there is at least one incident of a whale (usually a humpback whale) entangled in a gill net every year.

Another anthropological impact on whales to be avoided is the inappropriate whale watching activities. Aside the study on the whale-watching impact on gray whale in a feeding area off Canada (Duffus 1996) or during their migration off Ensenada (Heckel 2001, Heckel *et al.* 2001), little information is available in the breeding lagoons, where the most intense whale-watching activities occurs. Regulation of whale-watching should be promoted particularly in non protected areas such as Los Cabos region before it become a real problem as it is reported for Bahía Banderas, a well known aggregation area of the mainland humpback whales (Guerrero-Ruiz *et al.* 2006).

In accordance to Etnoyer *et al.* (2004), the offshore area off the southern portion is, 1) an important foraging area for blue whales and probably also for Sperm whales, and 2) a corridor for the migrating Humpback whales that winter off the Revillagigedo islands and should be promoted as a marine protected area.

9. CETACEAN STRANDING SURVEYS: A GOOD ILLUSTRATION OF SPECIES PRESENCE AND SEASONALITY ALONG A PORTION OF THE BAJA CALIFORNIA WEST COAST

Despite the ecological importance of the area, little is known about the community structure of small cetaceans. The lack of estimates in diversity, abundance and

temporal occurrence of these marine organisms represent clear gaps in our knowledge. These gaps can be partially filled with information obtained by stranding records in land when the information in water is scarce or absent.

To illustrate how cetacean stranding data are useful to gather information on the populations that use the coastal area of the Peninsula, an analysis was made of the stranding data from a systematic survey conducted weekly along the beach of Magdalena Island (CICIMAR research project SEP-CONACyT 46806), a long sandy bar of 55 km in length located in the Bahía Magdalena lagoon complex (see Figure 1).

These three year surveys (2003–2006) allowed to identify a natural seasonal rhythm of cetacean strandings associated with natural processes occurring within the ecosystem with higher incidences in the late spring and early summer months (April, May, June and July), coinciding with the seasonality of the highest rates of net primary production in the area (Mercuri 2007). Based on these results, a schematic model of the seasonal evolution of significant ecosystem events adjacent to Magdalena Island was performed, showing that the upwelling process gives place to the development of primary productivity, followed by an increment in sardine abundance and finally the maximum incidence of strandings of high trophic marine mammals (Mercuri 2007). The correspondence of marine mammal abundance in the coastal area with the incidence of strandings was previously proposed by several authors (Mead 1979, Woodhouse 1991, López *et al.* 2002, Evans *et al.* 2005).

This research also produced baseline information for cetacean diversity in this region, with twelve cetacean species identified: 9 odontocetes and 3 mysticetes (see Table 1), which represents 38% of the thirty-two cetacean species reported for the Mexican Pacific Ocean (Aurioles Gamboa 1993). The most abundant group was composed of species that belongs to the subfamily Delphininae, including small size dolphins that mainly prey on small schooling fish such as sardines. Of these species, the common dolphins were the most abundant, particularly the long-beaked common dolphin (*Delphinus capensis*), recorded only during spring and summer with a maximum peak in June; coinciding with high sighting numbers off Magdalena Bay also in June (Valles Jiménez 1998). The next in abundance were the bottlenose dolphins (*Tursiops truncatus*) stranding principally during spring and summer. Although two ecotypes are recognized: the coastal and the oceanic (Walker 1981), no differentiation were made in the stranding records. The Pacific white-sided dolphin (*Lagenorrynchus obliquidens*), a temperate species that uses the coast of Baja California and occasionally the southern Gulf of California as its southern distribution boundary, was also recorded in the stranding surveys. This species is well known to move north-south and inshore-offshore in relation with the temperature

TABLE 1. Cetacean species identified in the strandings, proportion and seasonal occurrence along the Magdalena Island (species marked with a * belongs to the subfamily Delphininae).

Species	% frequency	Month
Non identified dolphin	38	From January to September
*Delphinus capensis**	23.1	From March to September
*Tursiops truncatus**	10.6	From February to September
Delphinus sp.*	9.1	From April to August
*Delphinus delphis**	8.7	From May to August
*Lagenorhynchus obliquidens**	4.3	January, May, July and August
*Stenella longirostris**	2.4	January and March
Eschrichtius robustus	2	January and February
*Grampus griseus**	0.5	October
Globicephala macrorhynchus	0.5	July
Mesoplodon peruvianus	0.5	August
Physeter macrocephalus	0.5	July
Balaenoptera sp.	0.5	May
Megaptera novaeangliae	0.5	December

of the water and the distribution of its preys (Leatherwood *et al.* 1984), so it is not strange that we found this species during the most productive season. In contrast, a pan-tropical species characteristic of warm water, the spinner dolphin (*Stenella longirostris*), occurred once in winter.

The rest of the strandings consisted of pelagic species that generally prey on squid, such as the pygmy beaked whale (*Mesoplodon peruvianus*), Risso's dolphin (*Grampus griseus*), pilot whale (*Globicephala macrorhynchus*), and the sperm whale. In the group of mysticetes, we registered an unidentified rorqual that was in high state of decomposition, made it difficult to identify the species. Judged by the size, the individual could be one of the three rorquals similar in morphology, the fin, sei or Bryde's whales. Two gray whales and one humpback whale were recorded during winter, and are clear examples of how the strandings are good indicators of residence and migration patterns (Moore *et al.* 2003). Each of these species appeared only one or two times in the stranding records.

In several of the fresh strandings, the animals showed marks caused by human interaction (net or chain marks, entanglement with nets or fluke mutilation with a knife). The gray whale migrating along the proximity to the coast is particularly

vulnerable to get entangle in fishing nets and being struck by ships or panga. There are several examples of these incidents in Mexico (Urbán *et al.* 2003), mainly during the winter season, when the whales are inside the lagoons and the small fiberglass fishing boats (pangas) occasionally hit them during the transit to the fishing areas outside the lagoons.

However, the evidences of these incidents (entanglement and ship strike) are hard to distinguish in the carcasses of the animals. The factors that could influence in the detection of signs of human interaction are: 1) marks of entanglement are difficult to detect in decomposed specimens, they usually have lost the skin or it has been burned by the sun; 2) some animals are founded after scavenger animals had preyed on, so they lost parts of the body that should have been examined; and 3) the training of field staff to identify marks usually gets better over time with the experience.

Bahía Magdalena is the most important fishing ground for artisanal fisheries in the state of Baja California Sur (Carta Nacional Pesquera 2004). There are several fishing gear types that are used in the area, but the most dangerous or threatening to marine mammals are those used in the scale fish fishery (gillnets) during May to September. Little is known about the fisheries that operates in the offshore region of Bahía Magdalena, where larger fleet (ships of 45 feet in length or more), that principally focused in shark fishing, use 2000 m of drift gillnets or 20 km of longlines with 700 hooks (Rivera 2004). These activities and possible interactions with cetaceans should not be underestimated.

Although there are few published estimates of the magnitude of incidental capture (bycatch) in marine mammals, it is known that the consequences are likely to have demographic effects that might significantly threaten many marine mammal populations (Read *et al.* 2006), therefore, more and better data to understand the impact of these interactions are required. Strandings, in this context, are a useful tool to estimate at least a minimum rate of mortality due to anthropogenic interaction.

The continental shelf region of the west coast of Baja California has a vast amount of natural resources that are poorly exploited in the present, however, considering the great potential of the fisheries it is not difficult to assume that more extraction will be promoted in the future (Lluch-Cota *et al.* 2006). And with this, certainly, more interactions with marine mammals will occur.

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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.

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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.

Elisabet V. Wehncke

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