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Extralimital Distribution of Galapagos (*Zalophus wollebaeki*) 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 wollebaeki*) and the Northern (*Eumetopias jubatus*) sea lions. Three adult *Z. wollebaeki* 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 wollebaeki*, 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 wollebaeki*) 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. wollebaeki*); 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. wollebaeki* 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. wollebaeki* 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. wollebaeki* (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 15º 41' 15" N and 92º 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 Mexico (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, Anlt = interorbital constriction, AnRo = face breadth, and AnFp = pterigoidea breadth

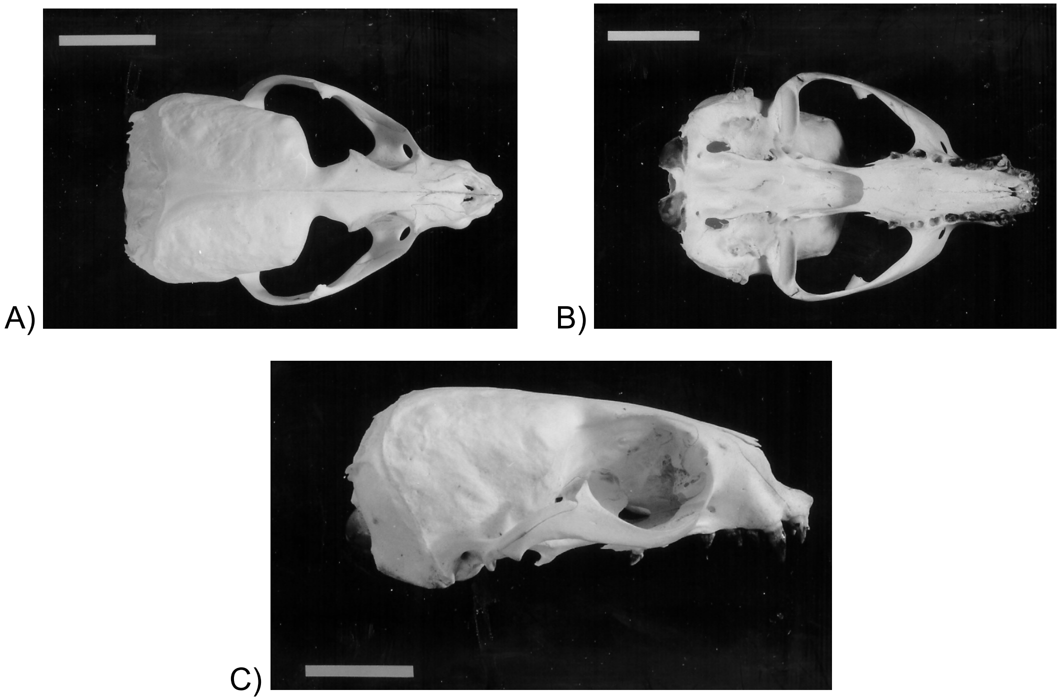
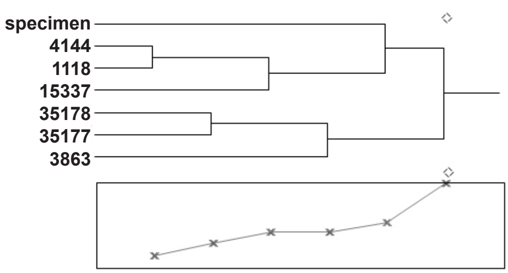


Figure 1. Dorsal (A), ventral (B), and lateral (C) views of the skull of one of the three stranded Galapagos sea lions (*Zalophus wollebaeki*), showing typical characteristics of the species such as narrow mandible insertion condyles, well-developed mastoid crests (not shown in *Z. californianus* females),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



Number of Clusters	Distance	Leader	Joiner
6	0.7587976268	4144	1118
5	1.5078960959	35178	35177
4	2.0922227707	4144	15337
3	2.0997772428	35178	3863
2	2.6353860518	specime	4144
1	4.8392928504	specime	35178

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. wollebaeki* 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

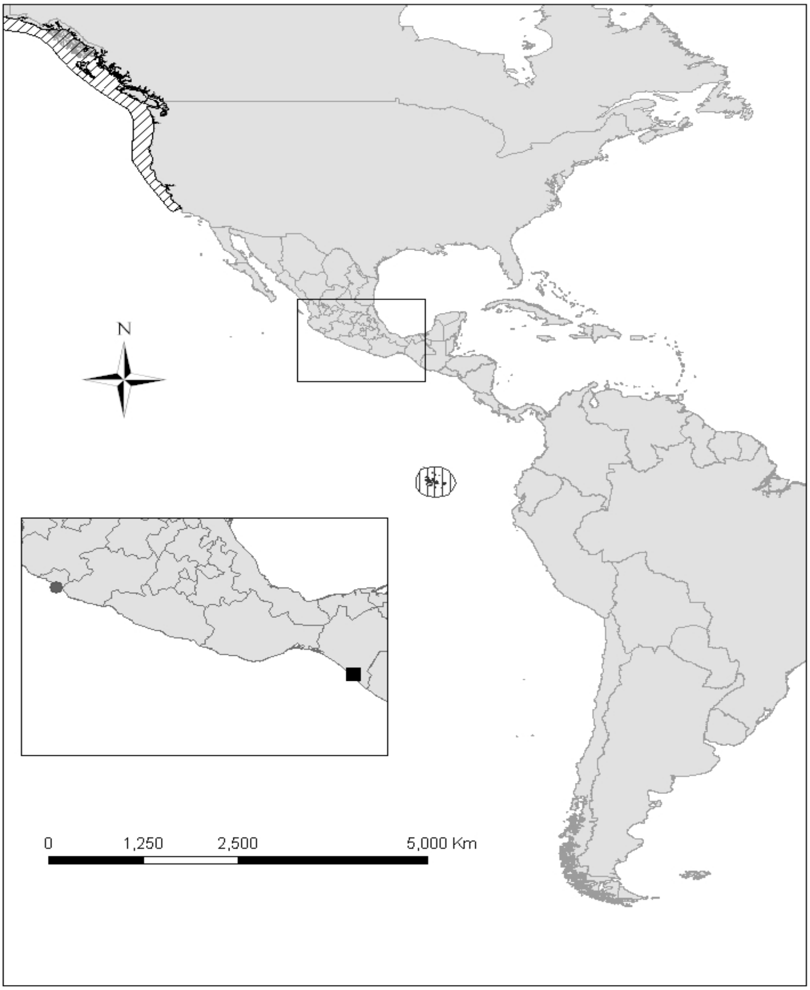


Figure 3. Extralimital distributions of the Galapagos sea lion (*Z. wollebaeki*) in the coast of Chiapas, with registered distribution in straight lines and locality of sighting (square); and of the Northern sea lion (*Eumetopias jubatus*) in the coast of Colima, with registered distribution in inclined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

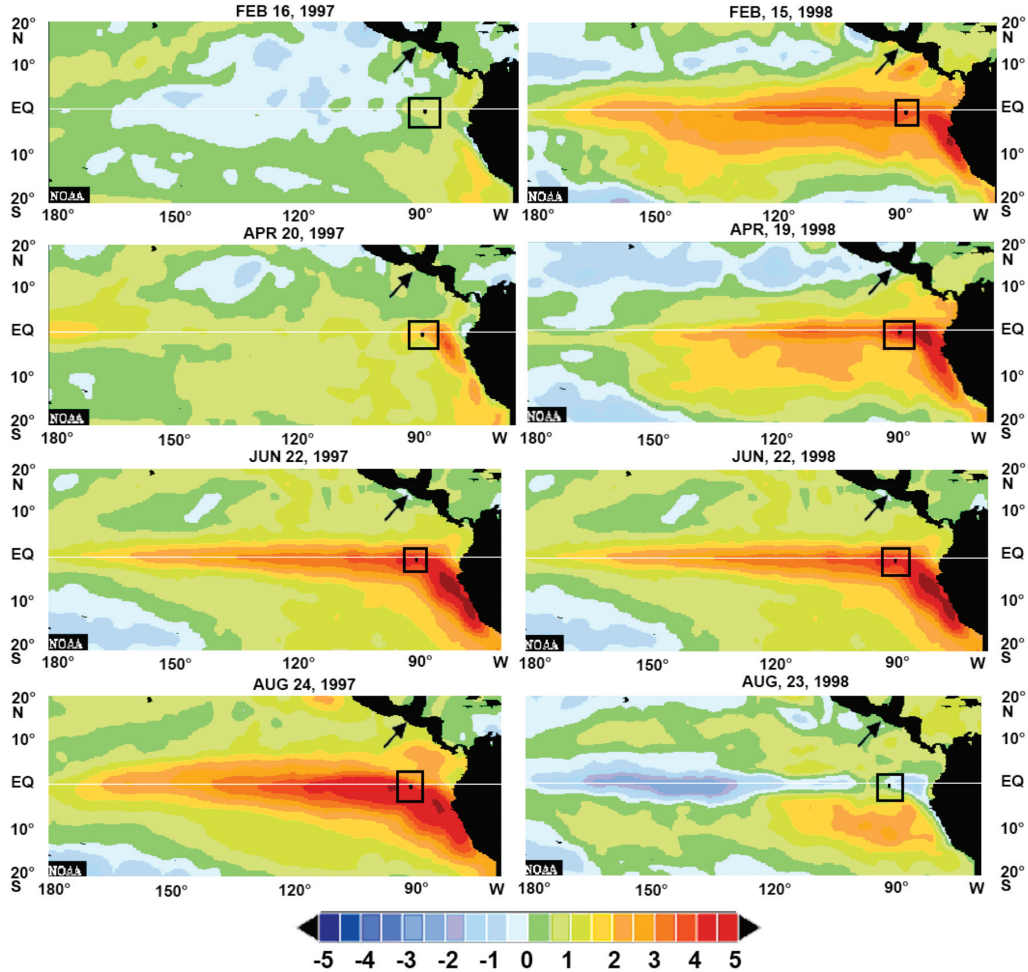


Figure 4. Sea surface temperature (SST) during the 1997 El Niño phenomenon (data from NOAA, 2009, analyzed at the University of California–Irvine School of Biological Sciences and modified for this publication); see the Galapagos Islands (box) and where our specimen *Z. wollebaeki* was found (arrow). 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

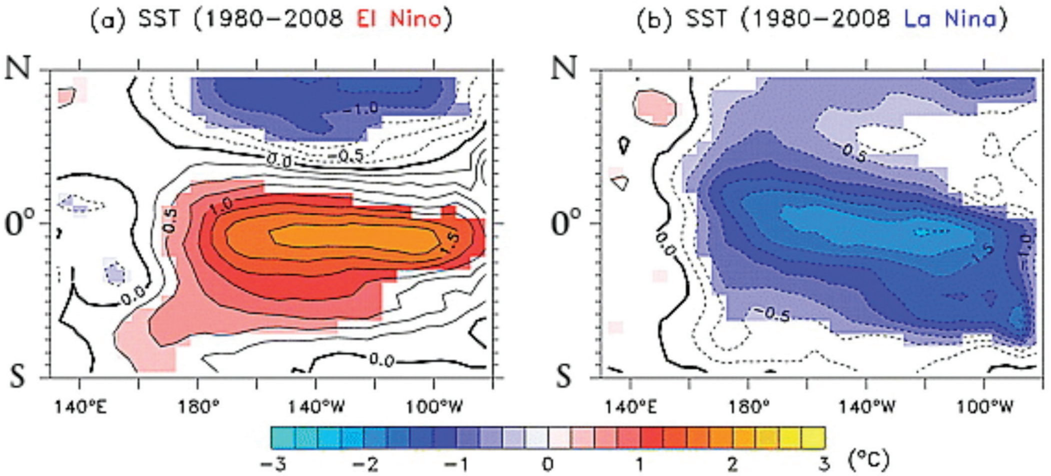


Figure 6. Composite of ENSO SST anomalies as a function of time and longitude along the equator for (a) El Niño and (b) La Niña for the period 1980 to 2008; contour interval is 0.25° C for all plots. Shading indicates the most robust features of the composites where the mean exceeds one SE (modified 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; Learmoth et al., 2006; Simmonds & Isaac, 2007).

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Literature Cited

Aurioles-Gamboa, D., Le Boeuf, B. J., & Findley, L. T. (1993). Registros de pinnípedos poco comúnes para el Golfo de California [Sightings of uncommon pinnipeds for the Gulf of California]. *Revista de la Investigacion Cientifica de la Universidad Autonoma de Baja California Sur*, *1*(No. Especial de la SOMEMMA), 13-19.

Aurioles-Gamboa, D., Flacón, S. C., Contreras, I., & Barnes, L. G. (2000). Patrón latitudinal en caracteres dentarios del lobo marino de California en Norteamérica [Latitudinal pattern in dental characters on the California sea lion in North America (*Zalophus californianus californianus*)]. *XXV Reunión Internacional para el Estudio de los Mamíferos Marinos*, La Paz, Mexico.

Aurioles-Gamboa, D., Sinsel, F., Fox, C., Alvarado, E., & Maravilla, O. (1983). Winter migration of subadult male California sea lions (*Zalophus californianus*) in the southern part of Baja California. *Journal of Mammalogy*, *64*, 513-518.

Ceballos, G., & Oliva, G. (2005). *Los mamíferos silvestres de México*. México D.F.: CONABIO – Fondo de Cultura Económica. 988 pp.

Gallo-Reynoso, J. P., & Ortega-Ojeda, A. (1986). First record of *Zalophus californianus* in Acapulco, México. *Marine Mammal Science*, *2*, 158.

Gallo-Reynoso, J. P., & Solórzano-Velasco, J. L. (1991). Two new sightings of California sea lions on the southern coast of Mexico. *Marine Mammal Science*, *7*(1), 96.

García, R. M., & Ortega-del Valle, D. (2002, May). Avistamiento de un lobo marino de California en Bahía Riscalillo, Huatulco, Oaxaca, México [Sighting of California sea lion in Bahia Riscalillo, Huatulco, Oaxaca, Mexico]. *XXVII Reunión Internacional para el Estudio de los Mamíferos Marinos*, Veracruz, Mexico.

Hall, R. (1981). *The mammals of North America*. New York: John Wiley & Sons.

Hancock, D. (1970). California sea lion as a regular visitant off the British Columbia coast. *Journal of Mammalogy*, *51*(3), 614.

Intergovernmental Panel for Climate Change (IPCC). (2007). *Climate change 2007: Synthesis report.* Retrieved 17 May 2010 from www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

International Union for Conservation of Nature (IUCN). (2009). *2009 IUCN red list of threatened species.* Retrieved 17 May 2010 from www.iucnredlist.org.

Learmoth, J. A., Macleod, C. D., Santos, M. B., Pierce, G. J., Crick, H. Q. P., & Robinson, R. A. (2006). *Potential effects of climate change on marine mammals.* In R. N. Gibson, R. J. A. Atkinson, & J. D. Gordon (Eds.), *Oceanography and marine biology: An annual review 44* (pp. 431-464). Oxford, UK: Taylor & Francis.

LeBoeuf, B. J., Aurioles-Gamboa, D., Condit, R., Fox, C., Gisiner, R., Romero, R., et al. (1983). Size and distribution of the California sea lion population in México. *Proceedings of the California Academy of Sciences*, *43*(7), 77-85.

Mate, B. R. (1982). History and present status of the California sea lion, *Zalophus californianus*. In G. Clark, J. Goodman, & G. A. Soave (Eds.), *Mammals in the seas. Vol. IV: Small cetaceans, seals, sirenians and otters* (pp. 303-309). Rome: Food and Agriculture Organization of the United Nations.

McGravin, M., & Simmonds, M. P. (1996). Whales and climate change. In M. P. Simmonds & J. D. Hutchinson (Eds.), *The conservation of whales and dolphins: Science and practice* (pp. 321-332). Chichester, UK: John Wiley & Sons.

McPhaden, M. J., & Zhang, X. (2009). Asymmetry in zonal phase propagation of ENSO sea surface temperature anomalies. *Geophysical Research Letters, 36*, L13703. doi:10.1029/2009GL038774

Medrano-González, L. (2006). Hacia una dinámica de la mastofauna marina Mexicana: Análisis de composición funcional y de algunas estructuras genéticas poblacionales [Towards a dynamic view of the Mexican marine mammal fauna: Functional composition anaylysis and genetic structure of some populations]. In E. Vázquez-Domínguez & D. J. Hafner (Eds.), Genética y mamíferos Mexicanos: Presente y futuro. *New Mexico Museum of Natural History and Science Bulletin*, *32*, 9-19.

National Oceanic and Atmospheric Administration (NOAA). (2009). *PSD map room climate products: Sea surface temperature.* Retrieved 17 May 2010 from www.esrl.noaa.gov/psd/map/clim/sst.shtml.

Nowak, R. M. (1999). *Walker's mammals of the world, Vol. II* (6th ed.). Baltimore: The Johns Hopkins University Press.

Orr, T. R., Schonewald, J., & Kenyon, K. W. (1970). The California sea lion: Skull growth and a comparison of two populations. *Proceedings of the California Academy of Sciences, 38*(11), 381-394.

Pompa, S. (2007). *Distribución y abundancia de los géneros* Kogia *y* Steno *en la Bahía de Banderas y aguas adyacentes* [*Distribution and abundance of the genus* Kogia *and* Steno *in Bahía de Banderas and adjacent waters*]. Tesis de Maestría, Facultad de Ciencias, Universidad Nacional Autónoma de México.

Rice, D. W. (1998). *Marine mammals of the world: Systematics and distribution* (Special Publication No. 4). Lawrence, KS: Society of Marine Mammalogy. 231 pp.

Simmonds, M. P., & Isaac, S. J. (2007). The impacts of climate change on marine mammals: Early signs of significant problems. *Oryx*, *41*(1), 19-26.

Trillmich, F., & Dellinger, T. (1991). The effects of El Niño on Galapagos pinnipeds. *Ecological Studies – Pinnipeds and El Niño 1991*, *88*, 66-74.

University of California–Irvine School of Biological Sciences. (1997). *The 1997-98 El Niño/Southern Oscillation (ENSO 97-98): One of the most severe ENSO events in history?* (Comp. D. Duffy & P. J. Bryant). Retrieved 17 May 2010 from http://darwin.bio.uci.edu/~sustain/ENSO.html.

Wolf, J. B. W., & Trillmich, F. (2007). Fine-scale site fidelity in a breeding colony of the Galapagos sea lion (*Zalophus californianus wollebaeki*): A prerequisite for social networking? *Oecologia*, *152*, 553-567.

Wolf, J. B. W., Tauta, D., & Trillmich, F. (2007). Galápagos and Californian sea lions are separate species: Genetic analysis of the genus *Zalophus* and its implications for conservation management. *Frontiers in Zoology*, *4*, 20. doi:10.1186/1742-9994-4-20

Würsig, B. (2002). Ecology, overview. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *The encyclopedia of marine mammals* (pp. 367-370). San Diego: Academic Press.