Supplementary Material.

Methods S1. Acoustic recording specifics.

Recordings were made with a custom-built stereo hydrophone array (Barlow et al. 2008) on a 50 m cable, deployed while the whale was at the surface and recovered 10 min after fluke-up. The hydrophone elements each contained a 40 dB pre-amplifier with a 3 dB/octave high-pass filter (corner frequency 3.39 kHz) to reduce low-frequency engine and flow noise. While this particular array was not calibrated, an identical array (Barlow et al. 2008) had a reasonably flat frequency response (±3.5 dB) from 5 to 40 kHz. The signal was recorded with a Roland R44 digital recorder, producing high resolution WAV files (sampling rate 96.0 kHz, 16 bit). At Kaikōura, sperm whales usually surface alone, typically spaced more than two kilometres apart. Therefore, there was usually no ambiguity in attributing the recorded clicks to a particular individual. However, if other whales came close to the target whale, the acoustic recording was stopped to avoid other whales being louder than the target whale. Sightings of female sperm whales are extremely rare at Kaikōura (Childerhouse et al. 1995), and no females (body length < 12 m) were encountered during this time. Our study included males only, with all whales being longer than 12.8 m.

Methods S2. Length estimation analysis.

The body lengths of sperm whales were estimated acoustically from the inter-pulse intervals (IPI) within their echolocation clicks. Multiple pulses arise from reflections within the whale's head (Møhl et al. 2003), and so IPI is proportional to total body length (Rhinelander & Dawson 2004, Growcott et al. 2011). This allometric relationship, *total length = 1.258 IPI + 5.736*, was established in previous studies on sperm whales at Kaikōura (Growcott et al. 2011). Recordings were analysed using a Pamguard (v 1.6) IPI plug-in developed by Brian S. Miller, and IPI measurements were calculated as in Miller et al. (2013), using recordings containing a minimum of 100 clicks. This method does not require isolation of on-axis clicks because all analysed clicks are produced by the same individual. Miller et al. (2013) concluded that at least six months between recordings were necessary to detect growth of sperm whales at Kaikōura. Therefore, if an individual whale was recorded multiple times in the same season (<3 months apart), the average total length for that season was calculated based on the available recordings.

There were nine cases in which a whale had been sampled for skin but no acoustic recordings were available for that particular season. In these cases, we extrapolated body length from estimates obtained in the previous or subsequent season, using acoustically derived growth rates specific for the whales at Kaikōura (Miller et al. 2013). Because growth rates vary with body size (Miller et al. 2013), size-specific growth rates (at 1m intervals) were used for this purpose. To quantify extrapolation error, a random selection of 25 acoustically derived lengths was compared with lengths estimated via extrapolation. The resulting error was ±11 cm (SE = 2), or around 0.7% of body length, which was considered acceptable for this study, given that body length estimates ranged between 12.5 and 16 m.

Table S1. Model selection of GAMMs used to explain intra-population variation of $\delta^{13}C$ of sperm whales at Kaikōura. Metrics of model performance (a) and significance of model terms (b) are shown for each model with some support (Akaike weight ≥ 1%). ΔAIC_C = difference in AIC_C score relative to best model in the set; w_i = Akaike weight; Adjusted R^2 = explained variance (by fixed effects only); edf = estimated degrees of freedom; coef. = coefficient; SF = global mean sighting frequency; BL = total body length; (1|ID) = random effect of whale identity; '-' = not applicable.

(a) Model selection table:

Rank	**Model**	**edf**	**ΔAICc**	**w_i (%)**	**Adj. R^2**
1	$\delta^{13}C$ ~ month + SF + (1|ID)	6	0	64	0.41
2	$\delta^{13}C$ ~ month + (1|ID)	4	1.98	24	0.17
3	$\delta^{13}C$ ~ month + SF + skin type + (1|ID)	7	5.22	5	0.40
4	$\delta^{13}C$ ~ month + SF + BL + (1|ID)	8	5.43	4	0.42
5	$\delta^{13}C$ ~ month + skin type + (1|ID)	5	7.07	2	0.15

(b) Significance of terms retained in each model:

Model rank	**Month**		**SF**		**BL**		**Skin type**	
	edf	**p-value**	**edf**	**p-value**	**edf**	**p-value**	**coef.**	**p-value**
1	1.70	<0.001	1.82	0.006	–	–	–	–
2	1.70	<0.001	–	–	–	–	–	–
3	1.69	<0.001	1.81	0.006	–	–	–0.03	0.75
4	1.70	<0.001	1.52	0.005	1.59	0.16	–	–
5	1.69	<0.001	–	–	–	–	–0.02	0.76

Table S2. Model selection of GAMMs used to explain intra-population variation in $\delta^{15}N$ of sperm whales off Kaikōura. Metrics of model performance (a) and significance of model terms (b) are shown for each model with some support (Akaike weight ≥ 1%). ΔAIC_C = difference in AIC_C score relative to best model in the set; w_i = Akaike weight; Adjusted R^2 = explained variance; edf = estimated degrees of freedom; coef. = coefficient; SF = mean sighting frequency; BL = total body length; (1|ID) = random effect of whale identity; '-' = not applicable.

(a) Model selection table:

Rank	**Model**	**edf**	**ΔAICc**	**w_i (%)**	**Adj. R^2**
1	$\delta^{15}N$ ~ SF + (1|ID)	5	0.00	62	0.39
2	$\delta^{15}N$ ~ SF + month + (1|ID)	6	2.29	20	0.39
3	$\delta^{15}N$ ~ SF + skin type + (1|ID)	6	4.00	8	0.38
4	$\delta^{15}N$ ~ SF + month + skin type + (1|ID)	7	6.35	3	0.38
5	$\delta^{15}N$ ~ SF + BL + (1|ID)	7	6.71	2	0.38

(b) Significance of terms retained in each model:

Model rank	**Month**		**SF**		**BL**		**Skin type**	
	edf	**p-value**	**edf**	**p-value**	**edf**	**p-value**	**coef.**	**p-value**
1	–	–	2.25	<0.001	–	–	–	–
2	0.11	0.29	2.25	<0.001	–	–	–	–
3	–	–	2.24	<0.001	–	–	–0.03	0.81
4	0.06	0.30	2.24	<0.001	–	–	–0.03	0.82
5	–	–	2.17	<0.001	1.00	0.73	–	–

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