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Systematic Review of Pinniped Sightings and Strandings Along the Pacific Coast of Colombia: Implications for Pinniped Conservation

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Abstract

Sightings of pinnipeds in Colombian waters of the Pacific Ocean have sporadically been reported since 1970. Despite the Colombian Pacific region (CPR) not being within their typical distribution range, six pinniped species—the Galápagos fur seal (*Arctocephalus galapagoensis*), the Galápagos sea lion (*Zalophus wollebaeki*), the South American fur seal (*Arctocephalus australis*), the South American sea lion (*Otaria byronia*), the Juan Fernández fur seal (*Arctocephalus philippii*), and the southern elephant seal (*Mirounga leonina*)—have been recorded in recent times. This study presents an overall systematic review of pinniped sightings and strandings from 1970 to 2023 along the Pacific coast of Colombia, with a total of 68 sightings of 80 individuals. Pinnipeds were recorded most often in 1998 (13 individuals), followed by 2014 (nine individuals); 1997 (eight individuals); 1983 (seven individuals); and 1993, 1996, 2015, and 2020 (with three individuals each year). Most pinniped observations correspond to vagrants—solitary, young individuals sighted on the southern coast of the Colombian Pacific, specifically in Tumaco. Some records of these species appear to be influenced by upwelling events and changes in climatic-oceanographic phenomena (ENSO episodes) in the region. Further monitoring is necessary to determine whether species presence and abundance in the CPR is a response to (1) vagrant behavior of the species, (2) altered habitat use associated with bioecological changes in the species populations, and/or (3) shifts in distribution ranges related to potential new habitat suitability.

Key Words: Otariidae, Phocidae, vagrant, range distribution, Eastern Tropical Pacific, ENSO, ICEN

Introduction

Before 2000, 28 marine mammal species had been documented in the Colombian Pacific region (CPR), including six mysticetes (baleen whales), 17 odontocetes (toothed whales), and four pinnipeds (seals, sea lions, and fur seals) (Ministerio de Ambiente y Desarrollo Sostenible, 2022). The pinniped species registered from the late 1980s through the early 2000s were the Galápagos fur seal (*Arctocephalus galapagoensis*), the Galápagos sea lion (*Zalophus wollebaeki*), the South American fur seal (*Arctocephalus australis*), and the South American sea lion (*Otaria byronia*) (Von Prahl, 1987; Mora-Pinto & Muñoz-Hincapié, 1994; Flórez-González &

Capella, 1995; Palacios et al., 1997; Capella et al., 2002; Herrera et al., 2011; Avila et al., 2013a; Solari et al., 2013). However, the count of marine mammals, and particularly pinniped species reported in the CPR, has notably increased since 2000. In 2017, the Juan Fernández fur seal (*Arctocephalus philippii*; Avila et al., 2014) was added to the Colombian marine mammals list in the *Responsible Sighting Guide of Aquatic Mammals in Colombia* (Ministerio de Ambiente y Desarrollo Sostenible, 2017, 2022) as was the southern elephant seal (*Mirounga leonina*) in 2022 (Avila et al., 2021).

The documented sightings and new records of vagrant pinniped species—those beyond their usual distribution range—along the Pacific coast of Colombia (Flórez-González & Capella, 1995; Capella et al., 2002; Avila et al., 2013a, 2014, 2021) could be considered accidental or occasional as South American pinnipeds do not have breeding and haul-out sites in the CPR, and individuals' exploratory and feeding behaviors influence their decisions to travel long distances from their usual habitats (Riedman, 1990). While vagrant behavior generates most pinniped sightings in areas outside their usual distribution ranges, records in new areas have also been related to potential species population recovery after marine mammal harvesting stopped in the early 20th century (Hofmeyr et al., 2006; Wilson et al., 2006), a phenomenon suggested for the southern elephant seal (Alava et al., 2022b).

It is also plausible that certain areas within the CPR offer resources and suitable habitats that are attractive to South American pinnipeds. Some oceanographic and ecological characteristics in the CPR, including the persistence of coastal upwelling cores throughout the year (Villegas, 1997a, 1997b, 2003), promote important primary productivity (Wyrtki, 1981) and prey availability (e.g., fish, squid), resulting in potentially important foraging areas for pinnipeds, particularly during regional marine warming events caused by the El Niño-Southern Oscillation (ENSO). A reduction in primary production is observed during El Niño events in the eastern South Pacific Ocean (Chavez et al., 1999), which may impact South American pinniped populations due to important changes in prey availability (Trillmich & Mohren, 1981), influencing their foraging behaviors (Soto et al., 2006) and habitat preferences, and ultimately altering their distribution range (Salazar & Denkinger, 2010; Avila et al., 2021; Alava et al., 2022a, 2022b). As a result, unusual sightings and strandings are generated such as the ones reported in the CPR (Palacios et al., 1997; Avila et al., 2014, 2021). These occurrences are likely to become more pronounced under future climate change scenarios and the resulting increased frequency of extreme warm ocean events like ENSO (Yeh et al., 2009).

However, there is no established, clear association between pinniped occurrence in the CPR and ENSO events. Vagrant individuals that appear to be in good body condition may not reflect an adverse climatic scenario related to food shortage in their usual foraging grounds but, rather, inherent exploratory behavior or intraspecific foraging competition in populations undergoing a recovery process. As a result, multiple vagrants may be observed in areas outside their distribution range (Elorriaga-Verplancken et al., 2021). A recompilation of pinniped vagrant records is a useful first step to understand movements of individuals (juveniles and adults) for a better overall comprehension of pinniped biology.

Therefore, with the aim of enhancing our understanding of South American pinniped records in the CPR, an extensive systematic review of both published and unpublished data on pinniped sightings and strandings from 1970 to 2023 was undertaken. Data presented herein come mainly from isolated reports of live or dead individuals. It is expected that this work will serve as the basis for establishing a long-term monitoring and systematic program to assess the occurrence of pinnipeds in Colombia to determine if ENSO events are influencing the presence of pinniped species in the CPR. This 53-year analysis of pinniped occurrences could help to elucidate why pinnipeds appear to be increasing their distributional ranges to new areas and could imply early colonization of new potential long-term sites (Ferreira et al., 2007), with ecological and conservation implications still to be determined.

Methods

Study Area

The study area comprises the Colombian Pacific coast—from Cabo Marzo in the Choco department in the north, through Valle del Cauca and Cauca departments, to Cabo Manglares in the Nariño department in the south—where pinniped species records have been documented (Figure 1). In this area, the northeast and southeast trade winds converge, known as the Intertropical Convergence Zone (ITCZ) (Díaz-Ochoa & Quiñones, 2008; Dirección General Marítima [DIMAR], 2022), which influences the CPR. ITCZ south-north-south movements allow high levels of cloudiness and precipitation, as well as variable winds (Díaz-Ochoa & Quiñones, 2008). These ITCZ-influenced wind patterns allow the formation of pelagic upwelling events throughout the year (Villegas,

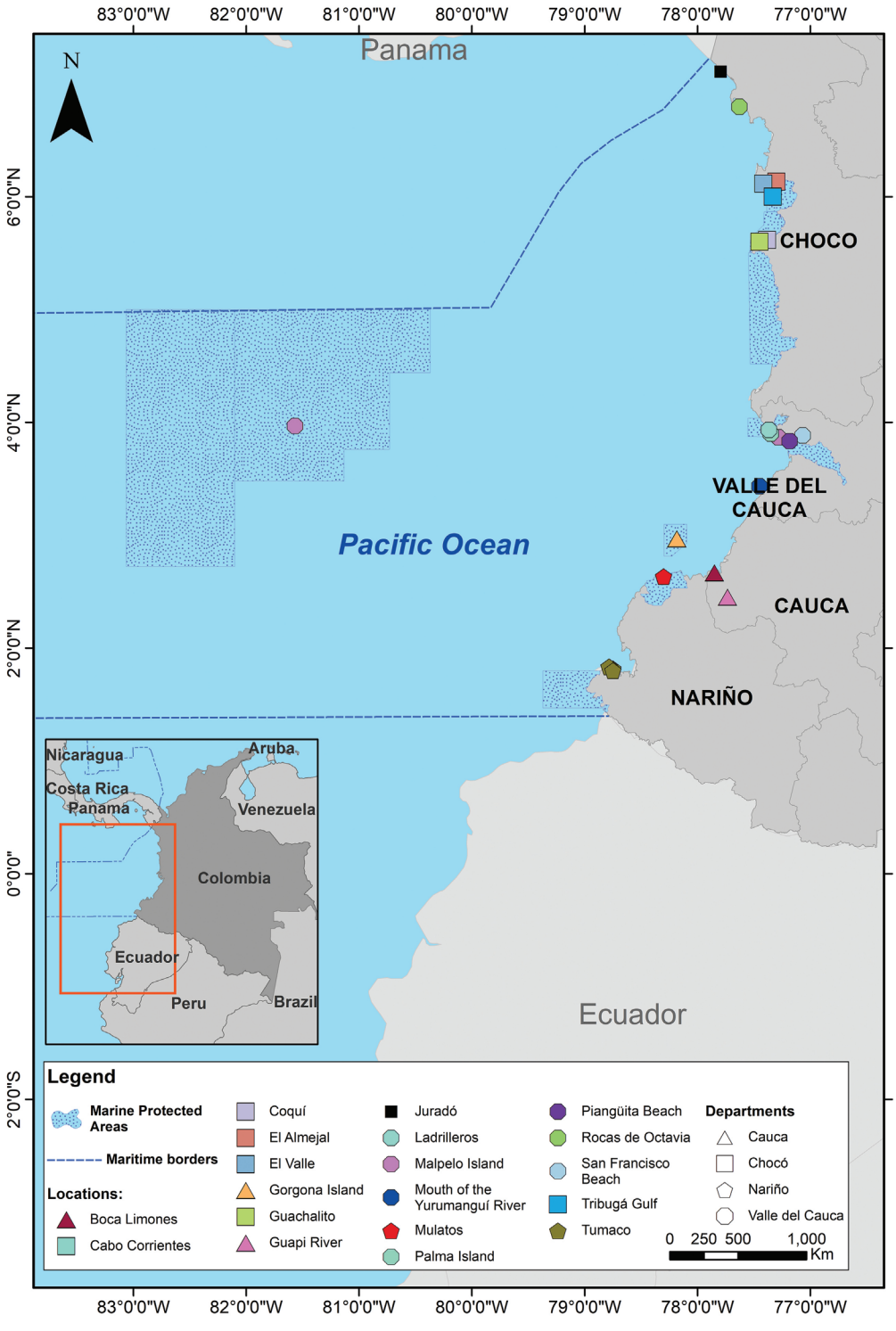

Figure 1. Locations of extralimital records of vagrant pinniped species sighted along the Colombian Pacific coast, registered by sites and departments as listed in Supplemental Table 1

1997a, 1997b; Díaz-Ochoa & Quiñones, 2008; DIMAR, 2022), generating nutrients along the CPR (Pineda, 1995)—although in some coastal areas in the CPR where neritic zone depths do not exceed 200 m, it is possible that the high coastal productivity is also enhanced by contributions from the input of some nearby rivers into the ocean (Díaz-Ochoa, 2003).

Pinniped Sighting and Stranding Data Collection
Records of pinniped species in the CPR were compiled from published data, including peer and nonpeer review articles, conference abstracts, reports, book chapters, books, and unpublished data. The search was conducted in the Scopus and EBSCO host databases, using combinations of five words which should be contained in either the article title, abstract, and/or key words. The search terms used were Pinnipedia OR Otariidae OR Phocidae OR seal AND Colombia. The search returned 69 scientific papers, which were reviewed to remove duplicates or studies with no confirmed species identification, resulting in eight papers. We also reviewed the cited literature within these papers to search for additional works that were not detected via the online search, which resulted in one additional work (a conference abstract). Only data with sighting and species confirmation were incorporated.

Additionally, we included information from new sightings collected in the field as opportunistic data by the Dirección General Marítima (DIMAR) between 2014 and 2022, as well as data provided by the local community in Tumaco (1° 50' N, 78° 47' W) and colleagues in El Valle (6° 6' N, 77° 25' E). For the community- and colleague-based sightings, information from the following sources were used and recorded: geographical position, number of individuals, and videos or photographs for posterior identification. Species were classified following the most up-to-date *List of Marine Mammal Species and Subspecies*, developed by the Taxonomy Committee of the Society for Marine Mammalogy (2022).

Finally, using all data from published sightings and visual documentation, the average frequency of individuals sighted per year was calculated to identify the years with the most sightings; years without any reported sightings were excluded. However, given that previously published sightings are from a variety of different sources and observers with dissimilar sighting effort, annual sightings calculations may be biased.

Pinniped Morphological Identification
For pinniped identification along the Pacific coast and waters of Colombia, we used marine mammal guides (e.g., Reeves et al., 1992, 2002; Allen et al., 2011), professional assessment by researchers or academics with experience in pinniped field work, as well as previous reports regarding fur seal sightings in Mexico and South America (e.g., Aurioles-Gamboa et al., 2004; Páez-Rosas et al., 2017). For identification and differentiation between seals, such as the southern elephant seal, and otariids, such as the Galápagos sea lion and the South American sea lion, external characteristics such as the absence of pinna (ears), the presence or elongation of proboscis, body size, and color, as well as the shape of fore flippers and hind flippers were taken into account. Among otariids, skull and body features such as a compact or chunky head, an upturned snout, short and blunt muzzle, extended lower jaw, prominent mane (males), large and massive neck, and body size with dark brown to light orange coloring were considered for South American sea lion identification. For Galápagos sea lions, the color of the fur from dark to light brown was considered, as well as the presence of a sagittal crest (adult male) and small body size.

For determination of fur seal species and age classes, body size and fur color, gross cranial appearance—muzzle length, shape, and orientation—as well as size of fore flippers and hind flippers were analyzed. Specifically for the Galápagos fur seal, which is the smallest fur seal species, the fur appearance around the snout area as yellow, blonde, or pale, with a pointed muzzle, large ear pinnae, and creamy vibrissae is typical for young age classes. However, subadult and adult male Galápagos fur seals have darker-brown fur and smaller body size than the South American and Guadalupe fur seals. The South American fur seal has a nostril that is slightly straighter and shorter than the Galápagos fur seal with a more robust and larger body size (Reeves et al., 1992, 2002; Allen et al., 2011).

However, it should be noted that we were limited in accessing additional methodologies to accurately verify species of the *Arctocephalus* genus (e.g., molecular analysis). Given that the estimation of age classes was assessed only by morphological appearance, the individual identification and age class determinations presented in this article should be regarded as "presumed species" and "presumed age."

Pinniped Sightings and Their Relationship with El Niño-Southern Oscillation
We described the relationship between the pinniped sightings and the ENSO using all data from published and unpublished records of pinniped sightings and two different climate indices: (1) the Oceanic Niño Index (ONI) and (2) the El Niño Coastal Index (ICEN—acronym in Spanish for "Índice Costero El Niño"). The ONI is a running 5-mo average of sea surface temperature (SST)

anomalies in the equatorial Pacific Ocean characterized by the El Niño 3.4 region (5N to 5S, 170 to 120W), while the ICEN represents a running average over 3 mo of SST anomalies in the equatorial coast of South America through the El Niño 1+2 region (0 to 10S, 90 to 80W). Both indices can be used to determine whether an ENSO event class (e.g., El Niño, La Niña, Neutral) was present in the months and years of the sightings.

For the ONI, temperature anomaly data were obtained from a National Oceanic and Atmospheric Administration (NOAA) database (https://psl.noaa.gov/data/climateindices); and for the ICEN, the data were obtained from the Geophysical Institute of Peru (http://met.igp.gob.pe/datos/icen.txt). Both versions of these indices are based on the extended and reconstructed SST (*ERSST*, Version 5) derived from the International Comprehensive Ocean-Atmosphere Dataset (ICOADS) (National Center for Atmospheric Research [NCAR], 2022).

Results

In the CPR, 68 sightings of 80 individuals from six different pinniped species—specifically, the Galápagos fur seal (Capella et al., 2002), the Galápagos sea lion (Flórez-González & Capella, 1995; Palacios et al., 1997; Herrera et al., 2011), the South American fur seal (Von Prahl, 1987), the South American sea lion (Von Prahl, 1987; Mora-Pinto & Muñoz-Hincapié, 1994; Capella et al., 2002), the Juan Fernández fur seal (Avila et al., 2014; Alava et al., 2022a), and the southern elephant seal (Avila et al., 2021; Alava et al., 2022b)—have been reported along the Colombian coastal and insular areas in works published between 1970 and 2021. Additionally, 22 sightings of 21 specimens were obtained from unpublished data during recent years up until 2023 (2011, 2014, 2015, 2017-2019, 2021-2023) (Supplemental Table 1; the supplemental table for this article is available on the *Aquatic Mammals* website). Among these sightings, the Galápagos fur seal (number of individuals n = 19), the Galápagos sea lion (n = 16), and the South American sea lion (n = 10) were the three most frequently reported species.

Extralimital records of the different species, including number of individuals, number of sightings, year and month of sighting, climate index (ONI and ICEN) and the phase (i.e., El Niño, La Niña, or Neutral), age class and sex, animal condition (live or dead), location (position), and sources are listed in Supplemental Table 1. The range of sighting distributions where these species have generally been reported extend from southern locations in Tumaco (1° 50' N, 78° 47' W) to northern locations in Juradó (7° 6' N, 77° 46' W) (Figure 2). Among Colombian departments, sightings were more frequent in the southern departments: Nariño (n = 30), Cauca (n = 22), Valle del Cauca (n = 19), and Chocó (n = 10) (Figure 2).

Visual Documentation

According to visual determination, 16 individual Galápagos sea lions, 10 individual South American sea lions, and one *Zalophus* sp. were identified. Among the fur seals, 19 individual Galápagos fur seals and seven South American fur seals were identified, with a single Juan Fernández fur seal identified. Some individuals were difficult to classify by age, but according to the external description and examination in the field, and using archived photos and videos, seven otariids were identified as presumed young juveniles (≥ 2 y), two as juveniles, and two as subadults. Only one Galápagos sea lion was reported among these unpublished records, and it was not possible to identify its age class; the single record of a South American fur seal was identified as a juvenile. Figure 3 shows one of these subadults identified as a Galápagos fur seal and the other subadult identified as a South American fur seal. Most juveniles reported were Galápagos fur seals (n = 5).

Seven individuals, identified as Otariidae spp., were reported at different times during August 2014 in Tumaco. Additionally, two fur seals that were identified as *Arctocephalus* sp. were found in this area with a fishhook in their mouths (Figure 4). In the first case, the fishhook was removed by personnel of the Colombian Naval Army under the direction of a veterinarian before releasing the animal (Infantería Marina No. 40, Tumaco). In the second case, the animal was found in poor body condition with a large wound in its mouth caused by a fishhook. This individual was maintained in rehabilitation under controlled conditions by veterinarians from the Environmental Corporation of Nariño (Corponariño) until its release.

The unpublished sighting data (n = 15 records) for otariid specimens (Supplemental Table 1) predominantly occurred in the southern Colombian Pacific in Tumaco (1° 48' N, 78° 45' W), while only one record was in the northern Colombian Pacific in El Valle (6° 7' N, 77° 25' W). Sightings occurred mainly in August (2011, 2014, 2018), May (2014, 2015, 2023), and October (2019, 2021, 2022; see Supplemental Table 1). The three unpublished records for the phocid identified as an adult southern elephant seal (Figure 5; Supplemental Table 1) were obtained from citizen science reports and information provided by Utría Natural National Park park rangers.

Unfortunately, it was not possible to obtain body measures for any pinnipeds; however, at the time of sighting and stranding, almost all

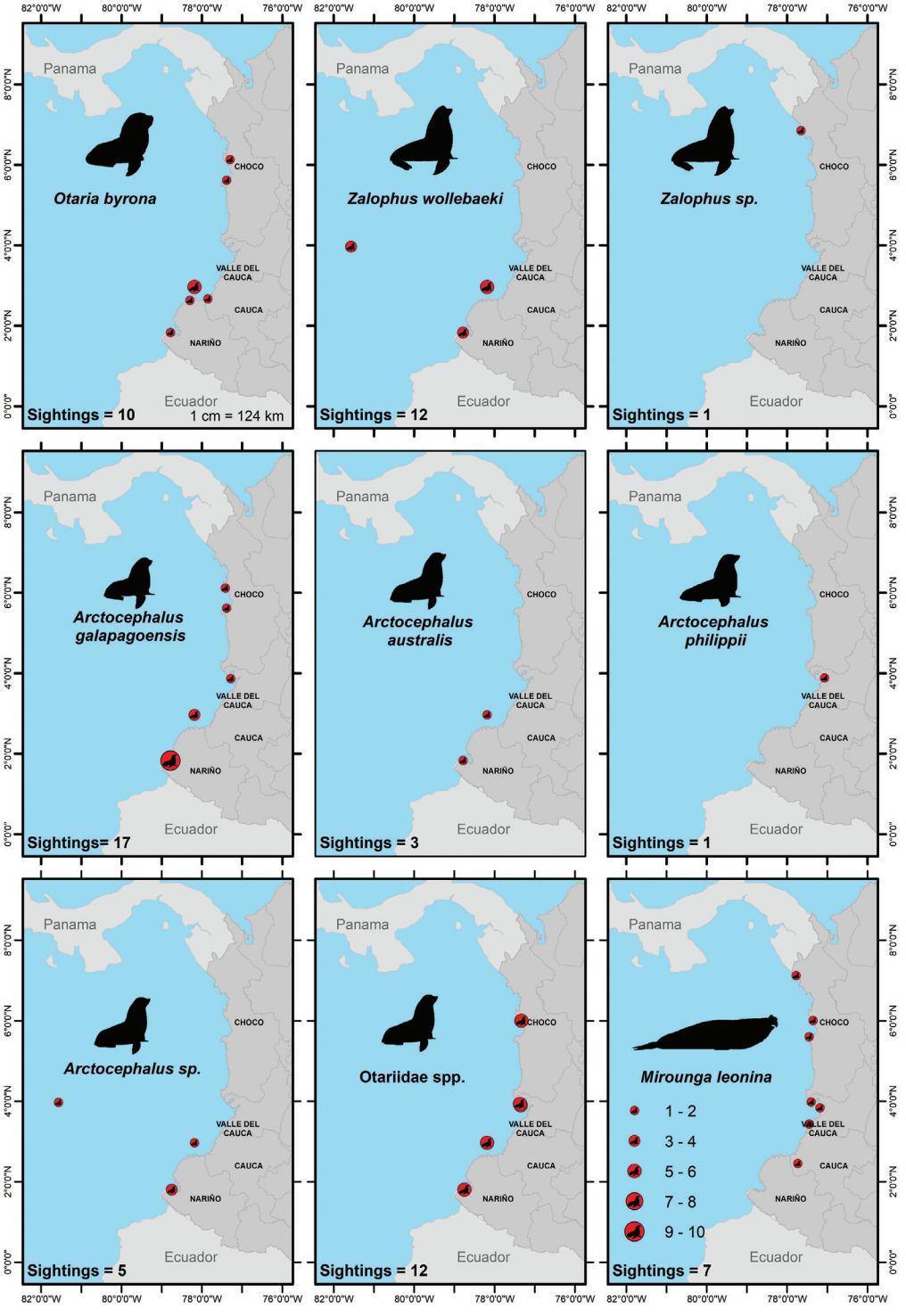

Figure 2. Extralimital records and sighting locations for vagrant pinniped species along the Colombian Pacific coast from 1970 to 2023 as listed in Supplemental Table 1

Figure 3. Photographs of Galápagos fur seals (*Arctocephalus galapagoensis*) reported in different locations along the Colombian Pacific coast. In El Valle (Chocó department, northern Colombia): (A) a subadult male specimen recorded in August 2011) (*Photo credit*: Arévalo-González); and in Tumaco (Nariño department, southern Colombia): (B) a young/juvenile specimen reported in May 2014, (C) a juvenile individual in May 2015, and (D) a subadult individual in August 2018. (*Photo credits*: [A] Arévalo-González; [B, C & D] DIMAR [Bermúdez-Rivas])

Figure 4. Photographs of two fur seals (*Arctocephalus* sp.): (A) likely a fur seal, presumably a South American fur seal (*Arctocephalus australis*) sighted in October 2021 with a fishhook in its mouth, which was treated before releasing; and (B) likely a Galápagos fur seal or South American fur seal observed in October 2022 with a wound on its mouth caused by a fishhook. Both individuals were observed in Tumaco (Nariño department, southern Colombia) with evidence of fishing interactions. (Photos provided by Infantería Marina No. 40, Tumaco, Nariño)

Figure 5. Southern elephant seal (*Mirounga leonina*) adult male observed at Utría National Natural Park (Chocó department, northern Colombia) in October 2022 (*Photo credit:* Julio Pérez, Bicivan, Colombia)

specimens exhibited moderate body condition (i.e., the prominence of ribs or vertebral spine was not observed). One otariid individual found in Tumaco during August 2014 had several pelagic gooseneck barnacles (*Lepas anatifera*) attached to its fore flippers, which were removed by a veterinarian.

Pinniped Sightings and Stranding Frequency

All the data collected in this study was opportunistic, with no direct effort in terms of years, months, or species. However, the annual average frequency of individuals sighted was assessed, with 1.51 individuals per year. Pinnipeds were registered most often in 1998 (13 individuals) and followed by the years 2014 (nine individuals), 1997 (eight individuals), and 1983 (seven individuals). The years 1993, 1996, 2015, and 2020 all had reports of three individuals each year (Supplemental Table 1). Coinciding with the year containing the most sightings, a very strong El Niño event occurred between June 1997 and July 1998 (Trenberth et al., 2002), while 1983 and the second half (July to December) of 1998 were influenced by a La Niña event (Figure 6; Supplemental Table 1). Additionally, we found indications that some species could be more susceptible to the different ENSO events. For example, in every strong El Niño event (1997 and 1998, based on the ICEN), the species with the most individuals sighted in CPR were the Galápagos sea lion (seven individuals in total) and the Galápagos fur seal (nine individuals in total), while southern elephant seals were recorded more during Neutral (three individuals in 2020) and La Niña (three individuals per year in 2018, 2021, and 2022) phases. Conversely, the other three species—South American sea lion, South American fur seal, and Juan Fernández fur seal—did not show any clear relation with ENSO events based on the ICEN (Figure 6).

Discussion

From a total of 33 extant pinniped species (Berta, 2018), six have been sighted along the Pacific coast and in the waters of Colombia over the last 53 years (1970 to 2023). This level of occurrence reflects the potential of suitable habitat for South American pinnipeds in the CPR and highlights the importance of the Colombian authorities and academic institutions performing systematic biological monitoring and developing marine mammal stranding protocols.

Overall, most individuals (n = 80) recorded in the CPR belonged to the Otariidae family (five species), while only six individuals were from the Phocidae family (Supplemental Table 1). The Galápagos sea lion, the Galápagos fur seal, and the South American sea lion were the most common pinnipeds recorded. The South American fur seal has been reported just three times; however, due to its morphological similarities with the Galápagos fur seal, this species may have been misidentified

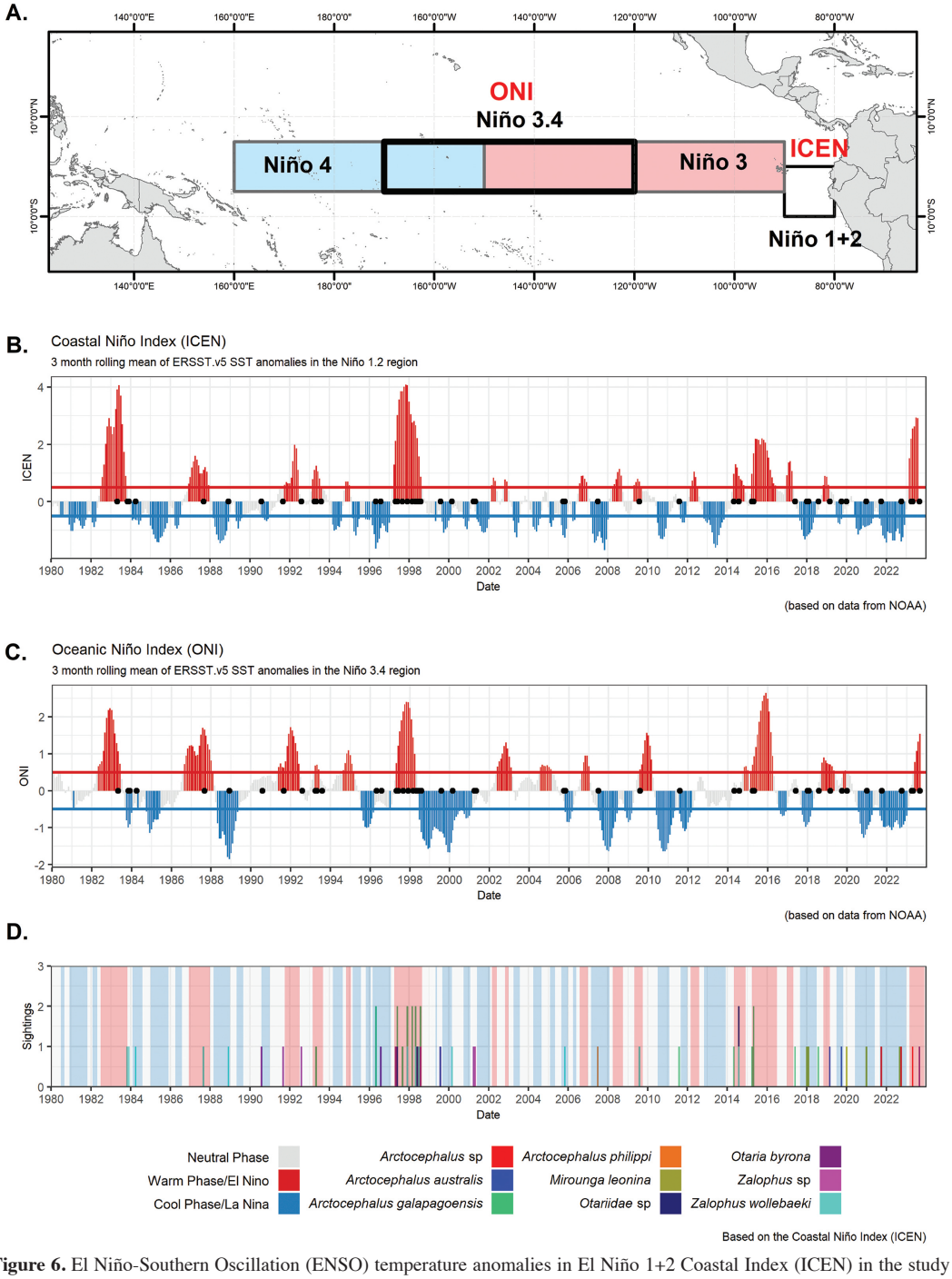

Figure 6. El Niño-Southern Oscillation (ENSO) temperature anomalies in El Niño 1+2 Coastal Index (ICEN) in the study area: (A) regions used for defining ENSO events based on sea surface temperature (SST); (B) Coastal Niño Index (ICEN); (C) Ocean Niño Index (ONI); and (D) sightings of pinniped individuals (colors of each bar represent different species) reported in the Colombian Pacific Ocean between 1983 and 2023 and its relationship with ENSO temperature anomalies in El Niño 1+2 Coastal Index (ICEN) (0 to 10S, 90 to 80W). Each climatic event is represented by gray (Neutral), red (El Niño), or blue (La Niña) colors. All the years begin in January.

in the field as it is usually difficult to differentiate between the two species. Further, it is possible that many of the unidentified otariid specimens (n = 16) could correspond to fur seal species (Capella et al., 2002; Herrera et al., 2014), including those from recent reports (2014 to 2023).

Typically, most pinniped extralimital records and strandings have been attributed to the presence of tropical, mid-latitude ENSO cycles (Rodgers et al., 2004; Alava & Salazar, 2006) or other sources of regional ocean warming such as the marine heatwaves recently reported along the northeast Pacific Ocean (Avila et al., 2021). All of these oceanographic events are related to important biological and ecological changes, including unusual marine mammal and sea bird sightings and strandings along the northeast Pacific Ocean (Cavole et al., 2016; Jones et al., 2018). However, our findings reflect that of the six species sighted in the CPR, only two (Galápagos fur seal and Galápagos sea lion) had a positive relation with an El Niño event (ICEN); one (southern elephant seal) appears to be related mainly with Neutral and La Niña events (ICEN); and the other three species (South American sea lion, South American fur seal, and Juan Fernández fur seal) showed no clear pattern related to ENSO events in the CPR (Figure 6).

El Niño events may result in pinniped migrations in Galápagos species (which are usually considered endemic only to the Galápagos Archipelago) in response to low prey availability, forcing animals to explore alternative feeding areas and strategies to survive (Félix et al., 2007). Consequently, these species (Galápagos fur seal and Galápagos sea lion) were the two most common pinniped species observed in the CPR.

The Galápagos fur seal, which is listed as an endangered species according to the IUCN's *Red List of Threatened Species* (RLTS) (Trillmich, 2015a), inhabits the Galápagos Archipelago, mainly in Fernandina and Isabela Islands at the western side of the Archipelago (Alava & Salazar, 2006; Aurioles-Gamboa & Trillmich, 2018). However, isolated births have been reported on the Ecuadorian mainland (Félix et al., 2007), plausibly increasing their range extension to the mainland coast of Ecuador as a secondary range of distribution (Aurioles-Gamboa & Trillmich, 2018). In 1993, a record of three Galápagos fur seals on the CPR contributed to the first confirmed sighting outside of their native Galápagos Archipelago area (Capella et al., 2002; Flórez-González & Capella-Alzueta, 2006), with animals having travelled up to 1,300 km (Capella et al., 2002; Supplemental Table 1). Currently, an increasing number of sightings of Galápagos fur seals, especially during the first half of the year (January to June), has been observed along the southern CPR, particularly in Tumaco (Nariño department, southern Colombia), resulting in them being the most common pinniped species reported with 16 records thus far (Supplemental Table 1). This species has also been reported in Panama, Costa Rica, and El Salvador (Montoya, 2008; Autoridad de los Recursos Acuáticos de Panamá [ARAP], 2014), as well as in Mexico, the northernmost location, with three records of nonreproductive individuals in 1997, 1998, and 2016 (Aurioles-Gamboa et al., 2004; Páez-Rosas et al., 2017). These sightings were associated with warming ocean conditions and with changes in prey availability within their foraging grounds around the Galápagos Archipelago (Aurioles-Gamboa et al., 2004; Páez-Rosas et al., 2017). Specifically, the 1997-1998 El Niño event affected prey availability within the Archipelago (Alava & Salazar, 2006), resulting in several reports of vagrants in the CPR (Figure 6).

The Galápagos sea lion, which is categorized as an endangered species according to the IUCN's RLTS (Trillmich, 2015b), has a small breeding colony reported at La Plata Island, Ecuador, located more than 1,000 km east of the Galápagos Islands (Trillmich, 2015b), so reports outside its normal distributional area do not appear to be uncommon. In Colombia, 16 records of vagrant Galápagos sea lions have been recorded southeast of Gorgona Island (Cauca department, southern Colombia), around 1,570 km from the Galápagos Archipelago, as well as along offshore islands such as Malpelo (Valle del Cauca department, central Colombia) and along coastlines in areas such as Tumaco (Flórez-González & Capella, 1995; Palacios et al., 1997; Capella et al., 2002; Herrera et al., 2011; Avila et al., 2013a; Supplemental Table 1). An additional record of one specimen identified as *Zalophus* sp. but presumably a Galápagos sea lion was reported at Rocas de Octavia (Cabo Marzo, Chocó department, northern Colombia; Avila et al., 2013b). If these vagrants do not come from La Plata Island, Ecuador, these records could indicate that individuals travel approximately 1,570 km from the Galápagos Archipelago to Colombian waters (Palacios et al., 1997; Capella et al., 2002; Flórez-González & Capella-Alzueta, 2006), similar to reports from Coco Island, Costa Rica, where several individuals were sighted in small groups or solitary (Acevedo-Gutiérrez, 1994; Montoya, 2008; Trillmich, 2015b).

Such instances of unusual sightings may be associated with intrinsic (e.g., age class, behavioral pattern) and/or environmental (e.g., SST) characteristics, particularly prey shortages in their usual foraging grounds. The species in our study

that have no clear relation with any ENSO events (ICEN) may reflect long distance movements due to exploratory behaviors of individuals that seek areas with more food resources (Riedman, 1990). This may be influenced by population recovery and intraspecific competition for marine resources (Trillmich et al., 2016), but more research on this topic is needed.

However, the lack of relationship detected between these two species with ENSO events could be misleading due to the low number of sightings in the CPR. For instance, the South American fur seal, a species of least concern according to the IUCN's RLTS, was reported only at Gorgona Island in March 1987 (Neutral Phase, ICEN; Von Prahl, 1987; Figure 6), and later at Tumaco in October 2019 (La Niña, ICEN; Figure 6). The geographical distribution of this species in the eastern South Pacific is one of the largest in South America, covering the entire Chilean coast to central-northern Peru (Cárdenas-Alayza et al., 2016), such as Isla Foca, Peru, where an isolated colony of the Peruvian subspecies (*Arctocephalus australis australis*) has been reported (Cárdenas-Alayza, 2018), with the northernmost distribution extending into Mexico (Villegas-Zurita et al., 2016). Therefore, it is not unexpected that some vagrants are being observed along the coast of Colombia and Ecuador, boosted by an increasing population trend (Cárdenas-Alayza et al., 2016), which could imply more juveniles exploring new areas (Ferreira et al., 2007), like the CPR, including records of the South American fur seal around the Colombian islands in the Pacific Ocean (Supplemental Table 1).

The same trend in population increases has been reported for the Juan Fernández fur seal, considered a species of least concern according to the IUCN's RLTS (Aurioles-Gamboa, 2015). Despite this, there are very few records of this fur seal outside the species' normal distribution range, which suggests that individuals are not dispersing and colonizing new areas (Alava et al., 2022a). Nevertheless, the migratory ability of this species is remarkable. Given its breeding colonies are located exclusively on the Juan Fernández Archipelago in Chile (Aurioles-Gamboa & Trillmich, 2018), it holds the longest-distance movement record travelled by any pinniped in the southeastern Pacific toward the CPR (Avila et al., 2014). Coincidentally, this species is considered the otariid with the longest foraging trips (Aurioles-Gamboa, 2015; Aurioles-Gamboa & Trillmich, 2018), lasting 12.3 d (Francis et al., 1998) to 40 d (Osman, 2008), and covering distances from 653 km (Osman, 2008) up to 1,394 km (Aurioles-Gamboa, 2015). Given the distance between the sighting at the CPR in Buenaventura Port (Valle del Cauca department, central Colombia) and Juan Fernández Archipelago (Chile), individuals would theoretically travel distances of approximately 3,700 to 4,600 km (Avila et al., 2014). The individual found was a young male in poor condition; he did not survive during rehabilitation due to gastroenteritis and a gastric ulcer (Avila et al., 2014).

While the fact that the Juan Fernández fur seal sightings did not show any pattern related to ENSO events may be due to their low numbers in the CPR, the South American sea lion also did not show any relationship with ENSO events and yet was the third most frequent pinniped reported outside of its distribution range. The South American sea lion sights reported in the CPR are the second northernmost unusual distribution in the Pacific Ocean since the South American seal was previously reported in Panama (Méndez & Rodríguez, 1984). The South American sea lion, which is distributed along northern Peru, is catalogued as a species of least concern according to the IUCN's RLTS (Cárdenas-Alayza et al., 2016). It has also been reported in Ecuador and the Galápagos Islands (Wellington & de Vries, 1976; Félix et al., 1994; Alava & Salazar, 2006; Cárdenas-Alayza et al., 2016), with established nonreproductive colonies in both locations (Félix, 2002). Consequently, the distribution range of this species could increase in the future and may include Colombia and Ecuador as a secondary habitat (Cárdenas-Alayza, 2018).

The southern elephant seal, a species of least concern according to the IUCN's RLTS with a stable population (Hofmeyr, 2015), is the only phocid species reported in the CPR (Avila et al., 2021). The sightings record suggests it may be traveling toward Colombian waters mainly due to La Niña events. During these events, a decrease in SST occurs, which produces changes in ocean circulation dynamics around the South American continent and Eastern Tropical Pacific (Kessler, 2006), resulting in cold and nutrient-rich areas that prompt migration of pinnipeds from the Southern Hemisphere toward northern latitudes (Ballance et al., 2006), allowing an expansion in their feeding areas (Romero-Tenorio et al., 2023). Additionally, a recent model analysis suggests that increasing temperatures in the western Atlantic Peninsula due to climate change (Mojica-Moncada et al., 2021) may also result in an increase of vagrant behavior with extralimital records and an extension of this species' distribution range (Alava et al., 2022b). A breeding colony of southern elephant seals has been recorded in southern Chile (Capella et al., 2017), and opportunistic sightings have been reported along the southern Pacific Ocean in Chile (Lewis et al., 2006; Sepúlveda et al., 2007), Peru, Ecuador (Rosero &

Alava, 2021), and the Galápagos Islands (Alava et al., 2022b). Nevertheless, recent records of southern elephant seals in higher latitudes like Mexico suggest that individuals have a great dispersal capacity, with presumed travel distances of 9,000 to 10,000 km from its nearest origin in the Southern Ocean (Elorriaga-Verplancken et al., 2020; Romero-Tenorio et al., 2023). These northernmost sightings coincide with recent records of juvenile or subadult southern elephant seals in the CPR (Avila et al., 2021; Supplemental Table 1).

The occurrence of pinnipeds in the CPR had previously been thought to be solely related to climatic-oceanic events, which have affected population dynamics and distribution patterns of pinnipeds in the Eastern Tropical Pacific (Trillmich et al., 1991; Soto et al., 2004; Alava et al., 2022b). Our data suggest that the occurrence of some pinnipeds from the Southern Hemisphere in the CPR does not appear to be associated with ENSO, likely due to the limited number of sightings, local oceanographic conditions, prey availability within their normal distribution area, population trends, sex–age class behavior (e.g., exploration), and field efforts which may influence pinniped reports in the CPR.

The northeastern tropical Pacific Ocean is particularly influenced by wind streams, which cause the development of significant upwellings throughout the year (Villegas, 2003), resulting in a highly productive tropical ecosystem in the CPR (Pineda, 1995; Palacios et al., 2006). This may provide substantial prey availability, including anchovy (*Cetengraulis mysticetus*) and an unidentified Gobiidae (Valencia et al., 2019) that could support pinniped occurrence in the CPR. Therefore, availability of other suitable habitat for South American pinnipeds may also play an important role in pinniped behavior and movements through the eastern South Pacific Ocean.

Endangered species in the CPR, such as the Galápagos sea lion and the Galápagos fur seal, are currently threatened by a host of environmental and anthropogenic stressors (Alava & Carvajal, 2005; Kovacs et al., 2012; Avila et al., 2018). This highlights the relevance of the CPR as potentially suitable habitat and protection areas for endangered species, especially for vulnerable age classes.

Finally, given that vagrant individuals have been reported regularly within the CPR (at least one individual per year), it is necessary to develop a monitoring program in the region. Additionally, a concerted database system to record species should be constructed, as well as a system for the rescue of stranded or vagrant animals in distress. Furthermore, it is recommended that molecular analysis (skin or hair) of individuals is performed to confirm pinniped species sighted in the CPR. The implementation of adequate land use and coastal marine zone management to protect marine biodiversity in the CPR should also be promoted, particularly in vulnerable areas like Tumaco or the Gulf of Tribugá, where a multipurpose port construction is planned, and where pinniped species are probably searching for refuge or a place to haul out.

Conclusion

Over a period of 53 years, 68 pinniped records (80 individuals) were observed in the CPR, of which 47 (69.1%) were associated with ENSO events (El Niño, $n = 31$; La Niña, $n = 16$; Supplemental Table 1), 12 (17.6%) occurred in Neutral years, and the remaining 13.2% represented data in which a relationship could not be established due to the lack of temporal information (month or year). However, this study suggests that Galápagos fur seals and Galápagos sea lions probably make regular excursions into the CPR, particularly during El Niño events, while South American fur seals and South American sea lions visit the tropical Colombian waters regularly. The excursions of the southern elephant seal are possibly related to La Niña events, which is consistent with previous records (Avila et al., 2021). Pinniped sightings in unusual areas are becoming more frequent, especially for juveniles, which undertake very long movements, appearing in unexpected places with a relatively high frequency (Reeves et al., 1992; Alava et al., 2022b). This exploratory and foraging behavior in pinnipeds is more likely to occur in young individuals, although all age classes are vulnerable to various degrees (e.g., related to experience and diet) to having to change their foraging behavior in order to survive (Trites & Donnelly, 2003). Further monitoring is needed to establish whether the occurrence of pinnipeds in the CPR is related to their species-specific vagrant behavior or because of altered oceanographic conditions.

Note: The supplemental table for this article is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147.

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