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Short Note

Abundance and Population Trends of the South American Fur Seal (*Arctocephalus australis*) in Uruguay

Valentina Franco-Trecu,[1] Massimiliano Drago,[2] M. Florencia Grandi,[3] Alvaro Soutullo,[2] Enrique A. Crespo,[3,4] and Pablo Inchausti[2]

[1]*Departamento de Ecología & Evolución, Facultad de Ciencias, Universidad de la República, Iguá 4225, Montevideo, Uruguay*
E-mail: vfranco-trecu@fcien.edu.uy
[2]*Departamento de Ecología, Centro Universitario Regional Este (CURE), Universidad de la República, Maldonado, Uruguay*
[3]*Laboratorio de Mamíferos Marinos, Centro para el Estudio de Sistemas Marinos, CENPAT, CONICET, Puerto Madryn, Chubut, Argentina*
[4]*Universidad Nacional de la Patagonia San Juan Bosco, Puerto Madryn, Chubut, Argentina*

There has been a general reduction in the abundance and spatial distribution of many marine species across habitats worldwide during the past two centuries (Costello et al., 2010). Within this context, monitoring and estimating trends in abundance are important components in the management and conservation of animal populations (Anganuzzi, 1993; Forney, 2000). Pinnipeds (otariids, phocids, and odobenids) are large-bodied mammals with long generation times and low reproductive rates (e.g., a maximum of one pup per female per year). These characteristics have often been associated with low resilience to exogenous perturbations and slow post-harvesting recoveries (McLaren & Smith, 1985; Gerber & Hilborn, 2001). Commercial sealing is believed to have been the main driver of pinniped population declines during the 19th and 20th centuries (Bonner, 1982; Gerber & Hilborn, 2001); however, post-harvesting responses have often differed among pinniped species and even among local populations of the same species (Trites & Larkin, 1996; Gerber & Hilborn, 2001; Raum-Suryan et al., 2002; Dans et al., 2004; Thompson et al., 2005; Grandi et al., 2015).

The South American fur seal (*Arctocephalus australis*) breeds in dense rookeries on the Atlantic and Pacific coasts of South America (Vaz-Ferreira, 1982), often in sympatry with the South American sea lion (SASL; *Otaria flavescens*). South American fur seal populations were exploited for at least 6,000 years, being the basis of livelihood for many Pre-Hispanic aboriginal populations along the South American coast (Schiavini, 1985). Archeofaunistic sites document the presence of fur seal bones and teeth along the southwestern Atlantic, from Buenos Aires to Santa Cruz (Argentina), in most places together with SASL (Borella, 2014). The South American fur seal was intensively exploited from the 18th century until the end of the 20th century in the Atlantic Ocean (Ponce de León, 2000). In Uruguay, commercial harvesting killed at least 527,000 individuals between 1873 and 1949 (Ponce de León, 2000); and later, the Uruguayan State directly oversaw the exploitation of approximately 280,000 South American fur seals between 1950 and 1991 (Ponce de León, 2000).

Atlantic and Pacific (Northern Chile and Peru) fur seals are now considered a subspecies based on their genetic and morphological differentiation (de Oliveira et al., 2008). The Pacific population (*A. a. gracilisis*) is currently estimated at approximately 21,000 individuals (15,467 in Peru [Instituto del Mar del Peru (IMARPE), 2014] and 5,400 along the northern coast of Chile [Bartheld et al., 2008]), and its dynamics are strongly influenced by the El Niño Southern Oscillation (Trillmich et al., 1986; de Oliveira et al., 2009). However, the total abundance of the Atlantic (including Southern Chile) populations (*A. a. australis*, hereafter SAFS) is currently unknown, largely because of the different methodologies that have been used to census local populations. According to the most recent SAFS pup abundance estimates, there are *ca*. 50,000 pups in Uruguay (Páez, 2000), 6,000 pups in southern Chile (Venegas et al., 2002; Oliva et al., 2012), and *ca*. 1,000 pups in Argentina (Crespo et al., 2015). This information on pup abundance suggests that SAFS dynamics would be largely influenced by the size and trend of the Uruguayan population which is believed to be the largest in its distribution range (Crespo et al., 2015). However, comparing

SAFS pup numbers should be done with caution because abundances have been obtained using different methodologies such as direct counts by aerial or ship-based surveys in Argentina (Crespo et al., 2015) and Southern Chile (Venegas et al., 2002; Oliva et al., 2012) and estimations based on capture-recapture methods (Chapman & Johnson, 1968) in Uruguay (Páez, 2000). Indeed, previous studies on pinnipeds comparing similar counting techniques, like ground and aerial counts, have detected important differences in accuracy and precision (Lowry, 1999).

Across the Southern Atlantic, local SAFS populations seem to be recovering at different rates after the cessation of harvests (Crespo et al., 2015). While SAFS pup counts have been estimated to increase at an annual rate of 2% in Uruguay (Páez, 2006), the total SAFS population abundance has been growing at 5 and 8% in Central and Southern Patagonia (Argentina), respectively, over the last 42 years (Crespo et al., 2015). Since only *ca.* 1,000 pups are born per year in a population of 15,000 juveniles and adults in Central/Southern Patagonia, the high population growth rate estimated in this area may reflect dispersal from the Uruguayan rookeries or the Falkland (Malvinas) Islands (Crespo et al., 2015) to Central/Southern Patagonia. This is consistent with findings from mitochondrial DNA analyses showing that the Central/Southern Patagonian and the Uruguayan rookeries constitute a single Atlantic population (Abreu, 2011; Crespo et al., 2015). However, comparable and frequent monitoring efforts of SAFS population abundance have been, until recently, unavailable in Uruguay. Such inconsistent monitoring efforts have hindered our ability to detect the potential role of the Uruguayan population in maintaining gene flow with Patagonian populations, as well as post-harvest recovery of SAFS in the Atlantic Ocean. The aims of this study were to contribute to the management of SAFS by (1) providing population estimates for the Uruguayan SAFS using the same method employed elsewhere in the species' geographic range and (2) estimating the trends of pup abundance in the main Uruguayan rookery.

We carried out aerial surveys across the Uruguayan population range and additionally conducted ground counts at one of the rookery sites. We used this ground count subsample to obtain a local correction factor that we could apply across all pup counts from the aerial surveys of the Uruguayan population. We also conducted an extensive review of historical pup abundance data (including internal reports and news releases from the Uruguayan state agencies, congress abstracts, and books locally published in Uruguay) to estimate population trends over the past 60 years. Out of the six published documents with abundance data, our search generated two comparable datasets that included exhaustive pup ground counts conducted in early February once all pups were born. These data were then used to inform our estimates of long-term trends in SAFS abundance (Vaz-Ferreira et al., 1984).

The SAFS Uruguayan population occupies the northernmost breeding sites of this species in the Atlantic Ocean. The population breeds on two main rookeries. First, Isla – Islote de Lobos (35º 01' S, 54º 52' W) are two granite islands (0.42 km^2 and 0.04 km^2, respectively) located 9 km offshore Punta del Este (Figure 1). Second, the Islas de Torres group (34º 21' S, 53º 44' W), which is comprised of Rasa (0.03 km^2), Encantada (0.02 km^2), and Islote (0.02 km^2), together with Isla del Marco (0.08 km^2) (34º 25' S, 53º 46' W), are located *ca.* 2 km offshore Cabo Polonio (Figure 1). The Cabo Polonio islands are included in a Marine Protected Area that was established in 2009.

The Punta del Este and Cabo Polonio rookeries were surveyed by flying a high-wing, single-engine aircraft (Cessna 182) at constant average speed of 90 nmi/h and an altitude of 150 m to detect the presence of SAFS individuals ashore. All islands were surveyed once at the end of the SAFS breeding season in early February (10 February 2011 and 6 February 2013) when most breeders were still present on land and 100% of the pups had been born (Franco-Trecu et al., 2010). Newborn Uruguayan SAFS pups remain at internal tidal pools within the island and do not venture out to sea until 4 to 5 mo of age (V. Franco-Trecu, pers. obs.); thus, we were confident that all pups were present on the rookeries at the time of the survey. During the aerial surveys, we took more than 600 photographs of each island using a Nikon D800 36.4 MP digital camera equipped with a 80-200 mm telephoto lens and a configuration of shutter speed and diaphragm opening adequate for the conditions of light and sensibility at the moment of the surveys (ISO 200 or higher). We then used a selection of the best shots (in terms of exposure, contrast, and angle of the photo that allowed for the clearest view of animals) from each survey to form one or several mosaics by mounting in *Image Composite Editor* (*ICE*) software. For the largest islands (e.g., Isla de Lobos), we also used distinct topographical features to construct a view without repeating or missing any terrain.

Three experienced observers independently estimated the number of SAFS in each photo mosaic using the *OTARIIDAE 1.0* software (Bartheld et al., 2006). Total counts in each photo mosaic were then segregated by age-class and sex: adult males (territorial and peripheral), subadult males, pups (born

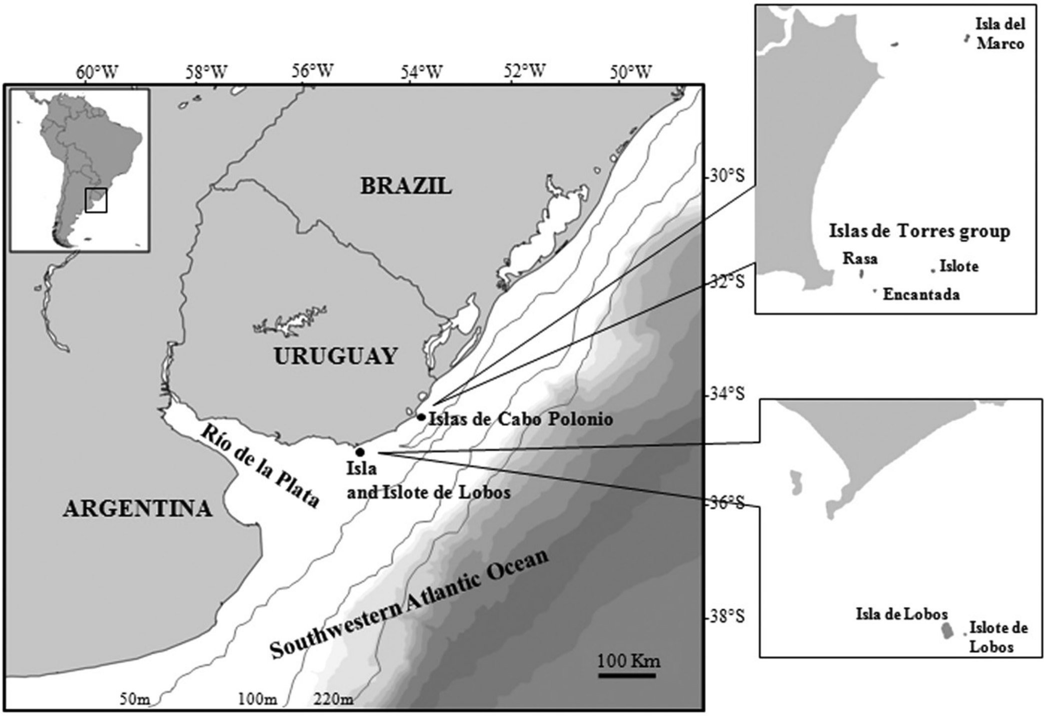

Figure 1. Breeding rookeries of the South American fur seal (*Arctocephalus australis*) in Uruguay at Isla – Islote de Lobos in Punta del Este, and Islas de Torres Group (Rasa, Encantada, and Islote) and Isla del Marco in Cabo Polonio

during the breeding season of the census), and indeterminate individuals (adult females and juveniles of both sexes). We differentiated the age-class and sex of individual SAFS based on individual body shape and color, location in the rookery, and other behavioural cues (Vaz-Ferreira & Sierra de Soriano, 1963; Vaz-Ferreira, 1982). Most of the photos contained only SAFS; however, in areas where SASL were present, we used differences in body size and color to differentiate species. Each photo mosaic was independently counted by observers, and counts were repeated whenever there was a difference of more than 10% between counts of each class of age and sex. Each aerial census in 2011 and 2013 provided a unique snapshot (i.e., we do not have multiple, independent aerial censuses per year for each site), and we further assumed that each observer was an "unbiased sampler" of each snapshot. Differences among observers were attributed to either missing animals or to animals being differentially assigned to incorrect age and sex classes. We then calculated the mean and standard deviation of counts per age-classes and sex in each island for the 2013 flight (and only for pups for the 2011 flight) between observers.

Aerial surveys are bound to underestimate SAFS pup counts because, despite all pups being on shore at the time of the flights, the topography of the shore and the tendency of pups to form dense aggregates hinder distinguishing individuals (Reyes et al., 1999; Schiavini et al., 2004; Sepúlveda et al., 2011; Grandi et al., 2015). We corrected the total pup counts per photo mosaic as follows. We carried out five exhaustive pup ground counts in a reproductive area of high visibility and access at Isla de Lobos on the same morning as the aerial survey in 2011 and considered these ground counts as being closest to the "true" pup count at this site. We calculated the pup correction factor as the ratio between the land pup count and the average aerial pup count for the same site. Therefore, the correction factor reflects the pups present at a site that were missed in the aerial counts due to the shore topography and the aggregative behaviour of pups. Given the topographical similarity among SAFS Uruguayan islands, we used the same (Isla de Lobos) correction factor for all pup counts for each photo mosaic (2011 and 2013).

Adult males, subadult males, and indeterminate individuals counts in each mosaic or island were not corrected. Aerial counts are bound to underestimate the abundance of non-pup sex and age-classes because of missing those individuals at sea at the time of the flight. However, assuming that the proportion of individuals at sea was similar at the time of the 2011 and 2013 flights, the uncorrected number of individuals of each category could be interpreted as indices of abundance of each sex and age-class and used in the long-term population monitoring and estimation of SAFS trends in Uruguay.

The estimated correction factor for pups was 3.9. Our estimated correction factor is high compared with several previous studies (e.g., Westlake et al., 1997; Lowry, 1999). The Uruguayan coastal topography is extreme, however, with overhanging cliffs, crevices, and boulders (see Figure 2); and similar underestimation of otariid pup count from aerial surveys has been reported by Reyes et al. (1999), Schiavini et al. (2004), and Grandi et al. (2015). Based on these disparities, we think correction factors among species and sites are not always comparable and should instead be carefully considered on a site-by-site or species-by-species basis. The adequacy of ground or aerial surveys (and the magnitude of the correction factors) is bound to depend on the local abundance, species' gregarious behaviour, and type of rookery substrate that determine the visibility of individual pups at the breeding site.

The total (uncorrected) SAFS abundance in Uruguay from aerial photos in 2013 was 45,588 (SD = 1,536) individuals (see Table 1), 67% of which were at Punta del Este (Isla – Islote de Lobos). In 2013, the corrected pup abundance estimated was 12,741 for Cabo Polonio islands and 18,419 for Isla – Islote de Lobos. The Islote at Cabo Polonio had a very low (< 2% of the total abundance of the island) proportion of pups, suggesting that it might primarily be a haul-out area for SAFS males.

We estimated the trend in SAFS pup production based on two historical counts in Isla – Islote de Lobos, Uruguay, in 1956 and 1981 (Vaz-Ferreira et al., 1984; Ponce de León, 2000) and our corrected pup counts for these islands in 2011 and

Figure 2. Mosaics of stitched aerial photographs taken over reproductive areas at a Uruguayan rookery (Isla de Lobos); all island Uruguayan rookery sites had similar complex topography.

Table 1. Raw counts of South American fur seal (*Arctocephalus australis*) of each age class (ADM = adult males, SAM = subadult males, Fem = females, Juv = juveniles, and pups) and total in each island in Uruguay in 2013. Values correspond to the mean (SD) of uncorrected counts of the photographs of each island by three independent observers (VFT, MD, and FG) by each age class.

Rookery	Island	ADM	SAM	Fem + Juv	Pups	Total
Cabo Polonio	Encantada	86 (6)	27 (4)	2,875 (234)	1,207 (47)	4,195 (274)
	Islote	85 (6)	2 (1)	888 (162)	20 (4)	995 (162)
	del Marco	322 (24)	3 (1)	3,602 (87)	906 (70)	4,833 (136)
	Rasa	50 (1)	1 (1)	4,091 (16)	1,134 (46)	5,276 (31)
Punta del Este	Isla de Lobos	772 (90)	587 (82)	22,250 (655)	4,544 (226)	28,153 (563)
	Islote Lobos	144 (8)	4 (0)	1,809 (102)	179 (10)	2,136 (107)

2013. We only considered previous estimates of SAFS pup abundance in Uruguay obtained using direct counts as other methods (e.g., abundance estimates by capture-recapture methods; Páez, 2000, 2006) may not be comparable due to their differences in accuracy and precision. Uruguayan SAFS showed a positive trend between 1956 and 2013 with a 1.5% (SE = 0.31%, 95% CI = 0.2 to 2.8%) finite annual growth rate in Isla – Islote de Lobos (Figure 3). These results are important for the management of SAFS given that Uruguayan rookeries constitute more than 70% of the species' total abundance (Venegas et al., 2002; Oliva et al., 2012; Crespo et al., 2015). Our estimate of SAFS pup abundance (*ca*. 31,000 in 2013) was 62% of the previous estimate based on non-exhaustive ground pup counts corrected by the probability of resighting (Páez, 2000).

Our estimates of the SAFS pup abundance use the same methodology of coupling corrected aerial surveys with ground counts by independent observers employed elsewhere in the species' geographic range (Sepúlveda et al., 2011; Crespo et al., 2015). Therefore, we believe that our estimates allow a more reliable assessment of the relative importance of the Uruguayan population to SAFS abundance and trends than previously collected data could provide. Currently, the SAFS Central/Southern Patagonia population is mostly comprised of adult males, juveniles of both sexes, and only *ca*. 1,000 pups (Crespo et al., 2015), a figure that is deemed too low for the current number of adults in Central/Southern Patagonia. Thus, it seems unlikely that the estimated

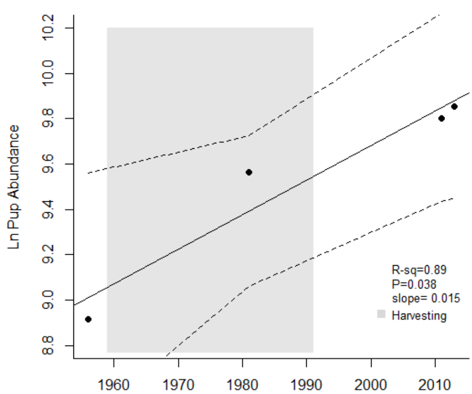

Figure 3. Abundances and trends (continuous lines) of South American fur seal pups from Isla de Lobos (Uruguay) between 1956 and 2013, showing the 95% confidence interval as dashed lines. The grey area refers to the period of commercial harvesting (1959 to 1991).

population growth of 5 and 8% in Central and Southern Patagonia (Crespo et al., 2015) results from local breeding. Therefore, the Uruguayan SAFS population is not only the largest of the subspecies but may also help sustain the rapid growth of the Argentine and southern Chilean populations through dispersal (Crespo et al., 2015).

Our findings also suggest the population has remained viable and increased over the last 60 years despite intensive commercial harvesting of SAFS in Uruguay. This is likely related to the following: (1) SAFS adult and subadult males were the main target of the harvest between 1893 and 1991 in Uruguay (*ca*. 70%; Ponce de León, 2000), and (2) SAFS has a polyginic (Lek) mating system with a small proportion of reproductive males (territorial and peripheral) (Franco-Trecu et al., 2014). Therefore, the removal of adult males presumably did not cause a disruption in the post-harvesting breeding of the species, which could explain the positive post-harvesting population trend in Uruguay.

Recoveries of harvested pinniped populations have often been hindered or at least delayed by the low availability of their food resources due to overfishing (Pauly et al., 1998; Alleway et al., 2014) and other anthropogenic impacts (e.g., pollution and disturbances in breeding areas) in coastal ecosystems (Davenport & Davenport, 2006; Bulleri & Chapman, 2010). Compared to that of phocids, the extended lactation period of otariids (and, therefore, restricted foraging behaviour of nursing mothers) appears to make them more sensitive to anthropogenic and climatic impacts that affect the local abundance and spatial distribution of food resources (Costa et al., 2006; Bowen et al., 2009). Within Otariidae, populations of fur seals (Arctocephalinae) typically have higher abundance and growth rates than those of sea lions (Otariinae) (Costa et al., 2006), which may be related to the species' foraging strategies. Sea lions tend to be benthic feeders that frequently forage near their aerobic dive limit (Hückstadt et al., 2016) and, hence, spend more energy gathering food than fur seals that are predominantly pelagic feeders (Costa et al., 2001; Costa & Gales, 2003). Therefore, sea lions would have a smaller margin to increase their searching effort if food resources become scarce due to fishing pressure or climatic variation (Costa et al., 2001, 2004). Such differences in energy expenditure on foraging may explain why many sea lion populations have lower resilience (i.e., longer recovery times) after intense harvest pressure than fur seals as observed for the SAFL in Uruguay (Franco-Trecu et al., 2015).

At a global level, the SAFS is listed as "Least Concern" by the International Union for Conservation of Nature, but it is listed in CITES Appendix II. Although the Uruguayan SAFS population has no evident conservation problems, the species is listed as a priority for conservation in Uruguay where it was set as a conservation target in the Marine Protected Area – Cabo Polonio National Park (González et al., 2013), partly because of the suspected significance of the Uruguayan SAFS population in sustaining the Southern Atlantic population (González et al., 2013). The pup estimates of abundance for SAFS in Uruguay that are reported herein for the first time using methods comparable to those employed elsewhere (Sepúlveda et al., 2011; Crespo et al., 2015) are thus highly relevant for future management plans regarding the conservation and protection of this species in other parts of its range.

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Literature Cited

Abreu, A. (2011). *Diversidade genética e estrutura populacional do lobo-marinho Sul-Americano (*Arctocephalus australis*, mammalia, carnivora, otariide) ao longo da costa Atlântica da América do Sul* [Genetic diversity and population structure of South American fur seals (*Arctocephalus australis*, mammalia, carnivora, otariid) to the length of the Atlantic coast of South America]. Rio Grande do Sul, Brazil: Pontifícia Universidade Católica do Rio Grande do Sul. 42 pp.

Alleway, H. K., Connell, S. D., Ward, T. M., & Gillanders, B. M. (2014). Historical changes in mean trophic level of southern Australian fisheries. *Marine and Freshwater Research*, *65*(10), 884-893. https://doi.org/10.1071/MF13246

Anganuzzi, A. A. (1993). A comparison of tests detecting trends in abundance indices of dolphins. *Fishery Bulletin*, *91*, 183-194.

Bartheld, J., Pavés, H., Contreras, F., Vera, C., Manque, C., Miranda, D., . . . Ossman, L. (2008). *Cuantificación poblacional de lobos marinos en el litoral de la I a IV Región* [Population quantification of fur seals on the coast of the I to IV Region] (Informe Final Proyecto FIP 2006-50).

Bonner, W. N. (1982). *Seals and man: A study of interactions*. Seattle: University of Washington Press.

Borella, F. (2014). Zooarchaeological evidence of otariids in continental coast of Patagonia, Argentina: Old and new perspectives. In S. A. Muñoz, C. M. Götz, & E. R. Roca (Eds.), *Neotropical and Caribbean aquatic mammals: Perspectives from biology* (pp. 135-160). Hauppauge, NY: Nova Science Publishers Inc.

Bowen, W. D., Beck, C. A., & Austin, D. A. (2009). Pinniped ecology. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *Encyclopedia of marine mammals* (2nd ed., pp. 852-861). San Diego, CA: Academic Press.

Bulleri, F., & Chapman, M. G. (2010). The introduction of coastal infrastructure as a driver of change in marine environments. *Journal of Applied Ecology*, *47*(1), 26-35. https://doi.org/10.1111/j.1365-2664.2009.01751.x

Chapman, D. G., & Johnson, A. M. (1968). Estimation of fur seal pup populations by randomized sampling. *Transactions of the American Fisheries Society*, *97*(3), 264-270. https://doi.org/10.1577/1548-8659(1968)97[264:EOFSPP]2.0.CO;2

Costa, D. P., & Gales, N. J. (2003). Energetics of a benthic diver: Seasonal foraging ecology of the Australian sea lion, *Neophoca cinerea*. *Ecological Monographs*, *73*(1), 27-43. https://doi.org/10.1890/0012-9615(2003)073[0027:EOABDS]2.0.CO;2

Costa, D. P., Gales, N. J., & Goebel, M. E. (2001). Aerobic dive limit: How often does it occur in nature? *Comparative Biochemical Physiology A: Molecular & Integrative Physiology*, *129*(4), 771-783. https://doi.org/10.1016/S1095-6433(01)00346-4

Costa, D. P., Weise, M. J., & Arnould, J. P. Y. (2006). Potential influences of whaling on the status and trends of pinniped populations. In J. A. Estes, T. M. Williams, D. Doak, & D. DeMaster (Eds.), *Whales, whaling and ocean ecosystems* (pp. 344-359). Berkeley: University of California Press.

Costa, D. P., Kuhn, C. E., Weise, M. J., Shaffer, S. A., & Arnould, J. P. Y. (2004). When does physiology limit the foraging behaviour of freely diving mammals? *International Congress Series*, *1275*, 359-366. https://doi.org/10.1016/j.ics.2004.08.058

Costello, M. J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H., & Miloslavich, P. (2010). A census of marine biodiversity knowledge, resources, and future challenges. *PLOS ONE*, *5*(8), e12110. https://doi.org/10.1371/journal.pone.0012110

Crespo, E. A., Schiavini, A. C. M., García, N. A., Franco-Trecu, V., Goodall, N. P., Rodríguez, D., . . . de Oliveira, L. R. (2015). Status, population trend and genetic structure of South American fur seals *Arctocephalus australis* in southwestern Atlantic waters. *Marine Mammal Science*, *31*(3), 866-890. https://doi.org/10.1111/mms.12199

Dans, S. L., Crespo, E. A., Pedraza, S. N., & Alonso, M. K. (2004). Recovery of the South American sea lion population in northern Patagonia. *Canadian Journal of Fisheries and Aquatic Science*, *61*(9), 1681-1690. https://doi.org/10.1139/f04-105

Davenport, J., & Davenport, J. L. (2006). The impact of tourism and personal leisure transport on coastal environments: A review. *Estuarine Coastal and Shelf Science*, *67*(1-2), 280-292. https://doi.org/10.1016/j.ecss.2005.11.026

de Oliveira, L. R., Meyer, D., Hoffman, J., Majluf, P., & Morgante, J. S. (2009). Evidence of a genetic bottleneck in an El Niño affected population of South American fur seals, *Arctocephalus australis*. *Journal of the Marine Biological Association of the United Kingdom*, *89*(8), 1717-1725. https://doi.org/10.1017/S0025315409000162

de Oliveira, L. R., Hoffman, J. I., Hingst-Zaher, E., Majluf, P., Muelbert, M. M. C., Morgante, J. S., & Amos, W. (2008). Morphological and genetic evidence for two evolutionarily significant units (ESUs) in the South American fur seal, *Arctocephalus gazella*. *Conservation Genetics*, *9*(6), 1451-1466. https://doi.org/10.1007/s10592-007-9473-1

Forney, K. A. (2000). Environmental models of cetacean abundance: Reducing uncertainty in population trends. *Conservation Biology*, *14*(5), 1271-1286. https://doi.org/10.1046/j.1523-1739.2000.99412.x

Franco-Trecu, V., Tassino, B., & Soutullo, A. (2010). Allosuckling in the South American fur seal (*Arctocephalus australis*) at Isla de Lobos, Uruguay: Cost or benefit of living in a group? *Ethology Ecology and Evolution*, *22*(2), 143-150. https://doi.org/10.1080/03949371003707745

Franco-Trecu, V., Costa, P., Schramm, Y., Tassino, B., & Inchausti, P. (2014). Sex on the rocks: Breeding tactics and reproductive success of South American fur seal males. *Behavioral Ecology*, *25*(6), 1513-1523. https://doi.org/10.1093/beheco/aru145

Franco-Trecu, V., Drago, M., García-Olazabal, M. D., Baladán, C., Crespo, E. A., Cardona, L., & Inchausti, P. (2015). Post-harvesting population dynamics of the South American sea lion (*Otaria byronia*) in the southwestern Atlantic. *Marine Mammal Science*, *31*(3), 963-978. https://doi.org/10.1111/mms.12197

Gerber, L. R., & Hilborn, R. (2001). Catastrophic events and recovery from low densities in populations of otariids: Implications for risk of extinction. *Mammal Review*, *31*(2), 131-150. https://doi.org/10.1046/j.1365-2907.2001.00081.x

González, E. M., Martínez-Lanfranco, J. A., Juri, E., Rodales, A. L., Botto, G., & Soutullo, A. (2013). Mamíferos [Mammals]. In A. Soutullo, C. Clavijo, & J. A. Martínez-Lanfranco (Eds.), *Especies prioritarias para la conservación en Uruguay: Vertebrados, moluscos continentales y plantas vasculares* [Priority species for conservation in Uruguay: Vertebrates, continental mollusks, and vascular plants] (pp. 175-207). Montevideo, Uruguay: SNAP/DINAMA/MVOTMA y DICYT/MEC.

Grandi, M. F., Dans, S. L., & Crespo, E. A. (2015). The recovery process of a population is not always the same: The case of *Otaria flavescens*. *Marine Biology Research*, *11*(3), 225-235. https://doi.org/10.1080/17451000.2014.932912

Hückstadt, L. A., Tift, M. S., Riet-Sapriza, F., Franco-Trecu, V., Baylis, A. M. M., Orben, R. A., . . . Costa, D. P. (2016). Regional variability in diving physiology and behavior in a widely distributed air-breathing marine predator, the South American sea lion, *Otaria byronia*. *Journal of Experimental Biology*, *219*, 2320-2330. https://doi.org/10.1242/jeb.138677

Instituto del Mar del Peru (IMARPE). (2014). *Anuario científico y tecnológico* [Scientific and technological yearbook] (Vol. 13). Lima, Peru: IMARPE.

Lowry, M. S. (1999). Counts of California sea lion (*Zalophus californianus*) pups from aerial color photographs and from the ground: A comparison of two methods. *Marine Mammal Science*, *15*(1), 143-158. https://doi.org/10.1111/j.1748-7692.1999.tb00786.x

McLaren, I. A., & Smith, T. G. (1985). Population ecology of seals: Retrospective and prospective views. *Marine Mammal Science*, *1*(1), 54-83. https://doi.org/10.1111/j.1748-7692.1985.tb00531.x

Oliva, D., Sepúlveda, M., Durán, L. R., Urra, A., Sielfeld, W., Moraga, R., . . . Muñoz, L. (2012). *Cuantificación poblacional de lobos marinos en las Regiones X -XI y propuesta de escenarios de manejo* [Population quantification of fur seals in Regions X-XI and proposed management scenarios] (Final Report Project FAP ID 4728-46-LP11). Chile. 156 pp.

Páez, E. (2000). Utilización de Boostrap y análisis de poder en estimaciones de abundancia de cachorros de *Arctocephalus australis* [Use of Bootstrap and power analysis in abundance estimates of *Arctocephalus australis* pups]. In M. Rey & F. Amestoy (Eds.), *Sinopsis de la biología y ecología de las poblaciones de lobos finos y leones marinos de Uruguay: Pautas para su manejo y administración* [Synopsis of the biology and ecology of the populations of fur seals and sea lions of Uruguay: Guidelines for their management and administration] (Proyecto URU/92/003, pp. 55-70). Montevideo, Uruguay: Instituto Nacional de Pesca-Programa de las Naciones Unidas para el Desarrollo.

Páez, E. (2006). Situación de la administración del recurso lobos y leones marinos en Uruguay [Situation of the administration of the fur seals and sea lions in Uruguay]. In R. Menafra, L. Rodríguez-Gallego, F. Scarabino, & D. Conde (Eds.), *Bases para la conservación y el manejo de la costa Uruguaya* [Bases for the conservation and management of the Uruguayan coast] (pp. 577-583). Montevideo, Uruguay: Vida Silvestre, Sociedad Uruguaya para la Conservación de la Naturaleza.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. *Science*, *279*(5352), 860-863. https://doi.org/10.1126/science.279.5352.860

Ponce de León, A. (2000). Taxonomía, sistemática y sinopsis de la biología y ecología de los pinipedios de Uruguay [Taxonomy, systematics, and synopsis of the biology and ecology of the pinnipeds of Uruguay]. In M. Rey & F. Amestoy (Eds.), *Sinopsis de la biología y ecología de las poblaciones de lobos finos y leones marinos de Uruguay: Pautas para su manejo y administración. Parte I. Biología de las especies* [Synopsis of the biology and ecology of the populations of fur seals and sea lions of Uruguay: Guidelines for its management and administration. Part I. Biology of the species (Proyecto URU/92/003, pp. 9-36). Montevideo, Uruguay: Instituto Nacional de Pesca-Programa de las Naciones Unidas para el Desarrollo.

Raum-Suryan, K. L., Pitcher, K. W., Calkins, D. G., Sease, J. L., & Loughlin, T. R. (2002). Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. *Marine Mammal Science*, *18*(3), 746-764. https://doi.org/10.1111/j.1748-7692.2002.tb01071.x

Reyes, L. M., Crespo, E. A., & Szapkievich, V. (1999). Distribution and population size of the southern sea lion (*Otaria flavescens*) in central and southern Chubut, Patagonia, Argentina. *Marine Mammal Science*, *15*(2), 478-493. https://doi.org/10.1111/j.1748-7692.1999.tb00814.x

Schiavini, A. C. M. (1985). *Determinación de las pautas de captura de pinnipedos del Canal Beagle por los Aborigenes Prehistoricos – Resultados preliminares* [Determination of the catch patterns of pinnipeds of the Beagle Channel by the Prehistoric Aborigines – Preliminary results]. First Argentine Conference of Mastozoology. 32 pp.

Schiavini, A. C. M., Crespo, E. A., & Szapkievich, V. (2004). Status of the population of South American sea lion (*Otaria flavescens* Shaw, 1800) in southern Argentina. *Mammalian Biology*, *69*(2), 108-118. https://doi.org/10.1078/1616-5047-00125

Sepúlveda, M., Oliva, D., Urra, A., Perez-Alvarez, M. J., Moraga, R., Schrader, D., . . . Sielfeld, W. (2011). Distribution and abundance of the South American sea lion *Otaria flavescens* (Carnivora: Otariidae) along the central coast off Chile. *Revista Chilena De Historia Natural*, *84*(1), 97-106. https://doi.org/10.4067/S0716-078X2011000100007

Thompson, D., Strange, I., Riddy, M., & Duck, C. D. (2005). The size and status of the population of southern sea lions *Otaria flavescens* in the Falkland Islands. *Biological Conservation*, *121*(3), 357-367. https://doi.org/10.1016/j.biocon.2004.05.008

Trillmich, F., Kooyman, G. L., & Majluf, P. (1986). Attendance and diving behavior of South American fur seals during El Niño in 1983. In R. L. Gentry & G. L. Kooyman (Eds.), *Fur seals: Maternal strategies on land and at sea* (pp. 153-167). Princeton, NJ: Princeton University Press.

Trites, A. W., & Larkin, P. A. (1996). Changes in the abundance of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1956 to 1992: How many were there? *Aquatic Mammals*, *22*(3), 153-166.

Vaz-Ferreira, R. (1982). *Arctocephalus australis*, Zimmermann, South American fur seal. In *Mammals in the seas: Volume IV. Small cetaceans, seals, sirenians and otters* (FAO Fisheries Series, No. 5, pp. 497-508). Rome: Food and Agriculture Organization of the United Nations.

Vaz-Ferreira, R., & Sierra de Soriano, B. (1963). División funcional del habitat terrestre y estructura de las agregaciones sociales de *Arctocephalus australis* (Zimmermann) estudio gráfico [Functional division of the terrestrial habitat and structure of the social aggregations of *Arctocephalus australis* (Zimmermann) graphic study]. *Actas y Trabajos Primer Congreso Sudamericano de Zoología. La Plata*, *1*, 175-183.

Vaz-Ferreira, R., Lessa, E., Achaval, F., & Melgarejo, A. (1984). Recuento de cachorros de lobos marinos (*Arctocephalus australis* y *Otaria flavescens*) en Isla de Lobos, Uruguay, en febrero de 1981 [Counting fur seal and sea lion pups (*Arctocephalus australis* and *Otaria flavescens*) in Isla de Lobos, Uruguay, in February 1981]. *Boletin de la Sociedad Zoologica del Uruguay*, *2*, Nueva Epoca.

Venegas, C., Gibbons, J., Aguayo, A., Sielfeld, W., Acevedo, J., Amado, N., & Valenzuela, C. (2002). Distribución y abundancia de lobos marinos (Pinnipedia: Otariidae) en la Región de Magallanes [Distribution and abundance of fur seals (Pinnipedia: Otariidae) in the Magallanes Region]. *Anales del Instituto de la Patagonia, Serie Ciencias Naturales*, *30*, 67-82.

Westlake, R. L., Perryman, W. L., & Ono, K. A. (1997). Comparison of vertical aerial photographic and ground censuses of Steller sea lions at Año Nuevo island, July 1990-1993. *Marine Mammal Science*, *13*(2), 207-218. https://doi.org/10.1111/j.1748-7692.1997.tb00628.x