The following supplement accompanies the article

Robust assessment of population trends in marine mammals applied to New Caledonian humpback whales

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Marine Ecology Progress Series 515: 265–273 (2014)

Supplement 1. Two-site analysis and simulation details.

Two-site analysis of the New Caledonian humpback whale population

As the goodness-of-fit test of the model ($\phi_1(t)\phi_2(t)$ $p^L(t)$ $p^S(t)$ $\psi^{LS}(t)$ $\psi^{SL}(t)$) correcting for the presence of transients (Pradel et al. 2005) calculated with the program U-CARE (Choquet et al. 2009) indicated no lack of fit ($\chi(41)=28.2$), model selection was based on Akaike's information criterion (AICc) (see Table S2). Given that several models were close, estimates were calculated by model averaging (Table S3). Values were similar for males and females.

Table S1. Notation of parameters and effects in models

	Notation	Descriptions
Parameters	ϕ_1	Apparent survival following initial encounter
	ϕ_2	Later survival (unaffected by the presence of transients)
	ϕ^L	Survival in the southern lagoon
	ϕ^S	Survival in the seamounts
	p^L	Probability of capture in the southern lagoon
	p^S	Probability of capture in the seamounts
	ψ^{LS}	Probability of movement from southern lagoon to the seamounts
	ψ^{SL}	Probability of movement from the seamounts to the southern lagoon
	ρ	Realized population growth rate
Effects	(.)	Constant parameter over time
	(t)	Time varying parameter
	(s)	Parameter function of sex (males vs. females)
	(+)	Additive model
	(*)	Interactive model

Table S2. Two-site model selection for survival, detection, and movement probabilities. This list includes selected models leading to the best supported ones, and is ordered according to the Akaike's Information Criterion (AICc) value. AICc wt: AICc weights. NP: number of identifiable parameters in model. See Table S1 for notations

No.	Model	AIC_c	ΔAIC_c	AIC_cwt	NP	Deviance
1	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\ \psi(.)$	1834.09	0.00	0.31	27	792.13
2	$\phi_1(s)_2(s)\ p^L(s+t)\ p^S(s+t)\ \psi(.)$	1834.70	0.60	0.23	29	788.48
3	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\psi^{LS}(.)\psi^{SL}(.)$	1834.97	0.87	0.20	28	790.87
4	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\ \psi(s)$	1835.67	1.57	0.14	28	791.57
5	$\phi_1(s)_2(s)\ p^L(s+t)\ p^S(s+t)\ \psi^{LS}(.)\psi^{SL}(.)$	1836.69	2.60	0.08	30	788.34
6	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\ \psi^{LS}(s)\ \psi^{SL}(s)$	1837.88	3.79	0.05	30	789.53
7	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\ \psi^{LS}(s+t)\ \psi^{SL}(s+t)$	1850.33	16.23	0.00	60	735.75
8	$\phi_1(s+t)_2(s+t)\ p^L(s+t)\ p^S(s+t)\ \psi(.)$	1855.02	20.93	0.00	58	744.00
9	$\phi_1(t)\phi_2(t)\ p^L(s+t)\ p^S(s+t)\ \psi(.)$	1878.33	44.24	0.00	56	772.84
10	$\phi_1(.)\phi_2(.)\ p^L(s+t)\ p^S(s+t)\ \psi^{LS}(s*t)\ \psi^{SL}(s*t)$	1900.91	66.82	0.00	90	715.47
11	$\phi_1(.)\phi_2(.)\ p^L(t)\ p^S(t)\ \psi^{LS}(s*t)\ \psi^{SL}(s*t)$	1913.20	79.11	0.00	90	727.77
12	$\phi_1(.)\phi_2(.)\ p^L(s*t)\ p^S(s*t)\ \psi^{LS}(s*t)\ \psi^{SL}(s*t)$	1923.13	89.04	0.00	110	687.63
13	$\phi_1^L(.)\ \phi_2^L(.)\ \phi_1^S(.)\ \phi_2^S(.)\ p^L(s*t)\ p^S(s*t)\ \psi^{LS}(s*t)\ \psi^{SL}(s*t)$	1926.69	92.60	0.00	112	686.05
14	$\phi^L(.)\phi^S(.)\ p^L(s*t)\ p^S(s*t)\ \psi^{LS}(s*t)\ \psi^{SL}(s*t)$	1975.17	141.08	0.00	110	739.67

Table S3. Estimates given by the averaging modeling of the multisite models. CI: confidence interval, Wgt. Ave. Est.: weighted average estimate

Parameter	Wgt. Ave. Est	95% CI
ϕ_2	0.93	[0.86;0.96]
ϕ_2	0.94	[0.87;0.98]
ψ^{LS}	0.29	[0.09;0.64]
ψ^{LS}	0.27	[0.08;0.63]
ψ^{SL}	0.47	[0.14;0.83]
ψ^{SL}	0.44	[0.11;0.82]

R scripts for simulations

Scripts are given in .R formats in Supplement 2:

script transience rev 1.R

script multisites rev 1.R

simul 2 sites ref4 exact approach.R

Parameter biases due to transients

Using simulations, we calculated the bias due to the presence of transients in survival, seniority, detection, and population growth rate estimators.

Table S4. Values of bias on parameters estimated with simulated data given different proportions of transients. The biases on the survival parameter (ϕ) and seniority (γ) compensate each other, leading to no bias on ρ estimates. However, there is strong bias on detection parameters in the presence of transients

Transient proportion	ρ.bias	p.bias	ϕ.bias	γ.bias
0.10	0.00	0.02	0.03	0.03
0.20	0.00	0.05	0.06	0.05
0.30	0.00	0.07	0.08	0.08
0.40	0.00	0.10	0.11	0.10
0.50	0.00	0.13	0.13	0.12
0.60	0.00	0.15	0.16	0.15

Parameter biases due to unequal sampling of subsites for ϕ = 0.975

This is a repeat of Fig. 2 of the main article when survival is changed to 0.975 (instead of 0.90).

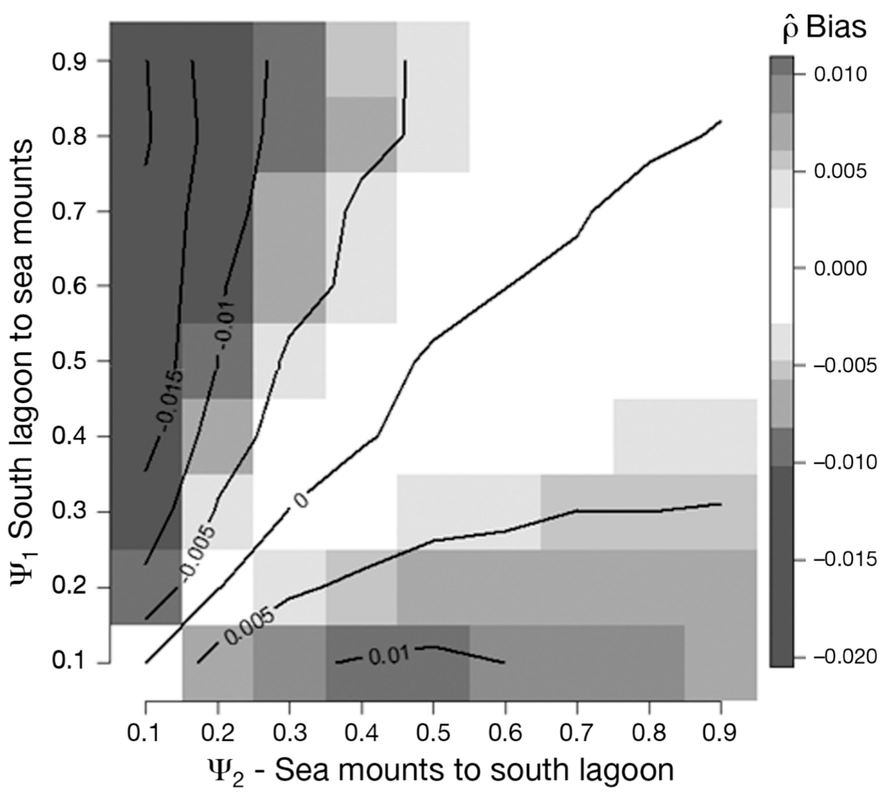

Fig. S1. Absolute bias in growth rate estimation using the constant-parameter Pradel model as a function of movement probabilities (Ψ_1 and Ψ_2) between the 2 sites (Site 1 and Site 2 have a detection probability of 0.3 and 0.1, respectively). Darker colors indicate stronger bias. The 'white zone' illustrates a combination of values of Ψ_1 and Ψ_2 for which the estimation of lambda is unbiased.