Journal of Aquatic Biology & Fisheries Vol. 1(1 & 2) 2013 : 106-116

PROXIMATE COMPOSITION OF FISH IN THE TRAWL BY-CATCH AND DISCARDS OF KERALA, SOUTH-WEST COAST OF INDIA

Bijukumar, A., [1*] Deepthi, G.R.[2] and K.G. Padmakumaran Nair[3]

[1]Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, Kerala, India

[2]Department of Zoology, Bishop Moore College, Kerala, India

[3]Department of Biochemistry, N.S.S. College, Pandalam, Kerala, India

[*]Email: abiju@rediffmail.com

Abstract: Fish, rich in protein and other essential nutrients, makes an essential contribution in meeting the nutritional security of human populace. Colossal amounts of fish landed as bycatch of trawlers in developing countries could be better utilized for making a host of value added products for human consumption. The protein, carbohydrates, total lipids, ash and moisture contents of 62 species of fish classified under 10 orders and 34 families collected from the trawl bycatch and discards of Kerala, south-west coast of India were estimated. The meat samples collected were analysed using standard protocols and statistical tests were performed using Statistical Package for Social Sciences (SPSS) using Analysis of variance, Duncan's Multiple Range Test and Student's t- test. The highest value of protein content (g %) was recorded in sawtooth barracuda, *Sphyraena putnamae* Jordan & Seale (26.61) and the lowest in dark- shouldered snake eel, *Ophichthus cephalozona* (Bleeker) (7.49). The protein content in various fish families ranged from 7.49 (Ophichthyidae) to 26.61 (Sphyraenidae). The protein content in fish orders varied from 12.64 in Gasterosteiformes to 18.94 in Aulopiformes. Significant variations were observed in the biochemical constituents of different fish species, families and orders could be due to the variations in their biology and phylogeny. The high protein and mineral content in majority of fish groups examined indicate that the larger diversity of fish fauna in the trawl bycatch and discards of Kerala coast could be used as a nutritious food and for the production of various value-added products.

Key words: Trawl fishery, value-added products, protein, carbohydrates, total Lipids, biochemical constituents

INTRODUCTION

The depletion of fishery resources from the oceans around the world, coupled with growing malnutrition in developing countries, underscore the need for better utilization of available fishery resources as human food. One of the major challenges facing the mangers of modern multi-species marine fisheries is the problem of by-catch of incidental species taken along with target species of commercial importance. The trawl fishing, particularly shrimp trawling in tropical waters, produces colossal amounts of by-catch (Bijukumar and Deepthi, 2006); in India major part of the by-catch is brought back to the fishing harbours because of economic considerations, and the low-value by-catch is used primarily for the production of fish meal and manure. With the increase in multi-day trawling, larger part of the by-catch is discarded back to the sea (discards). Tropical shrimp fisheries have high rate of discards, contributing to over 21 per cent of total discards (FAO, 2004).

Discards of trawlers from the east coast of India is estimated as 100,000 tonnes per year (Gordon, 1991), and from Kerala coast during 2000-'01 and 2001-'02 as 2.62 and 2.25 lakh tonnes respectively (Kurup *et al.,* 2003). A series of recent studies initiated by the Ocean and Atmospheric Sciences and Technology Cell (OASTC) of Ministry of Earth Sciences, Government of India, involving various fishery research institutions of India also reported higher amounts of discards and impacts of bottom trawling (Meenakumari *et al.,* 2008). Discarding, particularly from the shrimp trawlers in tropical waters, represents not only losses in economic opportunities for using such items in the production of fish byproducts, but also denies protein for human consumption in malnourished countries (Borges *et al.,* 2001; Bijukumar and Deepthi, 2006).

Though there are reports on proximate composition of some of the most common fish and shellfish species in the trawl bycatch of Indian waters (Devadoss, 1984; Gopakumar, 1997a, b, 2002; Gopakumar and Nair, 1980; Nair and Suseela Mathew, 2000; Ravichandran *et al.,* 2011; Sagar *et al*., 2012), reports are scarce on the biochemical constituents of discards, including young ones of commercially valuable species. This paper documents the biochemical constituents of 62 species of fish collected from the trawl bycatch and discards of Kerala coast.

MATERIALS AND METHODS

Sixty two species of fish classified under 10 orders and 34 families were collected from the by-catch and discards of shrimp trawlers operating from Neendakara and Sakthikulangara fishing harbours of Kerala State for the analysis of proximate composition. Identification of fish fauna of trawl by-catch was done following Fischer and Bianchi (1984), Talwar and Kracker (1984), Smith and Heemstra (1986) and Fish Base (Froese and Pauly, 2007).

The samples collected were cleaned, measured for their length and weight, wrapped in separate polythene bags, brought to the laboratory in ice boxes and kept in deep freezers. The tissue (body meat) extraction for the analysis was completed on the day of collection. Protein content of tissue samples was estimated by the Folin-Phenol reagent method (Lowry *et al.,* 1951). Total lipids were extracted following the methods of Folch and Stanley (1957). The total carbohydrate, moisture, and ash contents of fish and shellfish meat were estimated using the methods of AOAC (2000).

Data were analyzed using computer software, Statistical Package for Social Sciences (SPSS) version 11. Data are expressed in its mean and standard deviation. Analysis of variance (One Way ANOVA) was performed as parametric test to compare between each species with in each family as well as between family/orders. Duncan's Multiple Range (DMR) Test was also performed as post hoc analysis to delineate difference between each species. Student's t- test was employed for the comparisons, wherever there were only two species or groups for comparison. For all statistical evaluations, a two-tailed probability value, <0.05 was considered significant.

RESULTS AND DISCUSSION

The biochemical constituents in the flesh of fish fauna in the bycatch and discards of shrimp trawlers is given in Table 1.

Among the 62 species of fishes examined the highest value of protein content (g %) was recorded in sawtooth barracuda, *Sphyraena putnamae* Jordan & Seale (26.61) and the lowest in dark- shouldered snake eel, *Ophichthus cephalozona* (Bleeker) (7.49). The protein content of fishes in the trawl bycatch and discards of Kerala coast, in general, is in corroboration with earlier reports from Indian waters (Devadoss, 1984; Gopakumar, 1997b; Nair and Suseela Mathew, 2000). Further, the general observation is that the protein content of juveniles of commercially important species analysed during the present study was almost in comparison with the protein content in adult fishes. This shows that a larger diversity of fish fauna in the trawl bycatch of Kerala, could be better used as a proteinaceous food.

Carbohydrate content recorded was highest in *Arius tenuispinis* Day and in *Gerres oblongus* Cuvier (0.32) and lowest in *Gymnothorax reticularis* Bloch (0.03). The carbohydrate content would not exceed one percent of the body tissues of in elasmobranchs (Devadoss, 1984) and bony fishes as well (Huss, 1995; Sivakumar *et al.,* 1994). Since carbohydrate content is generally low in fish and its contribution to the energetic value is practically zero (Payne *et al.,* 1999; Anthony *et al.,* 2000).

In species such as *Thryssa vitrirostris* (5.7), *Gymnothorax reticularis* (4.55), *Ariosoma anago* (Temminck & Schlegel) (4.2) and *Saurida undosquamis* (Richardson) (4.15), the lipid content recorded highest values. Lipid content was lowest in *Mene maculata* (0.75). Quantitatively fat is the third major constituent in fish muscle. Gopakumar (1997b) and Nair and Suseela Mathew (2000) reported that the lipid contents in different fishes of Kerala varies between 0.5 to 20g%. The variations in lipid content may be due to the influence of feeding habits, season, adaptation, temperature, age, sex and stage of spawning.

Table 1. Proximate composition (g%) of fish fauna associated with trawl by-catch and discards of Kerala coast

Sl. No.	Species	Length (cm) Mean ± SD	Moisture Mean ± SD	Protein Mean ± SD	Lipid Mean ± SD	Ash Mean ± SD	Carbohydrate Mean ± SD
1	Order : Orectolobiformes Family : Hemiscylliidae *Chiloscyllium griseum*	19.8 ± 2.57	79.56 ± 2.61	14.36± 1.28	1.4 ± 0.42	2.34 ± 0.42	0.04 ± 0.01
2	*Chiloscyllium indicum*	41.1 ± 6.89	79.54 ± 4.06	24.08± 1.71	2.23 ± 0.6	2.23 ± 0.6	0.06 ± 0.01
3	Order: Carcharhiniformes Family: Carcharhinidae *Scoliodon laticaudus*	17.92 ± 3.37	71 ± 2.45	11.62± 1.09	3.1 ± 0.57	3.1 ± 0.57	0.18 ± 0.02
4	Family: Rhinobatidae *Rhinobatos obtuses*	35.92 ± 5.11	74 ± 3.81	19.69± 1.38	4.67 ± 0.7	4.67 ± 0.7	0.27 ± 0.02
5	*Rhinobatos granulatus*	27 ± 8.63	63.35 ± 1.71	25.61± 2.34	4.5 ± 0.86	4.5 ± 0.86	0.13 ± 0.01
6	Order: Anguilliformes Family: Muraenidae *Gymnothorax reticularis*	31.96 ± 4.06	64.8 ± 3.83	11.04± 1.09	4.77 ± 0.66	4.77 ± 0.66	0.03 ± 0.01
7	*Strophidon sathete*	62.18 ± 8.35	77.4 ± 2.41	7.49 ± 0.9	4.15 ± 0.6	4.15 ± 0.6	0.1 ± 0.01
8	Family: Ophichthydae *Ophichthus cephalozona*	29.46 ± 2.95	84.2 ±1.48	19.1 ± 1.2	2.33 ± 0.38	2.33 ± 0.38	0.26 ± 0.05
9	Family: Congridae *Ariosoma anago*	34.42 ± 0.56	67.5 ± 1.7	9.9 ± 1.45	3.19 ± 0.82	3.19 ± 0.82	0.12 ± 0.01
10	*Conger cinereus*	43.1 ± 0.82	78 ± 2.35	24.08± 1.71	4.38 ± 0.84	4.38 ± 0.84	0.11 ± 0.01
11	*Uroconger lepturus*	31.04 ± 1.25	76.7 ± 1.2	15.82± 1.05	1.8 ± 0.57	1.72 ± 0.71	0.08 ± 0.01
12	Family: Muraenesocidae *Muraenosox bagio*	41.16 ± 0.9	78.2 ± 2.59	16.48± 1.38	0.95 ± 0.37	3.98 ± 1.83	0.16 ± 0.02
13	Order: Clupeiformes Family: Engraulidae *Stolephorus devisi*	6.28 ± 0.74	76.56 ± 1.79	13.36 ± 0.5	3.6 ± 0.65	6.05 ± 0.77	0.11 ± 0.01
14	*Thryssa vitrirostris*	10.04 ± 0.69	71.2 ± 1.92	12.51± 1.69	5.7 ± 1.04	1.9 ± 0.81	0.06 ± 0.02

	Family: Clupeidae						
15	*Dussumieria acuta*	13.14 ± 0.87	78.65 ± 1.52	12.5 ± 1.67	2.2 ± 0.57	4.67 ± 0.53	0.18 ± 0.01
16	*Ilisha megaloptera*	7.44 ± 0.48	72.6 ± 1.14	14.35± 1.85	2.6 ± 0.65	5.2 ± 1.14	0.12 ± 0.01
17	*Opisthopterus tardoore*	10.86 ± 1.15	66.58 ± 1.78	25.75± 2.32	2.2 ± 0.57	5.18 ± 1	0.21 ± 0.01
	Order: Siluriformes Family: Ariidae						
18	*Arius tenuispinis*	22.32 ± 0.61	72.7 ± 0.99	18.49 ± 1	1.1 ± 0.29	5.69 ± 0.45	0.32 ± 0.01
	Family : Plotosidae						
19	*Plotosus canius*	15.94 ± 0.3	69.23 ± 1.66	16.95± 0.67	1.15 ± 0.22	4.96 ± 0.12	0.17 ± 0.03
	Order: Aulopiformes Family: Synodontidae						
20	*Saurida undosquamis*	17.5 ± 1.63	68.5 ± 0.88	18.94± 1.14	4.15 ± 0.6	7.98 ± 0.37	0.07 ± 0.03
	Order: Gasterosteiformes Family : Fistulariidae						
21	*Fistularia petimba*	36.42 ± 1.4	72.5 ± 0.79	12.64± 1.14	1.65 ± 0.49	3.8 ± 0.92	0.11 ± 0.02
	Order: Scorpaeniformes Family: Platycephalidae						
22	*Suggrundus rodericensis*	8.66 ± 0.97	67.3 ± 0.45	26.54± 1.53	1.4 ± 0.42	3.74 ± 0.3	0.21 ± 0.02
23	*Grammoplites scaber*	11.2 ± 0.92	80.9 ± 1.04	12.22± 1.14	1.05 ± 0.45	2.66 ± 0.78	0.15 ± 0.01
24	*Grammoplites suppositus*	14.8 ± 0.72	76.15 ± 1.29	13.26± 1.05	1.65 ± 0.72	3.82 ± 0.41	0.23 ± 0.02
	Order: Perciformes Family : Priacanthidae						
25	*Priacanthus hamrur*	8.06 ± 2.32	76.72 ± 1.15	9.16 ± 1.3	2.6 ± 0.65	6.01 ± 0.36	0.12 ± 0.01
	Family: Apogonidae						
26	*Apogon septemstriatus*	7.86 ± 1.12	76.35 ± 0.96	19.38± 0.92	1.05 ± 0.37	2.95 ± 0.65	0.05 ± 0.01
	Family: Echeneidae						
27	*Echeneis naucratus*	29.4 ± 9.7	74.75 ± 0.94	13.03± 1.75	2.3 ± 0.6	2.75 ± 0.51	0.25 ± 0.04
	Family: Rachycentridae						
28	*Rachycentron canadum*	14.7 ± 2.98	70.9 ± 1.21	18.91± 0.49	1.1 ± 0.58	2.81 ± 0.46	0.09 ± 0.01
	Family: Carangidae						
29	*Alectis ciliaris*	11.96 ± 0.88	76.4 ± 0.42	14.01± 0.74	1.4 ± 0.42	4.86 ± 0.36	0.06 ± 0.01
30	*Decapterus russelli*	14.38 ± 0.49	73.4 ± 0.42	13.62± 1.36	2.5 ± 0.35	3.75 ± 0.53	0.08 ± 0.01
	Family: Menidae						
31	*Mene maculata*	13.9 ± 0.69	71.1 ± 0.76	19.01± 0.56	0.75 ± 0.25	8 ± 0.62	0.28 ± 0.01
	Family: Leiognathidae						
32	*Leiognathus bindus*	4.92 ± 0.19	69.85 ± 1.27	15.96± 1.98	2.9 ± 0.68	3.81 ± 0.49	0.16 ± 0.02
33	*Leiognathus blochii*	4.6 ± 0.48	71.4 ± 0.42	13.03± 0.58	3.05 ± 0.27	6.08 ± 0.47	0.14 ± 0.03
34	*Leiognathus splendens*	6.38 ± 0.66	71.8 ± 1.26	15.61± 1.68	1.05 ± 0.37	3.13 ± 0.59	0.15 ± 0.03
35	*Secutor insidiator*	5.6 ± 0.48	75.7 ± 0.74	14.83± 0.48	2.1 ± 0.29	2.49 ± 0.42	0.1 ± 0
36	*Secutor ruconius*	5.73 ± 0.87	78.6 ± 1.29	17 ± 0.49	1.3 ± 0.33	2.24 ± 0.39	0.13 ± 0.02
	Family: Gerreidae						
37	*Gerres oblongus*	5.02 ± 0.79	65.9 ± 0.42	18.02± 0.34	2.84 ± 0.42	4.05 ± 0.06	0.32 ± 0.03
38	*Gerres setifer*	7.18 ± 1.81	79.6 ± 0.65	9.99 ± 4.54	1.4 ± 0.42	4.91 ± 0.82	0.2 ± 0.01
	Family: Haemulidae						
39	*Pomadasys maculatum*	12.34 ± 1.73	75.45 ± 0.97	10.61± 0.59	2.75 ± 0.25	4.17 ± 0.41	0.17 ± 0.01

	Family: Sciaenidae						
40	*Johnius belangerii*	14.68 ± 1.71	75.9 ± 2.46	15.83± 1.83	2.5 ± 0.35	1.85 ± 0.38	0.18 ± 0.06
41	*Otolithes cuvieri*	12.22 ± 1.22	72.95 ± 0.8	19.69± 1.94	1.35 ± 0.34	2.18 ± 0.43	0.04 ± 0.01
42	*Upeneus bensasi*	11.56 ± 0.85	70.45 ± 0.45	15.15 ± 2.3	1.25 ± 0.25	3.7 ± 0.45	0.14 ± 0.01
	Family: Mullidae						
43	*Upeneus vittatus*	8.62 ± 0.84	73.6 ± 2.61	12.48± 0.59	0.8 ± 0.45	4.12 ± 0.43	0.05 ± 0
	Family: Teraponidae						
44	*Terapon jarbua*	12.2 ± 1.15	68.66 ± 1.24	19.94± 0.57	1.75 ± 0.35	2 ± 0.29	0.05 ± 0.01
	Family: Pinguipedidae						
45	*Parapercis punctata*	12.66 ± 1.07	60.8 ± 0.91	25.44 ± 0.6	0.8 ± 0.45	6.03 ± 0.2	0.21 ± 0.01
	Family : Uranoscopidae						
46	*Uranoscopus guttatus*	13.07 ± 1.73	77.6 ± 0.65	13.31± 1.04	2.8 ± 0.27	3.91 ± 0.5	0.12 ± 0.02
	Family: Callionymidae						
47	*Callionymus saggita*	7.9 ± 1.46	80.5 ± 0.71	15.85± 0.83	0.8 ± 0.27	1.82 ± 0.47	0.1 ± 0.01
	Family: Gobiidae						
48	*Trypauchen vagina*	9.86 ± 2.21	65.6 ± 1.52	21.68± 1.11	3 ± 0.5	3.74 ± 0.4	0.16 ± 0
	Family: Sphyraenidae						
49	*Sphyraena putnamae*	20.06 ± 1.67	70.6 ± 0.42	26.61± 1.48	0.7 ± 0.27	1.45 ± 0.18	0.1 ± 0.01
	Order: Pleuronectiformes						
	Family: Bothidae						
50	*Bothus myriaster*	10.64 ± 0.98	68.6 ± 2.7	19.67 ± 0.7	2.16 ± 0.23	5.95 ± 0.65	0.1 ± 0.01
51	*Chascanopsetta lugubris*	16 ± 3.87	70.8 ± 2.08	19.82± 1.45	2.8 ± 0.57	5.95 ± 0.69	0.08 ± 0.01
52	*Laeops natalensis*	7.46 ± 2.11	68.6 ± 2.7	9.35 ± 0.76	1 ± 0.35	6.64 ± 0.54	0.08 ± 0.01
53	*Pseudorhombus arsius*	11.62 ± 0.94	70.8 ± 2.08	15.91± 0.73	0.9 ± 0.42	2.68 ± 0.54	0.17 ± 0.01
54	*Pseudorhombus elevatus*	10.2 ± 0.88	79.8 ± 0.57	22.58± 1.18	2.4 ± 0.42	4.9 ± 0.58	0.06 ± 0.01
	Family: Soleidae						
55	*Aesopia cornuta*	11.62 ± 2.51	80.1 ± 0.89	11.74± 2.78	1.3 ± 0.45	7.68 ± 0.39	0.16 ± 0.01
56	*Brachirus annularis*	9.4 ± 1.49	68.4 ± 0.42	24.2 ± 3.21	3.4 ± 0.42	8.68 ± 0.37	0.06 ± 0.01
57	*Synaptura albomaculata*	14.8 ± 0.82	74.7 ± 0.67	16.08± 0.57	1.9 ± 0.42	3.79 ± 0.53	0.12 ± 0.01
58	*Synaptura commersoniana*	12.88 ± 2.12	62.7 ± 0.76	17.9 ± 0.58	1.7 ± 0.27	4.16 ± 0.35	0.06 ± 0
59	*Zebrias synapturoides*	11.68 ± 2.55	74.3 ± 0.45	11.89 ± 1.2	2.2 ± 0.27	4.93 ± 0.22	0.07 ± 0.02
	Family: Cynoglossidae						
60	*Cynoglossus lida*	10.93 ± 1.13	72.9 ± 0.42	20.43 ± .76	2.5 ± 0	5.75 ± 0.58	0.23 ± 0.04
61	*Cynoglossus macrostomus*	9.38 ± 0.77	77.1 ± 0.42	13.12± 0.72	2.2 ± 0.45	6.83 ± 0.38	0.21 ± 0.03
62	*Cynoglossus puncticeps*	11.15 ± 1.04	71 ± 0.61	16.98± 0.75	3.6 ± 0.42	3.82 ± 0.47	0.07 ± 0.01
	F value	89.555**	38.289**	53.284**	24.612**	39.313**	71.847**

Table 2. Proximate composition (g%) of various fish families associated with trawl by-catch and discards of Kerala coast

Sl. No.	Family	Moisture Mean ± SD	Protein Mean ± SD	Lipid Mean ± SD	Ash Mean ± SD	Carbohydrate Mean ± SD
1	Hemiscylliidae	$78.20^{cdefg} \pm 3.33$	$12.82^{bcde} \pm 1.94$	$1.20^{abcdef} \pm 0.42$	$2.29^{abcd} \pm 0.49$	$0.05^{ab} \pm 0.01$
2	Carcharhinidae	$71.00^{efghi} \pm 2.45$	$24.08^{klm} \pm 1.71$	$0.78^{abc} \pm 0.23$	$3.10b^{cdefghi} \pm 0.57$	$0.18^{ghi} \pm 0.02$
3	Rhinobatidae	$72.68^{bcde} \pm 6.27$	$15.65^{defghi} \pm 4.41$	$1.70^{bcdefgh} \pm 1.14$	$4.59^{ijklmno} \pm 0.75$	$0.20^{hi} \pm 0.08$
4	Muraenidae	$72.10^{cdefgh} \pm 4.15$	$18.33^{fghij} \pm 7.87$	$3.88^{l} \pm 0.99$	$4.46^{hijklmn} \pm 0.68$	$0.06^{abc} \pm 0.04$
5	Ophichthydae	$82.70^{hijk} \pm 1.48$	$7.49^{a} \pm 0.90$	$2.10^{fghijk} \pm 0.42$	$2.33^{abcde} \pm 0.38$	$0.26^{k} \pm 0.05$
6	Congridae	$74.73^{cdefg} \pm 4.27$	$14.94^{cdefghi} \pm 4.11$	$2.90^{jk} \pm 1.15$	$3.10^{bcdefghi} \pm 1.34$	$0.10^{bcd} \pm 0.02$
7	Muraenosocidae	$78.20^{kl} \pm 2.59$	$16.48^{defghi} \pm 1.38$	$0.95^{abcd} \pm 0.37$	$3.98^{fghijk} \pm 1.83$	$0.16^{fghi} \pm 0.02$
8	Engraulidae	$72.70^{cdefg} \pm 1.83$	$12.93^{bcde} \pm 1.26$	$4.65^{l} \pm 1.38$	$3.98^{fghijk} \pm 2.31$	$0.08^{abcd} \pm 0.03$
9	Clupeidae	$72.80^{efghi} \pm 4.05$	$17.53^{defghij} \pm 6.33$	$2.33^{ghijk} \pm 0.59$	$5.02^{jklmno} \pm 0.89$	$0.17^{ghi} \pm 0.04$
10	Ariidae	$72.70^{efghi} \pm 0.99$	$18.49^{ghij} \pm 1.00$	$1.10^{abcde} \pm 0.29$	$5.69^{mno} \pm 0.45$	$0.32^{l} \pm 0.01$
11	Plotosidae	$72.23^{bcdef} \pm 1.66$	$16.95^{defghij} \pm 0.67$	$1.15^{abcdef} \pm 0.22$	$4.96^{jklmno} \pm 0.12$	$0.17^{ghi} \pm 0.03$
12	Synodontidae	$74.50^{ghij} \pm 0.88$	$18.94^{hij} \pm 1.14$	$4.15^{l} \pm 0.60$	$7.98^{p} \pm 0.37$	$0.07^{abc} \pm 0.03$
13	Fistulariidae	$76.50^{defghi} \pm 0.79$	$12.64^{bcd} \pm 1.14$	$1.65^{abcdefgh} \pm 0.49$	$3.80^{efghijk} \pm 0.92$	$0.11^{cde} \pm 0.02$
14	Platycephalidae	$74.45^{ghij} \pm 5.12$	$17.34^{defghij} \pm 6.85$	$1.37^{abcdefg} \pm 0.57$	3.41cdefghi ± 0.74	$0.20^{hi} \pm 0.04$
15	Priacanthidae	$76.72^{ijkl} \pm 1.15$	$9.16^{ab} \pm 1.30$	$2.60^{hijk} \pm 0.65$	$6.01^{o} \pm 0.36$	$0.12^{cdef} \pm 0.01$
16	Apogonidae	$76.35^{hijk} \pm 0.96$	$19.38^{ij} \pm 0.92$	$1.05^{abcde} \pm 0.37$	$2.95^{bcdefgh} \pm 0.65$	$0.05^{a} \pm 0.01$
17	Echeneidae	$75.82^{bc} \pm 0.94$	$13.03^{bcde} \pm 1.75$	$2.30^{ghijk} \pm 0.60$	2.75abcdef ± 0.51	$0.25^{jk} \pm 0.04$
18	Rachycentridae	$71.90^{cdefg} \pm 1.21$	$18.91^{hij} \pm 0.49$	$1.10^{abcde} \pm 0.58$	$2.81^{abcdefg} \pm 0.46$	$0.09^{abcd} \pm 0.01$

19	Carangidae	$74.80^{cdefg} \pm 2.14$	$13.82^{bcdefg} \pm 1.05$	$1.95^{efghij} \pm 0.69$	$4.31^{ghijklm} \pm 0.72$	$0.07^{abc} \pm 0.02$
20	Menidae	$71.20^{cdefgh} \pm 0.76$	$19.01^{hij} \pm 0.56$	$0.75^{ab} \pm 0.25$	$8.00^{p} \pm 0.62$	$0.28^{kl} \pm 0.01$
21	Leiognathidae	$74.10^{ghij} \pm 4.07$	$15.29^{cdefghi} \pm 1.76$	$2.08^{fghijk} \pm 0.91$	$3.55^{defghij} \pm 1.47$	$0.14^{defg} \pm 0.03$
22	Gerridae	$75.10^{bcd} \pm 2.53$	$14.01^{cdefgh} \pm 5.21$	$2.12^{fghijk} \pm 0.86$	$4.48^{ijklmn} \pm 0.71$	$0.26^{jk} \pm 0.07$
23	Haemulidae	$77.45^{cdefg} \pm 0.97$	$10.61^{abc} \pm 0.59$	$2.75^{ijk} \pm 0.25$	$4.17^{fghijkl} \pm 0.41$	$0.17^{ghi} \pm 0.01$
24	Sciaenidae	$74.43^{ghij} \pm 2.32$	$17.76^{efghij} \pm 2.70$	$1.93^{efghi} \pm 0.69$	$2.02^{abc} \pm 0.42$	$0.11^{cdef} \pm 0.08$
25	Mullidae	$76.03^{cdefgh} \pm 2.42$	$13.82^{bcdefg} \pm 2.12$	$1.03^{abcde} \pm 0.42$	$3.91^{fghijk} \pm 0.47$	$0.10^{abcd} \pm 0.05$
26	Teraponidae	$72.66^{bcde} \pm 1.24$	$19.94^{ijk} \pm 0.57$	$1.75^{cdefgh} \pm 0.35$	$2.00^{abc} \pm 0.29$	$0.05^{ab} \pm 0.01$
27	Pinguipedidae	$63.80^{a} \pm 0.91$	$25.44^{lm} \pm 0.60$	$0.80^{abc} \pm 0.45$	$6.03^{o} \pm 0.20$	$0.21^{ij} \pm 0.01$
28	Uranoscopidae	$77.60^{jkl} \pm 0.65$	$13.31^{bcdef} \pm 1.04$	$2.80^{ijk} \pm 0.27$	$3.91^{fghijk} \pm 0.50$	$0.12^{cdef} \pm 0.02$
29	Callionymidae	$80.50^{l} \pm 0.71$	$15.85^{defghi} \pm 0.83$	$0.80^{abc} \pm 0.27$	$1.82^{ab} \pm 0.47$	$0.10^{abcd} \pm 0.01$
30	Gobiidae	$65.60^{b} \pm 1.52$	$21.68^{jkl} \pm 1.11$	$3.00^{k} \pm 0.50$	$3.74^{defghijk} \pm 0.40$	$0.16^{efgh} \pm 0.00$
31	Sphyraenidae	$70.60^{l} \pm 0.42$	$26.61^{m} \pm 1.48$	$0.70^{a} \pm 0.27$	$1.45^{a} \pm 0.18$	$0.10^{abcd} \pm 0.01$
32	Bothidae	$73.34^{fghi} \pm 4.08$	$17.47^{defghij} \pm 4.76$	$1.85^{defghi} \pm 0.87$	$5.22^{klmno} \pm 1.52$	$0.10^{abcd} \pm 0.04$
33	Soleidae	$70.74^{bcde} \pm 4.52$	$16.36^{defghi} \pm 5.03$	$2.10^{fghijk} \pm 0.80$	$5.85^{no} \pm 2.04$	$0.09^{abcd} \pm 0.04$
34	Cynoglossidae	$73.53^{fghij} \pm 1.11$	$16.84^{defghi} \pm 3.17$	$2.77^{ijk} \pm 0.70$	$5.47^{lmno} \pm 1.36$	$0.17^{ghi} \pm 0.08$
	F value	8.995**	6.651**	13.208**	13.039**	21.328**

** $P < 0.01$

a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p - Means with same superscript do not differ each other (Duncan's Multiple Range Test)

Table 3. Proximate composition (g%) of various fish orders associated with trawl by-catch and discards of Kerala coast

Sl. No.	Order	Moisture Mean ± SD	Protein Mean ± SD	Lipid Mean ± SD	Ash Mean ± SD	Carbohydrate Mean ± SD
1	Orectolobiformes	78.60^{ab} ± 3.33	12.82^{a} ± 1.94	1.20^{a} ± 0.42	2.29^{a} ± 0.49	0.05^{a} ± 0.01
2	Carcharhiniformes	70.92^{a} ± 5.60	18.46^{b} ± 5.50	1.39^{ab} ± 1.03	4.09^{bc} ± 0.99	0.20^{d} ± 0.06
3	Anguilliformes	73.54^{ab} ± 4.57	15.06^{ab} ± 5.96	2.79^{cd} ± 1.33	3.50^{ab} ± 1.36	0.12^{bc} ± 0.07
4	Clupeiformes	72.36^{ab} ± 3.34	15.69^{ab} ± 5.41	3.26^{d} ± 1.50	4.60^{bcd} ± 1.66	0.14^{c} ± 0.06
5	Siluriformes	70.97^{ab} ± 2.24	17.72^{b} ± 1.14	1.13^{a} ± 0.24	5.33^{cd} ± 0.49	0.25^{d} ± 0.08
6	Aulopiformes	68.50^{b} ± 0.88	18.94^{b} ± 1.14	4.15^{e} ± 0.60	7.98^{e} ± 0.37	0.07^{ab} ± 0.03
7	Gasterosteiformes	76.50^{ab} ± 0.79	12.64^{a} ± 1.14	1.65^{ab} ± 0.49	3.80^{b} ± 0.92	0.11^{bc} ± 0.02
8	Scorpaeniformes	74.45^{b} ± 5.12	17.34^{b} ± 6.85	1.37^{ab} ± 0.57	3.41^{ab} ± 0.74	0.20^{d} ± 0.04
9	Perciformes	72.83^{ab} ± 4.93	16.33^{ab} ± 4.49	1.79^{ab} ± 0.91	3.71^{b} ± 1.63	0.14^{c} ± 0.07
10	Pleuronectiformes	71.62^{ab} ± 4.41	16.90^{ab} ± 4.52	2.16^{bc} ± 0.87	5.52^{d} ± 1.70	0.11^{bc} ± 0.06
	Total	72.29 ± 4.58	16.32 ± 4.85	2.06 ± 1.15	4.22 ± 1.77	0.14 ± 0.07
	F value	1.512	2.020*	13.459**	14.594**	9.483**

* P < 0.05; ** P < 0.01
a,b,c,d,e - Means with same superscript do not differ each other (Duncan's multiple range test)

The ash content in fishes varied 1.45 g% in *Sphyraena putnamae* to 8.68 g% in *Brachirus annularis* Fowler. The mean moisture content was maximum in *Ophichthus cephalozona* (84.20) and minimum in *Parapercis punctata* (Cuvier) (60.80). Gopakumar (1997b) reported 60-80% of moisture content in marine fishes of Indian coast, and the present study also recorded similar values. The results of one-way ANOVA showed that the variations in biochemical constituents in various fish species were statistically significant (Table 1).

The values of biochemical constituents (g %) of 34 fish families in the trawl bycatch of Kerala coast are given in Table 2. Among the fish families examined, protein content ranged from 7.49 in Ophichthyidae to 26.61 in Sphyraenidae. The protein content was more than 10 g% in all the fish families in the trawl bycatch except in Ophichthyidae (7.49) and Priacanthidae (9.16).

The carbohydrate content recorded its highest value (0.32) in Ariidae and lowest (0.05) in Hemiscyllidae, Apogonidae and Teraponidae. The maximum value of total lipid content was recorded for Engraulidae (4.65) and minimum for Sphyraenidae (0.7). The ash content recorded higher values in Menidae (8.0), Synodontidae (7.98), Pinguipedidae (6.03) and Priacanthidae (6.01); it was lowest in Sphyraenidae (1.45). The moisture content in different fish families ranged from a minimum value of 63.80 in Pinguipedidae to 82.70 in Ophichthydae. The biochemical constituents in various fish families registered significant variations and a general pattern of similarity was not evident from the results of Duncan's multiple range test (Table 2).

The values of biochemical constituents (g %) of selected 10 fish orders in the trawl bycatch and discards is given in Table 3. In general, protein content was higher in all the fish orders studied and it varied between 12.64 (Gasterosteiformes) and 18.94 (Aulopiformes).

Carbohydrate content was highest (0.25) in Siluriformes and lowest (0.05) in Orectolobiformes. Highest lipid values were recorded in Pleuronectiformes (2.16), Anguilliformes (2.79), Cluepeiformes (3.26) and Aulopiformes (4.15) and the lowest in the order Siluriformes (1.13). The mean value of ash content was maximum (7.98) in Aulopiformes and minimum in Orectolobiformes (2.29). Ash content registered higher values in orders such as Carcharhiniformes (4.09), Clupeiformes (4.6), Siluriformes (5.35) and Pleuronectiformes (5.52). The moisture content was more than 70 percent in all the fish orders except in Aulopiformes (68.50). But for the moisture content, the variations of biochemical constituents recorded significant variations between various fish orders (Table 3).

For marine organisms, body composition in fish is variable with respect to species, geographical location, time of year, size, maturity condition, sex, and feeding regime or ecological habits (Lawson *et al.,* 1998; Saadettin *et al.,* 1998). Some authors have found a reduction of the protein component during the spawning season (Ando and Hatano, 1986). Reinitz *et al.* (1979) consider that the nutritional composition of food is the most important factor affecting the proximal composition of fish. These reasons could explain the variations in protein content in various species of fish in the trawl bycatch and discards. Significant variations in biochemical constituents of different fish families/orders recorded during the present study could be due to their different phylogeny.

The analysis of biochemical constituents of fish in the bycatch and discards recorded higher content of proteins in their muscles and hence they were suitable for the preparation fish by-products. Despite the smaller size ranges of specimens available in the trawl bycatch and discards, the protein content of 25 fish species was in the trawl bycatch found to be more than 15% and that of 10 species was more than 20% in the present study, indicating possibilities of maximally utilizing the trawl bycatch, including the juveniles of commercially valuable species, as a valuable nutritional source.

Commercially valuable fish orders such as Carcharhiniformes (ground sharks), Siluriformes (sea catfishes) and Pleuronectiformes (flatfishes) in trawl by-catch, though represented mainly by smaller-sized specimens, could be better utilized as protein rich food and for developing byproducts. Fish orders such as Aulopiformes and Scorpaeniformes, which are unappealing in their appearance, but rich in protein, could be converted into value-added products. Since some of the members of Scorpaeniformes are toxic, this could be attempted only after thorough toxicity studies.

A variety of speciality products such as fish paste, fish sausages, fish pappads, fish wafers, fish spirals, fish save, fish diamond cuts, fish jam, fish noodles are produced from fish. All species in the bycatch can be utilized for the production of fish hydrolysates (Gopakumar, 2002; Gopakumar and Nair, 1980). While in the West almost all the bycatch are discarded, in countries like India bycatch is brought back to the landing centers because of its economic utilities. The Code of Conduct for Responsible Fisheries calls on states to "encourage those involved in fish processing, distribution and marketing to improve the use of bycatch to the extent that is consistent with responsible fisheries management practices" (FAO, 1995).

In countries like India, where the per capita protein availability is below the recommended level, the proper utilization of bycatch from trawlers is important, as it is found to be a good source of protein and minerals (Zynudheen *et al.,* 2004). Since the 'appearance' of many fish species in the trawl bycatch and discards is not flattering for consumers, production of value-added products from the bycatch should be given priority. The high protein and mineral content in majority of fish groups in the trawl bycatch and discards of Kerala coast warrants their better utilization as human food rather than as animal feed and manure.

ACKNOWLEDGEMENT

Authors acknowledges the financial support of Kerala State Council for Science, Technology and Environment for the project.

REFERENCES

Ando, S. and Hatano, M. 1986. Biochemical characteristics of chum salmon muscle during spawning migration. *Bull. Jpn. Soc. Sci. Fish.,* 52: 229–234.

Anthony, J.A., Roby D.D. and Turco, K.R. 2000. Lipid content and energy density of forage fishes from the northern Gulf of Alaska. *J. Exp. Mar. Biol.* Ecol., 248: 53–78.

AOAC 2000. *Official Methods of Analysis, 17th edn*. Association of Official Analytical Chemists, Washington, DC, USA.

Biju Kumar, A. and Deepthi, G.R. 2006. Trawling and by-catch: Implications on marine ecosystem. *Curr. Sci.,* 90: 922-931.

Borges, T.C., Erzini, K., Bentes, L., Costa, M.E., Gonclaves, J.M.S., Lino, P.G., Pais, C. and Ribeiro, J. 2001. By-catch and discarding practices in five Algarve (Southern Portugal) metiers. *J. Applied Ichthyol.,* 17: 104-114.

Devadoss, P. 1984. Nutritive values of sharks, skates and rays from Porto Novo Coast. *Indian J. Fish.,* 31: 156-161.

FAO, 1995. Code of conduct for Responsible Fisheries, Food and Agriculture Organization, Rome, 41 pp.

FAO, 2004. The State of World Fisheries and Aquaculture. Food and Agriculture Organisation, Rome, 153pp.

Fischer, W. and Bianchi, G. 1984. FAO Species Identification Sheets for Fishery Purposes. Western Indian Ocean (Fishing Area 51). FAO, Rome.

Folch, J., Lees, M. and Stanley, S. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.,* 226: 497-506.

Froese, R. and Pauly, D. (Eds.) 2007. Fish Base. World Wide Web electronic publication.www.fishbase.org, version (09/2007).

Gordon, A. 1991. The by-catch from Indian shrimp trawlers in the Bay of Bengal: the potential for its improved utilization. BOBP/WP/68, p 27, Bay of Bengal Programme, Madras, India.

Gopakumar, K. 1997a. *Tropical Fishery Products.* Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, 190pp.

Gopakumar, K. (Ed.). 1997b. *Biochemical Composition of Indian Food Fish.* Central Institute of Fisheries Technology, Cochin, 44pp.

Gopakumar, K. 2002. *Text Book of Fish Processing Technology.* Indian Council of Agricultural Research, New Delhi, 491pp.

Gopakumar, K. and Nair, M.R. 1980. Development of fish products from low priced fish. *J. mar. boil. ass. India,* 22: 45-49.

Huss, H.H. 1995. Quality and quality changes in fresh fish. FAO Fish. Tech. Pap. 348,

Kurup, B.M., Premlal, P., Thomas, J.V. and Anand, V. 2003. Bottom trawl discards along Kerala coast: A case study. *J. mar. boil. ass. India,* 45: 99-107.

Lawson, J.W., Magalhães, A.M. and Miller, E.H. 1998. Important prey species of marine vertebrate predators in the northwest Atlantic: proximate composition and energy density. *Mar. Ecol. Prog. Ser.*, 164: 13–20.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randel, R.J. 1951. Protein measurement with Folin phenol reagent. *J. Biol. Chem.,* 193: 265-275.

Meenakumari, B., Usha Bhagirathan and Pravin, P. 2008. Impact of bottom trawling on benthic communities: A review. *Fish. Technol.,* 45: 1-22.

Nair, P.G.V. and Mathew, S. 2000. *Biochemical composition of fish and shellfish.* Central Institute of Fisheries Technology, Technology Advisory Series, Cochin, India.

Payne, S.A., Johnson, B.A. and Otto, R.S. 1999. Proximate composition of some north-eastern Pacific forage fish species. *Fish Oceanogr.,* 8: 159–177.

Ravichandran, S., Kumaravel, K. and Pamela Florence, E. 2011. Nutritive composition of some edible fishes. *Int. J. Zool. Res.,* 7: 241-251.

Reinitz, G.L., Onne, L.E. and Hitzel, F.N. 1979. Variations of body composition and growth among strains of rainbow trout *(Salmo gairdneri). Trans. Am. Fish. Soc.,* 108: 204–207.

Saadettin, G., Dincer, B., Alemdag, N., Colak, A. and Tufekci, M. 1998. Proximate composition an selected mineral content of commercially important fish species from the Black Sea. *J. Sci. Food Agric.,* 78: 337-342.

Sagar, S., Pratap, N. and Raju, P. 2012. Quantification and nutritional value of bycatch of Ratnagiri coast, Maharashtra, India. *AJBB Online,* 1(1): e108.

Sivakumar, R., Manickasundaram, M., Sivakumaran and Ramraiyan, V. 1994. Biochemical composition of some commercial fishes from Parangippettai waters. *J. mar. biol. ass. India,* 36: 106-109.

Smith, M.M. and Heemstra, P.C. 1986. *Smith's Sea Fishes,* Springer-Verlag, Berlin, 1047pp.

Talwar, P.K and Kacker, R.K. 1984. *Commercial Sea Fishes of India.* Zoological Survey of India, Calcutta, 997pp.

Zynudheen, A. A., Ninan, G., Sen, A. and Badonia, R. 2004. Utilization of by-catch in Gujarat (India). Naga, *ICLARM Quart.,* 27: 20-23.