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# Trophic position and foraging ecology of Ross, Weddell, and crabeater seals revealed by compound-specific isotope analysis

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1 **TROPHIC POSITION AND FORAGING ECOLOGY OF ROSS, WEDDELL, AND**  
2 **CRABEATER SEALS REVEALED BY COMPOUND-SPECIFIC ISOTOPE ANALYSIS**

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**ABSTRACT**

28

29 Ross seals (*Ommatophoca rossii*) are one of the least studied marine mammals, with little

30 known about their foraging ecology. Research to date using bulk stable isotope analysis suggests

31 that Ross seals have a trophic position intermediate between that of the Weddell (*Leptonychotes*

32 *weddellii*) and crabeater (*Lobodon carcinophaga*) seals. However, consumer bulk isotope values

33 not only reflect trophic dynamics, but also variations in baseline isotope values, which can be

34 substantial. Here, we use a compound specific isotope analysis of amino acids (CSI-AA) to

35 separate isotopic effects of a shifting baseline versus trophic structure on the foraging ecology of

36 these ecologically important, but poorly understood Antarctic pinnipeds. We find that all three

37 seals use different foraging habitats; Ross seals forage in a pelagic food web distinct from that of

38 crabeater and Weddell seals. Crabeater and Weddell seals are foraging within similar food webs

39 closer to shore. However, isotopic evidence suggests that crabeater seals are likely following sea

40 ice, while Weddell seals target productive areas of the continental shelf of Western Antarctica. In

41 addition, our CSI-AA data indicate that Ross seals have a high trophic position equivalent to that

42 of Weddell seals, contrary to prior conclusions from nitrogen isotope results on bulk tissues.

43 CSI-AA indicates that crabeater seals are at a trophic position lower than that of Ross and

44 Weddell seals, consistent with a krill-dominated diet. Our results redefine the view of the Ross

45 seal trophic dynamics and foraging ecology, while also highlighting the importance of

46 quantifying baseline isotope variations in foraging studies.

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## KEYWORDS

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50 Ross seal, Weddell seal, Crabeater seal, Compound specific isotopes, amino acids, Antarctica,

51 Foraging ecology, Trophic dynamics

52

## INTRODUCTION

53

54 The Ross seal (*Ommatophoca rossii*) is one of the least studied marine mammals (Reeves

55 et al. 2008, Bengtson et al. 2011). The total population estimate for this species is around

56 200,000, considerably less than the estimates for other Antarctic true seals, which are 10 to 15

57 million individuals for crabeater seals (*Lobodon carcinophaga*) and approximately one million

58 individuals for Weddell seals (*Leptonychotes weddellii*) (Laws 1977, Reeves et al. 2008,

59 Bengtson et al. 2011). With individuals likely spending most of their time at sea and in habitats

60 that are logistically challenging to access, the Ross seal is not commonly observed. Several keys

61 aspects of their biology remain poorly understood, including their preferred prey, foraging

62 habitat, and behavior. In contrast, many studies have been conducted on crabeater and Weddell

63 seals and, thus, more information is available on their ecology.

64 Conventional techniques for studying an animal's diet, such as scat and stomach content

65 analysis, have significant limitations when applied to Antarctic pinnipeds. These methods

66 capture only a snapshot of a predator's diet, perhaps one to two days (Dellinger and Trillmich

67 1988, Burns et al. 1998). In addition, since soft tissues are more completely digested than hard

68 tissues, resulting in biases towards prey with indigestible hard parts (Burns et al. 1998, Staniland

69 2002, Arim and Naya 2003, Yonezaki et al. 2003). Given these drawbacks, recent research on  
70 Antarctic seal ecology has often used bulk isotope values.

71         Measurements of bulk tissue carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) isotope values (i.e., the  
72 weighted average of all components within in a tissue) have been used to indicate a predator's  
73 foraging region and trophic position (Boecklen et al. 2011). This approach has the advantage of  
74 providing an integrated view of an animal's diet over longer time scales (weeks to years  
75 depending on the tissue) than the traditional procedures (Vander Zanden et al. 2015). Carbon  
76 isotope values show little  $^{13}\text{C}$ -enrichment with trophic transfer. Thus, consumer  $\delta^{13}\text{C}$  values are  
77 often thought to closely reflect values at the base of marine food webs, making them useful for  
78 studying the foraging areas of a predator. Spatial changes in the  $\delta^{13}\text{C}$  of phytoplankton (often  
79 referred to as "baseline"  $\delta^{13}\text{C}$  values) reflect variations in dissolved inorganic carbon  $\delta^{13}\text{C}$   
80 values, dissolved  $\text{CO}_2$  concentrations, temperature, cell size and geometry, internal biological  
81 parameters (e.g., growth rate), and  $\text{CO}_2$  drawdown (reviewed in McMahon et al. 2013). Provided  
82 the primary processes driving variation are known, bulk  $\delta^{13}\text{C}$  values of an animal can give  
83 valuable information on its foraging habitat. The Southern Ocean is known to have considerable  
84 spatial variation in baseline  $\delta^{13}\text{C}$  ( $\delta^{13}\text{C}_{\text{baseline}}$ ) values (Rau et al. 1982, Quillfeldt et al. 2010,  
85 Brault et al. 2018). Several studies have observed decreasing  $\delta^{13}\text{C}$  values with increasing  
86 latitude, with offsets between about 55 °S and 79 °S of approximately 3 ‰, largely reflecting  
87 variations in sea surface temperature (Rau et al. 1982, Graham et al. 2010, Quillfeldt et al. 2010,  
88 Magozzi et al. 2017, Brault et al. 2018).

89         In contrast to carbon isotopes, trophic transfers considerably affect an animal's  $\delta^{15}\text{N}$   
90 values. Since a consumer's tissues become enriched in  $^{15}\text{N}$  by ~ 2-5 ‰ with each trophic step  
91 (e.g., primary producers to herbivores to carnivores) due to the preferential loss of  $^{14}\text{N}$  during

92 amino acid metabolism (Minagawa and Wada, 1984),  $\delta^{15}\text{N}$  values are often used to indicate an  
93 animal's trophic position. However, variations in baseline  $\delta^{15}\text{N}$  values ( $\delta^{15}\text{N}_{\text{baseline}}$ ) also occur  
94 and are passed on, with additional change due to trophic transfers, to upper trophic level  
95 predators (McMahon et al. 2013). Nutrient source (e.g., nitrate, ammonium, or  $\text{N}_2$  fixation),  
96 microbial transformations (e.g., denitrification), and extent of nitrogen pool drawdown in a given  
97 environment can all strongly impact primary producer  $\delta^{15}\text{N}$  values (reviewed in McMahon et al.  
98 2013). If variations in these factors are well understood, then the bulk  $\delta^{15}\text{N}$  values of a consumer  
99 provide insights into its foraging region and trophic position (Post 2002). As with carbon,  
100 substantial spatial variations in  $\delta^{15}\text{N}_{\text{baseline}}$  values occur in the Southern Ocean (DiFiore et al.  
101 2006, DiFiore et al. 2009, Somes et al. 2010, Jaeger et al. 2010, Brault et al. 2018). Low  
102  $\delta^{15}\text{N}_{\text{baseline}}$  values have been found for much of the Southern Ocean except in areas near the  
103 continent with extensive coastal open water polynya "hot spots" (Arrigo and Van Dijken 2003),  
104 where the baseline is up to  $\sim 3$  ‰ higher than in pelagic regions (DiFiore et al. 2006, DiFiore et  
105 al. 2009, Brault et al. 2018). This pattern likely derives from changes in the extent of nutrient  
106 drawdown due to enhanced primary productivity, the main process influencing  $\delta^{15}\text{N}_{\text{baseline}}$  in the  
107 Southern Ocean since it is a high nutrient-low chlorophyll (HNLC) region (Brault et al. 2018).

108         Although much remains unknown, especially regarding the behaviors and movements of  
109 the Ross seal, recent studies have furthered our understanding of Antarctic seal ecology. Isotopic  
110 measurements, coupled with traditional ecological methods, have indicated that Weddell seals  
111 forage near the top of the Antarctic food web, consuming diverse diets of fish, cephalopods, and  
112 invertebrates (Burns et al. 1998, Plötz 2001, Lake et al. 2003, Goetz et al. 2017). Researchers  
113 have debated the contribution of the upper trophic level prey species, in particular the Antarctic  
114 toothfish (*Dissotichus mawsoni*), to Weddell seal diets with some studies suggesting a substantial

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115 contribution of *D. mawsoni* (Ponganis and Stockard 2007, Ainley and Siniff 2009, Goetz et al.  
116 2017). Hard parts of *D. mawsoni* are not consumed and, thus, not detected via scat and stomach  
117 content analyses, which have been used for much of the prior research on Weddell seal foraging  
118 ecology. Recently, Goetz et al. (2017) assessed Weddell seal foraging ecology with bulk  $\delta^{13}\text{C}$   
119 and  $\delta^{15}\text{N}$  measurements of vibrissae and red blood cells from Ross Sea specimens. They reported  
120 considerable individual variability in diet and that Antarctic silverfish (*Pleuragamma*  
121 *antarcticum*) and cod icefishes (*Trematomus* species) were the primary prey consumed by  
122 Weddell seals. Overall, *D. mawsoni* contribute less than 2 % to the Weddell seal diet. However,  
123 *D. mawsoni* may become increasingly important with age and at certain times in the life cycle,  
124 such as during reproduction and molting, since this fish has a high fat content and energy density  
125 (Goetz et al. 2017). Additionally, Goetz et al. (2017) noted temporal diet shifts – likely in  
126 response to sea ice dynamics affecting prey abundances.

127 Crabeater seals occupy a much lower trophic level than Weddell seals, with diets  
128 dominated by Antarctic krill (*Euphausiia superba*), as evidenced by the results of both scat and  
129 stomach content analyses as well as bulk isotopic analysis (Laws 1977, Rau et al. 1992, Burns et  
130 al. 2004, Zhao et al. 2004, Burns et al. 2008, Aubail et al. 2011). Recent work by Hückstädt et al.  
131 (2012a) has revealed temporal variability in crabeater seal diet composition via bulk  $\delta^{13}\text{C}$  and  
132  $\delta^{15}\text{N}$  measurements of vibrissae. The *E. superba* contribution ranged from 81 % to 95 %, likely  
133 in response to climate shifts affecting krill abundances. The authors also reported significant  
134 variation in  $\delta^{13}\text{C}$  values with body mass (increasing  $\delta^{13}\text{C}$  values with increasing body mass) and  
135 season (highest  $\delta^{13}\text{C}$  values in the austral winter) that they suggested might result from changes  
136 in  $\delta^{13}\text{C}_{\text{baseline}}$  values associated with temporal and/or spatial shifts between pelagic phytoplankton  
137 and sea ice phytoplankton communities (Hückstädt et al. 2012a).



138           Only a small number of studies have examined Ross seal foraging ecology. Dive records  
139 suggest that these animals typically dive from 100 to 300 m (maximum depth of 792 m) in  
140 search of mesopelagic squid and fish (Bengtson and Stewart 1997, Blix and Nordøy 2007).  
141 Analysis of Ross seal stomach contents showed that Antarctic silverfish (*Pleurogramma*  
142 *antarcticum*) and glacial squid (*Psychroteuthis glacialis*) were found in varying proportions  
143 (Skinner and Klages, 1994). Arcalís-Planas et al. (2015) suggested little use of sea ice by Ross  
144 seals, based on telemetry and remote sensing data. Seals tracked in this study generally  
145 remained in pelagic regions except for haul outs on ice to molt (from December to January) and  
146 breed (from late October to mid-November). During their extended pelagic period (February to  
147 mid-October), Ross seals remained an average ~ 840 km (range 587 to 1,282 km) seaward from  
148 the ice edge (Arcalís-Planas et al. 2015). Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  isotope measurements place the  
149 Ross seal a trophic level intermediate between Weddell seals and crabeater seals (Rau et al.  
150 1992, Zhao et al. 2004, Aubail et al. 2011). Thus, bulk isotope results to date suggest that Ross  
151 seals consume mostly squid and fish, but with a contribution from lower trophic level prey like  
152 *E. superba* (Rau et al. 1992, Zhao et al. 2004, Aubail et al. 2011).

153           While these bulk isotope approaches have shed new light on the foraging ecology of  
154 these Antarctic pinnipeds, it is critical to remember that the Southern Ocean exhibits strong  
155 spatial gradients in both  $\delta^{13}\text{C}_{\text{baseline}}$  and  $\delta^{15}\text{N}_{\text{baseline}}$  values (DiFiore et al. 2006, DiFiore et al.  
156 2009, Jaeger et al. 2010, Somes et al. 2010, Brault et al. 2018), suggesting that we likely need to  
157 explicitly tease apart the relative influences of trophic dynamics and baseline variation on seal  
158 isotope values. For instance, Ross seals may spend more time in pelagic regions than other true  
159 Antarctic seals (Arcalís-Planas et al. 2015), and thus forage in areas with lower  $\delta^{15}\text{N}_{\text{baseline}}$  values  
160 than the nearshore regions of Weddell and crabeater seals (DiFiore et al. 2006, DiFiore et al.

161 2009, Brault et al. 2018). If so, not accounting for spatial variation in the  $\delta^{15}\text{N}_{\text{baseline}}$  would result  
162 in Ross seals being assigned a lower trophic position than species foraging nearer the continent.

163 Compound-specific isotopic analysis of amino acids (CSI-AA) has opened new doors to  
164 studying the foraging ecology and trophic dynamics of marine predators (e.g., Graham et al.  
165 2010). Since only certain amino acids become enriched in  $^{15}\text{N}$  with increasing trophic level  
166 (“trophic” amino acids), while others (“source” amino acids) do not, impacts of  $\delta^{15}\text{N}_{\text{baseline}}$   
167 variation and trophic position on consumer  $\delta^{15}\text{N}$  values can be disentangled using this technique  
168 (Ohkouchi et al. 2017). Glutamic acid/glutamine (Glu) and phenylalanine (Phe) are widely  
169 considered the most representative trophic and source amino acids, respectively, with Phe  $\delta^{15}\text{N}$   
170 values typically used a proxy for baseline isotope values, and Phe and Glu  $\delta^{15}\text{N}$  values ( $\delta^{15}\text{N}_{\text{Phe}}$   
171 and  $\delta^{15}\text{N}_{\text{Glu}}$ , correspondingly) used together to estimate an organism’s trophic position (TP)  
172 internally indexed to the baseline (Ohkouchi et al. 2017). Proline (Pro) has also been shown to be  
173 a reliable trophic amino acid, however, with less variability than Glu for trophic  $^{15}\text{N}$ -enrichment  
174 factors between organisms (McMahon et al. 2015). As a consequence, Pro and Phe may  
175 represent a new CSI-AA combination that provides more ecologically realistic TP estimates for  
176 higher trophic level consumers (McMahon and McCarthy 2016).

177 Here, we report the first CSI-AA data for modern Ross, Weddell, and crabeater seals to  
178 refine our understanding of the trophic dynamics and foraging ecology of these important  
179 Antarctic predators. In particular, CSI-AA allows us to directly examine changes in baseline  
180  $\delta^{15}\text{N}$  values linked to these seals’ diets, and so to gain information on their foraging regions in  
181 conjunction with their trophic dynamics. Comparison of amino acid isotope data across these  
182 three Antarctic seals will also further our understanding of present Antarctic food web structures,

183 which will provide valuable ecosystem baselines in light of ongoing climate change (Atkinson et  
184 al. 2004, Ducklow et al. 2007, Ducklow et al. 2012, Montes-Hugo et al. 2009).

185

186

## MATERIALS AND METHODS

### 187 **Sample collection**

188 Tissue samples from Ross ( $n = 15$ ), Weddell ( $n = 38$ ), and crabeater seals ( $n = 41$ ) were  
189 collected along western Antarctica from the West Antarctic Peninsula (WAP) to the Ross Sea  
190 during multiple field seasons in the austral summers of 2008/09 and 2010/11 aboard the *RV*  
191 *Oden*. These animal captures were conducted in accordance with the regulations of the Swedish  
192 Polar Research Secretariat (Registration No. 2010-112). All other samples were obtained from  
193 animal captures conducted under National Marine Fisheries Service permit No. 87-1851-00. In  
194 most cases, body mass, age class (juvenile, subadult, and adult), gender, and location were  
195 recorded for each sampled seal (Table S1). Additionally, the Institutional Animal Care and Use  
196 Committee (IACUC) at the University of Santa Cruz (UC Santa Cruz) approved all protocols for  
197 these samples.

198 Whole blood samples were obtained from most seals, and in some cases, clot (blood with  
199 serum removed), red blood cells (RBCs, whole blood exposed to an anticoagulant, heparin,  
200 before having plasma removed), and hair samples were also collected. The sampling protocols  
201 are described in Aubail et al. (2011) and Goetz et al. (2017). Whiskers were taken from crabeater  
202 seals during multiple cruises on the *RV Lawrence M. Gould* along the WAP, during fall 2001 ( $n$   
203 = 7), winter 2001 ( $n = 7$ ), fall 2002 ( $n = 15$ ), winter 2002 ( $n = 14$ ), and fall 2007 ( $n = 9$ ). Plasma  
204 was also obtained from a few of the fall 2007 individuals (G105, G110, and G112) (Hückstädt et  
205 al. 2012a). In addition, serum or plasma was obtained from two Weddell seals during the fall

206 2007 sampling in this region, and whiskers were taken from two WAP Weddell seals in the  
207 austral summer of 2009/10. Whisker samples were also collected from Weddell seals during the  
208 summer 2009/10 ( $n=11$ ), summer 2010/11 ( $n=10$ ), summer 2011/12 ( $n=18$ ) (Goetz et al. 2017).  
209 Hückstädt et al. (2012a) describe the procedure for sampling the whiskers, and Goetz et al.  
210 (2017) describe the protocol used for collecting seal blood.

211         Several blood samples were obtained from Weddell seals in the McMurdo Sound region,  
212 Ross Sea, Antarctica over multiple field seasons. Twelve whole blood samples were taken from  
213 juvenile Weddell seals near Inexpressible Island (74.9 °S, 163.7 °E) during the austral summer of  
214 2010/11. Whole blood samples were taken from Weddell seals in the austral summer of 2010/11  
215 ( $n=5$ ) and austral spring of 2012 ( $n=5$ ). RBCs were sampled in the austral summer of 2009/10  
216 ( $n=5$ ), austral summer of 2011/12 ( $n=5$ ), and austral spring of 2012 ( $n=5$ ). Whole blood, plasma,  
217 and serum were obtained from five Weddell seals sampled in the austral spring of 2015, and  
218 whole blood from an additional seven Weddell seals was also acquired during this time. Goetz et  
219 al. (2017) describe the sampling protocol for these Weddell seals.

220         Lastly, a few samples were obtained from crabeater seals in McMurdo Sound. Hair  
221 samples were taken from three recently deceased juvenile crabeater seals that were found on the  
222 seasonal pack ice around Cape Royds in the austral summer of 2009/10. Whole blood was  
223 sampled, using the protocol of Goetz et al. (2017), from a male adult crabeater seal found in  
224 Erebus Bay during the austral summer of 2010/11.

225

## 226 **Sample preparation**

227         After sample collection, all samples were kept frozen at -20 °C. Blood samples were  
228 freeze-dried with a Labconco Freeze Dry System (Lyph Lock 4.5) and homogenized manually

229 prior to isotope analysis. Lipid extraction was not performed on the blood samples, as blood has  
230 a relatively low lipid content. A test set of blood samples with and without lipid extraction  
231 revealed no significant effect of lipid extraction on blood  $\delta^{13}\text{C}$  values (Table S2), though lipid  
232 extraction did have an undesired impact on  $\delta^{15}\text{N}$  values (Table S2).

233 Hair and whisker samples are known to have high enough lipid contents to affect  $\delta^{13}\text{C}$   
234 values so these samples were lipid extracted a la Hückstädt et al. (2012a). These samples were  
235 washed with Milli-Q water (Thermo Fisher Scientific, Inc.) and then rinsed three times in an  
236 ultrasonic bath with petroleum ether for 15 minutes.

237

### 238 **Bulk stable isotope analysis**

239 For all blood and hair samples, ~ 1 mg was weighed into tin cups (Costech, 3x5 mm) for  
240 bulk stable carbon and nitrogen isotope analysis. For hair, the follicle was removed since prior  
241 work has shown it to have a different biochemical and isotopic composition than the rest of the  
242 hair (Hückstädt et al. 2012b). This analysis was performed at the Stable Isotope Lab (SIL) of  
243 University of California - Santa Cruz (UCSC) on a Carlo Erba EA 1108 elemental analyzer  
244 coupled to a Thermo-Finnigan Delta<sup>Plus</sup> XP isotope ratio mass spectrometer. The  $\delta^{13}\text{C}$  values  
245 were referenced to the V-PDB standard, and  $\delta^{15}\text{N}$  values were referenced to AIR. PUGel and  
246 Acetanilide standards were analyzed in each instrument session in order to correct for variations  
247 in mass across samples and instrument drift. Across 10 analytical sessions, the standard  
248 deviations were 0.1 ‰ (n = 139) for  $\delta^{13}\text{C}$ , 0.1 ‰ (n = 139) for  $\delta^{15}\text{N}$ , and 0.1 (n = 139) for C/N  
249 (atomic) for PUGel and 0.2 ‰ (n = 38) for  $\delta^{13}\text{C}$ , 0.2‰ (n = 38) for  $\delta^{15}\text{N}$ , and 0.4 (n = 38) for  
250 C/N (atomic) for Acetanilide.

251

252 **Compound-specific isotope analysis**

253 CSI-AA was performed at UCSC via gas chromatography-combustion-isotope ratio mass  
254 spectrometry (GC-C-IRMS). All samples were prepared for GC-C-IRMS analysis using the  
255 methods described in McCarthy et al. (2007) and McCarthy et al. (2013). In brief, samples were  
256 hydrolyzed (6 N HCl for 20 hr at 110 °C) and converted to trifluoro-acetylated isopropyl amino  
257 acid derivatives. Samples were stored at -20 °C in a 1:3 TFAA:DCM (dichloromethene) solution  
258 until analysis. Immediately before the analysis, the TFAA/DCM mixture was evaporated under  
259 N<sub>2</sub> and samples were diluted in ethyl acetate.

260 Amino acid  $\delta^{15}\text{N}$  values were measured on a Thermo Trace GC coupled to a Thermo-  
261 Finnigan Delta<sup>Plus</sup> XP isotope-ratio-monitoring mass spectrometer (oxidation furnace at 980 °C  
262 and reduction furnace at 650 °C) using an SGE Analytical Science BPX5 column (60 m by 0.32  
263 mm with a 1  $\mu\text{m}$  film thickness). The injector temperature was 250 °C with a split He flow of 2  
264 mL/min. The GC temperature program was: initial temp = 70 °C hold for 1 min; ramp 1 = 10 °C  
265 /min to 185 °C, hold for 2 min; ramp 2 = 2 °C/min to 200 °C, hold for 10 min; ramp 3 = 30  
266 °C/min to 300 °C, hold for 6 min. Directly measured amino acid  $\delta^{15}\text{N}$  values were corrected  
267 based on bracketed external standards of amino acids with known isotopic composition, as  
268 described in McCarthy et al. (2013). The  $\delta^{15}\text{N}$  values of 11 amino acids were quantified: alanine  
269 (Ala), glycine (Gly), threonine (Thr), serine (Ser), valine (Val), leucine (Leu), Pro, aspartic acid  
270 + asparagine (Asp), Glu, Phe, and lysine (Lys).

271

272 **Data analysis**

273 Most samples were whole blood. Since bulk isotope values can vary across different  
274 tissues, species-specific corrections were applied to account for isotopic offsets between different

275 types of samples (see methods in *Supplementary Material* and resulting correction factors in  
276 Tables S3-S6). These corrections were applied to all bulk isotope data from tissues other than  
277 whole blood that had significant isotopic offsets from whole blood. An isotopic offset  $> 0.2 \text{ ‰}$   
278 was considered significant, since the instrument error is  $\leq 0.2 \text{ ‰}$ .

279 All data analyses were performed in R statistical software (R Core Team, 2014). Tests of  
280 normality and equal variance were conducted to assure test assumptions were met. In a few  
281 cases, an assumption was violated and a data transformation was applied, as noted in *Results*.  
282 Bulk isotope values of the three different seal species were compared with a one-way analysis of  
283 variance (ANOVA) and post-hoc Bonferroni pairwise comparisons. Data were Box-Cox  
284 transformed (Box and Cox, 1964). A four-way ANOVA with post-hoc Bonferroni pairwise  
285 comparisons was used to test for significant effects of gender, sampling period, age class, and  
286 region (WAP, Amundsen Sea, and Ross Sea) on the bulk isotopic values of Ross, Weddell, and  
287 crabeater seals. Both Weddell and crabeater seal data were Box-Cox transformed. Linear  
288 regression analyses were used to test for significant relationships between bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$   
289 values and body mass for each species.

290 A one-way ANOVA with post-hoc Bonferroni pairwise comparisons was used to test for  
291 significant differences in the  $\delta^{15}\text{N}$  values of each amino acid among the three seal species. This  
292 same procedure was conducted to compare the  $\delta^{15}\text{N}$  values for each category of amino acid (i.e.,  
293 source or trophic) among the different seal species. For both Weddell and crabeater seals, a two-  
294 tailed student's *t*-test was used to compare the  $\delta^{15}\text{N}$  values of Pro, Glu and Phe for the WAP to  
295 those of a combined Amundsen and Ross Sea region ("Amundsen/Ross Sea" in the subsequent  
296 text). Amino acid  $\delta^{15}\text{N}$  values for seals from the Amundsen/Ross Seas were combined by species  
297 (crabeater or Weddell) since both species had bulk  $\delta^{15}\text{N}$  values that were similar between these

298 two regions. This analysis was not done for Ross seals since this species was almost exclusively  
 299 sampled in the Amundsen Sea. A two-tailed student's *t*-test was used to compare the  $\delta^{15}\text{N}_{\text{Phe}}$   
 300 values of Weddell seals to those of crabeater seals for the WAP, and a one-way ANOVA with  
 301 post-hoc Bonferroni pairwise comparisons was conducted to assess variation between the  $\delta^{15}\text{N}_{\text{Phe}}$   
 302 values of Ross, Weddell, and crabeater seals from the Amundsen/Ross Sea region.

303 CSI-AA based trophic positions ( $\text{TP}_{\text{CSI-AA}}$ ) were calculated using a modified version of  
 304 the equation originally proposed by Chikaraishi et al. (2009). Here, we substituted Pro for Glu as  
 305 the trophic amino acid, as suggested by the comparative synthesis of  $\text{TP}_{\text{CSI-AA}}$  methods in  
 306 McMahon and McCarthy (2016), because Pro trophic discrimination appears to be less variable  
 307 across variations in diet. McMahon and McCarthy (2016) suggest that this new equation will  
 308 likely produce more ecologically realistic TP estimates for marine mammals.  $\text{TP}_{\text{CSI-AA}}$  was,  
 309 therefore, calculated as follows:

$$\text{TP}_{\text{CSI-AA}} = 1 + [(\delta^{15}\text{N}_{\text{Pro}} - \delta^{15}\text{N}_{\text{Phe}} - \beta_{\text{Pro/Phe}})/\text{TDF}_{\text{Pro}}]$$

310 where  $\delta^{15}\text{N}_{\text{Pro}}$  is the seal Pro  $\delta^{15}\text{N}$  value,  $\beta_{\text{Pro/Phe}}$  is the isotopic difference between Pro and Phe in  
 311 marine phytoplankton (3.1 ‰; Chikaraishi et al. 2009), and  $\text{TDF}_{\text{Pro}}$  is the trophic discrimination  
 312 between diet and consumer for Pro minus the same for Phe ( $\Delta^{15}\text{N}_{\text{pro}} - \Delta^{15}\text{N}_{\text{Phe}} = 4.5$  ‰;  
 313 McMahon and McCarthy 2016). Differences in  $\text{TP}_{\text{CSI-AA}}$  among the three seal species were  
 314 determined with a one-way ANOVA with post-hoc Bonferroni pairwise comparisons using data  
 315 for individuals only from the Ross and Amundsen Seas to reduce the effect of location on our  
 316 findings. Differences in  $\text{TP}_{\text{CSI-AA}}$  between the WAP versus Amundsen and Ross Seas were  
 317 determined with a two-tailed students *t*-test for Weddell and crabeater seals. For all statistical  
 318 analyses, a result was considered significant if  $p < 0.05$ .



319           Lastly, maps were produced in Ocean Data View (ODV) version (4.7.4) (Schlitzer 2015)  
320 to show spatial patterns in bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values, as well as  $\delta^{15}\text{N}_{\text{Phe}}$  and  $\delta^{15}\text{N}_{\text{Pro}}$ .

321

322

## RESULTS

323

### 324 **Bulk $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of Ross, Weddell, and crabeater seals**

325 Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values varied significantly among the three species (Fig. 1, Table S7). Ross  
326 seals had significantly higher  $\delta^{13}\text{C}$  values ( $-23.8 \pm 0.3$  ‰ for the mean  $\pm$  standard deviation,  $n =$   
327 15) than both Weddell seals ( $-25.0 \pm 0.6$  ‰,  $n = 125$ ) and crabeater seals ( $-25.0 \pm 1.4$  ‰,  $n = 97$ )  
328 ( $p < 0.001$  for post-hoc Bonferroni pairwise comparisons). All seals had  $\delta^{15}\text{N}$  values  
329 significantly different from each other: crabeater seal ( $7.2 \pm 0.8$  ‰,  $n = 97$ )  $<$  Ross seal ( $9.1 \pm 0.4$   
330 ‰,  $n = 15$ )  $<$  Weddell seal ( $12.3 \pm 0.6$  ‰,  $n = 125$ ) ( $p < 0.001$  for all Bonferroni post-hoc  
331 comparisons). We found no consistent relationships between bulk stable isotope values of seals  
332 and measures of sampling period, gender, age class, or body mass (see the *Supplementary*  
333 *Material*).

334

### 335 **Spatial patterns of bulk $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for Antarctic seals**

336           Both Weddell and crabeater seals showed significant spatial variation in their  $\delta^{13}\text{C}$   
337 values. Weddell seal  $\delta^{13}\text{C}$  values were significantly greater in the Ross Sea ( $-25.1 \pm 0.5$  ‰,  $n =$   
338 100) and the Amundsen Sea ( $-24.7 \pm 0.4$  ‰,  $n = 21$ ) than in the WAP ( $-22.9 \pm 0.9$  ‰,  $n = 4$ ) ( $p \leq$   
339 0.002 in all cases from Bonferroni post-hoc comparisons; Fig. 2a, Table S7). Likewise, the  $\delta^{13}\text{C}$   
340 values of crabeater seals along the WAP were significantly higher ( $-24.0 \pm 1.1$  ‰,  $n = 52$ ) than

341 those in the Amundsen Sea ( $-26.1 \pm 0.4$  ‰,  $n = 35$ ) and Ross Sea ( $-26.1 \pm 0.5$  ‰,  $n = 10$ ) ( $p <$   
342  $0.001$  in both cases for Bonferroni post-hoc comparisons; Fig. 3a, Table S7).

343 Unlike their bulk  $\delta^{13}\text{C}$  values, Weddell seals showed no significant differences in bulk  
344  $\delta^{15}\text{N}$  values across the three regions (Fig. 2b, Table S7). In contrast, crabeater seals from the  
345 WAP had significantly lower  $\delta^{15}\text{N}$  values ( $6.8 \pm 0.6$  ‰,  $n = 52$ ) than those from the Amundsen  
346 Sea ( $7.6 \pm 0.6$  ‰,  $n = 35$ ) and Ross Sea ( $8.0 \pm 1.4$  ‰,  $n = 10$ ) ( $p < 0.001$  in both cases from  
347 Bonferroni post-hoc comparisons, Fig. 3b, Table S7). Note, spatial variation in bulk  $\delta^{13}\text{C}$  and  
348  $\delta^{15}\text{N}$  values of Ross seals across West Antarctica could not be examined because all but one of  
349 the individuals were from the Amundsen Sea (Fig. S1).

350

### 351 **Compound-specific $\delta^{15}\text{N}$ values of Ross, Weddell, and crabeater seals**

352 Nitrogen isotope values were significantly different among at least two of the three seal  
353 species for all amino acids, except Gly (Figs. 4 and S2, Tables S8 and S9). For most trophic  
354 amino acids (Glu, Ala, Ile, Leu, Pro, and Val),  $\delta^{15}\text{N}$  values differed significantly among all three  
355 species (Table S9), with Weddell  $>$  Ross  $>$  crabeater. For example, Pro  $\delta^{15}\text{N}$  values of Weddell  
356 seals ( $20.0 \pm 1.4$  ‰,  $n = 6$ ) are significantly greater than those of Ross ( $17.2 \pm 0.5$  ‰,  $n = 6$ ) and  
357 crabeater ( $15.6 \pm 0.6$  ‰,  $n = 6$ ) seals ( $p < 0.001$  in both cases from Bonferroni post-hoc  
358 comparisons). Pro  $\delta^{15}\text{N}$  values of Ross seals ( $17.2 \pm 0.5$  ‰,  $n = 6$ ) are significantly greater than  
359 those of crabeater seals ( $15.6 \pm 0.6$  ‰,  $n = 6$ ) with a  $p$ -value of 0.03 from Bonferroni post-hoc  
360 comparisons. For the trophic amino acid, Asp, crabeater seals had significantly lower  $\delta^{15}\text{N}$   
361 values ( $10.1 \pm 0.6$  ‰,  $n = 6$ ) than Weddell ( $16.2 \pm 2.2$  ‰,  $n = 6$ ) and Ross seals ( $14.1 \pm 1.0$  ‰,  $n$   
362  $= 6$ ) ( $p < 0.001$  in both cases from Bonferroni post-hoc comparisons). Additionally,  $\delta^{15}\text{N}$  values  
363 among all trophic amino acids were significantly different among all three seal species ( $p <$

364 0.001 in all cases from Bonferroni post-hoc comparisons) with these values decreasing in the  
365 manner: Weddell seals ( $21.1 \pm 2.7 \text{ ‰}$ ,  $n = 42$ ) > Ross seals ( $17.7 \pm 1.9 \text{ ‰}$ ,  $n = 41$ ) > crabeater  
366 seals ( $13.5 \pm 1.9 \text{ ‰}$ ,  $n = 42$ ).

367  $\delta^{15}\text{N}$  values were significantly different between at least two seal species for both  
368 commonly defined source amino acids (Phe and Lys). For Lys, Ross seals had significantly  
369 lower  $\delta^{15}\text{N}$  values ( $2.8 \pm 0.7 \text{ ‰}$ ,  $n = 6$ ) than Weddell ( $5.2 \pm 1.5 \text{ ‰}$ ,  $n = 6$ ) and crabeater seals ( $5.0$   
370  $\pm 0.4 \text{ ‰}$ ,  $n = 6$ ) ( $p$ -values of 0.005 and 0.009, correspondingly, from Bonferroni post-hoc  
371 comparisons). Likewise, Ross seals had significantly lower  $\delta^{15}\text{N}_{\text{Phe}}$  values ( $2.7 \pm 0.7 \text{ ‰}$ ,  $n = 6$ )  
372 than Weddell ( $5.7 \pm 0.5 \text{ ‰}$ ,  $n = 6$ ) and crabeater seals ( $5.2 \pm 1.0 \text{ ‰}$ ,  $n = 6$ ) ( $p < 0.001$  in both  
373 cases from Bonferroni post-hoc comparisons). Combined, the  $\delta^{15}\text{N}$  values of these source amino  
374 acids (Phe and Lys) for Ross seals ( $2.7 \pm 0.7 \text{ ‰}$ ,  $n = 11$ ) are less than those of crabeater ( $5.1 \pm$   
375  $0.7 \text{ ‰}$ ,  $n = 12$ ) and Weddell seals ( $5.5 \pm 1.1 \text{ ‰}$ ,  $n = 12$ ) with  $p < 0.001$  in all cases from from  
376 Bonferroni post-hoc comparisons.

377 While Gly and Ser are challenging to accurately categorize in terms of conventional  
378 trophic and source groupings (McMahon and McCarthy 2016), we do note that Ser  $\delta^{15}\text{N}$  values  
379 of Weddell seals ( $8.7 \pm 1.4 \text{ ‰}$ ,  $n = 6$ ) were significantly higher than those of both crabeater ( $4.2$   
380  $\pm 1.9 \text{ ‰}$ ,  $n = 6$ ) and Ross seals ( $5.3 \pm 0.6 \text{ ‰}$ ,  $n = 6$ ) ( $p$ -values of  $< 0.001$  and 0.002, respectively,  
381 from Bonferroni post-hoc comparisons). No significant differences among the three seal species  
382 occur for Gly  $\delta^{15}\text{N}$  values. Ross, Weddell, and crabeater seals have Gly  $\delta^{15}\text{N}$  values of  $4.9 \pm 1.1$   
383  $\text{‰}$  ( $n = 6$ ),  $5.4 \pm 2.9 \text{ ‰}$  ( $n = 6$ ), and  $3.8 \pm 2.8 \text{ ‰}$  ( $n = 6$ ), correspondingly.

384

385 **Spatial patterns of Phe, Pro, and Glu  $\delta^{15}\text{N}$  values for Antarctic seals**

386 For Weddell seals, Phe, Pro, and Glu values did not differ significantly between the  
387 Amundsen/Ross Sea and the WAP (Fig. S4). In contrast, crabeater seals had significantly lower  
388  $\delta^{15}\text{N}_{\text{Phe}}$  values in the WAP ( $4.3 \pm 0.4 \text{ ‰}$ ,  $n = 3$ ) relative to those from the Amundsen/Ross Sea  
389 region ( $6.0 \pm 0.7 \text{ ‰}$ ,  $n = 3$ ) ( $p = 0.04$ , two-tailed student's  $t$ -test) (Figs. 5 and 6, Table S8).  
390 Crabeater  $\delta^{15}\text{N}_{\text{Pro}}$  and  $\delta^{15}\text{N}_{\text{Glu}}$  were not significantly different between the WAP ( $15.9 \pm 0.5 \text{ ‰}$   
391 and  $15.0 \pm 0.2 \text{ ‰}$ , respectively,  $n=3$  for both) and the Amundsen/Ross Sea region ( $15.4 \pm 0.6 \text{ ‰}$   
392 and  $14.8 \pm 0.4 \text{ ‰}$ , correspondingly,  $n = 3$  for both, Table S8). As with bulk isotope values,  
393 spatial variation in  $\delta^{15}\text{N}$  values of source amino acids for Ross seals could not be examined since  
394 all but one individual were from the Amundsen Sea (Fig. S3).

395 Both crabeater and Weddell seals had similar  $\delta^{15}\text{N}_{\text{Phe}}$  for the Amundsen/Ross Sea region,  
396  $6.0 \pm 0.7 \text{ ‰}$  ( $n = 3$ ) and  $5.7 \pm 0.7 \text{ ‰}$  ( $n = 3$ ), respectively, that were significantly higher than the  
397  $\delta^{15}\text{N}_{\text{Phe}}$  for Ross seals ( $2.7 \pm 0.7 \text{ ‰}$ ,  $n = 6$ ) ( $p$ -values  $< 0.001$  in all cases from Bonferroni post-  
398 hoc comparisons). However, crabeater seals had significantly lower  $\delta^{15}\text{N}_{\text{Phe}}$  ( $4.3 \pm 0.4 \text{ ‰}$ ,  $n = 3$ )  
399 than Weddell seals ( $5.7 \pm 0.4 \text{ ‰}$ ,  $n = 3$ ) for the WAP ( $p = 0.01$  from a two-tailed student's  $t$ -test).

400

#### 401 **Trophic positions of Ross, Weddell, and crabeater seals**

402 Among species, both Ross seals ( $3.5 \pm 0.2$ ,  $n = 6$ ) and Weddell seals ( $3.7 \pm 0.1$ ,  $n = 3$ )  
403 were over a full trophic level higher than crabeater seals ( $2.4 \pm 0.2$ ,  $n = 3$ ) ( $p < 0.001$  from  
404 Bonferroni post-hoc comparisons in both cases, restricted to Amudsen/Ross Seas where all  
405 species were collected) (Fig. 7). Within species, Weddell seals had similar  $\text{TP}_{\text{CSI-AA}}$  values for  
406 the WAP ( $3.3 \pm 0.4$ ,  $n = 3$ ) and Amundsen/Ross Sea region ( $3.7 \pm 0.1$ ,  $n = 3$ ). However,  
407 crabeater seals had significantly higher  $\text{TP}_{\text{CSI-AA}}$  values in the WAP ( $2.9 \pm 0.1$ ,  $n = 3$ ) than the  
408 Amundsen/Ross Sea region ( $2.4 \pm 0.2$ ,  $n = 3$ ) ( $p = 0.03$  from a two-tailed student's  $t$ -test). For

409 crabeater seals, note that one subadult was included along with five adult seals in the CSI-AA  
410 sample set. Although some significant variation in bulk  $\delta^{15}\text{N}$  values was observed across  
411 different age classes for this species (see *Supplementary Material*), the  $\text{TP}_{\text{CSI-AA}}$  value of the  
412 subadult from the Amundsen/Ross sea region (2.3) was indistinguishable from those of the adults  
413 from this region ( $2.4 \pm 0.2$ ,  $n = 2$ ). Finally, we note that there were some significant differences  
414 in the bulk  $\delta^{15}\text{N}$  values of Weddell seal age classes (discussed in the *Supplementary Material*),  
415 but only samples from adults are used in our CSI-AA subset.

416

## 417 **DISCUSSION**

418

419 Ross, Weddell, and crabeater seal bulk isotope values in our study were similar to those  
420 reported in earlier work on these species for our study region (Burns et al. 1998, Zhao et al.  
421 2004, Aubail et al. 2011, Goetz et al. 2017, Botta et al. 2018), after correction for isotopic offsets  
422 for different tissue types (Table S10). These new bulk isotope results are especially valuable for  
423 Ross seals since very little isotopic measurements exist to date. Our bulk  $\delta^{15}\text{N}$  values, like those  
424 of prior studies (Rau et al. 1992, Burns et al. 1998, Zhao et al. 2004, Aubail et al. 2011, Cipro et  
425 al. 2012, and Hückstädt et al. 2012a), all point to Ross seals being at an intermediate trophic  
426 position between those of Weddell and crabeater seals. In the following discussion we explore  
427 the trophic positions, diets, and foraging habitats of these three seal species using novel CSI-AA  
428 data to help interpret our bulk isotope data.

429

### 430 **Spatial patterns in seal bulk and amino acid isotope values**

431 Both Weddell and crabeater seals showed spatial patterns in their bulk  $\delta^{13}\text{C}$  values.  
432 Weddell and crabeater seals had significantly higher  $\delta^{13}\text{C}$  values in the WAP than the Amundsen  
433 and Ross Seas. As this carbon isotope gradient occurs in Weddell and crabeater seals at different  
434 trophic levels, it is likely driven by changes in baseline  $\delta^{13}\text{C}$  values. Prior research has shown  
435 that  $\delta^{13}\text{C}$  values decrease with increasing latitude in the West Antarctic as a result of increasing  
436  $\text{CO}_2$  solubility with decreasing sea surface temperatures (Cherel and Hobson 2007, Quillfeldt et  
437 al. 2010, Brault et al. 2018). Thus, the spatial variation in the bulk  $\delta^{13}\text{C}$  values of these two  
438 species likely predominantly reflects the sea surface temperature gradient in the West Antarctic,  
439 with colder temperatures in the higher latitude Amundsen and Ross Sea compared to the warmer,  
440 lower latitude WAP. The difference in sea surface temperatures of the WAP and Ross Sea  
441 (Ducklow et al. 2007, Ducklow et al. 2012, Smith et al. 2014) has been shown to contribute to an  
442  $\sim 2\text{‰}$  decrease in the  $\delta^{13}\text{C}_{\text{baseline}}$  between these regions (Brault et al. 2018), similar to the offset  
443 between the WAP and Ross Sea bulk  $\delta^{13}\text{C}$  values that we observe for Weddell and crabeater  
444 seals (2.0 ‰ and 2.1‰, respectively).

445 Weddell and crabeater seals showed different spatial patterns in their bulk  $\delta^{15}\text{N}$  values  
446 across West Antarctica. Weddell seals showed no spatial patterns in bulk  $\delta^{15}\text{N}$  values across the  
447 study region, Crabeater seals had significantly lower bulk  $\delta^{15}\text{N}$  values in the WAP than the  
448 Amundsen and Ross Seas. A spatial gradient in  $\delta^{15}\text{N}_{\text{baseline}}$  in the Southern Ocean has been  
449 detected by previous research, and likely reflects changes in nutrient utilization and primary  
450 productivity (DiFiore et al. 2006, DiFiore et al. 2009, Brault et al. 2018). A lower  $\delta^{15}\text{N}_{\text{baseline}}$  ( $\sim 2$   
451 ‰) in the WAP compared to the Amundsen and Ross Seas was found in a study of zooplankton  
452 (Brault et al. 2018); this is similar to the difference observed here between WAP and  
453 Amundsen/Ross Sea crabeater seal  $\delta^{15}\text{N}_{\text{Phe}}$  values (1.7 ‰). This difference in  $\delta^{15}\text{N}_{\text{baseline}}$  values

454 appears to reflect the relative proportion of oceanic versus coastal production across the West  
455 Antarctic (DiFiore et al. 2006, DiFiore et al. 2009, Brault et al. 2018). Baseline  $\delta^{15}\text{N}$  values  
456 likely increase from oceanic to coastal areas due to increasing productivity and nutrient  
457 drawdown towards the continent in the summer (DiFiore et al. 2006, DiFiore et al. 2009, Brault  
458 et al. 2018). The WAP, with its narrow shelf, likely has a greater influence from oceanic waters  
459 beyond the continental margin, whereas the Amundsen Sea and Ross Sea have wider, more  
460 productive shelf systems consistent with higher  $\delta^{15}\text{N}_{\text{baseline}}$  values (Arrigo et al. 1998, 2008,  
461 DiFiore et al. 2006, Smith & Comiso 2008, DiFiore et al. 2009, Alderkamp et al. 2012, Brault et  
462 al. 2018).

463 Continental shelves in Antarctica are especially productive areas compared to offshore  
464 waters since both light and iron become available for phytoplankton blooms at times of coastal  
465 polynya formation and increased iron inputs from various sources (e.g., melting glaciers)  
466 (Gordon et al. 2000, Alderkamp et al. 2012, Arrigo et al. 2015). Although annual production in  
467 the Amundsen and Ross Seas exceeds that of the WAP (Arrigo et al. 1998, 2008, Smith and  
468 Comiso 2008, Alderkamp et al. 2012), localized regions in the WAP may experience high rates  
469 of primary productivity comparable to those within the Amundsen and Ross Seas. For example,  
470 Schmidt et al. (2003) found that Marguerite Bay in the WAP can be a “hot spot” of productivity,  
471 as revealed by high phytoplankton and zooplankton  $\delta^{15}\text{N}$  values. To date, examinations of  
472  $\delta^{15}\text{N}_{\text{baseline}}$  variation in West Antarctica have suggested that it increases from oceanic to coastal  
473 waters, tracking a gradient in productivity and nutrient drawdown (Brault et al. 2018).

474 While it is likely that the observed spatial differences in Weddell and crabeater seal bulk  
475  $\delta^{15}\text{N}$  values reflect these  $\delta^{15}\text{N}_{\text{baseline}}$  gradients, spatial patterns in seal bulk  $\delta^{15}\text{N}$  values could be  
476 related to shifts in diet,  $\delta^{15}\text{N}_{\text{baseline}}$  values, or both. The  $\delta^{15}\text{N}_{\text{Phe}}$  values of Ross, Weddell, and

477 crabeater seals, on the other hand, reflect  $\delta^{15}\text{N}_{\text{baseline}}$ , driven by spatial gradients in nutrient  
478 utilization and primary productivity, without the confounding factor of trophic fractionation. As  
479 such, the spatial changes in  $\delta^{15}\text{N}_{\text{baseline}}$  in West Antarctica are useful for deducing the relative  
480 foraging habitats of Weddell and crabeater seals. Weddell seals from the WAP to the Ross Sea  
481 consistently have the highest  $\delta^{15}\text{N}_{\text{Phe}}$  values ( $5.7 \pm 0.4$  ‰ for the WAP and  $5.7 \pm 0.7$  ‰ for the  
482 Amundsen/Ross Sea region,  $n = 3$  in both cases) within the overall range of  $\delta^{15}\text{N}_{\text{Phe}}$  for all  
483 Antarctic seal (1.90 ‰ to 6.81 ‰). This suggests that Weddell seals throughout West Antarctica  
484 follow a similar foraging behavior in which they predominantly target the most productive  
485 environments within an area (i.e., highest  $\delta^{15}\text{N}_{\text{baseline}}$ ; Brault et al. 2018). These are likely to be  
486 coastal regions, given our understanding of the West Antarctic  $\delta^{15}\text{N}_{\text{baseline}}$  gradients. Satellite  
487 tracking data of different seal species in this region support this hypothesis. Costa et al. (2010)  
488 used satellite data to show that in the WAP, Weddell seals (unlike crabeater seals) moved  
489 minimally, foraging almost exclusively in likely highly productive coastal fjords (Schmidt et al.  
490 2003, DiFiore et al. 2006, 2009). Goetz (2015), likewise, found that Weddell seal movements do  
491 not extend beyond the Ross Sea continental shelf.

492 In contrast to Weddell seals, crabeater  $\delta^{15}\text{N}_{\text{Phe}}$  values vary significantly across West  
493 Antarctica, with higher values in the Amundsen and Ross Seas versus the WAP. These data  
494 indicate that crabeater seals have greater foraging habitat flexibility than Weddell seals, and thus  
495 make use of a wider range of productivity regimes. Weddell and crabeater seals also have  
496 significantly different  $\delta^{15}\text{N}_{\text{baseline}}$  for the WAP, which is not observed for the Amundsen/Ross Sea  
497 region, pointing to environmental heterogeneity in the WAP. Our current knowledge of crabeater  
498 seals indicates that this seal heavily consumes *E. superba* (Laws 1977, Rau et al. 1992, Burns et  
499 al. 2004, Zhao et al. 2004, Burns et al. 2008, Aubail et al. 2011, Hückstädt et al. 2012a), a krill



500 species with a distribution linked to that of sea ice. As a consequence, crabeater seals move on  
501 and off the continental shelf, depending on the krill life cycle stage and seasonal ice cover (Nicol  
502 2006). We hypothesize that crabeater seals move across the heterogeneous environments of the  
503 WAP, at times of the year incorporating the lower off-shelf  $\delta^{15}\text{N}_{\text{baseline}}$  values, in contrast with  
504 Weddell seals. Such a movement pattern by crabeater seals is supported by the tracking results of  
505 Costa et al. (2010). Since crabeater seals in the Amundsen/Ross Sea region have  $\delta^{15}\text{N}_{\text{Phe}}$  values  
506 more similar to those of Weddell seals from this area, the same interpretation would suggest that  
507 crabeater seals in this region stay within the wider and more productive continental shelf areas of  
508 the Amundsen and Ross Seas. Overall, our results indicate that Weddell seals have a strong  
509 preference for productive coastal sites, whereas crabeater seals use more diverse habitats in West  
510 Antarctica, but that their foraging patterns vary by region.

511 Ross seals sampled in the Amundsen/Ross Seas had significantly lower  $\delta^{15}\text{N}_{\text{Phe}}$  values  
512 than both Weddell and crabeater seals from this region (Fig. 4). This result suggests that Ross  
513 seals are foraging in a different region from the other two species. These low  $\delta^{15}\text{N}_{\text{baseline}}$  values  
514 coupled with our current understanding of the West Antarctic  $\delta^{15}\text{N}_{\text{baseline}}$  gradient (Brault et al.  
515 2018) strongly suggest that Ross seals are likely feeding much further offshore than Weddell and  
516 crabeater seals, largely in the oceanic region of the Southern Ocean that experiences low nutrient  
517 drawdown and low productivity relative to coastal areas (DiFiore et al. 2006, DiFiore et al. 2009,  
518 Jaeger et al. 2010, Somes et al. 2010).

519 Prior research supports our hypothesis that Ross seals are largely oceanic feeders. For  
520 example, Blix and Nordøy (2007) examined the foraging behavior of Ross seals via satellite-  
521 linked dive recorders. The tags tracked the movements of 10 adult Ross seals captured off Queen  
522 Maud Land (East Antarctica) just after their molt in February 2001. The animals migrated 2,000

523 km north to pelagic waters south of the Antarctic Polar Front. These Ross seals stayed in that  
524 area until October when they traveled south into the pack ice (Blix and Nordøy 2007). Similarly,  
525 Arcalís-Planas et al. (2015) showed that Ross seals minimally use sea ice, hauling out for only  
526 short periods each year to molt (December to January) and breed (late October to mid-  
527 November). They report that Ross seals are moving from 587 to 1,282 km off the ice edge during  
528 much of the year (Arcalís-Planas et al. 2015). The low  $\delta^{15}\text{N}_{\text{baseline}}$  value measured in our study  
529 represents independent evidence that Ross seals are indeed are spending the majority of each  
530 year foraging in less productive, oceanic waters, separate from the more coastal food webs of the  
531 crabeater and Weddell seals.

532

### 533 **Reevaluating trophic dynamics of Antarctic Seals**

534 Differences in regional foraging habitat utilization among seals, indicated by  $\delta^{15}\text{N}_{\text{phe}}$   
535 between Ross seals versus crabeater and Weddell seals ( $\sim 3\text{‰}$ ), suggest the need for a  
536 reevaluation of the TP and associated food web ecology for Ross seals. Our compound-specific  
537 approach allowed us to calculate trophic positions of these Antarctic seals that were internally  
538 indexed to  $\delta^{15}\text{N}_{\text{baseline}}$ . We found that Ross seals had  $\text{TP}_{\text{CSI-AA}}$  values similar to those of Weddell  
539 seals, both of which were significantly higher than crabeater seals. This result differed from  
540 previous conclusions based on bulk  $\delta^{15}\text{N}$  values, which suggested that Ross seals were at an  
541 intermediate trophic position between crabeater and Weddell seals (Rau et al. 1992, Zhao et al.  
542 2004, Aubail et al. 2011). Our results suggest that, like Weddell seals, Ross seals are  
543 predominantly feeding on high trophic level prey, such as mid-to-deep water fish and squid, and  
544 that lower trophic level prey (e.g., *E. superba*) are not a major part of their diets. This conclusion  
545 is supported by dive records, which indicate that Ross seals forage at depths associated with

546 capturing mesopelagic squid and fish (Bengtson and Stewart 1997, Blix and Nordøy 2007), and  
547 corroborate limited stomach content analyses that have reported Antarctic silverfish and glacial  
548 squid comprising their diets in varying proportions (Skinner and Klages, 1994).

549         Our compound-specific isotope approach to trophic dynamics also revealed significant  
550 spatial variation in the trophic dynamics of crabeater seals across West Antarctica. The  $TP_{CSI-AA}$   
551 value of crabeater seals decreases by approximately 0.5 from the WAP to the Amundsen/Ross  
552 Sea region, which is substantial for a low trophic level consumer like the crabeater seal that is  
553 thought to specialize on krill. Variations of this range have been shown to be significant in many  
554 past studies (e.g., McCarthy et al. 2007; Batista et al. 2014), with recent ecological work  
555 showing that  $TP_{CSI-AA}$  variation as small as 0.2 to 0.3 indicates real ecological change (Ostrom et  
556 al. 2017). This pattern is not likely driven by differences in age class across regions as all but one  
557 crabeater seal from both regions were adults. The WAP has been experiencing increased krill  
558 fishing pressure, a resurgence in baleen whales (competitors for krill), and dramatic reductions in  
559 sea ice extent as a function of rapid regional warming, all of which have negative effects on *E.*  
560 *superba* abundance (Ducklow et al. 2007, Trivelpiece et al. 2011, Ducklow et al. 2012, Nicol et  
561 al. 2012). Perhaps these environmental changes have decreased the availability of krill for  
562 crabeater seals in this area, causing crabeater seals to supplement their diet with fish in the WAP  
563 relative to the Amundsen/Ross Sea region.

564         Alternatively, the regional differences in crabeater seal  $TP_{CSI-AA}$  values could be the  
565 result of bottom-up effects. Prior research has shown omnivorous behaviors by *E. superba* in the  
566 WAP and Drake Passage regions, possibly contributing to a higher euphausiid TP in this region  
567 than other areas of the Antarctic (Schmidt et al. 2006). However, euphausiid omnivory in the  
568 Ross Sea has also been suggested (Hopkins 1987, Pinkerton et al. 2010), and it is possible that

569 omnivory by this taxon varies in time and space (Schmidt et al. 2006). Given these uncertainties,  
570 it is not possible to definitively assess the relative roles of shifts in diet versus krill omnivory to  
571 our observed spatial gradient of crabeater seal  $TP_{CSI-AA}$ .

572

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## CONCLUSIONS

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575 Our work using bulk and amino acid isotope analyses revealed significant variability in  
576 the foraging habitats and trophic dynamics of three important Antarctic seal species in the West  
577 Antarctic. Ross seals are foraging in a low productivity, oceanic food web far offshore from that  
578 of crabeater and Weddell seals. Crabeater and Weddell seals are foraging within similar food  
579 webs closer to shore, but isotopic data suggest that crabeater seals are likely following sea ice to  
580 capture *E. superba*, while Weddell seals target the most productive, near-shore areas within the  
581 western Antarctic to take prey. In addition, our CSI-AA data revealed that Ross seals occupy a  
582 higher trophic position than originally thought, equivalent to Weddell seals and greater than that  
583 of crabeater seals. Additionally, since bulk isotope-based TP estimates are unable to account for  
584 varying baseline  $\delta^{15}N$  values, we hypothesize that the strong baseline changes across the  
585 environments inhabited by these species are responsible for this underestimate of TP. This study  
586 will begin to reshape our understanding of Ross seal foraging ecology while also highlighting the  
587 challenges and potential solutions to accounting for variability in baseline and trophic dynamics  
588 when interpreting consumer isotope data in studies of foraging ecology.

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591

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592

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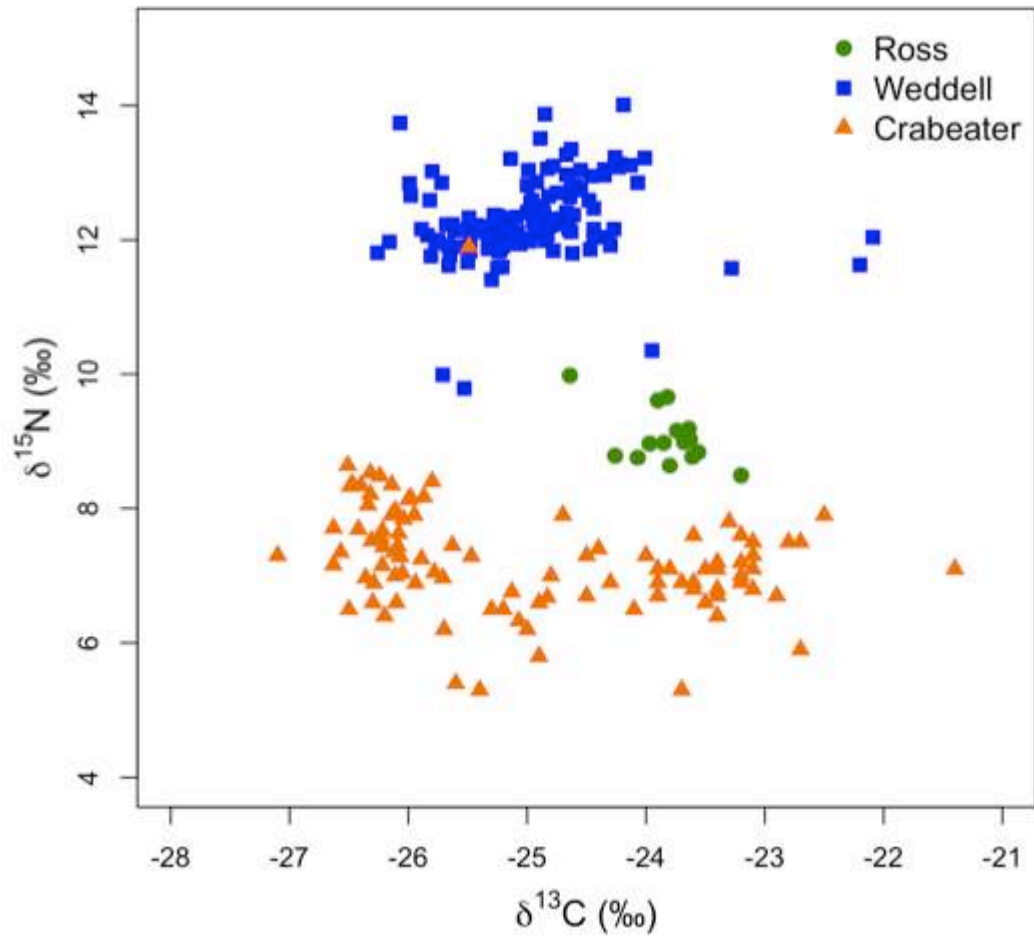
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FIGURES

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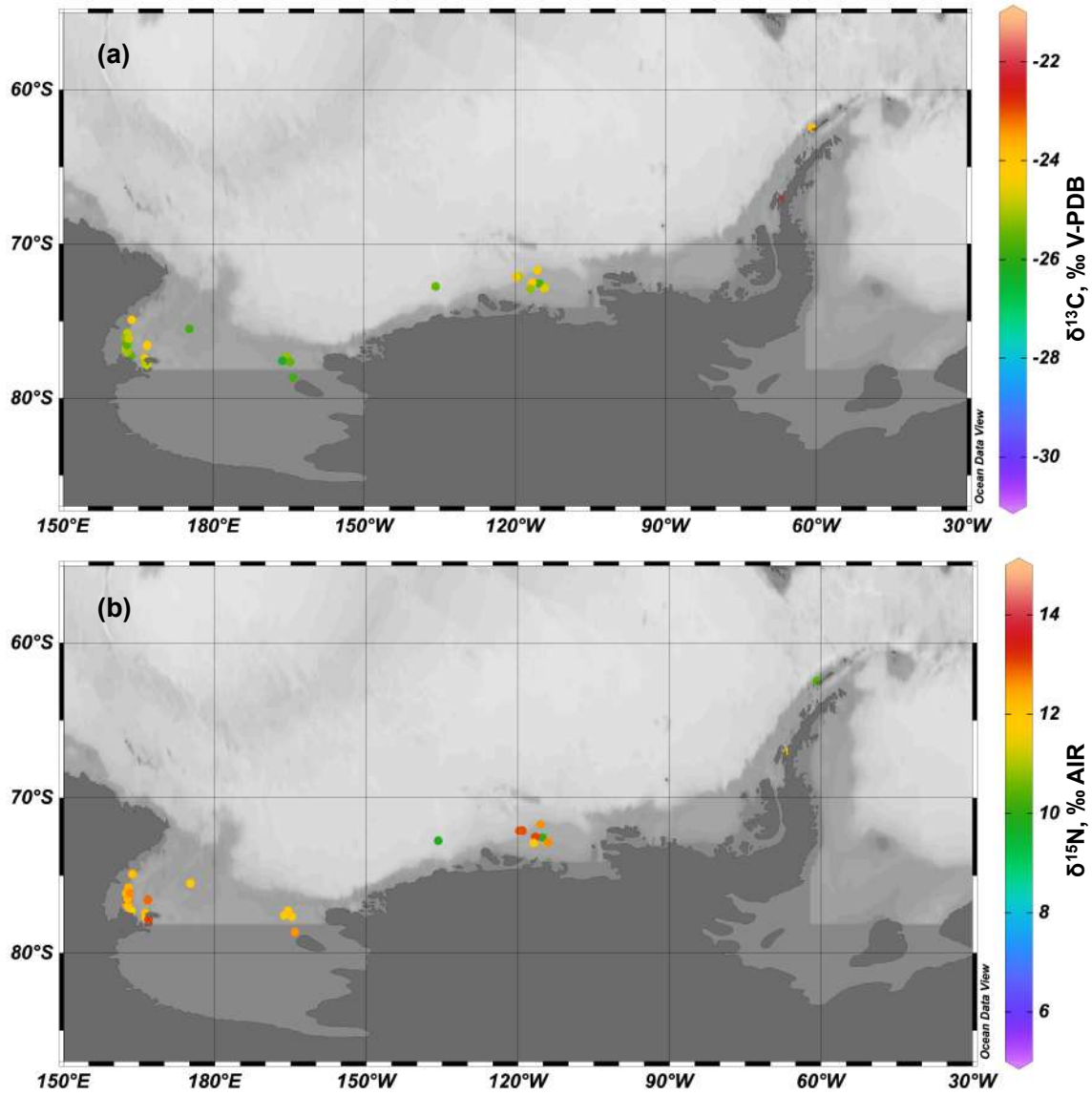
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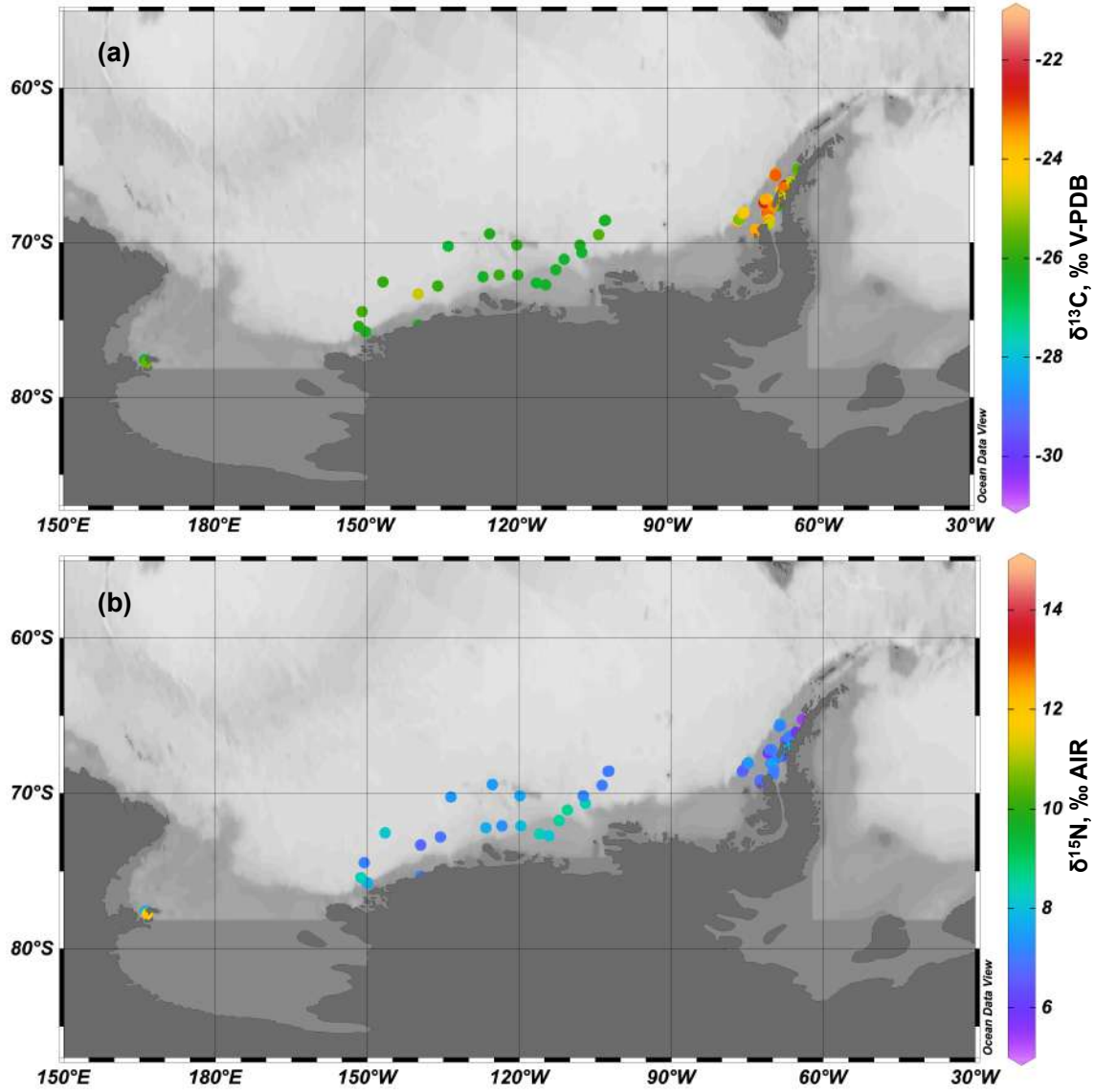
Fig. 1. Bulk  $\delta^{15}\text{N}$  values versus  $\delta^{13}\text{C}$  values for Ross seals (green circles), Weddell (blue squares), and crabeater (orange triangles) in the West Antarctic.



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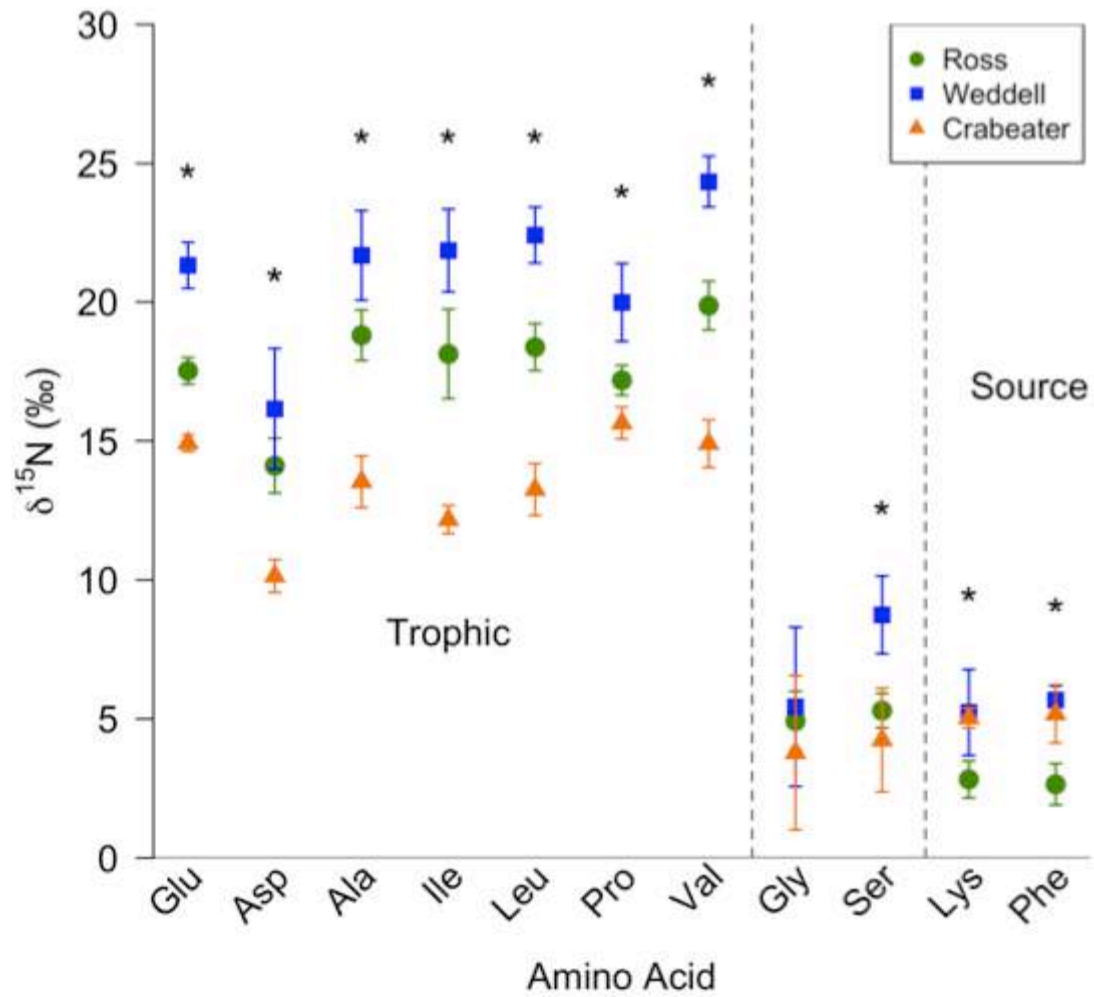
Fig. 2. Spatial variation in  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values of Weddell seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).



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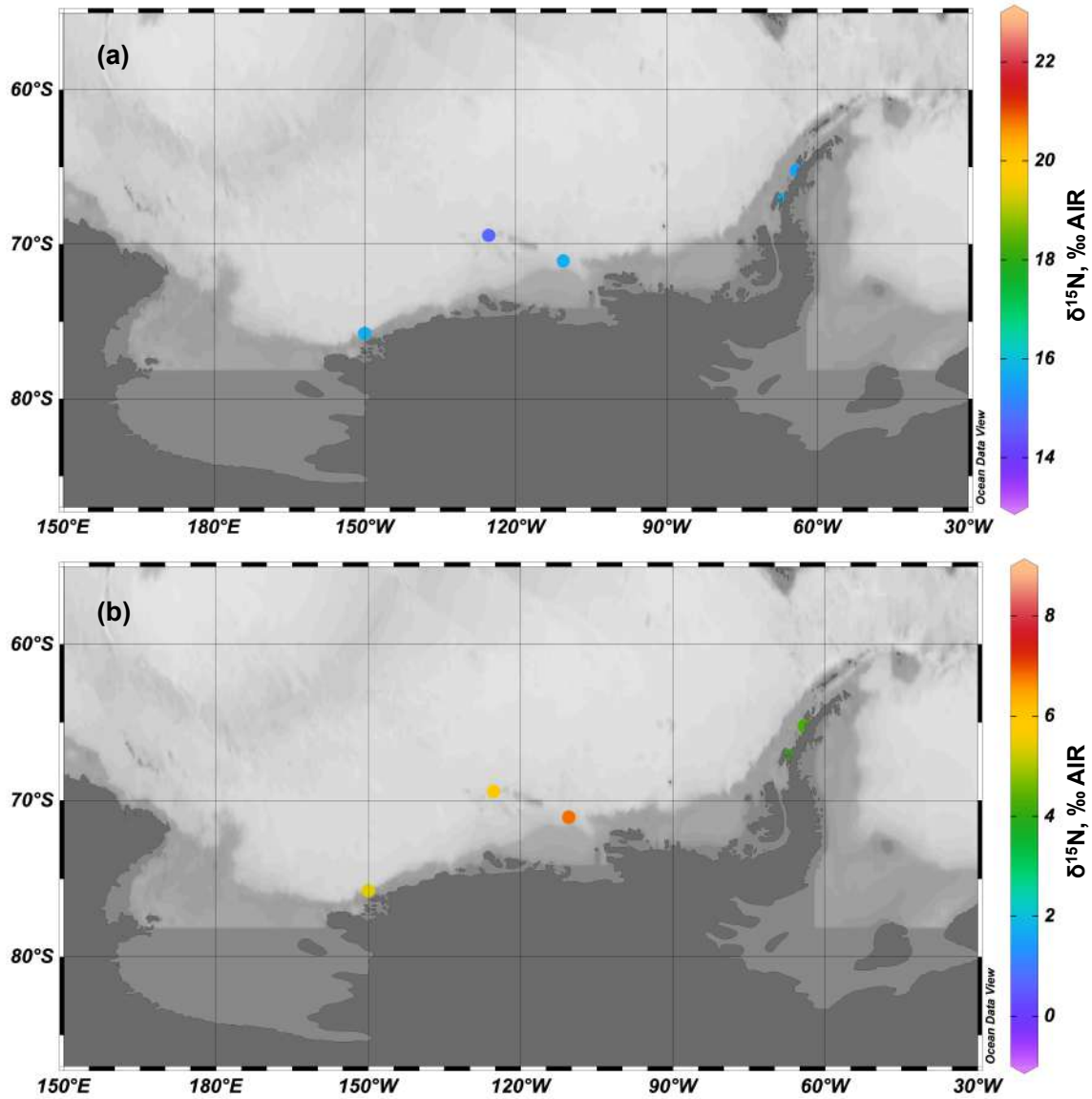
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Fig. 3. Spatial variation in  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values of crabeater seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).



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Fig. 4. Mean  $\delta^{15}\text{N}$  values ( $\pm 1$  SD) of amino acids for Ross (green circles), Weddell (blue squares), and crabeater (orange triangles) seals. Significant differences ( $p < 0.05$ ) among species for an amino acid are indicated with asterisks. Amino acids are divided into trophic and source amino acids, with Gly and Ser separate given uncertainty in their classification for marine mammals (McMahon and McCarthy 2016).

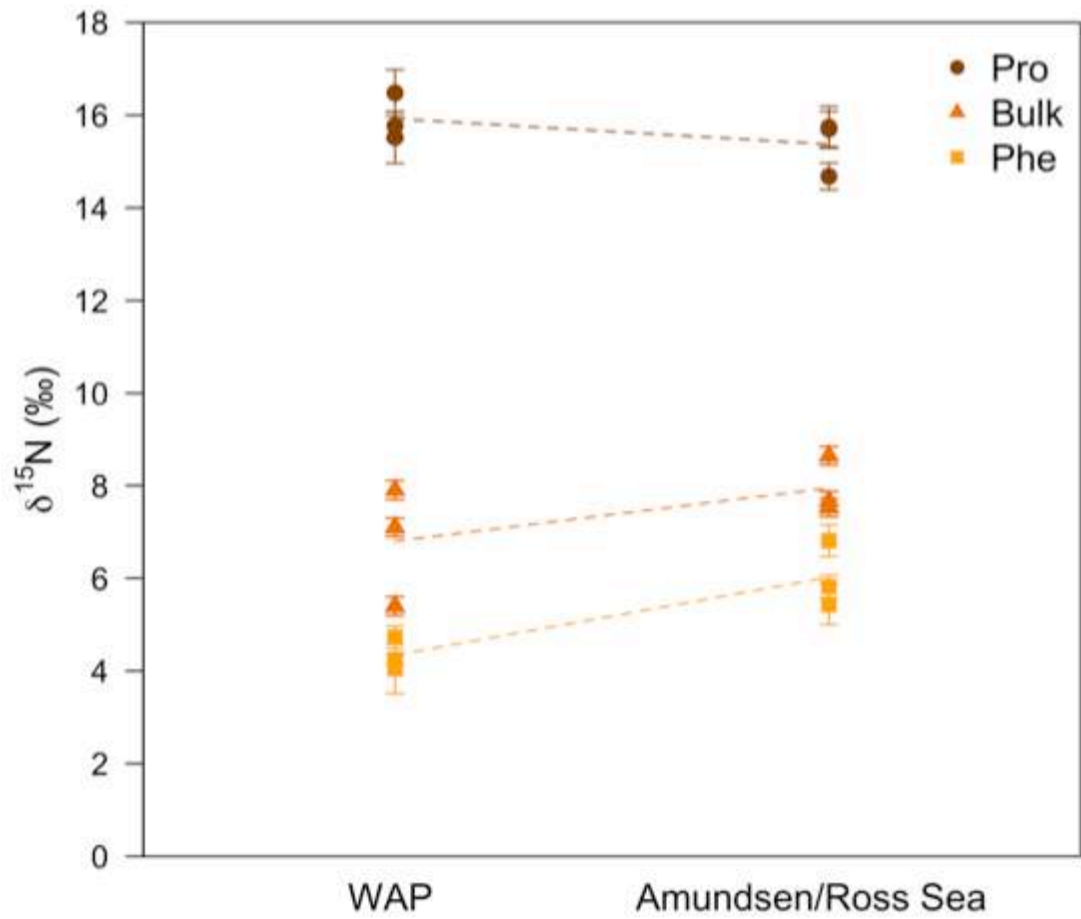


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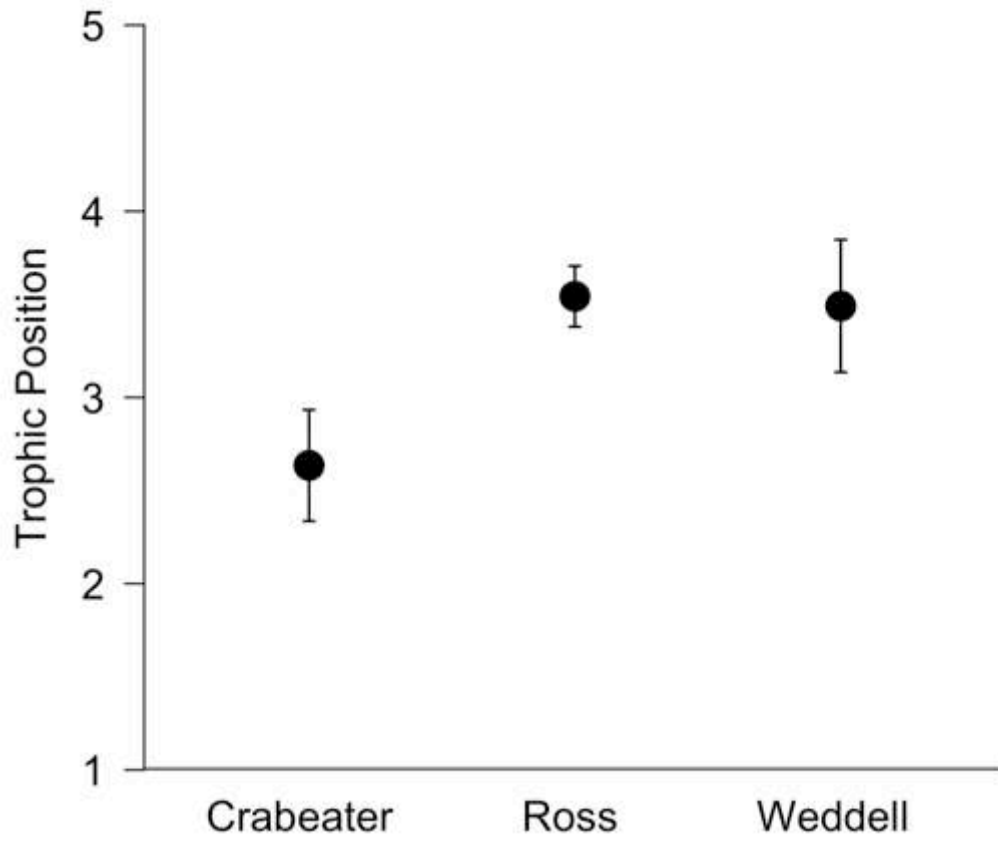
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Fig. 5. Spatial variation in  $\delta^{15}\text{N}$  values of Pro (a) and Phe (b) values for crabeater seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).





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911 Fig. 6. Comparison of  $\delta^{15}\text{N}$  values (mean  $\pm$  1 SD) of Pro, bulk material, and Phe for crabeater seals. Dark  
912 orange circles, medium orange triangles, light orange squares represent Pro, bulk, and Phe  $\delta^{15}\text{N}$  values,  
913 respectively. Bulk  $\delta^{15}\text{N}$  values represent whole blood, with corrections applied if the given sample type  
914 analyzed was not whole blood.  
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Fig. 7. Trophic position estimates (mean  $\pm$  1 SD) for crabeater, Ross, and Weddell seals from the Amundsen and Ross Seas. Trophic positions were calculated based on Pro and Phe  $\delta^{15}\text{N}$  values.

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**SUPPLEMENTAL MATERIAL**

**Relationships of bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values with gender, sampling period, age class, and body mass of the Antarctic seals**

Sampling period, gender, and age class have no significant effects on the bulk  $\delta^{13}\text{C}$  values of Ross Seals (Figs. S5 and S6). However, there is a significant, but weak negative relationship between body mass and  $\delta^{13}\text{C}$  values ( $R^2$  value of 0.3 from a linear regression analysis, Fig. S6). Sampling period, gender, age class, and body mass all have no significant effects on the bulk  $\delta^{15}\text{N}$  values of Ross seals (Figs. S5 and S6).

For Weddell seals, sampling period, gender, and body mass have no significant effects on bulk  $\delta^{13}\text{C}$  values (Figs. S7 and S8). Adult Weddell seals have significantly higher bulk  $\delta^{13}\text{C}$  values ( $-24.9 \pm 0.6 \text{ ‰}$ ,  $n=93$ ) than juveniles ( $-25.2 \pm 0.6 \text{ ‰}$ ,  $n=17$ ) and subadults ( $-25.4 \pm 0.5 \text{ ‰}$ ,  $n=15$ ) ( $p = 0.002$  in both cases). Sampling period, gender, and body mass have no significant effects on bulk  $\delta^{15}\text{N}$  values (Figs. S7, and S8). However, Weddell bulk  $\delta^{15}\text{N}$  values are significantly lower in subadults ( $11.9 \pm 0.7 \text{ ‰}$ ,  $n=15$ ) than juveniles ( $12.6 \pm 0.6 \text{ ‰}$ ,  $n=17$ ) and adults ( $12.3 \pm 0.6 \text{ ‰}$ ,  $n=93$ ) ( $p$ -values of 0.02 and 0.004, correspondingly, from Bonferroni post-hoc comparisons) (Fig. S7).

Crabeater seal  $\delta^{13}\text{C}$  values are not affected significantly by sampling period or gender (Fig. S9). Adult crabeater seals have significantly higher  $\delta^{13}\text{C}$  values ( $-24.6 \pm 1.3 \text{ ‰}$ ,  $n=76$ ) than subadults ( $-26.3 \pm 0.2 \text{ ‰}$ ,  $n=10$ ) and juveniles ( $-26.2 \pm 0.4 \text{ ‰}$ ,  $n=11$ ) from Bonferroni post-hoc comparisons ( $p < 0.001$  in both cases) (Fig. S9). Additionally, crabeater seal  $\delta^{13}\text{C}$  values increase significantly with increasing body mass ( $R^2$  value of 0.4 from a linear regression analysis) (Fig.

24 S10). The  $\delta^{15}\text{N}$  values of crabeater seals do not vary significantly with gender (Fig. S9). One  
25 significant difference occurs across sampling periods: Amundsen Sea  $\delta^{15}\text{N}$  values are  
26 significantly higher for the austral summer 2007/08 sampling ( $8.1 \pm 0.4 \text{ ‰}$ ,  $n = 14$ ) than the  
27 austral summer 2010/11 sampling ( $7.3 \pm 0.6 \text{ ‰}$ ,  $n = 21$ ) ( $p < 0.001$  from Bonferroni post-hoc  
28 comparisons). Adult crabeater seals have significantly lower  $\delta^{15}\text{N}$  values ( $7.0 \pm 0.8 \text{ ‰}$ ,  $n = 76$ )  
29 than subadult animals ( $8.3 \pm 0.4 \text{ ‰}$ ,  $n = 10$ ,  $p < 0.0001$  for the Bonferroni post-hoc comparison)  
30 and juvenile seals ( $7.8 \pm 0.3 \text{ ‰}$ ,  $n = 11$ ,  $p = 0.01$  for the Bonferroni post-hoc comparison) (Fig.  
31 S9). The  $\delta^{15}\text{N}$  values significantly increase with decreasing body mass (Fig. S10,  $R^2$  value of 0.4  
32 from a linear regression analysis).

33 **Discussion of relationships of bulk isotope values with gender, sampling period, age class,**  
34 **and body mass of the Antarctic seals**

35 Our Ross seal bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  results suggest a similar diet and foraging region across  
36 different genders and age classes. In contrast, the significant relationship between body mass and  
37  $\delta^{13}\text{C}$  (increasing  $\delta^{13}\text{C}$  values with decreasing body mass) suggests that Ross seals of different  
38 sizes are foraging in slightly different areas. However, no significant relationship exists between  
39 body mass and phenylalanine (Phe)  $\delta^{15}\text{N}$  value for Ross seals, which varies across different  
40 environments as described in the main text. Zhao et al. (2004) found no significant effects of age  
41 or sex on Ross seal  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values.

42 Our Weddell and crabeater seal results show no significant effects of gender on  $\delta^{13}\text{C}$  and  
43  $\delta^{15}\text{N}$  values, indicating that foraging area and diet do not differ across genders for these species.  
44 This finding is consistent with the results of Zhao et al. (2004) and Burns et al. (1998) for  
45 crabeater and Weddell seals, respectively. However, Zhao et al. (2004) reported that male  
46 Weddell seals have significantly higher  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values than females.

47 Weddell seal bulk  $\delta^{13}\text{C}$  values of adults are significantly higher than those of juveniles  
48 and subadults, suggesting that these animals vary their foraging region with age. In contrast,  
49 Zhao et al. (2004) and Aubail et al. (2011) found no significant variation in bulk  $\delta^{13}\text{C}$  values  
50 across Weddell seal age classes. However, Goetz et al. (2017) found increasing  $\delta^{13}\text{C}$  values with  
51 age for Weddell seals from analysis of red blood cells (RBC), consistent with our finding. Our  
52 results point to adult crabeater seals foraging in a different area than subadults and juveniles,  
53 perhaps further offshore given their higher  $\delta^{13}\text{C}$  values, as well as the positive relationship  
54 between body mass and  $\delta^{13}\text{C}$  value for this species. Likewise, Aubail et al. (2011) found  
55 significantly higher  $\delta^{13}\text{C}$  values in crabeater adults than juveniles, and Hückstädt et al. (2012)  
56 found  $\delta^{13}\text{C}$  values significantly increasing with increasing crabeater seal body mass. In contrast,  
57 Zhao et al. (2004) found no significant variability in  $\delta^{13}\text{C}$  values across age groups.

58 In this study, both Weddell and crabeater seals have significant variability in  $\delta^{15}\text{N}$  values  
59 across age classes. For crabeater seals, our finding of significantly lower  $\delta^{15}\text{N}$  values in adults  
60 than juveniles is supported by the results of Aubail et al. (2011). The observed bulk isotope  
61 variation for Weddell and crabeater seals in this study could have resulted from differences in  
62 foraging regions, diet, or both between the various age classes. We did not attempt to explore the  
63 drivers of  $\delta^{15}\text{N}$  variations across age classes of Weddell and crabeater seals further in our  
64 compound-specific isotope analysis of amino acids (CSI-AA) since limitations entailed in this  
65 analysis (i.e., expense and extensive laboratory processing) did not allow for amino acid  $\delta^{15}\text{N}$   
66 measurements from a sufficient number of samples for such an investigation. For Weddell seals,  
67 we only conducted CSI-AA on tissues from adults. We performed CSI-AA on one subadult and  
68 five adults for crabeater seals. The subadult had a higher Phe  $\delta^{15}\text{N}$  value (6.8 ‰) relative to that  
69 of the adults ( $5.6 \pm 0.3$  ‰) for the Amundsen/Ross sea region. The nitrogen isotope values of Pro

70 and Glu for the subadult (15.7 ‰ and 15.1 ‰, respectively) were slightly higher than Pro and  
71 Glu  $\delta^{15}\text{N}$  values of adults ( $15.2 \pm 0.8$  ‰ and  $14.7 \pm 0.5$  ‰) for the Amundsen and Ross Seas.  
72 This result indicates the higher bulk  $\delta^{15}\text{N}$  values of subadult than adult crabeater seals may be  
73 driven by the former using a habitat with moderately higher baseline  $\delta^{15}\text{N}$  values and, perhaps,  
74 nitrogen drawdown than the latter. However, CSI-AA must be conducted on considerably more  
75 crabeater seal samples before  $\delta^{15}\text{N}$  variation across age classes can be clearly established and the  
76 possible causes can be identified.

77         The results of other studies measuring bulk  $\delta^{15}\text{N}$  values of Weddell and crabeater seals  
78 differed from our findings. Goetz et al. (2017) found increasing  $\delta^{15}\text{N}$  values with increasing  
79 Weddell seal age. Zhao et al. (2004) compared  $\delta^{15}\text{N}$  values of Weddell seal pups, juveniles,  
80 subadults, and adults, and found only one significant result: adults have higher  $\delta^{15}\text{N}$  values than  
81 subadults. Aubail et al. (2011) reported no significant difference across Weddell seal age groups,  
82 which included juveniles and adults. For crabeater seals, Zhao et al. (2004) found no significant  
83 variability in  $\delta^{15}\text{N}$  values of pups, juveniles, subadults, and adults. Overall, the effects of age, as  
84 well as gender, on the isotopic values of crabeater and Weddell seals vary across the research to  
85 date. Furthermore, isotope baseline variability may contribute to the differences in bulk isotope  
86 values across age groups or genders, as mentioned above and discussed in detail in the main text.

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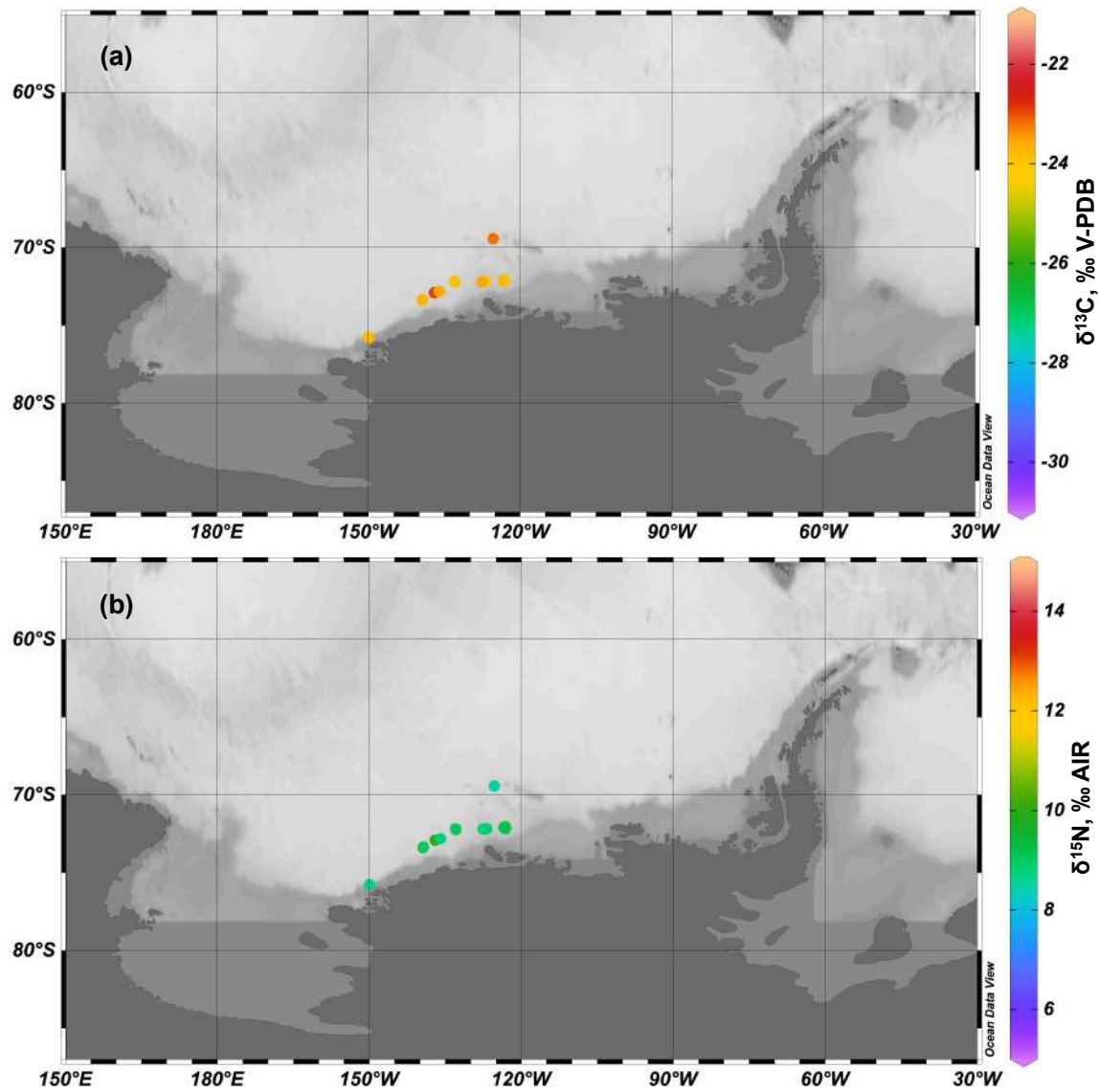
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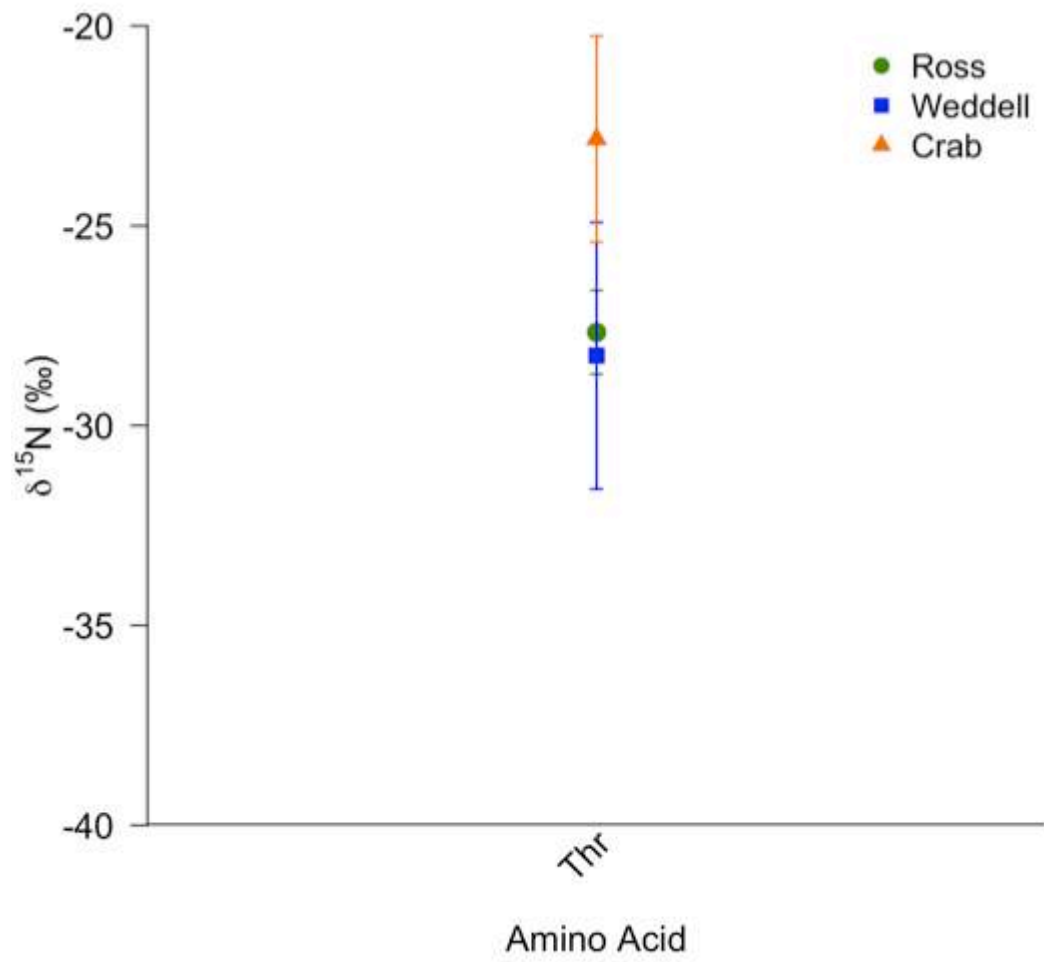
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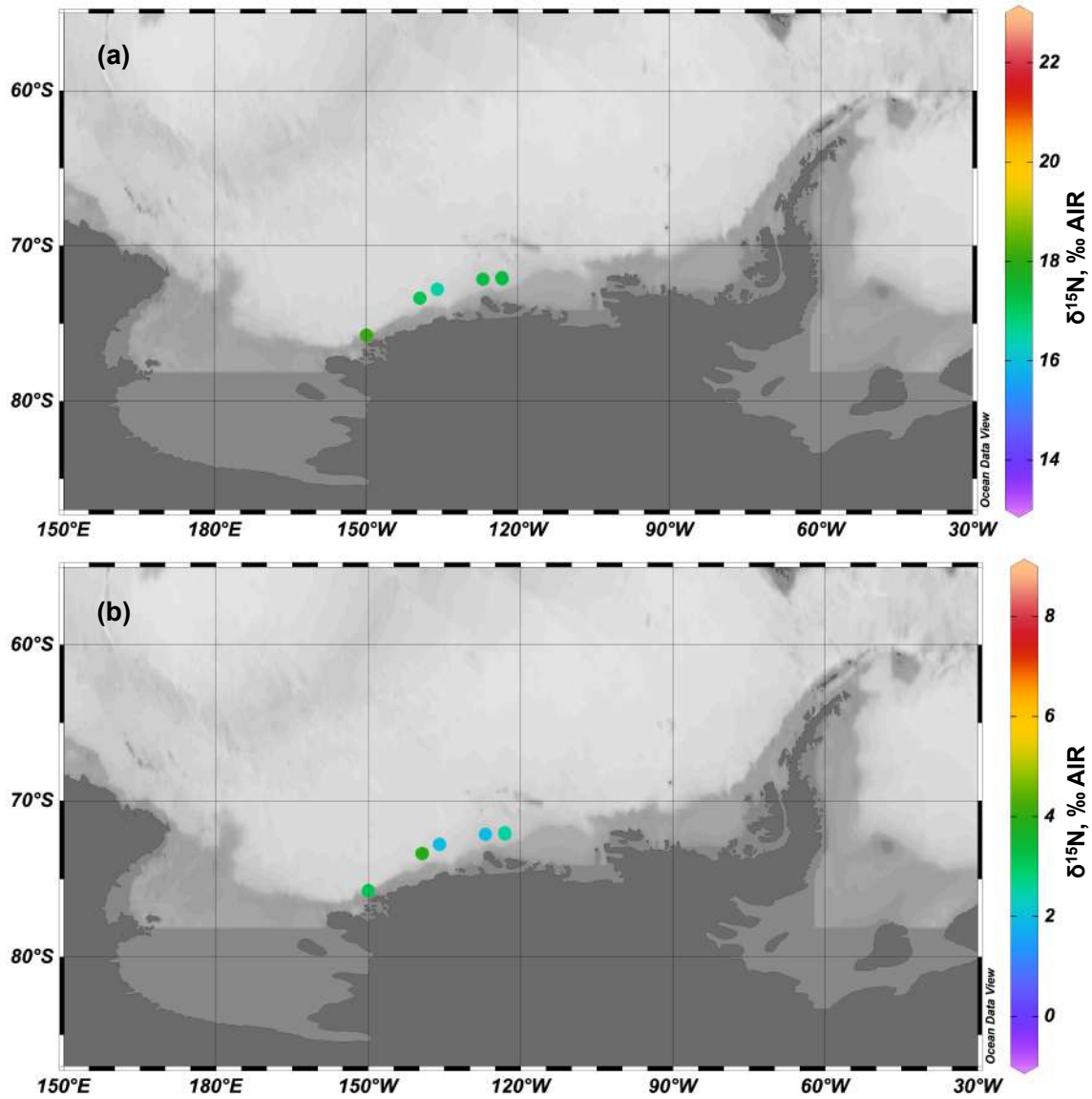
Fig. S1. Spatial variation in bulk  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values of Ross seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).



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Fig. S2.  $\delta^{15}\text{N}$  values (mean  $\pm$  1 standard deviation) of threonine for Ross, Weddell, and crabeater seals. Species are shown with colors: blue squares for Weddell seals, orange triangles for crabeater seals, and green circles for Ross seals.

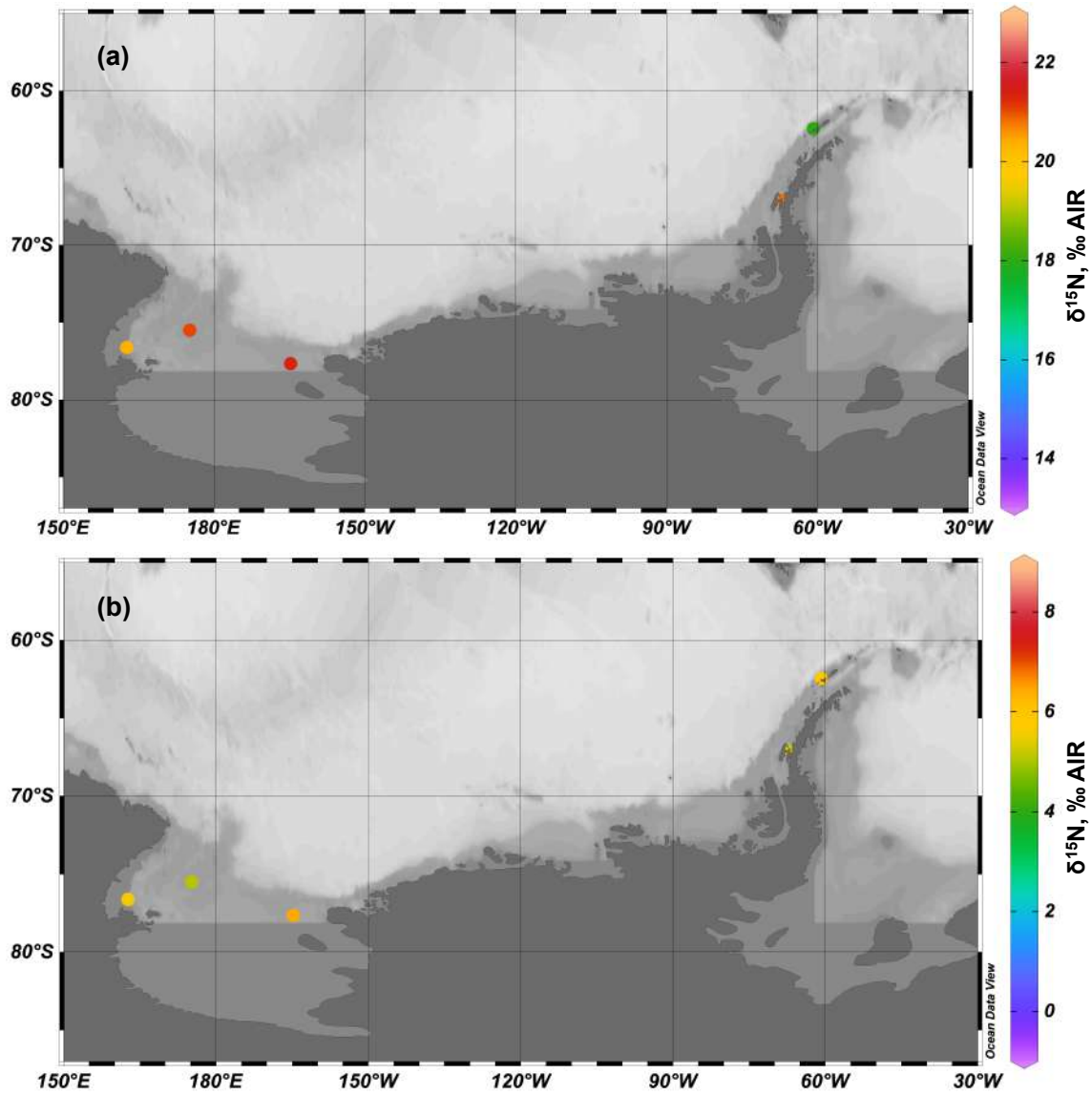




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Fig. S3. Spatial variation in  $\delta^{15}\text{N}$  values of Pro (a) and Phe (b) values for Ross seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).

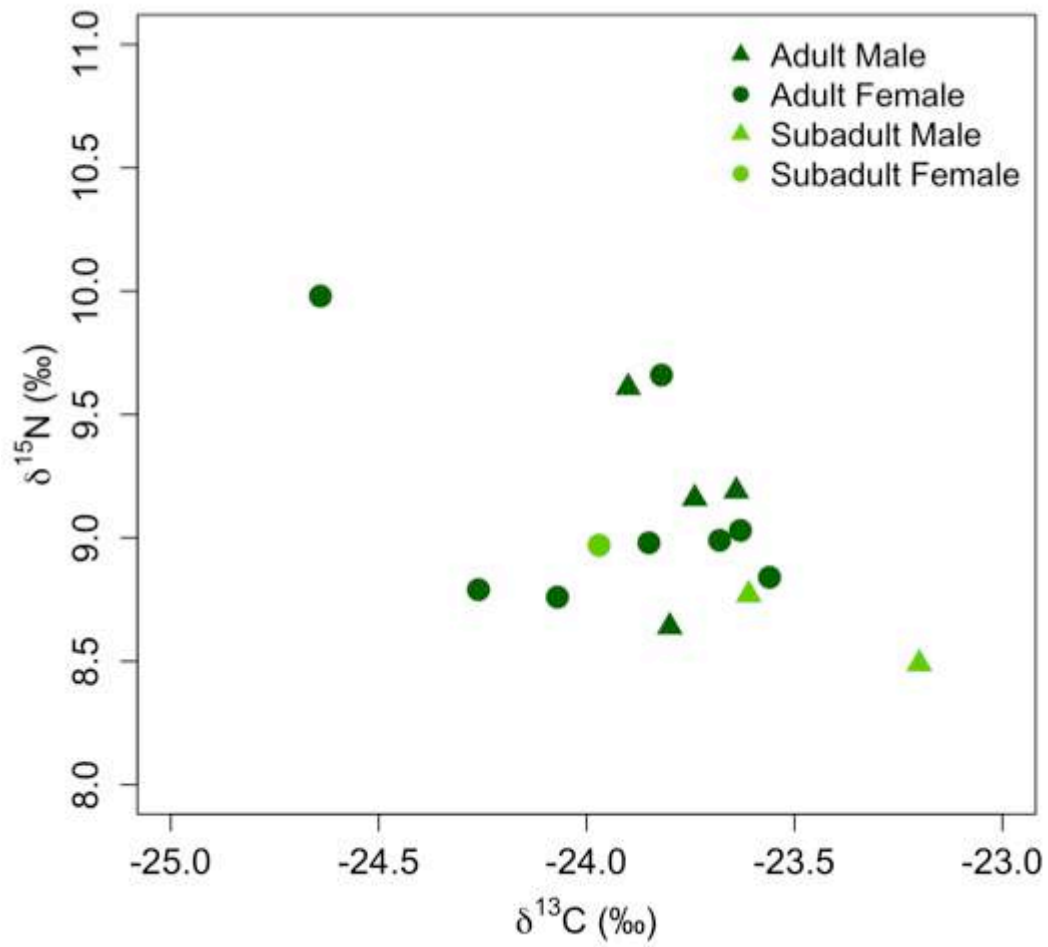


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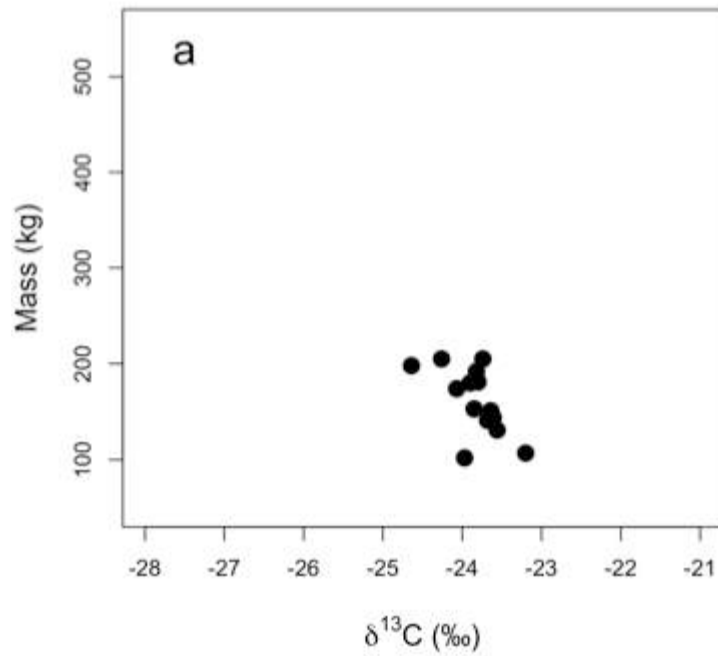
Fig. S4. Spatial variation in  $\delta^{15}\text{N}$  values of Pro (a) and Phe (b) values for Weddell seals. Figures were produced in Ocean Data View 4.7.4 (Schlitzer 2015).

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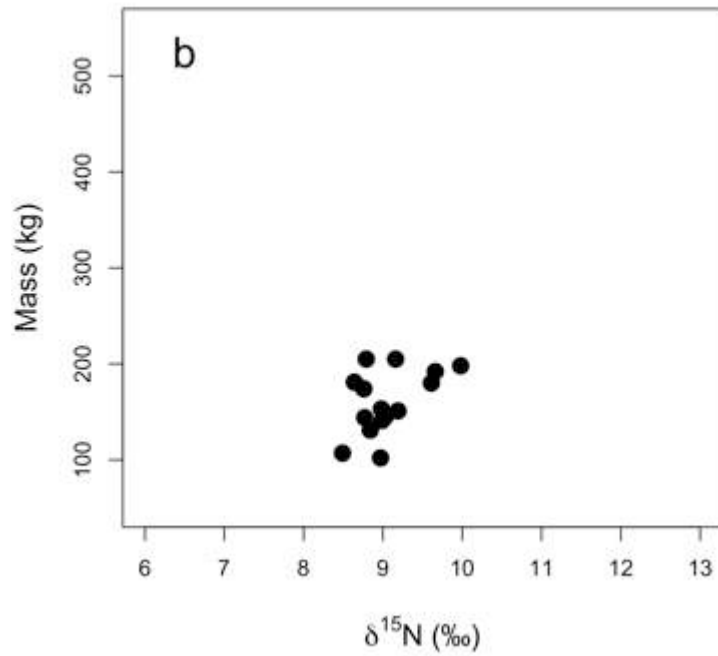


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116 Fig. S5. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for Ross Seals. Age class and gender are indicated with colors (light green  
117 for subadults and dark green for adults) and shapes (triangles and circles for males and females,  
118 correspondingly).  
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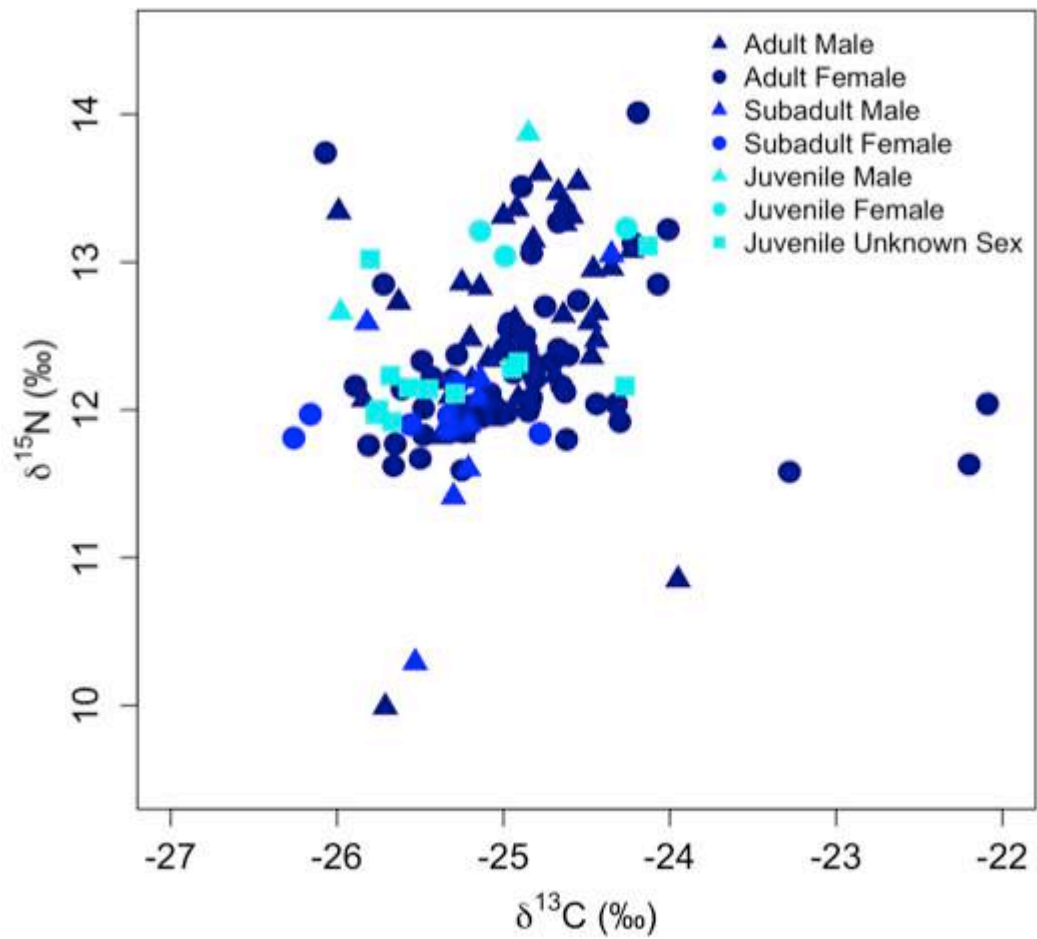


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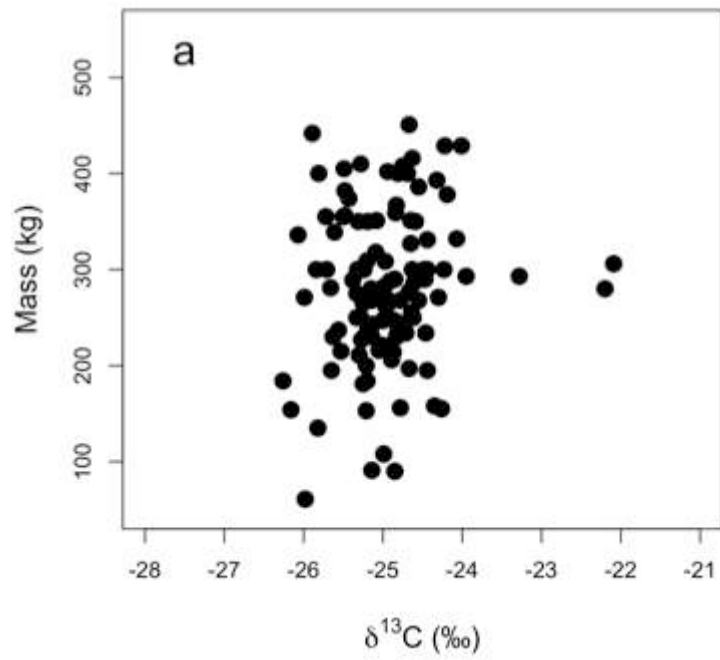


122 Fig. S6. Mass (kg) versus bulk  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values for Ross  
123 Seals.  
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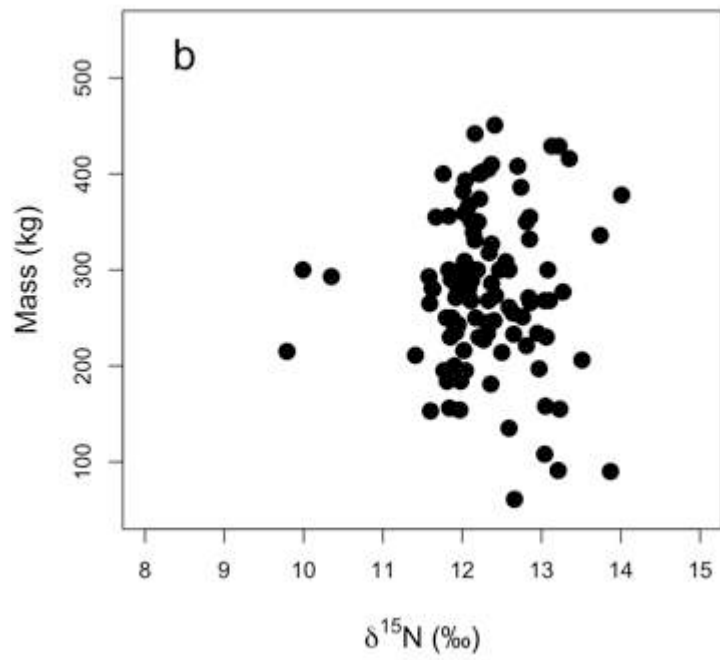
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132 Fig. S7. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for Weddell Seals. Age class and gender are indicated with colors (light  
133 blue for juveniles, medium blue for subadults, and dark blue for adults) and shapes (triangles, circles,  
134 and squares for males, females, and unknown sex, correspondingly).  
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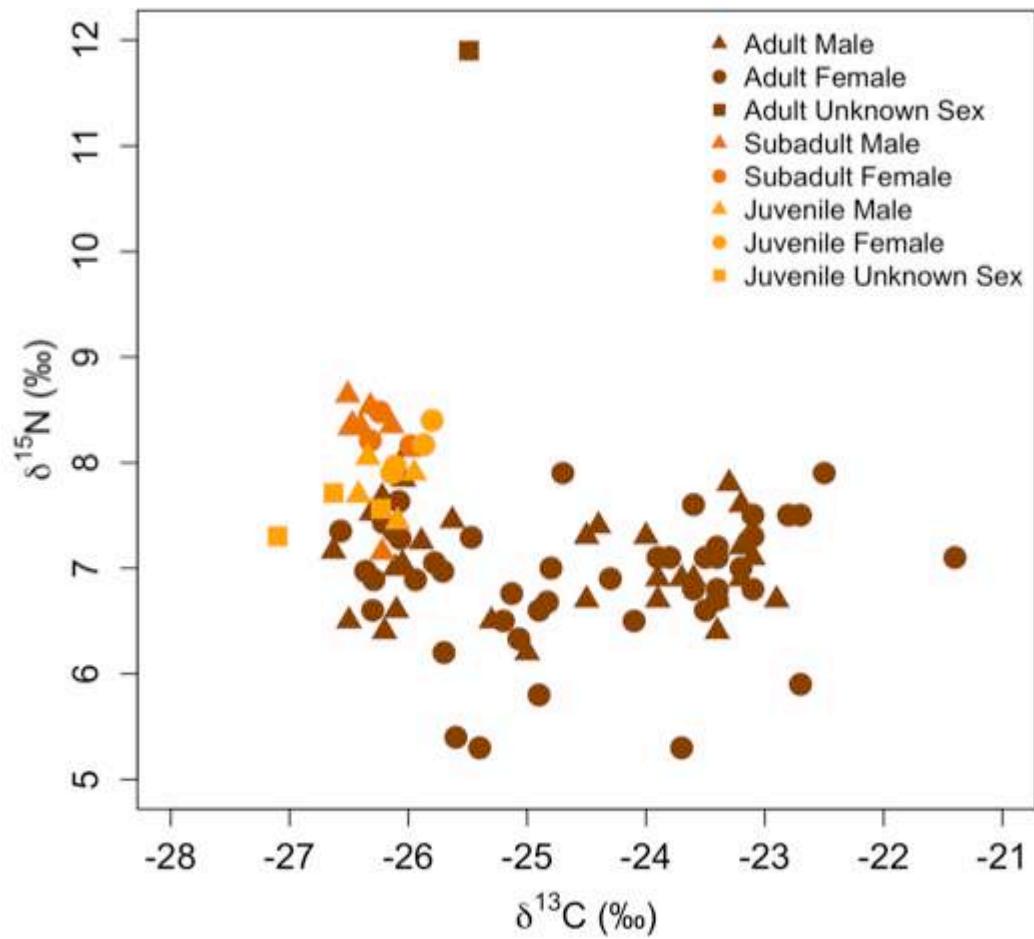


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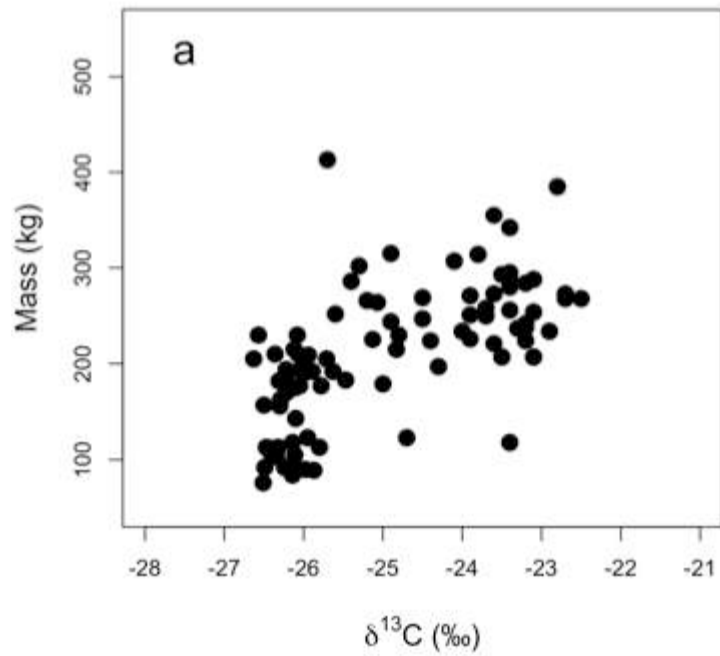
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Fig. S8. Mass (kg) versus bulk  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values of Weddell Seals.

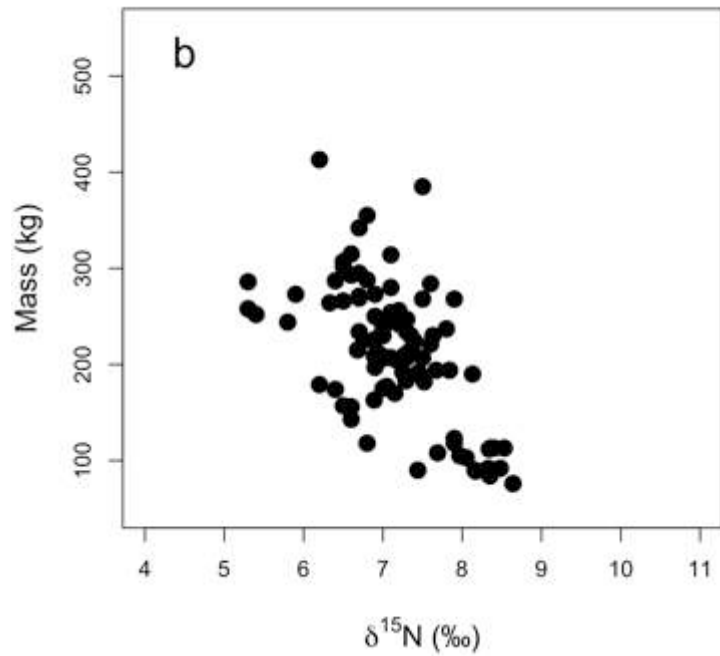


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143 Fig. S9. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for Crabeater Seals. Age class and gender are indicated with colors (light  
144 orange for juveniles, medium orange for subadults, and dark orange for adults) and shapes (triangles,  
145 circles, and squares for males, females, and unknown sex, correspondingly).  
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Fig. S10. Mass (kg) versus bulk  $\delta^{13}\text{C}$  (a) and  $\delta^{15}\text{N}$  (b) values of crabeater Seals.



## Antarctic Seal Foraging Ecology

153 Table S1. Sample information for Antarctic Seals. In cases where multiple sample types were obtained  
 154 from a seal, we indicate the tissue from which isotopic values were used in figures and statistical  
 155 analyses. Negative latitude and longitude indicate degrees south and west, respectively. Abbreviations:  
 156 DD, decimal degrees; WB, whole blood; RBCs, red blood cells; F, female; M, male; na, information not  
 157 available; Su, summer; Sp, spring; F, fall; W, winter; Oden, *RV Oden* cruises; MCM, McMurdo Station  
 158 region; WAP, West Antarctic Peninsula area; Ad, adult; Sub, subadult; Juv, juvenile; Lat, latitude; Long,  
 159 longitude.

Species	Sample ID	Source	Season	Sample Type	Age Class	Sex	Weight (kg)	Lat (DD)	Long (DD)
Crabeater	C02	<i>Oden</i>	Su 2010/11	Clot	Ad	F	163	-68.6	-102.3
	C03	<i>Oden</i>	Su 2008/09	WB	Sub	F	na	-70.6	-107.0
	C03	<i>Oden</i>	Su 2010/11	Clot	Ad	F	210	-68.6	-102.5
	C04	<i>Oden</i>	Su 2008/09	WB	Sub	M	92	-70.6	-107.0
	C06	<i>Oden</i>	Su 2008/09	WB	Sub	M	76	-71.1	-110.5
	C07	<i>Oden</i>	Su 2008/09	WB	Sub	F	92	-71.1	-110.5
	C07	<i>Oden</i>	Su 2010/11	Hair	Ad	F	205	-69.5	-103.7
	C10	<i>Oden</i>	Su 2010/11	Hair	Ad	F	225.4	-69.5	-103.7
	C11	<i>Oden</i>	Su 2010/11	Hair	Ad	F	264	-69.5	-103.7
	C14	<i>Oden</i>	Su 2010/11	Clot	Ad	F	215	-70.1	-107.4
	C15	<i>Oden</i>	Su 2010/11	WB	Sub	M	170	-70.1	-107.4
	C20	<i>Oden</i>	Su 2008/09	WB	Ad	M	190	-72.6	-116.0
	C20	<i>Oden</i>	Su 2010/11	RBCs	Juv	M	90	-72.7	-114.2
	C21	<i>Oden</i>	Su 2008/09	Clot	Sub	M	112	-72.6	-116.0
	C21	<i>Oden</i>	Su 2010/11	RBCs	Juv	M	103	-72.7	-114.2
	C22	<i>Oden</i>	Su 2008/09	Clot	Sub	M	113	-72.6	-116.0
	C32	<i>Oden</i>	Su 2008/09	WB	Ad	F	230	-70.2	-119.9
	C33	<i>Oden</i>	Su 2008/09	WB	Ad	M	194	-70.2	-119.9
	C43	<i>Oden</i>	Su 2008/09	WB	Ad	F	190	-69.4	-125.3
	C44	<i>Oden</i>	Su 2008/09	WB	Ad	M	182	-69.4	-125.3
	C45	<i>Oden</i>	Su 2008/09	WB	Ad	F	230	-70.2	-133.5
	C46	<i>Oden</i>	Su 2008/09	WB	Sub	F	90	-72.5	-146.5
	C47	<i>Oden</i>	Su 2008/09	WB	Ad	M	192	-74.4	-150.7
	C48	<i>Oden</i>	Su 2008/09	WB	Ad	F	177	-74.4	-150.7
	C50	<i>Oden</i>	Su 2008/09	WB	Sub	M	84	-75.4	-151.3

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C51	<i>Oden</i>	Su 2008/09	WB	Ad	F	210	-75.4	-151.3
C52	<i>Oden</i>	Su 2008/09	WB	Ad	F	183	-75.4	-151.3
C143	<i>Oden</i>	Su 2010/11	WB	Juv	F	105	-72.1	-119.7
C144	<i>Oden</i>	Su 2010/11	WB	Juv	F	118	-72.1	-119.7
C153	<i>Oden</i>	Su 2010/11	WB	Ad	M	192	-72.1	-123.5
C154	<i>Oden</i>	Su 2010/11	WB	Ad	M	177	-72.1	-123.5
C155	<i>Oden</i>	Su 2010/11	Hair	Juv	M	108	-72.2	-126.7
C156	<i>Oden</i>	Su 2010/11	WB	Juv	M	123	-72.2	-126.7
C157	<i>Oden</i>	Su 2010/11	WB	Juv	F	113	-72.2	-126.7
C158	<i>Oden</i>	Su 2010/11	WB	Juv	F	89	-72.2	-126.7
C173	<i>Oden</i>	Su 2010/11	WB	Ad	F	209	-72.8	-135.6
C174	<i>Oden</i>	Su 2010/11	WB	Ad	M	175	-75.3	-139.5
C175	<i>Oden</i>	Su 2010/11	Hair	Ad	F	215	-73.3	-139.5
C176	<i>Oden</i>	Su 2010/11	WB	Ad	M	205	-73.3	-139.5
C177	<i>Oden</i>	Su 2010/11	WB	Ad	M	194	-75.8	-150.0
Cr 1	MCM	Su 2009/10	Hair	Juv	na	na	-77.6	166.2
Cr Royds	MCM	Su 2009/10	Hair	Juv	na	na	-77.6	166.2
Cr 2	MCM	Su 2009/10	Hair	Juv	na	na	-77.6	166.2
CS11- 01	MCM	Su 2010/11	WB	Ad	na	na	-77.7	166.5
G001	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	F	na	-67.3	-67.6
G003	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	F	258	-67.3	-67.6
G004	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	M	342	-69.2	-72.3
G005	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	F	293	-69.3	-72.4
G006	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	F	413	-69.3	-72.5
G007	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	M	287	-69.3	-72.5

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G008	Hückstädt et al. (2012a)	F 2001	Whisker	Ad	F	355	-69.1	-72.4
G009	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	M	179	-67.7	-69.3
G010	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	F	307	-68.1	-70.4
G012	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	F	288	-68.1	-70.2
G013	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	M	234	-68.1	-70.2
G014	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	M	284	-68.1	-70.1
G015	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	M	234	-67.2	-70.2
G016	Hückstädt et al. (2012a)	W 2001	Whisker	Ad	F	273	-67.4	-70.9
G017	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	118	-66.4	-66.8
G018	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	157	-66.8	-66.8
G019	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	156	-66.8	-66.8
G020	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	143	-66.6	-67.5
G021	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	271	-66.6	-67.5
G022	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	268	-67.4	-67.7
G023	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	174	-67.6	-68.2
G024	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	256	-67.6	-69.0
G026	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	266	-67.6	-69.0
G027	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	226	-66.6	-67.5

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G028	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	314	-68.5	-69.8
G029	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	242	-68.7	-70.0
G030	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	M	250	-66.6	-67.5
G031	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	385	-66.3	-66.6
G032	Hückstädt et al. (2012a)	F 2002	Whisker	Ad	F	230	-68.8	-69.9
G033	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	268	-66.3	-66.7
G034	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	295	-66.5	-67.1
G035	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	238	-66.4	-66.9
G036	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	207	-66.4	-66.9
G038	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	273	-67.2	-70.6
G039	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	247	-68.6	-76.0
G040	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	302	-68.5	-75.8
G041	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	269	-68.1	-75.0
G042	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	224	-68.0	-74.9
G043	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	224	-68.0	-74.8
G044	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	280	-65.7	-68.7
G045	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	F	221	-65.6	-68.6
G046	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	237	-65.5	-68.5

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	G047	Hückstädt et al. (2012a)	W 2002	Whisker	Ad	M	254	-65.7	-68.5
	G102	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	286	-67.2	-66.9
	G104	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	197	-67.2	-66.9
	G105	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	251	-67.2	-66.8
	G106	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	207	-67.2	-66.8
	G107	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	315	-67.0	-67.4
	G108	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	207	-67.2	-66.8
	G110	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	123	-67.1	-66.8
	G112	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	252	-65.2	-64.2
	G113	Hückstädt et al. (2012a)	F 2007	Whisker	Ad	F	244	-66.1	-65.4
	W02	<i>Oden</i>	Su 2008/09	WB	Sub	M	113	-71.7	-112.2
Weddell	W01	<i>Oden</i>	Su 2010/11	Hair	Ad	M	251	-72.6	-115.1
	W02	<i>Oden</i>	Su 2010/11	Hair	Ad	F	300	-72.6	-115.1
	W04	<i>Oden</i>	Su 2010/11	Clot	Ad	F	400	-72.8	-114.4
	W06	<i>Oden</i>	Su 2010/11	Clot	Ad	M	400	-72.9	-114.2
	W10	<i>Oden</i>	Su 2008/09	WB	Sub	F	156	-77.3	-165.5
	W11	<i>Oden</i>	Su 2008/09	WB	Sub	M	153	-77.3	-165.5
	W12	<i>Oden</i>	Su 2008/09	WB	Ad	M	318	-77.3	-165.5
	W14	<i>Oden</i>	Su 2008/09	WB	Ad	M	288	-77.3	-165.5
	W15	<i>Oden</i>	Su 2008/09	WB	Sub	M	211	-77.3	-165.5
	W17	<i>Oden</i>	Su 2008/09	WB	Ad	M	278	-77.3	-165.5
	W19	<i>Oden</i>	Su 2008/09	WB	Ad	F	309	-77.3	-165.5
	W103	<i>Oden</i>	Su 2010/11	WB	Ad	M	300	-72.6	-115.1

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W112	<i>Oden</i>	Su 2010/11	Hair	Ad	M	350	-72.9	-114.0
W113	<i>Oden</i>	Su 2010/11	WB	Ad	M	255	-72.9	-114.0
W116	<i>Oden</i>	Su 2010/11	WB	Ad	M	300	-71.7	-115.5
W117	<i>Oden</i>	Su 2010/11	WB	Ad	F	290	-71.7	-115.5
W118	<i>Oden</i>	Su 2010/11	WB	Ad	F	216	-71.7	-115.5
W130	<i>Oden</i>	Su 2010/11	WB	Sub	M	158	-72.5	-116.6
W133	<i>Oden</i>	Su 2010/11	WB	Ad	M	300	-72.5	-116.6
W136	<i>Oden</i>	Su 2010/11	WB	Ad	F	235	-72.9	-116.9
W137	<i>Oden</i>	Su 2010/11	WB	Ad	F	243	-72.9	-116.9
W155	<i>Oden</i>	Su 2010/11	WB	Juv	F	155	-72.1	-119.2
W157	<i>Oden</i>	Su 2010/11	WB	Juv	F	108	-72.1	-119.2
W174	<i>Oden</i>	Su 2010/11	WB	Ad	F	250	-72.1	-119.7
W175	<i>Oden</i>	Su 2010/11	WB	Ad	M	300	-72.1	-119.7
W176	<i>Oden</i>	Su 2010/11	WB	Ad	M	na	-72.1	-119.7
W177	<i>Oden</i>	Su 2010/11	WB	Ad	M	234	-72.1	-119.7
W182	<i>Oden</i>	Su 2010/11	Hair	Sub	M	215	-72.8	-135.8
W185	<i>Oden</i>	Su 2010/11	WB	Ad	F	400	-75.5	-184.9
W186	<i>Oden</i>	Su 2010/11	WB	Sub	F	154	-75.5	-184.9
W208	<i>Oden</i>	Su 2010/11	WB	Sub	M	135	-78.7	-164.2
W209	<i>Oden</i>	Su 2010/11	WB	Juv	M	61	-78.7	-164.2
W214	<i>Oden</i>	Su 2010/11	WB	Sub	F	184	-77.6	-166.3
W216	<i>Oden</i>	Su 2010/11	WB	Juv	F	91	-77.6	-166.3
W219	<i>Oden</i>	Su 2010/11	WB	Sub	F	237	-77.7	-164.7
W220	<i>Oden</i>	Su 2010/11	WB	Ad	F	261	-77.7	-164.7
W222	<i>Oden</i>	Su 2010/11	WB	Ad	M	350	-77.7	-164.7
W223	<i>Oden</i>	Su 2010/11	WB	Juv	M	90	-77.7	-164.7
WS10-11	MCM	Su 2009/10	RBCs	Ad	F	308.5	-75.8	162.8
WS10-12	MCM	Su 2009/10	RBCs	Ad	F	282.5	-75.8	162.8
WS10-13	MCM	Su 2009/10	RBCs	Ad	F	245	-75.8	162.8

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WS10-17	MCM	Su 2009/10	RBCs	Ad	F	356	-76.5	162.8
WS10-18	MCM	Su 2009/10	RBCs	Ad	F	265	-76.5	162.8
WS11-11	MCM	Su 2010/11	WB	Ad	F	281	-76.6	162.7
WS11-12	MCM	Su 2010/11	WB	Ad	F	355	-77.9	166.8
WS11-13	MCM	Su 2010/11	WB	Ad	F	247	-76.9	162.5
WS11-14	MCM	Su 2010/11	WB	Ad	F	286	-76.6	162.7
WS11-15	MCM	Su 2010/11	WB	Ad	F	195	-77.2	163.5
WS12-11	MCM	Su 2011/12	RBCs	Ad	F	273	-76.9	162.8
WS12-12	MCM	Su 2011/12	RBCs	Ad	F	374	-77.9	166.8
WS12-13	MCM	Su 2011/12	RBCs	Ad	F	410	-77.9	166.8
WS12-14	MCM	Su 2011/12	RBCs	Ad	M	227	-76.1	162.4
WS12-15	MCM	Su 2011/12	RBCs	Ad	M	289	-76.5	162.7
WS12-22	MCM	Sp 2012	WB	Ad	F	451	-77.7	166.5
WS12-23	MCM	Sp 2012	WB	Ad	F	442	-77.7	166.9
WS12-24	MCM	Sp 2012	WB	Ad	F	339	-77.7	166.8
WS12-25	MCM	Sp 2012	WB	Ad	F	355	-77.7	166.9
WS12-26	MCM	Sp 2012	WB	Ad	F	408	-77.7	166.7
G103	WAP	F 2007	Serum	Ad	F	306	-67.2	-66.9
G111	WAP	F 2007	Plasma	Ad	F	280	-67.1	-66.8
LW11-03	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-05	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-06	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-07	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-08	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-09	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-10	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-11	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-12	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-13	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7

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LW11-14	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW11-15	MCM	Su 2010/11	WB	Juv	na	na	-74.9	163.7
LW15-01	MCM	Sp 2015	WB	Ad	M	300	-77.8	166.8
LW15-02	MCM	Sp 2015	WB	Sub	M	280	-77.8	166.8
LW15-03	MCM	Sp 2015	WB	Ad	M	300	-77.8	166.8
LW15-04	MCM	Sp 2015	WB	Ad	M	300	-77.8	166.8
LW15-05	MCM	Sp 2015	WB	Ad	M	300	-77.8	166.8
LW15-06	MCM	Sp 2015	WB	Ad	M	300	-77.7	166.4
LW15-07	MCM	Sp 2015	WB	Ad	F	350	-77.7	166.4
LW15-08	MCM	Sp 2015	WB	Sub	F	250	-77.8	166.8
LW15-09	MCM	Sp 2015	WB	Sub	F	275	-77.7	166.3
LW15-10	MCM	Sp 2015	WB	Sub	M	230	-77.7	166.4
LW15-11	MCM	Sp 2015	WB	Sub	F	250	-77.7	166.4
LW15-12	MCM	Sp 2015	WB	Sub	M	200	-77.7	166.4
W006	WAP	Su 2009/10	Whisker	Ad	M	293	-62.5	-60.8
W013	WAP	Su 2009/10	Whisker	Ad	F	293	-62.5	-60.8
WS10-01	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	327	-77.8	166.8
WS10-02	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	378	-77.7	166.8
WS10-03	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	214	-77.7	166.7
WS10-04	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	195	-77.7	166.7
WS10-05	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	271	-77.7	166.7
WS10-06	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	M	271	-77.6	166.2
WS10-07	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	234	-77.7	166.7
WS10-19	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	M	184	-76.6	162.7
WS10-20	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	M	181	-76.6	162.7
WS10-21	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	F	393	-77.8	166.8
WS10-22	Goetz et al. (2017)	Su 2009/10	Whisker	Ad	M	290	-77.8	166.8



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WS11-03	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	367	-77.9	166.8
WS11-04	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	402	-77.9	166.8
WS11-05	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	M	197	-76.6	162.7
WS11-06	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	206	-76.6	162.7
WS11-08	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	277	-76.6	162.7
WS11-09	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	336	-77.9	166.8
WS11-17	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	359	-77.9	166.7
WS11-18	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	247	-77.9	166.7
WS11-19	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	M	266	-77.7	166.7
WS11-21	Goetz et al. (2017)	Su 2010/11	Whisker	Ad	F	382	-77.9	166.8
WS11-37	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	331	-77.4	166.3
WS11-38	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	268	-77.4	166.3
WS11-39	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	268	-77.7	166.3
WS11-40	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	268	-77.7	166.3
WS11-41	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	268	-77.7	166.3
WS12-01	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	405	-77.9	166.8
WS12-02	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	351	-77.0	162.8
WS12-04	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	351	-77.9	166.8
WS12-05	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	386	-76.6	166.7
WS12-06	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	332	-76.5	166.8
WS12-07	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	416	-77.8	166.8
WS12-08	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	429	-77.8	166.8
WS12-09	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	429	-77.8	166.8
WS12-10	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	221	-76.6	162.9
WS12-16	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	230	-76.5	162.7
WS12-17	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	230	-77.8	166.8
WS12-19	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	F	230	-77.9	166.8

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	WS12-20	Goetz et al. (2017)	Su 2011/12	Whisker	Ad	M	233	-76.1	163.1
Ross	R01	<i>Oden</i>	Su 2008/09	WB	Sub	M	107	-69.4	-125.3
	R101	<i>Oden</i>	Su 2010/11	WB	Ad	M	180	-72.1	-123.2
	R102	<i>Oden</i>	Su 2010/11	WB	Ad	F	145	-72.2	-123.2
	R103	<i>Oden</i>	Su 2010/11	WB	Sub	F	102	-72.1	-123.1
	R104	<i>Oden</i>	Su 2010/11	WB	Ad	M	205	-72.1	-123.5
	R105	<i>Oden</i>	Su 2010/11	WB	Ad	M	151	-72.2	-126.9
	R106	<i>Oden</i>	Su 2010/11	WB	Ad	F	174	-72.1	-127.0
	R107	<i>Oden</i>	Su 2010/11	WB	Ad	F	131	-72.2	-127.6
	R108	<i>Oden</i>	Su 2010/11	WB	Ad	F	198	-72.2	-132.9
	R109	<i>Oden</i>	Su 2010/11	WB	Ad	F	153	-72.2	-133.0
	R110	<i>Oden</i>	Su 2010/11	Hair	Ad	F	205	-72.9	-137.1
	R111	<i>Oden</i>	Su 2010/11	WB	Sub	M	144	-72.8	-136.0
	R112	<i>Oden</i>	Su 2010/11	WB	Ad	F	192	-73.4	-139.4
	R113	<i>Oden</i>	Su 2010/11	WB	Ad	F	141	-73.3	-139.4
	R114	<i>Oden</i>	Su 2010/11	WB	Ad	M	181	-75.8	-150.0

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169 Table S2. Effect of lipid extraction on isotopic values of crabeater, Weddell, and Ross seals. Sample  
 170 ID as in Table S1. Abbreviations: WB, whole blood without lipid extraction; LE, whole blood with  
 171 lipid extraction. The difference in isotopic value between whole blood samples with and without lipid  
 172 extraction is reported. The average difference is  $0.0 \pm 0.1$  ‰ and  $0.2 \pm 0.1$  ‰ for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ,  
 173 respectively. The average difference between the isotopic values with and without lipid extraction do  
 174 not exceed the instrument error of 0.2 ‰ for either  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values.

Species	Sample ID	Year	Sample Type	$\delta^{13}\text{C}$ (‰)	LE $\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	LE $\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C} - \text{LE } \delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N} - \text{LE } \delta^{15}\text{N}$ (‰)
Crabeater	C03	2008	WB	-26.3	-26.5	8.2	8.0	0.2	0.2
	C06	2008	WB	-26.5	-26.6	8.6	8.5	0.1	0.1
	C07	2008	WB	-26.2	-26.3	8.5	8.3	0.1	0.2
	C20	2008	WB	-26.0	-26.0	8.1	7.9	0.0	0.2
	C46	2008	WB	-26.0	-26.0	8.2	8.1	0.0	0.1
	C52	2008	WB	-25.5	-25.7	7.3	7.1	0.2	0.2
	C153	2010	WB	-25.9	-25.9	7.3	7.2	0.0	0.1
	C154	2010	WB	-26.1	-26.1	7.0	6.9	0.0	0.1
	C176	2010	WB	-26.6	-26.7	7.2	7.0	0.1	0.2
Weddell	W12	2008	WB	-25.1	-25.1	12.3	12.1	0.0	0.2
	W15	2008	WB	-25.3	-25.3	11.4	11.2	0.0	0.2
	W117	2010	WB	-24.9	-24.9	12.0	11.8	0.0	0.2
	W216	2010	WB	-25.1	-25.2	13.2	13.1	0.1	0.1
	W223	2010	WB	-24.9	-24.9	13.9	13.8	0.0	0.1
Ross	R01	2008	WB	-23.2	-23.2	8.5	8.4	0.0	0.1
	R101	2010	WB	-23.9	-23.9	9.6	9.4	0.0	0.2
	R102	2010	WB	-23.6	-23.7	9.0	8.8	0.1	0.2
	R103	2010	WB	-24.0	-24.0	9.0	8.8	0.0	0.2
	R108	2010	WB	-24.6	-24.7	10.0	9.8	0.1	0.2
	R112	2010	WB	-23.8	-23.8	9.7	9.6	0.0	0.1
	R114	2010	WB	-23.7	-23.7	8.6	8.5	0.0	0.1

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176 Table S3. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of crabeater, Weddell, and Ross seals for multiple tissue types.  
 177 These isotopic values are used to calculate the isotopic offsets between different tissue types, see Table  
 178 S4 below. Abbreviations are as in Tables S1.

Species	ID	Year	WB		Clot		RBCs		Hair	
			$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
Crabeater		Su			-26.1	7.3			-23.7	6.4
	C14	2010/11								
		Su							-24.5	7.5
	C143	2010/11	-26.1	8.0						
		Su							-24.6	8.7
	C157	2010/11	-25.8	8.4						
		Su							-24.4	8.0
	C158	2010/11	-25.9	8.2						
		Su							-24.2	6.6
	C173	2010/11	-25.9	6.9						
		Su			-26.1	6.8			-24.4	7.5
	C174	2010/11	-26.1	7.0						
		Su					-26.8	6.9		
C176	2010/11	-26.6	7.2							
	Su							-24.7	7.1	
C02	2010/11			-26.3	6.9					
	Su							-25.0	7.0	
C20	2010/11					-26.1	7.4			
	Su							-24.9	7.3	
C21	2010/11					-26.3	8.1			
	Su							-24.2	7.0	
C03	2010/11			-26.4	7.0					
Weddell	WS12-22	Sp 2012	-24.7	12.4					-24.4	12.1
	WS12-23	Sp 2012	-25.9	12.2					-25.3	11.7
	WS12-24	Sp 2012	-25.6	12.1					-25.5	12.1
	WS12-25	Sp 2012	-25.7	12.9					-25.0	12.0
	WS12-26	Sp 2012	-24.8	12.7					-24.7	12.5
		Su							-23.2	12.9
	W116	2010/11	-24.5	12.6						
		Su							-23.3	12.7
	W117	2010/11	-24.9	12.0						
		Su			-24.9	11.9				
	W118	2010/11	-25.1	12.0						
		Su					-24.4	13.0		
	W130	2010/11	-24.4	13.1						
		Su							-23.0	13.1
	W133	2010/11	-24.4	12.5						
		Su			-25.3	12.0				
	W136	2010/11	-25.2	11.9						
		Su					-25.1	11.9	-23.6	12.8
	W137	2010/11	-25.1	12.0						
	Su							-22.9	13.0	
W176	2010/11	-24.3	13.0							
	Su									
W208	2010/11	-25.8	12.6					-25.9	12.4	

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	W216	Su 2010/11	-25.1	13.2	-25.0	13.2				
	W219	Su 2010/11	-25.6	11.9	-25.4	11.9				
	W220	Su 2010/11	-25.0	12.6	-25.0	12.4				
	W04	Su 2010/11			-24.8	12.2			-23.5	12.6
	W06	Su 2010/11			-24.7	12.2			-23.5	12.2
Ross	R101	Su 2010/11	-23.9	9.6					-22.6	10.3
	R103	Su 2010/11	-24.0	9.0					-22.8	11.0
	R105	Su 2010/11	-23.6	9.2					-22.4	10.1
	R107	Su 2010/11	-23.6	8.8					-22.4	10.5
	R108	Su 2010/11	-24.6	10.0					-23.0	10.8

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183 Table S4. Calculated isotopic offsets between different tissue types for crabeater, Weddell, and Ross  
 184 seals. Abbreviations are as in Tables S1. If a calculated mean offset is  $\leq 0.2$  ‰, then the offset between  
 185 the two tissue types is considered insignificant (less than instrumental error as indicated by the quality  
 186 control standard).

Species	Offset Type	Sample ID	$\delta^{13}\text{C}$ Offset (‰)	$\delta^{15}\text{N}$ Offset (‰)	Mean $\delta^{13}\text{C}$ Offset (‰)	Mean $\delta^{15}\text{N}$ Offset (‰)			
Crabeater	WB – Clot	C174	0.0	0.2	0.0	0.2			
		C176	0.2	0.2					
		C143	-1.6	0.4					
	WB – Hair	C157	-1.2	-0.3	-1.6	0.0			
		C158	-1.5	0.2					
		C173	-1.7	0.3					
		C174	-1.7	-0.5					
		Clot – Hair	C14	-2.4			0.9	-2.0	0.0
			C174	-1.7			-0.7		
	C2		-1.5	-0.2					
	RBCs – Hair	C3	-2.1	0.0	-1.3	0.6			
		C20	-1.1	0.4					
		C21	-1.5	0.8					
Weddell	WB – Clot	W118	-0.2	0.1	-0.1	0.1			
		W136	0.1	-0.1					
		W216	-0.1	0.0					
		W219	-0.2	0.0					
		W220	0.0	0.2					
	WB – RBCs	WS12-22	-0.2	0.3	-0.2	0.3			
		WS12-23	-0.6	0.4					
		WS12-24	-0.2	0.1					
		WS12-25	-0.7	0.9					
		WS12-26	-0.1	0.2					
		W130	0.1	0.1					
		W137	0.0	0.0					
		W208	0.0	0.2					
	WB – Hair	W116	-1.3	-0.3	-1.4	-0.5			
		W117	-1.5	-0.7					
		W133	-1.4	-0.6					
		W137	-1.5	-0.9					
		W176	-1.4	0.0					
	Clot – Hair	W4	-1.3	-0.4	-1.2	-0.2			
		W6	-1.2	0.0					
RBCs – Hair	W137	-1.5	-0.9	-1.5	-0.9				

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Ross	WB – Hair	R101	-1.3	-0.7	-1.3	-1.2
		R103	-1.2	-2.0		
		R105	-1.2	-0.9		
		R107	-1.2	-1.6		
		R108	-1.6	-0.8		

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192 Table S5. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of Weddell seals for multiple blood sample types. These  
 193 isotopic values are used to calculate the isotopic offsets between these different sample types, see  
 194 Table S6 below. Abbreviations are as in Tables S1.

ID	Year	WB		Plasma		Serum		RBCs	
		$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)
LW15-01	Sp 2015	-25.8	12.1	-26.4	12.3	-26.2	12.7		
LW15-02	Sp 2015	-25.2	12.1	-25.6	13.0	-25.3	13.4		
LW15-03	Sp 2015	-25.3	12.1	-25.7	12.7	-25.5	13.1		
LW15-11	Sp 2015	-25.3	12.2	-26.2	12.8	-25.8	13.3		
LW15-12	Sp 2015	-25.2	11.9	-25.8	12.8	-25.5	13.3		
WS12-22	Sp 2012	-24.7	12.4					-24.4	12.1
WS12-23	Sp 2012	-25.9	12.2					-25.3	11.7
WS12-24	Sp 2012	-25.6	12.1					-25.5	12.1
WS12-25	Sp 2012	-25.7	12.9					-25.0	12.0
WS12-26	Sp 2012	-24.8	12.7					-24.7	12.5
W130	Su 2010/11	-24.4	13.1					-24.4	13.0
W137	Su 2010/11	-25.1	12.0					-25.1	11.9
W208	Su 2010/11	-25.8	12.6					-25.9	12.4

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197 Table S6. Calculated isotopic offsets between different blood sample types for Weddell seals.  
 198 Abbreviations are as in Tables S1. If a calculated mean offset is  $\leq 0.2$  ‰, then the offset between the  
 199 two sample types is considered insignificant (less than instrumental error as indicated by the quality  
 200 control standard).

Offset Type	Sample ID	$\delta^{13}\text{C}$ Offset (‰)	$\delta^{15}\text{N}$ Offset (‰)	Mean $\delta^{13}\text{C}$ Offset (‰)	Mean $\delta^{15}\text{N}$ Offset (‰)
Plasma – Serum	LW15-01	-0.2	-0.4	-0.3	-0.4
	LW15-02	-0.3	-0.4		
	LW15-03	-0.2	-0.4		
	LW15-11	-0.3	-0.5		
	LW15-12	-0.3	-0.5		
WB – Serum	LW15-01	0.4	-0.6	0.3	-1.1
	LW15-02	0.2	-1.3		
	LW15-03	0.1	-1.0		
	LW15-11	0.5	-1.2		
	LW15-12	0.3	-1.4		
WB – Plasma	LW15-01	0.5	-0.2	0.6	-0.7
	LW15-02	0.4	-0.9		
	LW15-03	0.4	-0.6		
	LW15-11	0.9	-0.7		
	LW15-12	0.6	-0.9		
WB – RBCs	WS12-22	-0.3	0.3	-0.2	0.3
	WS12-23	-0.6	0.5		
	WS12-24	-0.1	0.0		
	WS12-25	-0.7	0.9		
	WS12-26	-0.1	0.2		
	W130	0.1	0.1		
	W137	0.0	0.0		
	W208	0.0	0.2		

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206 Table S7. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of crabeater, Weddell, and Ross seals. Note, bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values are  
 207 reported for the original measurement (Orig.) and with a correction to whole blood (Corr.) if the sample is a tissue  
 208 type with a significant isotopic offset from whole blood. Isotopic offset between whole blood and the given sample  
 209 type are reported in Tables S4 and S6, above. Atomic C:N ratios are from the original measurements. Samples with  
 210 an asterisk and two asterisks are from Hückstädt et al. (2012a) and Goetz et al. (2017), correspondingly; all other  
 211 data are from this study. Whisker data are from the segment representing the most recent time period, which best  
 212 overlaps with the collection location and integrated time of blood tissues, except data from Hückstädt et al. (2012a)  
 213 are an average for all segments. Abbreviations are as in Table S1. Additionally, “WAP,” “RS,” and “AM”  
 214 abbreviate “West Antarctic Peninsula,” “Ross Sea,” and “Amundsen Sea,” respectively.

Species	Sample ID	Season	Region	Sample Type	Orig. $\delta^{13}\text{C}$ (‰)	Orig. $\delta^{15}\text{N}$ (‰)	Corr. $\delta^{13}\text{C}$ (‰)	Corr. $\delta^{15}\text{N}$ (‰)	Atomic C:N
Crabeater	C02	Su 2010/11	AM	Clot	-26.3	6.9	–	–	3.8
	C03	Su 2008/09	AM	WB	-26.3	8.2	–	–	3.9
	C03	Su 2010/11	AM	Clot	-26.4	7.0	–	–	3.8
	C04	Su 2008/09	AM	WB	-26.5	8.3	–	–	4.0
	C06	Su 2008/09	AM	WB	-26.5	8.6	–	–	3.9
	C07	Su 2008/09	AM	WB	-26.2	8.5	–	–	3.9
	C07	Su 2010/11	AM	Hair	-24.1	7.0	-25.7	–	3.4
	C10	Su 2010/11	AM	Hair	-23.5	6.8	-25.1	–	3.4
	C11	Su 2010/11	AM	Hair	-23.5	6.3	-25.1	–	3.4
	C14	Su 2010/11	AM	Clot	-26.1	7.4	–	–	3.9
	C15	Su 2010/11	AM	WB	-26.2	7.2	–	–	3.9
	C20	Su 2008/09	AM	WB	-26.0	8.1	–	–	3.9
	C20	Su 2010/11	AM	RBCs	-26.1	7.4	–	–	3.8
	C21	Su 2008/09	AM	Clot	-26.4	8.3	–	–	3.9
	C21	Su 2010/11	AM	RBCs	-26.3	8.1	–	–	3.9
	C22	Su 2008/09	AM	Clot	-26.5	8.4	–	–	3.9
	C32	Su 2008/09	AM	WB	-26.1	7.6	–	–	3.9
	C33	Su 2008/09	AM	WB	-26.0	7.8	–	–	3.8
	C43	Su 2008/09	AM	WB	-26.2	7.4	–	–	3.9
	C44	Su 2008/09	AM	WB	-26.3	7.5	–	–	3.9
	C45	Su 2008/09	AM	WB	-26.6	7.4	–	–	3.9
	C46	Su 2008/09	AM	WB	-26.0	8.2	–	–	3.8
	C47	Su 2008/09	RS	WB	-25.6	7.5	–	–	3.9
	C48	Su 2008/09	RS	WB	-25.8	7.1	–	–	4.0
	C50	Su 2008/09	RS	WB	-26.1	8.4	–	–	4.0
	C51	Su 2008/09	RS	WB	-26.1	7.3	–	–	3.8
	C52	Su 2008/09	RS	WB	-25.5	7.3	–	–	3.8
	C143	Su 2010/11	AM	WB	-26.1	8.0	–	–	3.9
	C144	Su 2010/11	AM	WB	-26.1	7.9	–	–	3.9
	C153	Su 2010/11	AM	WB	-25.9	7.3	–	–	3.9
	C154	Su 2010/11	AM	WB	-26.1	7.0	–	–	3.9
	C155	Su 2010/11	AM	Hair	-24.8	7.7	-26.4	–	3.4
	C156	Su 2010/11	AM	WB	-26.0	7.9	–	–	3.9
	C157	Su 2010/11	AM	WB	-25.8	8.4	–	–	4.0
	C158	Su 2010/11	AM	WB	-25.9	8.2	–	–	4.0
	C173	Su 2010/11	AM	WB	-25.9	6.9	–	–	3.9
	C174	Su 2010/11	AM	WB	-26.1	7.0	–	–	3.9
	C175	Su 2010/11	AM	Hair	-23.2	6.7	-24.8	–	3.4
	C176	Su 2010/11	AM	WB	-26.6	7.2	–	–	3.9
	C177	Su 2010/11	RS	WB	-26.2	7.7	–	–	3.9
	Cr-1	Su 2009/10	RS	Hair	-25.0	7.7	-26.6	–	3.4
	Cr-CR	Su 2009/10	RS	Hair	-24.6	7.6	-26.2	–	3.4
	Cr-2	Su 2009/10	RS	Hair	-25.5	7.3	-27.1	–	3.4
CS11-01	Su 2010/11	RS	WB	-25.5	11.9	–	–	4.0	

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	G001*	F 2001	WAP	Whisker	-19.8	7.1	-21.4	–	3.4
	G003*	F 2001	WAP	Whisker	-22.1	5.3	-23.7	–	3.5
	G004*	F 2001	WAP	Whisker	-21.8	6.7	-23.4	–	3.5
	G005*	F 2001	WAP	Whisker	-21.9	6.6	-23.5	–	3.5
	G006*	F 2001	WAP	Whisker	-24.1	6.2	-25.7	–	3.5
	G007*	F 2001	WAP	Whisker	-21.8	6.4	-23.4	–	3.4
	G008*	F 2001	WAP	Whisker	-22.0	6.8	-23.6	–	3.4
	G009*	W 2001	WAP	Whisker	-23.4	6.2	-25.0	–	3.4
	G010*	W 2001	WAP	Whisker	-22.5	6.5	-24.1	–	3.4
	G012*	W 2001	WAP	Whisker	-21.5	6.8	-23.1	–	3.5
	G013*	W 2001	WAP	Whisker	-21.3	6.7	-22.9	–	3.5
	G014*	W 2001	WAP	Whisker	-21.6	7.6	-23.2	–	3.4
	G015*	W 2001	WAP	Whisker	-22.4	7.3	-24.0	–	3.5
	G016*	W 2001	WAP	Whisker	-21.1	5.9	-22.7	–	3.5
	G017*	F 2002	WAP	Whisker	-21.8	6.8	-23.4	–	3.3
	G018*	F 2002	WAP	Whisker	-24.9	6.5	-26.5	–	3.3
	G019*	F 2002	WAP	Whisker	-24.7	6.6	-26.3	–	3.3
	G020*	F 2002	WAP	Whisker	-24.5	6.6	-26.1	–	3.3
	G021*	F 2002	WAP	Whisker	-22.3	6.7	-23.9	–	3.4
	G022*	F 2002	WAP	Whisker	-20.9	7.9	-22.5	–	3.4
	G023*	F 2002	WAP	Whisker	-24.6	6.4	-26.2	–	3.3
	G024*	F 2002	WAP	Whisker	-21.8	7.2	-23.4	–	3.3
	G026*	F 2002	WAP	Whisker	-23.6	6.5	-25.2	–	3.3
	G027*	F 2002	WAP	Whisker	-22.3	6.9	-23.9	–	3.3
	G028*	F 2002	WAP	Whisker	-22.2	7.1	-23.8	–	3.3
	G029*	F 2002	WAP	Whisker	-21.6	7.2	-23.2	–	3.3
	G030*	F 2002	WAP	Whisker	-22.1	6.9	-23.7	–	3.3
	G031*	F 2002	WAP	Whisker	-21.2	7.5	-22.8	–	3.3
	G032*	F 2002	WAP	Whisker	-23.2	7.0	-24.8	–	3.3
	G033*	W 2002	WAP	Whisker	-21.1	7.5	-22.7	–	3.3
	G034*	W 2002	WAP	Whisker	-21.8	6.7	-23.4	–	3.3
	G035*	W 2002	WAP	Whisker	-21.6	7.0	-23.2	–	3.3
	G036*	W 2002	WAP	Whisker	-21.5	7.3	-23.1	–	3.4
	G038*	W 2002	WAP	Whisker	-22.0	6.9	-23.6	–	3.4
	G039*	W 2002	WAP	Whisker	-22.9	7.3	-24.5	–	3.4
	G040*	W 2002	WAP	Whisker	-23.7	6.5	-25.3	–	3.4
	G041*	W 2002	WAP	Whisker	-22.9	6.7	-24.5	–	3.4
	G042*	W 2002	WAP	Whisker	-21.6	6.9	-23.2	–	3.5
	G043*	W 2002	WAP	Whisker	-22.8	7.4	-24.4	–	3.4
	G044*	W 2002	WAP	Whisker	-21.8	7.1	-23.4	–	3.5
	G045*	W 2002	WAP	Whisker	-22.0	7.6	-23.6	–	3.4
	G046*	W 2002	WAP	Whisker	-21.7	7.8	-23.3	–	3.4
	G047*	W 2002	WAP	Whisker	-21.5	7.1	-23.1	–	3.5
	G102*	F 2007	WAP	Whisker	-23.8	5.3	-25.4	–	na
	G104*	F 2007	WAP	Whisker	-22.7	6.9	-24.3	–	3.4
	G105*	F 2007	WAP	Whisker	-22.3	7.1	-23.9	–	na
	G106*	F 2007	WAP	Whisker	-21.9	7.1	-23.5	–	3.5
	G107*	F 2007	WAP	Whisker	-23.3	6.6	-24.9	–	na
	G108*	F 2007	WAP	Whisker	-21.5	7.5	-23.1	–	3.4
	G110*	F 2007	WAP	Whisker	-23.1	7.9	-24.7	–	na
	G112*	F 2007	WAP	Whisker	-24.0	5.4	-25.6	–	3.4
	G113*	F 2007	WAP	Whisker	-23.3	5.8	-24.9	–	3.5
	W02	Su 2008/09	AM	WB	-26.3	8.5	–	–	4.0
Weddell	W01	Su 2010/11	AM	Hair	-23.2	13.3	-24.6	12.8	3.5
	W02	Su 2010/11	AM	Hair	-23.2	12.6	-24.6	12.1	3.5
	W04	Su 2010/11	AM	Clot	-24.8	12.2	–	–	3.9

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W06	Su 2010/11	AM	Clot	-24.7	12.2	-	-	3.9
W10	Su 2008/09	RS	WB	-24.8	11.8	-	-	3.9
W11	Su 2008/09	RS	WB	-25.2	11.6	-	-	4.0
W12	Su 2008/09	RS	WB	-25.1	12.3	-	-	3.9
W14	Su 2008/09	RS	WB	-24.9	12.1	-	-	3.9
W15	Su 2008/09	RS	WB	-25.3	11.4	-	-	3.9
W17	Su 2008/09	RS	WB	-25.1	11.9	-	-	4.0
W19	Su 2008/09	RS	WB	-25.2	12.0	-	-	3.9
W103	Su 2010/11	AM	WB	-25.7	10.0	-	-	3.9
W112	Su 2010/11	AM	Hair	-23.2	13.3	-24.6	12.8	3.5
W113	Su 2010/11	AM	WB	-24.6	12.6	-	-	4.0
W116	Su 2010/11	AM	WB	-24.5	12.6	-	-	3.9
W117	Su 2010/11	AM	WB	-24.9	12.0	-	-	4.0
W118	Su 2010/11	AM	WB	-25.1	12.0	-	-	4.0
W130	Su 2010/11	AM	WB	-24.4	13.1	-	-	3.9
W133	Su 2010/11	AM	WB	-24.4	12.5	-	-	3.9
W136	Su 2010/11	AM	WB	-25.2	11.9	-	-	4.0
W137	Su 2010/11	AM	WB	-25.1	12.0	-	-	3.9
W155	Su 2010/11	AM	WB	-24.3	13.2	-	-	4.0
W157	Su 2010/11	AM	WB	-25.0	13.0	-	-	4.0
W174	Su 2010/11	AM	WB	-24.6	11.8	-	-	3.9
W175	Su 2010/11	AM	WB	-24.2	13.1	-	-	4.0
W176	Su 2010/11	AM	WB	-24.4	13.0	-	-	3.9
W177	Su 2010/11	AM	WB	-24.5	13.0	-	-	3.9
W182	Su 2010/11	AM	Hair	-24.1	10.3	-25.5	9.8	3.5
W185	Su 2010/11	RS	WB	-25.8	11.8	-	-	3.9
W186	Su 2010/11	RS	WB	-26.2	12.0	-	-	3.9
W208	Su 2010/11	RS	WB	-25.8	12.6	-	-	3.9
W209	Su 2010/11	RS	WB	-26.0	12.7	-	-	3.9
W214	Su 2010/11	RS	WB	-26.3	11.8	-	-	4.0
W216	Su 2010/11	RS	WB	-25.1	13.2	-	-	4.0
W219	Su 2010/11	RS	WB	-25.6	11.9	-	-	4.0
W220	Su 2010/11	RS	WB	-25.0	12.6	-	-	4.0
W222	Su 2010/11	RS	WB	-25.2	12.2	-	-	3.9
W223	Su 2010/11	RS	WB	-24.9	13.9	-	-	4.1
WS10-11	Su 2009/10	RS	RBC	-25.0	12.3	-	12.6	3.9
WS10-12	Su 2009/10	RS	RBC	-25.0	11.7	-	12.0	3.8
WS10-13	Su 2009/10	RS	RBC	-24.8	12.0	-	12.3	3.9
WS10-17	Su 2009/10	RS	RBC	-25.5	11.5	-	11.8	4.0
WS10-18	Su 2009/10	RS	RBC	-25.3	11.3	-	11.6	3.8
WS11-11	Su 2010/11	RS	WB	-25.7	11.6	-	-	4.0
WS11-12	Su 2010/11	RS	WB	-25.5	11.7	-	-	3.9
WS11-13	Su 2010/11	RS	WB	-24.9	12.4	-	-	3.9
WS11-14	Su 2010/11	RS	WB	-24.6	12.4	-	-	3.9
WS11-15	Su 2010/11	RS	WB	-25.7	11.8	-	-	4.0
WS12-11	Su 2011/12	RS	RBC	-25.0	12.1	-	12.4	3.9
WS12-12	Su 2011/12	RS	RBC	-25.4	11.9	-	12.2	3.9
WS12-13	Su 2011/12	RS	RBC	-25.3	12.1	-	12.4	3.9
WS12-14	Su 2011/12	RS	RBC	-25.3	12.0	-	12.3	3.8
WS12-15	Su 2011/12	RS	RBC	-25.4	11.8	-	12.1	3.9
WS12-22	Sp 2012	RS	WB	-24.7	12.4	-	-	4.1
WS12-23	Sp 2012	RS	WB	-25.9	12.2	-	-	4.3
WS12-24	Sp 2012	RS	WB	-25.6	12.1	-	-	4.1
WS12-25	Sp 2012	RS	WB	-25.7	12.9	-	-	4.4
WS12-26	Sp 2012	RS	WB	-24.8	12.7	-	-	4.0
G103	F 2007	WAP	Serum	-22.4	13.1	-22.1	12.0	4.3

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G111	F 2007	WAP	Plasma	-22.8	12.3	-22.2	11.6	4.2
LW11-03	Su 2010/11	RS	WB	-24.3	12.2	-	-	3.9
LW11-05	Su 2010/11	RS	WB	-25.7	12.2	-	-	3.9
LW11-06	Su 2010/11	RS	WB	-25.8	12.0	-	-	3.9
LW11-07	Su 2010/11	RS	WB	-25.6	12.2	-	-	3.9
LW11-08	Su 2010/11	RS	WB	-24.9	12.3	-	-	3.9
LW11-09	Su 2010/11	RS	WB	-25.0	12.3	-	-	3.9
LW11-10	Su 2010/11	RS	WB	-25.7	11.9	-	-	3.9
LW11-11	Su 2010/11	RS	WB	-24.1	13.1	-	-	3.9
LW11-12	Su 2010/11	RS	WB	-25.8	12.0	-	-	3.9
LW11-13	Su 2010/11	RS	WB	-25.3	12.1	-	-	3.9
LW11-14	Su 2010/11	RS	WB	-25.5	12.1	-	-	3.9
LW11-15	Su 2010/11	RS	WB	-25.8	13.0	-	-	4.1
LW15-01	Sp 2015	RS	WB	-25.8	12.1	-	-	4.2
LW15-02	Sp 2015	RS	WB	-25.2	12.1	-	-	3.9
LW15-03	Sp 2015	RS	WB	-25.3	12.1	-	-	3.9
LW15-04	Sp 2015	RS	WB	-25.3	12.0	-	-	3.9
LW15-05	Sp 2015	RS	WB	-25.3	12.2	-	-	3.9
LW15-06	Sp 2015	RS	WB	-25.2	11.8	-	-	4.0
LW15-07	Sp 2015	RS	WB	-25.3	12.2	-	-	4.0
LW15-08	Sp 2015	RS	WB	-25.3	11.9	-	-	3.9
LW15-09	Sp 2015	RS	WB	-25.3	12.0	-	-	3.9
LW15-10	Sp 2015	RS	WB	-25.1	12.2	-	-	3.9
LW15-11	Sp 2015	RS	WB	-25.3	12.2	-	-	3.9
LW15-12	Sp 2015	RS	WB	-25.2	11.9	-	-	4.0
W006	Su 2009/10	WAP	Whisker	-22.6	10.9	-24.0	10.4	3.4
W013	Su 2009/10	WAP	Whisker	-21.9	12.1	-23.3	11.6	3.4
WS10-01**	Su 2009/10	RS	Whisker	-23.3	12.9	-24.7	12.4	na
WS10-02**	Su 2009/10	RS	Whisker	-22.8	14.5	-24.2	14.0	na
WS10-03**	Su 2009/10	RS	Whisker	-23.5	13.0	-24.9	12.5	na
WS10-04**	Su 2009/10	RS	Whisker	-23.0	12.5	-24.4	12.0	na
WS10-05**	Su 2009/10	RS	Whisker	-22.9	12.4	-24.3	11.9	na
WS10-06**	Su 2009/10	RS	Whisker	-24.6	13.3	-26.0	12.8	na
WS10-07**	Su 2009/10	RS	Whisker	-23.3	12.8	-24.7	12.3	na
WS10-19**	Su 2009/10	RS	Whisker	-23.8	12.5	-25.2	12.0	na
WS10-20**	Su 2009/10	RS	Whisker	-23.8	12.9	-25.2	12.4	na
WS10-21**	Su 2009/10	RS	Whisker	-22.9	12.5	-24.3	12.0	na
WS10-22**	Su 2009/10	RS	Whisker	-23.1	12.4	-24.5	11.9	na
WS11-03**	Su 2010/11	RS	Whisker	-23.4	12.6	-24.8	12.1	na
WS11-04**	Su 2010/11	RS	Whisker	-23.5	12.8	-24.9	12.3	na
WS11-05**	Su 2010/11	RS	Whisker	-23.3	13.5	-24.7	13.0	na
WS11-06**	Su 2010/11	RS	Whisker	-23.5	14.0	-24.9	13.5	na
WS11-08**	Su 2010/11	RS	Whisker	-23.3	13.8	-24.7	13.3	na
WS11-09**	Su 2010/11	RS	Whisker	-24.7	14.2	-26.1	13.7	na
WS11-17**	Su 2010/11	RS	Whisker	-23.4	12.5	-24.8	12.0	na
WS11-18**	Su 2010/11	RS	Whisker	-23.6	12.9	-25.0	12.4	na
WS11-19**	Su 2010/11	RS	Whisker	-23.5	13.4	-24.9	12.9	na
WS11-21**	Su 2010/11	RS	Whisker	-24.1	12.5	-25.5	12.0	na
WS11-37**	Su 2011/12	RS	Whisker	-23.0	12.7	-24.4	12.2	na
WS11-38**	Su 2011/12	RS	Whisker	-23.1	13.5	-24.5	13.0	na
WS11-39**	Su 2011/12	RS	Whisker	-23.5	12.6	-24.9	12.1	na
WS11-40**	Su 2011/12	RS	Whisker	-23.7	12.8	-25.1	12.3	na
WS11-41**	Su 2011/12	RS	Whisker	-23.4	13.6	-24.8	13.1	na

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	WS12-01**	Su 2011/12	RS	Whisker	-24.1	12.8	-25.5	12.3	na
	WS12-02**	Su 2011/12	RS	Whisker	-23.7	12.6	-25.1	12.1	na
	WS12-04**	Su 2011/12	RS	Whisker	-23.3	12.7	-24.7	12.2	na
	WS12-05**	Su 2011/12	RS	Whisker	-23.2	13.2	-24.6	12.7	na
	WS12-06**	Su 2011/12	RS	Whisker	-22.7	13.4	-24.1	12.9	na
	WS12-07**	Su 2011/12	RS	Whisker	-23.2	13.8	-24.6	13.3	na
	WS12-08**	Su 2011/12	RS	Whisker	-22.6	13.7	-24.0	13.2	na
	WS12-09**	Su 2011/12	RS	Whisker	-22.8	13.6	-24.2	13.1	na
	WS12-10**	Su 2011/12	RS	Whisker	-23.6	13.3	-25.0	12.8	na
	WS12-16**	Su 2011/12	RS	Whisker	-24.2	12.7	-25.6	12.2	na
	WS12-17**	Su 2011/12	RS	Whisker	-23.8	12.4	-25.2	11.9	na
	WS12-19**	Su 2011/12	RS	Whisker	-23.4	13.6	-24.8	13.1	na
	WS12-20**	Su 2011/12	RS	Whisker	-23.4	13.2	-24.8	12.7	na
Ross	R01	Su 2008/09	AM	WB	-23.2	8.5	–	–	3.9
	R101	Su 2010/11	AM	WB	-23.9	9.6	–	–	3.9
	R102	Su 2010/11	AM	WB	-23.6	9.0	–	–	4.0
	R103	Su 2010/11	AM	WB	-24.0	9.0	–	–	4.0
	R104	Su 2010/11	AM	WB	-23.7	9.2	–	–	4.0
	R105	Su 2010/11	AM	WB	-23.6	9.2	–	–	4.0
	R106	Su 2010/11	AM	WB	-24.1	8.8	–	–	3.9
	R107	Su 2010/11	AM	WB	-23.6	8.8	–	–	3.9
	R108	Su 2010/11	AM	WB	-24.6	10.0	–	–	4.0
	R109	Su 2010/11	AM	WB	-23.9	9.0	–	–	4.0
	R110	Su 2010/11	AM	Hair	-23.0	10.0	-24.3	8.8	3.5
	R111	Su 2010/11	AM	WB	-23.6	8.8	–	–	4.0
	R112	Su 2010/11	AM	WB	-23.8	9.7	–	–	3.9
	R113	Su 2010/11	AM	WB	-23.7	9.0	–	–	4.0
	R114	Su 2010/11	RS	WB	-23.8	8.6	–	–	4.0

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217 Table S8. Amino acid  $\delta^{15}\text{N}$  values for crabeater, Ross, and Weddell seals. Values are reported as the  
 218 mean  $\pm$  one standard deviation for the injections on the GC/C/IRMS. For crabeater seals, whole  
 219 blood (C06, C44, C177) and plasma (G112, G105, and G110) samples were analyzed. All Ross seal  
 220 samples analyzed for amino acid  $\delta^{15}\text{N}$  values were whole blood. For Weddell seals, whole blood  
 221 (W185, W220, and WS11-11), plasma (G111), and sample from the first segment nearest the  
 222 whisker base, 0.0-0.5 cm, (W006 and W013) were used for CSI-AA. Abbreviation: na, not available.

Species	Sample ID	Region	Amino Acid	Injections	$\delta^{15}\text{N}$ (‰)
Crabeater	C06	AM	Alanine	3	13.7 $\pm$ 0.3
	C06	AM	Glycine	3	8.5 $\pm$ 0.1
	C06	AM	Threonine	3	-21.9 $\pm$ 0.6
	C06	AM	Serine	3	7.0 $\pm$ 0.5
	C06	AM	Valine	3	14.9 $\pm$ 0.3
	C06	AM	Leucine	3	13.9 $\pm$ 0.2
	C06	AM	Isoleucine	3	12.8 $\pm$ 0.2
	C06	AM	Proline	3	15.7 $\pm$ 0.4
	C06	AM	Aspartic	3	11.0 $\pm$ 0.3
	C06	AM	Glutamic acid	3	15.1 $\pm$ 0.4
	C06	AM	Phenylalanine	3	6.8 $\pm$ 0.3
	C06	AM	Lysine	3	5.5 $\pm$ 0.6
	G112	WAP	Alanine	3	12.0 $\pm$ 0.7
	G112	WAP	Glycine	3	0.6 $\pm$ 0.1
	G112	WAP	Threonine	3	-20.7 $\pm$ 0.1
	G112	WAP	Serine	3	1.9 $\pm$ 0.2
	G112	WAP	Valine	3	13.5 $\pm$ 0.2
	G112	WAP	Leucine	3	11.8 $\pm$ 0.6
	G112	WAP	Isoleucine	3	11.6 $\pm$ 1.0
	G112	WAP	Proline	3	15.5 $\pm$ 0.6
	G112	WAP	Aspartic	3	9.9 $\pm$ 0.2
	G112	WAP	Glutamic acid	3	15.0 $\pm$ 0.4
	G112	WAP	Phenylalanine	3	4.3 $\pm$ 0.1
	G112	WAP	Lysine	2	4.5 $\pm$ 0.2
	C44	AM	Alanine	3	14.3 $\pm$ 0.4
	C44	AM	Glycine	3	4.7 $\pm$ 0.4
	C44	AM	Threonine	3	-25.4 $\pm$ 0.4
	C44	AM	Serine	3	4.2 $\pm$ 0.2
	C44	AM	Valine	3	15.1 $\pm$ 0.5
	C44	AM	Leucine	3	13.4 $\pm$ 0.5
	C44	AM	Isoleucine	3	12.2 $\pm$ 0.1
	C44	AM	Proline	3	14.7 $\pm$ 0.3
	C44	AM	Aspartic	3	9.3 $\pm$ 0.2
	C44	AM	Glutamic acid	3	15.0 $\pm$ 0.2
	C44	AM	Phenylalanine	3	5.8 $\pm$ 0.2
	C44	AM	Lysine	3	4.9 $\pm$ 0.3
	G105	WAP	Alanine	3	13.3 $\pm$ 0.4
	G105	WAP	Glycine	3	1.6 $\pm$ 0.3
	G105	WAP	Threonine	3	-19.6 $\pm$ 0.4
	G105	WAP	Serine	3	2.5 $\pm$ 0.3
	G105	WAP	Valine	3	14.4 $\pm$ 0.5
	G105	WAP	Leucine	3	12.7 $\pm$ 0.1
	G105	WAP	Isoleucine	3	11.5 $\pm$ 0.6
	G105	WAP	Proline	3	16.5 $\pm$ 0.5
G105	WAP	Aspartic	3	10.4 $\pm$ 0.0	
G105	WAP	Glutamic acid	3	15.2 $\pm$ 0.3	
G105	WAP	Phenylalanine	3	4.7 $\pm$ 0.2	
G105	WAP	Lysine	3	5.3 $\pm$ 0.5	
C177	RS	Alanine	4	14.6 $\pm$ 0.4	

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	C177	RS	Glycine	4	3.9 ± 0.4
	C177	RS	Threonine	4	-26.1 ± 0.8
	C177	RS	Serine	4	5.2 ± 0.6
	C177	RS	Valine	4	15.7 ± 0.8
	C177	RS	Leucine	4	14.4 ± 0.5
	C177	RS	Isoleucine	4	12.6 ± 0.7
	C177	RS	Proline	4	15.7 ± 0.5
	C177	RS	Aspartic	4	9.8 ± 0.1
	C177	RS	Glutamic acid	4	14.4 ± 0.3
	C177	RS	Phenylalanine	4	5.4 ± 0.4
	C177	RS	Lysine	4	5.1 ± 0.5
	G110	WAP	Alanine	3	13.4 ± 0.1
	G110	WAP	Glycine	3	3.4 ± 0.1
	G110	WAP	Threonine	3	-23.4 ± 0.3
	G110	WAP	Serine	3	4.7 ± 0.5
	G110	WAP	Valine	3	15.8 ± 0.3
	G110	WAP	Leucine	3	13.5 ± 0.2
	G110	WAP	Isoleucine	3	12.3 ± 0.4
	G110	WAP	Proline	3	15.8 ± 0.3
	G110	WAP	Aspartic	3	10.4 ± 0.4
	G110	WAP	Glutamic acid	3	14.8 ± 0.4
	G110	WAP	Phenylalanine	3	4.1 ± 0.5
	G110	WAP	Lysine	3	5.0 ± 0.2
Weddell	G111	WAP	Alanine	3	18.9 ± 0.4
	G111	WAP	Glycine	3	5.0 ± 0.4
	G111	WAP	Threonine	3	-22.1 ± 0.6
	G111	WAP	Serine	3	8.6 ± 0.1
	G111	WAP	Valine	3	22.9 ± 0.5
	G111	WAP	Leucine	3	20.8 ± 0.4
	G111	WAP	Isoleucine	3	19.6 ± 0.6
	G111	WAP	Proline	3	20.8 ± 0.9
	G111	WAP	Aspartic	3	16.7 ± 0.5
	G111	WAP	Glutamic acid	3	20.4 ± 0.5
	G111	WAP	Phenylalanine	3	5.3 ± 0.4
	G111	WAP	Lysine	3	6.7 ± 0.4
	W006	WAP	Alanine	3	20.7 ± 0.2
	W006	WAP	Glycine	3	2.1 ± 0.1
	W006	WAP	Threonine	3	-29.4 ± 0.3
	W006	WAP	Serine	3	6.7 ± 0.2
	W006	WAP	Valine	3	24.0 ± 0.5
	W006	WAP	Leucine	3	21.7 ± 0.4
	W006	WAP	Isoleucine	3	21.4 ± 0.9
	W006	WAP	Proline	3	18.0 ± 0.1
	W006	WAP	Aspartic	3	12.8 ± 0.1
	W006	WAP	Glutamic acid	3	20.8 ± 0.2
	W006	WAP	Phenylalanine	3	5.9 ± 0.5
	W006	WAP	Lysine	1	3.1
	W013	WAP	Alanine	3	22.1 ± 0.1
	W013	WAP	Glycine	3	2.3 ± 0.1
	W013	WAP	Threonine	3	-31.9 ± 0.3
	W013	WAP	Serine	3	8.0 ± 0.2
	W013	WAP	Valine	3	25.5 ± 0.5
	W013	WAP	Leucine	3	23.5 ± 0.1
	W013	WAP	Isoleucine	3	24.0 ± 0.2
	W013	WAP	Proline	3	18.5 ± 0.2
	W013	WAP	Aspartic	3	14.2 ± 0.1



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	W013	WAP	Glutamic acid	3	22.2 ± 0.2
	W013	WAP	Phenylalanine	3	5.9 ± 0.1
	W013	WAP	Lysine	2	3.6 ± 0.8
	W185	RS	Alanine	3	22.8 ± 0.1
	W185	RS	Glycine	3	6.9 ± 0.9
	W185	RS	Threonine	3	-29.9 ± 0.4
	W185	RS	Serine	3	9.0 ± 0.5
	W185	RS	Valine	3	24.2 ± 0.4
	W185	RS	Leucine	3	22.6 ± 0.4
	W185	RS	Isoleucine	3	21.7 ± 0.6
	W185	RS	Proline	3	21.0 ± 0.1
	W185	RS	Aspartic	3	17.2 ± 0.2
	W185	RS	Glutamic acid	3	20.7 ± 0.4
	W185	RS	Phenylalanine	3	5.0 ± 0.0
	W185	RS	Lysine	3	5.4 ± 0.4
	W220	RS	Alanine	3	23.1 ± 0.1
	W220	RS	Glycine	3	9.4 ± 0.3
	W220	RS	Threonine	3	-27.9 ± 0.3
	W220	RS	Serine	3	10.9 ± 0.3
	W220	RS	Valine	3	25.0 ± 0.6
	W220	RS	Leucine	3	23.3 ± 0.2
	W220	RS	Isoleucine	3	22.8 ± 1.0
	W220	RS	Proline	3	21.3 ± 0.7
	W220	RS	Aspartic	3	18.6 ± 0.1
	W220	RS	Glutamic acid	3	22.3 ± 0.2
	W220	RS	Phenylalanine	3	6.4 ± 0.1
	W220	RS	Lysine	3	6.8 ± 0.8
	WS11-11	RS	Alanine	3	22.5 ± 0.1
	WS11-11	RS	Glycine	3	7.0 ± 0.9
	WS11-11	RS	Threonine	3	-28.3 ± 0.3
	WS11-11	RS	Serine	3	9.2 ± 0.5
	WS11-11	RS	Valine	3	24.6 ± 0.3
	WS11-11	RS	Leucine	3	22.6 ± 0.3
	WS11-11	RS	Isoleucine	3	21.7 ± 0.9
	WS11-11	RS	Proline	3	20.4 ± 0.9
	WS11-11	RS	Aspartic	3	17.5 ± 0.5
	WS11-11	RS	Glutamic acid	3	21.5 ± 0.3
	WS11-11	RS	Phenylalanine	3	5.6 ± 0.2
	WS11-11	RS	Lysine	3	5.8 ± 0.5
Ross	R101	AM	Alanine	3	20.3 ± 0.3
	R101	AM	Glycine	3	2.9 ± 0.2
	R101	AM	Threonine	3	-29.2 ± 0.2
	R101	AM	Serine	3	4.4 ± 0.7
	R101	AM	Valine	3	21.5 ± 0.1
	R101	AM	Leucine	3	19.9 ± 0.3
	R101	AM	Isoleucine	3	20.1 ± 1.0
	R101	AM	Proline	3	17.3 ± 0.3
	R101	AM	Aspartic	3	15.9 ± 0.1
	R101	AM	Glutamic acid	3	18.3 ± 0.7
	R101	AM	Phenylalanine	3	2.5 ± 0.2
	R101	AM	Lysine	na	Na
	R103	AM	Alanine	3	18.5 ± 0.3
	R103	AM	Glycine	3	5.1 ± 0.4
	R103	AM	Threonine	3	-27.4 ± 0.7
	R103	AM	Serine	3	5.4 ± 0.8
	R103	AM	Valine	3	20.0 ± 0.4

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R103	AM	Leucine	3	18.6 ± 0.3
R103	AM	Isoleucine	3	15.7 ± 0.6
R103	AM	Proline	3	16.9 ± 0.6
R103	AM	Aspartic	3	13.9 ± 0.2
R103	AM	Glutamic acid	3	17.2 ± 0.6
R103	AM	Phenylalanine	3	2.6 ± 0.4
R103	AM	Lysine	3	1.8 ± 0.4
R106	AM	Alanine	3	18.8 ± 0.1
R106	AM	Glycine	3	5.7 ± 0.3
R106	AM	Threonine	3	-27.5 ± 0.3
R106	AM	Serine	3	5.8 ± 0.4
R106	AM	Valine	3	19.3 ± 0.4
R106	AM	Leucine	3	17.9 ± 0.3
R106	AM	Isoleucine	3	18.8 ± 0.7
R106	AM	Proline	3	17.3 ± 0.2
R106	AM	Aspartic	3	14.0 ± 0.2
R106	AM	Glutamic acid	3	16.9 ± 0.3
R106	AM	Phenylalanine	3	1.9 ± 0.2
R106	AM	Lysine	3	2.5 ± 0.4
R111	AM	Alanine	3	18.6 ± 0.3
R111	AM	Glycine	3	5.2 ± 0.1
R111	AM	Threonine	3	-28.0 ± 0.1
R111	AM	Serine	3	5.7 ± 0.3
R111	AM	Valine	3	19.7 ± 0.3
R111	AM	Leucine	3	18.2 ± 0.3
R111	AM	Isoleucine	3	18.4 ± 0.7
R111	AM	Proline	3	16.4 ± 0.9
R111	AM	Aspartic	3	13.6 ± 0.2
R111	AM	Glutamic acid	3	17.6 ± 0.3
R111	AM	Phenylalanine	3	1.9 ± 0.1
R111	AM	Lysine	3	3.4 ± 0.2
R112	AM	Alanine	3	19.2 ± 0.5
R112	AM	Glycine	3	4.8 ± 0.5
R112	AM	Threonine	3	-28.0 ± 0.7
R112	AM	Serine	3	4.7 ± 0.4
R112	AM	Valine	3	19.7 ± 0.1
R112	AM	Leucine	3	18.2 ± 0.1
R112	AM	Isoleucine	2	17.7 ± 0.6
R112	AM	Proline	3	17.1 ± 0.6
R112	AM	Aspartic	3	14.3 ± 0.4
R112	AM	Glutamic acid	3	17.6 ± 0.5
R112	AM	Phenylalanine	3	3.9 ± 0.2
R112	AM	Lysine	3	3.1 ± 0.4
R114	RS	Alanine	3	17.6 ± 0.4
R114	RS	Glycine	3	5.9 ± 0.3
R114	RS	Threonine	3	-25.9 ± 0.2
R114	RS	Serine	3	5.9 ± 0.8
R114	RS	Valine	3	19.0 ± 0.4
R114	RS	Leucine	3	17.5 ± 0.4
R114	RS	Isoleucine	na	Na
R114	RS	Proline	3	18.1 ± 0.8
R114	RS	Aspartic	3	12.9 ± 0.2
R114	RS	Glutamic acid	3	17.5 ± 0.8
R114	RS	Phenylalanine	3	3.1 ± 0.3
R114	RS	Lysine	2	3.3 ± 0.1

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224 Table S9. Results of one-way ANOVA Bonferroni post-hoc comparisons for  
 225 amino acid  $\delta^{15}\text{N}$  data for the three seal species. Significant  $p$ -values are  $< 0.05$ .

<b>Amino Acid</b>	<b>ANOVA Post-hoc <math>p</math>-values</b>	<b>Comparison</b>
Ala	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	0.003	Ross vs. Weddell
Gly	–	Crabeater vs. Ross
	–	Crabeater vs. Weddell
	–	Ross vs. Weddell
Thr	0.01	Crabeater vs. Ross
	0.006	Crabeater vs. Weddell
	–	Ross vs. Weddell
Ser	–	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	0.002	Ross vs. Weddell
Val	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Leu	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Ile	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Pro	0.03	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Asp	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	–	Ross vs. Weddell
Glu	<0.001	Crabeater vs. Ross
	<0.001	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Phe	<0.001	Crabeater vs. Ross
	–	Crabeater vs. Weddell
	<0.001	Ross vs. Weddell
Lys	0.009	Crabeater vs. Ross
	–	Crabeater vs. Weddell
	0.005	Ross vs. Weddell

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228 Table S10. Bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of crabeater, Weddell, and Ross seals from the literature. Note,  
 229 bulk  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values are reported for the original measurement (Orig.) and with a correction to  
 230 whole blood (Corr.) if the sample is a tissue type with a significant isotopic offset from whole blood.  
 231 Isotopic offset between whole blood and the given sample type are reported in Tables S4 and S6, above.  
 232 Abbreviations: RBCs, red blood cells; F, female; M, male; na, information not available; NDR, no dive  
 233 records; RS, Ross Sea; AS, Amundsen Sea; WAP, West Antarctic Peninsula; *n*, sample size.

Species	Sample Type	<i>n</i>	Sex	Age Class	Area	Orig. $\delta^{13}\text{C}$ (‰)	Orig. $\delta^{15}\text{N}$ (‰)	Corr. $\delta^{13}\text{C}$ (‰)	Corr. $\delta^{15}\text{N}$ (‰)	Source
Ross	Serum	21	M	na	RS/AS	24.3 ± 0.4	10.6 ± 0.6	-24.0 ± 0.4	9.5 ± 0.4	Zhao et al. (2004)
	Serum	12	F	na	RS/AS	-24.0 ± 0.4	10.0 ± 0.5	-23.7 ± 0.4	8.9 ± 0.5	Zhao et al. (2004)
	Hair	1	M	na	RS	-22.3	10.4	-23.6	9.2	Aubail et al. (2011)
Weddell	Serum	17	M	na	RS/AS	-24.6 ± 0.6	13.3 ± 0.8	-24.3 ± 0.6	12.2 ± 0.8	Zhao et al. (2004)
	Serum	16	F	na	RS/AS	-25.3 ± 0.9	12.5 ± 1.1	-25.0 ± 0.9	11.4 ± 1.1	Zhao et al. (2004)
	Serum	22	na	Adult	RS/AS	-24.9 ± 0.8	13.0 ± 0.9	-24.6 ± 0.8	11.9 ± 0.9	Zhao et al. (2004)
	Serum	4	na	Subadult	RS/AS	-25.5 ± 0.9	11.5 ± 1.1	-25.2 ± 0.9	10.4 ± 1.1	Zhao et al. (2004)
	Serum	6	na	Juvenile	RS/AS	-24.8 ± 1.0	13.1 ± 1.0	-24.5 ± 1.0	12.0 ± 1.0	Zhao et al. (2004)
	Serum	1	na	Pup	RS/AS	-25.2	13.4	-24.9	12.3	Zhao et al. (2004)
	Plasma	12	na	Adult	RS	-25.5 ± 0.1	13.1 ± 0.2	-24.9 ± 0.1	12.4 ± 0.2	Burns et al. (1998)
	Plasma	6	na	Deep-diving yearling	RS	-25.4 ± 0.2	12.6 ± 0.2	-24.8 ± 0.2	11.9 ± 0.2	Burns et al. (1998)
	Plasma	4	na	NDR yearling	RS	-25.1 ± 0.2	12.9 ± 0.1	-24.5 ± 0.2	12.2 ± 0.1	Burns et al. (1998)
	Plasma	4	na	Shallow-diving yearling	RS	-23.5 ± 0.1	13.3 ± 0.1	-22.9 ± 0.1	12.6 ± 0.1	Burns et al. (1998)
	Plasma	16	na	Pup	RS	-26.0 ± 0.2	13.8 ± 0.1	-25.4 ± 0.2	13.1 ± 0.1	Burns et al. (1998)
	Hair	12	na	na	RS	-23.2 ± 0.1	13.5 ± 0.2	-24.6 ± 0.1	13.0 ± 0.2	Aubail et al. (2011)
	Whisker	14	na	na	WAP	-21.6 ± 0.6	12.7 ± 0.7	-23.0 ± 0.6	12.2 ± 0.7	Botta et al.

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	RBCs	116	na	na	RS	-25.2 ± 0.3	12.0 ± 0.3	-25.2 ± 0.3	12.3 ± 0.3	(2018) Goetz et al. (2017)
Crabeater	Serum	26	M	na	RS/AS	-26.7 ± 0.9	8.2 ± 0.5	-26.4 ± 0.9	7.1 ± 0.5	Zhao et al. (2004)
	Serum	15	F	na	RS/AS	-26.5 ± 1.2	8.4 ± 0.4	-26.2 ± 1.2	7.3 ± 0.4	Zhao et al. (2004)
	Serum	30	na	Adult	RS/AS	-26.5 ± 1.0	8.4 ± 0.6	-26.2 ± 1.0	7.3 ± 0.6	Zhao et al. (2004)
	Serum	4	na	Subadult	RS/AS	-26.1 ± 1.2	8.4 ± 0.3	-25.8 ± 1.2	7.3 ± 0.3	Zhao et al. (2004)
	Serum	3	na	Juvenile	RS/AS	-27.2 ± 1.2	8.0 ± 0.1	-26.9 ± 1.2	7.9 ± 0.1	Zhao et al. (2004)
	Serum	4	na	Pup	RS/AS	-27.4 ± 0.4	7.7 ± 0.1	-27.1 ± 0.4	6.6 ± 0.1	Zhao et al. (2004)
	Hair	33	na	na	RS	-24.3 ± 0.1	7.7 ± 0.1	-25.9 ± 0.1	7.7 ± 0.1	Aubail et al. (2011)
	Whisker	13	na	na	WAP	-23.0 ± 0.6	7.0 ± 0.8	-24.6 ± 0.6	7.0 ± 0.8	Botta et al. (2018)

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