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Short Note

Northernmost Record of the Galapagos Fur Seal (*Arctocephalus galapagoensis*): A Consequence of Anomalous Warm Conditions Around the Galapagos Archipelago

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Several pinniped species inhabit the Pacific coast of North and South America; the distributions of many of these populations tend to be restricted to specific coastal areas or oceanic islands where ideal conditions specific to those populations exist (Riedman, 1990). These species include the Galapagos fur seal (*Arctocephalus galapagoensis*; GFS), an endemic otariid distributed on the northwestern islands of the Galapagos Archipelago (Figure 1). This species has undergone a marked population decline (~50%) over the last 50 y (Alava & Salazar, 2006; Páez-Rosas et al., 2012), leading to serious conservation concerns. The International Union for Conservation of Nature (IUCN) declared the GFS an endangered species based on the population impact caused by anomalous oceanographic events typical of the region, including the El Niño Southern Oscillation (ENSO) (Trillmich, 2015). At the beginning of this century, the GFS population was estimated at 6,000 to 8,000 individuals of which over 50% were found at two breeding colonies on the western portion of Fernandina Island in the Galapagos (Alava & Salazar, 2006) (Figure 1). Although some population recovery has been observed, with an increase in the number of animals at colonies on the southern portion of Pinta Island (Páez-Rosas, unpub. data), data is lacking on the species' current population trend.

Since the early 1980s, ENSO has been recognized as an important climate event affecting the population dynamics and distribution patterns of pinnipeds in the Eastern Tropical Pacific (Trillmich & Ono, 1991; Soto et al., 2004). In addition to being associated with high mortality among the youngest age classes, this phenomenon also impacts the migration patterns and foraging trips of adults (Páez-Rosas et al., 2012; Elorriaga-Verplancken et al., 2016b). Specifically, ENSO is associated with a decrease in resources as prey are displaced to colder or deeper regions (Soto et al., 2004; Trites et al., 2007). Thus, the distribution of pinnipeds in this region is limited by the temperature of the ocean and its effect on prey availability (Trillmich & Ono, 1991).

Galapagos fur seals face considerable challenges. On the one hand, GFSs are able to travel long distances; on the other, they exhibit high fidelity to their breeding and foraging grounds (Páez-Rosas, 2011). Females and juveniles restrict their foraging trips to areas < 70 km from the coast (Jeglinski et al., 2013; Villegas-Amtmann et al., 2013). Meanwhile, males tend to undertake longer trips, particularly during the months leading up to the breeding season from February to July (Trillmich, 1987). This strong site fidelity is due in large part to the fact that the areas of greatest productivity around the Galapagos Islands are located mainly in the western portion of the archipelago where the so-called island effect occurs. This effect generates important upwelling events as marine currents collide with the islands' submarine walls, contributing to the proliferation of nutrients at the base of the food web and to other consumers (Banks, 2002; Palacios et al., 2006).

The dispersal capability of pinnipeds has resulted in different species being reported hundreds or even thousands of kilometers from their breeding or foraging areas (Reeves et al., 1992), and the GFS is no exception. In recent years, a number of sightings of vagrant GFSs have been reported along the coasts of Peru, Ecuador, Colombia, Costa Rica, and El Salvador (Capella et al., 2002; Félix et al., 2007; Montero-Cordero

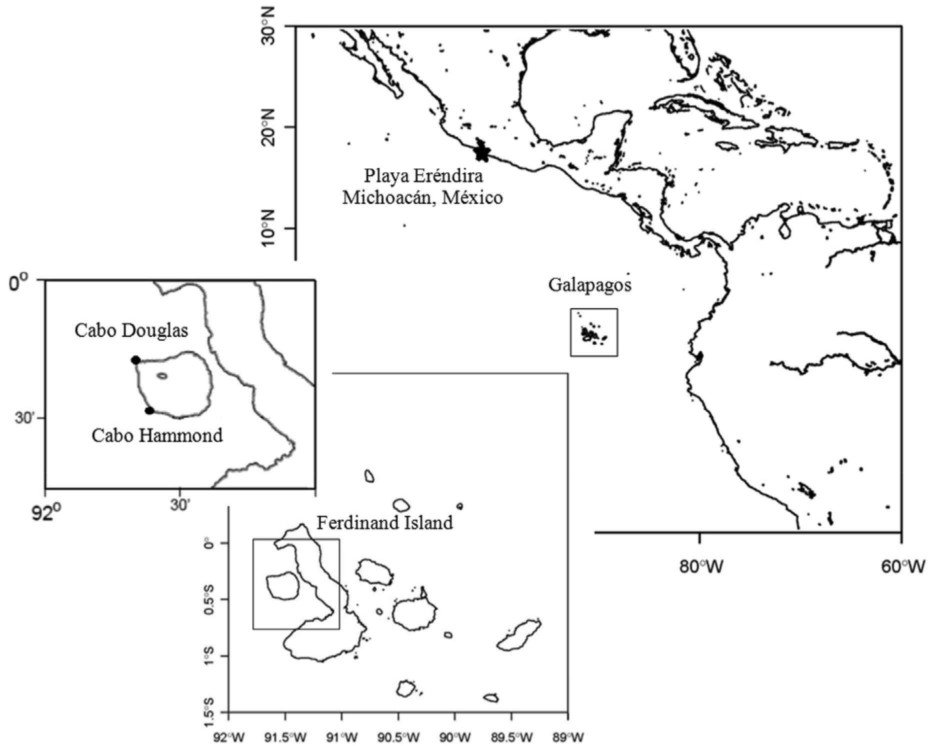

Figure 1. Geographic location and distribution range of the main reproductive colonies of *Arctocephalus galapagoensis*; Playa Eréndira (Lázaro Cárdenas) in Michoacán, Mexico, is also indicated.

et al., 2010; Lopes et al., 2015; Ibarra et al., 2016). Most have been identified as adults that presumably became lost during feeding trips as their body conditions were apparently good; however, Aurioles-Gamboa et al. (2004) also reported the sighting of two GFS juveniles in poor physical condition on the beaches of Chiapas and Guerrero, Mexico, in early 1998.

In this report, we present the northernmost record of *A. galapagoensis* on the Pacific coast of North and South America. On 15 April 2016, a subadult male fur seal measuring ~1.4 m in total length (Figure 2) was sighted on Eréndira Beach in Lázaro Cárdenas, Michoacán, Mexico (17° 58' N, 102° 19' W). The animal was captured by one of this article's coauthors (LAV) and placed under observation at Las Truchas Environmental Research Center (Lázaro Cárdenas, Michoacán), where it was observed for 24 h before being returned to sea, diagnosed as apparently healthy. A boat was used to transport the individual approximately 12 nmi offshore from the beach where it was originally reported. All procedures were undertaken with previous knowledge and authorization by authorities from Procuraduría Federal de Protección Ambiental (PROFEPA) from Michoacán.

The animal was identified as a GFS based on its small body size and dark brown color, head size in relation to its body, and the light color of its short pointed snout (Reeves et al., 1992) (Figure 2). Considering the morphological similarities between the GFS (*A. galapagoensis*) and the South American fur seal (*Arctocephalus australis*) and the fact that both species previously have been reported on the Mexican Pacific coast (Villegas-Zurita et al., 2015), we conducted a thorough photographic review by comparing images of this individual with photographic GFS records in a database curated by this article's first author, thus corroborating the initial species identification.

We hypothesize that the displacement of this individual to Mexican waters may be related to the anomalous temperatures recorded in the Pacific Ocean at the end of 2015 and beginning of 2016 (Penalba & Rivera, 2016) during the ENSO 2015-2016. These months were also characterized by an unusually high frequency of marine mammal strandings for this region (nearly one stranding per month between October 2015 and April 2016 of both pinnipeds and dolphins; Valdovinos, unpub. data). Based on the Southern Oscillation Index (SOI) values for National Oceanic and Atmospheric Administration (NOAA) Regions 1 + 2 (data obtained from www.ncdc.noaa.gov/teleconnections/enso/indicators/soi), a positive moderate anomaly persisted during the first months of 2016 (SOI: 1.23) (Figure 3, upper maps). The sea surface temperature of this species' potential

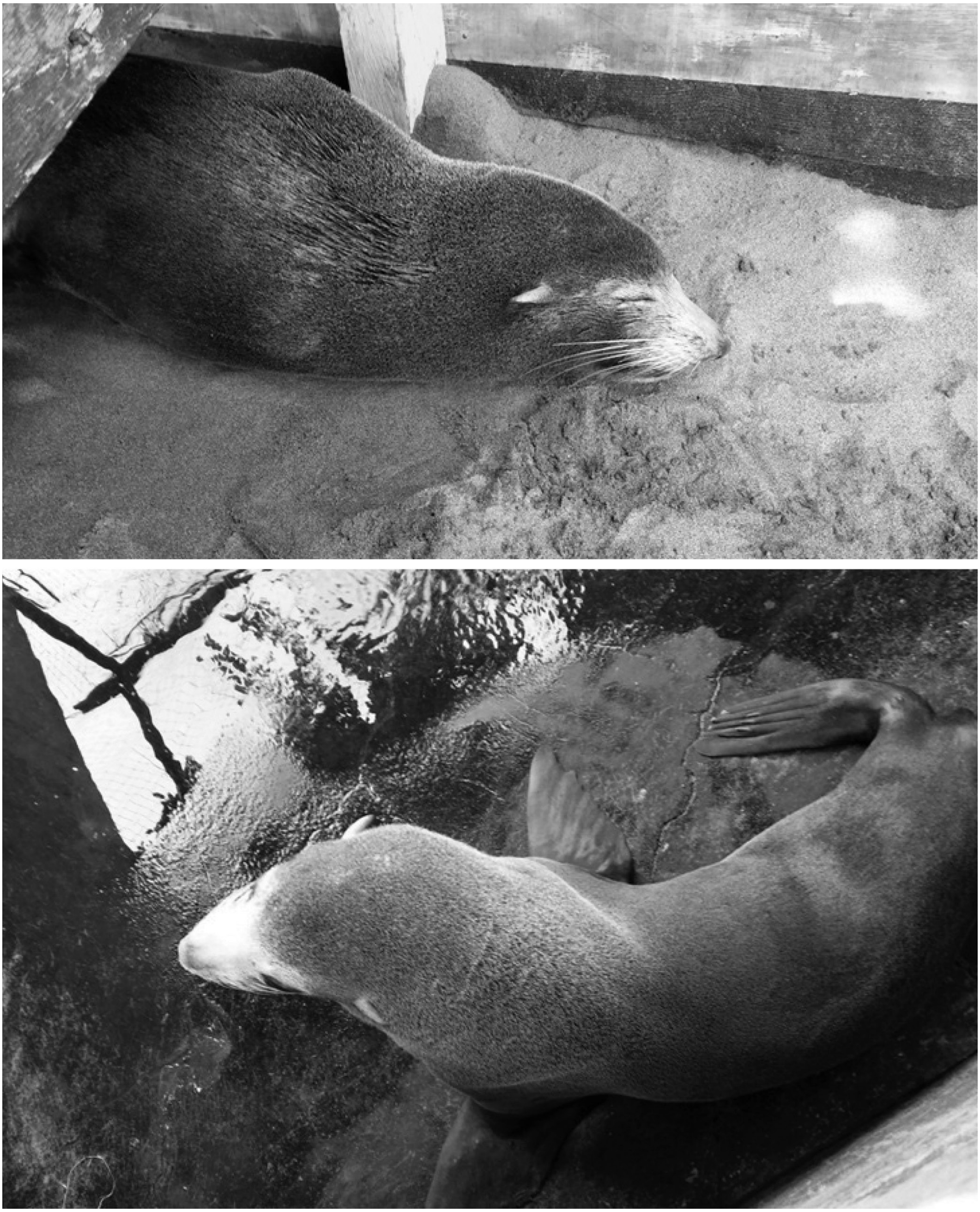

Figure 2. Stranding of subadult male *A. galapagoensis* in Lázaro Cárdenas, Mexico. Note the short, light-colored snout typical of the species as well as a compact body size, relative to similar species.

foraging grounds (Villegas-Amtmann et al., 2013) were compared during April 2015 (26.27° C) and April 2016 (27.29° C) (data obtained from www.ospo.noaa.gov/Products/ocean/sst.html), with an observed increase of ~1° C between years (Figure 3, lower maps). These anomalous temperature conditions are directly related to a decrease in primary productivity levels around the archipelago in 2016, which may have influenced the GFS to make foraging trips outside its typical geographic

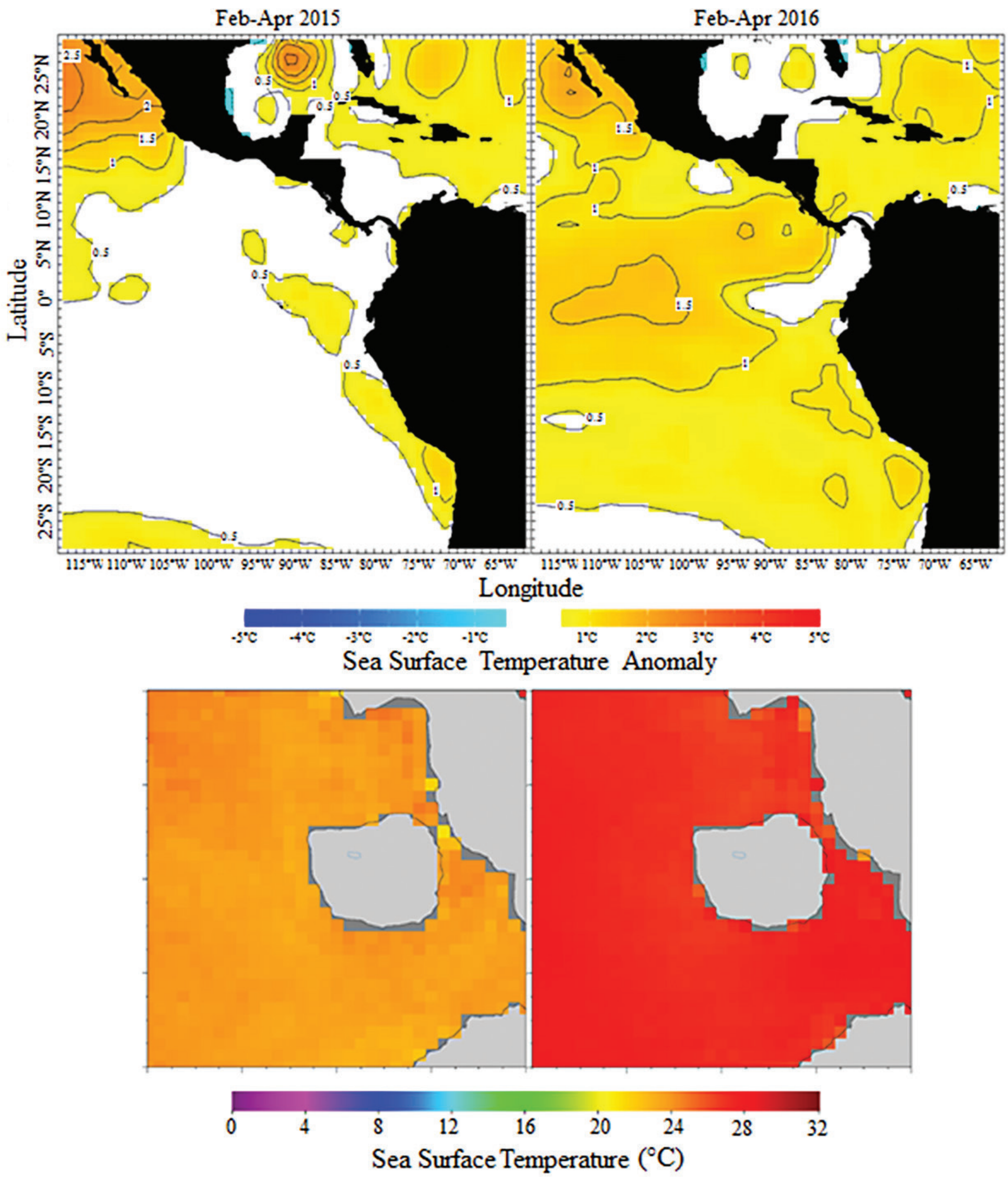

Figure 3. *Upper maps:* Seasonal anomalies (February-April 2015 and February-April 2016) of the sea surface temperature (SST) in the Pacific Ocean. Anomalies are expressed as the Southern Oscillation Index (SOI) with a resolution of 0.5. *Lower maps:* Satellite images (April 2015 and 2016) of the SST (Aqua MODIS, NPP, 0.025 degrees) for the predicted foraging distribution adjacent to the main *A. galapagoensis* reproductive colonies.

range and which could explain its arrival on the Mexican Pacific coast.

This record has important ecological implications given the good physical condition of the individuals previously sighted by Medrano et al. (2008). In that report, two live animals were sighted in the sea (average position of 17° 30' N, 104° 42' W) in early 2006 during an oceanographic research cruise off the Pacific coast of Mexico. The presence of tropical pinnipeds outside of their potential foraging or reproductive areas is primarily associated with oceanographic anomalies like ENSO (Capella et al., 2002; Elorriaga-Verplancken et al., 2016b). As a result, several endemic pinniped species have been sighted far from their typical habitats, including the Galapagos sea lion (*Zalophus wollebaeki*), the Juan Fernández fur seal (*Arctocephalus philippii*) (Ceballos et al., 2010; Ávila et al., 2014), and the Guadalupe fur seal (*Arctocephalus philippii townsendi*) (Elorriaga-Verplancken et al., 2016a). Such extralimital sightings highlight the importance of improving communication between research groups stationed throughout the Pacific to more closely monitor the pinniped populations endemic to the Galapagos Archipelago. This is particularly important considering the precarious conservation status of Galapagos fur seals and the population impacts associated with unfavorable oceanographic conditions.

We predict that continued anomalously warm ocean temperatures in this region will result in more frequent extralimital observations of this species. An expansion of the GFS range may result in the need for coordination between governments on protection measures for this species.

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