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Compositions of Fatty Acids in the Lipids of Chum Salmon during Spawning Migration

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The fatty acid compositions of total lipids from various tissues of chum salmon caught on the coast and upstream at the spawning site have been investigated in detail with open-tubular gas-liquid chromatography. At least 100 components were detected by GLC, of which 53 components were identified. Furan fatty acids could be detected in other tissues except for the flesh.

In the skin, flesh and gonad, lipid contents and fatty acid contents decreased during the migration from seawater to freshwater. The distributions of positional isomers within 20: 1 and 22: 1 changed in this period. Although lipid contents and fatty acid contents in the liver and viscera almost maintained at constant levels, the fatty acid compositions changed during the migration. Especially, the contents of C_{20} and C_{22} monounsaturated fatty acids increased in this period. There were sex differences of fatty acid compositions in other tissues except for the liver of chum salmon caught on the upstream.

Chum salmon *Oncorhynchus keta* is the most popular salmonid species in Japan, and its consumption has gradually increased. Chum salmon grows into adulthood in the ocean except during breeding, and spends the early part of its life in freshwater. As the spawning time approaches, the adult fish re-enters freshwater revers, and migrates upstream to the spawning area where eggs are laid among the gravel of riverbeds. The depletion of total body lipid and the utilization of mobilized lipid as the principal substrate for energy provision during the spawning migration are well known.[1] There have been a number of detailed reports describing the changes of proximate composition during spawning migration of chum salmon.[2-5] Ando *et al.*[4] studied on the changes in lipid composition and fatty acid composition of flesh lipid during the spawning migration, and reported that no selective consumption of fatty acids in flesh lipid occurred during spawning migration of chum salmon.

In this study, the fatty acid compositions of total lipids (TL) from various tissues of chum salmon caught on the coast and upstream at the spawning site were investigated in detail by the analysis with open-tubular gas-liquid chromatography. The fatty acid compositions of TL from various tissues of chum salmon were compared, respectively.

Materials and Methods

Materials

Two kinds of chum salmon of different physiological states were used as materials (Table 1). After their biological properties were measured, each salmon was divided into some tissues (skin, flesh, liver, gonad, and viscera other than liver and gonad) and then each tissue was kept at −20°C until used.

Preparation of Fatty Acid Methyl Esters (FAME)

TL were extracted from each tissue by the method of Bligh and Dyer.[6] Preparations of FAME were carried out as described previously.[7] The resulting products were purified by thin-layer chromatography (TLC) with Kiesel Gel 60G plate of thickness 0.5 mm using toluene/diethyl ether (97: 3, v/v) as a solvent to remove dimethyl acetals. The relative contents of fatty acids to TL were calculated on the basis of the weight of fatty acids obtained by the saponification of TL from each tissue of chum salmon.

Gas-Liquid Chromatography (GLC)

Open-tubular GLC of FAME was carried out with a Shimadzu GC-6AM (Shimadzu Seisakusho Co., Kyoto) equipped with a flame-ionization detector. The metal wall-coated open-tubular column used for the analyses of FAME was 50 m

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Table 1. Biological characteristics of chum salmon

Sample	Sex	Collecting date and locality	Body length (cm)	Body weight (g)
C-M	Male	Nov. 18, 1988 Hakodate coast of Hokkaido.	53.0	2216
U-M	Male	Dec. 8, 1988	64.2	3200
U-F	Female	Lower reaches (0.5 km) of Hekirichi river, Hokkaido.	54.7	1970

Table 2. Lipid contents in some tissues of chum salmon (wt%)

Tissue	C-M*	U-M*	U-F*
Skin	2.9 (77.5)	0.8 (66.5)	0.8 (70.4)
Flesh	1.7 (93.1)	0.9 (76.4)	1.6 (74.7)
Liver	2.5 (70.0)	3.0 (42.9)	2.0 (76.5)
Viscera	1.7 (60.0)	1.8 (47.8)	3.7 (79.4)
Gonad	2.1 (71.8)	1.3 (56.1)	11.6 (78.7)

* C-M: Male caught on the coast, U-M: Male caught on the upstream, U-F: Female caught on the upstream.
Values in parenthesis are relative contents of fatty acids to total lipids.

in length and 0.25 mm i.d., coated with Silar 5CP. The column temperature was 190°C. The detector and injector were held at 230°C. The carrier gas was H_2. Peak area percentages and retention data were obtained with a Shimadzu integrator C-R6A. Each peak on the gas chromatograms was identified as described previously.[7] The furan fatty acids (F acids) were identified on the basis of the agreement of the retention data with those of the F acids of kokanee and chum salmon identified in our laboratory.[8,9]

Results and Discussion

Lipid Contents

Table 2 shows the lipid contents of each tissue of chum salmon caught on the coast and upstream at the spawning site. The lipid contents of the skin, flesh and gonad based on the fresh weight decreased to 28%, 54% and 64% of the lipid present on the coast during the migration from seawater to freshwater, respectively. While the lipid contents of the liver and viscera was almost maintained at constant levels, it is known that the lipid depleted from the body stores during the spawning migration of salmonids are almost entirely triacylglycerols (TG).[1] Therefore, the decrease of TL in the skin and flesh may be due to the decrease of TG.

Comparing the sexes on the upstream, the lipid contents of the flesh and viscera of female were twice as much as those of male. No significant difference in lipid contents of the skin and liver between the sexes was found. The lipid content of the gonad was the highest content (11.6%) in all tissues.

Fatty Acid Compositions of TL from Some Tissues of Chum Salmon

Table 3 shows the fatty acid compositions of TL from some tissues of chum salmon. At least 100 components were detected by GLC, of which 53 components were identified as described previously.[7] The sums of 53 components were more than 95% of total fatty acids. The open-tubular GLC method of FAME could detect minor components [16:3(n-4), 18:3(n-6), 20:2(n-6), 20:3 (n-3), branched fatty acids, etc.] which could not be easily detected by the analysis using a packed column. Furthermore, the positional isomers of double bonds within fatty acids could be separated in this study.

The major components were 14:0, 16:0, 16:1 (n-7), 18:0, 18:1(n-9), 18:1(n-7), 20:1(n-11), 20:1(n-9), 20:4(n-6), 20:5(n-3), 22:1(n-11 and n-13), 22:1(n-9), 22:5(n-3) and 22:6(n-3). These components were detected at the level of 3% or more of the total fatty acids in one or in more samples. The total contents of major components were more than 85% in all samples. The fatty acid compositions of chum salmon were similar to those of masu salmon, pink salmon[10] and other salmonids.[11-15]

F Acids of TL from Some Tissues of Chum Salmon

F acid was found for the first time in the seed oil by Morris *et al.*[16], and a series of F acids was detected in some fish by Glass *et al.*[17] Table 4 shows F acid compositions of TL from some tissues of chum salmon. The F acids could not be detected in other samples except for seven samples which were shown in Table 4. It was reported that TG in testes of chum salmon have eleven F acids.[18] Only three F acids (F_4, F_5 and F_6) could be detected in TL from some tissues of chum salmon. F_6 acid (12, 15-epoxy-13, 14-dimethyleicosa-12, 14-dienoic acid) was the most predominant in all samples. The contents of F acids from some tissues of chum salmon on the upstream were greater than those on the coast.

Changes in Fatty Acid Compositions of TL from Some Tissues during Spawning Migration

The proportions of total monounsaturated fatty acids decreased in the skin and flesh and increased in the liver and viscera during the migration from seawater to freshwater. Correspondingly, the proportions of total polyunsaturated fatty acids (PUFA) increased in the former tissues and decreased in the latter tissues in this period. Based on the results of Tables 2 and 3, the individual fatty acid contents were calculated and were shown in Table 5. The skin and flesh lost 76% and 52% of total fatty acid contents present on the coast during the migration, respectively. The relative contents of 20: 1(n-11) and 22: 1(n-11 and n-13) were lower than those of other fatty acids in the skin and flesh. While the relative contents of 20: 1(n-9), 20: 1(n-7) and 22: 1(n-9) were higher than those of other fatty acids. Especially, those of 20: 1(n-7) and 22: 1(n-9) in the flesh exceeded 100%, and the contents of these fatty acids increased during the migration. The gonad lost a half of total fatty acid content. The relative contents of 20: 1(n-7) and 22: 1(n-9) were more than 100% in the gonad as well as in the flesh. Individual isomers of 20: 1 and 22: 1 showed various relative contents in these tissues. Unless monounsaturated fatty acids were distinguished between positional isomers of double bonds, the fatty acid compositions hardly changed in the skin, flesh and gonad during the migration. Ando *et al.*[4] reported the same results in flesh lipids of chum salmon. However, it has become apparent in this study that the distributions of positional isomers within 20: 1 and 22: 1 changed in the skin, flesh and gonad during the migration. The liver and viscera lost 34% and 15% of total fatty acid contents during the migration. The relative contents of C_{20} and C_{22} monounsaturated fatty acids exceeded 100%. The contents of these fatty acids increased during the migration. Consequently, fatty acid compositions in the liver and viscera changed during the migration. Beare-Rogers reported that the rate of metabolism of 22: 1(n-9) appeared to be slower than that of shorter chain fatty acids and this acid accumulated in the cardiac tissues of rats.[19] It can therefore be presumed that 20: 1(n-7) and 22: 1(n-9) are less readily metabolized than other fatty acids in the tissues of chum salmon during spawning migration as well as in the cardiac tissues of rats.

Comparison of Fatty Acid Compositions between the Sexes of Chum Salmon on the Upstream

Table 3 shows the fatty acid compositions of TL in some tissues from the male and female of chum salmon caught on the upstream. The total proportions of 20: 1 isomers in the skin and flesh of the male were almost the same as those of the female. However, the proportion of 20: 1(n-11) isomer were higher in the male and lower in the female than that of 20: 1(n-9) isomer. While both proportions of 22: 1(n-11 and n-13) isomer and 22: 1(n-9) isomer in these tissues of the male were higher than those of the female. Ota and Takagi investigated fatty acid compositions of lipid classes in the serum, liver and dorsal muscle of chum salmon, and indicated that the male triacylglycerols and free fatty acids contained more 20: 1 and 22: 1 than the female.[20] They suggested that the lipid metabolism of chum salmon was affected by their maturation and proceed with different activity during the spawning season. In the viscera and gonad, the male had higher proportion of 16: 0 and lower proportions of 16: 1(n-7) and 18: 1(n-9) than the female. Moreover, the male had higher proportion (23.60%) of 22: 5(n-3) in the viscera than the female (17.60%), and a double proportion (18.62%) of 20: 5(n-3) in the gonad as the female (7.89%). No sex difference of fatty acid composition in the liver was found. It was reported that the overall depletion of lipids in female of chum salmon during the spawning migration was greater than that in male.[4] It is konwn that total phospholipid from tissues of wild fish contains much higher and lower proportions of PUFA and monounsaturated fatty acids than TG, respectively.[1] The fatty acid composition of TL is obviously influenced by that of its constituent lipid classes. Therefore, it is inferred that the sex difference of fatty acid composition depend on the changes of lipid class composition which result from the decrease of lipids, especially of TG, during spawning migration.

Table 3. Fatty acid compositions of total lipids in some tissues of chum salmon (wt%)

No.	Fatty acid	RRT*1	Skin			Flesh			Liver			Viscera			Gonad		
			C-M*2	U-M*2	U-F*2	C-M	U-M	U-F	C-M	U-M	U-F	C-M	U-M	U-F	C-M	U-M	U-F
1	12:0	0.132	0.15	0.18	0.03	0.08	0.12	0.03	0.01	0.02	0.01	0.02	0.03	0.03	0.00	0.02	0.02
2	13:0	0.186	0.04	0.03	0.01	0.02	0.04	0.01	—	0.02	0.00	—	0.01	0.01	—	0.01	0.01
3	iso-14:0	0.222	0.03	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01
4	14:0	0.262	5.48	4.37	1.74	3.92	3.63	1.70	1.94	2.70	2.02	2.14	2.84	2.45	2.03	2.79	2.34
5	4, 8, 12-TMTD*3	0.272	0.15	0.16	0.06	0.10	0.10	0.04	0.05	0.16	0.04	0.03	0.04	0.02	0.06	0.04	0.02
6	14:1 n-7	0.283	0.04	0.03	0.03	0.02	0.02	0.02	—	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.02
7	14:1 n-5	0.297	0.03	0.04	0.02	0.01	0.03	0.02	—	—	0.01	—	0.01	0.02	0.01	0.01	0.01
8	iso-15:0	0.311	0.29	0.18	0.11	0.18	0.12	0.10	0.09	0.11	0.12	0.07	0.05	0.17	0.09	0.08	0.18
9	anteiso-15:0	0.330	0.12	0.07	0.05	0.07	0.05	0.04	0.03	0.04	0.04	0.03	0.01	0.11	0.03	0.03	0.04
10	15:0	0.366	0.37	0.30	0.28	0.34	0.28	0.22	0.48	0.38	0.36	0.51	0.49	0.35	0.45	0.44	0.32
11	iso-16:0	0.436	0.07	0.06	0.04	0.04	0.03	0.02	0.06	0.06	0.05	0.04	0.03	0.06	0.04	0.05	0.06
12	Pristanic*3	0.486	0.16	0.14	0.04	0.09	0.08	—	0.02	0.12	0.02	0.02	0.01	—	0.11	0.02	—
13	16:0	0.517	10.99	11.34	14.05	15.33	15.22	13.59	21.11	17.55	15.95	21.50	18.89	13.69	20.00	21.30	11.80
14	16:1 n-11	0.560	0.38	0.24	0.16	0.30	0.19	0.11	0.26	0.10	0.14	0.34	0.23	0.21	0.21	0.16	0.18
15	16:1 n-9	0.570	0.23	0.40	0.50	0.16	0.15	0.26	0.21	0.14	0.45	0.24	0.37	0.66	0.21	0.21	0.70
16	16:1 n-7	0.587	4.54	3.68	4.12	4.18	3.50	6.07	2.44	2.65	3.60	2.05	2.34	7.32	2.65	1.95	8.08
17	iso-17:0	0.608	0.34	0.28	0.28	0.38	0.20	0.28	0.55	0.38	0.41	0.39	0.31	0.47	0.35	0.30	0.49
18	anteiso-17:0	0.645	0.08	0.07	0.05	0.06	0.05	0.03	0.07	0.08	0.07	0.05	0.04	0.07	0.06	0.05	0.09
19	16:2 n-6	0.704	0.78	1.19	0.92	0.45	0.37	0.26	0.75	0.36	—	1.19	0.86	0.47	—	0.43	0.31
20	17:0	0.715	0.73	0.69	0.48	0.58	0.59	0.33	0.63	0.81	1.07	0.65	0.54	0.34	1.09	0.40	0.33
21	16:3 n-4	0.804	0.32	0.25	0.19	0.26	0.22	0.19	0.22	0.16	0.18	0.21	0.17	0.29	0.23	0.14	0.31
22	16:4 n-1	0.943	0.08	0.05	0.01	0.06	0.06	0.03	—	—	0.02	—	—	0.03	—	—	0.03
23	18:0	1.000	3.34	4.14	4.45	2.65	3.10	2.24	4.37	3.68	4.55	6.27	5.82	3.94	3.21	4.26	4.02
24	18:1 n-11	1.092	1.38	0.51	—	1.17	0.56	1.30	0.79	0.32	1.21	0.54	0.47	1.69	0.48	0.27	1.78
25	18:1 n-9	1.126	15.20	18.13	20.21	12.01	13.80	17.41	10.14	14.78	17.27	11.53	13.71	23.25	12.00	12.61	25.15
26	18:1 n-7	1.141	2.15	2.11	2.57	2.17	2.11	2.93	2.09	2.11	2.89	2.77	2.94	3.29	4.56	3.90	3.38
27	18:1 n-5	1.178	0.59	0.54	0.45	0.53	0.55	0.45	0.69	0.76	0.57	0.62	0.56	0.57	0.71	0.66	0.60
28	18:2 n-9	1.278	0.04	0.03	0.02	0.02	0.02	0.04	0.02	0.03	0.03	0.01	0.03	0.04	0.02	—	0.05

29	18:2 n-6	1.312	0.96	0.70	0.88	0.91	0.87	1.21	0.84	0.80	0.91	0.53	0.44	0.84	0.80	0.56	0.86
30	18:3 n-6	1.382	0.36	0.42	0.16	0.15	0.14	0.12	0.18	0.15	0.13	0.24	0.25	0.15	0.23	0.12	0.15
31	19:1 n-8	1.550	0.13	0.14	0.12	0.14	0.20	0.11	0.15	0.18	0.09	0.21	0.17	0.12	0.22	0.10	0.12
32	18:3 n-3	1.607	0.54	0.25	0.42	0.72	0.48	0.77	0.55	0.37	0.42	0.37	0.24	0.52	0.55	0.19	0.56
33	18:4 n-3	1.775	0.83	0.31	0.42	0.92	0.50	0.81	0.62	0.27	0.27	0.36	0.14	0.49	0.35	0.11	0.48
34	18:4 n-1	1.814	0.09	0.09	0.06	0.14	0.18	0.12	0.17	0.18	0.11	0.08	0.14	0.16	0.11	0.09	0.18
35	20:0	1.917	0.18	0.24	0.11	0.13	0.08	0.06	0.05	0.06	0.05	0.26	0.16	0.07	0.02	0.06	—
36	20:1 n-11	2.109	11.93	6.99	2.27	7.47	4.43	1.85	1.09	1.77	0.50	1.56	0.90	0.48	1.22	1.04	0.44
37	20:1 n-9	2.140	3.45	4.46	6.15	2.27	3.32	5.79	0.76	1.92	2.68	0.92	1.63	2.40	0.66	1.32	2.55
38	20:1 n-7	2.188	0.81	1.78	0.35	0.52	1.39	0.28	0.26	0.92	0.15	0.33	0.72	0.14	0.18	0.36	0.10
39	5, 11–20:2	2.263	0.12	0.09	0.05	0.08	0.06	0.03	0.04	0.05	0.03	0.06	0.04	—	0.03	0.03	0.02
40	20:2 n-6	2.509	0.26	0.22	0.16	0.21	0.21	0.17	0.16	0.21	0.20	0.16	0.16	0.13	0.19	0.14	0.13
41	20:4 n-6	2.927	0.69	1.49	1.78	0.52	0.66	0.59	2.61	2.52	3.83	3.78	2.80	1.33	2.65	2.75	0.54
42	20:3 n-3	3.068	0.07	0.03	0.05	0.07	0.04	0.05	0.06	0.04	0.06	0.07	0.05	0.07	0.08	0.03	0.08
43	20:4 n-3	3.373	0.75	0.50	0.78	0.77	0.68	0.99	1.02	0.81	1.41	0.63	0.66	1.56	0.59	0.40	1.76
44	20:5 n-3	3.590	4.32	5.40	6.16	7.03	9.35	6.60	12.40	13.74	10.30	8.14	6.80	8.29	19.25	18.62	7.89
45	22:1 n-11, n-13	3.985	10.13	5.09	2.86	5.83	2.97	2.35	0.89	1.52	0.53	0.97	0.61	0.31	0.52	0.85	0.27
46	22:1 n-9	4.074	2.10	4.88	0.94	1.17	3.19	0.78	0.28	1.54	0.22	0.34	0.68	0.15	0.16	0.56	0.09
47	22:1 n-7	4.158	0.19	0.22	0.06	0.09	0.12	0.04	0.04	0.06	—	0.05	0.08	—	—	—	—
48	21:5 n-3	5.059	0.16	0.11	0.11	0.13	0.12	0.13	0.13	0.11	0.11	0.09	0.11	0.19	0.09	0.22	0.24
49	22:4 n-6	5.650	0.05	0.08	0.05	—	—	0.04	0.04	0.05	0.08	0.09	0.13	—	—	—	—
50	22:5 n-6	5.948	0.27	0.22	0.19	0.25	0.25	0.20	0.38	0.33	0.23	0.30	0.27	0.14	0.20	0.20	0.10
51	22:5 n-3	6.923	2.01	3.54	3.33	2.07	3.00	3.51	3.55	6.06	5.52	2.62	5.46	3.81	2.17	3.22	4.14
52	22:6 n-3	7.329	8.09	9.45	18.06	20.20	20.59	23.90	22.63	16.01	19.06	23.86	23.60	17.60	17.32	14.00	17.50
53	24:1 n-9	7.627	0.84	1.06	0.85	0.59	0.47	0.48	0.53	0.28	0.57	0.92	0.89	0.19	0.26	0.37	0.06
Furan fatty acids			0.24	0.34	0.31	—	—	—	—	1.27	—	—	0.33	—	1.91	3.09	—
Others			2.33	2.67	2.44	2.42	1.51	1.29	3.55	1.25	1.44	1.83	1.73	1.29	1.61	1.42	1.41
Total saturated			22.52	22.27	21.79	23.99	23.70	13.70	29.46	26.18	24.77	31.98	29.27	21.79	27.55	29.86	19.73
Total monounsaturated			54.12	50.30	41.66	38.63	37.00	40.25	20.62	29.05	30.89	23.40	26.32	40.81	24.07	24.38	43.53
Total polyunsaturated			20.79	24.42	33.80	34.96	37.80	39.76	46.37	42.25	42.90	32.35	42.35	36.11	44.86	41.25	35.33

*1 Relative retention time.

*2 Abbreviations of samples are the same as shown in Table 2.

*3 TMTD: Trimethyltridecanoic acid, Pristanic: 2, 6, 10, 14-Tetramethylpentadecanoic acid.

Table 4. Furan fatty acid compositions of total lipids in some tissues of chum salmon*1

Furan fatty acid	RRT*3	Skin			Liver	Viscera	Gonad	
		C-M*4	U-M*4	U-F*4	U-M	U-M	C-M	U-M
F_4*2	3.522	—	0.04	0.03	0.29	0.05	0.39	0.48
F_5*2	4.717	—	0.06	0.09	0.12	0.05	0.29	0.23
F_6*2	5.943	0.24	0.24	0.19	0.86	0.23	1.23	2.38
Total		0.24	0.34	0.31	1.27	0.33	1.91	3.09

*1 % of total fatty acids.
*2 F_4: 12, 15-epoxy-13, 14-dimethyloctadeca-12, 14-dienoic acid.
F_5: 12, 15-epoxy-13-methyleicosa-12, 14-dienoic acid.
F_6: 12, 15-epoxy-13, 14-dimethyleicosa-12, 14-dienoic acid.
*3 Relative retention time against that of 18:0.
*4 Abbreviations of samples are the same as shown in Table 2.

Table 5. Individual fatty acid contents of total lipids in some tissues of chum salmon

Fatty acid	Skin		Flesh		Liver		Viscera		Gonad	
	C-M*	U-M*	C-M	U-M	C-M	U-M	C-M	U-M	C-M	U-M
	mg/100 g tissue									
14:0	124	24 (19)	63	28 (44)	34	35 (103)	22	24 (109)	30	21 (70)
16:0	249	63 (25)	247	118 (48)	371	229 (62)	222	165 (74)	319	160 (50)
18:0	75	23 (31)	43	24 (56)	77	48 (62)	65	51 (78)	64	32 (50)
16:1 n-7	103	20 (19)	67	27 (40)	43	35 (81)	21	20 (95)	29	15 (52)
18:1 n-11	31	3 (10)	19	4 (21)	14	4 (29)	6	4 (67)	7	2 (29)
n-9	344	100 (29)	193	107 (55)	178	193 (108)	119	120 (101)	180	95 (53)
n-7	49	12 (24)	35	16 (46)	37	27 (73)	29	26 (90)	68	29 (43)
20:1 n-11	270	39 (14)	120	34 (28)	19	23 (121)	16	8 (50)	18	8 (44)
n-9	78	25 (32)	37	26 (70)	13	25 (192)	10	14 (140)	10	10 (100)
n-7	18	10 (56)	8	11 (138)	5	12 (240)	3	6 (200)	3	3 (100)
22:1 n-11, n-13	229	28 (12)	94	23 (24)	16	20 (125)	10	5 (50)	8	6 (75)
n-9	48	27 (56)	19	25 (132)	5	20 (400)	4	6 (150)	2	4 (200)
16:2 n-6	18	7 (39)	7	3 (43)	13	5 (38)	12	8 (67)	—	3 (—)
18:2 n-6	22	4 (18)	15	7 (47)	15	10 (67)	5	4 (80)	12	4 (34)
20:4 n-6	16	8 (50)	8	5 (62)	46	33 (65)	39	25 (64)	40	21 (52)
n-3	17	3 (18)	12	5 (42)	18	11 (56)	7	6 (86)	9	3 (33)
20:5 n-3	96	30 (31)	113	73 (65)	218	179 (82)	84	60 (71)	288	140 (49)
22:5 n-3	45	20 (44)	33	2 (6)	62	79 (127)	28	48 (171)	33	24 (73)
22:6 n-3	183	52 (28)	325	160 (49)	398	209 (53)	246	207 (84)	259	105 (41)
Others	248	54 (22)	152	80 (53)	175	106 (61)	85	68 (83)	119	65 (55)
Total	2263	552 (24)	1610	778 (48)	1757	1303 (66)	1033	875 (85)	1498	750 (50)

* Abbreviations of samples are the same as shown in Table 2.
Values in parenthesis are relative contents of fatty acids present on the upstream to fatty acid contents present on the coast.

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