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The Northernmost and Westernmost Records of the Guadalupe Fur Seal (*Arctocephalus philippii townsendi*)

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The Guadalupe fur seal (*Arctocephalus philippii townsendi*; GFS) population was decimated in harvests for fur by commercial sealers in the late 18th and early 19th centuries to the point of presumed extinction by the late 1920s (Townsend, 1916; Weber et al., 2004; García-Aguilar et al., 2018). Presently, these animals are protected as an "Endangered" species under Mexican law (NOM-059-SEMARNAT-2010) and as a "Threatened" species under the U.S. Endangered Species Act (National Oceanic and Atmospheric Administration [NOAA], 1985); however, the International Union for Conservation of Nature considers it of "Least Concern" (Aurioles-Gamboa, 2015). The pre-exploitation population size was estimated to be approximately 200,000 individuals (Hubbs, 1979). Following this intensive hunting period, the species was considered extinct until a single adult male was sighted on San Nicholas Island in 1949 (Bartholomew, 1950), and, subsequently, a small breeding colony was observed on Guadalupe Island, Baja California, in 1954 (Hubbs, 1956). The population size was estimated at 500 individuals in 1967 and about 7,400 individuals in 1993 (Peterson et al., 1968; Gallo-Reynoso, 1994; García-Aguilar et al., 2018). As of 2013, the GFS population was estimated between 34,000 and 44,000 individuals and has an annual growth rate of 5.9% (García-Aguilar et al., 2018). This current abundance represents around one-fifth of the estimated historical population (García-Aguilar et al., 2018). Their recovery has been challenged by anomalously warm water in the GFS range since 2013 that has resulted in shifts in distribution, abundance, body mass, and mortality related to food availability (McCue et al., 2021).

The GFS historical range included the islands of Baja California, Mexico, to the Channel Islands in southern California in the United States (Peterson et al., 1968; García-Aguilar et al., 2018). However, archaeological data indicate its range may have included areas from California to Washington (Etnier, 2006) and south toward Socorro Island, Mexico (Revillagigedo Archipelago; Hamilton, 1951). A figure is provided by McCue et al. (2021) indicating current suspected core and geographic ranges for the species. Both ranges appear to be derived from analysis of tag returns from satellite-tracked animals, strandings, and consideration of the location of suspected optimal feeding habitat. The McCue et al. (2021) report presents core range as the best estimates of the area of highest abundance and geographic range as the area of widest distribution (see Figure 1). The majority of the GFS population centers around Guadalupe Island, the only recognized breeding colony for this species. However, recolonization has occurred at a secondary site with mostly sexually immature animals at the San Benito Islands (Gallo-Reynoso, 1994; Hambrecht et al., 2016; García-Aguilar et al., 2018). At this time, Guadalupe Island, the San Benito Islands, and Farallón de San Ignacio Island in the southern Gulf of California are the only locations where this species hauls out year-round (Aurioles-Gamboa et al., 2010; García-Aguilar et al., 2018; Gutiérrez-Osuna et al., 2022).

Extralimital sightings of GFSs have occurred mostly northward of Guadalupe Island (Aurioles-Gamboa et al., 1999). Numerous reports have occurred along the California coast, as well as along the Oregon and Washington coasts, and at least one individual was reported at Vancouver Island, British Columbia, Canada (Table 1). Many of these sightings have coincided with abnormal oceanic conditions. The increased sightings in Oregon and Washington have been attributed to a reemergence of the species in their northern

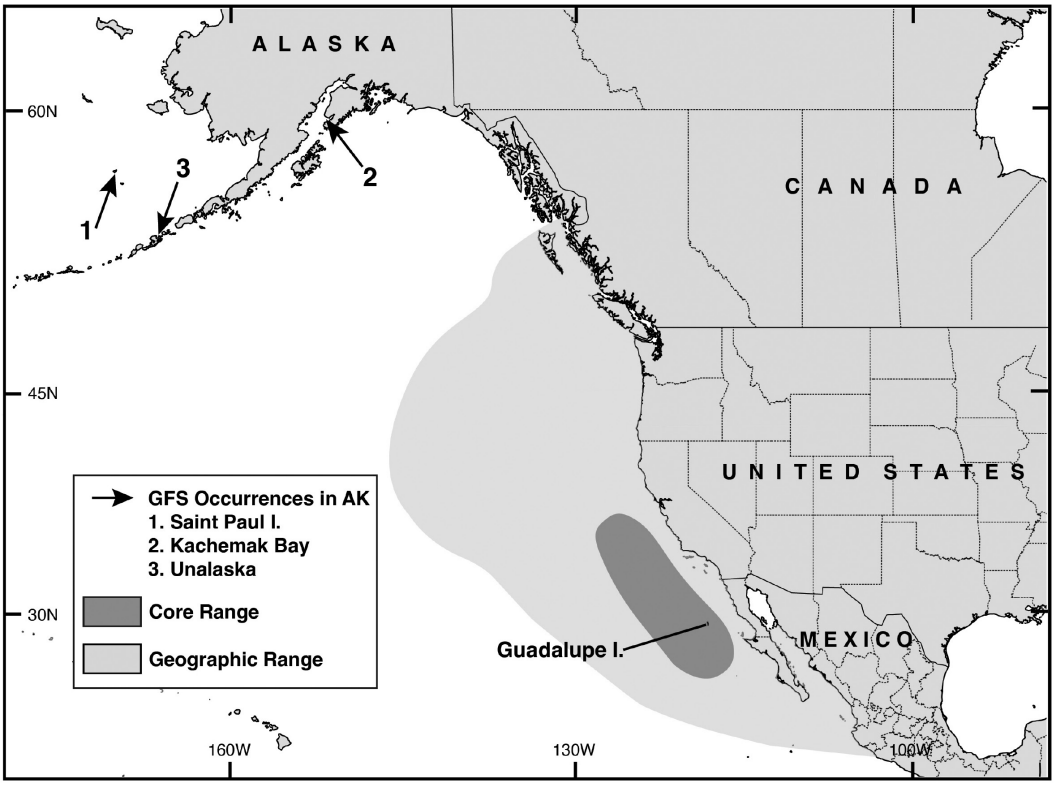

Figure 1. Core and geographic range of Guadalupe fur seals (*Arctocephalus philippii townsendi*) and the stranding locations for Records #1 through 3 (adapted from McCue et al., 2021)

historic range (D'Agnese et al., 2020). Relative to the northern sightings, less frequent observations have occurred south of Guadalupe Island, and the southernmost record for the species comes from an extreme extralimital sighting in the Galápagos Archipelago (Páez-Rosas et al., 2020). The following records add the GFS as a second fur seal species in Alaska, alongside the northern fur seal (*Callorhinus ursinus*).

Record #1

Between 1 to 5 July 1998, a GFS in apparent good condition came ashore at a northern fur seal rookery on Saint Paul Island in the Bering Sea (Figures 1 & 2). Scott Buckel, a visiting birder, posted his photograph to the iNaturalist citizen scientist online application (https://www.inaturalist.org) in 2018, at which point it was reviewed and identified as a GFS by one of the authors (SP). When contacted, Buckel did not recall the exact day the photographs were taken, but the dates provided cover the span of his visit to Saint Paul. The sighting location was near the Reef Rookery Public Viewing Platform near Saint Paul Village (57.111231 N, 170.285654 W). To the best of our knowledge, the animal was not resighted or reported by other sources around this time. Its sex and length are unknown, but it appeared to be a 4- to 6-y-old young male (R. L. DeLong, pers. comm., 21 May 2019).

Record #2

On 28 July 2007, a juvenile male GFS was found (by DDBT) in distress in Kachemak Bay, Alaska (59.32733 N, 151.51220 W; Figure 1). On initial presentation, it was thought to be a northern fur seal due to the location. The individual was observed to bump up against a stationary vessel with little to no reaction and appeared lethargic, emaciated, and obtunded (Figure 3C). The animal was then transported to the Alaska SeaLife Center (ASLC) in Seward, Alaska, for rehabilitation. Upon initial assessment, the yearling animal weighed 12.4 kg and was dehydrated and in poor body condition. It was positively identified as a GFS based on its long and pointed snout, abundant dark gray color, characteristic vocalizations, presence of fur on the dorsum of the foreflippers beyond the metatarsals,

Table 1. Guadalupe fur seal (*Arctocephalus philippii townsendi*) extralimital sightings north of Mexico. The criteria for defining sightings as extralimital has changed since the mid-20th century as the population has reoccupied parts of its former range north of Guadalupe Island.

Location	Km from Guadalupe Island	Year	Records	Animal condition	Oceanic condition	References
Southern CA Bight, USA	330-590	1949-1986	62 on islands; 3 at sea	Normal	El Niño (multiple) La Niña (multiple)	Stewart et al., 1987
San Miguel Island, CA, USA	590	1992-1993 1997	1 on island 2 (mother–pup)	Normal Normal	El Niño El Niño	Melin & DeLong, 1999
Princeton, CA, USA Monterey, CA, USA	943-1,020	1984 1997	1 stranded 1 stranded	Poor	El Niño and La Niña	Webber & Roletto, 1987
Central/Northern CA, USA (including SE Farallon Island)	700-1,125	1988-1995	9 stranded; 4 on island; 1 at sea	Poor; normal; poor	El Niño (multiple); La Niña (1 y)	Hanni et al., 1997
Saint Paul Island, AK, USA	5,090	1998	1 on island	Normal	El Niño	This study (Record #1)
WA & OR, USA	1,550-2,250	2005-2016	169 stranded	Mostly poor	El Niño (multiple), La Niña (multiple), MHW/"The Blob"	D'Agnese et al., 2020
Kachemak Bay, AK, USA	4,230	2007	1 rescued at sea	Poor	El Niño	This study (Record #2)
Dutch Harbor, AK, USA	4,718	2014	1 stranded	Poor	MHW/"The Blob"	This study (Record #3)
CA, OR & WA, USA	400-2,250	2015-2021	715 stranded	Mostly poor	MHW/"The Blob," El Niño, La Niña	NOAA, 2022
Vancouver Island, BC, Canada	2,382	2016	1 stranded	Poor	El Niño	CBC News, 2016

and the shorter hind flippers relative to the northern fur seal (Webber & Roletto, 1987; Jefferson et al., 2015; Elorriaga-Verplancken et al., 2021; Figure 3A & B). The animal's health was assessed, and appropriate treatment was administered, consisting of anti-parasitic medication and assisted feeding. Hematology and biochemistry data collected during rehabilitation were compared to published values for northern fur seals, and results were within normal range. Thoracic and abdominal radiographs were unremarkable, and fecal culture was negative for *Salmonella*, *Shigella*, and *Campylobacter* spp. Serology was negative for *Leptospira serovars*, phocine distemper virus, and phocine herpesvirus. Genetic testing at the NOAA Southwest Fisheries Science Center was a match to *A. townsendi*. In October 2007, the animal (named "Mica") was declared healthy for release and was transported to The Marine Mammal Center in Sausalito, California. To monitor this individual, the animal was equipped with a satellite tag (SPOT tags, Model 293; Wildlife Computers, Redmond, WA, USA) glued to the dorsum using epoxy. The fur seal was released on 26 October 2007 in San Simeon, California (Figure 4). Following release, the satellite tag returns indicated that this animal followed movement patterns and frequented areas typical of other fur seals in the area (Figure 5). The tag transmitted for 82 d, with the last received transmission on 26 January 2008. The subsequent fate of the animal is unknown.

Record #3

The third Alaska record was discovered when one of the authors (MAW) saw a photograph of a GFS in the *Unalaska Port of Dutch Harbor Official 2015 Visitors Guide* while traveling to Unalaska on an Alaska Marine Highway ferry. The photographer, Bret Richardson of Unalaska, was contacted, and he shared his images. This animal came ashore at Second Priest Rock in Summer Bay near the entrance to Dutch Harbor (53.902798 N, 166.466262 W) and was photographed over a

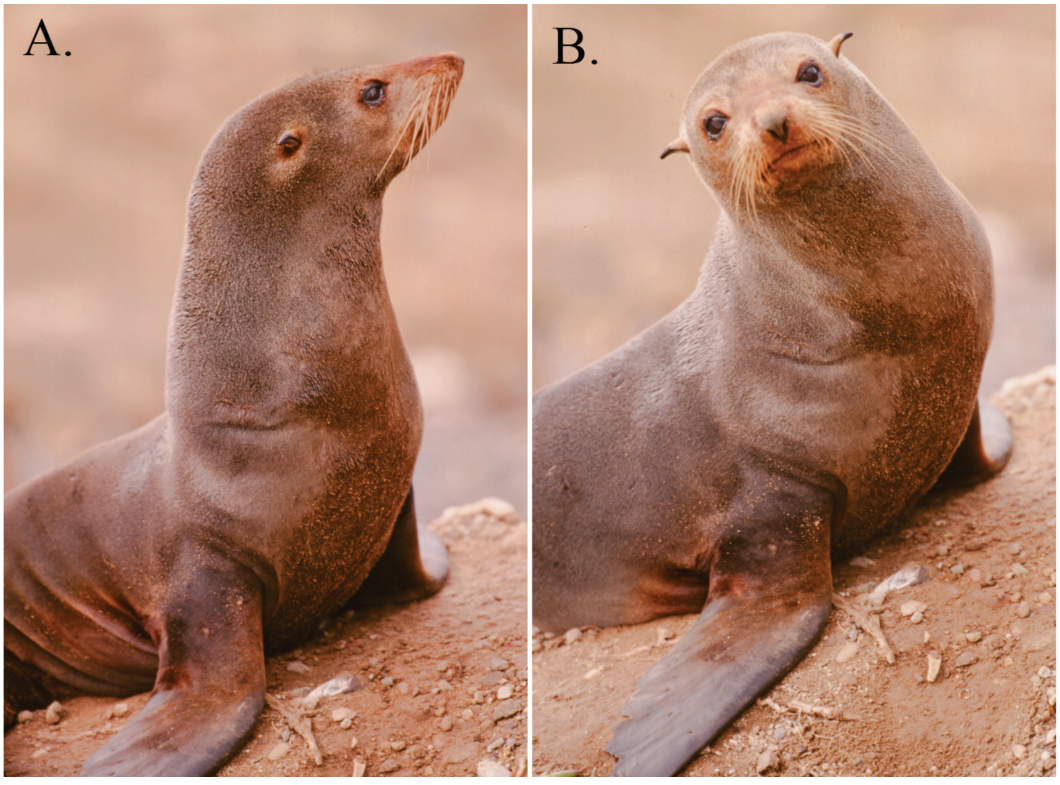

Figure 2. Guadalupe fur seal (Record #1) from Saint Paul Island, Alaska, 1998: (A) side view showing the long muzzle, which is longer than in northern fur seals; and (B) view showing the fur on the dorsum of the foreflipper extending beyond the bend in the flipper characteristic of the GFS. (*Photo credit:* Scott Buckel)

brief period in the middle of the day on 25 March 2014 before it left the area (Figures 1 & 6). This GFS looked moderately emaciated and appeared to have been the size of an adult or a large sub-adult female; sex and length are unknown.

All three animals in this report were found well out of the current core and geographic ranges of this species (McCue et al., 2021; Figure 1). They were also far from the primary rookery at Guadalupe Island. Minimum distances to Guadalupe Island are presented in Table 1. Record #1 from Saint Paul Island represents the longest reported distance from Guadalupe Island for this species. At 5,090 km, it exceeds the southernmost sighting of a GFS in the Galápagos reported by Páez-Rosas et al. (2020) of approximately 4,500 km from Guadalupe Island by almost 600 km. All these records taken together underscore the extreme wandering and movement capable by this species and the wide habitat tolerances of Guadalupe fur seals from the subarctic to tropical waters.

It is unknown if these extralimital sightings were due to climate change, disorientation caused by emaciation, range and population expansion, or other reasons. Effects of climate change on marine mammals can potentially include effects of reduced sea ice and rising sea levels on animal haul-out sites or species tracking a specific range of water temperatures in which they can physically survive (Learmonth et al., 2006). Other more indirect effects include changes in prey availability affecting distribution, abundance and migration patterns, community structure, exposure to predators, increased risk of human interaction, and susceptibility to disease and contaminants (Learmonth et al., 2006; NOAA, 2013). A species' distribution is often affected by several factors; however, prey availability plays a significant role and, in turn, decreases in prey can lead to nutritional stress and immune suppression (Forcada, 2002; NOAA, 2013). Ultimately, climate change can potentially influence growth, reproduction, and the overall success of a marine mammal population (Learmonth et al., 2006; McCue et al., 2021).

Strandings of GFSs have increased in recent years with most occurring in California, Oregon, and Washington (NOAA Fisheries Marine Mammal Health and Stranding Response Program

Figure 3. Guadalupe fur seal (Record #2) "Mica" after admission to the Alaska SeaLife Center: (A) image displaying the characteristic gradual transition of haired to hairless areas down the dorsum of the foreflipper, and the relatively short hind flipper seen in this species as compared to the northern fur seal; (B) view showing the characteristic long, pointed muzzle; and (C) image showing Mica malnourished. (*Photos:* Alaska SeaLife Center; activities permitted under NOAA/NMFS MMHSRP Permit #932-1489)

[MMHSRP] National Database, unpub. data, 1984-2019; Lambourn et al., 2012; D'Agnese et al., 2020; McCue et al., 2021). A high frequency of strandings between 2005 and 2007 prompted the NOAA Working Group to declare an Unusual Mortality Event (UME); however, no specific environmental factors were found to have caused the increased number of GFS strandings or their movement north (Lambourn et al., 2012). In contrast, adverse effects of unusual warming events on GFSs were documented a few years later. A large scale (~2,000 km wide and ~200 m deep) surface warming anomaly (1 to 4°C above normal), termed the Pacific Marine Heatwave or "The

Figure 4. Guadalupe fur seal (Record #2) Mica (left), released in 2007 after rehabilitation, with another GFS that stranded in California. A white satellite tag is attached to the back of Mica's neck. (*Photo credit:* The Marine Mammal Center)

Blob," was present in the northeastern Pacific Ocean. This anomaly was first observed off the southern coast of Alaska in December 2013, and it expanded into the west region of Baja California by mid-2014, thus creating a barrier to nutrients that would normally flow from the subarctic to the central Pacific, leading to secondary biological impacts (Bond et al., 2015; Kintisch, 2015; Elorriaga-Verplancken et al., 2016b).

These abnormal environmental conditions were thought to play a role in the unusual distribution of these GFSs. This anomaly of warmer conditions led to the increased stranding of 715 mostly emaciated, recently weaned GFS pups along the coasts of California, Oregon, and Washington from 2015 to 2021 (McCue et al., 2021; Table 1). Additionally, a few emaciated GFSs were recorded in the southwest Gulf of California in 2015-2016 (Elorriaga-Verplancken et al., 2016a). This phenomenon, declared a UME, was attributed to malnutrition secondary to suboptimal prey conditions (McCue et al., 2021). The Pacific Marine Heatwave "reduced the upwelling influence on the upper water column in the southern California Current Large Marine Ecosystem (CCLME) diminishing the primary productivity and consequently altering the abundance and distribution of important prey species for several oceanic predators" (Gálvez et al., 2020, p. 7), including the Guadalupe fur seal (Barth et al., 2007; Cavole et al., 2016; Zaba & Rudnick, 2016; Gálvez et al., 2020). In addition, the positive sea surface temperature (SST) anomalies were determined to have a negative effect on GFS neonatal body weight gain (Gálvez et al., 2020). Neonates had the lowest weights at birth and the slowest weight gain in 2014, as well as low weights and the lowest survival rate in 2015, all of which were likely due to persistently warm environmental conditions (Gálvez et al., 2020). The warm SST conditions may have led to a reduction or dispersion of prey species typically found in nursing GFS females' foraging range. This effect on food availability may have led to lower forage quality followed by dietary changes for nursing females, which may have resulted in limited nutrition for their pups (Gálvez et al., 2020). Additionally, changes in feeding trip duration and maternal attendance may have occurred (Gálvez et al., 2020). Overall, this documents a sensitivity of GFSs to regional warming conditions and potential vulnerability to continued climate change that may ultimately impact their recovery (Gálvez et al., 2020). Both the 1998 and 2007 records from Alaska were associated with or nearly with El Niño events, while the 2014 record took place during the 2013-2015 marine heat wave event in the northeastern Pacific.

While the presence of these GFSs in Alaska is most likely associated with the occurrence of warmer waters, it may indicate potential new foraging grounds and/or increases in population size or range. Less knowledge is available on the GFS

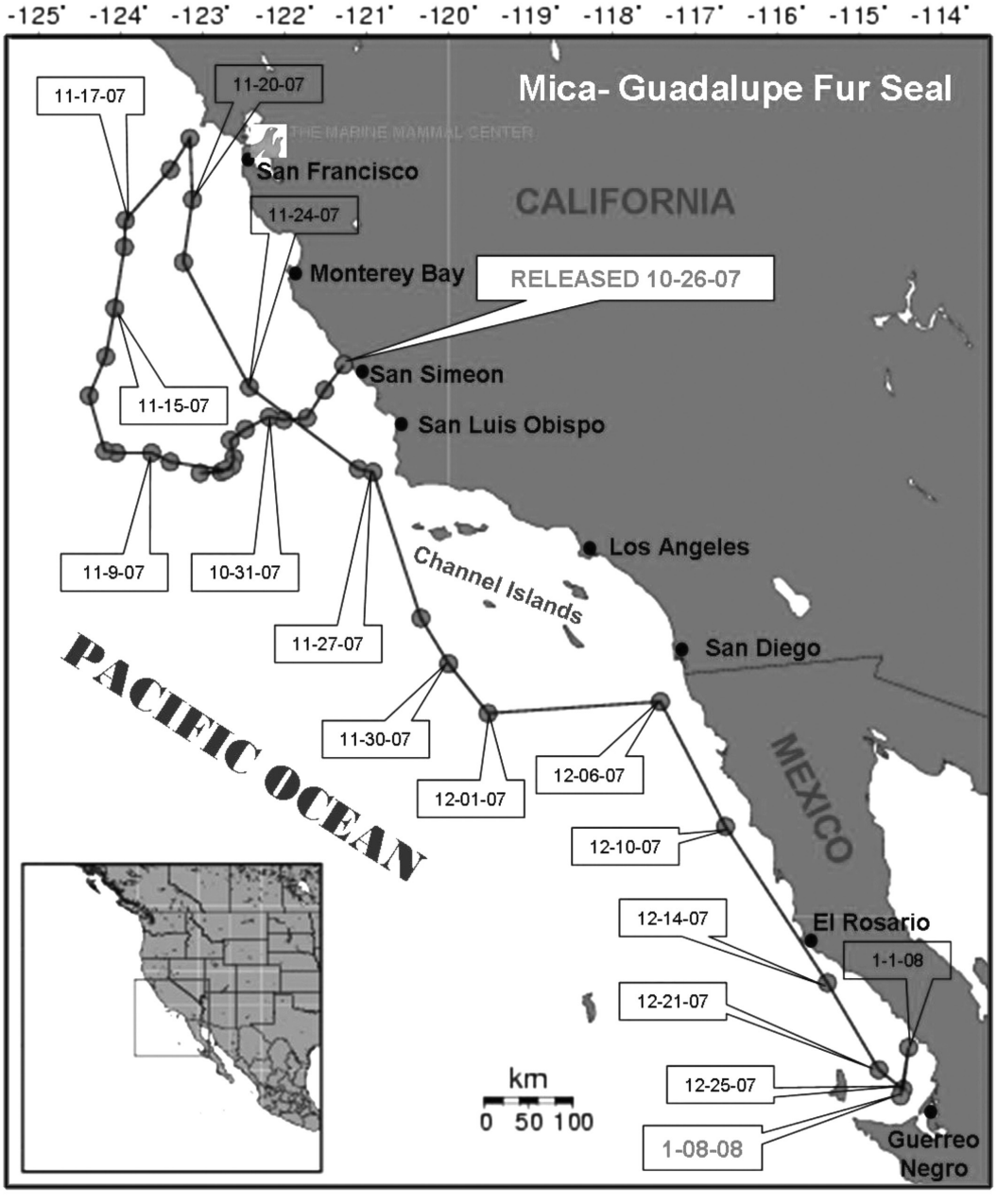

Figure 5. Guadalupe fur seal (Record #2) Mica was released 26 October 2007 in San Simeon, California. Following release, the satellite tag returns indicated that this animal followed movement patterns and frequented locations typical of other GFSs in the area. Graphic created through the Maptool program, a product of SEATURTLE.ORG; dates in MM-DD-YY format.

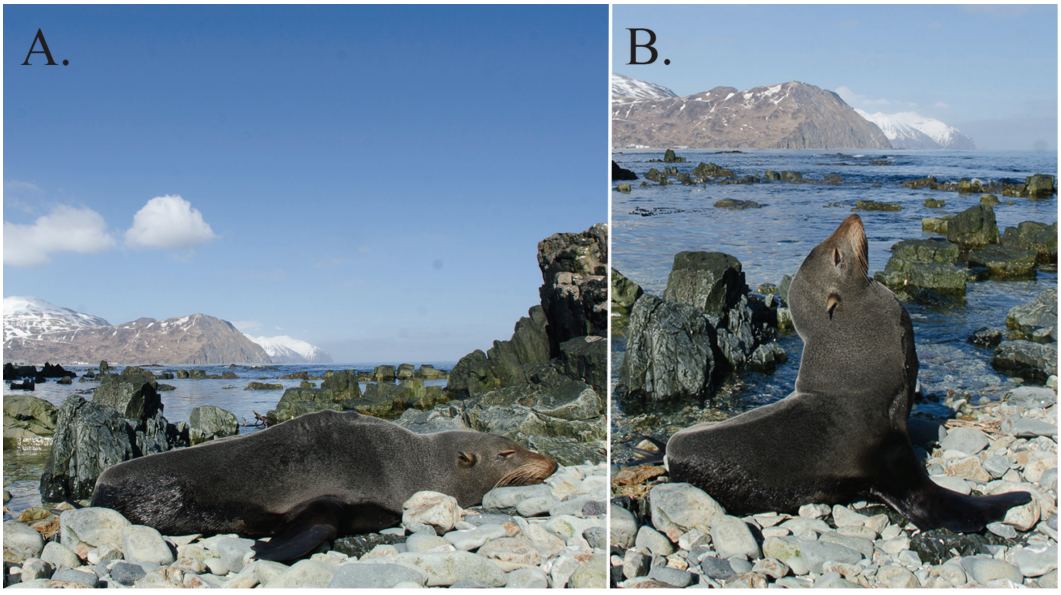

Figure 6. Guadalupe fur seal (Record #3) on Unalaska Island in 2014: (A) moderate emaciation can be seen along the top of the back and side of the chest; and (B) side view showing the long muzzle and evidence of emaciation. (*Photos:* Brett Richardson)

compared to other pinnipeds (Lander et al., 2000), and these extralimital sightings may indicate that GFSs occur in Alaskan waters more commonly than previously believed (Aurioles-Gamboa et al., 1999). In addition, this report contributes to the few studies documenting post-release movement patterns of this species, which, in turn, may aid in the management and release criteria for rehabilitated GFSs (Lander et al., 2000).

The GFS population continues to increase and rebound; therefore, it is likely this species will extend its breeding range and foraging grounds. Continued monitoring of these animals is essential to obtain a better understanding of population dynamics and to identify potential local and regional threats (García-Aguilar et al., 2018). Although GFSs continue to recover, prolonged warming conditions or oceanographic abnormalities pose a threat to this species with potentially additional UMEs (Gálvez et al., 2020). GFSs have one main breeding colony, have a narrower feeding strategy, and dive mostly to shallow depths for cold-blooded species (mainly squid) that are sensitive to changes in ocean temperatures; thus, the effects of climate change may negatively impact this population undergoing recovery (McCue et al., 2021). In addition, the decreased genetic diversity secondary to the genetic bottleneck may have left the population more vulnerable to infectious disease or environmental stressors (Weber et al., 2004; D'Agnese et al., 2020). Furthermore, it is imperative to report strandings (such as Record #2) and analyze trends in relation to oceanic conditions and population growth; and because two species of fur seals can be found in Alaska, care must be taken to identify them at sea and on land (Villegas-Zurita et al., 2015; D'Agnese et al., 2020).

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