

Zinc in commercial marine fish from Peninsular Malaysia: Biomonitoring, health risks, and UNSDGs' connection

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Supplementary Information

TABLE S1 Purchased commercial fishes from different purchased sites and dates.

Site	Common name	Scientific name	Purchased date	Purchased site	GPS purchased site
1	Butterfish (Daun baru)	<i>Drepana punctata</i>	25/4/2023	Pasar Malam Sri Serdang, Selangor	3°01.336'; 101°70.115'
2	Yellowstripe scad (ikan selar kuning)	<i>Selaroides leptolepis</i>	1/5/2023	Segi Fresh, Batu Caves	3°24.990'; 101°66.273'
3	Gold-spotted sweetlips (Ikan kaci)	<i>Plectorhinchus flavomaculatus</i>	25/4/2023	Pasar Besar, Kuantan	2°81.431'; 102°41.265'
4	Rainbow runner (Ikan pisang-pisang)	<i>Elagatis bipinnulata</i>	28/4/2023	Lotus Hypermarket Bahau, Negeri Sembilan	2°81.431', 102°41.265'
5	Silver White Croaker (Ikan Gelama)	<i>Pennahia argentata</i>	1/5/2023	Chow Kit Road Market, KL	3°16.506', 101°69.589'
6	Threadfin sea catfish (Ikan Duri Jahan)	<i>Arius arius</i>	1/5/2023	Chow Kit Road Market, KL	3°16.506', 101°69.589'
7	Bigeye scad (Ikan Lolong Mata Besar)	<i>Selar crumenophthalmus</i>	03/05/2023	Pasar Jabi, Besut, Terengganu	5°67.652', 102°56.542'
8	Starry triggerfish (Ikan jebong)	<i>Abalistes stellaris</i>	26/4/2023	ZEMART, Seremban, Negeri Sembilan	2°72.616', 101°96.263'
9	Grouper (Ikan kerapu balong)	<i>Epinephelus tauvina</i>	03/05/2023	Pasar Kok Lanang, Ketereh, Kelantan	5°91.709', 102°24.104'
10	Fourfinger threadfin (Senangin)	<i>Eleutheronema tetradactylum</i>	25/4/2023	Pasar Awam Sungai Besar, Selangor	3°66.414', 100°98.473'
11	Barred Javelin (Ikan gerut)	<i>Pomadasys kakaan</i>	28/4/2023	Unknown	-
12	Hound Needlefish (Ikan banang)	<i>Tylosurus crocodilus</i>	26/4/2023	GIANT hypermarket, Batu Caves, Selangor	3°23.488', 101°69.162'
13	Fringescale Sardinella (Ikan Tamban Sisek)	<i>Sardinella fimbriata</i>	2 /5/2023	Pasar Borong Seri Kembangan, Selangor	2°98.477', 101°66.762'
14	Indian mackerel (kembong)	<i>Rastrelliger kanagurta</i>	27/04/2023	Kedai Runcit Tanah Puteh, Pekan, Pahang	3°53.417', 103°15.428'
15	Longtail tuna (ikan tongkol hitam)	<i>Thunnus tonggol</i>	25/4/2023	Pasar Tani Slim River, Perak	3°76.479', 101°38.128'
16	Eastern Little Tuna (Ikan tongkol putih / Aya kurik)	<i>Euthynnus affinis</i>	29/4/2023	Hassan Mart, Bandar Sungai Buaya, Rawang, Selangor	3°14.257', 101°25.351'
17	Black pomfret (bawal hitam)	<i>Parastromateus niger</i>	27/4/2023	AEON Supermarket Shah Alam, Selangor	2°99.086', 101°57.226'
18	Blackfin scad (pelata)	<i>Alepes melanoptera</i>	28/4/2023	Pasar Borong Batu Berendam, Melaka	2°25.449', 102°23.697'
19	Oxeeye Scad (Lolong Kuning)	<i>Selar boops</i>	29/4/2023	Kedai Runcit Arridzky Enterprise, Selangor	2°95.461', 101°77.636'

Site	Common name	Scientific name	Purchased date	Purchased site	GPS purchased site
20	Obtuse barracuda (ikan kacang-kacang)	<i>Sphyaena obtusata</i>	28/4/2023	Pasar Borong Selayang, Selangor	3°23.611', 101°66.655'
21	Climbing perch (ikan puyu)	<i>Anabas testudineus</i>	5/5/2023	Pasar Borong Seri Kembangan, Selangor	2°98.477', 101°66.762'
22	Hardtail scad (ikan cincaru)	<i>Megalaspis cordyla</i>	25/4/2023	S'mart Pandan Jaya Selangor	3°10.087', 101°35.886'
23	Sulphur Goatfish (Ikan Biji Nangka)	<i>Upeneus sulphureus</i>	30/4/2023	Unknown	-
24	Indo-pacific mackerel (ikan pelaling)	<i>Rastrelliger brancysoma</i>	18/4/2023	Kedai runcit rezeki mulia, Kajang	2°99.921', 101°76.921'
25	Largehead hairtail (Ikan Timah/ Selayur)	<i>Trichiurus lepturus</i>	25/04/2023	BS Freshmart frozen Temerloh, Pahang	3°44.515', 102°42.171'
26	Streaked spinefoot (Ikan dengkis)	<i>Siganus javus</i>	31/3/2023	Pasar Borong Pandan, Johor Bharu, Johor	1°52.604', 103°76.163'
27	Yellowtail scad (ikan selar)	<i>Atule mate</i>	29/4/2023	Pasar Keramat, Kuala Lumpur	3°17.132', 101°73.508'
28	Barramundi (Ikan siakap)	<i>Lates calcarifer</i>	1/5/2023	Hero Market, Damansara Damai, Selangor	3°19.178', 101°59.072'
29	Fivelined threadfin bream (Kerisi jalur lima)	<i>Nemipterus tambuloides</i>	26/4/2023	Nirwana Maju Sdn Bhd, Kuala Berang, Terengganu	2°35.369', 102°03.889'
30	Indo Pacific King Mackerel (Dengkih)	<i>Scomberomorus guttatus</i>	27/4/2023	Pasar Matang, Perak	4°81.432', 100°67.386'
31	Narrow-barred Spanish Mackerel (Ikan Tenggiri)	<i>Scomberomorus commerson</i>	27/4/2023	Pasar Matang, Perak	4°81.432', 100°67.386'
32	Longfin Trevally (Ikan Cermin)	<i>Carangoides armatus</i>	28/4/2023	TMG Mart Kuantan, Pahang	3°82.412', 103°15.944'
33	Chevron/Military barracuda	<i>Sphyaera putnamae</i>	21/4/2023	Econsave Baling, Kedah	5°65.650', 100°87.019'
34	White Sardine (ikan sardin putih)	<i>Escualosa thoracata</i>	28/4/2023	Pasar Awam Taman Kenari, Kedah	5°58.041', 100°28.312'
35	Indian threadfin (Kurau)	<i>Leptomelanosoma indicum</i>	28/4/2023	Pasar Awam Telok Panglima Garang, Selangor	2°90.330', 100°85.930'
36	Doublespotted queenfish (Ikan talang)	<i>Scomberoides lysan</i>	27/4/2023	Pasar Besar Alor Setar, Kedah	6°10.358', 99°74.079'
37	Toli Shad (terubuk)	<i>Tenualosa toli</i>	27/4/2023	Kampung Boyan Kuching, Sarawak	1°56.144', 110°35.026'
38	Diamond trevally (Rambai Ebek)	<i>Alectis indicus</i>	25/4/2023	Market Bandar Riyal, Samarahan, Sarawak	1°45.551', 110°40.863'
39	Shortfin scad (Ikan selayang)	<i>Decapterus macrosoma</i>	26/4/2023	Pasaraya Shakri Padang Luas Jerneh	5°74.024', 102°40.577'
40	Bluespot mullet (Belanak/ Kedera Tanda Biru)	<i>Valumugil seheli</i>	27/4/2023	Pasar Awam Sungai Besar, Selangor	3°66.414'; 99°76.782'

TABLE S2. Description of the purchased commercial fishes, biometric features, water content and conversion factors of dorsal muscle parts.

Niche Habitat	Scientific name	N	Range of body weight (g)	Range of length (cm)	Water content (%)	Conversion factor
Family Ariidae						
Amphidromous	<i>Arius arius</i>	3	20-40	24.5-28.9	91.34	0.087
Family Anabantidae						
Demersal Potamodromous	<i>Anabas testudineus</i>	3	7.25-26.66	15.7-17.2	71.38	0.286
Family Balastidae						
Amphidromous	<i>Abalistes stellaris</i>	3	18-25	31.0-34.0	80.00	0.200
Family Belanidae						
Reef-associated, Oceanodromous	<i>Tylosurus crocodilus</i>	3	3-5	48.3-55.9	78.80	0.212
Family Carangidae						
Reef-associated	<i>Alectis indicus</i>	3	15.4-19.9	16.0-19.0	30.61	0.694
Pelagic neritic, tropical	<i>Alepes melanoptera</i>	3	30-43	19.0-20.0	83.05	0.169
Reef associated	<i>Atule mate</i>	3	10-13	-	82.21	0.178
Reef-associated	<i>Carangoides armatus</i>	3	12-20	18.3-20.2	81.41	0.186
Reef associated	<i>Decapterus macrosoma</i>	5	10.0-11.0	19.8-22.5	73.80	0.262
Reef associated	<i>Elagatis bipinnulata</i>	3	8-12	29.0-33.3	75.62	0.244
Reef associated	<i>Megalaspis cordyla</i>	3	-	-	80.00	0.200
reef-associated; amphidromous	<i>Parastromateus niger</i>	3	17-26	19.0-28.5	77.47	0.225
Reef associated	<i>Scomberoides lysan</i>	3	-	-	80.00	0.200
Reef associated	<i>Selar boops</i>	3	10-20	20.0-25.0	89.90	0.101
Reef-associated	<i>Selar crumenophthalmus</i>	3	18-23	27.6-30.5	77.64	0.224
Reef associated	<i>Selaroides leptolepis</i>	3	6-9	14.7-16.4	80.02	0.200
Family Dorosomatidae						
Pelagic-neritic, Amphidromous	<i>Escualosa thoracata</i>	3	12-32	-	80.00	0.200
Pelagic-neritic, anadromous	<i>Tenualosia toli</i>	3	24-42	30.0-32.7	80.00	0.200
Pelagic- Neritic	<i>Sardinella fimbriata</i>	3	3.8-4.3	20.0-21.0	56.19	0.438
Family Drepaneidae						
Reef associated	<i>Drepana punctata</i>	3	30-60	17.0-18.8	91.89	0.081
Family Epinephelidae						
Oceanodromous	<i>Epinephelus tauvina</i>	3	9-22	16.5-18.5	81.30	0.187
Family Haemulidae						
reef-associated	<i>Plectorhinchus flavomaculatus</i>	3	17-25	21.0-26.0	81.56	0.184
Reef-associated	<i>Pomadasys kakaan</i>	3	18-27	29.3-32.2	78.39	0.216
Family Latidae						
Catadromous	<i>Lates calcarifer</i>	2	9-12	28.0-31.0	77.91	0.221
Family Mugillidae						
Catadromous, Reef-associated	<i>Valumugil seheli</i>	3	3-4	16.5-16.8	80.00	0.200
Family Mullidae						
Demersal, Oceanodromous	<i>Upeneus sulphureus</i>	3	-	-	91.89	0.081
Family Nemipteridae						
Demersal	<i>Nemipterus tambuloides</i>	2	10-20	23.0-26.0	83.59	0.164
Family Polynemidae						
Pelagic-neritic	<i>Eleutheronema tetradactylum</i>	3	10-12	24.1-25.3	71.25	0.287
Demersal, amphidromous	<i>Leptomelanosoma indicum</i>	3	10-23	29.4-34.2	79.82	0.202
Family Sciaemidae						

Niche Habitat	Scientific name	N	Range of body weight (g)	Range of length (cm)	Water content (%)	Conversion factor
Benthopelagic, Oceanodromous	<i>Pennahia argentata</i>	3	8-14	17.5-18.4	83.30	0.167
Family Scombridae						
Pelagic neritic, Oceanodromous	<i>Euthynnus affinis</i>	3	245-315	46.9-48.2	91.89	0.081
Pelagic-Neritic, Oceanodromous	<i>Rastrelliger brancysoma</i>	3	7-10	16.0-17.0	74.74	0.253
Pelagic neritic, Oceanodromous	<i>Rastrelliger kanagurta</i>	3	8-11	23.0-23.6	76.60	0.234
Pelagic-neritic, Oceanodromous	<i>Scomberomorus commerson</i>	3	11.3-11.7	37.4-40.5	66.13	0.339
Pelagic-neritic, oceanodromous	<i>Scomberomorus guttatus</i>	3	10.8-19.4	37.4-40.5	78.13	0.219
Pelagic neritic, Oceanodromous	<i>Thunnus tonggol</i>	3	50	26.9-29.0	80.00	0.200
Family Siganidae						
Reef associated, Oceanodromous	<i>Siganus javus</i>	2	9-12	22.0-23.8	50.88	0.491
Family Sphraemidae						
Reef associated	<i>Sphyaena obtusata</i>	3	72-102	51.0-56.0	90.57	0.094
Reef-associated	<i>Sphyaera putnamae</i>	3	46-61	41.0-43.0	80.17	0.198
Family Trichiuridae						
Benthopelagic, amphidromous	<i>Trichiurus lepturus</i>	3	23-69	80.0-93.0	76.85	0.232

TABLE S3. Values of estimated daily intake (EDI) (mg/kg bw), target hazard quotient (THQ), and estimated weekly intake (EWI) (mg/kg bw) of Zn in fishes (n=40) were calculated based on the present study.

No.	This study	DW	WW	EDI	High EDI	THQ	High THQ	EWI	High EWI	PTWI%	High PTWI %
1	<i>Abalistes stell aris</i>	82.30	16.46	38.53	7.71	0.13	0.26	269.71	539.42	0.062	0.124
2	<i>Alectis indicus</i>	63.59	12.72	20.52	41.03	0.07	0.14	143.61	287.23	0.033	0.066
3	<i>Alepes melanoptera</i>	66.72	11.31	18.24	36.48	0.06	0.12	127.67	255.34	0.029	0.059
4	<i>Anabas testudineus</i>	42.68	12.21	19.69	17.81	0.07	0.13	62.32	124.65	0.014	0.029
5	<i>Arius arius</i>	24.05	2.08	3.36	6.72	0.01	0.02	23.53	47.06	0.005	0.011
6	<i>Atule mate</i>	45.37	8.07	13.02	26.03	0.04	0.09	91.11	182.23	0.021	0.042
7	<i>Carangoides armatus</i>	28.54	5.31	8.56	17.12	0.03	0.06	59.91	119.82	0.014	0.028
8	<i>Decapterus macrosoma</i>	58.83	15.41	24.85	49.71	0.08	0.17	173.98	347.97	0.040	0.080
9	<i>Drepana punctata</i>	31.75	2.58	4.16	8.32	0.01	0.03	29.13	58.26	0.007	0.013
10	<i>Elagatis bipinnulata</i>	57.48	14.02	22.61	45.23	0.08	0.15	158.29	316.58	0.036	0.073
11	<i>Eleutheronema</i>	35.59	10.23	16.50	33.01	0.06	0.11	115.52	231.05	0.027	0.053
12	<i>Epinephelus tauvina</i>	40.25	7.53	12.15	24.29	0.04	0.08	85.02	170.03	0.020	0.039
13	<i>Escualosa thoracata</i>	52.06	10.41	16.79	33.59	0.06	0.11	117.55	235.11	0.027	0.054
14	<i>Euthynnus affinis</i>	39.68	9.18	14.81	29.61	0.05	0.10	103.65	207.29	0.024	0.048
15	<i>Lates calcarifer</i>	24.86	5.49	8.85	17.71	0.03	0.06	61.98	123.97	0.014	0.029
16	<i>Leptomelanosoma</i>	51.58	10.40	16.77	33.55	0.06	0.11	117.42	234.84	0.027	0.054
17	<i>Megalaspis cordyla</i>	46.82	9.36	15.10	10.06	0.05	0.10	35.20	70.41	0.008	0.016
18	<i>Nemipterus tambuloides</i>	63.52	10.43	16.82	33.65	0.06	0.11	117.76	235.52	0.027	0.054
19	<i>Parastrumateus niger</i>	39.53	8.91	14.37	28.74	0.05	0.10	100.60	201.19	0.023	0.046
20	<i>Pennahia argentata</i>	25.72	4.30	6.94	13.87	0.02	0.05	48.55	97.10	0.011	0.022
21	<i>Plectorhinchus</i>	27.53	5.08	8.19	16.39	0.03	0.05	57.35	114.71	0.013	0.026
22	<i>Pomadasys kakaan</i>	24.69	5.34	8.61	17.21	0.03	0.06	60.24	120.48	0.014	0.028
23	<i>Rastrelliger brancysoma</i>	35.82	8.40	13.55	27.10	0.05	0.09	94.84	189.68	0.022	0.044
24	<i>Rastrelliger kanagurta</i>	35.82	8.38	13.52	27.03	0.05	0.09	94.61	189.23	0.022	0.044
25	<i>Sardinella fimbriata</i>	84.83	37.16	59.94	119.87	0.20	0.40	419.55	839.10	0.097	0.193
26	<i>Scomberoides lysan</i>	32.46	6.49	10.47	20.94	0.03	0.07	73.30	146.59	0.017	0.034
27	<i>Scomberomorus</i>	39.18	13.27	21.40	42.81	0.07	0.14	149.82	299.65	0.035	0.069
28	<i>Scomberomorus</i>	52.87	11.56	18.65	37.29	0.06	0.12	130.52	261.03	0.030	0.060
29	<i>Selar boops</i>	54.64	5.52	8.90	28.74	0.03	0.06	100.60	201.19	0.023	0.046
30	<i>Selar</i>	46.81	10.47	16.88	33.76	0.06	0.11	118.17	236.35	0.027	0.054
31	<i>Selaroides leptolepis</i>	51.07	10.20	16.45	32.90	0.05	0.11	115.16	230.32	0.027	0.053
32	<i>Siganus javus</i>	36.29	17.83	28.76	57.52	0.10	0.19	201.31	402.61	0.046	0.093
33	<i>Sphyraera putnamae</i>	33.02	6.55	10.56	21.12	0.04	0.07	73.94	147.87	0.017	0.034
34	<i>Sphyraena obtusata</i>	33.17	3.12	5.03	36.48	0.02	0.03	127.67	255.34	0.029	0.059
35	<i>Tenualosa toli</i>	34.22	6.84	11.04	22.08	0.04	0.07	77.27	154.54	0.018	0.036
36	<i>Thunnus tonggol</i>	45.89	9.18	14.81	29.61	0.05	0.10	103.65	207.29	0.024	0.048
37	<i>Trichiurus lepturus</i>	37.46	8.67	13.98	27.97	0.05	0.09	97.89	195.77	0.023	0.045
38	<i>Tylosurus crocodilus</i>	152.66	32.37	52.21	104.42	0.17	0.35	365.47	730.94	0.084	0.168
39	<i>Upeneus sulphureus</i>	25.79	9.36	15.10	30.21	0.05	0.10	105.72	211.45	0.024	0.049
40	<i>Valumugil seheli</i>	39.52	7.90	12.75	25.50	0.04	0.08	89.24	178.48	0.021	0.041

TABLE S4. Values of estimated daily intake (EDI) (mg/kg bw), target hazard quotient (THQ), and estimated weekly intake (EWI) (mg/kg bw), Provisional tolerable weekly intake (PTWI) of Zn in the muscles and skin parts of 10 species of commercial fish purchased from Peninsular Malaysia.

Species	High EDI	High THQ	High EWI	PTWI%	High PTWI %
<i>Drepana punctata</i>	8.310	0.028	58.172	0.007	0.013404
Skin part	9.179	0.031	64.250	0.01	0.0148
<i>Selar crumenophthalmus</i>	33.762	0.113	236.337	0.0272	0.0545
Skin part	60.712	0.202	424.987	0.0490	0.0979
<i>Eleutheronema tetradactylum</i>	33.011	0.110	231.079	0.0266	0.0532
Skin part	192.559	0.642	1347.914	0.1553	0.3106
<i>Pomadasys kakaan</i>	17.207	0.057	120.448	0.0139	0.0278
Skin part	51.320	0.171	359.241	0.0414	0.0828
<i>Megalaspis cordyla</i>	30.207	0.101	211.450	0.0244	0.0487
Skin part	65.472	0.218	458.306	0.0528	0.1056
<i>Trichiurus lepturus</i>	27.972	0.093	195.802	0.0226	0.0451
Skin part	36.457	0.122	255.202	0.0294	0.0588
<i>Siganus javus</i>	57.501	0.192	402.507	0.0464	0.0927
Skin part	140.094	0.467	980.660	0.1130	0.2260
<i>Leptomelanosoma indicum</i>	33.583	0.112	235.079	0.0271	0.0542
Skin part	42.747	0.142	299.229	0.0345	0.0689
<i>Scomberoides lysan</i>	20.944	0.070	146.607	0.0169	0.0338
Skin part	90.645	0.302	634.516	0.0731	0.1462
<i>Tenualosa toli</i>	22.078	0.074	154.546	0.0178	0.0356
Skin part	53.637	0.179	375.462	0.0433	0.0865