Supplementary material –

Vulnerability to fluctuations in prey and predation landscape in a central place foraging marine predator

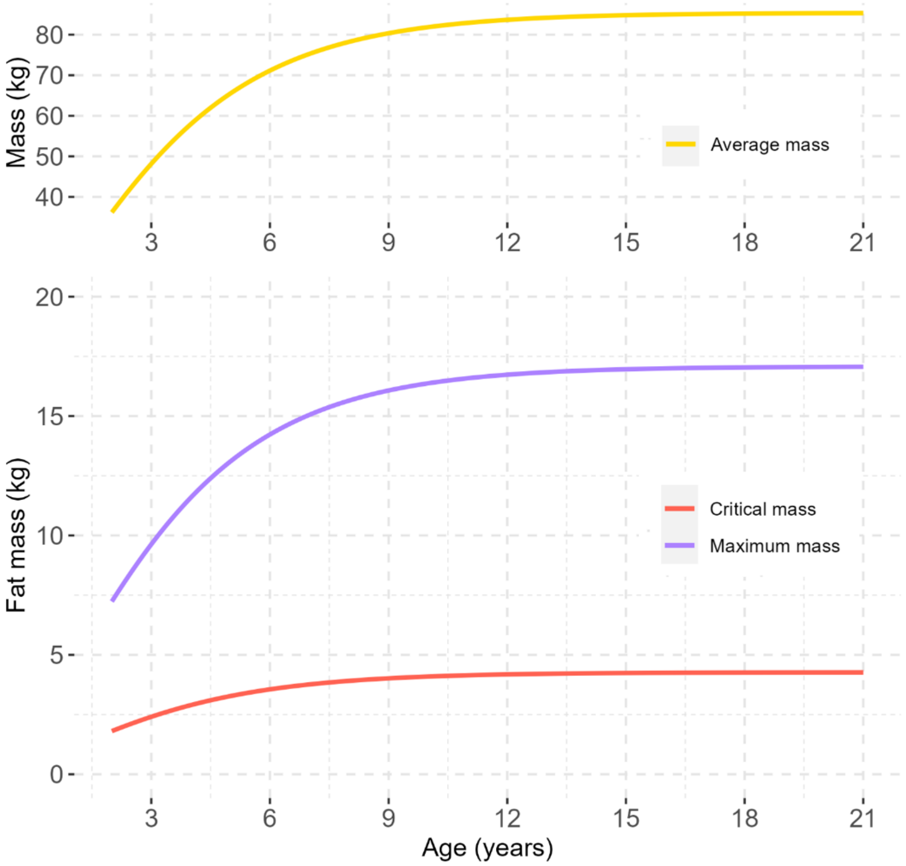
Speakman et al. (2024)

Contents

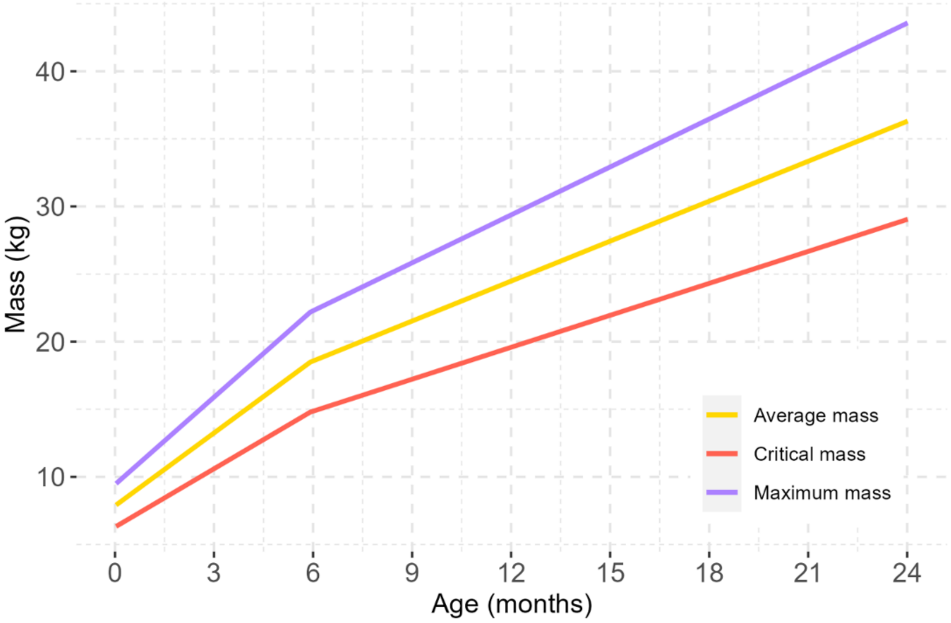
Supplementary material A – Physiology

Physiological state variables

Non-reproductive and pregnant females (States 1 and 2) were characterised by a single physiological state variable, fat mass at time $t,\ X_F(t)$, representing the energy reserves available to the female. A female's fat mass was bounded by an age-specific minimum value x_{crit} and maximum value x_{max}. The minimum and maximum fat mass of a female were calculated as 5% and 20% of the average age-specific body mass (kg), respectively. Critical and maximum mass values were calculated as a function of age (SM-A Figure 1) since we were modelling individuals throughout their lifetime and the mass range is known to vary with age (Gibbens and Arnould, 2009). Lactating females (States 3 and 4) were characterised by an additional physiological state variable, $X_{P\ or\ J}(t)$, the mass of the dependant pup or juvenile at time t. The pup and juvenile masses could also vary between an age-specific minimum and maximum mass (SM-A Figure 2). Offspring mass thresholds were set to ±20% of the average age-specific mass. Values used in calculating the physiological dynamics are shown in SM-A Table 1.



SM-A Figure 1. Average mass and fat mass thresholds for simulated adult Australian fur seal females.



SM-A Figure 2. Mass thresholds for simulated pup and juvenile Australian fur seal females.

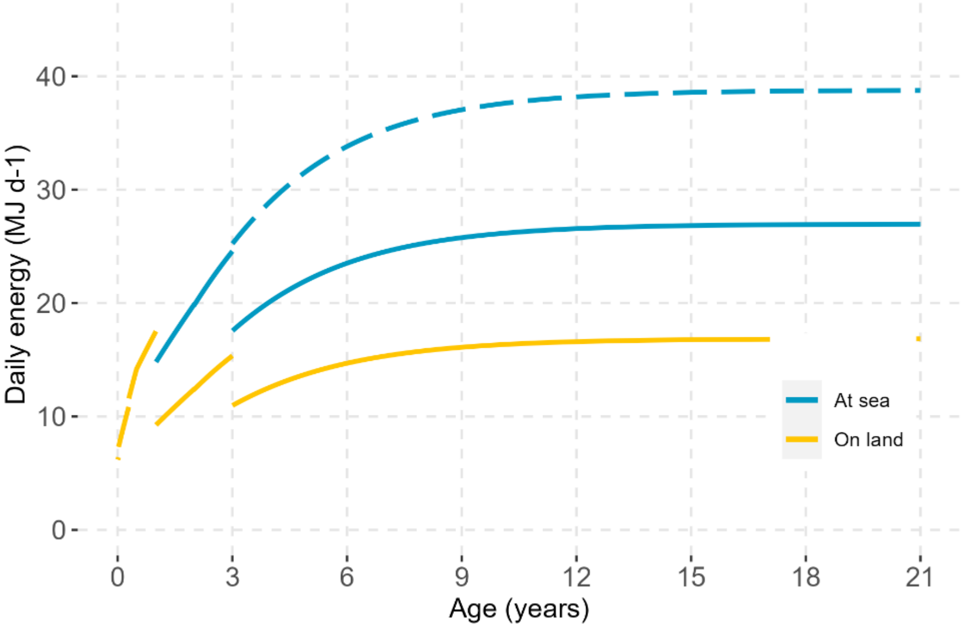
Field metabolic rates

Field metabolic rates (FMRs) have not been measured in Australian fur seals. As such, pup, juvenile and adult female metabolic rates were estimated using information from closely related species. Adult mass-specific FMRs were calculated using metabolic measurements from free-ranging California sea lions (*Zalophus californianus*) (Williams et al., 2007, McHuron, 2016) (SM-A Figure 3). Female California sea lions and female Australian fur seals have a similar average adult female mass and, thus, presumably similar metabolic rates. Metabolic rates for adult females were applied to the average age-specific body mass. Metabolic measurements from free-ranging Australian sea lions (*Neophoca cinerea*) indicated that the mass-specific FMR of juveniles was 1.4 times that of adults (Costa and Gales, 2003, Fowler et al., 2007). Correspondingly, we calculated the juvenile mass-specific at-sea and on-land FMRs as 1.4 times the mass-specific FMR used for adults (SM-A Figure 3). For pup metabolic rates, we used the perinatal, pre-moult, and post-moult metabolic rates of Antarctic fur seal (*A. gazella*) pups (McDonald et al., 2012), adjusted for differences in mass between the two species (SM-A Figure 3).

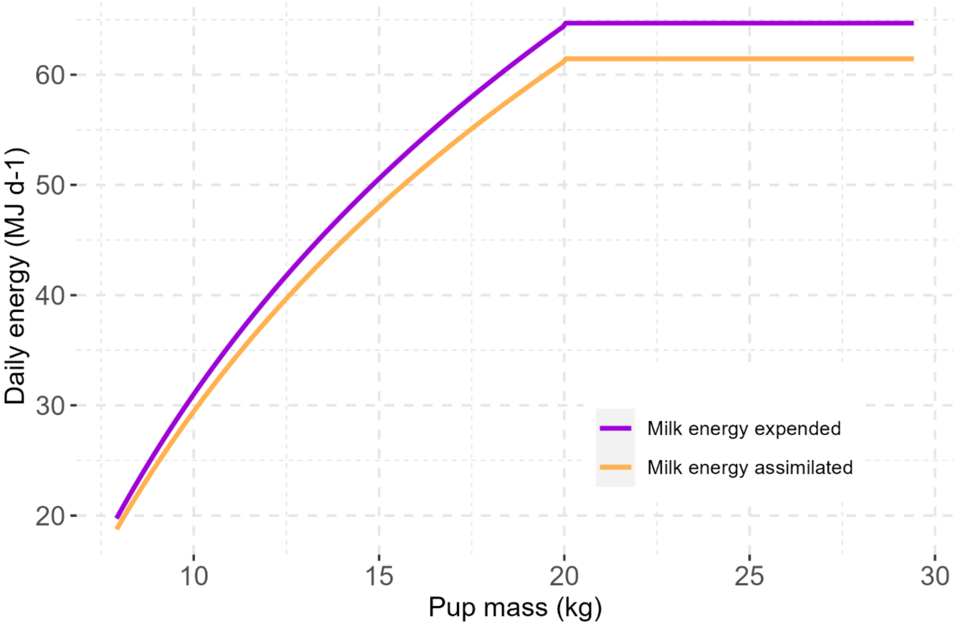
Reproductive costs

The cost of lactation (α_l, Eq. 1, SM-A Figure 4) was estimated using mass-specific milk consumption rates from free-ranging Australian fur seal pups (Arnould and Hindell, 1999, Arnould and Hindell, 2002). Energy delivered via lactation was capped at the level provisioned to a 20 kg pup as older pups and juveniles begin foraging on their own to supplement their intake and, thus, female provisioning is unlikely to continue to increase with pup mass.

$$\begin{aligned} \alpha_l &= 48.234 \cdot \ln(x_{PorJ}) - 80.057 && \text{for } x_{PorJ} = 6 - 20 \text{ kg} \\ &= 48.234 \cdot \ln(20.1) - 80.057 && \text{for } x_{PorJ} > 20 \text{ kg} \end{aligned} \tag{1}$$



SM-A Figure 3. Mass-specific metabolic rates for pup, juvenile and adult female Australian fur seals. The dashed blue line indicates the metabolic rate for lactating females. Solid lines represent non-lactating metabolic rates or metabolic rates that are the same for lactating and non-lactating females.



SM-A Figure 4. Daily energetic cost of lactation (purple) for adult female Australian fur seals as a function of pup mass, and the energy assimilated by pups (yellow) assuming a 95% milk assimilation efficiency.

We calculated the cost of gestation (α_g, Eq. 2, SM-A Figure 5) using Australian fur seal foetal growth rates (unpublished data), body composition (unpublished data), and the heat increment of gestation, such that

$$\alpha_g = HIG + SFE + SPE \tag{2}$$

where *HIG* is the heat increment of gestation (Eq. 3), *SFE* is the stored foetal energy (Eq. 4-5), and *SPE* is the stored placental energy (Eq. 6-7). The HIG is calculated as a function of gestational time (t_g in days). When t_g < 70 days, the HIG cost is 0 and otherwise

$$HIG = \left(1 \times 10^{-7} \cdot t_g^3\right) + \left(4 \times 10^{-5} \cdot t_g^2\right) - \left(4.6 \times 10^{-3} \cdot t_g\right) + 0.0735 \tag{3}$$

The stored foetal energy (*SFE*) was calculated from Australian fur seal foetal growth data (Arnould, unpublished data), such that

$$SFE = (FMA \cdot Prop_{Lipid} \cdot ED_{Lipid}) + (FMA \cdot Prop_{Protein} \cdot ED_{Protein}) \tag{4}$$

where FMA is the foetal mass added (Eq. 5), $Prop_{Lipid}$ is the proportion of the mass added that is lipid (0.104), $Prop_{Protein}$ is the proportion of added mass that is protein (0.231), ED_{Lipid} is the energy density of lipid (39.3 MJ kg^{-1}), and $ED_{Protein}$ is the energy density of protein (18.0 MJ kg^{-1}). The FMA is calculated as a function of gestational time (t_g), such that

$$FMA = 0.0004 \cdot t_g - 0.0277 \qquad \text{for } t \geq 70 \tag{5}$$

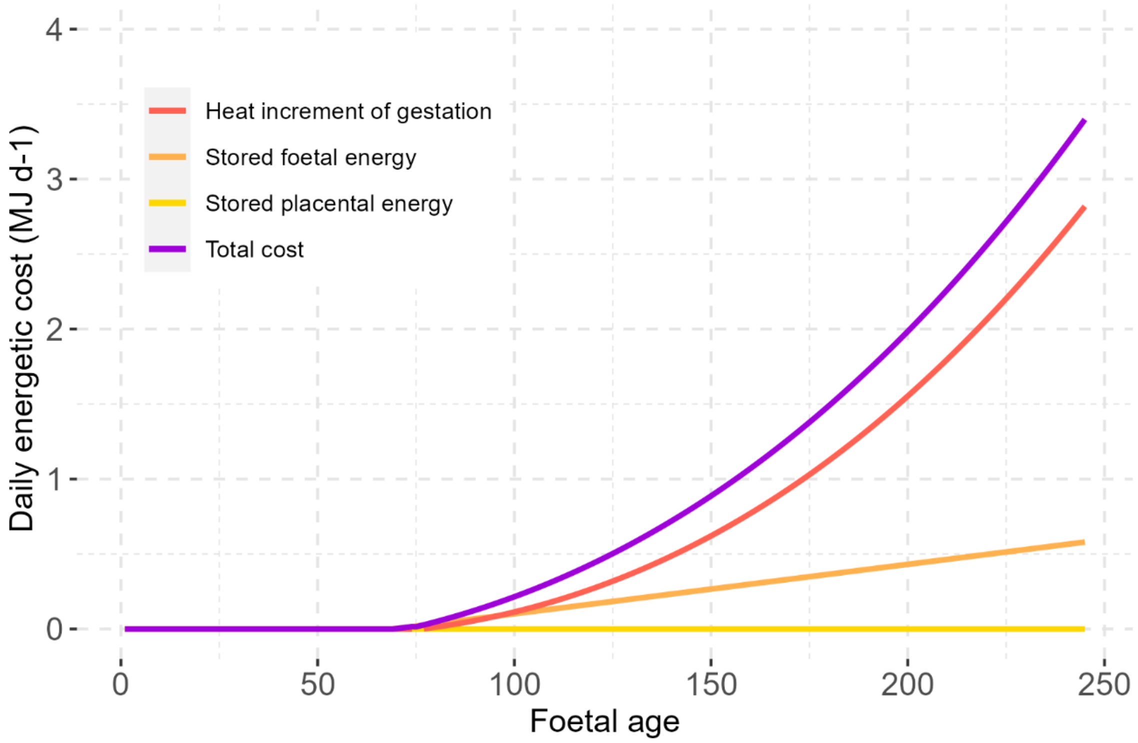
and otherwise FMA is 0.

The stored placental energy (*SPE*) was calculated using the relationship between foetal and placental mass in Antarctic fur seals (Boyd and McCann, 1989), such that

$$SPE = PMA \cdot ED_{Placenta} \tag{6}$$

where *PMA* is the placental mass added as a function of gestational time (Eq. 7) and $ED_{Placenta}$ is the energy density of placental tissue (3.3 MJ kg^{-1}). The *PMA* is calculated as

$$PMA = 8.0E^{-7} \cdot t_g^{0.7586} \tag{7}$$



SM-A Figure 5. Daily energetic costs associated with gestation for pregnant female Australian fur seals. Costs include the heat increment of gestation and energy associated with the foetal and placental tissue.

Growth costs

Structural growth costs were estimated from the average growth rates calculated from average masses of female Australian fur seals (Arnould and Warneke, 2002) (SM-A Figure 1). Growth rates for offspring were estimated at 60 g d^{-1} based on estimates from Arnould and Hindell (2002). Growth rates for females were estimated at 35 g d^{-1} for females < 5 years old, 20 g d^{-1} for females 5-6 years old, 11 g d^{-1} for females 7-8 years old, and 5 g d^{-1} for females 8-9 years old. As female Australian fur seals reach asymptotic growth at approximately 10 years old (SM-A Figure 1), growth rates of females 10 years and older were set to 0 g d^{-1}. Growth rates were then converted to an energetic cost (α_s) using the energy density of blubber such that

$$\alpha_s = GR \cdot ED_{Blubber} \tag{8}$$

where GR is the growth rate (g d^{-1}) of the individual and $ED_{Blubber}$ is 20.7 MJ kg^{-1} (Liwanag et al., 2012). We used the energy density of blubber since some structural growth is likely to be blubber and there is little understanding of how different tissue types (e.g. blubber, skeletal tissue) is portioned within the structural mass.

SM-A Table 1. Parameter values used to calculate the physiological dynamics. F and O indicate values associated with the females and offspring, respectively.

Parameter	**Description**	**Range**
$X_F(t)$	Female fat mass (kg) at time *t*	
$X_O(t)$	Offspring mass (kg) at time *t*	
x_F	Specific value of the fat mass (kg) for females	$x_{F_{crit}} - x_{F_{max}}$
$x_{F_{crit}}$	Critical value for the age-specific fat mass (kg) as a percentage of the average age-specific mass for females	5%
$x_{F_{max}}$	Maximum value for the age-specific fat mass (kg) as a percentage of the average age-specific mass for females	20%
x_O	Specific value of the mass (kg) for offspring	$x_{O_{crit}} - x_{O_{max}}$
$x_{O_{crit}}$	Critical value for the age-specific mass (kg) as a percentage of the average age-specific mass for offspring	-20%
$x_{O_{max}}$	Maximum value for the age-specific mass (kg) as a percentage of the average age-specific mass for offspring	+20%
$FMR(x)$	Field Metabolic Rate (MJ $kg^{0.75}$) at mass *x* for	
	- Lactating female at sea*	1.38
	- Non-lactating female at sea*	0.96
	- Female on land*	0.60
	- Juvenile at sea	1.34
	- Juvenile on land	0.84
$MR_P(x)$	Pup metabolic rate (MJ $kg^{0.75}$) at mass *x* for the	
	- perinatal period	1.31
	- pre-moult period	1.49
	- post-moult period	1.59
α_l	Daily energetic cost of lactation (MJ d^{-1})	Eq. 1
α_g	Daily gestation cost (MJ d^{-1})	Eq. 2

*Female metabolic rates are based on the average age-specific body mass not the fat mass.

Supplementary material B – Physiological dynamics

The state dynamics for non-lactating females (States 1 and 2) while at sea are as follows:

$$X_{F_{sea}}(t+1) = X_F(t) + \frac{E_{prey} - \left(FMR_{sea} X_{F_{BM}}(t) + \alpha_s + \alpha_g\right)}{ED_{Lipid}} \tag{9}$$

where $X_{F_{BM}}(t)$ is her body mass in kg at time *t* (linearly interpolated from her fat mass in kg at time *t*), E_{prey} is the net energy in MJ day^{-1} gained from foraging (see 'Foraging environment' for details on how this was calculated), FMR_{sea} is the metabolic cost of metabolism, thermoregulation and maintenance while at sea, which is dependent on time t, α_s is the daily cost of age-specific structural growth, and α_g is the daily cost of gestation at time *t* (if applicable). An energy conversion factor of 39.3 MJ kg^{-1} (ED_{Lipid}) was used to calculate changes in mass based on estimates from Kuhnleini and Soueida (1992). If a non-lactating female is on land, her state dynamics are:

$$X_{F_{land}}(t+1) = X_F(t) - \frac{FMR_{land} X_{F_{BM}}(t) + \alpha_s + \alpha_g}{ED_{Lipid}} \tag{10}$$

where FMR_{land} is the metabolic cost for a female of mass $X_F(t)$.

The state dynamics for females nursing a pup (States 3 and 5) at sea are the same as for a non-reproductive or pregnant female at sea as in Eq. 1. The mass dynamics of her dependent pup while fasting on land can be described as:

$$X_{P_{fasting}}(t+1) = X_P(t) - \left(\frac{\left(E_{prey} - \left(MR_P X_P(t) + \alpha_s\right)\right)\cdot 0.95}{ED_{Lipid}} + \frac{\left(E_{prey} - \left(MR_P X_P(t) + \alpha_s\right)\right)\cdot 0.05}{ED_{Protein}}\right) \tag{11}$$

where $X_P(t)$ is the pup mass in kg at time *t*, E_{prey} is the energy intake via supplemental feeding (see 'Foraging environment' for details), and MR_P is the metabolic rate of the pup as a function of pup mass at time *t*. We have assumed that 95% of tissue catabolism is lipid and 5% is protein based on the mass dynamics of fasting pups.

The mass dynamics of a female nursing a pup (States 3 and 5) when on land have an additional cost of lactation such that:

$$X_{F_{land}}(t+1) = X_F(t) - \frac{(FMR_{land}X_{F_{BM}}(t) + \alpha_s + \alpha_g + \alpha_l(X_P(t)))}{ED_{Lipid}} \tag{12}$$

where $\alpha_l(X_P(t))$ is the energetic cost of lactation in MJ kg^{-1} as a function of pup mass in kg at time *t*. Her dependent pup's mass dynamics are as follows:

$$X_{P_{nursing}}(t+1) = X_P(t) + \left(\frac{(\alpha_{l_a}(X_P(t)) - (MR_P X_P(t) + \alpha_s)) \cdot 0.6}{ED_{Lipid}} + \frac{(\alpha_{l_a}(X_P(t)) - (MR_P X_P(t) + \alpha_s) \cdot 0.4}{ED_{Protein}}\right) \tag{13}$$

where $\alpha_{l_a}(X_P(t))$ represents the energy assimilated by the nursing pup as a function of pup mass at time *t*, assuming an assimilation rate of 0.95 (Oftedal et al., 1987). We have assumed that 60% of energy intake was utilised for building lipid mass and 40% for building protein mass based on the tissue composition of Australian fur seal pups (Arnould and Hindell, 2002).

The state dynamics for females nursing a juvenile (States 4 and 6) at sea can be calculated as per Eq. 1. The mass dynamics of her juvenile while the female is calculated similarly to a dependent pup (Eq. 11), such that

$$X_{J_{fasting}}(t+1) = X_J(t) + \left(\frac{(E_{prey} - (FMR_J X_J(t) + \alpha_s) \cdot 0.95}{ED_{Lipid}} + \frac{(E_{prey} - (FMR_J X_J(t) + \alpha_s) \cdot 0.05}{ED_{Protein}}\right) \tag{14}$$

where $X_J(t)$ is the juvenile mass in kg at time *t* and FMR_J is the metabolic rate of the juvenile as a function of juvenile mass at time *t*. We have assumed that tissue is catabolised and anabolised in the same way as pups due to the need to prioritise structural growth.

The mass dynamics of a female nursing a juvenile (States 4 and 6) when nursing on land can be described as:

$$X_{F_{land}}(t+1) = X_F(t) - \frac{FMR_{land}X_{F_{BM}}(t) + \alpha_s + \alpha_g + \alpha_l\left(X_J(t)\right)}{ED_{Lipid}} \tag{15}$$

We have assumed that the energy delivered by the female is modified to juvenile demand, such that a juvenile that is foraging efficiently will be provisioned less than a juvenile that forages inefficiently. The juvenile’s mass dynamics are as follows:

$$X_{J_{nursing}}(t+1) = X_J(t) + \left(\frac{\left((E_{prey_J} + \alpha_{l_a}\left(X_J(t)\right)) - (FMR_J X_J(t) + \alpha_s)\right) \cdot 0.6}{ED_{Lipid}} + \frac{\left((E_{prey_J} + \alpha_{l_a}\left(X_J(t)\right)) - (FMR_J X_J(t) + \alpha_s)\right) \cdot 0.4}{ED_{Protein}}\right) \tag{16}$$

Supplementary material C – Foraging environment

The total energy gained per foraging day for adult females was determined by their reproductive state, the probability of capturing food and the number of productive foraging areas encountered per foraging day. Individuals were assumed to have an 85% cumulative probability of capturing food on each foraging day in the baseline prey scenario. Given the lack of empirical data on temporal and spatial dynamics of Australian fur seal prey and Australian fur seal prey consumption, the energy intake from foraging (E_{prey}) was calculated as a percentage increase from a female's gross energy requirements. For non-lactating females, this covered the costs of metabolism, growth, and, if applicable, gestation. For lactating females, this also incorporated the costs associated with nursing their pup or juvenile, assuming that the offspring was under the maximum allowable mass. The increased consumption of lactating females represents the increased requirements of females throughout lactation and is supported by the increased prey intake reported in a range of marine mammals (McHuron et al., 2023).

The metabolizable energy (ME) was then calculated from the gross energy intake (GEI) accounting for faecal energy losses (FEL) and urinary energy losses (UEL), such that:

$$DE = GEI - FEL \tag{17}$$

$$ME = DE - UEL \tag{18}$$

where DE is the digestible energy, $FEL = 0.04 \cdot GEI$, and $UEL = 0.13 \cdot DE$. While FEL and UEL are known to vary with diet, the exact composition of the Australian fur seal diet is variable. As such, approximate FEL and UEL estimates were used based on estimates from Diaz Gomez et al. (2016).

Offspring foraging efficiency

When offspring begin foraging, they are not as successful as adults and undergo a gradual improvement in foraging ability and physiological development (Spence-Bailey et al., 2007). As such, we assumed all offspring underwent a learning period and applied a modifier to the probability of finding food when calculating the mass dynamics of dependent and independent offspring. The modifier is adapted from Stephens et al. (2014), such that

$$Pr_{Offspring}(Food) = a_{rel}Pr(Food) \tag{19}$$

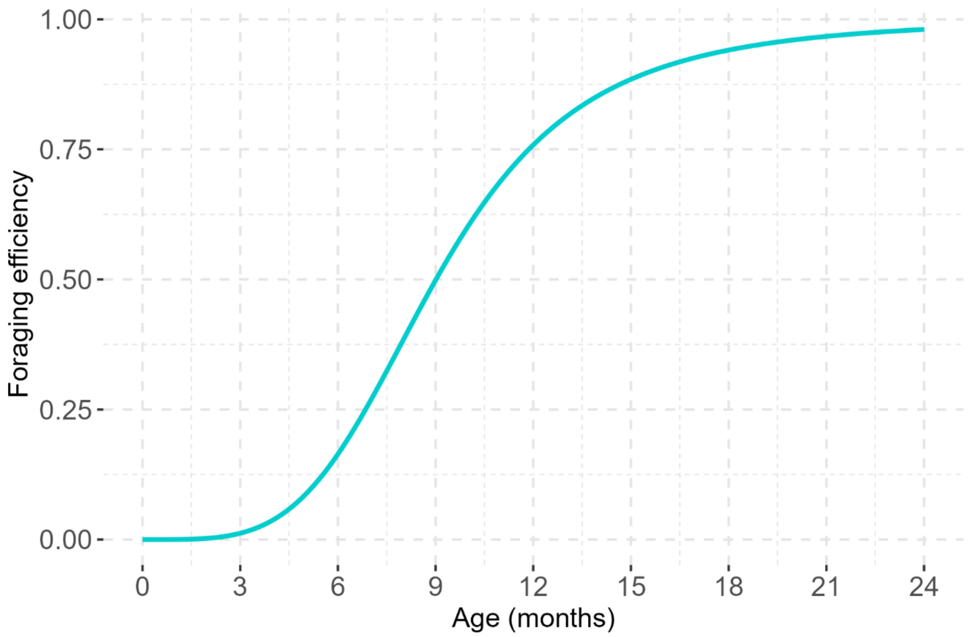
where $Pr(Food)$ is the probability of an adult female finding prey and a_{rel} is the foraging ability of the offspring relative to an adult female calculated as

$$a_{rel} = \frac{1}{1 + e^{-Q(t-q_{1/2})}} \tag{20}$$

where Q is a scaling constant, t is the offspring age in days, and $q_{1/2}$ is the age (d) that offspring foraging ability is assumed to reach 50% of the adult female. Here, we have set Q to 730 d and $q_{1/2}$ to 182 d. This calculation produces a sigmoidal curve to ensure a period of learning before the juvenile asymptotes at 99.9% of adult foraging competence at age 2 (SM-C Figure 1).

Dependent offspring can have additional energy intake through supplemental feeding when unattended by their mother. Here, the foraging efficiency modifier (a_{rel}) is applied to the proportion of the possible energy intake through foraging (Eq. 21). We have assumed that supplemental feeding could provide up to half of the possible daily energy intake since the offspring are unlikely to forage for extended periods of time prior to independence. If the energy required by the offspring to reach its maximum mass is exceeded, the energy supplied by the mother through lactation is reduced by the supplementation amount.

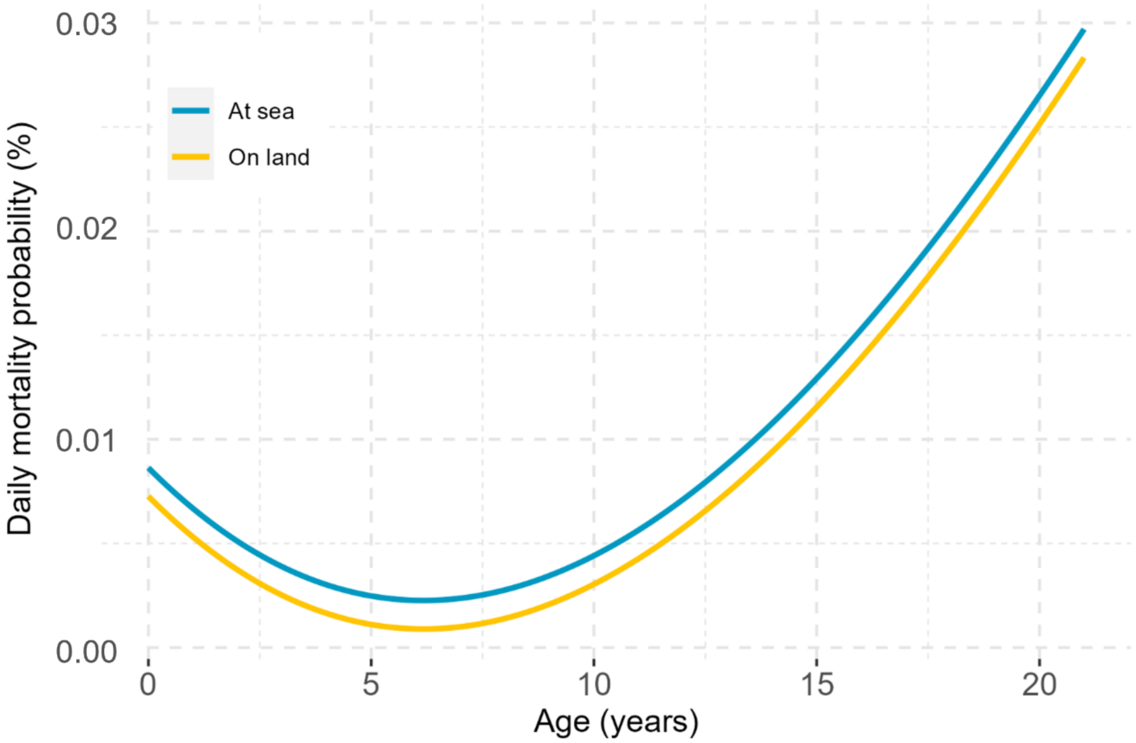
$$E_{Sup} = a_{rel} \cdot \left(\frac{E_{prey}}{2}\right) \tag{21}$$



SM-C Figure 1. Foraging efficiency curve used to determine the relative amount of energy intake from foraging for juveniles still learning to forage effectively.

Mortality

The daily mortality risk was derived from age-specific survival rate estimates for Australian fur seals (Gibbens and Arnould, 2009). The survival estimates were assumed to include all causes of death including deaths associated with predation, disease, starvation. Since predation and human-related threats (e.g. bycatch, entanglement, vessel collisions) occur at sea, we adjusted the daily mortality risk so that the mortality risk at sea was always higher than on land. The resulting mortality rates for on land and at sea are shown in SM-C Figure 2.



SM-C Figure 2. Daily age-specific mortality probability for simulated Australian fur seals on land and at sea under baseline conditions.

Supplementary material D – Stochastic Dynamic Programming equations

When solving the SDP equations, we assume that individuals act in such a way to maximise some measure of Darwinian fitness. The SDP equations for this study were calculated to maximise the lifetime reproductive fitness of females through accumulated offspring recruitment (i.e. maximising the number of offspring that survive to recruit into the population). Below, *V* designates the fitness value associated with each decision available and *F* designates the lifetime fitness function, calculated as the maximum of *V* at each timestep, to identify the optimal behaviours through time.

After reproductive senescence (one year prior to death), females can only be in three possible reproductive states: State 1 (non-reproductive) or States 3 - 4 (nursing). Models were initiated with a terminal fitness associated with offspring recruitment. Thus, the terminal fitness of nursing females is based on the offspring's mass-specific probability of recruitment. Non-reproductive females have a terminal fitness of 0 since there is no possibility of increasing accumulative recruitment if non-reproductive. Therefore, the terminal fitness, at time *T*, of females in States 1 (non-reproductive) or 3 - 4 (nursing), regardless of their physical location, are

$$F_{1_{Land\ or\ Sea}}(x_F, T) = 0 \tag{22}$$

$$F_{3\ or\ 4_{Land\ or\ Sea}}\left(x_F, x_{P\ or\ J}, T\right) = \phi_{P\ or\ J}(x_{P\ or\ J}) \tag{23}$$

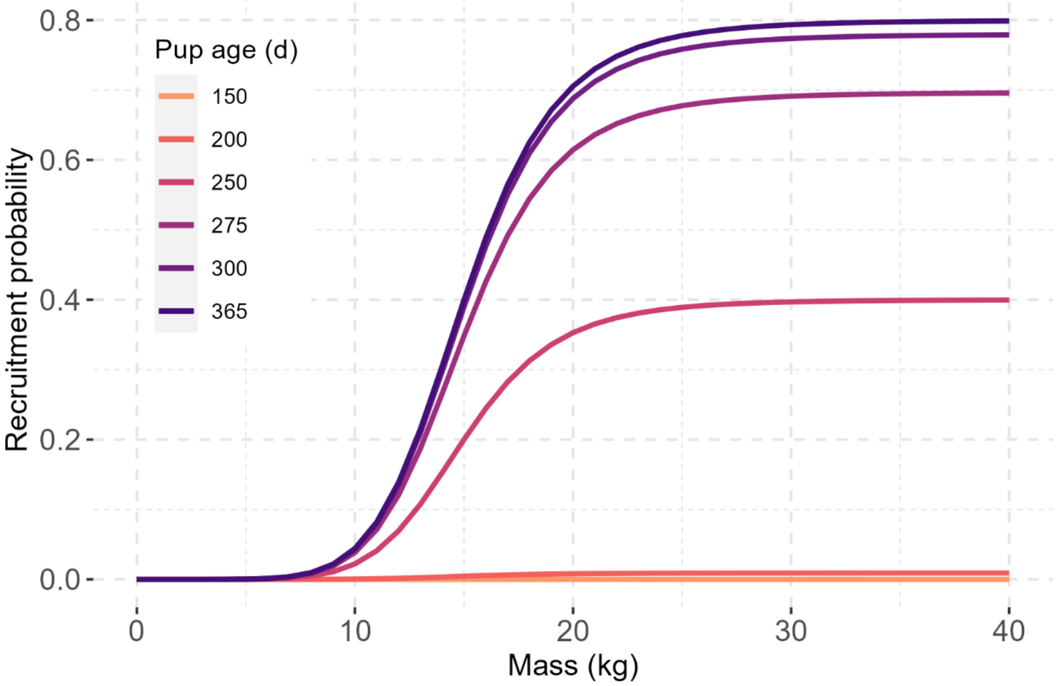
where $\phi_{P\ or\ J}\left(x_{P\ or\ J}\right)$ is the probability of pup or juvenile recruitment into the population as an adult as a function of mass at weaning $x_{P\ or\ J}$ (SM-D Figure 1). Since young pups are still learning to forage and, thus, are unable to sufficiently forage independently, the recruitment probability included an age-specific scalar, such that

$$\phi = \left(\frac{x^{\gamma}}{(x^{\gamma}+x_{50}^{\gamma}} \cdot 0.8\right) \cdot a_{scalar} \tag{24}$$

where x is the mass of the offspring in kg, γ is the scaling exponent for mass (set to 6), x_{50} is the mass in kg at which recruitment probability is 50% (set to 12 kg), 0.8 represents the upper limit on the recruitment probability (i.e. 80%), and a_{scalar} is the age-specific scalar. The age-specific scalar only influences the recruitment of individuals under 10 months old and uses a sigmoidal function under the assumption that offspring under 6 months old would be unable to survive independently ($a_{scalar} = 0$) but pups over 10 months old are fully capable of independence ($a_{scalar} = 1$). Between 6 and 10 months old, the scalar is calculated as

$$a_{scaler} = age^{\zeta}/(age^{\zeta} + \omega^{\zeta}) \tag{25}$$

where age is the age of the offspring in days, ζ is the scaling exponent for age, and ω is the age at which the pup is assumed to have reached an independence level of 50%. Here, ζ is 20 and ω is 250 days old. The influence of the scalar on the recruitment probability can be seen in SM-D Figure 1.



SM-D Figure 1. Fitness function based on the probability of offspring recruitment as a function of mass and age at weaning for simulated Australian fur seals pups.

If at any time a pup's (or juvenile's) mass fell below the critical level (SM-A Figure 2), a female's future expected fitness was based on a non-reproductive state. If at any time a female's future mass fell below the critical level, her fitness was based on the survival probability of her pup/juvenile given its mass (and age) at the time of the female's death.

In the case of fitness outcomes being equal, we assumed a female will choose the less energetically expensive reproductive state (i.e. if the fitness of lactating and being non-reproductive are identical, then a female should choose the non-reproductive state). Where fitness ties were associated with the location of the female (i.e. land vs sea), which only occurred in non-lactating individuals, the optimal location was set to 'either' to allow for random assignment in the forward simulation. Thus, individuals on land had a 50% chance of remaining on land and 50% chance of going to sea, while individuals at sea had a 50% chance of remaining at sea and 50% chance of going to land. This was done to avoid all females in a particular condition behaving identically.

Non-reproductive females (State 1)

We do not inherently model the behaviour of non-reproductive females between the time of the last possible implantation and senescence since the future expected fitness of all behaviours is 0. For all other times $< T$, except the time of implantation, the fitness of a non-reproductive female on land is

$$F_{1_{Land}}(x_F, t) = \max\left[V_{1_{Rest}}(x_F, t), V_{1_{GoToSea}}(x_F, t)\right] \tag{26}$$

where the right-hand side terms are the fitness values associated with each behavioural decision, whereby $V_{1_{Rest}}(x_F, t)$ is the fitness associated with resting on land and $V_{1_{GoToSea}}(x_F, t)$ is the fitness associated with going to sea to forage, such that

$$V_{1_{Rest}}(x_F, t) = e^{-\beta_{Land}} F_{1_{Land}}(x'_F, t+1) \tag{27}$$

$$V_{1_{GoToSea}}(x_F, t) = e^{-\beta_{Sea}}[\lambda F_{1_{Sea}}(x'_F, t+1) + (1-\lambda) F_{1_{Sea}}(x''_F, t+1)] \tag{28}$$

where β_{Land} is the mortality associated with being on land, $e^{-\beta_{Land}}$ is the daily probability of survival on land, β_{Sea} is the mortality associated with being at sea (i.e. due to predation), $e^{-\beta_{Sea}}$ is the daily probability of survival at sea, λ is the probability of finding prey, x'_F is the new fat mass if prey is found and x''_F is the new fat mass if prey is not found.

Similarly, the fitness of a non-reproductive female at sea is

$$F_{1_{Sea}}(x_F, t) = \max\left[V_{1_{Forage}}(x_F, t), V_{1_{GoToLand}}(x_F, t)\right] \tag{29}$$

where $V_{1_{GoToLand}}(x_F, t)$ is the fitness associated with going to land to rest, calculated the same as $V_{1_{Rest}}(x_F, t)$ in Eq. 27, and $V_{1_{Forage}}(x_F, t)$ is the fitness associated with foraging at sea, calculated the same as $V_{1_{GoToSea}}(x_F, t)$ in Eq. 28, such that

$$V_{1_{GoToLand}}(x_F, t) = e^{-\beta_{Land}} F_{1_{Land}}(x'_F, t+1) \tag{30}$$

$$V_{1_{Forage}}(x_F, t) = e^{-\beta_{Sea}}[\lambda F_{1_{Sea}}(x'_F, t+1) + (1-\lambda) F_{1_{Sea}}(x''_F, t+1)] \tag{31}$$

At the time of implantation, t_I, a non-reproductive female can choose to implant and transition to State 2 (pregnant) such that a female on land and at sea have the expected fitness

$$F_{1_{Land}}(x_F, t_I) = \max[\max\left[V_{1_{Rest}}(x_F, t), V_{1_{GoToSea}}(x_F, t)\right], F_{2_{Land}}(x_F, t_I)] \tag{32}$$

and

$$F_{1_{Sea}}(x_F, t_I) = \max[\max\left[V_{1_{Forage}}(x_F, t), V_{1_{GoToLand}}(x_F, t)\right], F_{2_{Sea}}(x_F, t_I)] \tag{33}$$

where $F_{2_{Land}}(x_F, t)$ is detailed in Eq. 34 and $F_{2_{Sea}}(x_F, t)$ is detailed in Eq. 37.

Pregnant females (State 2)

At any time between the day after implantation and the day before birth, a pregnant female may abort her foetus and return to a non-reproductive state (State 1). The expected fitness of a pregnant female on land is

$$F_{2_{Land}}(x_F, t) = \max\left[\max\left[V_{2_{Rest}}(x_F, t), V_{2_{GoToSea}}(x_F, t)\right], F_{1_{Land}}(x_F, t)\right] \tag{34}$$

where $V_{2_{Rest}}(x_F, t)$ is the fitness associated with resting on land and $V_{2_{Rest}}(x_F, t)$ is the fitness associated with going to sea to forage such that

$$V_{2_{Rest}}(x_F, t) = e^{-\beta_{Land}} F_{2_{Land}}(x_F', t+1) \tag{35}$$

$$V_{2_{GoToSea}}(x_F, t) = e^{-\beta_{Sea}}[\lambda F_{2_{Sea}}(x_F', t+1) + (1-\lambda) F_{2_{Sea}}(x_F'', t+1)] \tag{36}$$

Similarly, the expected fitness for a pregnant female at sea is

$$F_{2_{Sea}}(x_F, t) = \max\left[\max\left[V_{2_{Forage}}(x_F, t), V_{2_{GoToLand}}(x_F, t)\right], F_{1_{Sea}}(x_F, t)\right] \tag{37}$$

where $V_{2_{GoToLand}}(x_F, t)$ is the fitness associated with going to land to rest, calculated as in Eq. 35, and $V_{2_{Forage}}(x_F, t)$ is the fitness associated with foraging at sea, calculated as in Eq. 36, such that

$$V_{2_{GoToLand}}(x_F, t) = e^{-\beta_{Land}} F_{2_{Land}}(x_F', t+1) \tag{38}$$

$$V_{2_{Forage}}(x_F, t) = e^{-\beta_{Sea}}[\lambda F_{2_{Sea}}(x_F', t+1) + (1-\lambda) F_{2_{Sea}}(x_F'', t+1)] \tag{39}$$

At the time of birth, t_B, a female must give birth, regardless of whether she is on land or at sea. Since otariid pups cannot swim at birth, we assume that a female needs to be on land the day of birth for her pup to survive. Hence, we set

$$F_{2_{Land\ or\ Sea}}(x_F, t_B) = \max\left[V_{1_{Sea}}(x_F, t_B), V_{3_{Land}}\left(x_F, x_{P_B}, t_B\right)\right] \tag{40}$$

where x_{P_B} is the average birth mass of 7 kg, $V_{1_{Sea}}(x_F, t_B)$ is the fitness associated with aborting at sea and returning to a non-reproductive state, calculated as in Eq. 28 as

$$V_{1_{Sea}}(x_F, t) = e^{-\beta_{Sea}}[\lambda F_{1_{Sea}}(x_F', t+1) + (1-\lambda) F_{1_{Sea}}(x_F'', t+1)] \tag{41}$$

and $V_{3_{Land}}(x_F, x_{P_B}, t_B)$ is the fitness associated with giving birth on land, detailed in Eq. 45.

Females nursing a pup (State 3)

While otariids typically stay on land provisioning their pup during the perinatal period (approximately 7 d), we have allowed a female to remain on land or go to sea during this period. While the energy dynamics during this perinatal period are different to the rest of lactation, we have not altered the dynamics in this model. A female nursing a pup may choose to wean her pup (State 1) any time between the day of birth and the day before the pup's first birthday such that for all times (excluding the day of implantation) her expected fitness is

$$F_{3_{Land}}(x_F, x_P, t) = \max[\max[V_{3_{Nurse}}(x_F, x_P, t), V_{3_{GoToSea}}(x_F, x_P, t)], F_{1_{Land}}(x_F, t) + \phi_P(x_P)] \tag{42}$$

where $V_{3_{Nurse}}(x_F, x_P, t)$ is the fitness associated with nursing a pup on land and $V_{3_{Nurse}}(x_F, x_P, t)$ is the fitness associated with going to sea to forage while the pup fasts on land, such that

$$V_{3_{Nurse}}(x_F, x_P, t) = e^{-\beta_{Land}} F_{3_{Land}}(x_F', x_P', t+1) \tag{43}$$

$$V_{3_{GoToSea}}(x_F, x_P, t) \tag{44}$$

$$= e^{-\beta_{Sea}}[\lambda F_{3_{Sea}}(x_F', x_P', t+1) + (1-\lambda) F_{3_{Sea}}(x_F'', x_P'', t+1)]$$

and x_P' is the new state of the dependant offspring associated with each behaviour. Similarly, the fitness of a female in State 3 while at sea is

$$F_{3_{Sea}}(x_F, x_P, t) = \max\left[\max[V_{3_{Forage}}(x_F, x_P, t), V_{3_{GoToLand}}(x_F, x_P, t)], F_{1_{Sea}}(x_F, t) + \phi_P(x_P)\right] \tag{44}$$

where $V_{3_{GoToLand}}(x_F, x_P, t)$ is the fitness associated with going to land to nurse their pup, calculated as in Eq. 43, and $V_{3_{Forage}}(x_F, x_P, t)$ is the fitness associated with foraging at sea while their pup fasts on land, calculated as in Eq. 44, such that

$$V_{3_{GoToLand}}(x_F, x_P, t) = e^{-\beta_{Land}} F_{3_{Land}}(x_F', x_P', t+1) \tag{45}$$

$$V_{3_{Forage}}(x_F, x_P, t) = e^{-\beta_{Sea}}[\lambda F_{3_{Sea}}(x_F', x_P', t+1) + (1-\lambda) F_{3_{Sea}}(x_F'', x_P'', t+1)] \tag{46}$$

At the time of implantation, a female in State 3 could continue nursing and not implant (State 3), wean her dependant offspring and not implant (State 1), wean her dependant offspring and implant (State 2), or implant and continue nursing her pup (State 5). Thus, the expected fitness of a lactating female on land is

$$F_{3_{Land}}(x_F, x_P, t_I) = \max\begin{cases} \max\left[V_{3_{Nurse}}(x_F, x_P, t_I), V_{3_{GoToSea}}(x_F, x_P, t_I)\right], & F_{1_{Land}}(x_F, t_I) + \phi_P(x_P), \\ F_{2_{Land}}(x_F, t_I) + \phi_P(x_P), & F_{5_{Land}}(x_F, x_P, t_I) \end{cases} \tag{47}$$

where $F_{5_{Land}}(x_F, x_P, t_I)$ is detailed in Eq. 51.

Similarly, the expected fitness of a lactating female at sea is

$$F_{3_{Sea}}(x_F, x_P, t_I) = \max\begin{cases} \max\left[V_{3_{Forage}}(x_F, x_P, t_I), V_{3_{GoToLand}}(x_F, x_P, t_I)\right], & F_{1_{Sea}}(x_F, t_I) + \phi_P(x_P), \\ F_{2_{Sea}}(x_F, t_I) + \phi_P(x_P), & F_{5_{Sea}}(x_F, x_P, t_I) \end{cases} \tag{48}$$

where $F_{5_{Sea}}(x_F, x_P, t_I)$ is detailed in Eq. 54.

At the time of birth in the following year (i.e. the pup’s first birthday), a female may decide to wean her pup (State 1) or continue nursing her offspring as a juvenile (State 4) such that the expected fitness for a female in State 3 is

$$F_{3_{Land\ or\ Sea}}(x_F, x_P, t_B) = \max\left[F_{1_{Land\ or\ Sea}}(x_F, t_B) + \phi_P(x_P), F_{4_{Land\ or\ Sea}}\left(x_F, x_J, t_B\right)\right] \tag{49}$$

where $F_{4_{Land\ or\ Sea}}\left(x_F, x_J, t_B\right)$ represents the fitness of continuing to nurse her offspring as a juvenile.

Females nursing a juvenile (State 4)

A female nursing a juvenile may choose to wean that juvenile any time between their first birthday and the day before the juvenile's second birthday. Thus, her expected fitness for all times except the day of implantation can be calculated as for a female nursing a pup (Eq. 42-46) with the substitution of x_P and $\phi_P(x_P)$ with x_J and $\phi_J(x_J)$, respectively.

At the next possible time of implantation, a female nursing a juvenile could continue nursing (State 4), wean the juvenile (State 1), wean juvenile and implant (State 2), or may implant and continue nursing the juvenile (State 6). Thus, the expected fitness of a female in State 4 can be calculated as in Eq. 47-48 with the substitution of State 4 (for State 3) and State 6 (for State 5).

At the time of the juvenile's second birthday, a female must wean the juvenile (State 1) such that the expected fitness for a female in State 4 is

$$F_{4_{Land\ or\ Sea}}(x_F, x_J, t_B) = F_{1_{Land\ or\ Sea}}(x_F, t_B) + \phi_J(x_J) \tag{50}$$

Females nursing a pup and pregnant (State 5)

At any point in time between the time of implantation and the day before the pup's first birthday, a female in State 5 can wean her pup and/or abort her foetus such that

$$F_{5_{Land}}(x_F, x_P, t) \tag{51}$$

$$= \max\begin{cases} \max\left[V_{5_{Nurse}}(x_F, x_P, t), V_{5_{GoToSea}}(x_F, x_P, t)\right], & F_{1_{Land}}(x_F, t) + \phi_P(x_P), \\ F_{2_{Land}}(x_F, t) + \phi_P(x_P), & F_{3_{Land}}(x_F, x_P, t) \end{cases}$$

where $V_{5_{Nurse}}(x_F, x_P, t)$ is the fitness associated with remaining pregnant and nursing a pup on land and $V_{5_{GoToSea}}(x_F, x_P, t)$ is the fitness of remaining pregnant and going to sea to forage, such that

$$V_{5_{Nurse}}(x_F, x_P, t) = e^{-\beta_{Land}} F_{5_{Land}}(x_F', x_P', t+1) \tag{52}$$

$$V_{5_{GoToSea}}(x_F, x_P, t) \tag{53}$$

$$= e^{-\beta_{Sea}}[\lambda F_{5_{Sea}}(x_F', x_P', t+1) + (1-\lambda)F_{5_{Sea}}(x_F'', x_P'', t+1)]$$

Similarly, the expected fitness of a female at sea is

$$F_{5_{Sea}}(x_F, x_P, t) = \max\left\{\begin{matrix}\max\left[V_{5_{Forage}}(x_F, x_P, t), V_{5_{GoToLand}}(x_F, x_P, t)\right], & F_{1_{Sea}}(x_F, t) + \phi_P(x_P), \\ F_{2_{Sea}}(x_F, t) + \phi_P(x_P), & F_{3_{Sea}}(x_F, x_P, t)\end{matrix}\right. \tag{54}$$

where $V_{5_{GoToLand}}(x_F, x_P, t)$ is the fitness associated with remaining pregnant and going to land to nurse a pup, calculated as in Eq. 46, and $V_{5_{Forage}}(x_F, x_P, t)$ is the fitness associated with remaining pregnant and foraging at sea while their pup fasts on land, calculated as in Eq. 47, such that

$$V_{5_{GoToLand}}(x_F, x_P, t) = e^{-\beta_{Land}} F_{5_{Land}}(x_F', x_P', t+1) \tag{55}$$

$$V_{5_{Forage}}(x_F, x_P, t) \tag{56}$$

$$= e^{-\beta_{Sea}}[\lambda F_{5_{Sea}}(x_F', x_P', t+1) + (1-\lambda)F_{5_{Sea}}(x_F'', x_P'', t+1)]$$

At the time of birth and the pup's first birthday, a female in State 5 that is on land may wean her 1 year old pup and give birth (State 3), wean her newborn pup and continue nursing her 1 year old as a juvenile (State 4), or give birth and wean both the newborn pup and 1 year old (State 1) such that her expected fitness is

$$F_{5_{Land}}(x_F, x_P, t_B) = \max\,[F_{1_{Land}}(x_F, t_B) + \phi_P(x_{P_1}) + \phi_P(x_{P_2}), V_{3_{Land}}(x_F, x_{P_2}, t_B) + \phi_P(x_{P_1}), \tag{57}$$

$$F_{4_{Land}}(x_F, x_{P_1}, t_B) + \phi_P(x_{P_2})]$$

where P_1 is the initial pup and P_2 is the newborn pup. Since a female cannot give birth at sea, the expected fitness of a lactating and pregnant female that is at sea at the time of their pup's first birthday is

$$F_{5_{Sea}}(x_F, x_P, t_B) = \max\,[F_{1_{Sea}}(x_F, t_B) + \phi_P(x_{P_1}), V_{3_{Land}}(x_F, x_{P_2}, t_B) + \phi_P(x_{P_1}), \tag{58}$$

$$F_{4_{Sea}}(x_F, x_{P_1}, t_B)]$$

where $F_{1_{Sea}}(x_F, t_B)$ is the fitness associated with weaning their newborn and 1 year old pups, $V_{3_{Land}}(x_F, x_{P_2}, t_B)$ is the fitness associated with giving birth and weaning their 1 year old pup, and $F_{4_{Sea}}(x_F, x_{P_1}, t_B)$ is the fitness associated with weaning their newborn pup and continuing to nurse their 1 year old pup as a juvenile.

Female nursing a juvenile and pregnant (State 6)

Similar to State 5, a female in State 6 may choose to wean the juvenile and/or abort her foetus at any point in time between the time of implantation and the day before the juvenile's second birthday. Her expected fitness can be calculated as in Eq. 51-56 with the substitution of x_P and $\phi_P(x_P)$ with x_J and $\phi_J(x_J)$, respectively.

At the time of birth, a female in State 6 must wean the juvenile, transitioning to State 3 (nursing a pup) or State 1 (non-reproductive). Thus, her expected fitness when on land or at sea are

$$F_{6_{Land}}(x_F, x_J, t_B) = \max\,[F_{1_{Land}}(x_F, t_B) + \phi_J(x_J) + \phi_P(x_P), V_{3_{Land}}(x_F, x_P, t_B) + \phi_J(x_J)] \quad (59)$$

$$F_{6_{Sea}}(x_F, x_J, t_B) = \max\,[F_{1_{Sea}}(x_F, t_B) + \phi_J(x_J), V_{3_{Land}}(x_F, x_P, t_B) + \phi_J(x_J)] \quad (60)$$

If at any time a pup's (or juvenile's) mass fell below the critical level, a female's future expected fitness based on a non-reproductive state. If at any time a female's future mass fell below the critical level, her fitness was based on the survival probability of her pup/juvenile given its mass at the time of the female's death.

Interpolation

The fitness of each decision in the backward component was calculated using interpolation from the fitness arrays. For a non-lactating female, this was calculated as:

$$\mathrm{MD_F} = \mathrm{FM} - floor(\mathrm{FM}) \quad (61)$$

$$\text{Fitness} = \text{MD}_\text{F} \times V\big[[\text{State}]\big][\mathit{ceiling}(\text{FM}), t+1, \text{location}] \\ + (1-\text{MD}_\text{F}) \times V\big[[\text{State}]\big][\mathit{floor}(\text{FM}), t+1, \text{location}] \tag{62}$$

where MD_F is the mass difference between the female mass and the female mass rounded down to the nearest integer and FM is the female mass. Here, state represents non-reproductive (State 1) and pregnant (State 2) females.

For lactating females, the fitness was interpolated as:

$$\text{MD}_\text{F} = \text{FM} - \mathit{floor}(\text{FM}) \tag{63}$$

$$\text{MD}_\text{O} = \text{OM} - \mathit{floor}(\text{OM}) \tag{64}$$

$$\text{Fitness} = (\text{MD}_\text{F} \cdot \text{MD}_\text{O}) \cdot V\big[[\text{State}]\big][\mathit{ceiling}(\text{FM}), \mathit{ceiling}(\text{OM}), t+1, \text{Location}] \\ + \big(\text{MD}_\text{F} \cdot (1-\text{MD}_\text{O})\big) \cdot V\big[[\text{State}]\big][\mathit{ceiling}(\text{FM}), \mathit{floor}(\text{OM}), t+1, \text{Location}] \\ + \big((1-\text{MD}_\text{F}) \cdot \text{MD}_\text{O}\big) \cdot V\big[[\text{State}]\big][\mathit{floor}(\text{FM}), \mathit{ceiling}(\text{OM}), t+1, \text{Location}] \\ + \big((1-\text{MD}_\text{F}) \cdot (1-\text{MD}_\text{O})\big) \cdot V\big[[\text{State}]\big][\mathit{floor}(\text{FM}), \mathit{floor}(\text{OM}), t+1, \text{Location}] \tag{65}$$

where MDO is the mass difference between the offspring mass and the offspring mass rounded down to the nearest integer and OM is the offspring mass. Here, State represents any nursing females (i.e. States 3-6).

Supplementary material E – Forward simulations

Starting population

Simulations were initialised with a stable age structure representing an established population (Gibbens and Arnould, 2009), with a starting population of 500 females excluding their dependent offspring. Females were assigned a reproductive state based on their age following empirical estimates on the prevalence of pregnant and lactating females in the Australian fur seal population (Gibbens et al., 2010). All females under the age of four were set as non-reproductive, since pregnancy cannot commence until after 3 years old due to delayed implantation. Sexually mature females aged 4-5 years old were assigned as either non-reproductive or nursing a pup with a probability of 0.20 and 0.80, respectively. All other sexually mature females were assigned as either non-reproductive, nursing a pup, or nursing a juvenile with a probability of 0.15, 0.80, 0.05, respectively. To minimise the influence of the starting population set-up, the first year of the simulation was excluded from any analyses.

Females started the simulation at their maximum fat mass and offspring masses were drawn from normal distribution using an age-based mean and standard deviation. All new pups were randomly assigned a sex with equal probability of male or female. Individual metabolic rates were drawn from a truncated normal distribution, allowing the metabolic rates to vary between 0.9-1.1 times the standard age- and state-specific metabolic rate.

Recruitment and mortality

When a female pup or juvenile was weaned, a random number was generated between 0-1 and compared with the recruitment probability to determine if the offspring recruited into the population successfully. If the randomly generated number was lower than the recruitment probability, the pup was assumed to survive and recruit into the population. At each timestep, we determined if a female had died from background mortality using the same approach. If the randomly generated number was lower than the age-specific mortality risk for Australian fur seals (SM-C), the female died. If the female had a dependent offspring over 8 months old, the offspring could recruit into the population as described above, otherwise they were removed from the simulation.

Productive areas encountered

Each foraging day, simulated females under baseline conditions encountered four productive foraging areas, with a cumulative probability of capturing prey of 85%. When a female was unsuccessful at a productive area, the energy from this productive area was deducted from the total daily energy intake assuming that all foraging attempts were equivalent. If females were successful foraging at all productive areas, they gained the full amount of energy intake for the day. Four productive areas was selected as this resulted in behaviour that had the best overall agreement with empirical data (Arnould and Hindell, 2001; Arnould and Hindell, 2002; Arnould et al., 2003).

Scenarios

A total of 36 scenarios were simulated to investigate the effects of shifting prey and predation landscapes on the behavioural and reproductive decisions of female Australian fur seals. For details, see *Scenarios* in the *Forward simulations* section of the main text.

Supplementary material F – Summary table of model outputs

SM-F Table 1. Summary of the on land/maternal attendance and foraging trip durations of simulated female Australian fur seals under different prey availability and mortality risk scenarios. Sc. # – scenario number; PPC – probability of prey capture (B – baseline, I – increased, R – reduced); PA – number of productive areas encountered; M – at-sea mortality risk (B – baseline, 10% - 10% higher than on-land risk, 20% - 20% higher than on-land risk). S1 – non-reproductive; S2 – pregnant; S3 – females nursing pups; S5 – females concurrently pregnant and nursing pups. No females nursed juveniles.

Sc. #	PPC	PA	M	S1 – Land (d)	S1 – Sea (d)	S2 – Land (d)	S2 – Sea (d)	S3 – Land (d)	S3 – Sea (d)	S5 – Land (d)	S5 – Sea (d)
1	B	2	B	2.1 ± 6.9	12.4 ± 60.3	1.6 ± 3.4	2.7 ± 4.5	1.4 ± 0.7	3.2 ± 2.8	1.0 ± 0.3	2.6 ± 2.0
2	B	4	B	3.4 ± 11.0	24.4 ± 90.5	2.2 ± 5.2	3.1 ± 5.8	1.3 ± 0.6	2.9 ± 1.8	1.0 ± 0.3	2.5 ± 1.9
3	B	6	B	4.6 ± 13.5	33.4 ± 106.8	2.7 ± 6.3	3.5 ± 6.6	1.3 ± 0.6	2.8 ± 1.5	1.0 ± 0.3	2.5 ± 1.9
4	B	8	B	5.2 ± 14.8	38.3 ± 115.5	3.0 ± 6.8	3.8 ± 7.1	1.3 ± 0.6	2.8 ± 1.4	1.0 ± 0.4	2.5 ± 1.9
5	I	2	B	4.4 ± 13.4	34.0 ± 107.6	2.8 ± 6.5	3.5 ± 6.6	1.3 ± 0.6	2.8 ± 1.5	1.0 ± 0.3	2.5 ± 1.9
6	I	4	B	5.5 ± 15.4	42.6 ± 120.9	3.3 ± 7.3	3.9 ± 7.4	1.3 ± 0.6	2.8 ± 1.4	1.0 ± 0.4	2.5 ± 1.9
7	I	6	B	6.1 ± 16.5	47.1 ± 127.2	3.6 ± 7.8	4.2 ± 7.7	1.3 ± 0.6	2.7 ± 1.3	1.0 ± 0.4	2.5 ± 1.9
8	I	8	B	6.6 ± 17.2	50.3 ± 131.0	3.9 ± 8.2	4.4 ± 8.0	1.3 ± 0.6	2.7 ± 1.3	1.0 ± 0.4	2.5 ± 1.9
9	R	2	B	1.5 ± 3.6	5.9 ± 33.6	1.3 ± 1.8	2.7 ± 3.7	1.6 ± 0.8	4.1 ± 5.0	1.0 ± 0.4	2.6 ± 2.1
10	R	4	B	2.4 ± 8.1	15.0 ± 68.4	1.7 ± 3.8	2.8 ± 4.8	1.4 ± 0.7	3.1 ± 2.4	1.0 ± 0.3	2.5 ± 2.0
11	R	6	B	3.3 ± 10.8	22.9 ± 87.5	2.1 ± 5.0	3.1 ± 5.6	1.4 ± 0.7	2.9 ± 1.9	1.0 ± 0.3	2.5 ± 1.9
12	R	8	B	3.7 ± 11.9	26.2 ± 94.9	2.3 ± 5.4	3.2 ± 6.0	1.3 ± 0.6	2.9 ± 1.7	1.0 ± 0.3	2.5 ± 1.9
13	B	2	10%	2.0 ± 6.7	11.9 ± 58.9	1.6 ± 3.3	2.7 ± 4.4	1.4 ± 0.7	3.2 ± 2.8	1.0 ± 0.3	2.6 ± 2.1
14	B	4	10%	3.3 ± 11.1	24.6 ± 91.6	2.2 ± 5.3	3.1 ± 5.8	1.3 ± 0.6	2.9 ± 1.8	1.0 ± 0.3	2.6 ± 2.0
15	B	6	10%	4.1 ± 12.9	30.7 ± 104.0	2.6 ± 6.1	3.4 ± 6.5	1.3 ± 0.6	2.8 ± 1.6	1.0 ± 0.3	2.5 ± 1.9
16	B	8	10%	4.5 ± 13.9	34.3 ± 110.1	2.7 ± 6.5	3.6 ± 6.8	1.3 ± 0.6	2.8 ± 1.5	1.0 ± 0.3	2.6 ± 1.9
17	I	2	10%	3.6 ± 11.9	28.2 ± 98.9	2.4 ± 5.9	3.3 ± 6.2	1.3 ± 0.6	2.8 ± 1.6	1.0 ± 0.3	2.6 ± 2.0
18	I	4	10%	4.7 ± 14.5	37.6 ± 115.9	3.0 ± 7.0	3.8 ± 7.2	1.3 ± 0.6	2.8 ± 1.4	1.0 ± 0.4	2.6 ± 1.9
19	I	6	10%	5.3 ± 15.3	41.5 ± 120.4	3.3 ± 7.5	4.0 ± 7.5	1.3 ± 0.6	2.8 ± 1.3	1.0 ± 0.4	2.6 ± 1.9

20	I	8	10%	5.6 ± 16.1	44.2 ± 124.9	3.5 ± 7.8	4.1 ± 7.7	1.3 ± 0.6	2.8 ± 1.3	1.0 ± 0.4	2.6 ± 1.9
21	R	2	10%	1.4 ± 3.4	5.6 ± 31.7	1.3 ± 1.7	2.7 ± 3.6	1.6 ± 0.9	4.2 ± 5.1	1.0 ± 0.3	2.7 ± 2.2
22	R	4	10%	2.2 ± 7.6	13.8 ± 65.3	1.6 ± 3.6	2.8 ± 4.6	1.4 ± 0.7	3.1 ± 2.5	1.0 ± 0.3	2.6 ± 2.0
23	R	6	10%	3.0 ± 10.1	20.5 ± 82.9	2.0 ± 4.7	3.0 ± 5.5	1.4 ± 0.7	2.9 ± 1.9	1.0 ± 0.3	2.6 ± 2.0
24	R	8	10%	3.6 ± 11.8	26.1 ± 95.1	2.3 ± 5.4	3.2 ± 6.1	1.3 ± 0.6	2.9 ± 1.7	1.0 ± 0.3	2.6 ± 2.0
25	B	2	20%	1.8 ± 6.2	10.7 ± 55.5	1.5 ± 3.1	2.6 ± 4.3	1.5 ± 0.7	3.3 ± 2.8	1.0 ± 0.3	2.7 ± 2.1
26	B	4	20%	2.8 ± 9.9	20.4 ± 83.7	1.9 ± 4.8	3.0 ± 5.5	1.4 ± 0.7	2.9 ± 1.9	1.0 ± 0.3	2.7 ± 2.0
27	B	6	20%	3.2 ± 11.5	24.9 ± 96.0	2.2 ± 5.6	3.2 ± 6.2	1.3 ± 0.6	2.9 ± 1.6	1.0 ± 0.3	2.7 ± 2.0
28	B	8	20%	3.6 ± 12.5	28.1 ± 101.6	2.4 ± 6.0	3.4 ± 6.5	1.3 ± 0.6	2.8 ± 1.5	1.0 ± 0.3	2.7 ± 2.0
29	I	2	20%	3.1 ± 11.0	24.9 ± 94.1	2.2 ± 5.6	3.2 ± 6.1	1.4 ± 0.6	2.9 ± 1.6	1.0 ± 0.3	2.7 ± 2.0
30	I	4	20%	4.0 ± 13.6	32.8 ± 110.6	2.7 ± 6.7	3.6 ± 7.0	1.3 ± 0.6	2.8 ± 1.4	1.0 ± 0.3	2.7 ± 2.0
31	I	6	20%	4.2 ± 14.1	34.1 ± 113.3	2.8 ± 6.9	3.7 ± 7.2	1.3 ± 0.6	2.8 ± 1.4	1.0 ± 0.3	2.7 ± 2.0
32	I	8	20%	4.5 ± 14.9	37.0 ± 119.1	3.0 ± 7.4	3.8 ± 7.5	1.3 ± 0.6	2.8 ± 1.3	1.0 ± 0.3	2.7 ± 2.0
33	R	2	20%	1.4 ± 3.0	5.5 ± 29.9	1.3 ± 1.6	2.7 ± 3.6	1.6 ± 0.9	4.2 ± 5.1	1.0 ± 0.3	2.8 ± 2.2
34	R	4	20%	1.9 ± 6.8	12.3 ± 60.8	1.5 ± 3.3	2.7 ± 4.5	1.5 ± 0.7	3.2 ± 2.5	1.0 ± 0.3	2.7 ± 2.1
35	R	6	20%	2.5 ± 9.1	17.6 ± 77.5	1.8 ± 4.3	2.9 ± 5.3	1.4 ± 0.7	3.0 ± 2.0	1.0 ± 0.3	2.7 ± 2.0
36	R	8	20%	2.9 ± 10.3	21.3 ± 86.4	2.0 ± 4.8	3.0 ± 5.7	1.4 ± 0.7	2.9 ± 1.8	1.0 ± 0.3	2.7 ± 2.0

SM-F Table 2. Summary of the growth metrics (mean ± SD) from simulated female Australian fur seals under different prey availability and at-sea mortality risk scenarios. Sc. # – scenario number; PPC – probability of prey capture (B – baseline, I – increased, R – reduced); PA – number of productive areas encountered; M – at-sea mortality risk (B – baseline, 10% - 10% higher than on-land risk, 20% - 20% higher than on-land risk). Pup and juvenile metrics are based on dependent offspring. Female and pup mass change were calculated as the total mass change during lactation divided by the duration of lactation.

Sc. #	**PPC**	**PA**	**M**	**Female mass change (g·d-1)**	**Pup growth rate (g·d-1)**	**Pup weaning mass – all (kg)**	**Pup weaning age – all (d)**	**Pup weaning age – weaned (d)**	**Pup weaning mass – weaned (kg)**
1	B	2	B	-10.3 ± 8.4	40.4 ± 24.8	18.5 ± 8.0	184.5 ± 124.8	316.9 ± 13.0	26.6 ± 0.7
2	B	4	B	-7.4 ± 7.3	48.9 ± 22.9	19.1 ± 7.5	189.5 ± 118.0	316.1 ± 12.6	26.6 ± 0.7
3	B	6	B	-6.2 ± 6.7	50.8 ± 21.6	19.5 ± 7.3	194.2 ± 115.6	315.7 ± 13.0	26.5 ± 0.7
4	B	8	B	-5.9 ± 6.4	51.7 ± 20.9	19.6 ± 7.1	194.8 ± 113.7	316.1 ± 12.4	26.6 ± 0.6
5	I	2	B	-6.2 ± 6.7	50.7 ± 21.8	19.4 ± 7.3	193.4 ± 116.0	315.8 ± 12.8	26.6 ± 0.7
6	I	4	B	-5.7 ± 6.2	52.2 ± 21.3	19.9 ± 7.1	199.1 ± 113.2	315.8 ± 12.6	26.6 ± 0.7
7	I	6	B	-5.4 ± 6.1	52.5 ± 21.3	19.9 ± 7.0	198.7 ± 112.5	315.6 ± 13.1	26.6 ± 0.7
8	I	8	B	-5.2 ± 5.9	53.0 ± 21.3	20.1 ± 6.8	200.3 ± 111.6	315.6 ± 13.1	26.6 ± 0.7
9	R	2	B	-15.0 ± 7.8	25.9 ± 24.7	17.6 ± 8.6	174.4 ± 134.0	319.3 ± 11.7	26.6 ± 0.7
10	R	4	B	-9.3 ± 8.1	43.6 ± 24.1	18.8 ± 7.8	186.7 ± 122.0	316.6 ± 12.5	26.6 ± 0.7
11	R	6	B	-7.4 ± 7.4	48.1 ± 22.7	19.0 ± 7.6	190.1 ± 119.0	316.4 ± 12.6	26.6 ± 0.7
12	R	8	B	-7.0 ± 7.1	49.6 ± 22.0	19.3 ± 7.4	192.5 ± 116.8	315.9 ± 12.9	26.6 ± 0.7
13	B	2	10%	-10.7 ± 8.2	41.4 ± 25.4	18.6 ± 7.9	185.1 ± 123.4	317.5 ± 12.0	26.6 ± 0.7
14	B	4	10%	-7.4 ± 7.1	50.3 ± 22.4	19.2 ± 7.4	190.9 ± 117.2	316.0 ± 12.6	26.5 ± 0.7
15	B	6	10%	-6.5 ± 6.7	51.9 ± 21.5	19.6 ± 7.2	195.9 ± 115.3	316.3 ± 12.4	26.5 ± 0.7
16	B	8	10%	-6.2 ± 6.5	52.7 ± 20.8	19.6 ± 7.1	195.9 ± 114.3	315.7 ± 13.2	26.5 ± 0.7
17	I	2	10%	-6.8 ± 6.8	51.4 ± 21.9	19.4 ± 7.3	192.4 ± 116.1	316.4 ± 13.3	26.6 ± 0.7
18	I	4	10%	-6.0 ± 6.2	53.4 ± 20.8	19.9 ± 7.0	198.7 ± 112.9	316.0 ± 12.4	26.6 ± 0.7
19	I	6	10%	-5.7 ± 6.0	54.0 ± 20.8	20.0 ± 6.9	199.4 ± 112.0	315.7 ± 13.0	26.6 ± 0.7
20	I	8	10%	-5.6 ± 6.0	54.1 ± 20.5	20.1 ± 6.8	201.2 ± 111.0	315.4 ± 13.1	26.6 ± 0.7

21	R	2	10%	-15.3 ± 7.6	25.5 ± 24.7	17.6 ± 8.6	173.5 ± 133.5	319.1 ± 11.9	26.6 ± 0.8
22	R	4	10%	-9.8 ± 8.1	43.9 ± 24.2	18.7 ± 7.8	186.2 ± 121.9	317.2 ± 12.6	26.6 ± 0.7
23	R	6	10%	-7.9 ± 7.3	48.7 ± 22.5	19.1 ± 7.5	190.9 ± 118.9	316.0 ± 12.9	26.5 ± 0.7
24	R	8	10%	-7.1 ± 6.9	51.0 ± 21.8	19.4 ± 7.3	193.1 ± 115.6	316.2 ± 12.4	26.6 ± 0.7
25	B	2	20%	-11.3 ± 8.0	42.0 ± 25.2	18.7 ± 7.9	185.4 ± 123.4	317.6 ± 12.5	26.6 ± 0.7
26	B	4	20%	-8.2 ± 7.1	51.7 ± 21.8	19.3 ± 7.4	191.6 ± 117.3	316.2 ± 12.8	26.6 ± 0.8
27	B	6	20%	-7.2 ± 6.6	53.8 ± 20.3	19.7 ± 7.1	196.6 ± 114.7	316.3 ± 12.8	26.5 ± 0.8
28	B	8	20%	-6.9 ± 6.4	54.6 ± 20.0	19.9 ± 7.1	198.5 ± 113.8	316.7 ± 12.5	26.6 ± 0.7
29	I	2	20%	-7.4 ± 6.6	53.6 ± 21.2	19.7 ± 7.3	196.4 ± 115.9	316.5 ± 12.7	26.6 ± 0.7
30	I	4	20%	-6.5 ± 6.1	55.7 ± 19.7	19.9 ± 7.0	198.5 ± 113.5	316.1 ± 12.7	26.6 ± 0.7
31	I	6	20%	-6.4 ± 6.0	56.0 ± 19.2	20.1 ± 6.8	200.7 ± 111.9	316.3 ± 12.2	26.6 ± 0.7
32	I	8	20%	-6.2 ± 5.9	56.1 ± 19.2	20.3 ± 6.7	202.4 ± 111.1	316.4 ± 12.9	26.6 ± 0.7
33	R	2	20%	-15.6 ± 7.2	25.5 ± 24.8	17.4 ± 8.6	171.6 ± 133.9	320.0 ± 12.2	26.6 ± 0.8
34	R	4	20%	-10.5 ± 7.8	44.9 ± 25.0	18.8 ± 7.8	186.8 ± 122.4	317.5 ± 11.9	26.6 ± 0.7
35	R	6	20%	-8.6 ± 7.3	50.2 ± 22.1	19.2 ± 7.5	190.7 ± 118.5	317.0 ± 12.5	26.6 ± 0.7
36	R	8	20%	-7.9 ± 6.9	52.4 ± 22.0	19.4 ± 7.3	193.2 ± 116.6	316.6 ± 12.7	26.6 ± 0.8

SM-F Table 3. Summary of the reproductive rates (mean ± SD) of simulated female Australian fur seals under different prey availability and mortality risk scenarios. Sc. # – scenario number; PPC – probability of prey capture (B – baseline, I – increased, R – reduced); PA – number of productive areas encountered; M – at-sea mortality risk (B – baseline, 10% - 10% higher than on-land risk, 20% - 20% higher than on-land risk). Termination (%) – proportion of pregnancies that were terminated due to maternal death; Concurrent (%) – proportion of adult females that are concurrently lactating and pregnant; Pup loss (%) – proportion of pups that are lost due to maternal death; Recruit to 1Y (%) – proportion of pups that recruit into the population at the time of weaning; and Recruit to 3Y (%) – proportion of pups that are still alive at 3 years old.

Sc. #	PPC	PA	M	Pregnancy (%)	Abortion (%)	Termination (%)	Nursing (%)	Concurrent (%)	Abandoned (%)	Pup loss (%)	Recruit to 1Y (%)	Recruit to 3Y (%)
1	B	2	B	95.4 ± 1.1	0.0 ± 0.1	8.9 ± 1.6	99.9 ± 0.2	57.7 ± 14.7	39.0 ± 15.4	6.3 ± 1.8	43.2 ± 11.6	12.8 ± 3.7
2	B	4	B	95.5 ± 1.0	0.0 ± 0.1	8.8 ± 1.7	99.9 ± 0.2	78.1 ± 8.6	17.8 ± 8.6	8.5 ± 1.8	58.3 ± 6.7	18.2 ± 2.8
3	B	6	B	95.7 ± 1.0	0.0 ± 0.1	8.4 ± 1.5	99.9 ± 0.1	84.8 ± 6.0	10.9 ± 6.1	8.7 ± 1.8	63.0 ± 5.2	20.6 ± 2.2
4	B	8	B	95.8 ± 0.9	0.0 ± 0.1	8.9 ± 0.7	99.9 ± 0.1	87.9 ± 4.9	8.0 ± 4.7	9.2 ± 0.8	65.2 ± 4.7	21.0 ± 2.3
5	I	2	B	95.7 ± 1.0	0.0 ± 0.1	8.8 ± 1.8	99.9 ± 0.2	85.0 ± 6.4	10.8 ± 6.4	8.8 ± 1.8	63.7 ± 5.8	20.5 ± 2.6
6	I	4	B	95.8 ± 0.9	0.0 ± 0.1	8.6 ± 0.5	99.9 ± 0.1	89.5 ± 4.2	6.2 ± 4.0	9.4 ± 0.8	66.8 ± 4.4	21.4 ± 2.3
7	I	6	B	95.9 ± 1.0	0.0 ± 0.1	8.5 ± 1.5	99.9 ± 0.1	91.2 ± 3.6	4.6 ± 3.2	9.3 ± 1.8	67.7 ± 3.7	22.3 ± 2.3
8	I	8	B	95.8 ± 1.0	0.0 ± 0.1	8.4 ± 1.5	99.9 ± 0.1	92.3 ± 2.7	3.3 ± 2.4	9.3 ± 1.8	69.1 ± 3.2	22.5 ± 2.2
9	R	2	B	94.6 ± 1.6	0.0 ± 0.1	11.2 ± 1.7	99.9 ± 0.2	27.4 ± 14.1	69.9 ± 14.6	4.4 ± 1.11	20.4 ± 10.7	5.3 ± 2.6
10	R	4	B	95.4 ± 1.0	0.0 ± 0.1	9.1 ± 1.4	99.9 ± 0.2	64.7 ± 12.9	31.6 ± 13.2	7.3 ± 1.9	48.0 ± 10.0	14.3 ± 2.7
11	R	6	B	95.6 ± 1.0	0.0 ± 0.1	8.8 ± 1.5	99.9 ± 0.2	76.4 ± 10.0	19.6 ± 10.2	8.0 ± 1.8	57.1 ± 8.3	18.4 ± 2.8
12	R	8	B	95.4 ± 1.1	0.0 ± 0.1	8.7 ± 1.6	99.9 ± 0.2	80.3 ± 8.2	15.3 ± 8.2	8.7 ± 1.8	60.1 ± 7.0	18.9 ± 3.0
13	B	2	10%	94.1 ± 1.5	0.0 ± 0.1	11.3 ± 1.5	99.9 ± 0.2	57.9 ± 14.0	37.6 ± 14.6	8.5 ± 1.11	42.8 ± 10.7	11.0 ± 2.8
14	B	4	10%	94.5 ± 1.2	0.0 ± 0.1	10.8 ± 1.0	99.9 ± 0.2	78.9 ± 8.7	15.8 ± 8.8	10.5 ± 1.10	58.4 ± 7.4	16.9 ± 2.9
15	B	6	10%	94.7 ± 1.1	0.0 ± 0.1	10.3 ± 1.7	99.9 ± 0.2	84.1 ± 6.5	10.7 ± 6.4	10.7 ± 1.10	61.9 ± 5.3	18.3 ± 2.4
16	B	8	10%	94.7 ± 1.4	0.0 ± 0.1	10.5 ± 1.8	99.9 ± 0.2	86.3 ± 5.0	8.2 ± 4.8	11.2 ± 1.10	64.0 ± 5.0	18.7 ± 2.6
17	I	2	10%	94.5 ± 1.3	0.0 ± 0.1	10.5 ± 1.7	99.9 ± 0.2	82.1 ± 6.9	12.5 ± 6.8	11.0 ± 1.10	60.8 ± 5.3	17.4 ± 2.5
18	I	4	10%	94.9 ± 1.2	0.0 ± 0.1	10.5 ± 1.8	99.9 ± 0.2	88.4 ± 4.3	6.3 ± 4.1	11.6 ± 1.10	64.3 ± 3.9	18.6 ± 2.4

19	I	6	10%	94.6 ± 1.4	0.0 ± 0.1	10.5 ± 1.9	99.9 ± 0.2	89.6 ± 3.9	4.6 ± 3.4	12.0 ± 1.10	65.6 ± 3.7	19.2 ± 2.3
20	I	8	10%	94.9 ± 1.2	0.0 ± 0.1	10.8 ± 1.8	99.9 ± 0.2	90.8 ± 3.3	3.9 ± 2.8	11.7 ± 1.10	67.3 ± 3.4	19.9 ± 2.5
21	R	2	10%	93.7 ± 1.7	0.0 ± 0.1	12.8 ± 1.9	99.9 ± 0.3	26.4 ± 13.4	70.5 ± 14.3	5.0 ± 1.12	19.1 ± 9.7	4.6 ± 2.3
22	R	4	10%	94.5 ± 1.3	0.0 ± 0.1	11.0 ± 1.8	99.9 ± 0.2	63.3 ± 13.9	32.2 ± 14.1	8.8 ± 1.11	47.0 ± 10.9	12.9 ± 2.8
23	R	6	10%	94.6 ± 1.2	0.0 ± 0.1	10.6 ± 1.3	99.9 ± 0.2	75.4 ± 9.7	19.7 ± 9.8	10.0 ± 1.10	55.6 ± 7.5	15.7 ± 2.3
24	R	8	10%	94.6 ± 1.1	0.0 ± 0.1	10.7 ± 1.9	99.9 ± 0.2	81.2 ± 7.5	13.7 ± 7.5	10.9 ± 1.10	59.5 ± 6.5	17.1 ± 2.7
25	B	2	20%	92.0 ± 1.6	0.0 ± 0.1	15.3 ± 1.9	99.9 ± 0.2	57.9 ± 15.1	36.0 ± 15.7	11.6 ± 1.15	41.2 ± 11.3	8.9 ± 2.5
26	B	4	20%	92.6 ± 1.8	0.0 ± 0.0	14.7 ± 1.5	100.0 ± 0.2	76.6 ± 8.3	16.4 ± 9.0	14.3 ± 1.14	54.8 ± 6.8	13.1 ± 2.4
27	B	6	20%	92.8 ± 1.8	0.0 ± 0.2	14.5 ± 1.7	99.8 ± 0.3	82.5 ± 6.3	10.2 ± 6.4	15.0 ± 1.14	59.8 ± 5.8	14.0 ± 2.6
28	B	8	20%	93.0 ± 1.4	0.0 ± 0.1	14.6 ± 1.7	99.9 ± 0.2	84.3 ± 5.4	8.4 ± 5.3	15.4 ± 1.14	60.7 ± 5.1	14.6 ± 2.3
29	I	2	20%	92.9 ± 1.8	0.0 ± 0.1	14.4 ± 1.7	99.8 ± 0.3	82.0 ± 6.8	11.0 ± 6.7	14.7 ± 1.14	58.9 ± 6.0	13.6 ± 2.4
30	I	4	20%	92.9 ± 1.6	0.0 ± 0.1	14.3 ± 1.6	99.9 ± 0.2	86.6 ± 3.9	5.9 ± 3.7	15.9 ± 1.14	61.7 ± 4.2	15.1 ± 2.7
31	I	6	20%	93.3 ± 1.9	0.0 ± 0.1	14.7 ± 1.4	99.9 ± 0.2	87.9 ± 3.7	5.1 ± 3.2	15.9 ± 1.14	62.0 ± 3.8	14.9 ± 2.4
32	I	8	20%	93.1 ± 1.6	0.0 ± 0.1	14.3 ± 1.7	99.9 ± 0.2	88.8 ± 3.2	3.8 ± 2.8	15.9 ± 1.14	63.7 ± 4.3	16.1 ± 2.5
33	R	2	20%	91.5 ± 2.4	0.0 ± 0.0	16.5 ± 2.4	99.9 ± 0.4	26.7 ± 13.5	69.3 ± 14.4	6.5 ± 2.16	18.8 ± 9.5	3.2 ± 1.8
34	R	4	20%	92.4 ± 1.9	0.0 ± 0.1	15.3 ± 1.9	99.9 ± 0.3	63.3 ± 13.6	30.4 ± 14.0	12.6 ± 1.15	45.0 ± 10.2	9.6 ± 2.7
35	R	6	20%	92.7 ± 2.1	0.0 ± 0.1	14.9 ± 2.1	99.9 ± 0.3	74.1 ± 9.4	19.3 ± 9.9	13.8 ± 2.14	52.8 ± 7.2	12.5 ± 2.9
36	R	8	20%	92.6 ± 1.8	0.0 ± 0.1	14.3 ± 1.3	99.9 ± 0.2	78.2 ± 8.4	14.7 ± 8.1	14.6 ± 1.14	56.0 ± 6.7	13.3 ± 2.8

Supplementary material G – Sensitivity analysis

Due to uncertainty in some of the parameters used in the model simulations, sensitivity analyses were performed to determine whether any parameters were having undue influence of model outputs. Sensitivity analyses were conducted using the Cohen's *d* statistic. Cohen's *d* calculates the difference between means in the baseline and modified scenarios scaled by their pooled standard deviation (Cohen, 2013). Values of Cohen's *d* of 0.2, 0.5 and 0.8 were taken to indicate small, moderate, and large effect sizes, respectively (Cohen, 2013).

Metabolic rates

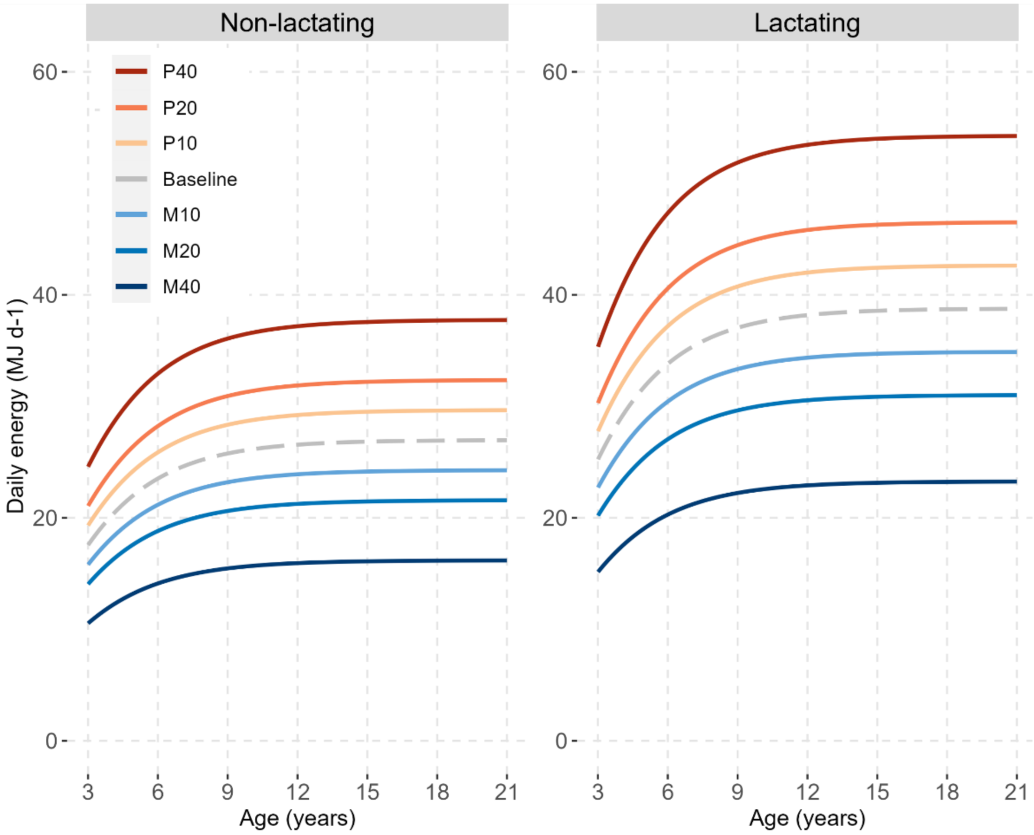
Adult female, juvenile, and pup metabolic rates were varied by ±10%, ±20% and ±40% from the metabolic rates used in the model simulations (SM-G Figure 1 & 2).

Recruitment function

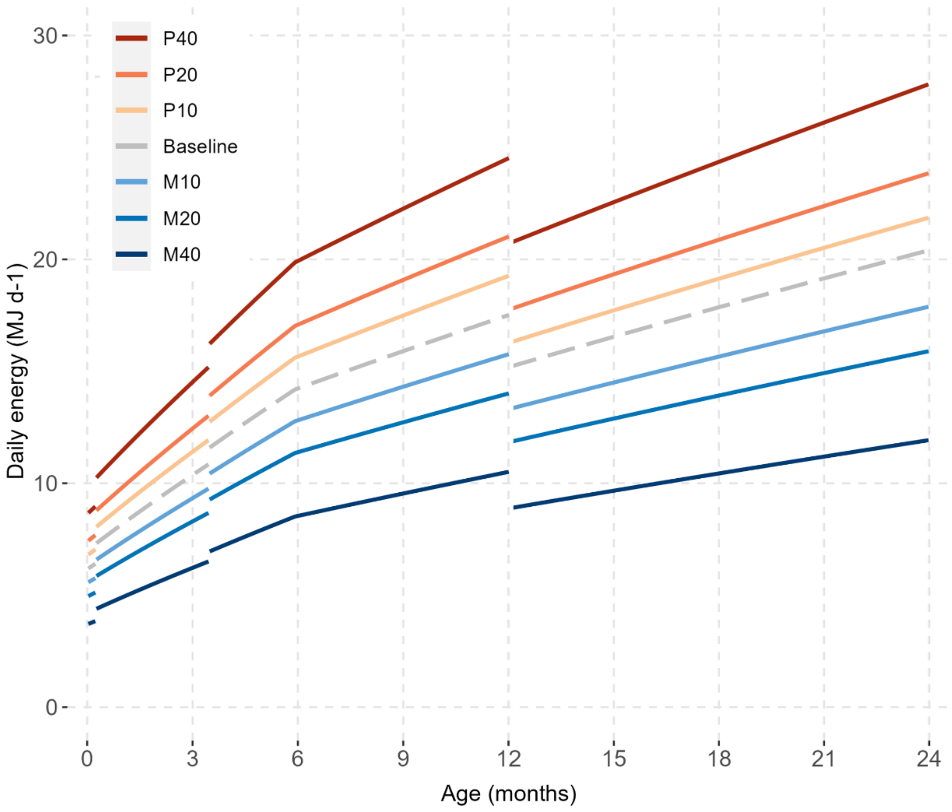
The recruitment function was varied to change the shape and slope of the recruitment function. Recruitment slopes followed the sigmoidal form:

$$Rec = \frac{m^{\gamma}}{m^{\gamma} + x_{50}^{\gamma}} \tag{66}$$

where m is the mass at weaning, γ is the exponent and x_{50} is the mass that results in a 50% probability of survival. The values used in the baseline scenario and sensitivity analysis are found in SM-G Table 1. The shape of the recruitment curve was investigated including shallower and steeper slopes (SM-G Figure 3).



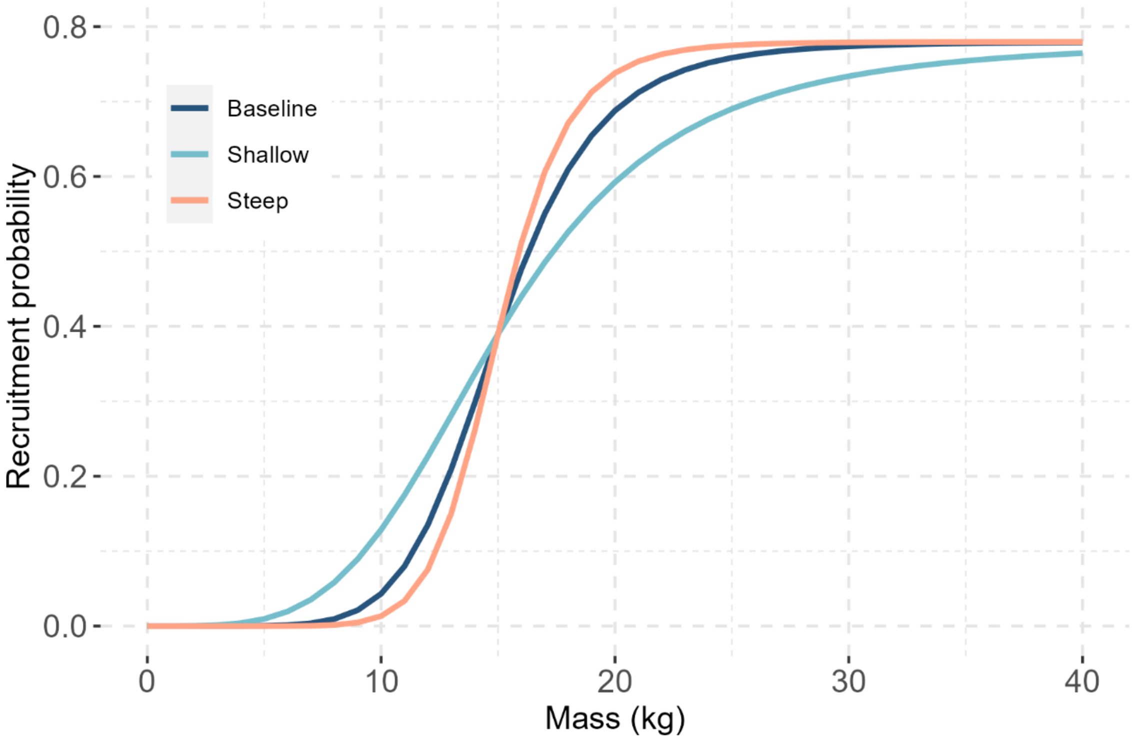
SM-G Figure 1. Metabolic rates used in the sensitivity analyses for non-lactating and lactating adult females.



SM-G Figure 2. Metabolic rates used in the sensitivity analyses for pup (0-12 months) and juveniles (12-24 months).

SM-G Table 1. Values used in the sensitivity analysis for the recruitment curve. γ is the exponent and x_{50} is the mass that results in a 50% probability of survival.

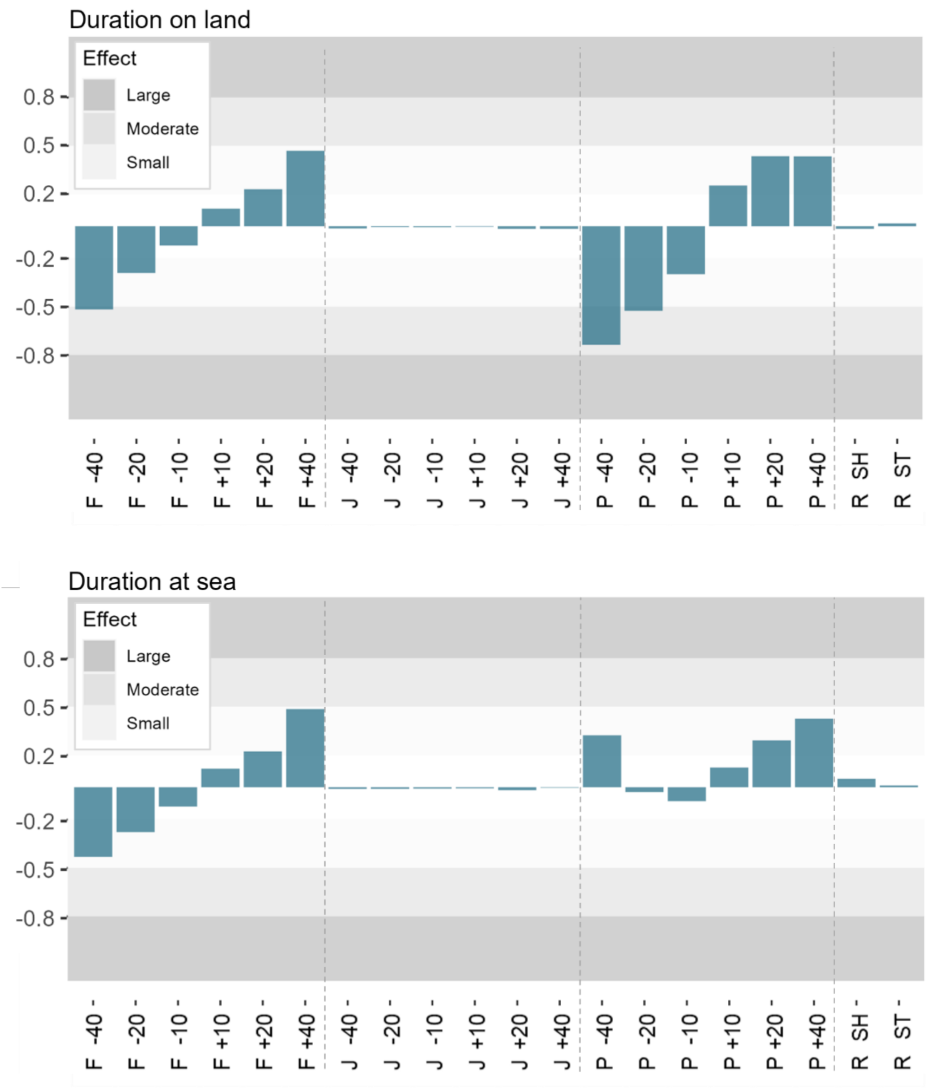
Curve version	γ	x_{50}
Baseline	7	15
Shallow	4	15
Steep	10	15



SM-G Figure 3. Shape of the recruitment curves used in the sensitivity analysis. These curves represent offspring weaning after 10 months of age. See SM-G Table 1 for details on the curve parameters.

Sensitivity analysis results for behavioural decisions

Female and pup metabolic rates had a small to moderate impact on maternal attendance periods and foraging trip durations (SM-G Figure 4; SM-G Table 2).



SM-G Figure 4. Outputs from the sensitivity analysis assessing the effect of metabolic rates and the shape of the recruitment curve on the maternal attendance period (‘Duration on land’; top) and foraging trip durations (‘Duration at sea’; bottom). The modification for the ‘F’, ‘J’ and ‘P’ refer to changes in adult female, juvenile, and pup metabolic rates, respectively. ‘-40’, ‘-20’ and ‘-10’ represent a reduction by 40%, 20% and 10%, respectively. ‘+10’, ‘+20’ and ‘+40’ represent an increase by 10%, 20% and 40%, respectively. ‘R SH’ is the shallow recruitment curve and ‘R ST’ is the steep recruitment curve.

SM-G Table 2. The change in maternal attendance period ('Duration on land') and foraging trip duration ('Duration at sea') under reduced and increased female and pup metabolic rates from the baseline parameterization. 'F -40' represents a 40% reduction in female metabolic rates; 'F +40' represents a 40% increase in female metabolic rates; 'P -40' represents a 40% reduction in pup metabolic rates; and 'P +40' represents a 40% increase in pup metabolic rates.

	F -40	**F +40**	**P -40**	**P +40**
Duration on land (d)	-0.3	+0.4	-0.4	+0.4
Duration at sea (d)	-0.7	+1.2	+0.6	+1.3

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