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Research Article

Annual food consumption/biomass ratio of demersal fish resources in the Persian Gulf and Oman Sea

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Abstract

The consumption/Biomass (Q/B) ratio and aspect ratio are basic inputs to mass-balanced trophic structures that are frequently used by ECOPATH software program. Here, we listed Q/B ratio for 154 fish species of the Persian Gulf and the Gulf of Oman to contribute to mass-balanced trophic model parametrization. Samples were collected using a research vessel bottom trawl from the Persian Gulf and the Gulf of Oman (Hormozgan province) between May and December 2017. All species were classified into six ecological groups (demersal, benthopelagic, reef-associated, pelagic-neritic, pelagic-oceanic, and bathypelagic). The aspect ratio value for all species ranged from 0.59 for *Plotosus lineatus* to 5.16 for *Megalaspis cordyla*. On the other hand, the Q/B ratio varied from 3.94 for *Epinephelus coioides* to 29.47 for *Pentaprion longimanus*. The Q/B index quantifies the proportion of food consumed within the ecosystems of the Persian Gulf and Gulf of Oman, establishing a significant correlation with fish production. It serves as a fundamental parameter in ECOPATH modeling, which is essential for sustainable fishing practices and effective fisheries management.

Introduction

Advanced fishing technology has led to critical conditions to many marine ecosystems worldwide (Christensen *et al.*, 2003; Froese and Proelß, 2010; Coll *et al.*, 2013). Like other marine ecosystems, the Persian Gulf and Gulf of Oman aquatic resources may face the same difficult situation due to overfishing, loss of habitats and nursery ground, oil pollution, and temperature stress during the past three decades (Nadim *et al.,* 2008). In this case, fisheries statistics have shown a significant reduction of many commercial aquatic resources in these regions (Valinassab *et al*., 2006). Although it is a notable region in terms of biodiversity in the northwestern Indian Ocean (Randall *et al.*, 1978; Randall, 1996; Assadi and Dehghani, 1997; Carpenter *et al*., 1997), many of its ecosystems are remarkably changed due to high fishing intensity (Valinassab *et al.*, 2006) and direct anthropogenic stressors (Hamza and Munawar, 2009). Specifically, increasing the fleets and fishing efforts maintain intensive pressure on the Persian Gulf and the Gulf of Oman marine resources (Valinassab *et al.*, 2006). Also, countries around the Persian Gulf and Gulf of Oman have misreported their artisanal and industrial catches, including discards, recreational, subsistence, and illegal fishing sectors (Al-Abdulrazzak *et al*., 2015).

Ecosystem modeling operating Ecopath with Ecosim (EwE) software presents a new approach to fisheries management, sustainable fisheries, and fisheries models (Christensen and Pauly, 1992; Pauly *et al.*, 2000). These ecosystem models are used to simulate the transfer of energy and mass between and within the different trophic levels in the ecosystem based on mathematical relationships (Pauly *et al.*, 2000). To contribute to the mass balance model, much information is required from an ecosystem, aquatics and their interactions. Consumption is one of the input parameters necessary for the construction of Ecopath models, which is intake of food by a species/group over a duration of time that is usually represented on an annual basis (Christensen and Pauly, 1993). The annual food consumption/biomass ratio (Q/B ratio) has been explained as the number of times a population consumes its weight in a year (Pauly, 1986). Christensen and Pauly's study on the published Ecopath models shows an extended usage of empirically derived Q/B values in most cases (see Christensen and Pauly, 1993). Also, it is important to understand how consumption and metabolism rates scale with body mass and temperature to know if and how the body growth of large fish within populations is limited by temperature and evaluate the physiological basis of growth models (Lindmark *et al*., 2022). Such data can be utilized as input values in cases when local Q/B estimates are unavailable for the species and also for comparison intentions.

In comparison with other ecosystems, required input information for mass-balanced trophic structure modeling in the Persian Gulf and Gulf of Oman is very scarce (Tajzadeh Namin *et al*., 2020). In the present study, we aimed to estimate the Q/B ratio for 154 species divided into six main ecological groups (demersal, benthopelagic, reef-associated, pelagic-neritic, pelagic-oceanic, and bathypelagic) from the Persian Gulf and Gulf of Oman. Our results provide new insights as basic input parameters for future ecosystem-based fisheries management in this region.

Materials and methods

The study area was located in Iranian waters of the Persian Gulf and Gulf of Oman (Hormozgan province), with coordinates 25º 23′ and 28º 57′ North and 52º 41′ and 58º 00′ East (Fig. 1). Specimens were captured during two cruises using commercial bottom trawler (with headline of 72 m and 60 min of duration) with "FERDOWS-1" between October and December 2017, included sampling at 109 randomly stations over the coastal and continental shelf areas and the upper slopes from 0 to 50 m in the Persian Gulf, and from 0 to 100 m in the Gulf of Oman. The biomass of each species was estimated based on Sparre and Venema (1998). The towing distance (d) at each station was measured using the formula d=vt, where; d is the towing distance in each station in nautical miles (n. m.); v is the speed of the vessel during towing (n. m. hours^{-1}) and t towing duration (hours) at each sampling station. The swept area at each station was then estimated using the equation a = dhx, where d is towing distance (n.m.); h is headline height and x is wing spread coefficient. The catch per unit area (CPUA) for each species is given by: CPUA=C/a, where: C is a catch (kg) and a is swept area (n.m^2). Finally, the total biomass (B) for each species in the study area was estimated by using the formula B=CPUA/N*0.54A, where N is; 0.54 is the escape coefficient proposed by Sparre and Venema (1998).

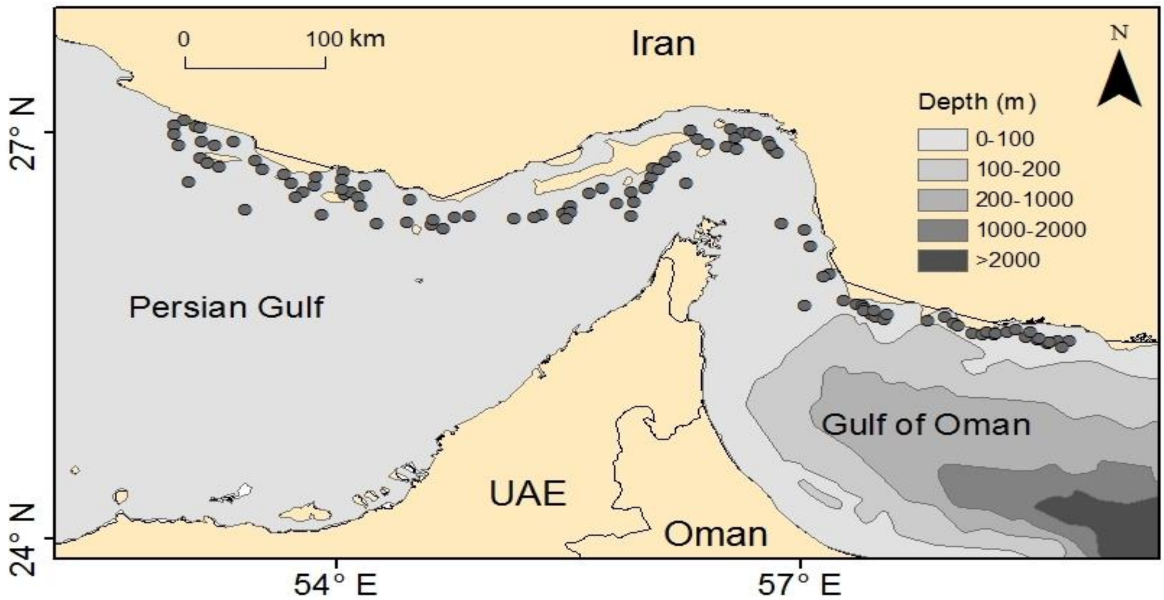

Figure 1: Map of the study area where samples were collected in the Persian Gulf and Oman Sea.

Before the towing, the water temperature was attained with conductivity, temperature, and depth profiler (CTD) in each sampling station. In addition, samples were taken from the landing areas and fishing tools (Traps, Gill nets and Set nets) that were used by traditional fishermen in order to collect the rare species. Species were identified on board based on literature (Randall *et al.*, 1978; Fischer and Bianchi, 1984; Randall, 1996; Assadi and Dehghani, 1997; Jabado *et al.*, 2017).

Many approaches exist to estimate Q/B ratio (Palomares and Pauly, 1989). In this study, the following equation was used (Christensen and Pauly, 1992):

$$Q/B = 10^{(7,9640-0,204logW_{\infty}-1,965T+0,083A+0,532h+0,398d)}$$

Where Q/B is the annual food consumption/biomass ratio of each fish population; W_{∞} is the asymptotic weight of the population (wet weight, in g); T is the mean habitat temperature for the fish population expressed as 1,000/(°C + 273.1); A is the aspect ratio of the caudal fin; and h and d are binary variables for types of food consumed (h=1, d=0 for herbivores; h=0, d=1 for detritivores; h=0, d=0 for carnivores).

The aspect ratio of the caudal fin (A) was measured in at least 50 percent of the samples from each fish species, that estimated by using the following equation: Aspect ratio = h^2/ S, where h is caudal fin height, and S is caudal fin surface area (measured using Image J software). The aspect ratio for elasmobranch species was assumed 7.0 (Optiz, 1996) and we excluded them from analyses. When the aspect ratio was not available, Pauly (1986) proposed the following formula:

$$Q/B=106.37* 0.0313(1000/T)* W_{\infty} -0.168*1.38 Pf * 1.89 hd$$

Where, W_{∞}, T and hd are as defined above; and Pf is 1 for apex and pelagic predators and zooplankton feeders, and 0 for other feeding types (Pauly, 1986).

For calculating Q/B most of the components of the equation were derived directly from field studies and in the absence of any of the components of the equation, the fish base database and library studies were used.

Results

A total of 9228 specimens included 55 families and 154 species were classified into six ecological groups: demersal (n=49), benthopelagic (n=9), reef-associated (n=77), pelagic-neritic (n=17), pelagic-oceanic (n=1) and bathypelagic (n=1). Among the demersal group, the caudal fin aspect ratio values ranged from 0.89 for *Johnius belangerii* to 4.17 for *Trachinotus mookalee*. In addition, the annul food consumption/biomass (Q/B) ratio values ranged from 4.64 for *Argyrosomus hololepidotus* to 29.47 for *Pentaprion longimanus* (Table 1). On the other hand, among benthopelagic ecological group, *Otolithes ruber* showed the lowest both caudal fin aspect ratio (0.99) and Q/B rate (6.02). Moreover, the maximum aspect ratio of caudal fin and Q/B rate were obtained for *Pampus argenteus* (4.63) and *Rhizoprionodon acutus* (18.53), respectively (Table 2).

Table 1: Estimated the annual food consumption/biomass ratio (Q/B) ratio of demersal fishes from the Persian Gulf and the Gulf of Oman (N: sample size; T: temperature; B: biomass, W_{max}: maximum weight, W_∞: infinitive weight, AR: aspect ratio of the caudal fin).

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_∞ (g)	AR	Q/B
Ariidae							
Plicofollis tenuispinis	521	28.3	3538.46	1890	2197.7	2.04	19.24
Plicofollis dussumieri	279	28.0	103.08	5120	5953.5	1.25	13.50
Netuma thalassina	311	27.5	156.02	7120	8279.1	1.32	12.79
Carangidae							
Trachinotus mookalee	9	26.8	10.07	3650	4244.2	4.17	10.11
Dasyatidae							
Maculabatis randalli	88	25.3	3796.14	5950	6918.6	7[a]	15.72
Brevitrygon walga	329	25.0	162.54	459	533.7	7[a]	26.50
Epinephelidae							
Epinephelus bleekeri	39	23.1	11.39	5430	6314.0	1.273	5.36
Epinephelus diacanthus	16	23.0	4.85	2345.78	2727.7	1.14	6.20
Epinephelus latifasciatus	9	22.9	24.77	1850	2151.2	1.41	6.85
Epinephelus epistictus	7	22.8	23.12	1450	1686.0	1.48	7.30
Gerreidae							
Pentaprion longimanus	32	24.2	60.29	23	26.7	4.36	29.47
Gerres filamentosus	23	23.7	118.88	285	331.4	2.14	11.54
Gymnuridae							
Gymnura poecilura	75	23.1	1404.827533	9550	11104.65116	7[a]	14.26
Hemiscylliidae							
Chiloscyllium arabicum	16	22.9	11.76	2940	3418.6	7[a]	18.15
Leiognathidae							
Aurigequula fasciata	258	22.7	784.55	210	244.2	1.99	11.93
Leiognathus lineolatus	326	22.6	151.66	15	17.4	2.19	21.24
Photopectoralis bindus	309	22.5	322.47	14.5	16.9	2.48	22.61
Myliobatidae							
Aetomylaeus nichofii	47	22.4	67.85	985	1145.3	7[a]	22.68
Monacanthidae							
Stephanolepis diaspros	4	22.4	1.14	425	494.2	1.56	23.80
Mullidae							
Upeneus doriae	109	22.4	1405.91	168	195.3	2.19	12.98
Muraenesocidae							
Muraenesox cinereus	16	22.4	261.00	6580	7651.2	7[a]	15.40
Narcinidae							
Narcine atzi	3	22.4	0.21	2650	3081.4	7[a]	18.53
Nemipteridae							
Nemipterus japonicas	185	22.4	2613.09	354	411.6	3.21	13.54
Nemipterus randalli	19	22.4	2.10	135	157.0	1.48	11.85
Nemipterus peronii	65	22.4	121.63	286	332.6	2.98	13.54
Paralichthyidae							
Pseudorhobus arsius	12	22.3	195.44	650	755.8	1.14	8.06
Platycphalidae							
Grammoplites scaber	62	22.3	10.45	365	424.4	1.62	9.93
Grammoplites suppositus	39	22.3	252.30	345	401.2	1.12	9.13
Polynemidae							
Polydactylus plebeius	16	22.3	1.04	359	417.4	1.98	10.68
Polydactylus sextarius	23	22.2	71.70	320	372.1	1.8	10.56
Psettodidae							
Psettodes eruemi	76	22.2	174.38	3100	3604.7	0.95	5.65
Cynoglossus arel	23	28.3	3.38	459	533.7	1.32	8.95
Rhinidae							
Rhynchobatus laevis	3	27.5	18.11	15450	17965.1	7[a]	12.94

Table 1 (continued):

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_∞ (g)	AR	Q/B
Rhynobatidae							
Glaucostegus granulatus	13	26.8	26.50	5430	6314.0	7[a]	16.01
Rhinobatos annandalei	34	25.9	109.56	2760	3209.3	7[a]	18.38
Sciaenidae							
Johnius belangerii	53	25.0	0.24	289	336.0	0.89	9.06
Pennahia anea	38	24.5	12.25	541	629.1	1.24	8.52
Argyrosomus hololepidotus	19	24.2	0.19	12580	14627.9	1.42	4.64
Protonibea diacanthus	21	23.7	80.44	13250	15407.0	1.6	4.76
Serranidae							
Epinephelus bleekeri	39	23.1	11.39	5430	6314.0	1.273	5.36
Epinephelus diacanthus	16	23.0	4.85	2345.78	2727.7	1.14	6.20
Epinephelus latifasciatus	9	22.9	24.77	1850	2151.2	1.41	6.85
Epinephelus epistictus	7	22.8	23.12	1450	1686.0	1.48	7.30
Sparidae							
Argyrops spinifer	42	22.6	754.34	4200	4883.7	2.11	6.63
Terapontidae							
Terapon jarbua	75	22.5	81.90	365	424.4	2.01	10.70
Tetraodontidae							
Lagocephalus inermis	19	22.4	34.08	3250	3779.1	1.96	6.79
Lagocephalus guentheri	13	22.4	51.16	450	523.3	2.11	10.45
Lagocephalus lunaris	9	22.4	4.28	560	651.2	0.99	8.07
Triacanthidae							
Triacanthus biaculeatus	35	22.4	5.59	255	296.5	1.11	24.24
Triglidae							
Lepidotrigla omanensis	21	22.4	0.33	134	155.8	1.54	12.00
Lepidotrigla bispinosa	9	22.4	1.22	124	144.2	1.63	12.40

[a] In general, indication of the aspect ratio of elasmobranch species from literature (Optiz, 1996).

Table 2: Estimated the Q/B ratio of benthopelagic fishes from the Persian Gulf and the Gulf of Oman (N: sample size; T: temperature; B: biomass, W_{max}: maximum weight, W_∞: infinitive weight, AR: aspect ratio of the caudal fin).

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_∞ (g)	AR	Q/B
Ariommatidae							
Ariomma indica	159	23.7	70.49	295	343.0	2.1	11.37
Carangidae							
Decapterus russelli	195	23.3	112.38	235	273.3	3.4	15.27
Carcharhinidae							
Rhizoprionodon acutus	41	23.2	74.80	2650	3081.4	7[a]	18.53
Aetobatidae							
Aetobatus ocellatus	65	23.0	43.40	4850	5639.5	7[a]	16.38
Aetobatus flagellum	11	22.9	102.00	5250	6104.7	7[a]	16.12
Myliobatidae							
Aetomylaeus milvus	32	22.7	86.93	6950	8081.4	7[a]	15.22
Sciaenidae							
Johnius borneensis	61	22.6	0.47	274	318.6	1.15	9.63
Otolithes ruber	46	22.6	336.08	2350	2732.6	0.99	6.02
Stromateidae							
Pampus argenteus	46	22.6	1176.34	1158	1346.5	4.63	13.95

[a] In general, indication of the aspect ratio of elasmobranch species from literature (Optiz, 1996).

Among reef-associated ecological group, in particular, the caudal fin aspect ratio values ranged from 0.59 for *Plotosus lineatus* to 5.16 for *Megalaspis cordyla*. In addition, Q/B ratio values varied from 3.94 for *Epinephelus coioides* to 24.43 for *Cyclichthys orbicularis* (Table 3).

Table 3: Estimated the Q/B ratio of reef-associated fishes from the Persian Gulf and the Gulf of Oman (N: sample size; T: temperature; B: biomass, W_{max}: maximum weight, W_{∞}: infinitive weight, AR: aspect ratio of the caudal fin).

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_{∞} (g)	AR	Q/B
Apogonaidae							
Ostorhinchus fasciatus	58	24.9	1.14	25	29.1	1.94	18.25
Verulux cypselurus	95	25.0	0.08	22	25.6	2.43	20.57
Carangidae							
Carangoides malabaricus	369	25.0	1881.39	560	651.2	3.87	13.99
Carangoides hedlandensis	87	25.1	18.41	1100	1279.1	3.85	12.15
Carangoides bajad	39	25.1	12.89	890	1034.9	4.35	13.95
Alepes djedaba	311	25.1	13.22	354	411.6	3.14	13.36
Atule mate	236	25.2	5.51	265	308.1	4.59	18.70
Alectis ciliaris	21	25.2	42.69	4850	5639.5	4.41	9.99
Alectis indicus	96	25.2	335.07	4760	5534.9	4.31	9.84
Megalaspis cordyla	142	25.2	382.47	1750	2034.9	5.16	14.19
Carangoides chrysophrys	135	25.2	1272.20	4590	5337.2	3.98	9.30
Ulua mentalis	68	25.2	101.15	5840	6790.7	2.97	7.30
Selar crumenophthalmus	206	25.2	3152.97	350	407.0	1.90	10.57
Uraspis helvola	41	27.7	3.66	365	424.4	3.92	15.42
Carangoides armatus	53	27.8	30.46	715	831.4	3.27	11.87
Gnathanodon speciosus	11	27.7	4.19	6350	7383.7	3.07	7.32
Selaroides leptolepis	12	28.2	4.90	125	145.3	2.48	14.57
Caranx sexfasciatus	12	28.3	19.33	5365	6238.4	4.21	9.42
Caranx ignobilis	9	28.3	49.66	6150	7151.2	3.47	7.95
Parastromateus niger	35	28.3	763.74	1450	1686.0	2.75	9.30
Seriolina nigrofasciata	1	28.3	0.85	1950	2267.4	1.97	7.55
Scomberoides commersoniannus	38	28.3	239.57	4580	5325.6	1.89	6.24
Carcharhinidae							
Carcharhinus sorrah	32	28.3	13.73	5955	6924.4	7[a]	15.71
Carcharhinus dussumieri	56	28.3	365.16	5850	6802.3	7[a]	15.77
Chaetodontidae							
Heniochus acuminatus	39	28.3	4.10	235	273.3	2.06	11.82
Dasyatidae							
Urogymnus asperrimus	1	27.9	0.40	25850	30058.1	7[a]	11.65
Himantura uarnak	11	27.7	409.76	45850	53314.0	7[a]	10.36
Pastinachus sephen	69	27.6	1795.47	6580	7651.2	7[a]	15.40
Derpaneidae							
Drepane punctata	45	27.0	1175.15	2650	3081.4	2.98	8.60
Drepane longimana	35	24.9	397.91	1100	1279.1	2.07	8.64
Diodontidae							
Cyclichthys spilostylus	6	25.0	14.56	1985	2308.1	1.32	16.60
Cyclichthys orbicularis	8	25.0	1.39	250	290.7	1.129	24.43
Ephippidae							
Ephippus orbis	39	25.1	103.33	302	351.2	2.31	11.78
Platax orbicularis	8	25.1	47.57	3950	4593.0	2.97	7.91
Engraulidae							
Encrasicholina punctifer	26	25.2	1.42	13	15.1	1.81	20.34
Fistulariidae							
Fistularia petimba	2	25.2	14.38	3580	4162.8	1.32	5.89
Gerreidae							
Gerres acinaces	16	25.2	279.91	112	130.2	2.63	15.33
Haemulidae							
Pomadasys comersonni	3	25.2	0.13	2568	2986.0	1.83	6.94
P. kaakan	193	27.7	2221.46	3750	4360.5	1.26	5.76
P. maculatum	112	27.8	7.60	235	273.3	1.53	10.68
P. stridens	97	27.7	474.22	215	250.0	1.61	11.04

Table 3 (continued):

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_∞ (g)	AR	Q/B
Plectorhinchus pictus	4	28.2	0.92	2450	2848.8	1.51	6.60
Diagramma pictum	15	28.3	148.64	5120	5953.5	0.79	4.95
Lethrinidae							
Lethrinus lentjan	13	28.3	27.92	980	1139.5	2.41	9.44
Lethrinus nebulosus	29	28.3	194.23	3256	3786.0	1.92	6.73
L.microdon	11	28.3	35.18	1650	1918.6	2.61	8.82
Lutjanidae							
Lutjanus johni	32	28.3	61.63	4859	5650.0	3.76	8.82
Lutjanus lutjanus	39	28.3	22.08	362	420.9	2.57	11.93
Lutjanus quinquelineatus	88	28.3	23.15	356	414.0	2.37	11.52
Lutjanus malabaricus	39	28.3	125.46	3985	4633.7	1.54	6.01
Lutjanus erythropterus	4	28.2	0.85	3850	4476.7	1.76	6.31
Lutjanus argentimaculatus	2	27.9	0.14	1510	1755.8	1.56	7.35
Pinjalo pinjalo	21	27.7	0.35	4350	5058.1	1.73	6.12
Menidae							
Mene maculate	21	27.5	208.00	254	295.3	4.89	19.98
Monacanthidae							
Aluterus monoceros	21	24.9	7.40	1960	2279.1	1.41	16.93
Nemipteridae							
Scolopsis vosmeri	14	25.0	9.49	165	191.9	4.11	18.80
Scolopsis ghanam	6	25.0	0.41	320	372.1	3.11	13.56
Platycphalidae							
Platycephalus indicus	49	25.1	1.40	1150	1337.2	1.87	8.24
Cociella crocodilla	2	25.1	6.08	2540	2953.5	1.35	6.35
Plotosidae							
Plotosus lineatus	29	25.2	9.80	245	284.9	0.59	8.85
Pomacanthidae							
Pomacanthus maculosus	26	25.2	1.17	895	1040.7	1.29	7.77
Rachycentridae							
Rachycentron canadum	16	25.2	70.09	29800	34651.2	3.102	5.37
Rhinidae							
Rhina ancylostoma	3	25.2	8.75	25600	29767.4	7[a]	11.67
Rhinopteridae							
Rhinoptera javanica	43	27.8	617.18	12540	14581.4	7[a]	13.50
Scorpaenidae							
Pterois russelli	16	28.2	9.41	401	466.3	1.39	9.32
Serranidae							
Epinephelus coioides	46	28.3	193.10	16530	19220.9	0.85	3.94
Epinephelus areolatus	21	28.3	5.84	450	523.3	1.57	9.43
Cephalopholis hemistiktos	19	28.3	0.84	352	409.3	1.39	9.58
Sparidae							
Rhabdosargus haffara	64	28.3	20.41	780	907.0	3.66	12.56
Acanthopagrus bifasciatus	11	28.3	12.84	1850	2151.2	1.93	7.57
Sphyraenidae							
Sphyraena putnamiae	53	28.3	810.12	4855	5645.3	2.11	4.30
Sphyraena jello	28	28.3	611.69	8450	9825.6	1.90	5.52
Synodontidae							
Saurida tumbil	77	27.9	3603.30	1350	1569.8	2.01	8.20
S. undosquamis	23	27.7	56.54	211	245.3	1.99	11.92
Tetraodontidae							
Chelonodon patoca	10	27.5	0.78	980	1139.5	1.38	7.76
Terapontidae							
Terapon theraps	65	24.9	38.48	284	330.2	1.93	11.09
Torpedinidae							
Torpedo sinuspersici	36	25.0	129.37	3850	4476.7	7[a]	17.17

[a] In general, indication of aspect ratio of elasmobranch species from literature (Optiz, 1996)

Also, among the pelagic-neritic ecological group, the caudal fin aspect ratio values ranged from 1.31 for *Thryssa malabarica* to 4.64 for *Atropus atropos*. Indeed, the Q/B ratio values ranged from 6.44 for *Elops machnata* to 17.84 for *Atropus atropos*.

Mobula kuhlii and *Acropoma japonicum* are the only species in the pelagic-oceanic and bathypelagic ecological group, respectively. The Q/B ratio values were estimated 14.18 and 17.84 for these two species, respectively (Table 4).

Table 4: Estimated the Q/B ratio of pelagic-neritic, pelagic-oceanic and bathypelagic fishes from the Persian Gulf and the Gulf of Oman (N: sample size; T: temperature; B: biomass, W_{max}: maximum weight, W_{∞}: infinitive weight, AR: aspect ratio of the caudal fin).

Family/Species	N	T (°C)	B (t)	W_{max} (g)	W_{∞} (g)	AR	Q/B
Pelagic-neritic							
Carangidae							
Atropus atropos	129	26.2	270.52	350	407.0	4.64	17.84
Clupeidae							
Nematalosa nasus	21	26.1	0.12	115	133.7	1.9	13.26
Chirocentridae							
Chirocentrus nudus	7	25.8	53.25	1100	1279.1	4.34	13.34
Dorosomatidae							
Sardinella sindensis	23	26.0	7.23	64	74.4	1.48	13.79
Anodontostoma chacunda	8	26.0	0.19	105	122.1	2.73	15.83
Elopidae							
Elops machnata	1	25.7	0.10	3520	4093.0	1.77	6.44
Engraulidae							
Thryssa mystax	109	25.7	3.06	197	229.1	2.42	13.13
Thryssa setirostris	43	25.6	0.16	168	195.3	2.32	13.30
Thryssa malabarica	91	25.6	0.92	156	181.4	1.31	11.13
Lactariidae							
Lactarius lactarius	86	25.5	119.37	358	416.3	2.13	10.99
Polynemidae							
Eleutheronema tetradactylum	7	25.5	15.41	2540	2953.5	2.34	7.67
Pristigasteridae							
Ilisha megaloptera	17	25.5	0.85	254	295.3	1.43	10.31
Ilishia compresa	42	25.5	1.55	211	245.3	2.11	12.20
Scombridae							
Scomberomorus guttatus	18	26.2	338.93	1750	2034.9	4.63	12.82
Rastrelliger kanagurta	28	26.2	207.47	395	459.3	3.99	15.37
Scomberomorus commerson	12	26.1	360.45	11500	13372.1	4.11	7.91
Sparidae							
Acanthopagrus arabicus	63	26.0	338.28	1150	1337.2	2.1	8.61
Pelagic-oceanic							
Mobulidae							
Mobula kuhlii	1	25.8	12.54	9850	11453.5	7[a]	14.18
Bathypelagic							
Acropomatidae							
Acropoma japonicum	182	25.7	1.97	29	33.7	1.98	17.84

[a] In general, indication of aspect ratio of elasmobranch species from literature (Optiz, 1996).

Discussion

Due to the rapid population growth, overexploitation, and mismanagement of fishing, ecosystem-based fisheries management has evolved a more critical role in the conservation of marine ecosystems (Hall and Mainprize, 2004; Long *et al.*, 2015). Since the Persian Gulf and the Gulf of Oman present different patterns of marine productivity and fishery activities, several studies have been documented to apply the Ecopath modeling approach, a mass-balance model integrated into the Ecopath with Ecosim software to depict the structure and functioning of this marine ecosystem (Tajzadeh-Namin *et al.*, 2020; Taghavimotlagh *et al*., 2021). However, the present study represents a significant effort to provide baseline information on trophic models in the Persian Gulf and Gulf of Oman, serving as an essential input for Ecopath modeling. In general, all the species studied here were encountered for a large proportion of the species in the sampling area (Valinassab *et al.*, 2006), suggesting it adequately sampled the diversity of sampling which covers the main trophic structure of the ecosystem in the studied area.

There is a close relationship between swimming activity and caudal fins; fish species with high swimming activity have caudal fins with higher aspect ratio values and consequently high metabolic rate (Palomares and Pauly, 1989; García and Duarte, 2002; Sawusdee *et al*., 2009). For instance, those species that showed maximum aspect ratios, like *Trachinotus mookalee*, *Pampus argenteus*, *Megalaspis cordyla*, and *Atropus atropos* have almost elongated body shapes and sharp caudal fins. All these species have a high swimming activity in their habitat to attack especially soft bottom prey. On the contrary, sedentary fish species have a relatively lower food intake and are characterized by almost rounded caudal fins with low values of aspect ratio. In this study, except *Thryssa malabarica*, all three species with low aspect ratio values have a round caudal fin, indicating that presumably do not require much energy to feed. In most cases, fish caudal fin shape is strongly related to swimming ability and metabolic needs (Giarrizzo *et al.*, 2013).

The annual food Q/B ratio varied from 3.94 for *Epinephelus coioides* to 29.47 for *Pentaprion longimanus*. In comparison, Giarrizzo *et al.* (2013) reported Q/B rate for 37 fish species collected in a micro-tidal mangrove estuary in Brazil from 2.3 for *Epinephelus itajara* to 67.3 for *Catengraulis edentulus*. These differences could be explained by species (García and Duarte, 2002), and temperature (Giarrizzo *et al.*, 2013). Furthermore, it is revealed that species with a higher proportion of plants in their diet tend to have higher estimated Q/B values (García and Duarte, 2002; Sawusdee *et al*., 2009). As can be expected, carnivorous frequently occupy the pelagic and soft bottom dwelling, as compared to herbivorous, whose representatives preferentially inhabit seagrasses, benthic algal turfs, and coral reefs.

Studies of Ecosystem-Based Fisheries Management can contribute to our understanding of the community structure of marine ecosystems (Coll *et al.*, 2013). Here, we have listed the aspect ratio and the annual food Q/B ratio that may set up basic information and contribute to mass-balanced trophic model construction for a large proportion of demersal fishes in the Persian Gulf and Gulf of Oman. By combining the Q/B ratio estimates reported here with studies of the prey composition in the fish stomachs from the Persian Gulf and Gulf of Oman and with total fish biomass by species, then integrating these studies with estimates of production and biomass at each trophic level, fisheries managers will be able to summarize the trophic structure of the Persian Gulf and Gulf of Oman ecosystem using ECOPATH model. Thus, the results of the present study may be useful in the formulation of ecological models and for supplying basic information for ecosystem-based fisheries management in the future.

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References

Al-Abdulrazzak, D., Zeller, D., Belhabib, D., Tesfamichael, D., and Pauly, D., 2015. Total marine fisheries catches in the Persian/Arabian Gulf from 1950 to 2010. *Regional Studies in Marine Science*, 2, 28-34. DOI: 10.1016/j.rsma.2015.08.003

Assadi, H. and Dehghani, R., 1997. Atlas of the Persian Gulf and the Sea of Oman fishes, Iranian Fisheries Research Organization, 226 P.

Carpenter, K.E., Krupp, F., Jones, D.A. and Zajonz, U., 1997. Living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates, Food and Agriculture Org.

Christensen, V. and Pauly, D., 1992. ECOPATH II—a software for balancing steady-state ecosystem models and calculating network characteristics. *Ecological modelling,* 61**,** 169-185. DOI: 10.1016/0304-3800(92)90016-8

Christensen, V. and Pauly, D., 1993. Trophic models of aquatic ecosystems. Manila, Philippines. 390 P.

Christensen, V., Guenette, S., Heymans, J.J., Walters, C.J., Watson, R., Zeller, D. and Pauly, D., 2003. Hundred-year decline of North Atlantic predatory fishes. *Fish and Fisheries,* 4**,** 1-24. DOI: 10.1046/j.1467-2979.2003.00103.x

Coll, M., Navarro, J. and Palomera, I., 2013. Ecological role, fishing impact, and management options for the recovery of a Mediterranean endemic skate by means of food web models. *Biological Conservation,* 157**,** 108-120. DOI: 10.1016/j.biocon.2012.06.029

Fischer, W. and Bianchi, G., 1984. FAO species identification sheets for fisheries purposes, west India Ocean. FAO. Rome, Italy.

Froese, R. and Proelß, A., 2010. Rebuilding fish stocks no later than 2015: will Europe meet the deadline?. *Fish and Fisheries,* 11**,** 194-202. DOI: 10.1111/j.1467-2979.2009.00349.x

García, C.B. and Duarte, L.O., 2002. Consumption to biomass (Q/B) ratio and estimates of Q/B-predictor parameters for Caribbean fishes. *Fishbyte,* 25**,** 19-31

Giarrizzo, T., Ferraz, D. and Isaac, V., 2013. Estimates of annual food consumption/biomass ratio (Q/B) from the fish fauna of a mangrove estuary in North Brazil. *Biota Amazônia*, 3(**2**), 149-154

Hall, S.J. and Mainprize, B., 2004. Towards ecosystem-based fisheries management. *Fish and Fisheries,* 5(**1**), 1-20. DOI: 10.1111/j.1467-2960.2004.00133.x

Hamza, W. and Munawar, M., 2009. Protecting and managing the Arabian Gulf: past, present and future. *Aquatic Ecosystem Health & Management,* 12**,** 429-439. DOI: 10.1080/14634980903361580

Jabado, R.W., Kyne, P.M., Pollom, R.A., Ebert, D.A., Simpfendorfer, C.A., Ralph, G.M. and Dulvy, N.K., 2017. The Conservation Status of Sharks, Rays, and Chimaeras in the Arabian Sea and Adjacent Waters, Vancouver, Canada, Environment Agency – Abu Dhabi, UAE and IUCN Species Survival Commission Shark Specialist Group.

Lindmark, M., Audzijonyte, A., Blanchard, J.L., and Gårdmark, A., 2022. Temperature impacts on fish physiology and resource abundance lead to faster growth but smaller fish sizes and yields under warming. *Global Change Biology*, 28(**21**), 6239-6253. DOI: 10.1111/gcb.16341

Long, R.D., Charles, A. and Stephenson, R.L., 2015. Key principles of marine ecosystem-based management. *Marine Policy*, 57**,** 53-60. DOI: 10.1016/j.marpol.2015.01.013

Nadim, F., Bagtzoglou, A.C., and Iranmahboob, J., 2008. Coastal management in the Persian Gulf region within the framework of the ROPME programme of action. *Ocean & Coastal Management*, 51(7), 556-565. DOI: 10.1016/j.ocecoaman.2008.04.007

Optiz, S., 1996. Trophic interactions in Caribbean coral reefs. ICLARM Technical Report, 43**,** 341 P.

Palomares, M. and Pauly, D., 1989. A multiple regression model for prediction the food consumption of marine fish populations. *Marine and Freshwater Research*, 40**,** 259-273. DOI: 10.1071/MF9890259

Pauly, D., 1986. A simple method for estimating the food consumption of fish populations from growth data and food conversion experiments. *Fishery Bulletin*, 84**,** 827-840

Pauly, D., Christensen, V. and Walters, C., 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES journal of Marine Science*, 57**,** 697-706. DOI: 10.1006/jmsc.2000.0726

Randall, J.E., Allen, G.R. and Smith-Vaniz, W.F., 1978. Illustrated identification guide to commercial fishes, FAO.

Randall, J.E. 1996. Coastal fishes of Oman. University of Hawaii Press, USA. 432 P.

Sawusdee, A., Jutagate, T., Chaidee, T.T., Thongkhoa, S. and Chotipuntu, P., 2009. Fish in the Pak Panang River and Bay in Relation to the Anti-Salt Dam Operation, Part II: Trophic Model. *Agriculture and Natural Resources*, 43(**5**), 107-119.

Sparre, P. and Venema, S.C., 1998. Introduction to tropical fish stock assessment, FAO, 422 P.

Taghavimotlagh, S.A., Vahabnezhad, A., and Shojaei, M.G., 2021. A trophic model of the coastal fisheries ecosystem of the northern Persian Gulf using a mass balance Ecopath model. *Regional Studies in Marine Science*, 42, 101639. DOI: 10.1016/j.rsma.2021.101639

Tajzadeh-Namin, M., Valinassab, T., Ramezani Fard, E. and Ehteshami, F., 2020. Trophic dynamics analysis and ecosystem structure for some fish species of northern Oman Sea. *Iranian Journal of Fisheries Sciences*, 19(**6**), 2804-2823. DOI:10.22092/ijfs.2020.122699

Valinassab, T., Daryanabard, R., Dehghani, R. and Pierce, G., 2006. Abundance of demersal fish resources in the Persian Gulf and Oman Sea. *Journal of the Marine Biological Association of the United Kingdom*, 86**,** 1455-1462. DOI: 10.1017/S0025315406014512.