

Extralimital Distribution of Galapagos (*Zalophus wolfebaeki*) and Northern (*Eumetopias jubatus*) Sea Lions in Mexico

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Abstract

Global pinniped distribution is greatly determined by changes in sea surface temperature. El Niño events also have been reported to directly influence pinniped distribution. These events have increased in frequency and intensity changing the foraging ecology of the two pinniped species analyzed. In this paper, we present new extralimital records of distribution of two species rarely found in Mexican waters: the Galapagos (*Zalophus wolfebaeki*) and the Northern (*Eumetopias jubatus*) sea lions. Three adult *Z. wolfebaeki* were found in Chiapas, and one *E. jubatus* was recorded off the coasts of Colima—both exceeding the maximum reported extralimital distance. These new records increase the number of marine mammal species recorded in Mexico and add evidence to the fact that large-scale climatic variation and possible effects of global warming shift the distribution of marine mammals.

Key Words: Galapagos sea lion, *Zalophus wolfebaeki*, Northern sea lion, *Eumetopias jubatus*, extralimital distribution, ENSO

Introduction

Global pinniped distribution is greatly determined by temperature; changes in sea surface temperature and El Niño events have been reported to directly influence pinniped distribution. These events have increased in frequency and intensity, changing the foraging ecology of these two pinniped species. New extralimital records of the distribution of two species rarely found in Mexican waters—the Galapagos (*Zalophus wolfebaeki*) and the Northern (*Eumetopias jubatus*) sea lions—that increase the number of marine mammal species recorded in Mexico and add evidence to the fact that large-scale climatic variation and possible

effects of global warming shift the distribution of marine mammals are presented here.

Mexico is abundant in the presence of marine mammal species, with documentation of between 45 to 49 species (35 to 38% of all known species; Ceballos & Oliva, 2005; Medrano-González, 2006; Pompa, 2007). Although Mexican marine mammal fauna are well-studied, with a growing literature on species and group composition, geographic range, ecology, and conservation, there are important new discoveries like the ones on the species recorded here (see Ceballos & Oliva, 2005, for a compilation).

There are three relatively isolated populations of the genus *Zalophus* recognized as different species or subspecies (Rice, 1998; Nowak, 1999; Wolf & Trillmich, 2007). The genus comprises the California sea lion (*Z. californianus*), a common species in northern Mexican coasts from Baja California to Sinaloa; the Galapagos sea lion (*Z. wolfebaeki*); and the Japanese sea lion (*Z. japonicus*). *Z. californianus* is found in coastal areas from British Columbia in Canada to the Tres Marias islands off the coast of west-central Mexico. The populations from California, Baja California, and other coastal areas of Mexico were estimated at 145,000 individuals in 1981 (LeBoeuf et al., 1983). During the breeding season, such populations concentrate in rookeries located as far north as the San Miguel and other California Channel Islands, throughout the west coast of Baja California to the San Benito Islands and to several islands in the Gulf of California as far south as Sinaloa (Orr et al., 1970; Hall, 1981; LeBoeuf et al., 1983). After the breeding season, adult sea lions migrate northward to Oregon, Washington, and British Columbia and southward to the Tres Marias Archipelago and the coast of Nayarit before returning to the breeding rookeries the next reproductive period (Aurioles-Gamboa et al., 1983).

The Galapagos sea lions are exclusively known from the Galapagos Islands and are found throughout the Galapagos Archipelago on all the major islands and on many smaller islands, as well as occasionally in coastal Ecuador and Colombia (Rice, 1998). A colony was established in 1986 at Isla de la Plata, just offshore from mainland Ecuador, but the site is not regularly used. Vagrants can be seen from the Ecuadorian coast north to Isla Gorgona in Colombia. There is also a record of a vagrant from Isla del Coco approximately 500 km southwest of Costa Rica (International Union for Conservation of Nature [IUCN], 2009). Due to its small range, small and fluctuating population size, and a suggested decline of 50% over the last 30 y, the Galapagos sea lion is classified as endangered (IUCN, 2009).

Z. japonicus, which is probably extinct, was known from coastal areas in Japan and Korea (Mate, 1982). Recent genetic data support the classification as a separate species (Wolf et al., 2007). These sea lion populations have apparently been isolated since the Pleistocene epoch (Aurioles-Gamboa et al., 2000).

The other pinniped involved in this work is the Northern sea lion, found from central California to the north along the west coast of North America to the Aleutian Islands across the Bering Sea to the Bering Strait. From there, they range to Kamchatka Peninsula, Sea of Okhotsk, Kuril Islands, northern Japan, and possibly to both Koreas. Vagrants have been recorded in China and at Herschel Island in the Beaufort Sea (Rice, 1998).

Methods

Our work is based on fortuitous observations of sea lions in the coast of Colima and Chiapas. In August 1997, three adult sea lions, two females and one male, later identified as Galapagos sea lions, were found on a beach in the Chiapas coast. The two males were dead; the female was in critical condition, lying still on the beach, very

weak, and very thin (bones, especially the ribcage, were noticeable). She made no attempt to escape during her transportation to the Tuxtla Gutierrez City Zoo (ZooMAT, Miguel Alvarez del Toro, founder) in Chiapas, and she died during the journey. A necropsy showed that the animal likely died from complications associated with starvation, and she had no stomach contents.

Regarding the Northern sea lion, an individual was registered from July through November 2008 off the coast of Colima, Mexico. An employee of a gas plant informed us of an animal resting over a buoy.

Results and Discussion

Galapagos Sea Lion

Our specimen showed characteristics that are diagnostic of *Z. wolfebaeki* such as narrow mandible insertion condyles, well-developed mastoid crests (not shown in *Z. californianus* females), smaller tympanic bulla, six post-canine teeth, and double-root molars. Skull morphology indicated that the female was around 4 y old (Figure 1). At the same age, *Z. wolfebaeki* is generally smaller than *Z. californianus*. The skull characteristics and a comparison with six *Z. californianus* females from the Gulf of California confirmed that this individual belonged to *Z. wolfebaeki* (Table 1). The cluster analysis showed that our specimen belongs to a single-tree branch by itself and did not cluster with any of the other female specimens of *Z. californianus* (Figure 2).

The sea lions were found within the Biosphere Reserve "La Encrucijada" at 15° 41' 15" N and 92° 01' 23" W, 25 km south of Acapetahua, Chiapas. This location is found approximately 1,800 km northeast of the Galapagos Islands (Figure 3). There is no documented evidence of movements of sea lions between the Galapagos and Mexican populations. Galapagos sea lions are sexually dimorphic, with males growing larger than females and having a suite of several secondary

Table 1. Comparative cranial measures of six female skulls of *Z. californianus* from the osteological collection at the Biological Institute at the Universidad Nacional Autónoma de México (UNAM) and our specimen

Catalog #	LoTo	CoCo	AnCr	ArCi	AnIt	AnRo	AnFp	Estimated age
Sample	186	92.3	91.1	113.3	22.3	33.1	27.5	4 years
35178	231	100.1	95.3	124.8	24.1	38.0	30.8	8 years
35177	225	100.3	95.8	122.3	26.4	45.2	34.6	8 years
3863	211	91.8	101.2	113.9	34.0	43.3	30.2	7 years
4144	210	79.0	94.7	97.6	32.2	37.4	27.5	Juvenile 2 years
1118	189	77.4	94.9	93.9	35.6	35.8	26.9	Juvenile 2 years
15337	151	71.2	89.7	84.8	37.9	34.8	26.5	Juvenile 1 year?

LoTo = greatest length of skull, CoCo = greatest breadth of skull, AnCr = breadth of braincase, ArCi = zygomatic breadth, AnIt = interorbital constriction, AnRo = face breadth, and AnFp = pterigoidea breadth

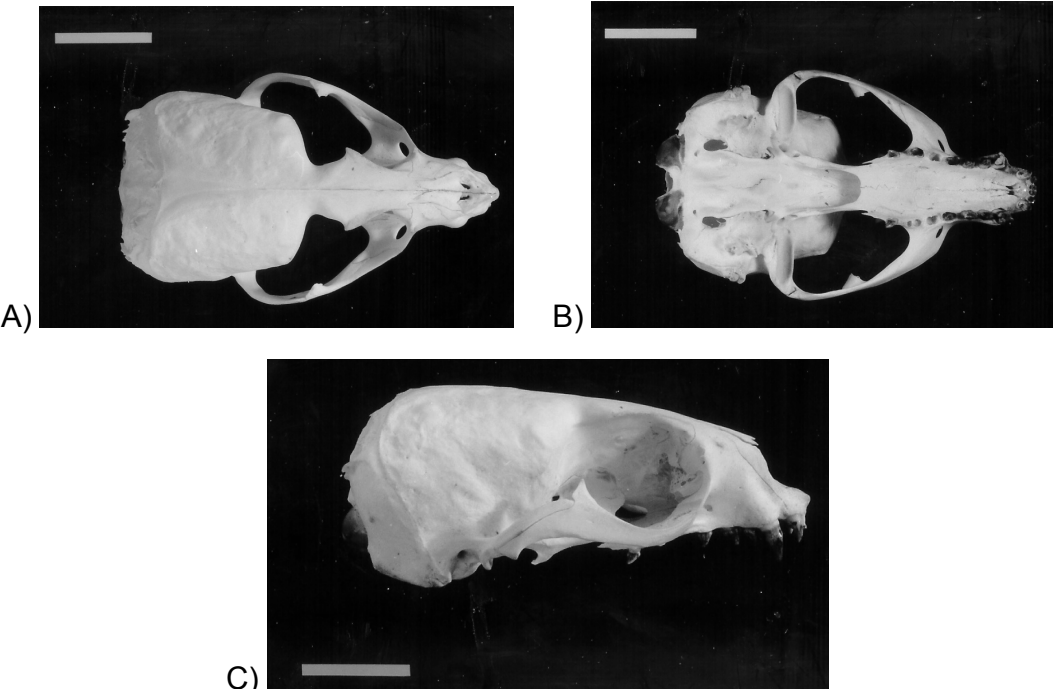


Figure 1. Dorsal (A), ventral (B), and lateral (C) views of the skull of one of the three stranded Galapagos sea lions (*Zalophus wolfebaeki*), showing typical characteristics of the species such as narrow mandible insertion condyles, well-developed mastoid crests (not shown in *Z. californianus* females), smaller tympanic bulla, six post-canine teeth, and double-root molars (Photos: Ana Isabel Bieler)

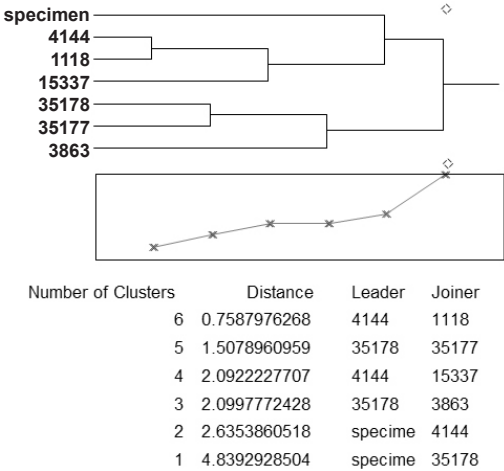


Figure 2. Statistical cluster analysis of cranial measures of six *Z. californianus* and our specimen; the tree shows three clades: one with three adult specimens, another with three juveniles, and our specimen. The distance and separation show that our specimen is different to *Z. californianus* and is comparable to *Z. wolfebaeki* from the Galapagos Islands.

sexual characteristics. The degree of sexual dimorphism appears to be less than in California sea lions, although few weights and measurements are available for adults to confirm this suggestion. The longest distance recorded as traveled by individuals of *Z. californianus* is more than 1,700 km from Baja California and California to Oregon and British Columbia (Hancock, 1970). There are occasional, extralimital records of individuals wandering south of what is considered their normal geographic range in Mexico. For example, there are recent records in Acapulco (State of Guerrero: Gallo-Reynoso & Ortega-Ojeda, 1986; Gallo-Reynoso & Solórzano-Velasco, 1991), Huatulco (Oaxaca: García & Ortega-del Valle, 2002), and Puerto Madero (Chiapas: Gallo-Reynoso & Solórzano-Velasco, 1991) in the southern coast of the Mexican Pacific.

What explanation can be given for the presence of the three Galapagos sea lion specimens along the coast of Mexico? In 1997, the El Niño phenomenon raised sea surface temperatures (SST) to 5° C comparative to 1998 (Figure 4). SST at Galapagos Islands in February 1997 was already 1° C higher, by April it was 2° C, 3° C in June, and around 4.5° C by August (National Oceanic and Atmospheric Administration [NOAA], 2009). This

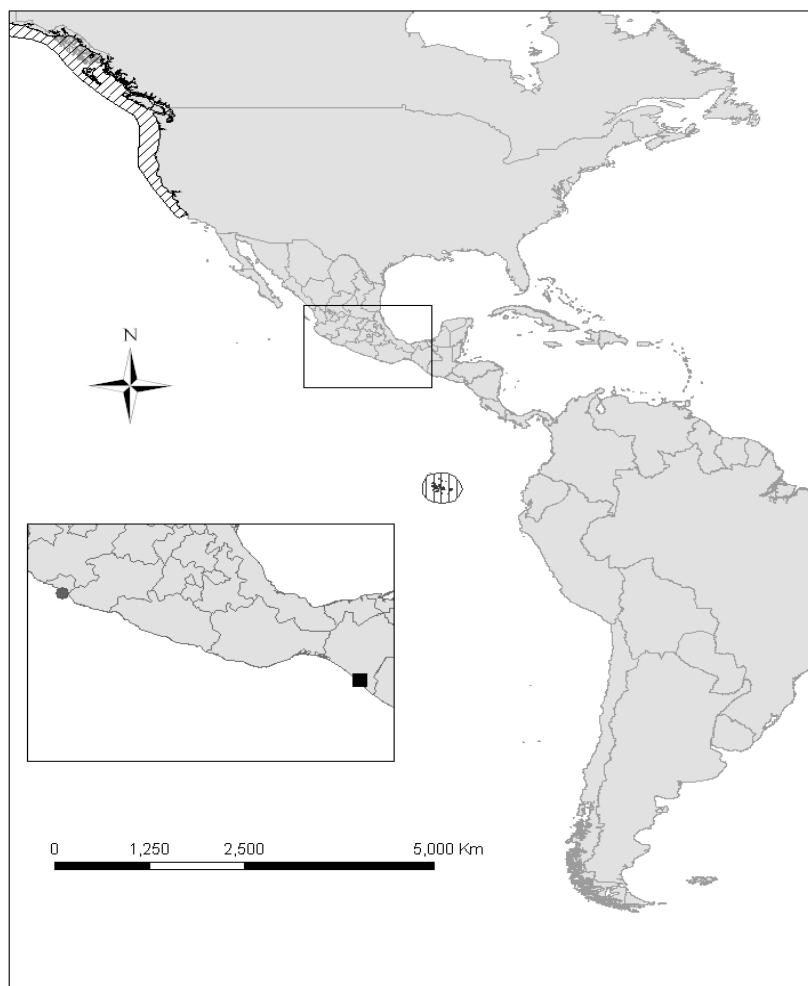


Figure 3. Extralimital distributions of the Galapagos sea lion (*Z. wollebaeki*) in the coast of Chiapas, with registered distribution in straight lines and locality of sighting (square); and of the Northern sea lion (*Eumetopias jubatus*) in the coast of Colima, with registered distribution in inclined lines and the locality of sighting (dot).

rise in SST killed 48% of the Galapagos sea lion population and their food resources (Trillmich & Dellinger, 1991). Based on the evidence presented here, we believe that the rise in SST triggered the Galapagos sea lion to search for prey beyond its known distribution boundaries, reaching as far north as Mexico. Aside from our record, specimens were recorded off the coast of Baja California (Auriolles-Gamboa et al., 1993). This climatological phenomenon can facilitate dispersal and promote gene flow between these two populations—*Z. californianus* and *Z. wollebaeki*—which may have diverged in the Pleistocene epoch (1.8 million years ago) (Wolf et al., 2007). This has important biogeographical, evolutionary, and conservation implications.

Northern Sea Lion

We identified the specimen from Colima as a Northern sea lion (*Eumetopias jubatus*) on the basis of its external morphology, which clearly shows the face, rostrum, and body shape typical of this species. The animal was approximately 3 m long, and its weight was around 800 to 1,000 kg (Figure 5). He continually took sunbaths on the buoys used to anchor boats. It did not seem to be disturbed by the presence of fishermen or the boats arriving to disembark. The sea lion disappeared in November. The animal was found off the coasts of Colima, Mexico, between Tepalcates Canal and Campos Village (UTM 13, 2101350.76 and 576251.36) in Manzanillo (Figure 3). This locality is 3,000 km south from its typical geographic range (IUCN,

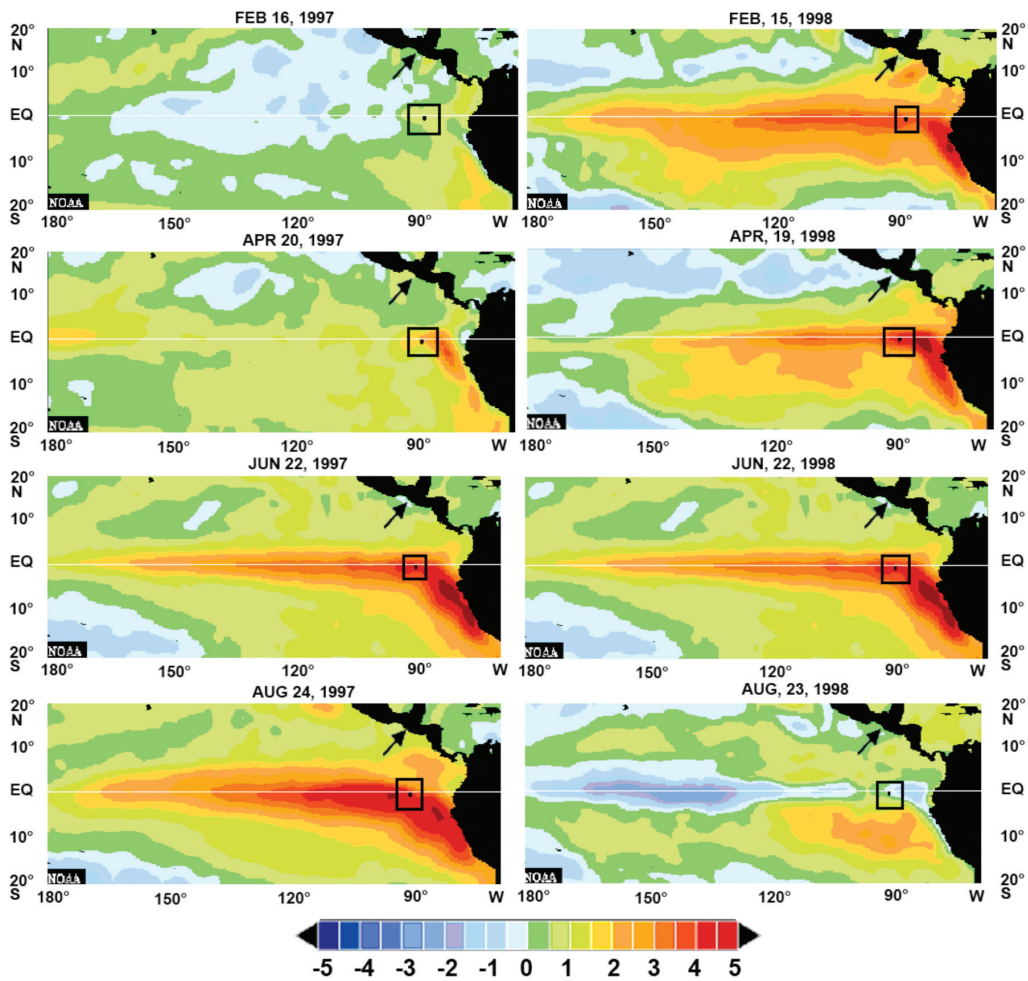


Figure 4. Sea surface temperature (SST) during the 1997 El Niño phenomenon (data from NOAA, 2009, analyzed at the University of California–Irvine School of Biological Sciences and modified for this publication); see the Galapagos Islands (box) and where our specimen *Z. wolfebaeki* was found (arrow). Shading indicates where the mean (zero on the scale) exceeds one standard error (SE).



Figure 5. Northern sea lion (*E. jubatus*) resting in a buoy off the coasts of Manzanillo, Colima

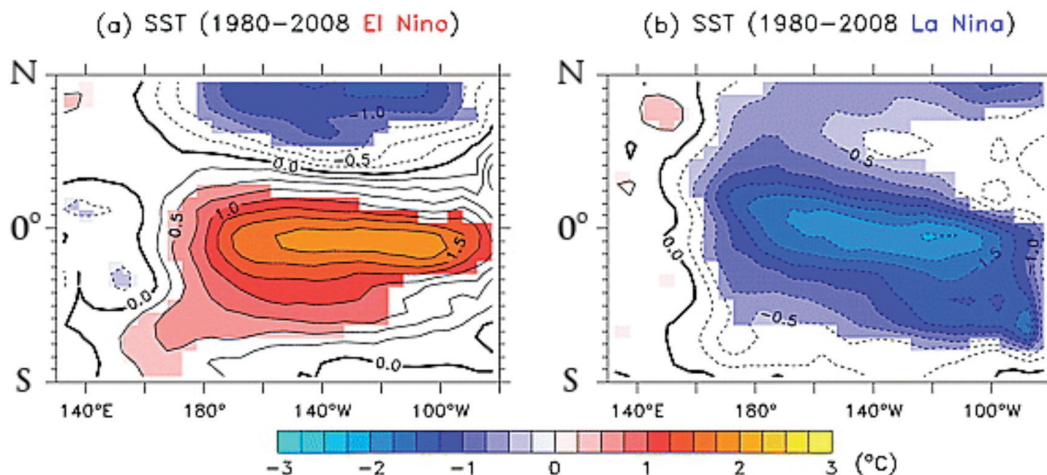


Figure 6. Composite of ENSO SST anomalies as a function of time and longitude along the equator for (a) El Niño and (b) La Niña for the period 1980 to 2008; contour interval is 0.25°C for all plots. Shading indicates the most robust features of the composites where the mean exceeds one SE (modified from McPhaden & Zhang, 2009).

2009), representing the most southern distribution record of the species. This exceptional record could probably be explained by the 2006 to 2008 ENSO (El Niño/Southern Oscillation) cycle, and a considerable (*ca.* -2°C) drop in SST in the 2008 La Niña year (Figure 6; McPhaden & Zhang, 2009).

Changes in SST and ENSO events directly influence pinniped distribution. In recent years, these events have become both more pronounced and frequent, thus changing the foraging ecology of these two pinniped species. Climatic changes affect prey distribution and abundance and, consequently, predator foraging ranges, explaining the unusual sightings mentioned in this manuscript (Würsig, 2002; Intergovernmental Panel for Climate Change [IPCC], 2007). The new records presented in this paper increase the number of marine mammal species documented along the coast of Mexico. They represent an excellent example of the effects of large-scale climatic variation and indicate some possible effects of global warming in the movements of marine mammals (McGravin & Simmonds, 1996; Learmonth et al., 2006; Simmonds & Isaac, 2007).

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