SURVIVAL RATES OF THE CALIFORNIA SEA LION, *ZALOPHUS CALIFORNIANUS*, IN MEXICO

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California sea lions (*Zalophus californianus*) in the Gulf of California have declined by 20% over the past 2 decades. The lack of data on life-history parameters for this species has limited the development of demographic models to assess the status of this population. We estimated age- and sex-specific annual survival probabilities for California sea lions using resighting data on 5 pup cohorts from 1981 to 2006. We modeled apparent survival and resighting probability using age-class, sex, and time as potential explanatory variables. Apparent survival rates varied for different age- and sex-classes. Only survival of pups varied by year (from 0.556 to 0.998). Survival was the same for immature males and females (0.90), but differed by sex for young (males = 0.90, females = 0.97) and old (males = 0.75, females = 0.91) adults. Resighting probabilities varied by time, age-class, and sex. Resighting probabilities were higher for females than for males, and lowest for juveniles. The survival estimates presented here provide practical insight into understanding age- and sex-specific survival rates for California sea lions.

Key words: demography, mark–recapture, survival probabilities

Demographic models that describe the dynamics and viability of long-lived vertebrate populations typically rely on age- and sex-specific life-history parameters (Eberhardt 1985). For polygynous, sexually dimorphic mammals, survival rates often differ between offspring and adults and between adult males and females (Caughley 1966; Clutton-Brock et al. 1985; Ralls et al. 1980). Heterogeneity in survival rates has important implications for the dynamics and persistence of wildlife populations (Eberhardt 1985; Eberhardt and Siniff 1977). For example, survival of juveniles contributes significantly to population growth rate, and it is often used as an indicator of population status (Beauplet et al. 2005; Eberhardt 1985). Obtaining accurate estimates of age- and sex-specific survival rates is essential for developing population models used in conservation and management (Caswell 2001).

There are few reliable estimates of age- and sex-specific survival rates for long-lived mammals because of the time required to follow cohorts over their entire life span (Gaillard et al. 1997; Pistorius and Bester 2002). Survival rates can be estimated from age frequency distributions; however, these estimates are usually biased because model assumptions (e.g., stable age distribution) are rarely met (Barlow and Boveng 1991). For many animals, mark–recapture methods provide the best approach for measuring survival rates as long as marks are permanent. The recent development of specialized software (e.g., MARK—White and Burnham 1999) has provided a powerful quantitative tool for fitting complex models that allow for variation by age, sex, and time in survival and recapture probabilities (Lebreton et al. 1992).

The California sea lion (*Zalophus californianus*) is distributed along the North Pacific Coast from British Columbia to the southern tip of the Baja California Peninsula in Mexico, including the Gulf of California (King 1983; Le Boeuf et al. 1983). California sea lions in the Gulf of California experienced a period of intensive harvesting in the 19th century. Since then the population is thought to have recovered throughout its range and some colonies have exhibited a consistent increase in abundance (Szteren et al. 2006; Zavala-González and Mellink 2000). However, recent estimates suggest that the total abundance has declined during the
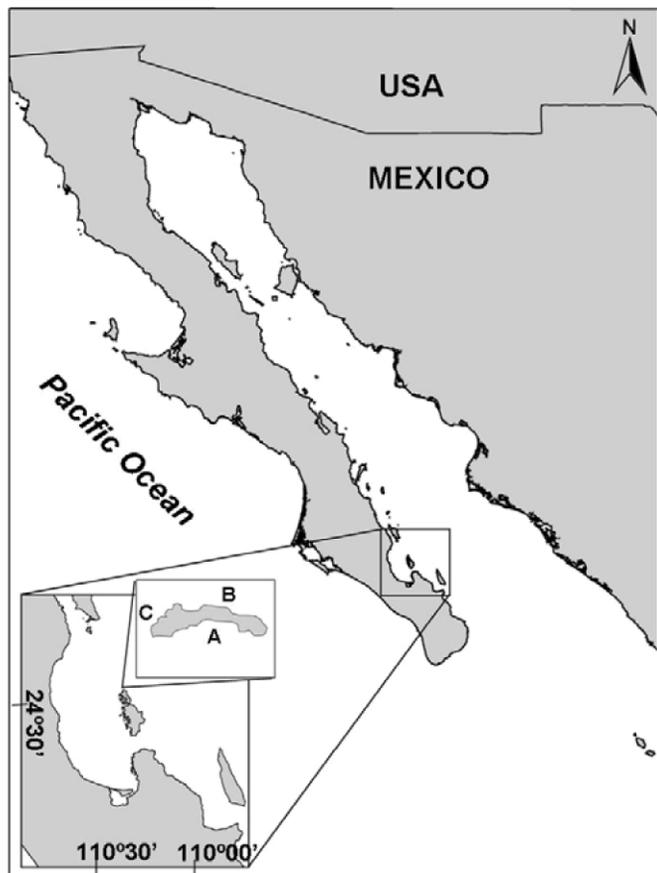
FIG. 1.—Los Islotes colony is the southernmost reproductive colony of California sea lions in the Gulf of California. Animals were branded at sites A and B.

TABLE 1.—Number of male and female pups branded during each of the breeding seasons from 1980 to 1984 at Los Islotes rookery, Gulf of California. The total number of pups born each year was estimated from land censuses during the 2nd week of July, shortly after most births had occurred (García-Aguilar and Aurioles-Gamboa 2003b).

Cohort	Males	Females	Branded relative to pups born (%)
1980	17	8	65.8
1981	18	17	76.0
1982	19	18	68.5
1983	24	26	100
1984	18	25	87.8
Total	96	94	79.6

last 2 decades (Szteren et al. 2006). The proximate causal factor for this decline has not yet been clearly identified. There are approximately 30,000 California sea lions in the Gulf of California, mostly concentrated in the upper Gulf (Szteren et al. 2006). Recent genetic studies suggest that the Gulf of California stock is genetically structured, with distinct populations in the Northern, Southern, and Midriff islands (Schramm-Urrutia 2002). This species is currently protected by laws in both Mexico (NOM-059-ECOL-1994) and the United States (Marine Mammal Protection Act); however, management strategies based on the demographic and genetic heterogeneity of this population are lacking. A better understanding of life-history traits will improve the predictive ability of demographic models used to assess the conservation status of this population.

In this study, we estimated age- and sex-specific annual survival rates and recapture probabilities for 5 cohorts of California sea lions marked as pups in Los Islotes, Gulf of California, using 23 years of mark–resighting data during 1980–2006.

MATERIALS AND METHODS

Study site.—Los Islotes is a small breeding colony (census population size is approximately 400 individuals) located in the southernmost range of the species distribution (Fig. 1). During the breeding season, California sea lions establish reproductive territories at 3 distinct areas (Fig. 1). This population has been monitored over the last 30 years, and is among the few colonies in the Gulf of California that has experienced an increase in abundance over the last 2 decades (Gerber 2006; González-Suárez et al. 2006; Szteren et al. 2006). Several aspects of the ecology and demography of sea lions have been studied at Los Islotes, including preliminary estimation of vital rates for newborns (Aurioles-Gamboa and Sinsel 1988; Hernández-Camacho et al., in press; Szteren et al. 2006).

Marking and data collection.—We used hot branding to permanently mark individuals. Hot branding and freeze branding are the only 2 marking methods that ensure long-term identification of pinnipeds in the field (McMahon et al. 2006a; Merrick et al. 1996). Nearly all pups born during each breeding season from 1980 to 1984 were marked using a unique combination of letters, numbers, or both (Table 1). Individuals were captured only from reproductive areas A and B because area C was occupied exclusively by subadult and adult males during these years. The handling and marking methods followed guidelines approved by the American Society of Mammalogists (Gannon et al. 2007). Although its invasive nature has been highly criticized (Dalton 2005), other studies of pinnipeds have demonstrated that hot branding does not have a negative impact on individual survival, reproductive rates, or behavior (McMahon et al. 2006b; Mellish et al. 2007; Van Den Hoff et al. 2004).

We visited the colony 2 or 3 times during each reproductive season (June–August) between 1980 and 2006, with the exception that in 1987, 1988, and 1990 the colony was not visited. Visits to the colony lasted between 6 and 8 days, with 6–8 continuous hours of observation each day. During each visit, we circumnavigated the colony 3 times per day by boat and on foot, using 10×42-power binoculars to search for branded individuals. For each resighting of marked individuals, we recorded the date, sex, and brand code.

Apparent survival and resighting probabilities.—We constructed an annual release–resighting history for each marked individual using the 5 marking events (releases) in 1980–1984 and the resighting data obtained during the breeding seasons from 1981 to 2006. Multiple sightings of the same individual during the same breeding season were grouped into a single

TABLE 2.—The 13 proposed models examined for apparent survival rate (φ) of 5 pup cohorts (1980–1984) of California sea lions on Los Islotes during 1980–2006. In some models, sex effect was limited to nonpups (>1 year old) or adults (5+ years old). Age at resighting was grouped into 4 age-classes (0, 1–4, 5–9, 10+), 3 age-classes (0, 1–4 , 5+), or 2 age-classes (0, 1+). The sex/age-class interaction was limited to ranges of ages for the sex effect. The pup/time effect allowed for different survival rates for each of the 5 pup cohorts in their 1st year. Time and juvenile/time were restricted to blocks of time during which the years 1986–1990 were combined because of missing effort. The juvenile/time effect was extended to 1988 because all marked sea lions were adults as of 1989.

Model	No. parameters	Intercept	Sex	Age-class	Sex/age-class	Time	Pup/time	Juvenile/time
1	1	Yes						
2	2	Yes	Yes					
3	4	Yes		4				
4	5	Yes	Yes	4				
5	8	Yes	Yes	4	Yes			
6	25	Yes	Yes	4		Yes		
7	28	Yes	Yes	4	Yes	Yes		
8	8	Yes		4			Yes	
9	7	Yes	Yes 1+	2	Yes		Yes	
10	8	Yes	Yes 5+	3	Yes		Yes	
11	9	Yes	Yes 1+	4			Yes	
12	9	Yes	Yes 5+	4			Yes	
13	13	Yes	Yes 1+	4			Yes	Yes

resighting event (i.e., present or absent that year). Resighting probability for the 3 years with no visits to the colony (1987, 1988, and 1990) were fixed at 0 for all models. Our sample size was too small to provide estimates for individual ages from 0 to 26, so we used age-classes based on the biology of the species (Aurioles-Gamboa and Zavala-González 1994; Melin 2002). We classified individuals that were resighted each year into 4 age-classes: pups (<1 year old), juveniles (1–4 years old), young adults (5–9 years old), and old adults (10+ years old).

We used the RMark interface (Laake and Rexstad 2007) to develop a sequence of Cormack–Jolly–Seber models (Lebreton et al. 1992) that were fitted with MARK (White and Burnham 1999) to estimate apparent survival probability (φ) and recapture (resight) probability (p). We considered 13 models for φ (Table 2) and 8 models for p (Table 3) with various

TABLE 3.—The 8 proposed models examined for resighting probability (p) of 5 pup cohorts (1980–1984) of California sea lions on Los Islotes during 1980–2006. Age was grouped into 3 age-classes (1, 2–5, 6+), which corresponds to age at resighting of the survival age-classes (0, 1–4, 5–9, 10+) with a single adult class. Age also was grouped into 2 age-classes (1–5, 6+), and sex effect was limited to adults (6+) in some models. The sex/age-class interaction was limited to ranges of ages for the sex effect. In all models, p was set to 0 for those years in which there were no visits to the colony (1987, 1988, and 1990).

Model	No. parameters	Intercept	Time	Sex	Age-class	Sex/age-class
1	1	Yes				
2	23	Yes	Yes			
3	25	Yes	Yes		3	
4	24	Yes	Yes	Yes		
5	26	Yes	Yes	Yes 6+	2	Yes
6	25	Yes	Yes	Yes 6+	3	
7	26	Yes	Yes	Yes	3	
8	28	Yes	Yes	Yes	3	Yes

combinations of age-class, sex, and time effects and their interactions. We predicted that survival would most likely vary with time for pups and juveniles because of their greater vulnerability to environmental stochasticity (Jorgenson et al. 1997). We also predicted that survival would vary with age and sex, and that age variation might differ between the sexes (age–sex interaction). Age and sex variation in life-history patterns have been noted in other polygynous mammals (Ralls et al. 1980). We expected that resighting probability at the breeding colony would be related to age and sex because most of the resighting occurred during the breeding season. Resighting probability should vary with time (year) because of variation in survey effort between years and other unknown environmental variables (e.g., weather), so most of the models for p included a time effect. However, we assumed that the effect of time on resighting probabilities was additive across the sex- and age-classes because of the gaps in the survey effort and because there was very little overlap of age-classes across time.

We fitted each pair of φ and p models, which provided a candidate set of 104 (8 × 13) models. We selected the most-parsimonious models using small-sample Akaike information criterion (AIC$_c$—Burnham and Anderson 2002). Differences in AIC$_c$ (ΔAIC$_c$) were used to determine the level of support for each model. We also computed Akaike weights (ω; relative likelihood of the model given the data). Models with ΔAIC$_c$ < 2 and the highest ω values are considered to have substantial support. Models with ΔAIC$_c$ = 4–7 are considered to have less support but still explain some variation in the data (Burnham and Anderson 2002). Using the ω values for the top 30 models (99.99% weight), RMark was used to compute model-averaged estimates, standard errors, and confidence intervals for the parameters.

We used the program RELEASE to test the goodness-of-fit (Lebreton et al. 1992), and estimate overdispersion ($\hat{c}$) for the most-general model ($\varphi_{age \times sex \times time} p_{age \times sex \times time}$) by splitting the data into 10 groups: 5 female and 5 male cohorts.

TABLE 4.—Model selection results showing the 10 best Cormack–Jolly–Seber models for release–resighting of 190 California sea lions marked as pups in cohorts from 1980 to 1984 and resighted for 23 years during 1981–2006. Numbers in parentheses for survival probability (φ) relate to the model number in Table 2, and for resighting probability (p) relate to the model number in Table 3.

Model	K	AIC_c	ΔAIC_c	Weight (ω)	Deviance
φ (12) p (7)	35	1,806.9	0.00	0.31	914.4
φ (12) p (3)	34	1,807.0	0.03	0.31	916.6
φ (12) p (6)	35	1,807.4	0.51	0.24	914.9
φ (12) p (8)	37	1,811.1	4.16	0.04	914.2
φ (11) p (3)	34	1,812.2	5.23	0.02	921.8
φ (11) p (7)	35	1,813.1	6.17	0.01	920.6
φ (11) p (6)	35	1,813.3	6.32	0.01	920.7
φ (13) p (3)	38	1,813.9	6.93	0.01	914.8
φ (13) p (7)	39	1,814.7	7.78	0.01	913.4
φ (13) p (6)	39	1,814.9	8.00	0.01	913.6

RESULTS

Model selection.—The most general model fit the data, and there was no evidence of overdispersion ($\hat{c} = 0.70$), so we did not adjust the AIC_c values.

The top 10 models accounted for 97% of the model weight, whereas the top 3 models accounted for 86% of the model weight (Table 4). Although no single model was clearly superior, all of the models with any appreciable weight were based on the same model for survival. In this model, survival of pups varied across time, the effect of sex was limited to adults (5+ years old), and age was grouped into 4 age-classes. The primary source of model uncertainty involved p. The top 3 models only differed in the manner in which p varied for males and females.

Survival probability (φ).—Although model uncertainty for survival was minimal, the model-averaged estimates of φ (Table 5) incorporate variation that results from different models for p. Survival of pups varied across time, with nearly a 2-fold difference between the years with the lowest (0.556) and highest (0.998) probabilities. There was very little evidence that survival of juveniles varied over time. Survival differed across age-classes: pups (<1 year old) and old adult (10+ years old) males had the lowest average survival rate, whereas young adult (5–9 years old) females had the highest average survival rate (Table 5). The average survival rates for juvenile males did not differ from that for juvenile females, but adult (5+ years old) males had lower survival rates than adult females.

Resighting probability (p).—Model uncertainty was greater for p but the uncertainty was included in the model-averaged estimates (Table 6). Resighting probability varied clearly with time and age, with a lower p for younger individuals. However, differences between males and females were less clear (Table 6). Pups had higher resighting rates as yearlings than juveniles, and juveniles were less likely to be resighted than adults within the same year (Table 6). Females generally had higher resighting rates than males (Table 6). The estimated p-values were higher in general during the 1990s, but all marked sea lions were adults so it is not possible to discern whether the

TABLE 5.—Model-averaged estimates of age-specific survival probabilities (φ) for male and female California sea lions at Los Islotes. The age-classes used are: pups (<1 year old), juveniles (1–4 years old), young adult (5–9 years old), and old adult (10+ years old).

	Males			Females		
	φ	SE	95% confidence interval	φ	SE	95% confidence interval
Pups						
1980	0.652	0.108	0.424, 0.826	0.653	0.109	0.423, 0.829
1981	0.556	0.087	0.386, 0.714	0.558	0.088	0.385, 0.717
1982	0.826	0.074	0.634, 0.929	0.828	0.073	0.639, 0.929
1983	0.727	0.076	0.556, 0.850	0.728	0.077	0.557, 0.852
1984	0.997	0.007	0.792, 1.000	0.998	0.005	0.818, 1.000
Juveniles	0.900	0.025	0.839, 0.939	0.904	0.023	0.848, 0.941
Young adults	0.904	0.029	0.830, 0.948	0.970	0.013	0.933, 0.986
Old adults	0.746	0.044	0.651, 0.823	0.909	0.015	0.874, 0.935

difference was related to age or time. For 2000 to 2005, p was correctly estimated at the boundary of 1. All of the sea lions that were resighted after each of these years (survived and observed) also were observed in the previous years during that period. This result is most likely due to the small sample size, adequate survey effort, and the fidelity of sea lions to the breeding colony in older age-classes.

DISCUSSION

Survival probability (φ) and resighting probability (p).—This study represents the 1st report of age- and sex-specific survival rates for wild California sea lions. As we expected, survival differed for males and females and varied with age. Pups had the lowest survival rate and were the only age-class to demonstrate variation over time. Although we were unable to describe the complete age-specific survival pattern for the California sea lion with our small sample, our results provide valuable insights into understanding the life history of this species. In particular, we found that the survival pattern for California sea lions was consistent with the age- and sex-specific pattern described for other large mammals. The typical mammalian survival pattern is characterized by low survival rates in young and old age-classes, and more variation in survival of young compared to adults (Caughley 1966; Gaillard et al. 1997).

As expected, survival of California sea lion pups varied considerably over time. The cohorts 1980 and 1981 had the lowest survival rate. Young individuals are more susceptible to stress induced by environmental variability and population density (Pistorius et al. 1999). Studies of California sea lions in the California Channel Islands have demonstrated that under conditions of limited food resources (i.e., El Niño years), the energy transferred from females to pups is reduced and, eventually, survival declines (Boness et al. 1991; DeLong et al. 1991; Francis and Heath 1991). However, we found that individuals who were born during or after the 1982–1983 El Niño event (i.e., the 1982–1984 cohorts) exhibited the highest survival rates, confirming previous reports that El Niño events had inconsistent effects on mortality of pups, maternal

TABLE 6.—Model averaged resighting probabilities (p) for male and female California sea lions at Los Islotes. Pups were observed as yearlings of 1 year old, juveniles from 1 to 4 years old were observed at ages 2–5 years old, and the adult age-class was observed at ages 6+ years old. Values in parentheses represent the standard error.

	Males			Females		
Year	Yearling	Juvenile	Adult	Yearling	Juvenile	Adult
1981	0.483 (0.131)			0.507 (0.133)		
1982	0.892 (0.051)	0.704 (0.107)		0.901 (0.047)	0.723 (0.103)	
1983	0.806 (0.058)	0.545 (0.084)		0.820 (0.054)	0.568 (0.083)	
1984	0.706 (0.067)	0.409 (0.066)		0.725 (0.062)	0.432 (0.066)	
1985	0.582 (0.068)	0.286 (0.051)		0.604 (0.064)	0.306 (0.051)	
1986		0.190 (0.041)	0.195 (0.071)		0.205 (0.042)	0.226 (0.079)
1989		0.395 (0.084)	0.403 (0.073)		0.418 (0.084)	0.449 (0.073)
1991			0.155 (0.045)			0.181 (0.047)
1992			0.383 (0.068)			0.428 (0.063)
1993			0.663 (0.071)			0.704 (0.060)
1994			0.895 (0.046)			0.912 (0.038)
1995			0.297 (0.070)			0.338 (0.066)
1996			0.954 (0.033)			0.961 (0.027)
1997			0.935 (0.045)			0.946 (0.037)
1998			0.904 (0.065)			0.920 (0.053)
1999			0.809 (0.090)			0.837 (0.073)
2000			1.000 (0.000)			1.000 (0.000)
2001			1.000 (0.000)			1.000 (0.000)
2002			1.000 (0.000)			1.000 (0.000)
2003			1.000 (0.000)			1.000 (0.000)
2004			1.000 (0.000)			1.000 (0.000)
2005			1.000 (0.000)			1.000 (0.000)
2006			0.546 (0.165)			0.592 (0.152)

attendance, and feeding habits (Aurioles-Gamboa and Le Boeuf 1991; García-Aguilar and Aurioles-Gamboa 2003a). Other studies on various marine fauna in the Gulf of California also have reported that the impact of El Niño on those populations is insignificant (Álvarez-Borrego and Lara-Lara 1991; Lluch-Cota et al. 2007). Thus, temporal variation in survival rates of pups may be associated with other factors, such as annual variability in local environmental conditions or genetic variation (Acevedo-Whitehouse et al. 2006; Coltman et al. 1998).

Low survival rates for mammals in old age-classes have generally been attributed to senescence (Promislow 1991). However, this explanation is not well supported by empirical data because it is based on small sample sizes (as are frequently found in older age-classes) and on life-history parameters derived from transversal life tables (Gaillard et al. 1994). Because of our small sample size, we cannot yet draw conclusions about the potential effect of senescence on survival rates; however, it should be noted that survival estimates were relatively high in older age-classes (>0.7). Similar estimates have been reported for other pinnipeds where senescence likely does not affect vital parameters (Pistorius and Bester 2002). Survival rates reported in the present study are high and similar to those reported for other large mammals (Boyd et al. 1995; Gaillard et al. 1993; Jorgenson et al. 1997). These results are not surprising considering that our study was conducted during a period of a steady increase in population size and pup production at the Los Islotes colony (Szteren et al. 2006). Females from Los Islotes not only have high survival rates (~0.90) but also high reproductive rates (0.50–0.80—Hernández-Camacho et al., in press). In other

mammals, high survival rates of females have been associated with high population growth rates (Pistorius et al. 2004).

Our best models supported the prediction that adult females should have higher survival rates than adult males. In this study, the maximum observed lifespan was 19 years for males and 25 years for females. Sexual selection on males favors morphological traits and behaviors that confer short-term reproductive advantages (Selander 1965). However, these exaggerated reproductive investments in males may negatively impact long-term survival because of their higher growth rates and metabolic activity, leading to increased susceptibility to nutritional stress and diseases; intrasexual competition for mates or resources that increases risk of death by infections and diseases provoked by physical debilitation; and the tendency to disperse, which exposes them to predation, diseases, and nutritional stress (Clinton and Le Boeuf 1993; Ralls et al. 1980).

The lack of certainty in model selection regarding the effect of sex on p may be due to the manner in which the resighting surveys were conducted. At Los Islotes, adult females go on foraging trips lasting 2.05 ± 0.87 days followed by nursing visits lasting 1.22 ± 1.33 days (García-Aguilar and Aurioles-Gamboa 2003a); thus, females should visit the colony and be resighted every 2–4 days. Most adult females are present at the colony during the breeding season, so we expected that adult females would have the highest resighting rates. Information on movements of adult males during the breeding season is lacking, but breeding-age males should have lower resighting rates than females because only a small proportion of them defend territorial areas during the breeding season. Subadult

males usually occupy bachelor areas in close proximity to territories, but the duration and frequency of their foraging trips is unknown (Odell 1975). We visited both territorial and bachelor areas during our resighting trips to increase our chances of resighting marked sea lions that were not breeding and to reduce heterogeneity in sighting probabilities of adult males.

Model assumptions.—Our analysis was based on the following assumptions for age-dependent models: every animal in a specific age- and sex-class had the same probability of surviving and being resighted, all emigration was permanent, brands were legible and correctly recorded during the study period, branding did not compromise survival, and all animals were correctly aged (Pollock et al. 1990). All of these assumptions were reasonable for our study. Hot brands were legible throughout the study period. Approximately 18% of the marks suffered minor distortion, but codes were still legible (Hernández-Camacho 2001). A preliminary analysis of our mark-recapture data revealed that more than 90% of marked pups survived the first 6 months of life, a survival rate that was comparable to that of nonmarked pups during the same period (Aurioles-Gamboa and Sinsel 1988). Individuals were marked during the breeding season in which they were born and we used unique identification codes for each animal and cohort, assuring that individuals were correctly aged.

Strictly speaking, we can only estimate apparent survival including losses due to permanent emigration. However, anecdotal evidence suggests that permanent emigration is rare. During 1980–2006 we completed annual censuses that included visits (lasting <4 h) to other sea lion colonies in the Gulf of California. During these censuses we only observed 3 branded sea lions outside of Los Islotes: two 1-year-old juveniles and one 5-year-old adult female. Both juveniles were resighted as adult animals at Los Islotes in subsequent reproductive seasons. In most mammals, juveniles tend to disperse more than adults (Greenwood 1984; Handley and Perrin 2007), which may explain why juveniles had the lowest resighting rate.

The survival estimates presented here provide practical insight into understanding of age- and sex-specific survival rates for sea lion colonies exhibiting similar population trends to those exhibited at Los Islotes during our study period. Estimating vital rates for other colonies in the Gulf of California and other parts of the range of California sea lions requires long-term mark–recapture studies of individuals of known age. Given that California sea lions do not appear to exhibit extreme plasticity in life-history parameters, it is likely that our estimates apply to other populations of California sea lions in the Gulf of California and Pacific. However, in the absence of long-term marking data for these areas, vital rates could be estimated for other colonies using stationary life tables or inverse methods based on age-structured abundance data (e.g., Holmes and York 2003; Wielgus et al. 2007). Comparing our results to survival estimates for colonies where only abundance data are available may improve our understanding of the strengths and weaknesses of estimates obtained using different methods.

RESUMEN

La población de lobo marino de California (*Zalophus californianus*) en el Golfo de California ha disminuido un 20% en las últimas 2 décadas. La falta de datos sobre parámetros de historia de vida para ésta especie ha limitado el desarrollo de modelos demográficos que permitan valorar el estado de esa población. En el presente estudio, se estimaron las probabilidades de supervivencia por edad y sexo de lobos marinos de California, utilizando datos de reavistamientos de 5 generaciones de crías obtenidos desde 1981 hasta el 2006. Se modeló la probabilidad de supervivencia aparente y la probabilidad de reavistar a los animales utilizando clases de edad, sexo, y año de observación como potenciales variables explicativas. Las tasas de supervivencia aparente variaron por clases de edad y sexo. Solo la supervivencia de las crías varió por año (de 0.556 a 0.998). La tasa de supervivencia fue la misma para juveniles de ambos sexos (0.90), pero varió por sexo en adultos jóvenes (machos = 0.90, hembras = 0.97) y adultos mayores (machos = 0.75, hembras = 0.91). La probabilidad de reavistamiento varió según el año de observación, la clase de edad y el sexo. Las probabilidades de reavistamiento fueron mayores para hembras que para machos y los juveniles presentaron la probabilidad más baja. Las estimaciones de supervivencia presentadas en este estudio permiten entender los patrones de supervivencia por edad y sexo en el lobo marino de California.

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