Lipid normalization and stable isotope discrimination in Pacific walrus tissues

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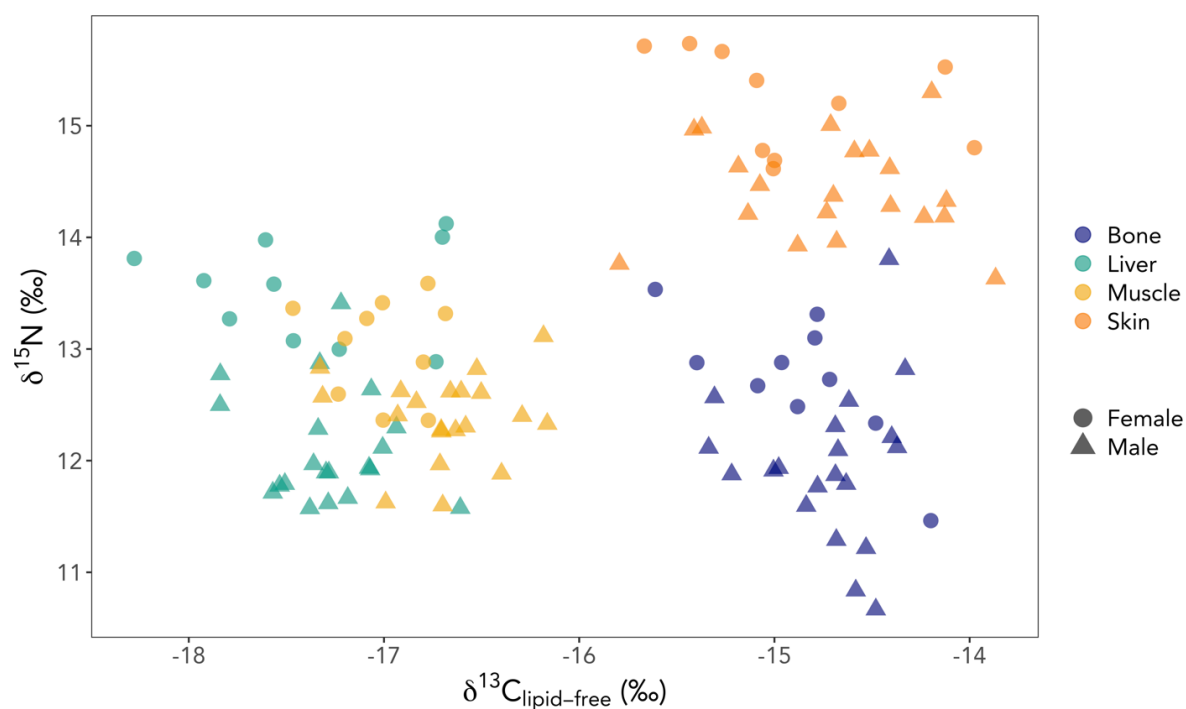

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Supplementary Discussion 1:

Female walrus tissues were only available for 2016, and only 10 of the 30 individuals sampled for this study were female. For these reasons, and because there is no evidence to support the assumption that observed isotopic differences in male and female walrus tissues collected in 2016 will remain constant across seasons, years, and longer timespans, sex was not included as a term in the linear mixed effects models presented in the main text of this paper. Visual analysis of the data, however, revealed that there were consistent $\delta^{13}C_{lipid-free}$ and $\delta^{15}N$ differences between males and females for all tissues examined in this study (Supplementary Discussion Fig. 1). In light of this observation, additional linear mixed effects models were run, including models with terms for sex and an interaction between sex and tissue. Model fit was examined using Akaike's Information Criterion corrected for sample size (AIC_c)[1], as calculated using the AICcmodavg R package[2]. Models were fitted using the R package lme4[3], and *post hoc* pairwise comparison tests were conducted in the lsmeans package in R[4].

Supplementary Discussion Fig. 1) Scatterplot of $\delta^{13}C_{lipid-free}$ and $\delta^{15}N$ for bone (blue), liver (green), muscle (yellow), and skin (orange) from female (circles) and male (triangles) Pacific walruses.

The best fitting model for $\delta^{13}C_{lipid-free}$ included terms for tissue and sex (Supplementary Discussion Table 1). The output from this model indicated that female $\delta^{13}C_{lipid-free}$ values were 0.2 (95% confidence interval [CI]: 0.0 – 0.4) ‰ lower than those of males for all tissues (Supplementary Discussion Table 2). This value is right on the edge of instrumental error (and its confidence interval extends into the range below instrument error), but is consistent across the four tissues examined in this study and likely represents a real difference. For $\delta^{15}N$, the best fitting model included terms for tissue, sex, and an interaction between tissue and sex (Supplementary Discussion Table 1). Male tissue $\delta^{15}N$ values were consistently lower than those

of females (Supplementary Discussion Tables 3). The interaction between sex and tissue appeared to be driven primarily by liver, for which the differences in male and female $\delta^{15}N$ were nearly double those observed in muscle, skin, and bone (Supplementary Discussion Tables 3 & 4).

Supplementary Discussion Table 1) Model selection results for linear mixed effects models testing the effects of tissue type and sex on $\delta^{13}C_{\text{lipid-free}}$ and $\delta^{15}N$ in walrus tissues. Model formula, number of parameters (k), and ΔAIC_c are presented for each model. All models included a random intercept for individual, to account for correlation among stable isotope values for tissues from individual walruses.

$\delta^{13}C_{\text{lipid-free}}$			$\delta^{15}N$		
Model	k	ΔAIC_c	Model	k	ΔAIC_c
~ tissue + sex	7	0.00	~ tissue × sex	10	0.00
~ tissue	6	2.14	~ tissue + sex	7	8.90
~ tissue × sex	10	5.47	~ tissue	6	32.46
Null	3	278.47	Null	3	219.78

Supplementary Discussion Table 2) Coefficient estimates and standard errors for the top-performing linear mixed effects model for $\delta^{13}C_{\text{lipid-free}}$, which included terms for tissue and sex. Coefficient estimates and standard errors for each tissue (muscle, liver, skin, and bone) are presented for females (left two columns) and males (middle two columns). Estimates and 95 % confidence intervals (95 % CI) for the differences between males and females for each tissue are also presented (right two columns). This model also included a random intercept for individual, to account for correlation among stable isotope values for tissues from individual walruses.

	Female $\delta^{13}C_{\text{lipid-free}}$ (‰)		Male $\delta^{13}C_{\text{lipid-free}}$ (‰)		Female – Male $\delta^{13}C_{\text{lipid-free}}$ (‰)	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	95 % CI
Muscle	-16.9	0.1	-16.7	0.1	0.2	0.0 – 0.4
Liver	-17.5	0.1	-17.3	0.1	0.2	0.0 – 0.4
Skin	-14.9	0.1	-14.7	0.1	0.2	0.0 – 0.4
Bone	-14.9	0.1	-14.7	0.1	0.2	0.0 – 0.4

Supplementary Discussion Table 3) Coefficient estimates and standard errors for the top-performing linear mixed effects model for $\delta^{15}N$, which included terms for tissue and sex, and an interaction between tissue and sex. Coefficient estimates and standard errors for each tissue (muscle, liver, skin, and bone) are presented for females (left two columns) and males (right two columns). This model also included a random intercept for individual, to account for correlation among stable isotope values for tissues from individual walruses.

	Female $\delta^{15}N$ (‰)		Male $\delta^{15}N$ (‰)	
	Estimate	Standard Error	Estimate	Standard Error
Muscle	13.0	0.2	12.1	0.2
Liver	13.5	0.2	11.3	0.2
Skin	15.2	0.2	12.0	0.2
Bone	12.7	0.2	12.0	0.2

Supplementary Discussion Table 4) Mean differences (95 % confidence intervals) in tissue $\delta^{15}N$ for female (top, white cells) and male (bottom, gray cells) walruses, as estimated by the linear mixed effects models and *post hoc* tests. Bolded values indicate significant differences (p < 0.05).

	Muscle	Liver	Skin	Bone	Female – Male $\delta^{15}N$ (‰)
			Female $\delta^{15}N$ (‰)		
Muscle	-	0.5 (0.3 – 0.7)	**2.2 (1.8 – 2.6)**	0.3 (0.1 – 0.5)	**0.7 (0.3 – 1.1)**
Liver	0.3 (0.1 – 0.5)	-	**1.7 (1.3 – 2.1)**	**0.8 (0.4 – 1.2)**	**1.4 (1.0 – 1.8)**
Skin	**2.1 (1.9 – 2.3)**	**2.3 (2.1 – 2.5)**	-	**2.5 (2.1 – 2.9)**	**0.8 (0.4 – 1.2)**
Bone	**0.4 (0.2 – 0.6)**	0.2 (0.0 – 0.4)	**2.5 (2.3 – 2.7)**	-	**0.8 (0.4 – 1.2)**
		Male $\delta^{15}N$ (‰)			

Male and female walruses exhibit sex-segregated migration[5]. The entire population winters together in the Bering Sea. In the summer, females and juveniles move northward into the Chukchi Sea, whereas most males move in the coastal waters of the Bering Sea, including Bristol Bay and the Russian coastline. The spatial segregation of male and female walruses for much of the year is likely the major driver of observed differences in $\delta^{13}C_{lipid-free}$ and $\delta^{15}N$ in tissues of males and females. Liver has the fastest turnover rate of the tissues examined[6–9], thus the large difference between male and female liver $\delta^{15}N$ as compared with other tissues analyzed in this study is likely a result of these differences in turnover rate. This is somewhat unexpected, as these animals were harvested in May and June, shortly after males and females had begun to separate and move into different habitats for the summer[5], and both sexes are believed to consume generally the same diet when in the same location[10]. Thus, the large difference in male and female liver $\delta^{15}N$ possibly indicates that the turnover rate of this tissue is slower than expected and liver isotope values still contain a dietary signal reflecting the previous summer when males and females were foraging in different habitats. Alternatively, it might mean that male and female walruses were foraging on different prey while using the same habitat, despite the results of previous studies indicating the contrary. Finally, the difference in liver $\delta^{15}N$ may reflect some other metabolic processes (perhaps associated with fasting or reproductive activities) occurring during the winter months that differ among males and females.

Future research using the tissue-specific discrimination factors presented in this paper could apply the sex-specific discrimination factors in this supplement to known sex animals; however, this should be done with caution. The analyses that examined stable isotope differences between males and females were not included in the main body of the paper because there are a number of caveats that complicate their interpretation. First, there is no reason to believe that the differences between males and females observed in this study will remain constant through time. Second, female tissues were not available in all years, and females made up only 10 of the 30 animals used in this study. Finally, sex may not be available for many historic or archaeological specimens, thus sex-specific discrimination factors are not useful for these samples. For these reasons, it may be more prudent to apply the tissue-specific discrimination factors presented in the main text, rather than the sex-specific discrimination factors presented in this supplement to make corrections among tissues.

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Supplementary Table 1. Examples of studies using lipid normalization models to estimate $\delta^{13}C_{lipid-free}$ in the tissues of invertebrates, fishes, amphibians, reptiles, birds, and mammals.

Taxon	Example References
Invertebrates	Kiljunen et al. (2006); Bodin et al. (2007); Logan et al. (2008); de Lecea and de Charmoy (2015); Choy et al. (2016)
Fishes	Sweeting et al. (2006); Kiljunen et al. (2006); Logan et al. (2008); Hoffman and Sutton (2010); Fagan et al. (2011); Reum (2011); Abrantes et al. (2012); de Lecea and de Charmoy (2015); Hoffman et al. (2015); Sardenne et al. (2015); Skinner et al. (2016); Giménez et al. (2017)
Amphibians	Trakimas et al. (2011); Caut et al. (2013); Arribas et al. (2015)
Reptiles	Rosenblatt and Heithaus (2013); Medeiros et al. (2015)
Birds	Kojadinovic et al. (2008); Doucette et al. (2010); Ehrich et al. (2011); Elliott et al. (2014); Elliott and Elliott (2016)
Mammals	Ehrich et al. (2011); Ryan et al. (2012); Yurkowski et al. (2015); Choy et al. (2016); Giménez et al. (2017)

Supplementary Table 2) Estimates of mammalian tissue-specific isotopic discrimination factors from this study and from the published literature. Diet-muscle fractionation of $\delta^{13}C$ and $\delta^{15}N$ is included where available, and values for all other tissues (liver, skin, bone collagen, hair/feather, whole blood, red blood cells) are expressed as the difference (‰) in $\delta^{13}C$ and $\delta^{15}N$ between each tissue and muscle (tissue – muscle).

Source	Species	Muscle − Diet		Liver − Muscle		Skin − Muscle		Bone Collagen − Muscle		Hair/Feather − Muscle	
		$\Delta\delta^{13}C$ (‰)	$\Delta\delta^{15}N$ (‰)	$\Delta\delta^{13}C$ (‰)	$\Delta\delta^{15}N$ (‰)	$\Delta\delta^{13}C$ (‰)	$\Delta\delta^{15}N$ (‰)	$\Delta\delta^{13}C$ (‰)	$\Delta\delta^{15}N$ (‰)	$\Delta\delta^{13}C$ (‰)	$\Delta\delta^{15}N$ (‰)
This study	Pacific Walrus *Odobenus rosmarus divergens*	-	-	−0.5	0.0	2.0	2.1	2.0	-0.4	-	-
Pinzone et al. (2017)	Hooded seal *Cystophora cristata*	1.1	4.3	-	-	-	-	-	-	0.8	−0.7
Sinisalo et al. (2008)	Ringed seal *Pusa hispida*	-	-	0.0	0.4	-	-	-	-	-	-
Hobson et al. (1996)	Harp, harbor, ringed seals *Pagophilus groenlandicus, Phoca vitulina, Pusa hispida*	1.3	2.4	−0.7	0.7	1.5	-0.1	-	-	1.5	0.6
Todd et al. (2010)	Steller sea lion *Eumetopias jubatus*	-	-	-	-	0.6	0.2	-	-	-	-
Todd et al. (2010)	California sea lion *Zalophus californianus*	-	-	-	-	0.9	0.5	-	-	-	-
Kurle and Worthy (2002)	Northern fur seal *Callorhinus ursinus*	-	-	−0.2	0.8	-	-	-	-	0.4	0.4
Jansen et al. (2012)	Harbor porpoise *Phocoena phocoena*	-	-	-	-	-	-	2.4	0.0	-	-
Toperoff (2002)	Harbor porpoise *Phocoena phocoena*	1.0	1.7	-	-	0.0	0.8	2.8	0.5	-	-
Borrell et al. (2012)	Fin whale *Balaenoptera physalus*	1.3	2.7	0.4	1.2	0.0	0.1	1.8	-0.7	-	-

Reference	Species										
Horstmann-Dehn et al. (2012)	Bowhead whale *Balaena mysticetus*	-	-	-	-	−0.2	0.3	-	-	-	-
Horstmann-Dehn et al. (2012)	Gray whale *Eschrichtius robustus*	-	-	-	-	0.6	1.2	-	-	-	-
Horstmann-Dehn et al. (2012)	Beluga *Delphinapterus leucas*	-	-	-	-	−0.4	0.1	-	-	-	-
Abend and Smith (1997)	Long-finned pilot whale *Globicephala melas*	1.1	-	-	-	−0.8	0.5	-	-	-	-
Abend and Smith (1995)	Long-finned pilot whale *Globicephala melas*	-	-	-	-	-	0.6	-	-	-	-
Todd et al. (1997)	Humpback whale *Megaptera novaeangliae*	-	-	-	-	-0.5	-	-	-	-	-
Kurle et al. (2014)	Norway rat *Rattus norvegicus*	1.8	2.6	−0.4	0.5	-	-	-	-	0.4	0.4
Webb et al. (2016)	Domestic pig *Sus domesticus*	-	2.4	-	0.8	-	-	-	0.1	-	-
Warinner and Tuross (2010)	Domestic pig *Sus domesticus*	2.0	2.1	-	-	-	-	1.3	−0.3	1.7	0.3
Nardoto et al. (2006)	Wild boar *Sus scrofa*	−1.6	2.8	−0.8	−0.6	-	-	-	-	1.8	−0.1
Miller et al. (2008)	Deer mouse *Peromyscus maniculatus*	−0.7	2.5	−0.1	0.9	-	-	-	-	1.0	0.8
Arneson and MacAvoy (2005)	House mouse *Mus musculus*	0.2	2.7	−0.3	1.5	-	-	-	-	-	-
MacAvoy et al. (2005)	House mouse *Mus musculus*	2.5	3.3	−0.7	2.0	-	-	-	-	-	-
Roth and Hobson (2000)	Red fox *Vulpes vulpes*	1.1	3.5	−0.7	0.0	-	-	-	-	1.5	−0.2
Tieszen et al. (1983)	Gerbil *Meriones unguiculatus*	−0.2	-	−0.5	-	-	-	-	-	1.3	-

Marine Mammal Mean	1.2	2.8	−0.2	0.6	0.3	0.6	2.3	−0.2	0.9	0.1
1 Standard Deviation	0.1	1.1	0.4	0.4	0.9	0.6	0.4	0.5	0.6	0.7
All Mammal Mean	0.8	2.8	−0.4	0.7	0.3	0.6	2.1	−0.1	1.2	0.2
1 Standard Deviation	1.1	0.7	0.4	0.7	0.9	0.6	0.6	0.4	0.5	0.5

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Supplementary Dataset 1. Raw stable isotope data for walrus bone collagen samples including animal ID, University of Alaska Museum specimen ID (UAM ID), sex, $\delta^{15}N$ (‰), $\delta^{13}C$ (‰), and carbon:nitrogen ratio. Asterisks next to IDs indicate individuals with all tissues (muscle, liver, skin, and bone collagen) used to evaluate tissue-specific isotope discrimination. Lipid-free values are not provided because collagen is a purified protein and does not require lipid extraction.

BONE COLLAGEN

ID	UAM ID	Sex	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	C:N
WAL137*	125312	M	11.9	-14.7	2.8
WAL146*	129168	M	10.8	-14.6	2.8
WAL234*	-	M	11.6	-14.8	2.7
WAL235*	-	M	12.1	-14.4	2.8
WAL238*	131795	M	11.3	-14.7	2.8
WAL239*	-	M	10.7	-14.5	2.8
WAL240*	-	M	12.6	-15.3	2.8
WAL779*	-	F	13.5	-15.6	2.9
WAL780*	131823	F	12.9	-15.0	2.8
WAL781*	131819	F	13.3	-14.8	2.7
WAL783*	131817	F	12.9	-15.4	2.8
WAL785*	131820	F	12.7	-14.7	2.9
WAL786*	131816	F	13.1	-14.8	3.0
WAL788*	131818	F	11.5	-14.2	2.9
WAL790*	131815	F	12.3	-14.5	2.8
WAL791*	131799	M	12.8	-14.3	2.8
WAL792*	131813	F	12.5	-14.9	3.0
WAL794*	131796	M	11.9	-15.0	2.9
WAL795*	131803	M	11.8	-14.8	2.9
WAL796*	131808	M	13.8	-14.4	2.8
WAL797*	131806	M	12.1	-15.3	2.9
WAL798*	131800	M	11.9	-15.2	3.0
WAL799*	131802	M	12.1	-14.7	3.0
WAL800*	131809	M	11.2	-14.5	2.9
WAL802*	131801	M	11.9	-15.0	3.1
WAL803*	131798	F	12.7	-15.1	3.0
WAL805*	131811	M	12.3	-14.7	2.9
WAL806*	131797	M	11.8	-14.6	2.9
WAL807*	131804	M	12.2	-14.4	3.0
WAL808*	131810	M	12.5	-14.6	2.9

Supplementary Dataset 2. Raw stable isotope data for walrus muscle samples including animal ID, University of Alaska Museum specimen ID (UAM ID), sex, $\delta^{15}N$ (‰), $\delta^{13}C$ (‰), C:N, $\delta^{15}N_{lipid-free}$ (‰), $\delta^{13}C_{lipid-free}$ (‰), C:N$_{lipid-free}$. Asterisks next to IDs indicate individuals with all tissues (muscle, liver, skin, and bone collagen) used to evaluate tissue-specific isotope discrimination.

			MUSCLE					
ID	UAM ID	Sex	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	C:N	$\delta^{15}N_{lipid-free}$ (‰)	$\delta^{13}C_{lipid-free}$ (‰)	C:N$_{lipid-free}$
WAL125	125300	M	13.6	−16.5	3.3	13.5	−17.2	3.1
WAL128	125302	M	12.3	−16.3	3.4	12.3	−16.2	3.3
WAL129	125303	M	13.2	−17.0	3.3	13.8	−16.8	3.2
WAL132	125306	F	12.8	−16.0	3.8	13.8	−15.2	3.2
WAL133	125307	M	11.8	−17.2	3.4	12.5	−16.0	3.1
WAL134	125309	M	12.5	−17.5	3.7	13.4	−16.3	3.2
WAL135	125310	M	12.2	−17.6	3.7	12.7	−17.0	3.3
WAL137*	125312	M	13.0	−16.4	3.2	13.5	−16.4	3.1
WAL138	125313	M	11.4	−16.9	3.3	11.6	−17.3	3.2
WAL139	125314	M	12.5	−16.9	3.2	12.4	−17.4	3.2
WAL140	125315	F	12.2	−17.1	3.4	12.5	−16.9	3.2
WAL141	125316	M	12.3	−16.4	3.3	12.1	−16.9	3.3
WAL143	125318	M	12.4	−16.3	3.2	12.2	−16.6	3.2
WAL144	125319	M	12.5	−16.7	3.4	12.2	−16.9	3.3
WAL145	125322	M	12.9	−16.8	3.3	12.6	−17.2	3.2
WAL146*	129168	M	12.1	−16.5	3.3	11.9	−17.0	3.2
WAL147	125324	M	12.3	−17.9	3.7	12.1	−17.6	3.3
WAL148	125327	M	12.6	−16.3	3.3	12.4	−16.7	3.2
WAL149	125328	F	13.1	−17.3	3.4	12.9	−17.4	3.3
WAL151	125287	F	12.1	−15.7	3.3	12.5	−15.4	3.2
WAL152	125288	M	12.0	−16.9	3.3	12.1	−17.3	3.2
WAL153	125289	F	12.0	−17.2	3.5	11.5	−17.2	3.3
WAL154	125290	M	12.3	−16.6	3.4	12.2	−17.0	3.2
WAL157	125293	F	12.5	−17.3	3.4	13.0	−17.0	3.2
WAL234*	-	M	12.3	−17.0	3.5	12.2	−16.7	3.1
WAL235*	-	M	12.3	−16.6	3.4	12.5	−16.2	3.1
WAL237	-	M	12.9	−18.0	4.2	13.2	−16.2	3.1
WAL238*	131795	M	12.5	−16.6	3.8	12.7	−16.3	3.6
WAL239*	-	M	12.3	−16.8	3.5	12.2	−16.6	3.1
WAL240*	-	M	12.6	−17.5	3.6	12.6	−17.3	3.2
WAL283	-	M	12.9	−16.9	3.7	12.9	−16.6	3.5
WAL434	116517	M	11.8	−16.0	3.3	11.9	−16.0	3.3
WAL435	-	M	13.7	−17.1	3.4	14.1	−17.5	3.3
WAL436	-	F	12.2	−17.2	3.4	12.4	−17.5	3.3
WAL438	-	M	12.1	−16.6	3.3	12.2	−17.1	3.3
WAL439	-	F	12.2	−19.2	4.8	12.9	−17.6	3.4
WAL443	-	F	12.3	−17.4	3.5	12.7	−17.5	3.3
WAL779*	-	F	13.3	−17.7	3.4	13.4	−17.5	3.4

WAL780*	131823	F	13.6	−16.8	3.4	13.6	−16.8	3.4
WAL781*	131819	F	13.3	−17.3	3.4	13.4	−17.1	3.4
WAL782	131814	F	13.4	−19.0	5.4	13.4	−16.7	3.5
WAL783*	131817	F	13.1	−17.5	3.6	13.1	−17.2	3.5
WAL784	131824	F	12.9	−16.9	3.4	12.7	−16.8	3.4
WAL785*	131820	F	13.3	−17.1	3.5	13.3	−16.7	3.4
WAL786*	131816	F	13.5	−17.8	3.5	13.1	−17.0	3.5
WAL787	131821	F	13.0	−17.3	3.6	12.6	−17.5	3.5
WAL788*	131818	F	12.6	−17.9	3.7	12.5	−17.2	3.5
WAL789	131822	F	12.5	−17.7	3.6	13.5	−17.5	3.5
WAL790*	131815	F	12.4	−17.1	4.0	12.5	−17.0	3.7
WAL791*	131799	M	12.6	−16.7	3.3	12.3	−16.5	3.1
WAL792*	131813	F	12.9	−17.0	3.4	12.9	−16.8	3.2
WAL793	131807	M	12.5	−16.7	3.4	12.3	−16.5	3.2
WAL794*	131796	M	12.6	−16.9	3.4	12.6	−16.7	3.3
WAL795*	131803	M	12.4	−16.9	3.3	12.3	−16.9	3.2
WAL796*	131808	M	12.4	−16.8	3.4	12.4	−16.7	3.3
WAL797*	131806	M	12.8	−16.6	3.4	12.7	−16.5	3.3
WAL798*	131800	M	12.6	−16.8	3.4	12.6	−16.8	3.3
WAL799*	131802	M	12.6	−16.6	3.4	12.5	−16.6	3.3
WAL800*	131809	M	11.6	−16.7	3.4	11.6	−16.7	3.3
WAL802*	131801	M	12.3	−16.6	3.4	12.4	−16.6	3.3
WAL803*	131798	F	12.4	−17.1	3.5	12.5	−16.8	3.4
WAL805*	131811	M	12.0	−16.9	3.6	12.1	−16.7	3.4
WAL806*	131797	M	12.6	−17.2	3.6	12.6	−16.9	3.4
WAL807*	131804	M	12.0	−16.6	3.4	12.1	−16.4	3.3
WAL808*	131810	M	13.1	−16.4	3.5	13.1	−16.2	3.4
WAL949	116807	M	11.7	−17.1	3.5	12.0	−17.3	3.3
WAL950	116808	M	12.4	−16.9	3.5	12.5	−17.2	3.4
WAL951	116811	M	12.0	−17.0	3.4	12.0	−17.4	3.3
WAL952	116530	M	11.8	−16.5	3.3	12.0	−16.9	3.3
WAL953	116716	M	12.1	−17.0	3.4	12.2	−17.4	3.3
WAL954	116717	M	11.9	−17.1	3.4	12.2	−17.4	3.3
WAL955	116614	M	11.6	−16.6	3.3	12.1	−17.1	3.2
WAL956	116718	M	12.3	−16.8	3.3	12.9	−17.3	3.2
WAL957	116711	M	12.1	−16.6	3.4	12.5	−16.7	3.3
WAL958	116509	F	11.7	−17.6	3.6	12.1	−17.5	3.4
WAL959	116876	M	11.4	−17.5	3.5	11.7	−17.8	3.3
WAL960	-	U	13.5	−17.3	3.6	13.9	−17.3	3.3
WAL961	116648	M	12.2	−16.7	3.3	12.5	−16.5	3.2
WAL962	116747	M	12.2	−16.6	3.3	12.5	−16.5	3.2
WAL963	116487	M	12.1	−16.3	3.4	12.4	−16.6	3.2
WAL964	116615	M	14.1	−16.4	3.2	14.2	−16.1	3.1
WAL965	116616	M	12.9	−16.7	3.5	12.5	−17.2	3.3
WAL966	116539	F	14.0	−17.6	3.4	13.9	−17.6	3.4

WAL967	116371	F	13.6	−17.6	3.6	14.0	−17.6	3.3
WAL968	116540	F	12.2	−17.2	3.4	12.2	−17.6	3.3
WAL969	117032	F	12.5	−19.5	5.7	13.1	−17.5	3.3
WAL970	116460	F	13.0	−17.5	3.3	13.2	−17.9	3.2
WAL971	117034	F	12.4	−16.8	3.3	12.5	−17.2	3.3
WAL972	116442	F	13.4	−17.4	3.5	13.5	−17.7	3.3
WAL973	116653	F	13.1	−17.9	3.6	12.9	−18.0	3.3
WAL974	116338	F	12.1	−17.2	3.4	12.4	−17.3	3.3
WAL975	116492	F	12.0	−17.1	3.4	12.1	−17.3	3.4
WAL976	116478	F	13.1	−17.3	3.4	13.6	−17.5	3.4
WAL977	116445	F	11.8	−16.9	3.3	11.9	−17.4	3.3
WAL978	116495	F	11.6	−16.7	3.4	12.0	−16.8	3.6
WAL979	116748	F	11.5	−18.4	4.0	11.9	−17.7	3.4
WAL980	116372	F	12.6	−17.6	3.6	13.0	−17.5	3.5
WAL981	116679	F	13.0	−17.7	3.6	13.9	−17.7	3.3
WAL982	116749	F	12.2	−17.8	3.5	12.7	−17.8	3.3
WAL983	116339	F	12.5	−17.9	3.6	12.8	−17.8	3.3
WAL984	116462	F	12.5	−17.3	3.5	12.7	−16.7	3.2
WAL985	119507	M	12.0	−17.4	3.7	12.1	−16.9	3.3
WAL986	119508	M	12.2	−17.3	3.8	12.1	−16.8	3.3
WAL987	119509	M	12.6	−16.7	3.4	12.5	−16.9	3.3
WAL988	119511	M	12.5	−17.2	3.6	12.5	−17.3	3.4
WAL989	119517	M	12.5	−16.6	3.4	12.2	−17.1	3.3
WAL990	119498	M	12.5	−17.1	3.4	12.1	−17.2	3.2
WAL991	119500	M	12.1	−16.5	3.4	12.1	−16.6	3.3
WAL992	119486	F	13.1	−17.8	3.7	12.4	−17.4	3.3
WAL993	119501	M	12.5	−17.3	3.5	12.3	−17.5	3.3
WAL994	119487	F	12.6	−18.0	3.8	12.3	−17.3	3.2
WAL995	119502	M	12.5	−16.6	3.6	12.3	−16.8	3.4
WAL996	119488	F	13.3	−17.1	3.4	13.4	−17.0	3.2
WAL997	119504	M	12.2	−16.4	3.3	12.0	−16.9	3.2
WAL998	119505	M	13.0	−17.3	3.5	13.1	−17.7	3.3
WAL999	119490	F	12.6	−17.6	3.5	12.6	−17.6	3.3
WAL1000	125308	M	12.0	−16.4	3.4	12.9	−16.1	3.1
WAL1001	125317	M	12.3	−16.6	3.3	12.2	−17.1	3.3
WAL1002	125318	M	12.1	−16.8	3.4	12.0	−17.1	3.3
WAL1003	125321	M	11.8	−16.4	3.3	12.0	−16.4	3.2
WAL1004	125325	M	12.2	−16.4	3.3	12.0	−17.0	3.2
WAL1005	125330	M	12.5	−16.5	3.3	12.3	−16.9	3.3
WAL1006	125332	M	11.3	−17.4	3.5	10.8	−17.4	3.3
WAL1007	125333	M	12.0	−16.2	3.2	11.4	−16.9	3.2
WAL1008	-	M	12.7	−16.8	3.3	12.0	−17.3	3.3

Supplementary Dataset 3. Raw stable isotope data for walrus liver samples including animal ID, University of Alaska Museum specimen ID (UAM ID), sex, $\delta^{15}N$ (‰), $\delta^{13}C$ (‰), C:N, $\delta^{15}N_{lipid-free}$ (‰), $\delta^{13}C_{lipid-free}$ (‰), C:N$_{lipid-free}$. Asterisks next to IDs indicate individuals with all tissues (muscle, liver, skin, and bone collagen) used to evaluate tissue-specific isotope discrimination.

			LIVER					
ID	UAM ID	Sex	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	C:N	$\delta^{15}N_{lipid-free}$ (‰)	$\delta^{13}C_{lipid-free}$ (‰)	C:N$_{lipid-free}$
WAL137*	125312	M	12.8	-18.1	4.2	12.9	-17.8	4.1
WAL146*	129168	M	11.9	-17.8	4.8	12.1	-17.1	4.2
WAL234*	-	M	11.9	-18.1	3.9	12.1	-17.3	3.4
WAL235*	-	M	11.8	-18.4	5.0	12.7	-17.5	4.5
WAL238*	131795	M	12.6	-17.9	5.1	12.8	-17.1	4.6
WAL239*	-	M	11.6	-18.2	4.5	12.4	-17.3	4.0
WAL240*	-	M	12.0	-18.3	4.2	12.2	-17.4	3.7
WAL779*	-	F	13.8	-19.4	5.2	14.0	-18.3	4.2
WAL780*	131823	F	14.0	-17.9	4.5	14.1	-16.7	3.6
WAL781*	131819	F	14.1	-18.5	4.4	14.1	-17.6	3.7
WAL782	131814	F	13.1	-17.8	4.1	13.1	-17.0	3.5
WAL783*	131817	F	13.6	-19.3	5.1	13.7	-17.6	3.7
WAL784	131824	F	13.7	-18.0	4.6	13.8	-17.0	3.7
WAL785*	131820	F	14.1	-17.8	4.3	14.1	-16.7	3.4
WAL786*	131816	F	13.6	-19.4	6.0	13.9	-18.1	4.6
WAL787	131821	F	13.5	-19.5	5.4	13.6	-17.9	4.0
WAL788*	131818	F	13.3	-18.8	4.6	13.4	-17.8	3.8
WAL790*	131815	F	12.9	-18.2	4.3	13.0	-16.7	3.4
WAL791*	131799	M	11.9	-18.1	4.1	12.1	-17.3	3.6
WAL792*	131813	F	13.0	-18.5	4.5	13.3	-17.2	3.6
WAL793	131807	M	11.7	-18.5	4.9	12.4	-17.6	4.4
WAL794*	131796	M	11.8	-18.4	4.9	12.6	-17.7	4.3
WAL795*	131803	M	12.5	-18.3	4.1	12.6	-17.8	3.7
WAL796*	131808	M	11.7	-18.5	5.0	12.5	-17.7	4.5
WAL797*	131806	M	12.4	-18.1	5.3	13.3	-17.5	4.7
WAL798*	131800	M	11.6	-17.7	4.4	12.0	-16.6	3.7
WAL799*	131802	M	11.9	-17.8	5.1	12.0	-17.1	4.4
WAL800*	131809	M	11.6	-18.0	4.0	11.9	-17.4	3.5
WAL802*	131801	M	12.3	-18.1	4.4	12.8	-17.1	4.5
WAL803*	131798	F	13.1	-18.7	4.8	13.6	-17.7	3.9
WAL804	131805	M	12.3	-18.3	4.5	12.6	-17.1	3.6
WAL805*	131811	M	12.9	-18.2	5.4	13.3	-17.3	4.4
WAL806*	131797	M	11.7	-17.7	4.7	11.9	-17.2	4.1
WAL807*	131804	M	12.1	-18.0	4.6	12.0	-17.0	3.6
WAL808*	131810	M	13.4	-17.7	5.4	13.5	-17.2	4.6

Supplementary Dataset 4. Raw stable isotope data for walrus skin samples including animal ID, University of Alaska Museum specimen ID (UAM ID), sex, $\delta^{15}N$ (‰), $\delta^{13}C$ (‰), C:N, $\delta^{15}N_{lipid-free}$ (‰), $\delta^{13}C_{lipid-free}$ (‰), C:N$_{lipid-free}$. Asterisks next to IDs indicate individuals with all tissues (muscle, liver, skin, and bone collagen) used to evaluate tissue-specific isotope discrimination.

			SKIN					
ID		Sex	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	C:N	$\delta^{15}N_{lipid-free}$ (‰)	$\delta^{13}C_{lipid-free}$ (‰)	C:N$_{lipid-free}$
WAL137*	125312	M	14.4	-15.5	3.4	14.4	-14.7	2.8
WAL143	125318	M	14.0	-16.2	3.4	14.2	-14.8	2.9
WAL146*	129168	M	14.2	-14.4	3.2	14.3	-14.1	2.9
WAL234*	-	M	13.9	-17.3	3.7	14.3	-14.9	3.1
WAL235*	-	M	14.3	-15.2	3.3	14.4	-14.1	2.9
WAL238*	131795	M	14.2	-14.6	2.9	13.6	-14.2	3.0
WAL239*	-	M	13.6	-15.6	3.8	14.4	-13.9	3.0
WAL240*	-	M	15.0	-17.9	4.0	15.4	-15.4	3.1
WAL779*	-	F	15.7	-19.5	5.1	15.8	-15.4	3.2
WAL780*	131823	F	15.5	-15.6	3.2	15.2	-14.1	3.2
WAL781*	131819	F	15.2	-20.6	7.1	15.1	-14.7	3.2
WAL782	131814	F	14.3	-18.8	5.1	15.0	-14.9	3.0
WAL783*	131817	F	15.7	-18.6	4.1	16.0	-15.7	3.3
WAL785*	131820	F	15.4	-15.9	3.1	15.3	-15.1	3.2
WAL786*	131816	F	15.7	-16.4	3.3	15.7	-15.3	3.3
WAL788*	131818	F	14.8	-16.7	3.7	14.8	-14.0	3.2
WAL789	131822	F	15.0	-16.4	3.3	15.0	-15.6	3.0
WAL790*	131815	F	14.7	-18.8	5.2	15.3	-15.0	3.3
WAL791*	131799	M	14.8	-14.7	2.8	14.7	-14.5	2.9
WAL792*	131813	F	14.6	-16.3	3.2	14.9	-15.0	3.0
WAL794*	131796	M	14.0	-14.8	2.8	13.8	-14.7	3.0
WAL795*	131803	M	14.2	-20.1	6.6	14.3	-15.1	3.1
WAL796*	131808	M	14.3	-14.5	2.7	14.0	-14.4	3.0
WAL797*	131806	M	15.0	-14.9	2.8	15.1	-14.7	3.0
WAL798*	131800	M	14.6	-16.0	3.1	14.6	-15.2	3.1
WAL799*	131802	M	14.8	-14.7	2.8	14.8	-14.6	3.1
WAL800*	131809	M	14.5	-21.3	10.5	15.0	-15.1	3.3
WAL802*	131801	M	13.8	-17.6	4.3	13.7	-15.8	3.3
WAL803*	131798	F	14.8	-16.4	3.5	14.7	-15.1	3.0
WAL805*	131811	M	14.2	-16.3	3.4	14.2	-14.7	3.1
WAL806*	131797	M	14.6	-14.5	2.9	14.8	-14.4	3.1
WAL807*	131804	M	15.0	-20.9	8.8	15.3	-15.4	3.3
WAL808*	131810	M	15.3	-14.4	2.9	15.2	-14.2	3.1
WAL1002	125318	M	13.7	-15.7	3.2	13.6	-14.6	2.8
WAL1004	125325	M	14.0	-15.6	3.3	13.9	-14.5	3.0