Supplementary Material—Evaluating Resighting Probabilities

Cormack-Jolly-Seber (CJS) models were fitted to the 2012-2019 capture histories of translocated and control group Hawaiian monk seals with the primary objective of evaluating resighting probabilities, and particularly to assess the likelihood that all seals which survived to age two years were detected at that age or older. Models were fitted using Program MARK (White & Burnham, 1999) with RMark (Laake, 2013) as an interface. Factors known (from Baker & Thompson, 2007) to influence Hawaiian monk seal survival (age, subpopulation, time) and resighting probabilities (subpopulation, time) were included in candidate models. Model selection was based on small sample Akaike Information Criterion (AIC_c) (Table S1).

Table S1. Model selection results. Model specification indicates which factors (age, subpopulation, time) were included for apparent survival (ϕ) and resighting probability (p) parameters. "+" indicates additive effects, "*" indicates interactions among factors and "*p*." indicates a single, constant resighting probability was fitted. Models are ranked by AIC_c.

Model	AIC_c	ΔAIC_c	*Number of Parameters*
$\phi_{age+subpopulation}$, $p.$	550.10	--	12
$\phi_{age+subpopulation}$, p_{time}	552.13	2.03	18
$\phi_{age+subpopulation}$, $p_{subpopulation}$	555.31	5.21	16
ϕ_{age}, $p.$	556.14	6.04	8
$\phi_{age*subpopulation}$, $p.$	556.91	6.81	30
ϕ_{age}, p_{time}	557.90	7.80	14
$\phi_{age*subpopulation}$, p_{time}	559.24	9.14	36
$\phi_{age*subpopulation}$, $p_{subpopulation}$	562.56	12.46	34
$\phi_{age*subpopulation*time}$, $p.$	706.70	156.60	99

The top-ranked model had a single, constant resighting parameter and the second ranked model had time-varying resighting parameters. Both models had survival rates varying by age with an additive subpopulation effect. Figure S1 shows the survival rate estimates from the top-ranked model. The resighting rate was estimated to be 0.992 (95% confidence interval 0.980 – 0.997).

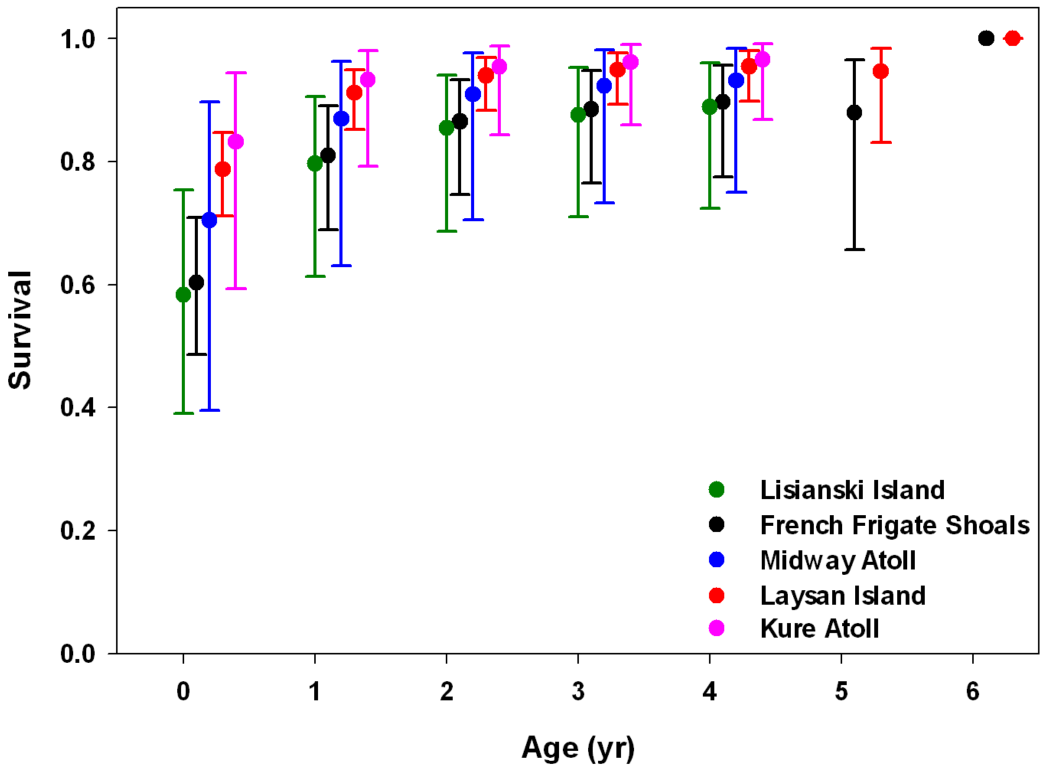

Figure S1. Estimated age-specific survival rates from the top-ranked model in Table S1. Survival rates beyond four years of age were only available for French Frigate Shoals and Laysan Island (between which translocations began in 2012). The remaining subpopulations were only involved in 2014 translocations. Resighting data through 2019 were analyzed.

Our metric for analyzing the efficacy of translocations is survival to two years of age, and this is evaluated according to whether individual seals were resighted at age two years or older. Seals could be erroneously scored if they survived to age two years but were not seen at that age or older. Here we assess the probabilities of capture histories that could represent such errors based on the survival estimates for each subpopulation (Figure S1), and the global estimate of resigthing probability.

For example, the expected probability that a seal with only an initial capture as a pup (age 0) and no resightings in subsequent years actually survived to age two years would be at most:

$$\phi_0 \times (1\text{-}p) \times \phi_1 \times (1\text{-}p) \times (1\text{-}\phi_2).$$

In this scenario, the seal would have survived and been overlooked in its two first years of life, then died between ages two and three years. Substituting supopulation-specific survival rates (Figure S1), the probabilities of this scenario occurring ranges only from 2.3 x 10^{-6} to 4.3 x 10^{-6} at the various subpopulations. All scenarios in which the seal survives unseen to age two years and does not die before age three are even less likely due to the very low probability of not being seen each subsequent year (1-p = 0.008). Of the 183 seal capture histories in this study, 51 were seen only as pups at all subpopulations combined. Multiplying the subpopulation-specific probabilities by the number seen only as pups at each location and summing the products yields

1.7×10^{-4}. That is, the expected number of seals seen only as pups that actually did survival to age two years is very near zero.

A somewhat more likely scenario would involve a seal being resighted at age one year, surviving but not being seen at age two years, and then dying between ages two and three years. Given a seal had survived to age one year, the probability of this scenario is:

$\phi_1 \times (1-p) \times (1-\phi_2)$.

Substituting values from Figure S1 yields a range of probabilities from 3.1×10^{-4} to 9.2×10^{-4} at the various subpopulations. Fifteen of the 183 seals were resighted at age one year and not thereafter. As above, all scenarios in which the seal survives unseen to age two years and does not die before age three are even less likely. As above, multiplying the subpopulation-specific probabilities by the number not seen after age one year at each location and summing the products yields 9.2×10^{-3}. Again, the expected number of seals not resighted after age one year that actually did survived to age two years is very near zero.

Given this study's high annual resighting probability and the multiple years of surveillance, there is very little chance that a seal survived to age two years and was not resighted at that age or older.

References

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White, G.C. & Burnham, K.P. (1999). Program MARK: survival estimation from populations of marked animals. Bird Study **46** (Suppl)**,** 120-139.