Chapter 8
Galápagos Sea Lion (*Zalophus wollebaeki*, Sivertsen 1953)

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Abstract The Galápagos sea lion (GSL, *Zalophus wollebaeki*) is the smallest sea lion species in the world, endemic to the Galápagos archipelago and formerly considered a subspecies of the California sea lion (*Zalophus californianus*). Breeding rookeries occur throughout the archipelago. Females are highly site faithful; hence genetic exchange between rookeries occurs predominantly through male dispersal. Females start their reproductive career rather late at a mean age of 6 years, give birth to a single pup, and nurse it unusually long for between 2 and 4 years. If a female bears another pup during lactation, the newborn's survival is seriously reduced. The extended period of maternal care lowers the reproductive rate to around 0.4 pups per adult female per year. Moreover, in years of strong El Niño events, pup mortality increases, and even older animals commonly die of starvation. Pups show distinct personalities such as shy and bold within their early social environment, thus shaping how they explore new situations and habitats. Once independent, diving strategies can also consistently differ between individuals: some forage via shallow dives, whereas others dive deep and/or mostly at night. Over the last 15 years, survival rates across all age classes have decreased in one important rookery located in the center of the species' distribution. Recent demographic models in the Caamaño rookery predict substantial population decrease in the coming years, likely to be further exacerbated by increasing sea surface temperatures due to global warming and more frequent El Niño events. Low abundance within a small distribution area makes the GSL vulnerable to a combination of anthropogenic and stochastic envi-

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ronmental disturbances. Fishery interactions, pressures from increased tourism, and habitat intrusion along with the potential for introduction of diseases are presently great dangers which may pose a serious threat to this endangered species.

Keywords El Niño · Foraging strategy · Life history · Population dynamics · Vital rates

Morphology and Systematic Position

The Galápagos sea lion (GSL, *Zalophus wollebaeki*, Fig. 8.1) is the smallest sea lion species in the world. Adult males have been accurately weighed up to 158 kg and had body lengths up to 2.05 m. Maximum male mass and body length are estimated to be in the range of 200 kg and 2.1 m (Trillmich et al. 2014). Males have dark brown fur and develop a prominent sagittal crest when fully mature. Adult females are smaller and attain body lengths of 1.56–1.76 m and an average body mass of 60 kg with maximum body mass of around 95 kg (Trillmich et al. 2014). Their fur is generally lighter and more tan compared with adult males. Pups are born with a body weight of around 6 kg, with males already being heavier (6.7 kg) than females (5.8 kg, Kraus et al. 2013). The lanugo of pups is dark brown or black, and the molt starts by about 3 months of age and lasts to about 5 months. The resulting sexual dimorphism ratio in adult body weight of 2.6 is considerably smaller than in the sister species, the California sea lion (3.3, Krüger et al. 2014).

Taxonomic and phylogenetic analyses agree that the species is most closely related to the California sea lion (*Zalophus californianus*; Higdon et al. 2007; Wolf et al. 2007b), and indeed it had been considered a subspecies of the California sea lion until only recently (Wolf et al. 2007b). The separation date of the two species has been estimated from less than 1 million to around 2.3 million years ago (Wolf et al. 2007b; Schramm et al. 2009).

Distribution

The GSL is endemic to the Galápagos Islands and is distributed throughout the archipelago, settling its largest rookeries in the islands of the southeastern region (Trillmich 2015; Riofrío-Lazo et al. 2017) (Fig. 8.2), where waters are shallower and conditions are less cold than in the western parts. This species is highly gregarious, settling on islands, islets, and sites protected from predators. Thus, it is a non-migratory otariid, with vagrants recorded along the coasts of Mexico, Colombia, and Ecuador (Capella et al. 2002; Ceballos et al. 2010).

Females show very high natal philopatry, i.e., they almost always recruit into those rookeries where they were born (Wolf and Trillmich 2007, 2008; Wolf et al.

Fig. 8.1 Adult male Galápagos sea lion amidst females (top panel), adult female, and her pup establishing olfactory recognition shortly after birth (middle panel) and pups of about 1 month of age (bottom panel)

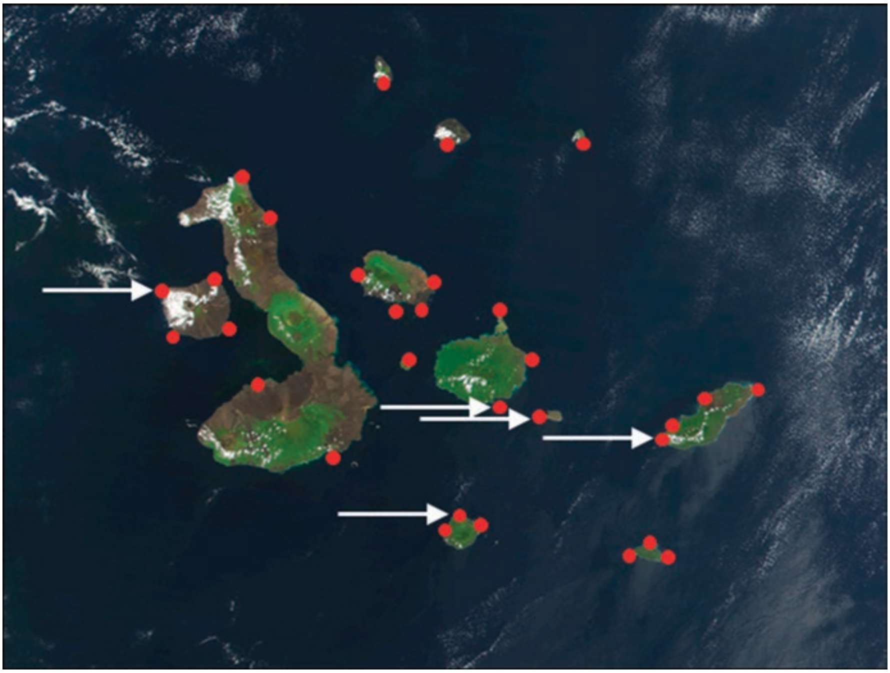


Fig. 8.2 Distribution of the Galápagos sea lion across the archipelago. Red circles show the approximate locations of the breeding colonies, and white arrows indicate which colonies have been scientifically investigated in detail. (Modified after Paez-Rosas, 2018)

2007a). This should lead to strong population structuring of matrilineal genetic markers, whereby most colonies, even if separated by a few kilometers, should be genetically distinguishable from another. However, detectable genetic differentiation of mitochondrial DNA was found mainly between central and western rookeries (Wolf et al. 2008). The largest breeding rookeries are found on San Cristóbal, Española, and Floreana islands (Fig. 8.2), which together harbor about half of the total population. Unusually for pinnipeds, the El Malecón rookery, at San Cristobal Island, is the largest in the archipelago and is located right in the town center of Puerto Baquerizo Moreno (Fig. 8.2). In this rookery, an increase of 2% per year has been observed from 2005 to 2015 (Riofrío-Lazo et al. 2017). However, despite this small increase, this rookery may still be affected by anthropogenic disturbances (Páez-Rosas and Guevara 2017).

GSL prefer to haul out on sandy beaches without large boulders but still require the opportunity to rest protected from the intense solar radiation of an equatorial habitat (Montero-Serra et al. 2014). Only a narrow fringe of coastline is useful as resting habitat, since most animals need access to water or at least shade at the hottest time of the day for thermoregulation (Wolf et al. 2005).

The Environment

The habitat of GSL consists of an area of the eastern tropical Pacific, the Galápagos archipelago. It has been described in detail in Chap. 3 about the Galápagos fur seal. In summary, the Galápagos archipelago is an unusually cold, productive marine environment right on the equator (Fernández-Álamo and Färber-Lorda 2006; Pennington et al. 2006). This results in rich marine life with species originating both from the tropics and from much more temperate regions, as is the case for both pinniped species of the archipelago. In addition, there is a profound seasonality with reduced cold upwelling resulting in relatively warm sea surface temperatures (SST) between December and April and a colder season with lower SST between May and November. This seasonality can be massively perturbed during an El Niño event, when warming continues over several months and SST increase significantly. As a result, the thermocline is depressed often several tens of meters, making prey much less accessible to sea lions. Consequences can be devastating for marine life (Arntz et al. 1991; Robinson and del Pino 1985; Trillmich and Limberger 1985; Trillmich and Dellinger 1991). If the intensity and duration of El Niño events will increase due to climate change (as seems likely, Cai et al. 2014, but see Collins et al. 2010), this could endanger the survival of both pinniped species which have already declined, most likely due to the recurrent El Niño events over the last three decades (Alava and Salazar 2006; Trillmich 2015; Trillmich et al. 2016, Riofrio-Lazo et al. 2017). On the positive side, El Niño events are often followed by La Niña (Timmermann et al. 1999) or unusually cold conditions when the thermocline gets close to the surface and marine productivity is increased, allowing marine life to recover.

Population Dynamics

In 1978, the GSL population was estimated to a number of about 40,000 individuals (Trillmich 1979). This estimate was based on a nearly complete survey of the coastlines of all Galápagos Islands conducted by observers onshore and in boats nearshore. This resulted in an actual count of 9093 individuals. The number counted was subsequently adjusted to account for missed animals or those not onshore at the time of the counts. In November 2001, 7942 sea lions were counted at known haulouts and colonies (Alava and Salazar 2006). By correcting for the probability that animals could be seen at a distance, total abundance was estimated to be 14–16,000. The corresponding number of mature individuals was likely about 26,400 in 1978 and 9200–10,600 in 2001, which indicates a substantial reduction of about 60–65% in population size. Census data from Caamaño rookery in the center of the archipelago, covering the years from 2003 to 2015 (Fig. 8.3), showed no significant trend in the total number of sea lions counted (mean ± SD, 244 ± 63) nor in the number of pups born (mean 103 ± 34.7), but substantial fluctuations around the mean

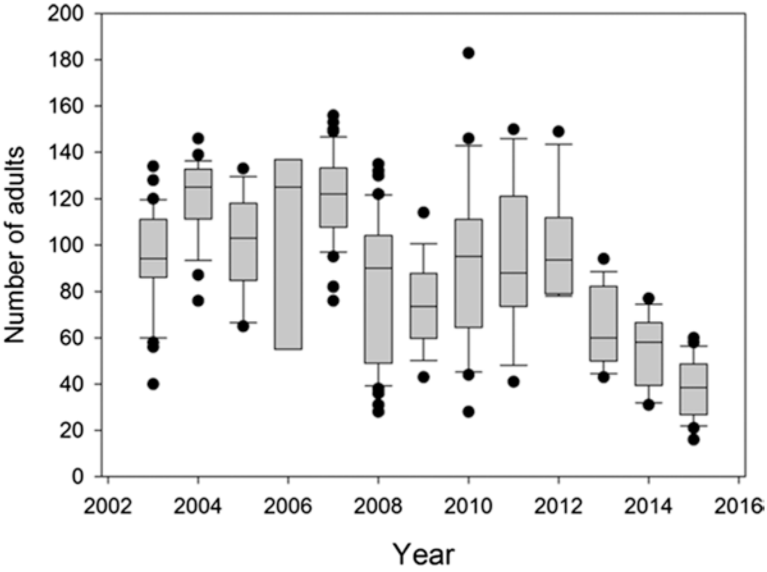


Fig. 8.3 Year-to-year cold-reproductive season variability in a total number of adults counted ashore. Boxes give medians and quartile ranges, barbs 10–90% ranges, dots indicate outliers. (Modified after Trillmich et al. 2016)

(Trillmich et al. 2016). This variability suggests that single counts as represented by the 1978 and 2001 census may be misleading about trends in total sea lion numbers.

The available data suggest that the GSL population declined greatly between 1978 and 2001 and further suggest that it has not recovered since then. If the number of adults in 2020 is still about 9,200–10,600, that would be a reduction of 60–65% in 40 years (four generations). Assuming an exponential decline pattern between 1978 and 2001 (with an annual decline of 3.9%), and a relatively stable population from 2001–2020, this would still represent a reduction of >50% (49–54%) over the last four generations (1984–2020). Recent results from population modeling of the Caamaño breeding rookery confirm that this population at least is most likely undergoing a severe decline (see *demography*). The causes of the reduction are partly understood (reduced survival rate), have not ceased, and may not be easily reversible. Recent global census data suggest the population at present comprises about 17,000 animals (Páez-Rosas et al. unpublished data). It may be worth to consider the historical long-term development of the population as well. Microsatellite data do not show strong evidence of a recent bottleneck, and no particularly low allelic richness or other measures of genetic diversity (Stoffel et al. 2018).

Foraging Behavior and Diet

The transition toward independent foraging starts late and is exceptionally slow compared to other pinnipeds, likely a consequence of the slow growth and development of physiological diving abilities found in this species (Mueller et al. 2011; Trillmich et al. 2008). Galápagos sea lion pups are terrestrial at birth and start swimming in shallow open water at around 2–3 months. Pups exhibit substantial individual variation in behavior that is both consistent and repeatable; hence they exhibit so-called personalities (Fig. 8.4, DeRango et al. 2019). Early differences in boldness and exploration may translate to pups utilizing their terrestrial habitat differently based on their personality type. Substantial diving activity starts at approximately 12 months of age, when juveniles dive on average to depths of 30 m and for 2.5 min (Jeglinski et al. 2012). Successful independent foraging supplementing continuing milk consumption seems to take place even later, on average at around 18 months. Diving performance increases with age and body mass, but 2-year-old juveniles still dive to only approximately 75% of the average diving depths of adult females (Jeglinski et al. 2012). Juvenile Galápagos sea lions therefore depend on average for the first 2 years of life on maternal input while slowly shifting from complete reliance on maternal milk to independent foraging, with profound differences between the sexes; females start independent foraging sooner than males (Fig. 8.5; Piedrahita et al. 2014). Development to independence varies considerably. Annual variation in marine productivity seems to cause differences between cohorts, but such cohort effects have been difficult to detect (Kalberer et al. 2018). During mild El Niño conditions, when food availability decreases, the onset of independent foraging was shifted beyond the age of 18 months (Jeglinski et al. 2012). Further, the onset of diving and independent foraging varies between

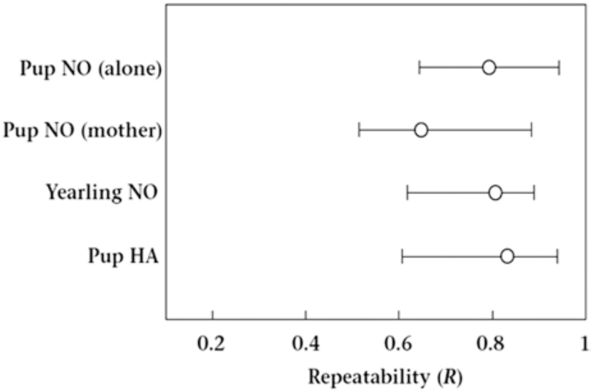


Fig. 8.4 Repeatability (R) of responses of GSL pups during seven trials of human approach (HA) tests and two trials of novel object (NO) tests during different scenarios: when alone, in the presence of their mother and again as a yearling. Error bars represent 95% confidence intervals calculated with parametric bootstrapping. After DeRango et al. (2019)

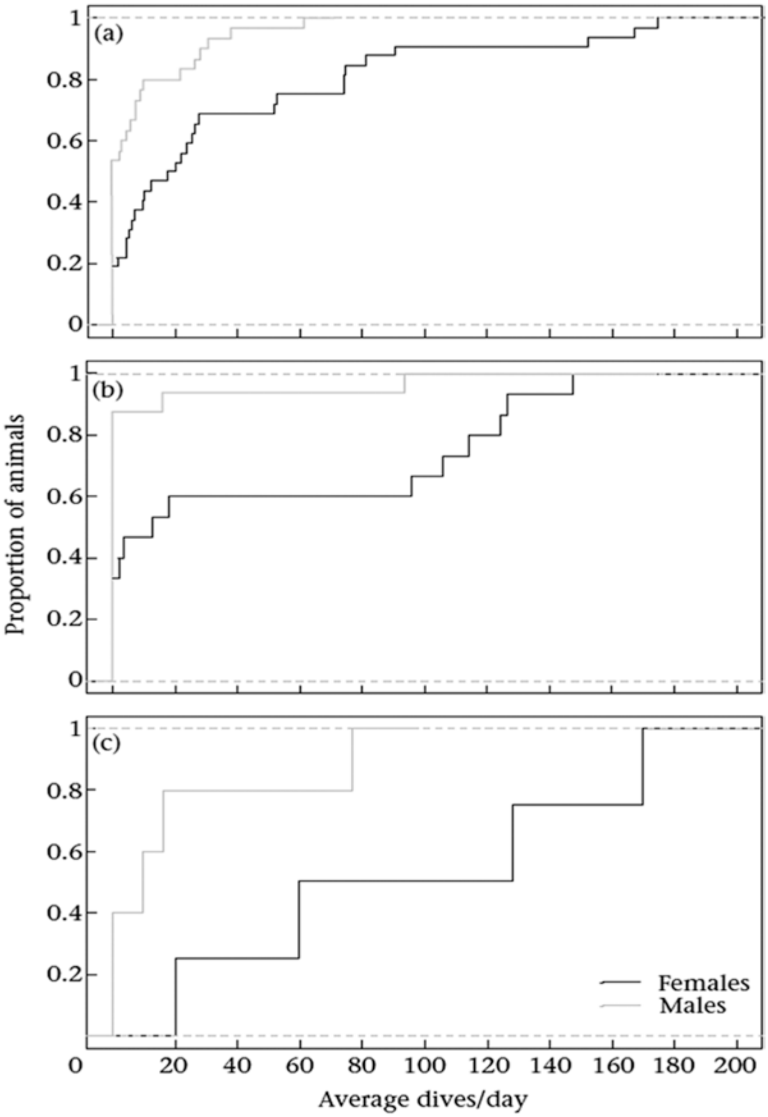


Fig. 8.5 Cumulative distribution of proportion of (**a**) yearlings (N = 62), (**b**) 1.5-year-olds (N = 31), and (**c**) 2-year-olds (N = 9) of each sex performing a given number of dives/day (only dives to ≥5 m). After Piedrahita et al. (2014)

colonies, possibly as a consequence of local differences in marine productivity (Jeglinski et al. 2012, 2013; Jeglinski 2013; Piedrahita and Trillmich, pers. obs.).

Information on spatial movements and diving behavior is available for adult females with dependent offspring and juveniles up to 2 years. Despite their small body size, compared to other sea lion species, Galápagos sea lions are exceptionally deep divers: 12-month-old juveniles already dive to a maximum depth of 367 m, and the deepest dive recorded for an adult female was 584 m (Jeglinski et al. 2012, 2013). However, adult females regularly dive to depths between 92 and 178 m for 3.3–4.7 min (Villegas-Amtmann et al. 2008; Villegas-Amtmann and Costa 2010; Jeglinski et al. 2012). Sea lions mix benthic and pelagic diving and forage both at day and at night, but there is considerable variation in foraging patterns within the species.

Juvenile sea lions dive predominantly at night and to shallow depths, a likely consequence of their small body size (Jeglinski et al. 2012, 2013). The diving behavior of adult females, especially diving depth and duration, as well as activity period, differs between individuals (Villegas-Amtmann et al. 2008; Villegas-Amtmann and Costa 2010). Recently, it has been found that individuals from the Caamaño rookery exhibit different diving and foraging strategies: some individuals forage closer to the coast in shallow water, some predominantly forage at night and utilize a broad spectrum of different depths, and others show consistently deeper dives in habitats further away from the colony (Fig. 8.6, unpublished data). Similar results have previously been observed in adult females of the El Malecón rookery on San Cristóbal island (Páez-Rosas et al. 2017). It is not yet clear if these

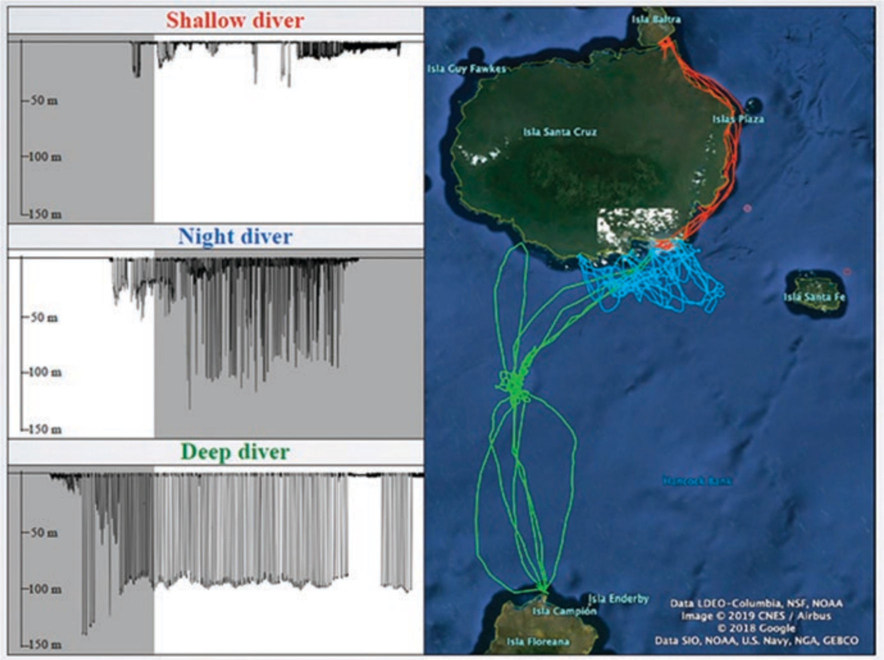


Fig. 8.6 Diving strategies of three female GSL from the Caamaño rookery. Diving profiles (18 hours, grey background represents night hours), and GPS tracks (two weeks) show the variability in dive depth and duration along with foraging location between the strategies. Schwarz et al., unpublished data

behavioral patterns are consistent throughout life or change with age, reproductive status, or ecological conditions, but in light of the documented juvenile personalities, it is tantalizing to suggest that these consistent individual differences in pup behavior have long-lasting consequences in other contexts. For example, are more explorative pups better able to exploit highly variable foraging grounds later in life, and thus have better access to a wider variety of prey? Or does the role of learning in early life depend on the personality and hence affect rates of cultural transmission?

GSL feed predominantly on small benthic and pelagic fish from approximately 12–33 different species and, in some rookeries, on cephalopods. A few fish species from the families Engraulidae, Carangidae, Serranidae, and Myctophidae dominate the diet (Dellinger and Trillmich 1999; Salazar and Bustamante 2003; Páez-Rosas and Aurioles-Gamboa 2010). There are dietary differences between GSL in the center of the archipelago that feed on a large variety of different fish species and western GSL that mainly feed on sardines and myctophids (Dellinger and Trillmich 1999; Páez-Rosas and Aurioles-Gamboa 2014), suggesting ecological differences in line with the genetic differentiation found (Jeglinski et al. 2015; Wolf et al. 2008). In the west, GSL live in sympatry with Galápagos fur seals, but both species exploit different foraging niches (Dellinger and Trillmich 1999; Páez-Rosas et al. 2012; Jeglinski et al. 2013; Villegas-Amtmann et al. 2013).

Sea lions forage on the shelf platform of the archipelago and, in the western archipelago, along its edge. Adult females with dependent offspring travel maximum distances between 50 and 97 km away from their colony, while juveniles cover maximum distances of less than 15 km (Jeglinski et al. 2013; Villegas-Amtmann et al. 2008; Villegas-Amtmann and Costa 2010). These foraging sojourns are short in comparison to other sea lion species. Both age groups haul out on numerous sites apart from their home colony, including other sea lion colonies (Jeglinski 2013; Villegas-Amtmann et al. 2008; Villegas-Amtmann and Costa 2010).

Reproductive Biology and Development

Galápagos sea lions display the typical otariid polygynous mating system with some slight distinctions from their more temperate sister species. Adult males try to monopolize access to females. Due to thermoregulatory constraints, males (as well as females) need direct access to water. Accordingly, the largest and most competitive males defend semiaquatic territories along beaches where females haul out to nurse their young (Trillmich and Trillmich 1984; Wolf et al. 2005). Indeed, only the most competitive males were able to establish territories in areas preferentially visited by females (Meise et al. 2014). In contrast to other polygynous pinnipeds forming harems on land, females move freely and define the social structure upon which male territories are superimposed (Wolf et al. 2007a; Wolf and Trillmich 2008).

Females come into estrus approximately 4 weeks after parturition (Heath 1989). The long reproductive season (September–January) and the predominance of aquatic mating make it impossible for males to monopolize access to receptive females. In contrast to other otariid species, they display and appear to depend on being chosen by a female, rather than copulating with each female that comes into estrus on their territory. Accordingly, reproductive success of Galápagos sea lions within a given season is not highly skewed toward territorial males (Pörschmann et al. 2010). Indeed, non-territorial males sire more than 50% of the annual number of pups where paternity could be assigned (Fig. 8.7; Pörschmann et al. 2010). Hence, for non-territorial males, roaming across the rookery proves to be an adequate strategy to gain reproductive success. The duration of attendance at the breeding rookery best predicts male reproductive success (Fig. 8.8; Pörschmann et al. 2010; Meise et al. 2014). Accordingly, large male body size might be selected for to allow extended fasting rather than to increase fighting abilities. The small rookery sizes and low density within Galápagos sea lion rookeries further suggest comparatively low pay-offs for territoriality. However, males establish territories in areas with highest female densities, thus increasing their chance to encounter receptive females which seem to be able to exercise female choice for indirect benefits (Lenz et al. 2013). Further, returning to territories where they previously gained matings increases a territorial male's lifetime reproductive success (Meise et al. 2014). For non-territorial males, the probability to encounter estrus females and mate successfully correlates positively with the size of their home range within a given season and thus with their ability to sneak into foreign territories (Wolf et al. 2005; Meise et al. 2014).

Galápagos sea lions can reproduce annually as do other otariids, but the breeding season is unusually long, extending over a period of more than 5 months. On Caamaño, it may start in early September, with a peak of birth in early November (Mueller et al. 2011). As the onset of the breeding season varies slightly among

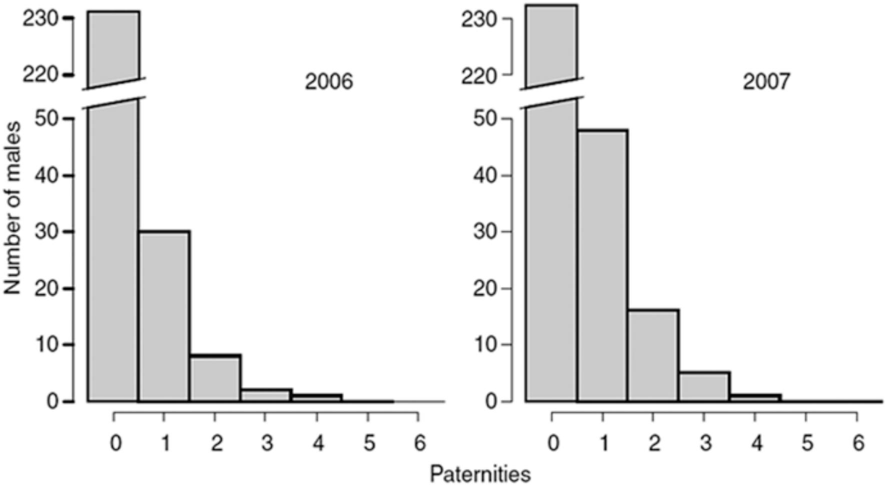
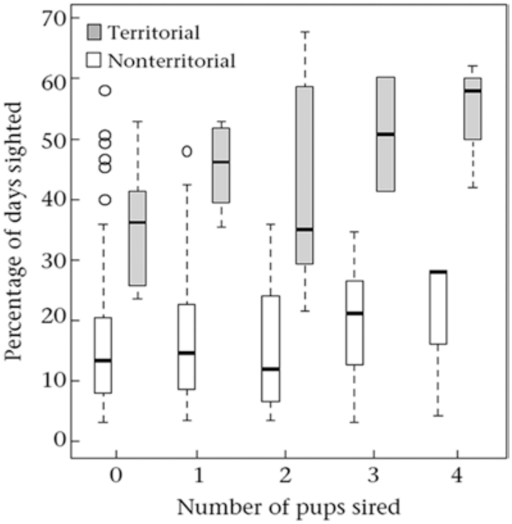


Fig. 8.7 Distribution of assigned paternities over all candidate males in the reproductive season 2006 (n = 272) and the reproductive season 2007 (n = 302). After Pörschmann et al. (2010)

Fig. 8.8 Male reproductive success in relation to their attendance in the colony. Box plots show medians, interquartile ranges (IQR), 1.5 * IQR and outliers (circles). After Meise et al. (2014)



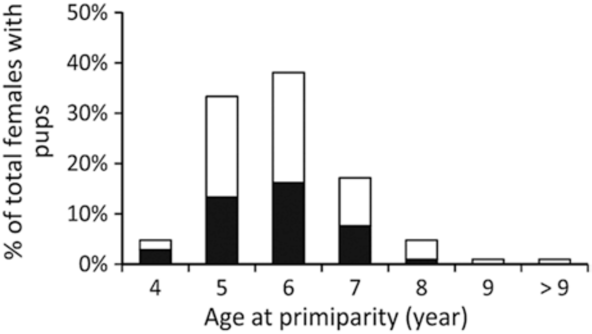


Fig. 8.9 Age at primiparity of female GSL born 2001 or later and seen every year during the breeding season from age of 4 until first pup (N = 105); pup sex: white, females (N = 62); black, males (N = 43). After Kalberer et al. (2018) and reproduced with permission from Springer Nature

colonies on different islands, females in various reproductive stages can be found throughout the year (Villegas-Amtmann et al. 2009).

Adult females initiate their reproductive life at a comparatively late age of 6 years with substantial variation between individual females (4–9 years, Fig. 8.9; Kalberer et al. 2018; Kalberer et al. 2019). Neither birth year nor body mass within the first week after birth influences age at primiparity. There is also no evidence for a relationship between body mass of females at the age of 1 year and age at primiparity (Kalberer et al. 2018). Hence, why some females start reproduction earlier than others is currently not understood.

Despite the annual breeding season, individual females reproduce every 2–3 years, resulting in a median offspring production of 0.4 pups per adult female per year (Kalberer et al. 2018). This low reproductive rate, compared to other otariid species, links to the variable productivity of the environment: Increased SST during the first 3 months after mating decreases female pupping probability (Mueller et al. 2011). Non-nursing, pregnant females return ashore 1–2 days prior to parturition (Trillmich 1986). Immediately after birth, females behave highly aggressively and defend the area around the newborn, calling frequently to it. The female stays on land with the newborn pup during a 4–7-day perinatal period. This period establishes an exclusive, mutual bond between mother and offspring (Trillmich 1981). Galápagos sea lion females, as income breeders, then resume a foraging cycle strategy, during which they continuously cycle between foraging trips at sea that last between 5 h and 4 days, in general increasing with offspring age (Trillmich 1986; Villegas-Amtmann et al. 2008; Jeglinski et al. 2012) and suckling bouts on land. Galápagos sea lion females lactate year-round. Also, given the long dependency periods of juvenile Galápagos sea lions, an annual reproduction would necessitate the simultaneous support of an older offspring, a newborn pup and self-maintenance, high costs that females rarely seem able to pay (Trillmich and Wolf 2008; Mueller et al. 2011). Therefore, inter-birth intervals of 1 and 2 years are most frequently observed (Kalberer et al. 2018). Sometimes (around 20%), females give birth to a pup while still suckling a dependent older offspring (Trillmich and Wolf 2008). This situation leads to sibling competition and can heavily impact the survival of the newborn pup when the older offspring is still around for suckling. Rarely, adult females manage to successfully support both the older offspring and the newborn, leading to the formation of a so-called trio (Trillmich and Wolf 2008). If a dependent offspring dies, lactation will end, but otherwise females will be essentially nursing all their reproductive lives, as long as the pup or juvenile offspring survives.

Demography

Galápagos sea lion females mature as early as in their 4th year, but most females exhibit an age of primiparity of 6 years of age (Kalberer et al. 2018). Females can produce one pup a year, because they always copulate about a week after parturition. Due to the slow development of their offspring, most females successfully rear a pup only every 2nd or 3rd year (Kalberer et al. 2018). Longevity is still unknown, but the oldest animals from the Caamaño population are at least 21 years old (unpublished data). Males presumably mature at a similar age to females.

Over the last 15 years, the study on Caamaño has compiled enough individual life histories to estimate female survival (Kalberer et al. 2019). As expected, pups had the lowest (0.688 ± 0.071 s.e.), juveniles intermediate (0.759 ± 0.033 s.e.), and adults the highest (0.825 ± 0.047 s.e.) average survival rate. Survival of all age classes varied among years (pups, 0.345–0.872; juveniles, 0.484–0.939; adults, 0.665–0.979), but overall showed a significant decrease since 2003 and particularly marked since 2008 (Fig. 8.10, Kalberer et al. 2019). Cold sea surface temperature and large birth mass positively affected survival in all age classes, particularly in pups. The 2015 El Niño reduced survival rates in all age classes. With these survival

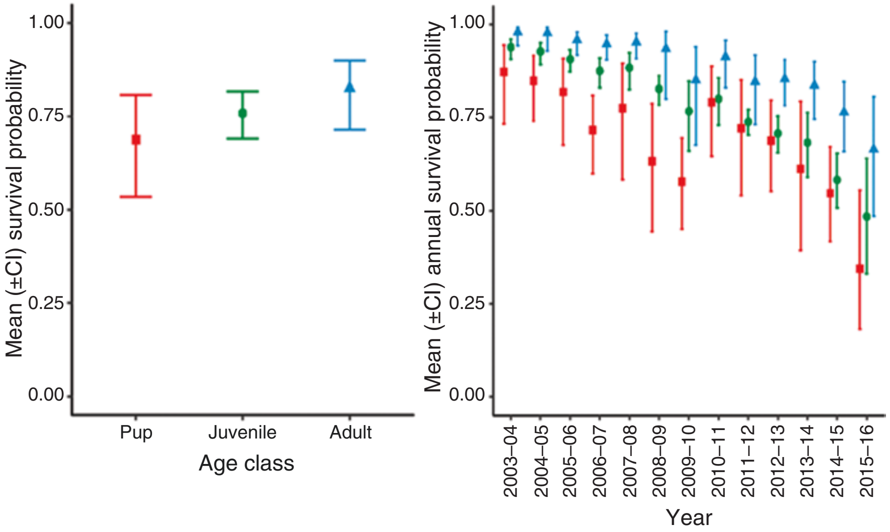


Fig. 8.10 Average female survival probability (± 95% confidence interval) (**a**) by age class and (**b**) over time🟥; pup●; juveniles▲; ≥ 4 years old. After Kalberer (2019)

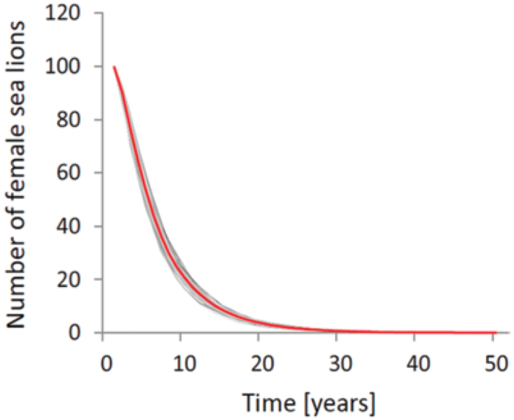


Fig. 8.11 Population projection over the next 50 years of a stochastic matrix model incorporating the pupping rate as of Kalberer et al. (2018), the average survival rates as depicted in Fig. 8.10, and the negative relationship between SST and survival rates as documented in Kalberer (2019). The average population trajectory is shown in red, and the thin grey lines depict the 100 individual simulations

estimates and the documented pupping rates, it was possible for the first time to construct matrix models and estimate population growth from vital rates. The estimated population growth rate for the Caamaño rookery in the next 50 years was predicted to be rather negative ($\lambda = 0.897$, Fig. 8.11). This growth rate translates into a population decline of 10% per annum. Prognoses worsened further when environmental stochasticity, represented by recent years' SST variation, was included (λ = 0.840) and even more so when the increase of 0.9 °C in mean SST predicted by the IPCC was considered (λ = 0.829). These results imply that over the next 50 years, the sea lion population on Caamaño is most likely facing a severe danger of extinction. Estimated population growth rate was most influenced by adult survival, as an elasticity analysis showed that 62% of variation in population growth rate was due to variation in adult survival rate. It is clear that during strong El Niño events (like 1982–1983, 1997–1998, and 2015–2016), when food availability for marine foragers is drastically reduced, numbers may substantially decline. During such events, pups of the year and adult territorial males were most affected (Trillmich and Limberger 1985; Trillmich and Dellinger 1991; Salazar and Bustamante 2003).

Conservation Status and Management

The GSL is currently classified as *Endangered* by the IUCN (Trillmich 2015). The Special Law for Galápagos (Ley Orgánica de Régimen Especial de la Provincia de Galápagos; Oficio No. SAN-2015-0989, Quito, 10 de junio de 2015) regulates that no endemic species of the Galápagos archipelago is subject to any trade, thereby providing complete protection. In addition, the sea lion population lives in an area that is protected since 1998 as the Galápagos Marine Reserve (GMR), covering an area of 138,000 km^2 and recognized in 2001 by the UNESCO as a World Heritage Site (Heylings et al. 2002). The GMR is defined as a 40-mile (74 km) zone around a baseline connecting the farthest points of the islands and therefore covers the main foraging area of the GSL. This almost excludes, but not totally, the danger of interaction with fisheries, since the international fishing activity around the perimeter of the GMR is intense and sometimes illegally encroaches into the reserve. Ghost nets and drifting long lines still endanger marine life within this region (Ventura et al. 2019).

Artisanal fishing by licensed local boats also interacts with sea lions because major sections of the coastline where sea lion rookeries exist are also used by local fishermen. Nevertheless, the increased tourism and loss or drifting of garbage led to a substantial increase in plastic pollution within the region (Alava et al. 2014). In particular, drifting nets have been documented to cause substantial mortality through entanglement (Poeta et al. 2017). In recent years, the catch per unit effort of the local legal fishery has declined. This implies a risk that in the future it may target lower trophic-level species and competition with GSL would increase or that perceived competition would lead to poaching.

Domestic animals, in particular rats, dogs, and cats in the settlements on Galápagos, pose a potential threat to the health of the GSL. All of these species must be considered a reservoir of infectious diseases like toxoplasmosis, leptospirosis, and even distemper virus (Levy et al. 2008; Alava et al. 2014). Sea lions are in intense contact with domestic animals as they often haul out in human settlements, most obvious on San Cristóbal and to a lesser extend Santa Cruz where they often rest on the dock area (Denkinger et al. 2015). Therefore, it is quite likely that exposure to introduced species in developed areas may impact immunity and overall health and fitness for specific sea lion colonies (Brock et al. 2013).

Connected to the increase in local human population and tourism, marine traffic has been increasing over the years, and ships have become much faster with the introduction of high-powered fiber glass boats. This obviously increases the risk of collision with pinnipeds as well as with whales and dolphins, but no systematic monitoring data are available. In addition, increased marine traffic harbors the risk of pollution which can have dramatic effects on GSL (Salazar 2003).

Finally, the potential increase in the frequency and intensity of El Niño events due to global warming (Cai et al. 2014) may endanger the persistence of GSL in the future. However, it is the strikingly low and variable adult survival which makes the Galápagos sea lion vulnerable to extinction in its variable environment, potentially strongly affected by future climate change. As the detailed local effects are difficult to predict (Karnauskas et al. 2015), the concerns listed above make further regular population monitoring as done over the last years by Galápagos National Park Directorate an urgent need, with a strong focus on interagency planning and management to achieve these goals (Páez-Rosas and Guevara 2017).

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