Comparison of Pinniped and Cetacean Prey Tissue Lipids with Lipids of their Elasmobranch Predator

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Abstract. *Background: The great white shark is known to include pinnipeds and cetaceans in its diet. Both groups of marine mammals deposit thick blubber layers around their bodies. Elasmobranchs do not produce adipose tissue, but rather store lipid in their livers, thus a great white predating on a marine mammal will deposit the lipids in its liver until required. Materials and Methods: Samples from great white liver and muscle, Cape fur seal, Indian Ocean bottlenose dolphin and common dolphin liver, muscle and blubber were analyzed for their lipid and fatty acid profiles. Results: The great white liver and marine mammal blubber samples showed a considerable degree of homogeneity, but there were significant differences when comparing between the muscle samples. Blubber from all three marine mammal species was calculated to provide greater than 95% of lipid intake for the great white shark from the tissues analyzed. Conclusion: Sampling of prey blubber may give a good indication of the lipids provided to the shark predator.*

Great white sharks (*Carcharodon carcharias*) are reported to predate on a wide range of teleosts, cephalopods and marine mammals (1, 2). Others have shown a high degree of conservation of lipid and fatty acid profile between predator and prey, or "fatty acid signatures", especially in predatory marine mammals. The fatty acid signature technique uses biopsy samples of full-depth blubber to characterise the lipid storage of the marine mammal and compare that to the whole body lipid profile of the prey species (3). Thiemann and Iverson (4) have applied the technique to ringed seals, while Koopman *et al*. (5) have used it in harbour porpoises, Krahn *et al*. (6) in white and killer whales and Samuel and Worthy (7) and Smith and Worthy (8) in bottlenose dolphins and common dolphins, respectively. These were all cold-adapted species in the northern hemisphere. Best *et al*. (9) did similar work in the southern hemisphere with cold-adapted southern elephant seals. In contrast, elasmobranchs do not have adipose tissue and thus biopsy samples of this tissue are not possible. Elasmobranchs store lipid in their liver, thus, if the prey pattern of lipids is conserved in the elasmobranch, then samples from that tissue may reflect dietary intake.

The KwaZulu-Natal Sharks Board (KZNSB) is responsible for the maintenance of the beach-protecting nets along the KwaZulu-Natal (KZN) Indian Ocean coastline of South Africa. Any sharks found alive in the nets are released, while dead animals are taken ashore for research and demonstration purposes (10). This practice has led to the development of a large database of the sharks most commonly found off the KZN coast. A range of shark species are caught with varying frequency, depending on species, site and season. We have previously published lipid profile data from several of the species more commonly caught (11-13). In parallel, there has been a by-catch of marine mammals species, including the Indian Ocean bottlenose (*Tursiops aduncus*) and common (*Delphinus spp*.) dolphins. Tissue samples were also collected from these for lipid and fatty acid profiling.

Cetaceans and pinnipeds make up a significant, but variable, proportion of the prey of great white sharks in South African waters (1, 2). In the Cape region pinnipeds constitute a larger proportion of the shark diet, but the species only rarely progresses into the KZN region, thus cetaceans contribute a greater proportion in this region. Thus comparison of the lipid and fatty acid profiles of the marine mammal species that occur around the South African coast may clarify if there is any conservation of prey lipids within the great white liver and, if so, which tissues are most significant.

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Materials and Methods

Study samples. Samples from the liver, abdominal muscle and blubber of 6 female Cape fur seals (*Arctocephalus pusillus pusillus*) were obtained through the Sea Fisheries Research Institute from 2000-

Table I. *The comparative total lipid and fatty acid profiles of tissues from the Cape fur seal, bottlenose dolphin, common dolphin and great white shark samples.*

	Cape fur seal (n=6)			Bottlenose dolphin (n=22)			Common dolphin (n=24)			Great white shark (n=8)	
	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle
Lipid (mg/g)	21±3	28±3	643±26	7±4	6±4	469±43	8±4	5±3	564±47	258±37	3±1
FAME (%)											
14:0	1.96±0.41	4.22±0.67	5.12±0.76	1.85±0.13	4.36±1.05	4.06±0.81	2.35±0.86	6.69±1.08	7.90±1.03	5.19±1.29	5.30±0.73
16:0	13.65±1.67	18.56±1.57	18.15±1.48	13.68±1.48	16.39±1.60	12.68±1.77	13.65±1.86	16.30±1.55	13.43±2.43	18.44±3.01	18.69±2.22
18:0	14.14±1.71	10.87±1.46	4.27±0.66	16.42±1.23	6.73±1.04	3.68±0.51	12.95±1.51	6.56±1.85	4.35±0.72	5.12±1.02	10.52±1.66
TSFA	29.75±2.58	33.65±2.56	27.54±1.69	31.98±2.07	27.76±2.56	20.42±3.05	28.96±2.45	29.78±2.59	25.68±2.88	28.75±3.94	34.51±4.16
14:1n7	0.53±0.11	1.67±0.53	4.54±0.80	0.52±0.23	2.34±0.30	4.23±0.40	0.53±0.11	1.85±0.31	5.04±1.70	2.66±0.47	1.63±0.22
16:1n9	8.74±0.96	8.80±0.79	13.12±1.53	8.22±1.81	14.50±1.14	19.51±2.28	9.54±1.66	13.38±1.91	16.19±2.26	10.74±1.95	5.80±0.98
18:1n9	20.68±2.90	19.55±1.47	9.56±1.26	19.09±1.37	25.93±2.28	18.79±2.26	22.98±2.70	23.73±2.26	11.57±2.16	15.19±1.10	17.61±1.99
TMUFA	29.95±2.63	30.02±2.37	27.22±2.35	27.83±1.72	42.77±3.66	32.53±2.43	33.05±2.01	38.95±2.87	32.80±2.48	27.59±3.87	25.04±1.71
16:2n6	0.39±0.04	0.32±0.09	0.04±0.02	0.51±0.18	0.43±0.21	0.87±0.12	0.41±0.21	0.99±0.26	2.12±0.35	1.07±0.18	0.73±0.13
18:2n6	0.71±0.12	4.93±0.54	2.81±0.46	0.89±0.21	1.01±0.25	0.99±0.22	0.37±0.11	0.70±0.29	1.08±0.40	0.90±0.15	0.51±0.14
20:2n6	0.04±0.02	0.71±0.26	0.47±0.14	0.09±0.07	0.46±0.16	0.31±0.09	0.11±0.03	0.51±0.40	0.63±0.27	0.61±0.06	0.23±0.07
20:4n6	9.92±1.70	2.04±0.37	1.63±0.37	14.35±2.01	6.96±1.95	1.67±0.33	12.55±1.87	4.85±0.92	1.56±0.26	2.66±0.39	5.10±1.88
22:4n6	0.98±0.22	0.61±0.16	0.32±0.11	1.43±0.43	0.58±0.16	0.61±0.18	0.64±0.20	0.25±0.10	0.43±0.07	0.75±0.17	2.01±0.44
22:5n6	0.84±0.15	0.24±0.05	0.31±0.05	1.15±0.32	0.72±0.19	0.64±0.14	0.59±0.23	0.44±0.18	0.30±0.10	0.82±0.17	0.87±0.15
Tn6PUFA	12.88±1.57	8.85±0.89	5.58±0.62	17.65±2.45	9.38±1.99	5.09±1.22	14.56±1.99	7.23±1.21	6.12±0.70	6.81±1.05	9.45±1.70
18:3n3	0.81±0.12	0.96±0.23	1.13±0.31	0.56±0.14	1.26±0.57	3.73±0.37	0.90±0.27	1.97±0.59	2.20±0.71	2.55±0.69	1.32±0.26
20:3n3	0.06±0.03	2.72±0.74	1.04±0.33	0.05±0.04	0.04±0.04	0.02±0.02	0.11±0.07	0.05±0.03	0.06±0.03	0.13±0.04	0.20±0.03
20:5n3	6.66±1.04	6.54±0.94	9.12±1.01	6.03±1.17	4.16±1.40	5.87±0.21	6.50±0.84	6.12±0.49	8.36±1.15	8.46±0.77	4.10±0.34
22:5n3	2.42±0.75	3.88±0.77	5.55±0.47	2.81±0.52	2.03±0.27	3.67±0.49	2.32±0.90	2.11±0.36	3.65±0.83	4.57±0.27	3.86±0.77
22:6n3	11.48±1.46	9.48±1.06	18.90±1.78	9.88±1.60	9.34±1.79	15.84±2.15	12.70±1.47	11.96±1.63	17.28±2.02	16.60±0.97	15.24±1.32
Tn3PUFA	21.43±1.93	23.58±2.62	35.74±2.63	19.36±2.84	16.72±1.67	29.13±1.95	22.73±1.14	22.20±1.71	31.55±2.01	31.31±1.56	24.72±2.33
TPUFA	34.31±2.43	32.43±2.72	41.32±2.73	37.79±2.24	26.42±2.97	34.22±2.24	37.28±2.08	29.43±1.89	37.67±2.69	38.12±1.75	34.17±3.31

2002. Samples from Cape fur seals were obtained from the left lobe of the liver, abdominal muscle adjacent to the left front flipper and blubber in the same region. Samples of 8 great white shark livers and abdominal muscles and of liver, abdominal muscle and abdominal blubber from 22 Bottlenose and 24 Common dolphins were obtained from 2003-2006. The sharks and dolphins had been caught in the beach-protecting nets off the coast of KZN. Details of the netting operation off the beaches of KZN are given by Cliff and Dudley (10). The sharks and dolphins were taken to the laboratories of the KZNSB, where the carcasses were dissected and approximately 20 g of samples were collected from the liver (upper portion of the left lobe) and abdominal muscle (adjacent to the left pectoral fin). Blubber samples were also taken from adjacent to the left pectoral fin of the dolphins. Seal samples had previously been obtained from similar anatomical sites. All samples were placed into labeled glass vials and frozen at −20˚C.

Samples were de-frosted in the laboratory of B.D. samples were weighed and the lipids extracted according to Bligh and Dyer (14). The extracts were reduced in volume and made to 20 ml with chloroform for storage. A 1-ml aliquot of each extract was then used to determine the lipid dry weight, and a further aliquot approximating to 20mg of lipid was then transmethylated using 10% acetyl chloride in methanol to prepare the fatty acid methyl esters (FAME) (15). These were then extracted into hexane, and separated using a Varian 3400 gas chromatograph with 4270 integrator and a 10% SP2330 on Chromosorb WAW 6’ × 1/8” packed column run isothermally at 195˚C with flame ionization detection (FID). FAME were identified by comparison with authentic standards purchased from Sigma-Aldrich (St louis, Missouri, USA) and the data compared using the *t*-test (Statistica 9 software package).

Results

Table I shows the total lipid and FAME profiles of the Cape fur seal, Indian Ocean bottlenose dolphin, common dolphin and great white shark samples, expressed as mg/g tissue and percentage total FAME, respectively. The total lipid levels were low in the liver and muscle of the Cape fur seals (21±3 and 28±3), Indian Ocean bottlenose dolphin (7±4 and 6±4), common dolphin (8±4 and 5±3) and the muscle of the great white sharks (3±1). In contrast, the blubber of the Cape fur seals (643±26), Indian Ocean bottlenose dolphins (469±43), common dolphins (564±47) and liver of the great white sharks (258±37) showed much higher levels of total lipid. The major fatty acids detected in all samples were 16:0, 18:0, 16:1n9, 18:1n9, 20:4n6, 20:5n3, 22:5n3 and 22:6n3.

Table IIa shows the significant differences between the samples, in relation to the great white shark liver. All total

Table II. *a. The significance of differences in total lipid and fatty acid profiles of tissues from the Cape fur seal, bottlenose dolphin, common dolphin relative to great white shark liver.*

	Cape fur seal (n=6)			Bottlenose dolphin (n=22)			Common dolphin (n=24)			Great white shark (n=8)	
	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle
Lipid (mg/g)	↓ $p<0.05$	↓ $p<0.05$	↑ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↑ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↑ $p<0.05$		↓ $p<0.05$
FAME (%)											
14:0	↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$				
16:0	↓ $p<0.05$					↓ $p<0.05$					
18:0	↑ $p<0.05$	↑ $p<0.05$		↑ $p<0.05$			↑ $p<0.05$				↑ $p<0.05$
TSFA		↑ $p<0.05$									
14:1n7	↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$		↑ $p<0.05$		↓ $p<0.05$
16:1n9					↑ $p<0.05$	↑ $p<0.05$					↓ $p<0.05$
18:1n9	↑ $p<0.05$		↓ $p<0.05$		↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$			
TMUFA								↑ $p<0.05$			
16:2n6	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$							
18:2n6	↑ $p<0.05$	↑ $p<0.05$									
20:2n6	↓ $p<0.05$			↓ $p<0.05$							↓ $p<0.05$
20:4n6				↑ $p<0.05$	↑ $p<0.05$		↑ $p<0.05$	↑ $p<0.05$	↓ $p<0.05$		↑ $p<0.05$
22:4n6											↑ $p<0.05$
22:5n6											
Tn6PUFA	↑ $p<0.05$										↑ $p<0.05$
18:3n3				↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$				↓ $p<0.05$
20:3n3		↑ $p<0.05$									
20:5n3	↓ $p<0.05$	↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$
22:5n3	↓ $p<0.05$			↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$			
22:6n3	↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$			
Tn3PUFA	↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$			↓ $p<0.05$
TPUFA	↓ $p<0.05$	↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$			

b. The significance of differences in total lipid and fatty acid profiles of tissues from the Cape fur seal, bottlenose dolphin, common dolphin relative to great white shark muscle.

	Cape fur seal (n=6)			Bottlenose dolphin (n=22)			Common dolphin (n=24)			Great white shark (n=8)	
	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle	Blubber	Liver	Muscle
Lipid (mg/g)	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$			↑ $p<0.05$			↑ $p<0.05$	↑ $p<0.05$	
FAME (%)											
14:0	↓ $p<0.05$			↓ $p<0.05$			↓ $p<0.05$				
16:0						↓ $p<0.05$					
18:0			↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	
TSFA						↓ $p<0.05$					
14:1n7	↓ $p<0.05$									↑ $p<0.05$	
16:1n9	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	
18:1n9			↓ $p<0.05$		↑ $p<0.05$		↑ $p<0.05$	↑ $p<0.05$	↓ $p<0.05$		
TMUFA		↑ $p<0.05$			↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$		
16:2n6			↓ $p<0.05$								
18:2n6		↑ $p<0.05$	↑ $p<0.05$								
20:2n6	↓ $p<0.05$	↑ $p<0.05$							↑ $p<0.05$	↑ $p<0.05$	
20:4n6	↑ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↑ $p<0.05$		↓ $p<0.05$	↑ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$	
22:4n6	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	↓ $p<0.05$	
22:5n6											
Tn6PUFA	↑ $p<0.05$		↓ $p<0.05$	↑ $p<0.05$		↓ $p<0.05$	↑ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$	
18:3n3						↑ $p<0.05$			↑ $p<0.05$	↑ $p<0.05$	
20:3n3		↑ $p<0.05$									
20:5n3	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$				↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	↑ $p<0.05$	
22:5n3	↓ $p<0.05$				↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$			
22:6n3		↓ $p<0.05$		↓ $p<0.05$	↓ $p<0.05$			↓ $p<0.05$			
Tn3PUFA			↑ $p<0.05$		↓ $p<0.05$	↑ $p<0.05$			↑ $p<0.05$	↑ $p<0.05$	
TPUFA					↓ $p<0.05$			↓ $p<0.05$			

lipid differences were significant, with Cape fur seals, Indian Ocean bottlenose dolphins and common dolphins all showing lower levels of total lipid, but higher blubber total lipid. In seal liver 14:0, 16:0, 14:1n7, 20:2n6, 20:5n3, 22:5n3, 22:6n3, Tn3PUFA and TPUFA were all significantly lower, while 18:0, 18:1n9, 18:2n6 and Tn6PUFA were significantly higher. Seal muscle showed lower levels of 16:2n6, 20:5n3, 22:6n3, Tn3PUFA and TPUFA, with higher levels of 18:0, TSFA, 18:2n6 and 20:3n3. There were only 2 significant differences between seal blubber and great white liver, with both 18:1n9 and 16:2n6 being lower in the seal blubber. For the Indian Ocean bottlenose dolphin the liver samples showed reduced levels of 14:0, 14:1n7, 20:2n6, 18:3n3, 22:5n3, 22:6n3 and Tn3PUFA, but increased levels of 18:0 and 20:4n6. The comparable muscle samples showed reduced 18:3n3, 20:5n3, 22:5n3, 22:6n3, Tn3PUFA and TPUFA, with increased 16:1n9, 18:1n9 and 20:4n6. There were only 3 significant differences between bottlenose blubber and great white liver, with 16:0 being lower and 16:1n9 and 18:1n9 greater. The common dolphin showed lower levels of 14:0, 14:1n7, 18:3n3, 22:5n3, 22:6n3 and Tn3PUFA, but higher levels of 18:0, 18:1n9 and 20:4n6 in the liver samples. The muscle samples showed lower levels of 20:5n3, 22:5n3, 22:6n3, Tn3PUFA and TPUFA, but higher 18:1n9 and TMUFA. There were only 2 significant differences when comparing common dolphin blubber and great white liver, with 14:1n7 increased and 20:4n6 decreased. In contrast, there were more differences between the shark liver and shark muscle, with 14:1n7, 16:1n9, 20:2n6, 18:3n3 and 20:5n3 being lower and 18:0, 20:4n6, 22:4n6 and Tn6PUFA higher in muscle when comparing these 2 shark tissues.

Table IIb shows the significant differences between the samples, relative to the great white shark muscle.

Table III shows the calculated proportions of the three body tissues within each of the three marine mammal species. The percentages contributed by liver (3%), muscle (27%) and blubber (40%) for the Cape fur seal were obtained from Mecenero *et al*. (16) and Koep *et al*. (17) and assumed their lowest percentage of bodily blubber. The equivalent percentages for bottlenose (2%, 27% and 25%, respectively) and common (2%, 27% and 25%, respectively) dolphins were obtained from Struntz *et al*. (18) and Plon *et al*. (19). For all three marine mammals, the percentage lipid and low percentage of body mass meant that the liver only contributed to a very small proportion of the total lipid. Muscle % lipid was also low, but contributed to a greater proportion of body mass; however this was still only a minor amount. In all three cases blubber was very high in lipid and constituted a major component of total body mass, thus the lipid provided by the blubber was greater than 95% of calculated body lipid in all cases.

Table IV shows the results from calculating the individual FAME amounts provided by the lipids from each tissue and species and the profile was very similar to that seen for total lipid, with the greatest amounts being contributed by blubber.

Table III. *Proportions of body from liver, muscle and blubber, and contribution to lipid provided by the three tissues in all three species of marine mammal.*

Tissue	% body	Body (Kg)	% lipid	Lipid (Kg)	% total lipid
Cape fur seal		55			
Liver	3	1.25	2.10	0.03	0.18
Muscle	27	14.85	1.80	0.27	1.85
Blubber	40	22.00	64.30	14.15	97.91
Bottlenose dolphin		100			
Liver	2	2.30	0.70	0.02	0.12
Muscle	27	29.43	0.60	0.18	1.36
Blubber	25	27.25	46.90	12.78	98.51
Common dolphin		114			
Liver	2	2.75	0.80	0.02	0.14
Muscle	27	30.78	0.50	0.15	0.95
Blubber	25	28.50	56.40	16.07	98.92

Percentage body composition data obtained from Mecenero *et al*. (2006), Koep *et al*. (2007), Struntz *et al*. (2004) and Plon *et al*. (2012).

Discussion

The three marine mammal species exhibited significantly different liver FAME profiles when compared to great white shark liver. In all three species the liver showed much lower levels of most n3 compounds as well as TPUFA and 14:0. In contrast 18:0 was higher in all three species, as was 20:4n6 in the dolphins and 18:2n6 in the seal. Similarly, there were marked differences between the three marine mammal species muscle FAME profiles compared to that from the great white shark muscle. Cape fur seal total lipid was significantly increased, as were 16:1n9 and TMUFA in all three marine mammals. 18:1n9 was increased in the two dolphin species, while 20:5n3 was increased in the seal and common dolphin. Conversely, all three mammals showed decreased 22:4n6 and 22:6n3, while both dolphins showed decreased TPUFA. Thus there were significant differences between the muscle samples depending on species.

In contrast, comparing between marine mammal blubber and shark liver, there were very few significant differences and also no consistent pattern of differences, except for the total lipid. Thus the main lipid storage tissues for marine mammals and sharks showed very similar qualitative lipid profiles. Quantitatively, the blubber from all three marine mammal species was the greatest contributor of both total lipid and fatty acids (greater than 95% for all three species). Thus from the point of view of dietary lipids, sampling of blubber from marine mammals may give a good indication of the major lipids available to predators. However, this

Table IV. *Amount (g) of each FAME provided by the total carcass amounts of each of the tissues and the combined total FAME.*

	Seal				Bottlenose				Common			
g FAME	Liver	Muscle	Blubber	Total	Liver	Muscle	Blubber	Total	Liver	Muscle	Blubber	Total
14:0	0.52	11.28	724.28	736.07	0.30	7.70	518.88	526.88	0.52	10.30	1269.85	1280.66
16:0	3.58	49.61	2567.50	2620.69	2.20	28.94	1620.54	1651.68	3.00	25.09	2158.74	2186.83
18:0	3.71	29.06	604.03	636.80	2.64	11.88	470.31	484.84	2.85	10.10	699.22	712.16
TSFA	7.81	89.95	3895.81	3993.56	5.15	49.02	2609.73	2663.89	6.37	45.83	4127.80	4180.01
14:1n7	0.14	4.46	642.23	646.83	0.08	4.13	540.61	544.82	0.12	2.85	810.13	813.09
16:1n9	2.29	23.52	1855.96	1881.77	1.32	25.60	2493.43	2520.35	2.10	20.59	2602.38	2625.07
18:1n9	5.43	52.26	1352.36	1410.04	3.07	45.79	2401.41	2450.27	5.16	36.52	1859.76	1901.34
TMUFA	7.86	80.24	3850.54	3938.65	4.48	75.52	4157.42	4237.42	7.27	59.94	5272.27	5339.49
16:2n6	0.10	0.86	5.66	6.62	0.08	0.76	111.19	112.03	0.09	1.52	340.77	342.38
18:2n6	0.19	13.18	397.50	410.87	0.14	1.78	126.52	128.45	0.08	1.08	173.60	174.76
20:2n6	0.01	1.90	66.49	68.40	0.01	0.81	39.62	40.45	0.02	0.79	101.27	102.08
20:4n6	2.60	5.45	230.58	238.64	2.31	12.29	213.43	228.03	2.76	7.46	250.75	260.98
22:4n6	0.26	1.63	45.27	47.16	0.23	1.02	77.96	79.21	0.14	0.39	69.12	69.64
22:5n6	0.22	0.64	43.85	44.72	0.19	1.27	81.79	83.25	0.13	0.68	48.22	49.03
Tn6PUFA	3.38	23.66	789.35	816.38	2.84	15.56	650.52	669.92	3.20	11.13	983.73	998.06
18:3n3	0.21	2.57	159.85	162.63	0.09	2.23	476.70	479.02	0.20	3.03	353.63	356.86
20:3n3	0.02	7.27	147.12	154.41	0.01	0.07	2.56	2.64	0.02	0.08	9.64	9.75
20:5n3	1.75	17.48	1290.12	1309.35	0.97	7.35	750.20	758.52	1.43	9.42	1343.79	1354.64
22:5n3	0.64	10.37	785.10	796.11	0.45	3.59	469.04	473.07	0.51	3.25	586.70	590.46
22:6n3	3.01	25.34	2673.59	2701.95	1.59	16.49	2024.39	2042.48	2.79	18.41	2777.59	2798.79
Tn3PUFA	5.63	63.03	5055.78	5124.44	3.12	29.52	3722.89	3755.53	5.00	34.17	5071.35	5110.52
TPUFA	9.01	86.69	5845.13	5940.82	6.08	46.65	4373.40	4426.14	8.20	45.29	6055.08	6108.57

assumption is ignoring any possible lipid provided by other tissues as these were not available for analysis. It is possible that significant amounts of lipids could be provided by other organs, especially the brain and lungs, which might reduce the influence of blubber, but only slightly.

It should be noted that the three marine mammal species occupy different environmental niches within geographical regions that only partially overlap, thus samples do not necessarily reflect a direct predator to prey relationship. However, the shark and dolphin samples were all obtained from the KZN nets, so all individuals were in KZN waters at the time. The prey species spectrum of the great white shark included many other species (1) as well as marine mammals, none of which have been analyzed in the present study, thus the lipid in the great white livers may have come from a variety of sources. There may also be other variables which could affect the inter-relationship of predator-prey lipid transfer and which have not been addressed in this study. Nevertheless, the FAME profiles from the seal and dolphin blubber and those of the great white liver are noteworthy for their similarities, rather than their differences. Whether this infers conservation of lipid profile between great white and marine mammal is debatable, but should be borne in mind as a possibility. Alternatively, it may just reflect common functional requirements for storage of a similar profile of lipids, as both potential energy sources and contributors to buoyancy control. However, this study does support the use of the "fatty acid signature" technique, previously proven with marine mammals such as predators (3-7, 18, 19), when those mammals become the prey.

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