

Short Note

Potential California Sea Lion (*Zalophus californianus*) Parturitions After the Pupping Season

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We present data that suggest some California sea lion (*Zalophus californianus*) females gave birth after the pupping season (June-July) in colonies on the west coast of the Baja California Peninsula and in the Gulf of California, Mexico. In June and July of 2010, we captured and tagged pups to estimate their growth rates during their first year of life on Santa Margarita Island (Figure 1). We returned to the colony in November 2010 and February 2011 to capture and weigh the tagged pups, as well as additional untagged pups. Surprisingly, among the newly captured pups, we found pups of similar weight and size to pups captured in July 2010 (pupping season). When we applied the estimated growth rates for U.S. colonies in retrospect, we determined that the pups captured in November 2010 must have been born between August and September of the same year, while the pups captured in February 2011 must have been born between October and November 2010. Another opportunistic observation was obtained in November 2019, when we sighted an apparently pregnant adult female at the Los Islotes colony. This is the first report on births after the pupping season in any pinniped.

The reproductive cycle of pinnipeds is usually synchronous and annual. It progresses from copulation to gestation to birth to lactation (Boyd, 1991; Greig et al., 2007). Adult female pinnipeds enter estrus just after parturition, and copulations occur between the end of June and the beginning of August (Boyd, 1991). Gestation occurs in two stages: (1) embryonic diapause and (2) active gestation. Embryonic diapause begins just after fertilization; during this stage, the blastocyst develops at a very slow rate, which allows synchronization among females in the timing of parturition (Boyd, 1991; Pomeroy, 2011). In late September and

early October, once the blastocyst is implanted, active gestation begins. It lasts approximately 9 mo (Colegrove et al., 2009). The synchronization is regulated by the photoperiod through effects on pineal gland secretion (Boyd, 1991; Temte, 1985, 1994). Synchronization of births is critical as it ensures that pups are born when environmental conditions are most favorable and that females will have enough to feed on, therefore enabling successful lactation (Wingfield & Kenagy, 1991; Pitcher et al., 2001).

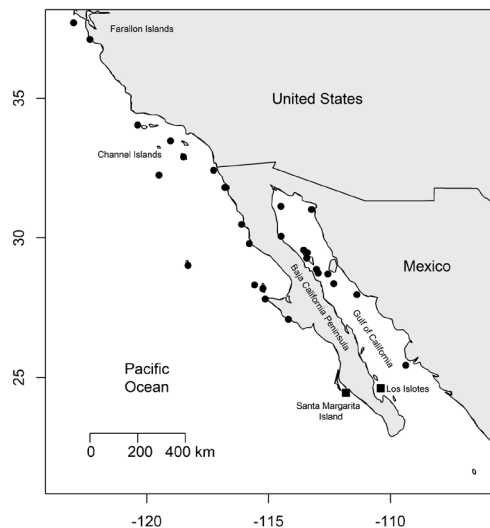


Figure 1. Location of California sea lion (*Zalophus californianus*) breeding colonies (black dots). Colonies where apparent newborns were observed after the breeding season are indicated with black squares.

The California sea lion is a polygynous, annually breeding species with a highly synchronized reproductive season. This species breeds from the Farallon Islands in the United States to the Marías Islands and the Gulf of California in Mexico (Bartholomew & Boolootian, 1960; Lowry & Forney, 2005; Lowry et al., 2017; Figure 1). The breeding season occurs in the summer (June to August) in both the U.S. and Mexican populations when upwellings intensify and the abundance of their primary prey items like Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) increase (Lluch-Belda et al., 1991; Zaytsev et al., 2003; Fiechter et al., 2015). In the Channel Islands, California sea lion births begin between mid- and late May and occur over 6 wks (pupping season), with the peak of births in mid-June (Lowry et al., 2017; Laake et al., 2018). In Mexico, birth events in the colonies of the central Gulf of California begin in mid-May and end in early July (8 wks), with peaks during the first and third weeks of June; while in the southernmost colony of the gulf, Los Islotes, pupping season begins in late May and ends in mid-July, with a single peak in mid-June (García-Aguilar & Aurióles-Gamboa, 2003a). Estrus begins approximately 4 wks after parturition, and copulations are synchronized among females within the colony, occurring between the end of June and beginning of August (Heath, 1989; Boyd, 1991; García-Aguilar & Aurióles-Gamboa, 2003a).

Studies on reproduction, feeding habits, behavior, demography, and health in the California sea lion are generally carried out during the reproductive season when individuals of all ages and sex classes congregate in the colonies (Hernández-Camacho et al., 2021). However, in the summers of 2010 and 2019, we started a couple of projects that required us to visit the Santa Margarita Island and Los Islotes colonies during and after the breeding season (Figure 1). During the development of these studies, we obtained opportunistic data suggesting that some California sea lion pups were born after the breeding season.

In June and July of 2010, we visited the Santa Margarita Island breeding colony to capture and tag pups to estimate their growth rates during their first year of life. A total of 3,270 sea lions were counted of which 891 were pups. We tagged 59 pups on 19 June and 55 pups from 26 to 29 July. We recoded body length and weight for each pup captured, using a tape measure and a spring scale, respectively. Pups were given unique plastic flipper tags (Dalton ID Systems Jumbo Tags; Dalton Tags, Nottinghamshire, UK) for long-term identification. After tagging, we returned to the colony from 6 to 9 November in 2010 and from 17 to 21 February in 2011 to capture and weigh the tagged pups and additional untagged pups.

Surprisingly, when we weighed the newly captured untagged pups in November, we found that some were of similar weight and size to the pups we had captured and tagged in July. In February, we captured pups of similar weight and size to the largest pups captured in July and the smallest pups captured in November, suggesting that they were recently born (Figure 2; Table 1). The months of observation were periods during which the 2010-2011 El Niño event occurred. However, the smallest pups did not appear lethargic or extremely underweight as is typically the case for animals stranded along the coast of California during El Niño or other unusual mortality events (NOAA Fisheries, n.d.). The lightest pups were females.

One plausible explanation for why there were small pups in November 2010 and February 2011 is that they were born at the end of the 2010 pupping season. To test this hypothesis, we projected the expected weight of a female pup with an initial weight of 5 kg and a birth date of 25 July. If the pup's actual weight was substantially lower than her projected weight, this would suggest that she was born after the expected birth date. We chose a birth weight of 5 kg because this was the weight of a newborn (i.e., with the umbilical cord still attached) female pup found during the reproductive season in this colony. We chose a birth date of 25 July because it is the latest recorded date of births in a colony located at a similar latitude but within the Gulf of California (García-Aguilar & Aurióles-Gamboa, 2003a).

We used two previously reported growth rates to consider maximum and minimum reasonable growth rates (Ono et al., 1987). We used the growth rate calculated for U.S. sea lion breeding colonies in normal years (0.12 kg/d for females and 0.15 kg/d for males) for the upper bound. For the lower bound, we used a rate estimated during anomalous years with El Niño conditions (0.08 kg/d for females and 0.12 kg/d for males), which led to lower growth rates and higher mortality in California sea lion pups (Ono et al., 1987). We used growth rates from U.S. sea lion colonies because the same large-scale oceanographic phenomena (e.g., El Niño) influence the sea lion colonies on the Pacific coast of the Baja California Peninsula (Trillmich & Ono, 1991). Although some pup growth rates have been calculated in colonies in the Gulf of California, Mexico, these are higher than those reported in colonies in the U.S. and did not decrease during warming events (Luque & Aurióles-Gamboa, 2001; García-Aguilar & Aurióles-Gamboa, 2003b). Thus, using the growth rates estimated from U.S. colonies provided a more conservative estimate of minimum expected weight.

The expected weight ranges were 13.64 to 17.96 kg in November and 21.72 to 30.08 kg

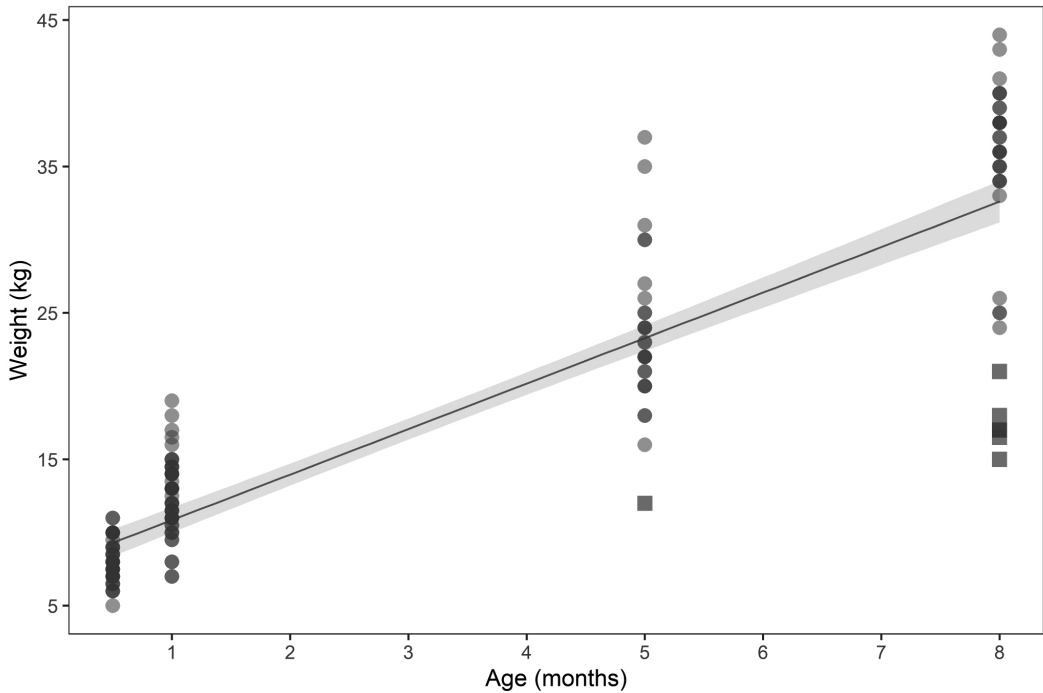


Figure 2. Relationship between weight and age of California sea lion pups in the Santa Margarita Island breeding colony between June 2010 and February 2011. Pups weighing less than expected are signified by black squares.

Table 1. California sea lion (*Zalophus californianus*) pup weights in Santa Margarita Island breeding colony (June 2010 to February 2011). Minimum expected weight (El Niño conditions) was estimated using 25 July as birth date, 5 kg as birth weight, and a growth rate of 0.08 kg/d. Maximum expected weight (normal environmental conditions) was estimated using 15 May as birth date, 9 kg as birth weight, and a growth rate of 0.15 kg/d.

Month	<i>n</i>	Mean weight (± SD)	Min. weight	Max. weight	Pups recaptured (<i>n</i>)	Expected weight (kg)		Lighter pups (<i>n</i>)	Heavier pups (<i>n</i>)
						Min.	Max.		
June	59	07.9 ± 1.3	5	11	--	5.0	13.5	--	--
July	55	12.4 ± 2.5	7	19	4	5.0	20.3	--	--
November	27	23.6 ± 5.5	12	37	2	13.6	35.9	1	1
February	37	32.3 ± 8.6	15	44	3	21.7	51.0	7	--

in February based on El Niño and normal year growth rates, respectively. The weights of our small pups both in November and February were below the estimated minimum weight. The weight of the smallest pup captured on 9 November was 12 kg; based on our projections, this animal would have been born on 12 September with a normal year growth rate and on 15 August with an El Niño year growth rate. The smallest female pup weighed 15 kg on 18 February. This female would have been born on 28 November or 17 October,

according to normal year and El Niño growth rates, respectively. Otherwise, if we assume that these pups were born during the reproductive season (25 July) and that they grew under unfavorable conditions (for which the growth rate would be 0.08 kg/d), their birth weights would have been 3.6 kg and 1.5 kg for pups captured in November and February, respectively. Thus, it is unlikely that these pups were born during the pupping season.

The heaviest pup captured in November was a male that weighed 37 kg on 6 November and

was, therefore, above the expected weight (13.6 to 35.9 kg; see Table 1). This male pup could have been born at the beginning of the reproductive season because the average weight of male newborns is greater than that of females (9.4 ± 0.35 kg for males and 7.7 ± 0.45 kg for females). Therefore, the weight of this pup was within the normal reported weight range for this species.

Further evidence of parturition following the reproductive season was obtained via an opportunistic observation of an apparently pregnant adult female at the Los Islotes breeding colony in November 2019 while we were conducting a study on the effect of tourist activity on the behavior of the California sea lions in that colony (Figure 3). While it is possible that this female's appearance was caused by a large abdominal or uterine tumor, she appeared to be in generally good health.

In light of these observations, we propose that certain females probably give birth some months after the usual reproductive season. Embryonic diapause could be prolonged in some adult females until they are in adequate physical and health conditions to initiate gestation. This would lead to late births and thus explain the observation of newborns in the fall season. It is also important to highlight

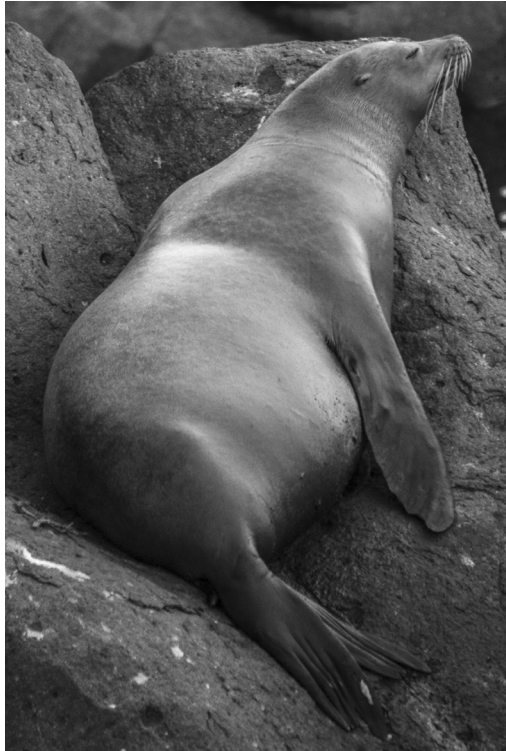


Figure 3. Adult female California sea lion observed on October 2019 at the Los Islotes breeding colony.

that the years of observation were periods where moderate and weak El Niño events occurred (2009-2010 and 2018-2019), which could influence the reproductive cycle of this species (NOAA Physical Sciences Laboratory, n.d.).

The duration of embryonic diapause in several species of otariids is regulated by the body condition and health of adult females, which are reflections of the conditions in their environment in addition to photoperiod (Pitcher et al., 2001; Villegas-Amtmann et al., 2009). For example, in the Australian sea lion (*Neophoca cinerea*), embryonic diapause has been reported to last from 3 to 5 mo (Gales et al., 1997). It has also been observed in the Antarctic fur seal (*Arctocephalus gazella*) that gestation was longer during years when environmental conditions were unfavorable (Boyd, 1996). It is possible that what we observed in our study reflects environmental variability throughout the reproductive cycle, which delayed the beginning of gestation.

Another factor that can affect the reproductive cycle and that potentially could influence the duration of embryonic diapause is the presence of neurotoxins (domoic acid), produced by marine algae (*Pseudonitzschia australis*), in the environment. Adult female California sea lions ingest neurotoxins through their diet, causing toxicosis, abortions, and premature births (Trillmich & Ono, 1991; Goldstein et al., 2009). The ingestion of this neurotoxin has caused massive strandings of pregnant females in this species for decades (Brodie et al., 2006; de la Riva et al., 2009; Bargu et al., 2010). Other causes of massive strandings in this species are leptospirosis, trauma, cancer, and malnutrition. Strandings caused by malnutrition were greatest during the El Niño events due to prey shifts (Greig et al., 2005). Anthropogenic impacts have not been considered until now as a factor that influences the reproductive rates or any other aspect of the reproductive cycle of this pinniped (French et al., 2011).

Our results are preliminary, and more studies are needed to determine whether this species' reproductive cycle is less synchronized than previously thought, as well as to examine the potential influence of significant ecosystem changes. We propose visits to different colonies throughout the distribution of this species after the breeding season, both in normal years and El Niño years, to observe the animals' behavior. The clearest way to determine whether there are births after the typical breeding season is to observe births and/or to observe pups that are irrefutable newborns (i.e., with the umbilical cord still attached) during the fall. In the case that late-born pups are detected, they should be captured to be weighed, measured, and marked. Systematic clinical analyses should be performed to determine how late birth influences survival and the duration of lactation.

Acknowledgments

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