Revista de Biología Marina y Oceanografía 44(3): 685-689, diciembre de 2009

Seasonal variation in the abundance of South American sea lions *Otaria flavescens* (Shaw, 1800) in Chañaral Island, Reserva Nacional Pingüino de Humboldt, Chile

Variación estacional de la abundancia del lobo marino común *Otaria flavescens* (Shaw, 1800) en Isla Chañaral, Reserva Nacional Pingüino de Humboldt, Chile

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Resumen.- Desde enero de 2007 y hasta marzo de 2008 se analizó la variación de la abundancia del lobo marino común *Otaria flavescens* en la lobera reproductiva Isla Chañaral, de acuerdo al sexo, clase de edad y estación reproductiva. El mayor número de lobos marinos en la lobera se registró durante el período reproductivo. Esta variación se debió principalmente a la fluctuación del número de hembras, ya que esta clase de edad fue la más importante en la colonia y mostró un aumento en su abundancia durante este período. No se registraron fluctuaciones estacionales en el número de machos adultos, machos subadultos y juveniles. La proporción de sexos durante la estación reproductiva estuvo fuertemente sesgada hacia las hembras, mientras que fue cercana a 1:1 durante el resto del año. Este estudio demuestra que la variación en la abundancia y composición por sexo y clase de edad del lobo marino común en Isla Chañaral se relaciona principalmente con la actividad reproductiva.

Palabras clave: Censos, costa chilena, lobos marinos, ritmos circanuales, *Otaria byronia*

Abstract.- From January 2007 to March 2008, we examined variation in the abundance of the South American sea lion *Otaria flavescens* in Chañaral Island breeding colony by sex, age-class, and reproductive seasonality. The number of sea lions on land was highest during the breeding season. This variation was mainly influenced by the number of adult females, because this age class was the most important in the colony and showed an increase in abundance during this period. No seasonal variation in the number of adult males, subadult males, and juveniles was detected. The sex ratio during the breeding season was highly biased towards females, while it was close to 1:1 during the rest of the year. This study demonstrates that variation in the abundance and sex/age class composition of sea lions at Chañaral Island colony is largely influenced by reproductive activity.

Key words: Census, Chilean coast, sea lions, circannual rhythms, *Otaria byronia*

Introduction

The South American sea lion *Otaria flavescens*[1] (Shaw, 1800) occurs within a broad latitudinal range along the South American coastline, from Peru to southern Chile along the Pacific Ocean, and from Brazil to southern Argentina along the Atlantic Ocean, including the Falkland Islands (King 1983). A global population estimate is unknown, but probably exceeds 200,000 individuals (Reijnders *et al*. 1993, Boness 2002). In Chile, this species shows a continuous distribution along the coast. Most recent surveys (Venegas *et al*. 2001, Sepúlveda *et al*. 2007a, Bartheld *et al*. 2008, Oliva *et al*. 2008) have estimated a population size of ~135,000 sea lions in Chile, representing approximately 50% of the global population.

Otaria flavescens, like other species of pinnipeds (which comprise otariids, phocids, and the walrus), combines marine feeding and terrestrial breeding (Cassini 1999). On land, sea lions congregate in colonies, which may be classified in breeding and non-breeding (= haulout) sites (Carrara 1952, Sielfeld *et al*. 1997). During the reproductive season, breeding colonies are composed

[1]Some taxonomists and scientists consider *Otaria byronia* (de Blainville, 1820) as the valid scientific name for the South American sea lion.

mainly of breeding males, females, and pups. In contrast, haulout sites are mostly inhabited by adult and subadult males, and juveniles, which are not involved in reproduction during the breeding season.

For *Otaria flavescens*, the breeding period extends from the third week of December to March (austral summer) (Aguayo & Maturana 1973, Vaz-Ferreira 1982, Acevedo *et al*. 2003). During this period, most breeding females give birth and copulate within territories established by adult males (Campagna & LeBoeuf 1988, Sielfeld 1999, Acevedo *et al*. 2003). After the breeding season, most individuals disperse to haulouts (Hamilton 1939, Piazza 1959). Therefore, breeding colonies and haulouts differ by the behavioral activity during the austral summer, and also by seasonal variation in the number of animals attending these sites. Whereas in non-breeding colonies population size decreases during summer and increases in the other seasons (Sepúlveda *et al*. 2001), the opposite might be expected in breeding colonies, where the largest number of individuals are found in a reproductive state during summer. Even though this pattern has been demonstrated in other species of pinnipeds (*e.g*. Lake *et al*. 1997, Vincent *et al*. 2005), for *O. flavescens* annual cycles of abundance are poorly documented. In fact, studies of abundance of this species in Chile have only been conducted during the reproductive season. To our knowledge however, no studies analyzed fluctuations in the number of sea lions during an entire year in breeding colonies. This information is relevant to the management of *O. flavescens* in Chile, since conflicts between South American sea lions and fisheries and aquaculture occur mainly during autumn and winter seasons (Sepúlveda & Oliva 2005, Sepúlveda *et al*. 2007b).

In this context, the objective of this study was to analyze seasonal variation in the abundance and age/sex composition of South American sea lions in the Chañaral Island breeding colony. We hypothesized that: (1) the number of sea lions is higher during breeding months, and (2) the age classes associated with breeding activities (adult males, females and pups) show a markedly seasonal variation in their abundance, compared to the age classes not involved in reproduction.

Material and methods

We conducted surveys of sea lions in the breeding colony Chañaral Island (29°02' S, 71°36' W), Reserva Nacional Pingüino de Humboldt, central-north of Chile (Fig. 1). Ten surveys were performed from January 2007 to March

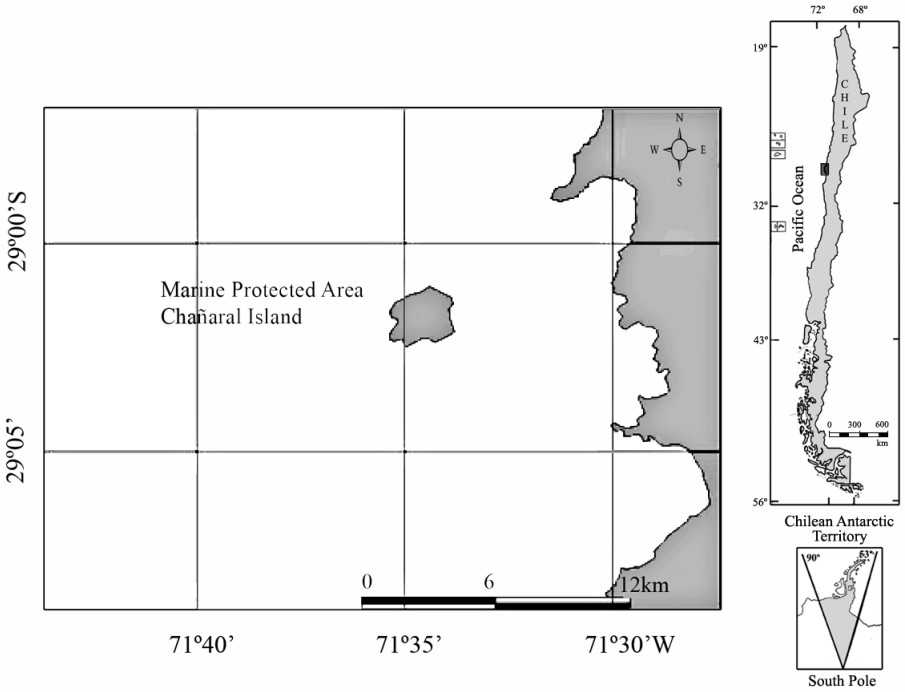

Figure 1

Map of the study area showing the geographic location of the marine protected area Chañaral Island

Mapa del área de estudio que muestra la ubicación geográfica del área marina protegida Isla Chañaral

2008, in order to determine seasonal variation in population abundance of sea lions, covering almost two entire breeding seasons (third week of December to March, Table 1). On each survey, the colony was surveyed from boats of artisanal fishermen (8 m length), at 50-100 m from the island, when weather conditions were favorable (Beaufort scale < 3).

Previous studies suggested that counting and categorizing sea lions in real time during surveys was error-prone due to movements of animals on shore and the potential for sea lions to be disturbed into the water by the proximity of survey boats. For these reasons, we surveyed using digital photographs, to provide a more accurate census than field counts. A photographic record was taken with digital cameras Canon® 20D and 30D, zoom lenses Canon® 100-400 f4.5-5.6 IS, and 70-200 f2.8 IS. All sea lions hauled out or in the water near of the colony (< 20 m from the island) were included in counts. Surveys were conducted from 10:00 to 12:00 hours, when number of sea lions on shore is maximal (Sepúlveda *et al*. 2001).

Sea lions were counted from digital photographs images using Adobe Photoshop CS2 (version 9.0). Three independent and trained observers classified the individuals into five categories according to age and sex: adult males, subadult males, females (both adult and subadult), juveniles (both sexes), and pups (born during the current reproductive season). Age and sex distinctions were determined from differences in size, body shape and/or coloration (Hamilton 1934, King 1983). Additionally, a category of indeterminate was considered, which corresponded to individuals that could not be classified in any of the classes mentioned above. The number of individuals in each sex/age class was counted separately. Final abundances were estimated by averaging the counts of the three observers, with a maximum error of 5% allowed among them.

The abundance comparison by age class was done considering breeding and non-breeding seasons. The non-parametric Mann Whitney test was used to evaluate the effects of seasonality on the sea lions' abundance, because the data were not normally distributed (Zar 1996). Additionally, sex ratio (ratio of adult males to females) was calculated for each season. All the analyses were performed in Statistica v. 6.0.

Results

There were no statistical differences in the total number of sea lions among the seasons, but a general tendency was observed. On average, the abundance was highest during the breeding season (mean = 1001 sea lions), compared to non-breeding season (mean = 765 sea lions). Pups were not recognized as a distinctive age class in the counts from June to December 2007, because they molt and could be easily confused with juveniles. For this reason, the abundance of juveniles in counts from June to December 2007 included the pups born in summer 2007 (Table 1).

We also investigated if the number of individuals for each age-sex class varied between breeding and non-breeding seasons. The number of juveniles did not vary significantly during the year ($U_{1,10}$= 8, P = 0.39). Similarly, the number of adult (AM) and subadult males (SM) did

Table 1

Number of South American sea lions (*Otaria flavescens*) registered in Chañaral Island from January 2007 to March 2008. Values are expressed as mean and 95% CI (in brackets)

Número de lobo marinos comunes (*Otaria flavescens*) censados en Isla Chañaral desde enero de 2007 hasta marzo de 2008. Los valores se muestran como la media y el 95% IC (en paréntesis)

Date	Adult males	Subadult males	Females	Juveniles	Pups	Indeterminates	Total
31 Jan 2007	77 (70-84)	60 (53-68)	544 (506-582)	65 (56-73)	109 (106-112)	85 (75-95)	940 (914-966)
7 Mar 2007	132 (119-146)	112 (101-124)	271 (242-200)	83 (74-92)	106 (101-111)	68 (59-78)	773 (750-796)
22 Apr 2007	67 (63-70)	38 (37-40)	162 (155-169)	39 (34-44)	112 (105-120)	18 (17-19)	436 (427-445)
22 Jun 2007	117 (112-121)	111 (94-128)	266 (259-272)	146 (138-153)	-	140 (135-145)	779 (745-814)
19 Aug 2007	168 (164-173)	135 (129-142)	328 (312-343)	133 (125-141)	-	126 (120-132)	890 (882-899)
9 Sep 2007	249 (247-251)	198 (197-200)	202 (201-202)	117 (115-119)	-	54 (50-59)	820 (814-827)
18 Nov 2007	306 (299-313)	212 (211-214)	250 (240-260)	174 (164-184)	-	102 (98-106)	1044 (1026-1062)
20 Dec 2007	147 (144-150)	139 (132-145)	204 (199-208)	94 (91-98)	-	39 (37-41)	623 (616-629)
2 Feb 2008	127 (122-132)	102 (94-110)	382 (380-384)	44 (41-47)	155 (150-160)	45 (41-50)	855 (841-869)
29 Mar 2008	253 (241-265)	207 (198-217)	552 (534-570)	146 (139-153)	162 (161-164)	117 (106-127)	1437 (1415-1459)

not show significant variation during the year (AM: $U_{1,10}$= 10, P = 0.06; SM: $U_{1,10}$= 9, P = 0.52). The number of adult females was significantly higher during breeding season ($U_{1,10}$= 1, P = 0.019). The sex ratio of adults was skewed to females during the reproductive season (adult male: adult female = 1:3), and near 1:1 during the rest of the year).

Discussion

The mean number of sea lions counted during the study period was higher during breeding season, as expected for a breeding colony (Aguayo & Maturana 1973). In the reproductive period, most of the individuals (especially adult males and females) spend more time on land, so that the number of sea lions onshore during this period was higher, according to the information described by Campagna (1985). Abundance was lower outside the breeding season, indicating that many animals moved from the breeding colonies to other sites after the breeding season. This annual cycle is opposite to that observed at a haulout by Sepúlveda *et al*. (2001), who observed the lowest number of sea lions during summer months. In that haulout, the number of individuals increased after March, remained relatively stable until the end of December. After this month the numbers abruptly dropped as sea lions moved to breeding colonies (Sepúlveda *et al*. 2001). These results suggest that the annual pattern of sea lion abundance in breeding and non-breeding colonies depends largely on reproductive activity, which greatly influences the temporal and geographical distribution of this species.

Seasonal variation in abundance was mainly due to variation in the number of females, because this category was the most abundant in the colony. The sex ratio during the breeding season was highly biased towards females, while it was close to 1:1 during the rest of the year. In early January, pregnant females arrive to the colony and integrate into males' territories (Acevedo *et al*. 2003, Pavés *et al*. 2005).

The abundance of females was highest during the breeding season due to concentration of all pupping during this period. Studies in other colonies in Chile report highly synchronized timing of births for this species, with a peak between the last week of January and the first week of February (Acevedo *et al*. 2003, Pavés *et al*. 2005). In order to maximize their fitness, females should give birth when the probability of offspring mortality is the lowest (Clutton-Brock 1988, Trites & Antonelis 1994). Because in summer food availability and suitable weather (primary factors that determinate the timing of births) are better, a synchronization in the timing of births in this period likely enhances the reproductive success of females (Boyd 1991, Majluf 1992, Pitcher *et al*. 2001, Soto *et al*. 2004).

At the end of the breeding season (March), reproductive activity ceases and males gradually leave the colony (Sepúlveda *et al*. 2001, Acevedo *et al*. 2003). Since pups are not able to swim long distances, females remain with their pups in the colony until May, and leave the breeding colony once pups are more proficient swimmers, when the abundance of sea lions diminishes notoriously.

The Chañaral colony showed a marked seasonal variation in abundance and age/sex composition, which was dependent on the reproductive activity of the South American sea lions. Seasonal variation in total numbers and age/sex composition was most influenced by numbers of females in the colony, which practically doubled from ~230 to 450 individuals outside versus during the breeding season, respectively. Further studies on reproductive biology and population dynamics (survival and fecundity) are needed to provide critical information for management and conservation of this species in Chile.

Acknowledgments

We appreciate the contributions made by the researchers Paula López and Macarena Santos; the local community support, the marine surveys and field experience of Aurelio Aguirre, Patricio Ortiz and Angel Talandiano, and the technical support of Corporación Nacional Forestal (CONAF), Subsecretaría de Pesca (SUBPESCA), and Servicio Nacional de Pesca (SERNAPESCA). We also gratefully acknowledge to the anonymous reviewers for their valuable comments and suggestions. Financial support for this study was provided by the Project DIPUV 25/2007.

Literature cited

Acevedo J, A Aguayo-Lobo & W Sielfeld. 2003. Eventos reproductivos del león marino común, *Otaria flavescens* (Shaw, 1800), en el norte de Chile (Pacífico Suroriental). Revista de Biología Marina y Oceanografía 38: 69-75.

Aguayo A & R Maturana. 1973. Presencia del lobo marino común (*Otaria flavescens*) en el litoral chileno. Arica a Punta Maiquillahue. Biología Pesquera 6: 45-75.

Bartheld JL, H Pavés, C Manque, C Vera & D Miranda. 2008. Cuantificación poblacional de lobos marinos en el litoral de la I a IV Región, 124 pp. Informe Final Proyecto FIP 2006-50. [on line] <http://www.fip.cl/proyectos/2006/2006-50.htm>

Bonnes DJ. 2002. Species. In: Perrin WF, B Würsig & H Thewissen (eds). Encyclopedia of marine mammals, pp. 1068. Academic Press, San Diego.

Boyd IL. 1991. Environmental and physiological factors

controlling the reproductive cycles of pinnipeds. Canadian Journal of Zoology 69: 1135-1148.

Campagna C. 1985. The breeding cycle of the southern sea lion, *Otaria byronia*. Marine Mammal Science 1: 210-218.

Campagna C & B Le Boeuf. 1988. Thermoregulatory behaviour of southern sea lions and its effect on mating strategies. Behaviour 107: 72-90.

Carrara F. 1952. Lobos marinos, pinguinos y guaneras de las costas del litoral marítimo e islas adyacentes de la República Argentina, 191 pp. Publicación Especial de la Facultad de Ciencias Veterinarias, Universidad de La Plata, La Plata.

Cassini MH. 1999. The evolution of reproductive systems in pinnipeds. Behavioral Ecology 10: 612-616.

Clutton-Brock TH. 1988. Reproductive success: studies of individual variation in contrasting breeding systems, 538 pp. University of Chicago Press, Chicago.

Hamilton J. 1934. The southern sea lion *Otaria byronia* (de Blainville). Discovery Reports 8: 269-318.

Hamilton J. 1939. A second report on the southern sea lion *Otaria byronia* (de Blainville). Discovery Reports 19: 121-164.

King J. 1983. Seals of the world, 240 pp. Cambridge University Press, Cambridge.

Lake SE, HR Burton & MA Hindell. 1997. Influence of time of day and month on Weddell seal haul-out pattern at the Vestfold Hills, Antartica. Polar Biology 18: 319-324.

Majluf P. 1992. Timing of births and juvenile mortality in the South American fur seal in Peru. Journal of Zoology 227: 367-383.

Oliva D, W Sielfeld, M Sepúlveda, MJ Pérez, R Moraga, A Urra, D Schrader, H Pavés & M Buscaglia. 2008. Plan de acción para disminuir y mitigar los efectos de las interacciones del lobo marino común (*Otaria flavescens*) con las actividades de pesca y acuicultura, 323 pp. Informe final Proyecto FIP 2006-34. [on-line] <http://www.fip.cl/proyectos/2006/2006-34.htm>

Pavés HJ, RP Schlatter & CI Espinoza. 2005. Patrones reproductivos del lobo marino común, *Otaria flavescens* (Shaw 1800), en el centro-sur de Chile. Revista Chilena de Historia Natural 78: 687-700.

Piazza A. 1959. Los lobos marinos en el Perú. Pesca y Caza, (Perú) 9: 1-29.

Pitcher KW, VN Burkanov, DG Calkins, BJ Le Boeuf, EG Mamaev, RL Merrick & GW Pendleton. 2001. Spatial and temporal variation in the timing of births of Steller sea lions. Journal of Mammalogy 82: 1047–1053.

Reijnders P, S Braseeur, J Toorn, P Wolf, I Boyd, J Harwood, D Lavigne & L Lowry. 1993. Seals, fur seals, sea lions, and walrus, 88 pp. International Union for Conservation of Nature and Natural Resources, Gland.

Sepúlveda M & D Oliva. 2005. Interaction between South American sea lions *Otaria flavescens* and salmon farms in southern Chile. Aquaculture Research 36: 1062-1068.

Sepúlveda M, D Oliva & F Palma. 2001. Daily and annual circarhythms activity in the South American sea lion *Otaria flavescens* (Carnivora:Otariidae) at the Central zone of Chile. Revista de Biología Marina y Oceanografía 36: 181-187.

Sepúlveda M, D Oliva, A Urra, MJ Pérez, R Moraga, D Schrader, P Inostroza, A Melo, H Díaz & W Sielfeld. 2007a. Cuantificación poblacional de lobos marinos en el litoral de la V a IX Región, 100 pp. Informe Final Proyecto FIP 2006-49. [on line] <http://www.fip.cl/proyectos/2006/2006-49.htm>

Sepúlveda M, MJ Pérez, W Sielfeld, D Oliva, LR Durán, L Rodríguez, V Araos & M Buscaglia. 2007b. Operational interaction between South American sea lions *Otaria flavescens* and artisanal (small scale) fishing in Chile: results from interview surveys and on-board observations. Fisheries Research 83: 332-340.

Sielfeld W. 1999. Estado del conocimiento sobre conservación y preservación de *Otaria flavescens* (Shaw 1800) y *Arctocephalus australis* (Zimmermann 1783) en las costas de Chile. Estudios Oceanológicos 18: 81-96.

Sielfeld W, C Guerra, LR Durán, E Acuña, A Aguayo, M Sepúlveda, F Palma, A Malinarich, G Cerda, A Bolvarán, R Grau, X Veloso, Y Guerra, M Vargas, N Amado, R Peredo & J Galáz. 1997. Monitoreo de la pesquería y censo del lobo marino común en el litoral de la I-IV Regiones, 119 pp. Informe Final Proyecto FIP 95-28. [on line] <http://www.fip.cl/prog_x_year/1995/9528.htm >

Soto K, A Trites & M Arias-Scheiber. 2004. The effects of prey availability on pup mortality and the timing of birth of South American sea lions (*Otaria flavescens*) in Peru. Journal of Zoology, (London) 264: 419-428.

Trites AW & GA Antonelis. 1994. The influence of climatic seasonality on the life cycle of the Pribilof northern fur seal. Marine Mammal Science 10: 311-324.

Vaz-Ferreira R. 1982. *Otaria flavescens* (Shaw) South American sea lion. Report of the Advisory Committee on marine resources research working party on marine mammals. FAO Fisheries Series 5: 477-495.

Venegas C, J Gibbons, A Aguayo, W Sielfeld, J Acevedo, N Amado, J Capella, G Guzmán & C Valenzuela. 2001. Cuantificación poblacional de lobos marinos en la XII Región, 92 pp. Informe Final Proyecto FIP 2000-22. [on line] <http://www.fip.cl/prog_x_year/2000/2000-22.htm>

Vincent C, MA Fedak, BJ McConnell, L Meynier, C Saint-Jean & V Ridoux. 2005. Status and conservation of the grey seal, *Halichoerus grypus*, in France. Biological Conservation 126: 62-73.

Zar JH. 1996. Biostatistical analysis, 3rd edition, 662 pp. Prentice Hall, New Jersey.

Recibido el 12 de enero de 2009 y aceptado el 21 de septiembre de 2009