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TRABAJOS ORIGINALES

Stranded Marine Mammals on the South-Central Coast of Peru during El Niño 1997-98

Mamíferos marinos varados en la costa sur-central del Perú durante El Niño 1997-98

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Resumen
During the 1997-98 El Niño event, an assessment of marine mammal strandings was conducted from August 1997 to April 1998 between 15°22' and 15°27' S. This assessment encompassed 30.4 km of coastline, distributed in seven sectors located along the borders of the Ica and Arequipa departments, during which 7 marine mammal species and 2500 stranded specimens were recorded in the study area. *Otaria byronia* (67.88%) and *Arctocephalus australis* (31.48%) accounted for 99.36% of the total strandings. The remaining five marine mammal species included *Physeter macrocephalus*, *Phocoena spinipinnis*, *Lagenorhynchus obscurus*, *Tursiops truncatus*, and *Lontra felina*, only accounted for 0.64% of specimens. Both Otariidae species exhibited similar stranding patterns, and a statistical correlation was found with sea surface temperature (SST). *Otaria byronia* showed increased mortality in February 1998, while *Arctocephalus australis* peak mortality occurred in January 1998, aligning with the reproductive seasons of both species. The Guanera-La Lobera sector recorded the highest number of strandings, attributed to its proximity to the Punta San Juan National Reserve, which shelters large colonies of both species. Analysis of the stranded specimens in the Otariidae indicated a strong correlation in age group differentiation, resulting in high mortality among females and juveniles, who accounted for 80.3% of *O. byronia* and 63.5% of *A. australis*. Overall, these findings underscore the vulnerability of marine mammals to environmental changes caused by El Niño events.

Abstract
Durante El Niño de 1997-98, se realizó una evaluación de los varamientos de mamíferos marinos entre agosto de 1997 hasta abril de 1998, en un área comprendida desde los 15°22' a 15°27' S. La evaluación abarcó 30,4 km de costa, divididos en siete sectores distribuidos entre los límites de los departamentos de Ica y Arequipa, donde se registraron 7 especies de mamíferos marinos y 2500 especímenes. *Otaria byronia* (67,88%) y *Arctocephalus australis* (31,48%) representaron el 99,36% de los varamientos, mientras que las cinco especies restantes, integradas por *Physeter macrocephalus*, *Phocoena spinipinnis*, *Lagenorhynchus obscurus*, *Tursiops truncatus* y *Lontra felina*, representaron el 0,64% de los especímenes. Los Otariidae exhibieron similares patrones de varamientos, y se determinó una correlación con la temperatura superficial del mar (TSM). *Otaria byronia* mostró la mayor mortalidad en febrero de 1998, mientras que *Arctocephalus australis* en enero de 1998, coincidiendo con las temporadas reproductivas de ambas especies. El sector Guanera-La Lobera registró el mayor número de varamientos, atribuido a su proximidad a la Reserva Nacional Punta San Juan, que alberga colonias de ambas especies. El análisis de los varamientos en los Otariidae indicó una fuerte correlación en la diferenciación de grupos de edad, con una alta mortalidad de hembras y juveniles, que representaron el 80,3% de *O. byronia* y el 63,5% de *A. australis*. En general, estos resultados subrayan la vulnerabilidad de los mamíferos marinos a los cambios ambientales causados por los eventos de El Niño.

Keywords:
El Niño, ENOS, strandings, marine mammals, Reserva Nacional Punta San Juan, Marcona.

Palabras clave:
El Niño, ENOS, varamientos, mamíferos marinos, Reserva Nacional Punta San Juan, Marcona.

Introduction

The El Niño-Southern Oscillation (ENSO) is Earth's dominant source of interannual climate variability, with impacts spanning local, regional, and larger scales (Barber and Chavez 1983; Liu et al. 2014; Holbrook et al. 2020). Along the Peruvian coast, oceanographic conditions are strongly influenced by this variability, known as the ENSO cycle, which alternates between a cold phase (La Niña) and a warm phase (El Niño), and its events intensity depends on their timing, duration, relative strength, and distance from the region of origin (Thatje et al. 2008).

Between 1997 and 1998, Peru experienced one of the strongest El Niño events of the 20th century, with a magnitude comparable to the events of 1982–1983 and possibly 1925–1926 (Tarazona et al. 1999; Bayer et al. 2014). The evolution of El Niño and La Niña can be tracked through indicators such as sea surface temperature (SST), zonal wind patterns, and the depth of the 20°C isotherm along the equator (McPhaden 2003; Turkington et al. 2019). During the 1997–1998 El Niño, SST anomalies were concentrated in the eastern tropical Pacific, extending from the South American coast between approximately 80°W and 160°W (McPhaden 1999).

Prior to the 1997–98 El Niño event, limited information was available regarding small cetacean strandings along the Peruvian coast. This was largely due to the lack of systematic coastal monitoring for strandings. Instead, most data on small cetaceans were derived from fisheries statistics, where they were categorized as landings until the mid-1990s. Only a few specific studies addressed this issue. Consequently, small cetacean mortality was primarily attributed to incidental catches in gillnet fisheries, their use as bait in longline fishing, direct capture for human consumption, and, to a lesser extent, stranding events (Read et al. 1988; Van Waerebeek and Reyes 1994a; Reyes and Van Waerebeek 1995; Van Waerebeek et al. 1997; Majluf et al. 2002; García-Godos and Félix 2007).

During the 1997–98 El Niño, most information on the movement and redistribution of marine mammals came from surveys conducted by the Instituto del Mar del Perú (IMARPE). Three assessment cruises were carried out along the Peruvian coast. The first cruise, conducted between May and June 1997, covered the northern coast from Puerto Pizarro (03°39'S) to Callao (12°03'S). Key odontocete species recorded included *Delphinus capensis*, *Delphinus* sp., and *Tursiops truncatus*. The highest frequency of individuals was observed between 6°03’S and 10°00’S, where sea surface temperatures (SSTs) ranged from 20.1 to 25.4°C. Under El Niño conditions, a total of 246 *T. truncatus*, 534 *D. capensis*, and 226 *Delphinus* sp. individuals were recorded per 100 nautical miles. El Niño appeared to influence the distance of these species from the coast or prompted southward movements. Notably, *Delphinus* sp., typically found in oceanic waters, was observed in coastal areas. In contrast, the absence of *Lagenorhynchus obscurus* from its usual distribution along the central and southern coasts suggested a southward shift. Among the species, *T. truncatus* showed the highest frequency and appeared to be the least affected by the 1997–98 El Niño event (Ontón Silva et al. 1997).

During the second cruise, conducted between September and October 1997, sightings of *T. truncatus* were reported south of 9°39’S, predominantly in oceanic waters —an unusual observation, given the species' typical coastal distribution along the Peruvian coast. However *Delphinus capensis* was recorded throughout the coast in both coastal and oceanic waters, consistent with its normal distribution, suggesting a minimal impact of El Niño on this species (Bello et al. 1998). By October 1997, the El Niño event had undergone significant variability, with warming peaks of +6°C in August 1997 and +9°C in January 1998 (Calienes 2014). Regarding *L. obscurus*, its distribution limit near Casma (9°47'S, 78°36'W) shifted southward, as also noted by Ontón Silva et al. (1997). In general, El Niño tends to drive whales and dolphins toward colder waters with favourable feeding conditions. During this cruise, the highest concentrations of odontocetes were observed south of 11°S (Bello et al. 1998).

In the final stage of the 1997–98 El Niño (March to May 1998), 89% of the small cetaceans identified belonged to *T. truncatus*, *Delphinus* sp., and *L. obscurus*. Sanchez et al. (1998) observe that these species were dispersed along the coast but showed a tendency to concentrate in the southern region, where higher abundances of pelagic resources, such as *Engraulis ringens* and *Sardinops sagax*, were recorded. A significant correlation was observed between *T. truncatus* and *Scomber japonicus*, while *Anchoa nasus* was associated with *Delphinus* sp. Although, *Tursiops truncatus* exhibited the highest abundance near 8°S, while *Delphinus* sp. displayed a wide distribution, with peaks in the central coast (10°S, 12°S, 14°S–15°S) and the extreme south (17°S–18°S). Mixed groups of *T. truncatus* and *Delphinus* sp. were noted at 14°S, and *L. obscurus* with *T. truncatus* at 17°S. The irregular distribution of *T. truncatus*, with concentrations in northern and southern areas, could correspond to oceanic forms. While *L. obscurus* predominantly occupied the central and southern coast, where lower temperatures were recorded, aligning with its typical distribution under normal oceanographic conditions. *Delphinus* sp. was found to exploit the most abundant resources available under El Niño conditions (Sánchez et al. 1998)

In summary, during the 1997–98 El Niño event, whales and dolphins migrated southward in search of colder waters and feeding grounds. Higher concentrations of small cetaceans were observed near Salaverry, Huacho to Callao, and between Mollendo and Ilo. Dolphins were distributed across a wide temperature range, predominantly moving southward in alignment with the distribution of anchovies and sardines (Sánchez-Rivas et al. 2000).

Unlike small cetaceans, the Otariidae family has more extensive data on mortality and strandings before and during the 1997-98 El Niño event. For instance, the Eastern North Pacific California sea lion (*Zalophus californianus*) experienced pup mortality and reduced natality rates during El Niño episodes. Additionally, El Niño

events have been associated with changes in prey distribution and abundance, as well as mortality linked to toxic algal blooms (Silvagni et al. 2005; Carretta et al. 2006). The Galápagos sea lion (*Zalophus wollebaeki*) found in the Galápagos Islands and occasionally on islands near the Ecuadorian coast, suffers high mortality rates, reduced pupping, and epidemic disease during El Niño events, likely due to fluctuations in prey availability (Trillmich and Dellinger 1991; Alava and Salazar 2006). Similarly, the South American sea lion (*Otaria byronia*), which inhabits both the Atlantic and Pacific coasts of South America, experiences severe mortality in Pacific populations during strong El Niño events (Soto et al. 2004).

The Galápagos fur seal (*Arctocephalus galapagoensis*), native to the Galápagos Islands, is particularly affected by prey shortages during El Niño episodes (Alava and Salazar 2006). Likewise, the Guadalupe fur seal (*A. townsendi*), found on Guadalupe Island and the San Benito Archipelago in Mexico, exhibits low pup survival rates during these events (Gallo-Reynoso 1994; Weber et al. 2004). The South American fur seal (*A. australis*), distributed along the Atlantic and Pacific coasts of South America, experiences high juvenile and pup mortality rates, as well as elevated mortality among reproductive females during El Niño episodes, due to the extended foraging periods required to find prey (Trillmich and Dellinger 1991; Oliveira et al. 2009; Weinberger et al. 2021).

During El Niño events in Peru (1982–83 and 1997–98), mortality rates among sea lion newborns reached approximately 50%, while fur seal newborns suffered nearly 100% mortality. These events led to widespread emigration, unusually high mortality rates, and the virtual loss of reproductive years in both Otariidae populations along the Peruvian coast (Arntz and Fahrbach 1996; Tarazona et al. 2001; Soto et al. 2004).

Lontra felina is a distinctive marine mammal inhabiting the western coast of South America, ranging from Chimbote (9°S), Peru, to Cape Horn (56°S), Chile. The main threats to *L. felina*, as identified in the literature, include hunting for commercial pelts, incidental catches, the introduction of non-native species, coastal urban development (particularly in the last 30 years), and both natural and human-caused strandings (Coker and Coker 1910; Medina-Vogel et al. 2007; Pizarro Neyra 2008; Cursach et al. 2012; Córdova and Rau 2016). Nevertheless, the impact of El Niño events on *L. felina* remains poorly understood (CPPS 2004). Vianna et al. (2010) reported low genetic diversity in Peruvian populations, suggesting that the increasing frequency of future ENSO events could reduce effective population sizes due to genetic drift. However, the full extent of these potential impacts has yet to be determined.

Finally, density can be estimated using total counts or sampling methods, while relative density can be assessed through various techniques depending on the species of interest. The data obtained for relative density indicates a consistent, yet unknown, correlation to the total population size. As a result, these methods yield an abundance index rather than a precise density estimate, as they aid in identifying significant changes in population density (Krebs 1972, 2014).

To quantify a specific species, researchers can use a Relative Density index (Bibby et al. 1992, Krebs 1999), which is based on sample collection and a variable with an unknown relation to the total population size. Relative density has been estimated through marine mammal strandings to compare rates over time or across different areas. For example, in 2017, Castañeda et al. (2020) conducted a stranding assessment of marine fauna along 182 kilometers of coastline on the northern coast of Peru (Lambayeque and Piura departments). During this monitoring, they reported Otaria flavescens, along with four species of Odontoceti: *Phocoena spinipinnis*, *Delphinus capensis*, *Tursiops truncatus*, and *Globicephala macrorynchus*. In 2017, *O. flavescens* had a stranding rate of 0.82 individuals per kilometer, *P. spinipinnis* had 0.061 individuals per kilometer, and *D. capensis* had 0.05 individuals per kilometer.

For otters, relative density has been used to estimate populations in coastal habitats through direct counts or genotyping methods. For instance, in Chile, the relative densities of Lontra felina have been determined along the coast. Castilla (1982) estimated densities of 1.50, 0.50, and 1.25 otters per kilometer for Punta Lobos, Yerba Buena, and Los Molles, respectively. Rozzi and Torres-Mura (1990) reported estimates of 8.0, 2.0, and 5.4 otters per kilometer for Isla Menor, Isla Mayor, and Isla Guafo, respectively. Following the work of Ebensperger and Castilla (1991), densities of 1.80 and 1.70 otters per kilometer were estimated for Isla Tilgo and Caleta Hornos, respectively. Medina-Volgel et al. (2007) established a density of 1.7 otters per kilometer for Caleta Quintay.

In Peru, an assessment in 2002 estimated an average density of 2.0 individuals (Apaza et al. 2002), followed by a density of 2.21 individuals per kilometer in 2003 (Apaza et al. 2004, CPPS 2004), and an average density of 1.48 individuals per kilometer in 2005 (Apaza et al. 2005, Apaza and Romero 2012). In 2012, genotyping based on scat analysis of sea otters estimated a density ranging from 1.0 to 2.7 individuals per kilometer (Valqui 2012). By 2017, densities ranged from 4.4 to 12.6 otters per kilometer (Biffi and Williams 2017), indicating that sighting-based abundance estimates are likely underestimated.

In this study, marine mammal strandings were evaluated along a 30 km stretch of coastline between the departments of Ica and Arequipa during the 1997-98 El Niño event. The study aimed to quantify the impact of El Niño on marine mammal mortality and correlate these findings with sea surface temperature (SST) measurements. The results showed consistent trends in marine mammal mortality throughout the study period, highlighting the necessity of expanding this monitoring approach to gain a deeper understanding of how this event affects marine fauna along the Peruvian coast.

Material and methods

Study Area. The study area covered 30.4 km of coastline south of the city of Marcona, extending from the southern boundary of the Punta San Juan National Reserve to the southern limit of Yanyarina Beach, spanning the districts of Marcona (department of Ica) and Lomas (department of Arequipa). Monthly surveys were conducted between August 1997 and April 1998 along this stretch of coastline. The study area included an intertidal zone approximately 40 m wide (Fig. 1, Tabla 1).

The northern boundary of the study area adjoins Punta San Juan de Marcona, a well-known habitat for marine wildlife, including significant populations of the South American sea lion (*O. byronia*) and the South American fur seal (*A. australis*). It is also home to species such as the marine otter (*L. felina*) and various seabirds, including the wandering albatross (*Diomedea exulans*, *D. epomophora*, *D. melanophris*), petrels (*Macronectes giganteus*, *Procellaria aequinoctialis*, *Puffinus griseus*), storm-petrels (*Oceanodroma markhami*), and the Humboldt penguin (*Spheniscus humboldti*).

Table 1. Sectors studied, location coordinates, length of the coastal perimeter.

SECTOR	Code	Lat.S	Long.S	Lat.S	Long.S	km
Guanera- La Lobera	Gua—L_Lob	15°22'13.12"	75°11'0.49"	15°24'24.41"	75° 8'28.68"	7.8
La Lobera- Cerro Colorado	L_Lob—CC	15°24'24.41"	75° 8'28.68"	15°25'16.95"	75° 5'57.24"	5.5
Cerro Colorado – Tres Hermanas	CC—3Hs	15°25'16.95"	75° 5'57.24"	15°26'33.96"	75° 4'15.90"	5.3
Tres Hermanas	3Hs	15°26'33.96"	75° 4'15.90"	15°26'34.78"	75° 4'10.60"	0.6
Tres Hermanas- La Aguada	3Hs—L_Agu	15°26'34.78"	75° 4'10.60"	15°27'31.59"	75° 2'30.46"	3.7
La Aguada- Yanyarina	L_Agu—Yan	15°27'31.59"	75° 2'30.46"	15°27'34.78"	75° 1'19.49"	2.2
Yanyarina- El Cable	Yan—E_Cab	15°27'34.78"	75° 1'19.49"	15°28'13.77"	74°59'16.98"	5.3
					Total	30.4

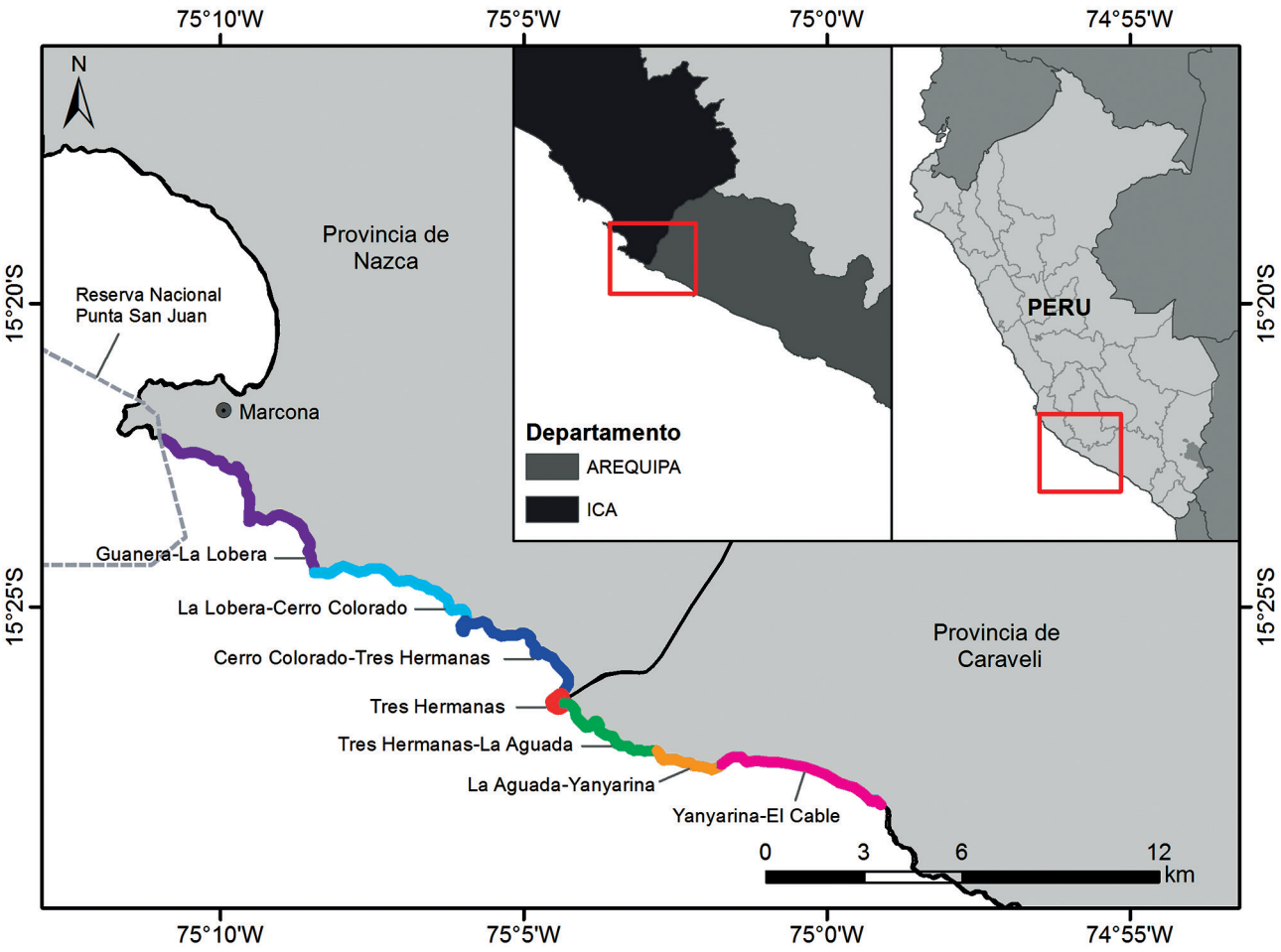


Figure 1. Study area, showing the sectors studied.

Since 1909, Punta San Juan has been under the protection of the Compañía Administradora del Guano. In 2009, it was officially incorporated into the Reserva Nacional Sistema de Islas, Islotes y Puntas Guaneras through Supreme Decree No. 024-2009-MINAM.

Coastal sectors studied. The study area was divided into seven sectors (Fig. 1 and Table 1), delineated according to the physiographic characteristics of the coastline. The start and end points of each segment were recorded using GPS and mapped onto the digital chart of the National Geographic Institute (IGN) for San Juan (31 m) at a 1:100,000 scale. The coastal perimeter and individual segments were delineated and measured (in km) using ArcView 3.2a software (Table 1).

The sectors were characterized as follows:

Guanera-La Lobera (7.8 km). This sector, extending southeast toward La Lobera, is the largest section of the study area. It features crescent-shaped beaches with rocky, stony, or sandy substrates. Most areas are accessible via the intertidal zone or adjacent terraces, which average 14 m in height, although some low cliffs descend directly into the sea.

La Lobera-Cerro Colorado (5.5 km). This narrow and continuous southeastern stretch consists of beaches with stony, rocky, or mixed sandstone substrates. The coastline adjoins terraces averaging 17 m in height. The sector ends at Cerro Colorado, a geological feature characterized by a reddish point approximately 300 m long, extending southwest into the sea.

Cerro Colorado-Tres Hermanas (5.3 km). Similar in configuration to the previous sector, this southeastern stretch consists mainly of stony-rocky beaches, with some sandy areas. The narrow coastline is bordered by a ravine averaging 22 m in height.

Tres Hermanas (0.6 km). This rocky cape, oriented west-southwest, separates adjacent sectors. It features an abandoned guano platform with a white terrace covering approximately 0.82 hectares. Low cliffs (~5 m) descend directly into the sea, and a tunnel through the rock provides access to a rocky beach and islets housing a sea lion colony.

Tres Hermanas-La Aguada (3.7 km). This sector, heading east-southeast, features a diverse coastal perimeter, including stony and rocky beaches, terraces, and cliffs averaging 9 m in height. The irregular coastline presents access challenges, requiring navigation through shallow elevations.

La Aguada-Yanyarina (2.2 km). This eastern sector consists of an irregular rocky and stony beach. The final 0.5 km section borders a low terrace (~4 m), and the intertidal zone is fully traversable.

Yanyarina-El Cable (5.3 km). This southeastern beach features a continuous sandy intertidal strip averaging 40 m in width. It is bordered by a low terrace (~12 m) and ends at a rocky beach segment (~150 m), terminating at a rock formation known as El Cable.

Stranding of Marine Mammals. Surveys were conducted monthly from August 1997 to April 1998 across the seven coastal sectors, moving from north to south. Two teams of evaluators, each comprising two individuals, were responsible for assessing three sectors per month, with the Tres Hermanas sector surveyed by both teams. Stranded marine mammals were identified to species level, following the marine mammals identification guide by Jefferson et al. (1993) and the number of specimens per identified species was recorded. For sea lions and fur seals (Otariidae), counts were categorized by sex and age class: males, females, juveniles, and pups (King 1983). For sperm whales, age groups were classified by total length (in meters), using the following categories: mature males (> 13 m); females and immature individuals (7-12 m); first-year individuals (5-6 m); and calves (< 4.5 m) (Ramos et al., 2001, adapted from Whitehead et al. 1997). To prevent duplicate counts, all recorded individuals were marked with spray paint, following established protocols for seabird strandings (Apaza and Figari 1999).

Marine Mammal Counts. As an ancillary activity, live marine mammal counts were conducted during stranding assessments. These counts provided insights into the activity and distribution of marine mammals during the El Niño 1997–1998 event. Although these were not comprehensive censuses, they contributed valuable observational data on species presence and behavior.

Sea Surface Temperature (SST). SST data were used to assess the relationship between temperature variations and the mortality of recorded species during the 1997–1998 El Niño event. Temperature measurements were obtained from the Punta San Juan Biological Station.

The highest El Niño Coastal Index (ICEN). The El Niño Coastal Index (ICEN) is developed using the 3-month moving average of sea surface temperature anomalies in the Niño 1+2 region with respect to the climatology of the period 1981-2010 (ENFEN 2024). The data were obtained from <http://met.igp.gob.pe/datos/ICEN.txt>.

Data analysis. The association between variables was assessed using the Spearman rank-order correlation coefficient (Rs), a non-parametric test that evaluates interdependency due to a common cause. Subsequently, the Kruskal-Wallis test was applied to compare the medians of different univariate specimen groups. This test serves as a non-parametric alternative to ANOVA, as it does not assume a normal distribution but requires equal-shaped distributions across all groups. It evaluates whether none of the samples stochastically dominate others, thereby indicating no significant difference in location between distributions. The significance of the Kruskal-Wallis test can be approximated using a Chi-squared distribution.

Additionally, the Kolmogorov-Smirnov test was used to compare the overall distribution of two datasets. This test does not assess equality of mean, variance, or any other parameter. The null hypothesis states that the two

samples originate from populations with the same distribution, and the maximum absolute difference between their empirical cumulative distribution functions serves as the test statistic.

Furthermore, the Mantel test was employed to evaluate the correlation between two or three distance or similarity matrices among variable groups. The R-value represents the correlation coefficient for all matrix entries, ranging from -1 to +1 (Hammer and Harper 2005; Legendre and Legendre 2012).

Results

Stranded marine mammals. During the 1997–98 El Niño event, 2500 stranded marine mammals belonging to seven species were recorded in the study area. The stranded species included *O. byronia* and *A. australis* (Otariidae), *Physeter macrocephalus* (Physeteridae), *Phocoena spinipinnis* (Phocoenidae), *Lagenorhynchus obscurus* and *Tursiops truncatus* (Delphinidae), and *L. felina* (Mustelidae). Among these, 67.88% of the stranded individuals belonged to *O. byronia*, while 31.48% were *A. australis*. Together, these two species accounted for 99.36% of all recorded strandings. The remaining five species represented only 0.64% of strandings, with a total of 16 specimens (Table 2).

***Otaria byronia* (de Blainville, 1820)**. Between August 1997 and April 1998, 1697 stranded specimens of *O. byronia* were recorded. Notably, the highest number of stranded individuals was observed in February 1998, coinciding with this species' breeding and reproductive season.

The Guanera-La Lobera sector recorded the highest number of stranded specimens, likely because it is located adjacent to the Punta San Juan National Reserve, home to large colonies of *O. byronia*. Except for Tres Hermanas, the remaining six sectors reported significant strandings of *O. byronia* throughout the study period, with fluctuations over time. The low number of strandings recorded in the Tres Hermanas sector was not due to its small area but rather to the presence of an *A. australis* colony occupying this sector (Table 3).

***Arctocephalus australis* (Zimmermann, 1783)**. Between August 1997 and April 1998, 787 stranded specimens of A. australis were recorded, making it the species with the second-highest number of strandings. The peak mortality occurred in January 1998, coinciding with its breeding and reproductive season.

The first five sectors exhibited similar stranding numbers throughout the study period, with a pattern of increase and decrease over time. Like *O. byronia*, the Guanera-La Lobera sector recorded the highest number of stranded specimens, as this segment is located near the Punta San Juan National Reserve, where large colonies of *A. australis* reside.

In August 1997, four *A. australis* specimens were found stranded in the Tres Hermanas sector. One had a tag labeled D27 (♂), while another had a yellow tag (♀) with an erased label. Additionally, in December 1997, two more tags were recovered, labeled 5498 and 5488. These identification marks corresponded to individuals previously tagged in the Punta San Juan National Reserve, where a monitoring project for this species was being conducted (Table 4).

***Otaria byronia* and *Arctocephalus australis* strandings versus SST.** The 1997–98 ENSO was considered the "El Niño of the twentieth century" (McPhaden 1999) and classified as an "Extreme El Niño", developing from May 1997 to May 1998 (Bertrand et al. 2020). The highest El Niño Coastal Index (ICEN) magnitudes were recorded between June 1997 and February 1998 (ICEN > 3.0, Calid Extraordinaire; Takahashi and Reupo 2015).

During the marine mammal stranding assessments conducted between August 1997 and April 1998, sea surface temperature (SST) data were collected in the field. Although the study covered a relatively short period, it provided sufficient data to establish a relationship between marine mammal mortality and the development of the El Niño event.

The SST and the two main marine mammal species affected by El Niño (*O. byronia* and *A. australis*), which together accounted for 99.36% of all recorded strandings, were analyzed using a Spearman rank-order correlation test (two-tailed). The results revealed a statistically significant association between these three variables (Table 5).

Table 5. Correlations Matrix Spearman coefficient (Rs), *Otaria byronia*, *Arctocephalus australis* and sea superficial temperature (SST). Bold values are significant correlations ($p < 0.05$).

Rs* / p	*O. byronia*	*A. australis*	SST
Otaria byronia	1	0.0039	0.0149
Arctocephalus australis	0.881	1	0.058
SST	0.8095	0.6905	1

Furthermore, as illustrated in Figure 2, the strong increase in SST closely corresponds to the peak mortality of *O. byronia* and *A. australis*. Notably, within a four-month period (December 1997 to March 1998), over 86% of the total recorded deaths for both species occurred, marking the peak mortality period for these species.

Relative Density. As shown in Figure 3, the stranding patterns of *O. byronia* and *A. australis* during the El Niño period (August 1997–April 1998) are described. The figure also highlights a difference in mortality peaks between the two species: *A. australis* reached its highest stranding mean density in January 1998 (8.75 ind/km), followed by *O. byronia* in February 1998 (16.94 ind/km).

Table 2. Marine Mammals Strandings Recorded during El Niño 1997-98 in southern Marcona area of study.

Scientific Name	Common Name	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	Total
Otaria byronia	South American sea lion	2	27	111	257	466	515	230	89	1697
Arctocephalus australis	South American fur seal	6	10	71	190	266	184	53	7	787
Phocoena spinipinnis	Burmeister's porpoises	0	1		0	3	1	1	1	7
Lontra felina	marine otter	0	0	2	0	1	1	0	0	4
Lagenorhynchus obscurus	dusky dolphin	0	0	0	0	3	0	0	0	3
Physeter macrocephalus	sperm whale	0	0	0	1	0	0	0	0	1
Tursiops truncatus	bottlenose dolphin	0	0	0	0	0	0	0	1	1
TOTAL		8	38	184	448	739	701	284	98	2500

Table 3. *Otaria byronia* stranded specimens by sector of the area studied in southern Marcona, during El Niño 1997-98.

SECTOR	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	N
Guanera- La Lobera	0	23	22	37	90	108	45	26	351
La Lobera- Cerro Colorado	0	1	26	37	84	109	30	8	295
Cerro Colorado – Tres Hermanas	0	0	13	35	75	60	31	2	216
Tres Hermanas	1	0	0	5	30	31	23	1	91
Tres Hermanas- La Aguada	1	0	20	31	103	106	63	24	348
La Aguada- Yanyarina	0	1	8	50	53	55	19	4	190
Yanyarina- El Cable	0	2	22	62	31	46	19	24	206
TOTAL	2	27	111	257	466	515	230	89	1697

Table 4. *Arctocephalus australis* stranded specimens by sector of the area studied in southern Marcona, during El Niño 1997-98.

SECTOR	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	N
Guanera - La Lobera	2	6	20	45	53	36	8	1	171
La Lobera - Cerro Colorado	0	3	15	21	40	38	9	1	127
Cerro Colorado – Tres Hermanas	0	0	5	18	47	30	5	1	106
Tres Hermanas	3	0	17	17	45	32	15	2	131
Tres Hermanas - La Aguada	0	0	10	25	46	25	11	0	117
La Aguada - Yanyarina	1	0	2	36	23	11	0	1	74
Yanyarina - El Cable	0	1	2	28	12	12	5	1	61
TOTAL	6	10	71	190	266	184	53	7	787

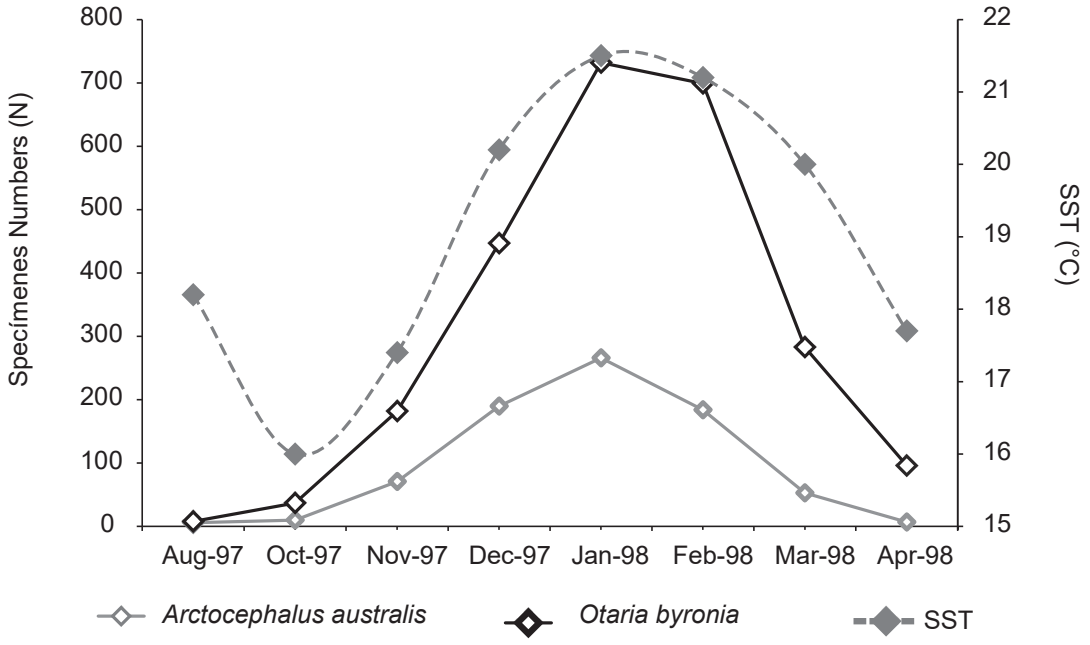
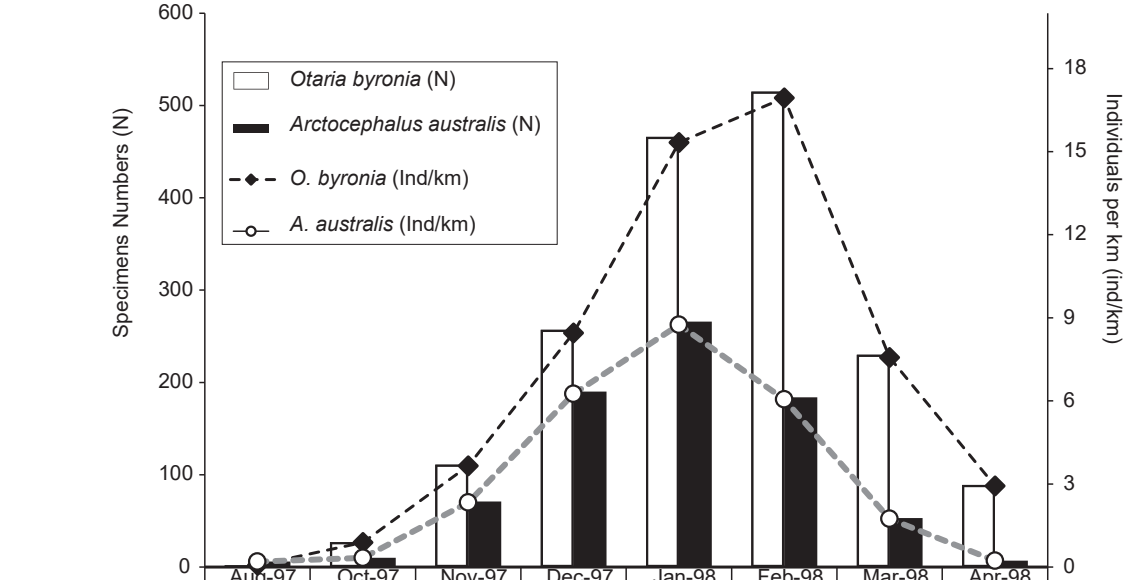


Figure 2. Stranded specimens of ***Otaraia byronia*** and ***Artocephalus australis*** and the ICEN index and sea surface temperature (SST).

However, as assessed using the Spearman rank-order correlation, both species exhibited a significant association throughout the study period (Rs = 0.8810, $p < 0.05$). Additionally, the data were analyzed for each species across seven sectors and eight months to determine whether relative density remained consistent in paired comparisons. No significant differences were found in 21 paired comparisons for *O. byronia* (Kruskal-Wallis: H = 2.0434, df = 6, p = 0.9157) or for A. australis (Kruskal-Wallis: H = 9.007, df = 6, p = 0.173).

Finally, to compare the relative density between *O. byronia* and *A. australis*, correlation matrices were tested using the Mantel test, based on paired sector data. The test revealed a significant correlation between the matrices of both species (r(AB) = 0.7330, p = 0.0003).

***Otaria byronia* and *Arctocephalus australis* recorded by sex and age group**. Among the stranded species and specimens, both *O. byronia* and *A. australis* were classified by sex and age group. The data indicated that females and juveniles accounted for the largest proportion of deceased specimens in both species. For *O. byronia*, 40.8% of the stranded individuals were females and 39.5% were juveniles, together representing 80.3% of the total mortality. The highest mortality for this species was recorded in February 1998, coinciding with its breeding and reproduction season. In the case of *A. australis*, females accounted for 41.0%, while juveniles represented 22.5%, accounting for 63.5% of the stranded specimens. The peak mortality for this species occurred in January 1998, also aligning with its breeding and reproduction season (Table 6).



	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98
O. byronia (N)	2	27	111	257	466	515	230	89
A. australis (N)	6	10	71	190	266	184	53	7
O. byronia (Ind/km)	0.07	0.89	3.65	8.45	15.33	16.94	7.57	2.93
A. australis (Ind/km)	0.20	0.33	2.34	6.25	8.75	6.05	1.74	0.23

Figure 3. Relative density (Ind/km) of *Otaria byronia* and *Arctocephalus australis*.

Table 6. Stranded *Otaria byronia* and *Arctocephalus australis* specimens by sex and age group.

Month	*Otaria byronia*					*Arctocephalus australis*				
	Males	Females	Juveniles	Pups	Total	Males	Females	Juveniles	Pups	Total
Aug-97		2			2	3	3			6
Oct-97	12	4	11		27	4	6			10
Nov-97	28	14	39	30	111	23	13	8	27	71
Dec-97	78	27	135	17	257	59	76	26	29	190
Jan-98	55	181	183	47	466	53	114	85	14	266
Feb-98	28	303	177	7	515	37	85	51	11	184
Mar-98	19	115	96		230	15	24	7	7	53
Apr-98	6	47	29	7	89	5	2			7
Total	226	693	670	108	1697	199	323	177	88	787
%	13.3	40.8	39.5	6.4	100	25.3	41	22.5	11.2	100

This stranding assessment was conducted near breeding colonies of both species, revealing notable proportional differences among the four identified age groups throughout the study period. Females were the most affected group, with a mortality rate of 41% for both species, followed by juveniles, with 39% mortality in *O. byronia* and 22% in *A. australis*. Pups were the least affected, with a mortality rate of 6% for *O. byronia* and 11% for *A. australis*. Finally, males accounted for 13% of the mortality in *O. byronia* and 25% in *A. australis*.

To determine whether these proportional differences were consistent at both interspecific and intraspecific levels, we initially evaluated the proportion of age groups for each species over the entire study period using the Kruskal-Wallis test. For *O. byronia*, no significant differences were found among the four age groups (Kruskal-Wallis: $X^2_3 = 0.1182$, $p > 0.05$). Similarly, for *A. australis*, the results indicated no significant differences (Kruskal-Wallis: $X^2_3 = 0.4528$, $p > 0.05$).

To further assess whether age group distributions differed between species, we compared Spearman's dissimilarity matrices using the Mantel test, which revealed a significant association between the dissimilarity matrices of the age groups across species ($r(AB) = 0.9276$, $p = 0.0123$).

To identify a suitable reference for comparison with the stranded data of both species, we used the census data of Peru for *O. byronia* (1993–2006) and *A. australis* (1992–2006) to establish the proportional representation of age groups. This data was analysed using a partial Mantel test, which showed that the Spearman's dissimilarity between stranded individuals of *O. byronia* and *A. australis* during the 1997–1998 El Niño event was strongly correlated with the age group proportions of the *O. byronia* census in Peru ($r(AB.C) = 0.9429$, $p = 0.0110$). In contrast, this correlation was not observed for *A. australis* when compared with its census data from 1992–2006 ($r(AB.C) = 0.6000$, $p = 0.2101$).

Additionally, a final comparison was made using census data from Chile for *O. byronia*, integrating it with census records from Punta Negra (Region I, 1985–2001) (Sielfeld and Guzmán 2002) and Regions I to IV (1996 census, Sielfeld Kowald 1997). The Spearman's dissimilarity between stranded *O. byronia* and *A. australis* during the 1997–1998 El Niño event was correlated with the age group proportions from the Chilean *O. byronia* census. Specifically, the stranded age group data were significantly correlated with the Punta Negra census ($r(AB.C) = 0.8857$, $p = 0.0250$) and with the 1996 census data from Regions I to IV ($r(AB.C) = 0.9429$, $p = 0.0096$).

Additional Records of Stranded Marine Mammals

Between October 1997 and April 1998, in addition to the two registered Otariidae species, five additional species of marine mammals and 16 deceased specimens (Table 7) were recorded by month and sector (Table 8). Among these species, *L. felina* was the only one with both stranded individuals and four live specimens.

Unlike the substantial number of stranded Otariidae recorded in the study area, other marine mammals were limited to just 16 specimens, representing five additional species, with notable differences among the seven surveyed sectors. In the three sectors near Punta San Juan RN (Guanera-La Lobera, La Lobera-Cerro Colorado, and Cerro Colorado-Tres Hermanas), three species of small cetaceans were identified, accounting for 9 of the 11 recorded specimens within this group. These included six specimens of *Phocoena spinipinnis*, followed by two specimens of *Lagenorhynchus obscurus*, and a single adult male *Tursiops truncatus* measuring 3.15 m in total

Table 7. Marine mammals identified during stranded assessment. (†): dead specimens; (N): live specimens.

Scientific Name	Common Name	ID	†	N
Physeter macrocephalus	sperm whale	P_mac	1	--
Phocoena spinipinnis	Burmeister's porpoises	P_spi	7	--
Lagenorhynchus obscurus	dusky dolphin	L_obs	3	--
Tursiops truncatus	bottlenose dolphin	T_tru	1	--
Lontra felina	marine otter	L_fel	4	4

Table 8. Marine mammals stranding by period and sector.

SECTOR	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98
Guanera – La Lobera	P_spi	--	--	P_spi	--	P_spi	--
La Lobera – Cerro Colorado	--	--	--	L_obs	--	--	T_tru
Cerro Colorado – Tres Hermanas	--	--	--	P_spi (2), L_obs	--	--	P_spi
Tres Hermanas	--	--	--	--	--	--	--
Tres Hermanas – La Aguada	--	L_fel	--	L_fel, L_obs	L_fel	--	--
La Aguada – Yanyarina	--	L_fel	--	--	P_spi	--	--
Yanyarina – El Cable	--	--	P_mac	--	--	--	--

length. No specimens were recorded in the sector of the abandoned guano extraction site at Tres Hermanas. In the subsequent sectors, Tres Hermanas-La Aguada and La Aguada-Yanyarina, one specimen each of *P. spinipinnis* and *L. obscurus* was recorded (Table 8).

Regarding the stranded specimens of *L. felina*, the first two records from November 1997 revealed skull fractures. The first specimen, found in the Tres Hermanas-La Aguada sector, exhibited a fracture in the middle section of the left zygomatic arch. The second specimen, located in the La Aguada-Yanyarina sector, showed an extensive fracture of the right parietal bone (Figure 4).

Figure 4. *Lontra felina* skull shows a fracture on the right parietal bone.

Two additional *L. felina* specimens were found resting in the Tres Hermanas-La Aguada sector in January and February 1998, respectively. No evident signs were observed to explain their deaths (Table 8). As previously mentioned, all *L. felina* specimens, whether stranded or alive, were primarily located in the Tres Hermanas-La Aguada area. This region features a diverse coastal perimeter, providing a suitable habitat for *L. felina*. Additionally, during activities conducted outside the assessed area, a fifth specimen of *L. felina* was found 2.8 km south of the study area's boundary at El Cachucho Beach (January 1998). This specimen, an old individual stranded prior to the 1997-1998 El Niño event, displayed advanced signs of bone weathering, excessive desiccation, sun bleaching, and cracked teeth. Bone weathering results from various processes, including prolonged exposure to sunlight and ultraviolet (UV) radiation, bleaching, and demineralization due to acid dissolution. Additionally, the loss of grease and moisture increases brittleness, recrystallization, and thermal expansion and contraction (Schultz et al. 2018; Outlaw 2022).

Finally, a large, toothed cetacean, *Physeter macrocephalus*, was recorded in the last sector, Yanyarina-El Cable (Table 8). This specimen was a first-year individual measuring 5.6 meters in total length (Figure 5). The reference specimen was collected and processed, with the skull and skeleton currently housed in the marine fauna collection at the Punta San Juan Project.

Abundance of Marine Mammals (live specimens)

Unlike strandings, where animals are often found randomly on beaches, live animals such as Otariidae typically form breeding colonies. However, they can also be found outside settlements in difficult-to-access areas, such as islets, small rookeries, or cliff bases where small rock platforms have formed. As detailed in the methodology, the registration of live specimens involved only counts (not censuses) because the activity was conducted throughout the day rather than in the early hours, as is typical for censuses.

Figure 5. *Physeter macrocephalus* specimen stranded in Yanyarina sector.

Otaria byronia. During the assessment period, 241 live specimens of *O. byronia* were recorded. The Tres Hermanas–La Aguada sector was the only location where this species was consistently observed, as a small beach served as a haul-out colony. This site accounted for 58.9% of the specimens observed, while the Tres Hermanas sector closely followed, representing 21.6% of the sightings. Together, these two adjacent areas comprised 80.5% of all recorded *O. byronia* specimens (Table 9). The collected data, although limited, identified a haul-out area outside the Punta San Juan National Reserve. This area was nearly abandoned in April 1998, but it remains unclear whether this was because of El Niño or if the animals dispersed to other coastal locations after the breeding period ended.

Arctocephalus australis. A total of 2956 live specimens of *A. australis* were recorded throughout the study period. The Tres Hermanas sector, an abandoned guano unit, has natural geomorphological characteristics suitable for establishing a reproductive colony, even prior to guano exploitation in Peru. In Tres Hermanas, *A. australis* was regularly recorded throughout the evaluation period, with notable abundances at the beginning of the reproductive period. However, these numbers decreased drastically during the summer of 1998, when El Niño reached its most critical phase. In April 1998, there was a slight increase in the abundance of specimens. Tres Hermanas accounted for 75.54% of the abundance recorded during the evaluation period, and together with the Guanera-La Lobera and La Lobera-Cerro Colorado sectors, represented 95.7% of the total abundance recorded (Table 10). Although the effect of El Niño was more evident in Arctocephalus australis, it is also likely that a fraction of this population emigrated from the locality at the end of the reproductive season.

Lontra felina. Recorded four live specimens, all located in the Tres Hermanas-La Aguada sector (Table 11). In November 1997, one otter was observed catching and eating a fish on the rocky shore. Later, in March 1998, a pair of otters was seen playing on the seashore for an extended period, showing no signs of discomfort despite the observer's presence. Finally, in April 1998, another otter was observed entering a den (Table 11). An aspect worth highlighting is that 7 out of 8 *L. felina* specimens (both live and dead) were registered in the Tres Hermanas-La Aguada sector. As mentioned earlier, this area has the most versatile coastal perimeter among all assessed areas, making it an attractive habitat for otters.

Table 9. Abundance of *Otaria byronia* (El Niño 1997-98).

SECTOR	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	Total	%
Guanera – La Lobera			4	3	1		1		9	3.7
La Lobera – Cerro Colorado				3		1	2		6	2.5
Cerro Colorado – Tres Hermanas			1	2		3	1		7	2.9
Tres Hermanas				6	27	14	4	1	52	21.6
Tres Hermanas – La Aguada	3	50	18	9	33	12	15	2	142	58.9
La Aguada – Yanyarina				18			2	1	21	8.7
Yanyarina – El Cable			2			2			4	1.7
TOTAL	3	50	25	41	61	32	25	4	241	100

Table 10. Abundance of *Arctocephalus australis* (El Niño 1997-98).

SECTOR	Aug-97	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98	Total	%
Guanera – La Lobera			4	3	1		1		9	3.7
La Lobera – Cerro Colorado				3		1	2		6	2.5
Cerro Colorado – Tres Hermanas			1	2		3	1		7	2.9
Tres Hermanas				6	27	14	4	1	52	21.6
Tres Hermanas – La Aguada	3	50	18	9	33	12	15	2	142	58.9
La Aguada – Yanyarina				18			2	1	21	8.7
Yanyarina – El Cable			2			2			4	1.7
TOTAL	3	50	25	41	61	32	25	4	241	100

Table 11. Abundance of *Lontra felina* (El Niño 1997-98)

SECTOR	Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98	Apr-98
Tres Hermanas - La Aguada		L_fel				L_fel (2)	L_fel

Discussion

General context. The impact of El Niño on marine mammals is complex, for example it is directly associated with significant mortality and changes in the distribution of marine mammals (Trillmich and Ono 1991; Learmonth et al. 2006; Stern and Friedlaender 2018) and changes in foraging (Crocker et al. 2006), population declines (Trillmich 2014). In addition, El Niño and its interactions with seasonal changes can be associated with impacts on the diet of dolphins (Sprogis et al. 2018), interactions with local oceanic phenomena such as upwelling can influence their diets and migrations (Tavares et al. 2020; Hsiao et al. 2024). El Niño impacts can last 2 to 3 years, while multidecadal warming causes gradual changes over generations (Adame et al. 2020; Páez-Rosas et al. 2021). This complexity must be addressed with observations at different study scales to understand the implications of global climate change for conservation.

The strandings observed in our study were notably high among females and juveniles. For *Otaria byronia*, 40.8% of the stranded specimens were females and 39.5% were juveniles, totaling 80.3%. In Arctocephalus australis, 41.0% were females and 22.5% were juveniles, representing 63.5%. However, pups and males accounted for 6% and 13% of stranded *O. byronia* specimens, and 11% and 25% for *A. australis*.

Strandings of Otariidae. *Otaria byronia* inhabits the southern Atlantic coast, encompassing areas of Brazil, Uruguay, and Argentina, as well as the southwestern Pacific, including Chile and Peru (Túnez et al. 2007; Artico et al. 2010). Genetic studies show that *O. byronia* exhibits strong breeding-ground fidelity, and male dispersal facilitates gene flow (Feijoo et al. 2011). *Otaria byronia* spends much of its life in the water, and its home range is determined by food availability in shallow waters of the continental slope (Riedman 1990). In Ica, Peru, Soto et al. (2006) found a strong link between maternal attendance patterns, prey availability, and oceanographic conditions near the colonies. However, during the 1997–1998 El Niño event, prey shortages forced female *O. byronia* to extend foraging trips and reduce time with their pups, resulting in widespread starvation. High abortion rates were observed in sea lions by late July 1997, with premature births peaking in mid-November. Food shortages resulted in approximately 60% mortality of adults and the loss of young cohorts aged 0–2 years (Soto et al. 2004).

On the other hand, in northern Chile, the 1997–1998 El Niño caused increased calf mortality and a significant decrease in breeding females, with reproductive rates falling to 10% of normal levels (Sielfeld and Guzmán 2002). Overall, our results indicate that females and juveniles of *O. byronia* and *A. australis* would be the most affected, which would coincide with what was observed in Chile.

On the other hand, El Niño events are known to have a negative effect on the reproduction of *A. australis*. Observations made during the 1982–83 El Niño showed that *A. australis* experienced high mortality of juveniles and pups, especially breeding females, due to prolonged foraging and low marine productivity (Trillmich et al. 1991; Oliveira et al. 2009). Similarly, Majluf (1988), studying the *A. australis* population at Punta San Juan (1983–1987), noted that high temperatures and changes in food supply, particularly during El Niño (Majluf and Reyes 1989), affected their reproductive patterns. Also, *A. australis* commonly reproduces from mid-October to late December, and pups are weaned between 12 and 36 months of age due to environmental unpredictability (Majluf 1988), so the timing of births is crucial (Majluf 1992). These considerations are important to understand the results on the effect of the 1997–98 El Niño event, which was most intense between January and February 1998 and coincided with the reproductive season of these Otariids.

The stranded analysis revealed a significant correlation between Otaria byronia and Arctocephalus australis data and age group proportions during the assessed period. This highlights the species' vulnerability, as both *O. byronia* and *A. australis* encounter survival challenges due to El Niño events, resulting in high mortality, particularly among females and juveniles, followed by males and pups. These conditions disrupt their breeding processes due to fluctuations in food supply and potential changes in foraging behavior.

Physeter macrocephalus, known as the sperm whale, is the largest species of toothed whale and has one of the widest distributions among marine mammals (40°N–40°S), preferring temperatures above 15°C (Whitehead et al. 2018). It is difficult to determine the cause of the stranding recorded in this study, but we can assume that this specimen was migrating between feeding and breeding grounds in search of cephalopods or alternative prey in a scenario of food scarcity. Overall, the various observations of cetaceans in different parts of the world support the general hypothesis that strandings are the result of oceanographic changes such as El Niño and their effect on food availability or the location of feeding grounds (Pierce et al. 2007). In Peru, (Ramirez and Urquizo 1985) associated *P. macrocephalus* sightings to sea surface temperature (SST), noting an increase in sightings in summer (Paita). However, during the 1982–1983 El Niño, sightings were rare (Ramirez and Urquizo 1985). On the other hand, (García-Godos 2006), analyzing 38 sperm whale sightings between 1995 and 2002, found more sightings in the summer of 1998, at the end of the 1997–1998 El Niño. In the Galapagos Islands, sperm whale sightings have been linked to environmental changes and the redistribution of their food resources (cephalopods), particularly those triggered by El Niño (Whitehead et al. 1989). In general, warm ENSO events lead to a lower availability of cephalopods (Humboldt squid), forcing sperm whales to migrate away from normally productive areas, as observed in the analysis of historical data (Ahuatzin Gallardo 2020).

A single specimen of a stranded sperm whale can serve as an important reference for the assessed region and the Peruvian coast, which has limited stranded specimen's records. Additionally, it highlights the signifi-

cant contribution of a first-year Physeter macrocephalus, which was collected, preserved, and remains part of the Punta San Juan Project collection. This report, along with other stranding records, further illustrates the ongoing lack of necessary efforts to obtain sufficient contemporary information about sperm whales along the Peruvian coast. Although it remains uncertain whether El Niño directly influences it, the majority of the observed movements are associated with the distribution of food resources, as described between Baja California and the Galapagos Islands, and subsequently with the northern Peruvian coast.

Small Cetaceans. Although the mortality and capture of small cetaceans in Peru has been monitored in some detail since the early 1980s, systematic assessments of strandings have not been conducted, as strandings have not been considered a primary source of information. Based on these studies, the most abundant small cetacean species are *Lagenorhynchus obscurus*, *Phocoena spinipinnis*, *Delphinus capensis*, and *Tursiops truncatus* (Read et al. 1988; Van Waerebeek and Reyes 1990; Van Waerebeek and Reyes 1994a; Van Waerebeek and Reyes 1994b; Van Waerebeek et al. 1997). In particular, monitoring in the artisanal port of Marcona, between November 1991 and June 1995, revealed a species composition of small cetaceans similar to that of the 1980s in central Peru, with *L. obscurus* predominating in the catch (63.8%), followed by *P. spinipinnis* (26.8%) and *T. truncatus* (9.4%) (Majluf et al. 2002). Subsequently, a review of small cetacean strandings along the Peruvian coast between 2000 and 2017 showed that the most frequent species are *P. spinipinnis* (66.3%), *L. obscurus* (14.9%) and *T. truncatus* (9.8%), which accounted for 91% of the total strandings (Van Waerebeek et al. 2018). In the present study, *P. spinipinnis* was observed to be the species with the most strandings, followed by *L. obscurus*, which would be consistent with the recorded dominance of these species. It is also noteworthy that strandings were most frequent in January 1998, when El Niño was most intense in the study area, and occurred in sectors close to the designated area, which could correspond to some local circulation pattern.

Lontra felina inhabits rocky shores, with dens located in tunnels beneath rocks to facilitate access to water. The presence of *L. felina* is associated with the availability of dens and nearby food sources, resulting in specific areas and reduced distribution (Medina-Vogel et al. 2007). The area studied presents the characteristics of an otter habitat, particularly the Tres Hermanas-La Aguada sector. The four dead *L. felina* specimens showed clear cranial lesions in the two stranded specimens in November.

Concerning to four dead and four alive Lontra felina specimens registered during the study, from November 1997 to April 1998, it's hard to determine if the El Niño event affected the population group settled in the study area. The assessment inverted nearly 24 full days to get the data presented, but Apaza et al. (2002), in a similar area in Marcona, just in one day in the segment from La Lobera to La Aguada, two dead and two alive specimens were registered. Further, Apaza et al. (2003), in five days in a large area, from La Lobera to Sombrerillo beach, five dead and eight alive specimens were registered. Finally, independent of estimates by counting methods, qualitative assessments of threats, or empirical approximations on the abundance and population of *L. felina*. Measuring a variable, such as mortality, in a species with low natural density is inherently complex, particularly within the context of El Niño events. Discrepancies in different publications highlight the ongoing need for implement regular monitoring of the species to achieve an accurate assessment of the *L. felina* population. Hence, phylogeographic studies, such as those conducted by Vianna et al. (2010), which assess the genetic viability, along with genotyping studies aimed at estimating the density and abundance, like those by Biffi et al. (2017), are necessary for ongoing, because configure as partial data of Lontra felina life history. Furthermore, otter counts are still essential to provide information regarding suitable habitats, population abundance, and analytical resources for genetic research, which will enhance the understanding of *L. felina* population dynamics.

Live specimens of marine mammals. Observing live specimens, in addition to stranded ones, is necessary because the study area constitutes a habitat or part of the habitat for these species. For instance, it includes resting areas for *O. byronia* or a potential site for establishing a breeding colony for *A. australis*. During the El Niño period of 1997-98, live specimens of *O. byronia* were recorded at the Tres Hermanas-La Aguada sector, where this species was consistently observed at a small beach that served as a haul-out area. This location was nearly abandoned in April 1998, and it remains unclear whether this was due to the effects of El Niño or if the animals dispersed to other coastal areas after the breeding season ended. The assessment of *A. australis* recorded a significant number of specimens in the Tres Hermanas sector. This abandoned guano unit, due to its unique geomorphological features, has functioned as a breeding colony since the era of the Compañía Administradora del Guano. Despite the effects of El Niño, some of this population likely emigrated from Tres Hermanas after the reproductive season concluded.

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