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Short Note

Unprecedented Records of Guadalupe Fur Seals in La Paz Bay, Southern Gulf of California, Mexico, as a Possible Result of Warming Conditions in the Northeastern Pacific

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During the 18th and 19th centuries, the Guadalupe fur seal (*Arctocephalus philippii townsendi*) (GFS) was hunted to the brink of extinction (Hubbs, 1956). In the 1950s, a few individuals were rediscovered on Guadalupe Island (GI), and it was declared a protected species (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT], 2010). As a result of this legal status, the GFS has experienced a remarkable population increase and is currently a species of "Least Concern" according to the International Union for Conservation of Nature (IUCN) (Aurioles-Gamboa, 2015). Its total abundance is estimated at 17,000 to 20,000 individuals, with ~87% of the population found at the GI breeding colony, and the remaining individuals found mostly in the summer months throughout the San Benito Archipelago (Figure 1), where they began to recolonize in the late 1990s (Maravilla-Chávez & Lowry, 1999; Aurioles-Gamboa et al., 2010; Esperón-Rodríguez & Gallo-Reynoso, 2012). GFSs also have been reported further north on San Miguel Island and other southern California islands like the Farallon Islands off the coast of northern California with increasing frequency since the 1980s (Hanni et al., 1997), particularly during El Niño Southern Oscillation (ENSO) conditions (e.g., Lander et al., 2000).

Female GFSs from GI undertake foraging trips of up to ~500 km (Gallo-Reynoso et al., 2008), reflecting their high dispersal capacity, mostly unknown for other age categories (e.g., juveniles or subadults). In April 1997, a fur seal was reported over 2,000 km south of GI at Zihuatanejo, Guerrero, Mexico (17° 38' N, 101° 36' W); initially identified as a GFS, this report was considered the southernmost record of this species at the time (Aurioles-Gamboa & Hernández-Camacho, 1999). However, following a more thorough analysis, the specimen was later cataloged as a Galapagos fur seal (*A. galapagoensis*) (Aurioles-Gamboa et al., 2004).

In this note, we report the first records of two GFSs in La Paz Bay, Baja California Sur (BCS), Mexico in 2015. The individuals were identified based on their greyish pelage and muzzle, which is long, straight, and flattened on top (typical of the species). The black and naked skin of the nose is also large and bulbous, and the nares are oriented downward (Merriam, 1897) (Figure 2). The GFS and the Juan Fernandez fur seal (*A. p. philippii*) from west Chile, are physically similar; however, there is little chance for them to overlap in range. In this regard, there is an extralimital record of an *A. p. philippii* as far north as Colombia (Avila et al., 2014). Therefore, the best way to differentiate between *A. p. townsendi* and *A. p. philippii* is by its geographic location (Jefferson et al., 2015). However, we cannot disregard the minor probability of misidentification.

These unusual records are considered ecologically relevant because of the poor condition of these GFSs and the unusual environmental conditions in the Pacific at the time. For instance, unusual records of several pinniped species have been associated with the impact of ENSO events in the eastern Pacific, including Mexican, Colombian, Ecuadorian, Galápagos, Peruvian, and southern waters (Wellington & De Vries, 1976; Capella et al., 2002; Alava & Carvajal, 2005; Alava & Salazar, 2006; Félix et al., 2007; Ceballos et al.,

2008; Avila et al., 2014). Interestingly, Merlen (1995) reported the possible presence of a GFS or Juan Fernandez fur seal on the southwest side of San Cristóbal, Galápagos Islands, which supports the notion of extralimital records for both species in the southeastern Pacific.

On 25 March 2015, a juvenile male GFS measuring 1.18 m (Figure 2) was sighted by rangers from the Procuraduría Federal de Protección Ambiental (PROFEPA; Federal Attorney for Environmental Protection) in the intertidal zone of La Partida Beach (24.531° N, 110.371° W) at the Espíritu Santo Archipelago, La Paz Bay. Based on the clearly visible ribs and spine, its body condition was determined to be emaciated due to a probable lack of food resources.

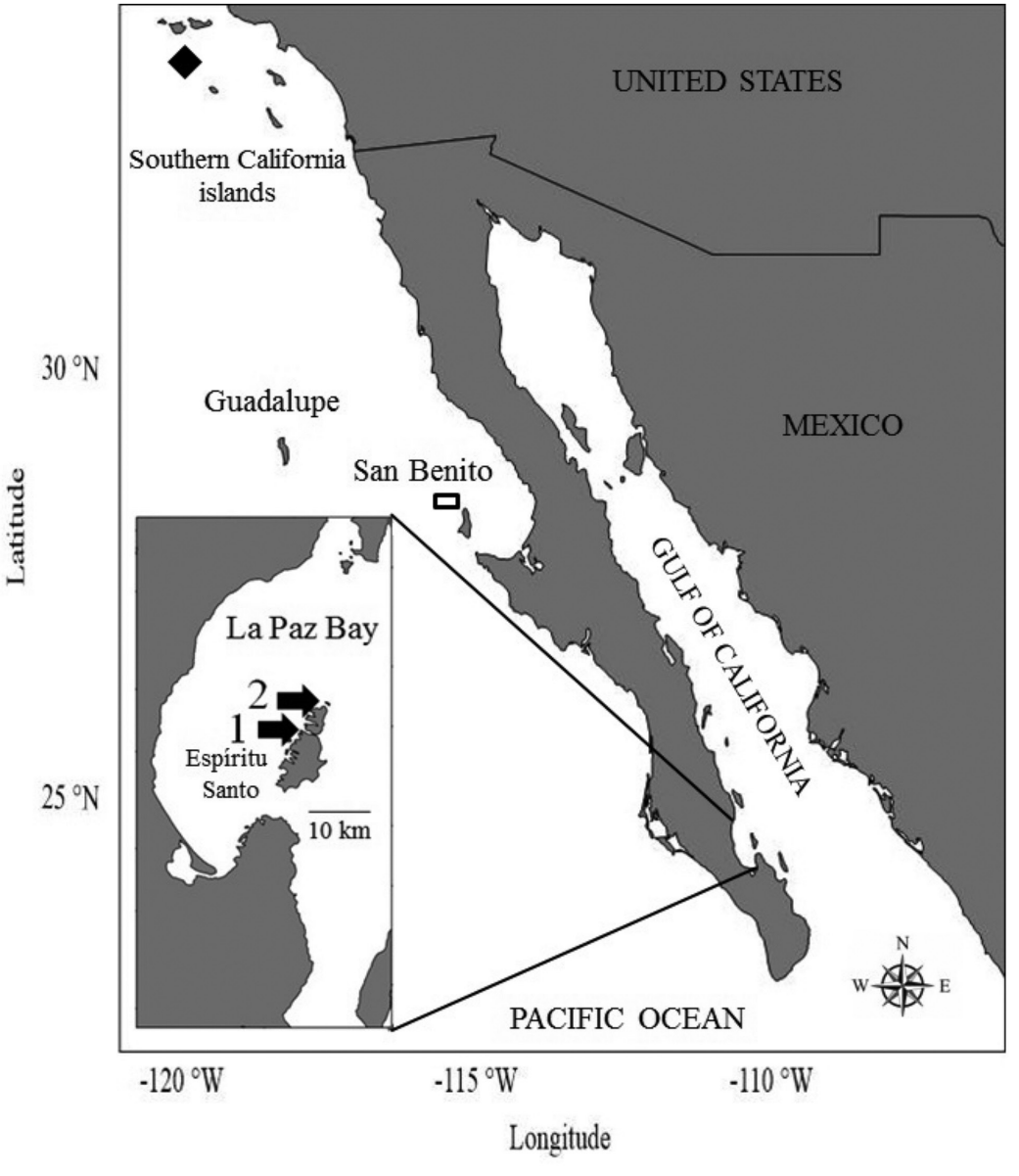

Figure 1. Geographical location of Guadalupe Island and the San Benito Archipelago. The locations of Guadalupe fur seals (GFS) 1 and 2 (a and b) are marked at Espíritu Santo Archipelago in La Paz Bay, Baja California Sur (BCS), Mexico. The Southern California islands where several vagrant GFSs have been recorded with increasing frequency since 1980 are shown.

It was captured for rehabilitation but died soon after because of its deteriorated condition. A fur sample was taken in order to assess stable isotopes using a mass spectrometer at the University of California at Santa Cruz (UCSC). From this technique, it is possible to make some inferences in regard to habitat use (Newsome et al., 2007; Elorriaga-Verplancken et al., 2013). The stable isotope of N ($\delta^{15}N$) was selected because its high values have been efficient (relative to other stable isotopes such as $\delta^{13}C$) in distinguishing the Gulf of California baseline from that of other ecosystems like the northeastern Pacific (Altabet et al., 1999; Aurioles-Gamboa et al., 2009; Elorriaga-Verplancken, 2009). The $\delta^{15}N$ (17.8‰) of GFS 1 was similar to the mean value (i.e., 16.8‰) reported in fur from 10 adult female GFSs from GI (Elorriaga-Verplancken et al., 2016) and 11 adult female California sea lions (*Zalophus californianus*) (CSL) from San Benito (17.8‰) (Sandoval, 2016). In contrast, the mean $\delta^{15}N$ (20.2‰) for three adult female CSLs and one juvenile female CSL (22.5‰) from the Los Islotes rookery at Espíritu Santo Archipelago (Sandoval, 2016) were ~3‰ higher than that showed by the GFS 1, a difference that is usually statistically different between groups (Elorriaga-Verplancken et al., 2013). All referenced data correspond to sea lions or fur seals sampled in 2014.

The difference in $\delta^{15}N$ between the two ecosystems reflects differences in basal enrichment; denitrification processes in the Gulf of California result in higher values (2 to 3‰) relative to the west coast of Baja California, where these bacterial processes are less intense (Altabet et al., 1999; Voss et al., 2001). This would suggest that GFS 1, with a $\delta^{15}N$ indicative of the Pacific, did not feed extensively enough in the Gulf for the regional $\delta^{15}N$ to be reflected by its fur, which typically provides a temporal window of around 4 mo (Porras-Peters et al., 2008). However, this hypothesis should be taken with caution. We acknowledge that our isotopic inferences are based on only one GFS; thus, further sampling on this type of event is required to strengthen our conclusion on probable habitat use.

On 2 June 2015, a subadult male GFS measuring 1.6 to 1.7 m (Figure 2) was sighted alive at the Los Islotes CSL rookery (within an effort of ~30 monthly surveys, between mid-2012 and this point) at the Espíritu Santo Archipelago (24.598° N, 110.400° W). The individual was also emaciated and obviously weakened. Due to its condition, we were able to place an object beside the individual in order to measure its approximate

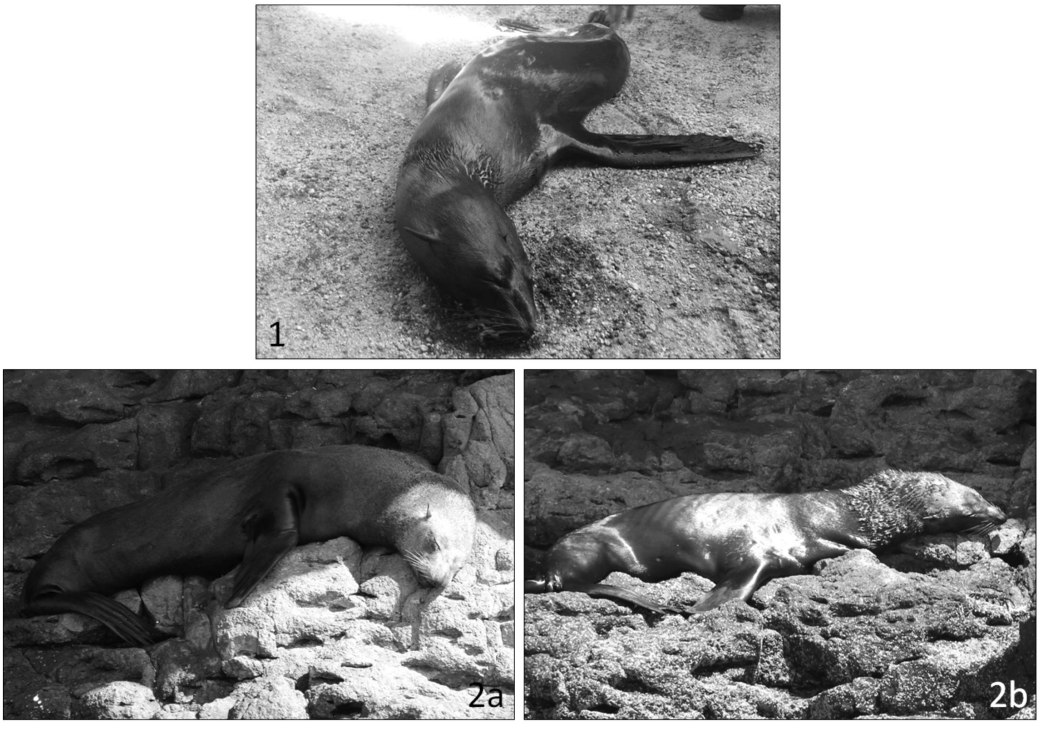

Figure 2. Images of GFS 1 (label "1") at La Partida Beach and GFS 2 (labels 2a and 2b) at Los Islotes rookery, both at the Espíritu Santo Archipelago, La Paz, BCS, Mexico. Both individuals exhibited pronounced emaciation.

length. The individual was resting in an area of low CSL density. Its presence was not recorded again after that date; thus, it was not possible to take samples; however, as with GFS 1, we hypothesize a foraging behavior more closely related to resources from the Pacific.

Globally, the distribution of pinnipeds relates to the sea surface temperature (SST) and its effect on the availability of prey (Riedman, 1990). Hence, the increment of SST during the ENSO has affected different populations (Trillmich & Dellinger, 1991; Trillmich & Ono, 1991; Alava & Salazar, 2006; Oliveira, 2011). An unusual large scale (~2,000 km wide and ~100 m deep) surface warming (1 to 4° C above normal) has recently been present in the northeastern Pacific. This anomaly called "The Blob" was first observed off the southern coast of Alaska in December 2013, expanding into the west region of Baja California by mid-2014 and creating a barrier to nutrients that would normally flow from the subarctic to the central Pacific, producing numerous biological impacts (Bond et al., 2015; Kintisch, 2015). Additionally, an intense ENSO has prevailed in the Pacific since spring 2015, with a high probability (80%) of continuing through the year (see the Climate Prediction Center website: www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_ advisory/ensodisc.html).

We hypothesize that these phenomena reaching the Mexican Pacific (Figure 3) may play a role in the abnormal dispersion of GFSs in search of prey, with some individuals traveling to unusual places like La Paz Bay (~1,200 and ~1,500 km from San Benito and GI, respectively), where both reported specimens exhibited poor body condition due to a possible reduction of food resources in their areas of origin. Based on telemetry studies on GFSs (Gallo-Reynoso et al., 2008), those distances could have been traveled in 8 to 10 d (based on a hypothetical maximum travel speed), but this is likely an underestimate given the poor condition of both individuals. An unusual dispersal event, also related to the ENSO, already has been reported in the past for a GFS female, which stranded alive in the late 1990s at Point Lobos State Reserve in California, ~900 km from GI (Lander et al., 2000). Between January and August 2015, which included our study period, the Marine Mammal Center reported a record number of ~80 mostly immature GFSs either stranded dead during an unusual mortality event or rescued alive in poor body condition along the California coast, supporting the hypothesis of an adverse effect of environment on fur seals' food resources (National Oceanic and Atmospheric Administration [NOAA] Fisheries, 2015).

Moreover, we recorded three additional juvenile GFSs in La Paz Bay in surveys after the timeline of this report, but still under ENSO conditions: an emaciated male stranded dead at La Concha Beach (24° 12.083' N, 110° 17.973' W) on 11 November 2015, and two alive that were sighted together at Los Islotes rookery (42nd survey since mid-2012) on 18 February 2016, with apparently good body condition. Therefore, there is an overall evidence of five GFSs recorded in La Paz Bay between 2015 and the beginning of 2016.

Adverse effects of unusual warming events have been documented on other pinniped species,

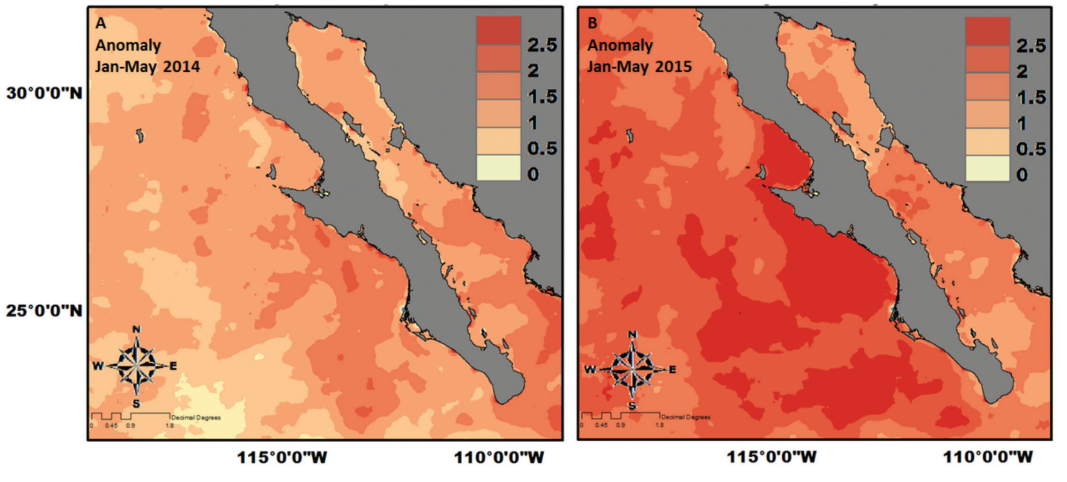

Figure 3. Positive sea surface temperature (SST) anomalies for January through May 2014 (A) and January through May 2015 (B) in relation to the same period for 2013, which was a typical year in terms of SST. The maps show the Pacific islands (Guadalupe Island and San Benito) where the GFS species inhabits and La Paz Bay where GFSs were reported.

including an increase in the duration of foraging trips by female CSLs from Magdalena Bay, BCS, Mexico (ENSO 1982-1983; Aurioles-Gamboa & Le Boeuf, 1991), and an increase in the duration and distance of the feeding effort undertaken by male CSLs from Monterey, California, during the unusually warm conditions in 2004 and 2005 (Weise et al., 2006). Likewise, both the population of Galapagos sea lions (*Z. wollebaeki*) and Galapagos fur seals have been drastically affected by strong ENSO events (i.e., 1982-1983 and 1997-1998) (Trillmich & Dellinger, 1991; Alava & Salazar, 2006). The Peruvian populations of South American sea lions (*Otaria flavescens*) and South American fur seals (*A. australis*) also have been significantly impacted by ENSO events in the past, leading to increased mortality and longer foraging trips by females (Soto et al., 2006; Campagna, 2008; Cárdenas-Alayza, 2012). In terms of extralimital records of Galapagos and Steller sea lions (*Eumetopias jubatus*), anomalous warm conditions (ENSO events in 1997-1998 and 2006-2008) have been considered factors that triggered these individuals to search for prey beyond known boundaries, reaching as far north as Chiapas (~1,700 km) and Colima (~5,000 km) in Mexico, respectively (Ceballos et al., 2010).

The prevalent conditions in the northeastern Pacific, including changes in the sardine (*Sardinops sagax*) population spawning outside of the foraging range of nursing CSLs and an absence of anchovy (*Engaulis mordax*), have been linked to a recent increase of *Zalophus* pup mortality in southern California (McClatchie et al., 2014; NOAA Fisheries, 2014). The GFS feeds mainly on cephalopods like the opalescent squid (*Doryteuthis opalescens*) and the Humboldt (jumbo) squid (*Dosidicus gigas*), among others (Gallo-Reynoso & Esperón, 2013); however, these squid eventually prey on sardine and other small fish species (Fields, 1965; MarineBio, 2013). This suggests an indirect effect on teutophagous predators like the GFS, caused by the decline of sardine or other species. Admittedly, there are other parsimonious explanations for these unprecedented GFS records at La Paz Bay such as disorientation caused by emaciation. More studies are needed to understand in detail how these anomalous conditions in the Pacific could actually affect these fur seals.

The GFS population has recovered significantly from the verge of extinction; however, the species is still considered endangered according to Mexican law (SEMARNAT, 2010). For this reason, the report of unusual dispersion events is ecologically relevant, whether such abnormal dispersions are due to population growth or environmental anomalies like the one that has prevailed in the northeastern Pacific for the past 2 y and which, should it continue, could potentially impact the GFS's recovery.

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