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Full Length Research Paper

Species composition and depth variation of cutlassfish (*Trichiurus lepturus* L. 1785) trawl bycatch in the fishing grounds of Bushehr waters, Persian Gulf

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Cutlassfish trawl fisheries have been used in the Persian Gulf, but very little information about species composition of the large rates of bycatch caught in this region is available. The data on total species composition of 40 hauls from vessels operating off the fishing grounds of Persian Gulf was collected from May 1st 2009 to 10th August 2010. From the estimated 952.3 tonnes of bycatch taken annually in the fishing grounds of cutlassfish, 39 species from 32 families were obtained which include: 30 teleost species with 88.3% of the total biomass (841.4 t) from the main composition of the catches and followed by 7 elasmobranchs with 8.3% (79.7 t) and 2 invertebrate with 3.3% (31.2 t) of the biomass. With 554.3 tonnes (58.2% of the total biomass), the major species in trawl bycatches were *Nemipterus japonicas* (234.1 t), *Saurida tumbil (*229.5) and *Ilisha melastoma* (90.5%). There was a significant difference in the total bycatch taken (biomass and number) from different depths. Some mean catch rates of the abundant species differed significantly between seasons which displayed dial differences in their catch values. This study provided the first comprehensive study of the species composition of cutlassfish trawl in fishing grounds of Bushehr waters in the Persian Gulf. The examination of the bycatch indicates the large impact on stocking density of commercial and non-commercial species in this region; which with respect to decline in stocking density of demersal fishes of Persian Gulf in recent years, has caused increasing concerns. The data collected in this study can be used in the quantitative assessments of fisheries pressure on bycatch stocks in the Persian Gulf.

Key words: Cutlassfish, Bushehr, bycatch, depth variation, trawl, Persian Gulf.

INTRODUCTION

The value of bycatch produced by different fishery depends on the type of gear used, and trawl fisheries usually produce the most overall value of bycatch biomass (Eayrs, 2007; Kelleher, 2005). Worldwide, 27 million tonnes of trawl bycatch are discarded each year (Alverson et al., 1994). Another common problem of bycatch is their high variability in space and time (Andrew and Pepperell, 1992; Alverson et al., 1994; Kennelly, 1995; Rochet et al., 2002). Non target species that have a commercial value (incidental catch) and unwanted species that are not valuable and poured back to sea (discard) are important challenge in fisheries with greatly diverse communities, such as tropical trawl fisheries (Walmsley et al., 2007; Bellido et al., 2011).

The waters of the Persian Gulf are environmentally unique with an unusual faunal assemblage (Carpenter et al., 1997; Valinassab et al., 2006). A review of fishery statistics shows a trend of increasing fishing effort in the Persian Gulf during the last years (Valinassab et al., 2006). Trawl fishing is very common fishing method in the Persian Gulf. Iranian fisheries organization for primary management strategy has imposed restrictions on fishing; for instance, limiting the number of trawlers, restrictions on fishing gears and spatial and temporal restrictions. Also, bottom fish trawling was previously

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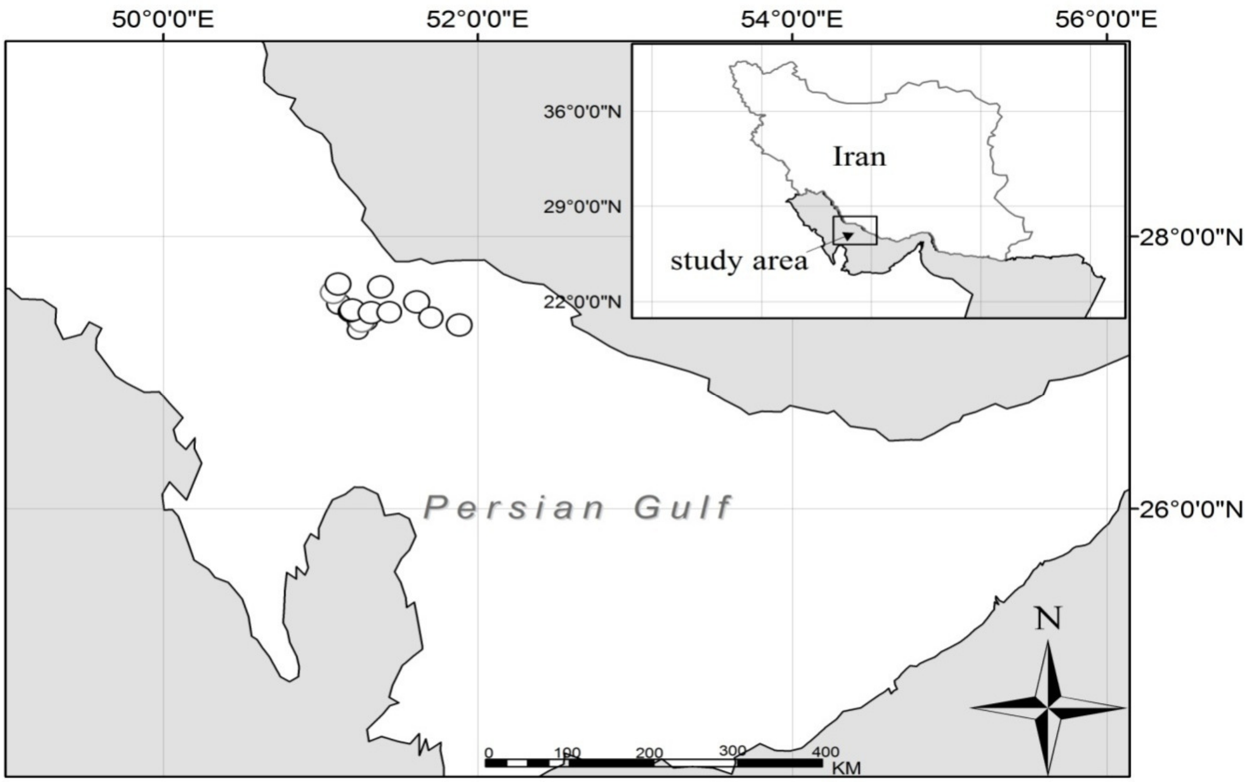

Figure 1. Location of study and sampling positions in Bushehr waters, Persian Gulf. Circles showed sampling study area.

used, but in the present time is banned (Nia-Meimandi and Khorshidian, 1993). The Iranian trawl fishery in the Persian Gulf can be divided to, demersal shrimp trawling for catching prawn, and cutlassfish trawl fisheries for catching cutlassfish, *Trichiurus lepturus* (Nia-Meimandi and Khorshidian, 1993). *T. lepturus* is fished in sub and tropical waters around the world (Nakamura and Parin, 1993) and its nominal worldwide catches in 2009 reached 134,591,1 t (FAO, 2009).

Poor data on bycatch rates can lead to biased estimates of fishing effort and can give ascend to inaccurate estimates of stock status (Walmsley et al., 2007). The cutlassfish trawl fisheries have been used since 2005 in fishing grounds of Iranian waters of the Persian Gulf. However, very little information about bycatch levels of cutlassfish trawling exists; whereas cutlassfish trawl is a non-selective fishing method and produces incidental catches and discards. Fishing seasons of *T. lepturus* in fishing grounds of Bushehr is (May to August), spring and summer seasons. Several studies had been conducted to identify and quantify prawn trawl bycatch in the Persian Gulf, but about cutlassfish trawl no study has been done (Mohammad et al., 1989; Yimin et al., 1999; Paighambari et al., 2001). This article therefore presents the first quantitative data on species composition; proportion of incidental catches and discards to the total of estimated catches of trawlers operating in the fishing grounds of Bushehr waters, in the Persian Gulf. Also, this article aims to determine the best depth where lowest bycatch exist relative to target species and identify weight and numerical value species to the total bycatch, and finally, based on these data, discuss implications for fisheries management.

MATERIALS AND METHODS

Collection of data

Data were collected by scientific observers that were sent on board of commercial operating vessels in the fishing grounds of *T. lepturus* in Bushehr province (SW of the Persian Gulf) between May 1st 2009 to August 2010. 18 samples from spring season (May to mid-June) and 22 samples from summer season (July to late August) were collected. The study area extended from 50° to 52°E and 27° to 28° (Figure 1). Depth of fishing, catch level and hauling duration were recorded on board. All commercial vessels were equipped with a trawl with a 36 m head rope and a 75 mm mesh size stretched in the cod end and 90 to 200 mm mesh size in the panel. The trawl was kept at about 2.5 m from the seabed during the towing. Trawl duration ranged from 1.5 to 4 h (mean 3.26 ± 0.14) at speed of about 3 knots and were operated in depths between 41 and 69 m.

After each haul, the total catches were emptied on the deck and bycatches were separated from the target species. Target species were spilled to trays and were sorted, weighed and counted. Total bycatch species on the deck were identified to the lowest taxonomic level using morphometric and meristic characteristics. Total Bycatch from each trawl were separated into 3 groups: 1- commercially valuable species (incidental catch), 2- small discarded species and 3- large discarded species. Incidental catch species were counted and weighed by a balance with 10 g accuracy. To determine the proportion of the discarded catch, after counting at least 20% of discarded small species, they were spilled into the basket and weighed and then total bycatch were calculated accordingly (Walmsley et al., 2007). Large discarded species, for instance, sharks and rays were counted and weighed individually and their proportion bycatch to target species was estimated. Also, to compare the mean of total bycatch among different depths, sampling zone were divided into 3 depths, 40 to 50, 50 to 60 and 60 to 70 m, and towing depth was recorded for each haul.

Data analysis

To calculate the annual bycatch from fishing grounds of cutlassfish, the hourly catch value obtained from this study was combined with total fishing effort. The data was collected from commercial fishing effort of Iranian fisheries organization during 2009 and 2010.

In order to determine the proportion of bycatch (discarded species and commercially valuable species,) the total catch, numerical and weight value of each species to the total bycatch were calculated and analyzed by SPSS software. Two-factor analysis of variance (ANOVA) was used to assess the mean differences between catch biomass, number of the total bycatch and five most abundant bycatch species between seasons and depths. Kolmogorov-Smirnov and Levene tests were used to analyze normality of the data and homogeneity of variances, respectively (Zar, 1999). To compare the means, Duncan's new multiple range test was used. For normality data and homogeneity variance, data were transformed by $\log_{10}^{(x+1)}$ wherever it was necessary.

RESULTS

Among 39 species of 32 families identified in this study, with 30 species belong to teleosts, 7 species belong to elasmobranchs and 2 species belong to invertebrate (Table 1). The total weight and number of bycatch estimated were 97.24 kg h^{-1} and 492.43 n h^{-1}, respectively. The proportion of total bycatch biomass to total cutlassfish biomass was estimated at 27.23 to 72.77%, while the total number of bycatch to total number of cutlassfish was estimated at 37.52 to 62.48%. The discard with 11.5% and incidental catch with 26.02% constituted total number of bycatch (Figure 2). The contribution of small discarded species which had commercial value, large discarded species (mainly elasmobranches) and small discarded species with no commercial value in the total bycatch was 10.5, 56.42 and 33.07% for bycatch by weight, and 7.38, 90.2 and 2.41% for bycatch by number, respectively.

The proportion of invertebrates, elasmobranchs and teleosts to the total bycatch weight were 3.28, 8.37 and 88.35%, respectively. Also, teleosts with 95.65, elasmobranchs with 1.53 and invertebrate with 2.82% constituted the total bycatch individual (Figure 3). Four species of teleosts occurring in more than 90% of trawls and one species of invertebrates and elasmobranchs occurred in more than 80% of trawls (Table 1). The highest proportion by weight and number to the total bycatch belonged to *N. japonicus* with 28.98 and 24.86%, respectively. *Carcharhinus dussumieri* with 2.84% of the total bycatch biomass and 34% by weight of the elasmobranchs component occurred as the highest biomass of the elasmobranchs bycatch. Numerically, *Dasyatis bennetti*, with 0.59% of the total bycatch and 38.54% of the elasmobranchs components formed the highest number to the elasmobranchs bycatch (Table 2).

Depth trends

The significant of mean catch values of the total bycatch biomass per trawl were between depths, with highest biomass bycatch ($F = 10.41$; $P < 0.01$) and highest bycatch number ($F = 43.16$; $P < 0.01$) in depths of 40 to 50 m (Figure 4). Also, the mean number of species differed significantly between depths with lower number in depth of 40 to 50 m ($F= 9.64$; $p < 0.01$). The mean bycatch by weight and number did not differ significantly between depths of 50 to 60 and 60 to 70 m ($P > 0.05$) (Figure 4). Of the 5 most abundant bycatch species, four species had significant difference in the mean catch rates (biomass and number) with higher catch in 40 to 50 m depth. *Saurida tumbil* had significantly different mean bycatch by number and mean bycatch by weight between 60 to 70 m depth with 40 to 50 and 50 to 60 m depth, and there was no significant difference in mean of total bycatch for 40 to 50 m depth in comparison with 50 to 60 m for this species (Figure 5).

Seasonal trends

Mean bycatch values of biomass ($F = 0.295$; $p > 0.05$) and number ($F = 1.631$; $P > 0.05$) of each trawl did not differ significantly between seasons. Mean number species also did not differ significantly between seasons (summer and spring) ($F = 0.385$ $P > 0.05$), (Figure 6). However, there was a significant difference by number in the mean catch rates of 2 species of the 5 most abundant species. In case of biomass, this was true for only one species of the five most abundant species. The highest catch by weight and by number in spring belonged to *S. tumbil*, while the highest catch by number in summer belonged to *D. Bennetti* (Table 3).

Diel trends

There was a significant difference in the mean catch rates of depths in combination with season ($F = 4.43$; $P < 0.05$) for biomass and ($F = 4.627$; $P < 0.05$) for number (Table 3, and Figure 4). Nevertheless, there was no significant difference in the mean number of species of

Table 1. Percentage occurrence and mean biomass and number catch rates of bycatch (incidental catch+ discard) species.

Bycatch group	Species	family	% occurrence (n=40)	Mean weight (kg h^{-1}) ± (S.E.)	Mean number (nh^{-1}) ± (S.E.)
Teleosts	*Ilisha melastoma*	Clupeidae	93	9.51 ± 4.8	92.4 ± 44.8
	*Trichiurus lepturus**	Trichiuridae	100	5.2 ± 1.8	82.6± 29.31
	Sphyraena forsteri	Sphyraenidae	47	1.4 ± 0.6	2.8 ± 1.25
	Nemipterus japonicus	Nemipteridae	100	24.6 ± 6	133.4 ± 32.58
	Grammoplites suppositus	Platycephalidae	76	0.3 ± 0.1	2.3 ± 0.89
	Epinephelus coioides	Serranidae	65	2.5 ± 1	0.50 ± 0.12
	Carangoide crysophrys	Carangidae	82	2.7 ± 0.9	1.1± 0.24
	Argyrops spinifer	Sparidae	88	0.9 ± 0.1	0.7 ± 0.11
	Pomadasys kaakan	Haemulidae	47	1 ± 0.2	0.50 ± 0.14
	Saurida tumbil	Synodontidae	100	24.1 ± 3.2	61.5 ± 7.5
	Psettodes erumei	Psettodidae	23	0.16 ± 0.08	0.16 ± 0.08
	Stephanolepis diaspros	Monacanthidae	65	0.04 ± 0.008	0.64 ± 0.11
	Carangoides malabaricus	Carangidae	65	5.3± 2.03	21.3 ± 7.8
	Uranoscopus guttatus	Uranoscopidae	29	0.14 ± 0.05	0.48 ± 0.18
	Lepidotrigla bispinosa	Triglidae	76	0.3 ± 0.07	3.7 ± 1.2
	Arius thalassinus	Ariidae	41	1.69 ± 0.87	2.1 ± 1.5
	Priacanthus tayenus	Priacathidae	23	0.02 ± 0.01	0.08 ± 0.04
	Leiognathus bindus	Leognathidae	64	0.59 ± 0.19	0.28 ± 0.10
	Solea elongata	Soleidae	42	0.06 ± 0.03	0.07 ± 0.04
	Fistularia petimba	Fistulariidae	24	0.07 ± 0.03	0.39 ± 0.17
	Alectis indicus	Carangidae	37	0.35 ± 0.11	0.11 ± 0.03
	Lutjanus erythropterus	Lutjanidae	18	0.05 ± 0.04	0.08 ± 0.05
	Cheleonodon patoca	Tetraodontidae	36	0.59 ± 0.20	0.49 ± 0.17
	Acanthoparus latus	Sparidae	24	0.12 ± 0.06	0.19 ± 0.09
	Ilisha megalopter	Clupeidae	12	0.12 ± 0.06	0.94 ± 0.50
	Caranx para	Carangidae	12	0.37 ± 0.22	2.1 ± 1.3
	Muraenesox cinereus	Muraenesocidae	17	0.23 ± 0.12	0.05 ± 0.03
	Epinephelus bleekeri	Serranidae	20	0.49 ± 0.26	0.05 ± 0.03
	Epinephlus malabaricus	Serranidae	30	2 ± 0.65	0.26 ± 0.08
Elasmobranshs	*Dasyatis bennetti*	Dasyatidae	88	2.7 ± 0.42	2.7 ± 0.35
	Carcharhinus dussumieri	Carcharhinidae	76	2.8 ± 0.51	2.5 ± 0.52
	Torpedo sinuspersici	Torpedinidae	82	0.84 ± 0.26	0.75 ± 0.25
	Chiloscyllium punctatum	Hemiscylliidae	30	0.90 ± 0.48	0.41 ± 0.21
	Chiloscyllium arabicum	Hemiscylliidae	17	0.25 ± 0.20	0.09 ± 0.07
	Aetobatus narinari	Myliobatidae	6	0.20 ± 0.1	0.08 ± 0.06
	Rhinobatus annandalei	Rhinobatidae	60	0.68 ± 0.23	0.50 ± 0.17
Invertebrates	*Loligo duvauceli*	Loliginidae	67	0.13 ± 0.04	1.3 ± 0.34
	Thenus orientalis	Scyllaridae	87	3.1 ± 0.68	11.6 ± 2.72

*Target species that caught under commercial size and discarded to sea.

depth in combination with season (F = 0.385; P > 0.05). Out of the five most abundant species, *Ilisha melastoma* and *S. tumbil* had a significant difference between depths with season combined (Table 3).

DISCUSSION

This is the first study of the cutlassfish trawl bycatch from the Persian Gulf. The bycatch of the Persian Gulf, like

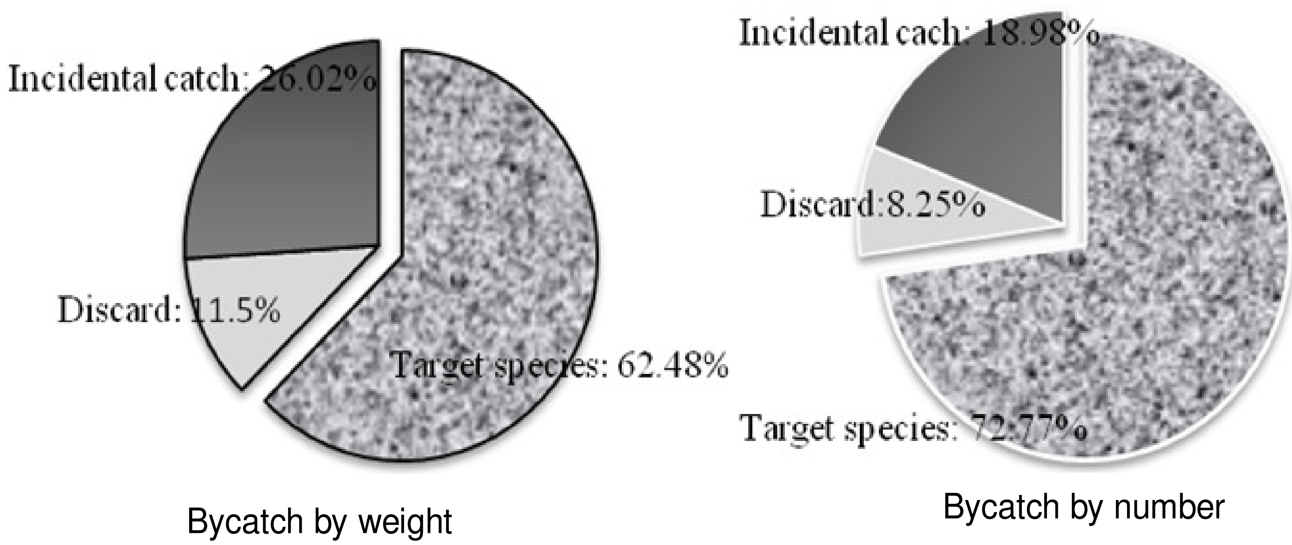

Figure 2. Proportion discards, incidental catch and target species to total catch biomass and total catch individual.

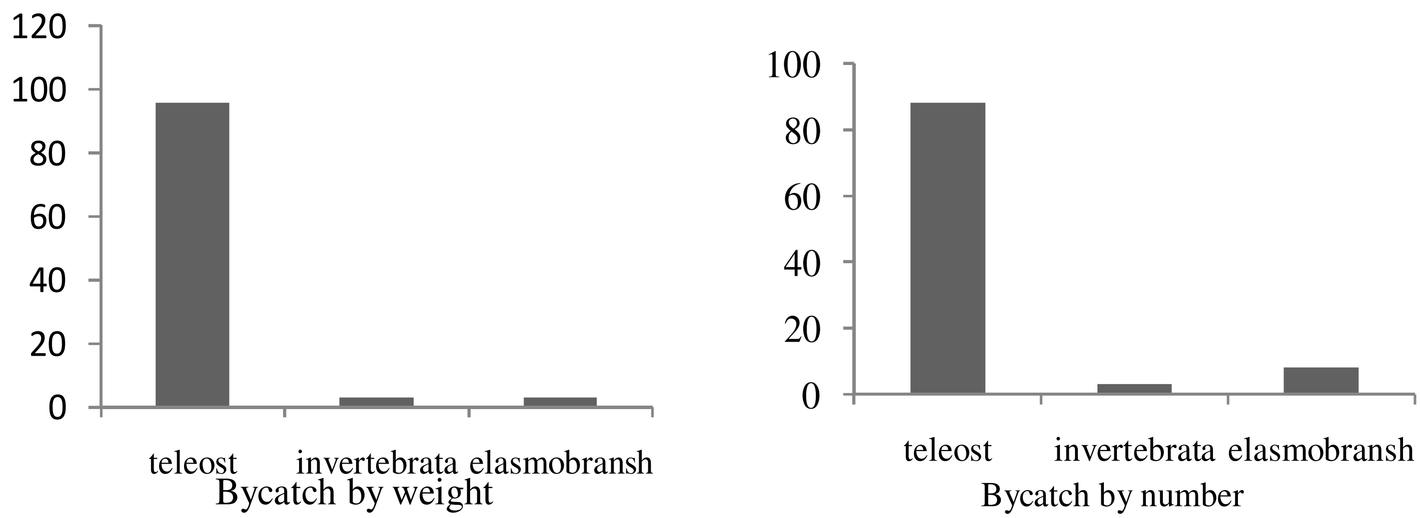

Figure 3. The portion teleosts, elasmobranchs and invertebrates to total bycatch biomass and number.

other tropical fisheries, has high diversity (Pender et al., 1992; Garcia Caudillo et al., 2000; Yimin et al., 1999; Stobutzki et al., 2001; Tonks et al., 2007). Although, studies on trawl bycatch in the Persian Gulf focused on bycatch of shrimp trawl fisheries (Mohammad et al., 1989; Yimin et al., 1999; Paighambari et al., 2001), there are no reported studies on the cutlassfish trawl bycatch fisheries in the fishing grounds of the Persian Gulf which is new and its impact on demersal fish stock is inevitable. Among the bony fishes registered during this study, the majority were demersal. Demersal fish species are one of the most important commercial species in Persian Gulf but catch data presents a 21% decrease in landings from 110,000 tonnes in 2002 to 87,240 tonnes in 2003 (Planning and Development Department, 2003). Therefore, these ecological groups of fishes are classified since they have been over-exploited in this region.

The bycatch cutlassfish trawl fisheries have a distinctly different species composition in comparison with shrimp trawl fisheries is used in the Persian Gulf. In the bycatch of shrimp trawl fisheries in the Persian Gulf, main families are Sciaenidae, Leiognathidae, Clupeidae and Ariidae (Yimin et al*.,* 1999). The main families in the bycatch of cutlassfish trawl fisheries are Nemipteridae, Synodontidae and Clupeidae. Moreover, some species that exist in bycatch of cutlassfish trawl fisheries have not been recorded in bottom shrimp trawl fisheries of the Persian Gulf include: *Fistularia petimba*, *Uranoscopus guttatus, Tennnus orientalis, Lpidotrigla bispinosa* and *Priacanthus tayenus*. The differences in the species

Table 2. Percentage contribution to the general number and weight of the catch belonging to species bycatch from cutlassfish trawl.

Bycatch group	Species	Weight (%)	Number (%)
	Ilisha melastoma	9.7	20.0
	Trichiurus lepturus	5.4	17.9
	Sphyraena forsteri	1.5	0.6
	Nemipterus japonicus	25.29	28.9
	Grammoplites suppositus	0.3	0.50
	Epinephelus coioides	2.6	0.1
	Carangoides crysophrys	2.8	0.2
	Argyrops spinifer	0.9	0.1
	Pomadasys kaakan	1.0	0.1
	Psettodes erumei	0.1	<0.1
	Stephanolepis diaspros	<0.1	0.1
	Carangoides malabaricus	5.4	4.6
	Uranoscopus guttatus	0.1	0.1
Teleosts	*Lpidotrigla bispinosa*	0.3	0.8
	Arius thalassinus	1.7	0.4
	Priacanthus tayenus	<0.1	<0.1
	Leiognathus bindus	0.6	6.1
	Solea elongata	<0.1	<0.1
	Fistularia petimba	<0.1	<0.1
	Alectis indicus	<0.1	<0.1
	Lutjanus erythropterus	<0.1	<0.1
	Cheleonodon patoca	0.60	<0.1
	Acanthopagrus latus	0.1	<0.1
	Illisha megaloptera	0.1	<0.2
	Caranx para	0.3	0.4
	Muraenesox cinereus	0.2	<0.1
	Epinephelus bleekeri	0.5	<0.1
	Epinephlus malabaricus	2.4	<0.1
	Saurida tumbil	24.3	13.3
	Dasyatis bennetti	2.8	0.5
	Carcharhinus dussumieri	2.9	0.5
	Torpedo sinuspersici	0.8	0.1
Elasmobranchs	*Chiloscyllium punctatum*	0.9	<0.1
	Chiloscyllium arabicum	0.2	<0.1
	Aetobatus narinari	<0.1	<0.1
	Rhinobatos annandalei	0.7	0.1
invertebrates	*Loligo duvauceli*	0.13	0.29
	Thenus orientalis	3.20	2.53

composition of the bycatch from cutlassfish trawl fisheries and shrimp trawl fisheries may be, in part, explained by biophysical factors. The fishing grounds of shrimp falls in to the coastal waters of Persian Gulf is characterized by depths less than 30 m and sediments dominated by biogenic gravels and mud (Al-ghadban and Abdali, 1998). Fishing grounds of cutlassfish are characterized by depths greater than 40 m and sediments dominated by sand (Al-ghadban, 1998).

Results obtained in this study demonstrated that the mean total bycatch among different depths have different significance ($P < 0.01$) except *C. dussumieri* that did not differ significantly among three depths. The greatest mean total bycatch was in 40 to 50 m depth, which made a significant proportion to the total catch per trawl. This result shows that fisheries operation in the less than 50 m

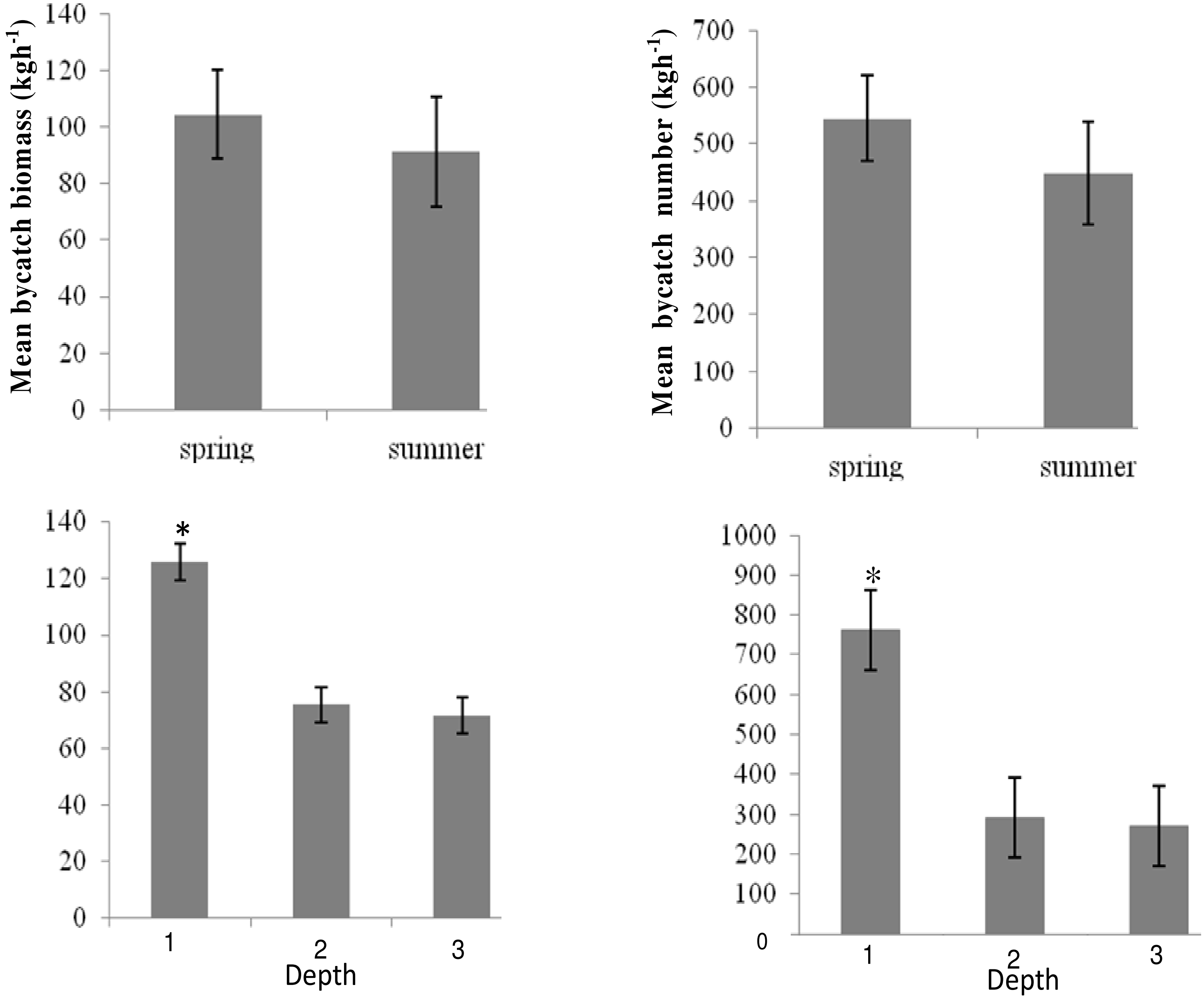

Figure 4. Mean catch rates for biomass and number (±S.E.) for total bycatch cutlassfish fishing between seasons and different depth. Means that differed significantly in two-factor ANOVAs are denoted by*.

depth has greater impact on stock of commercially valuable species and non-commercial species. Fisheries pressure on commercially valuable species resulted in decline catch of this species in future and impact of fishing on non-commercial species resulted to impact on ecosystem (Alversonet et al., 1994; Hall, 1999). Moreover, our study did not find a difference between the bycatch biomasses caught at spring and summer. Several studies reported temporal changes in bycatch assemblages in tropical regions (Rainer and Munro, 1982; Wright, 1988; Blaber et al., 1990; Thonks et al., 2008). These differences may be explained by wet and dry seasons, seasonal movement of water masses and seasonal variations in temperature (Watson et al., 1990; Vinna and Ameida, 2005; Thonks et al., 2008). However, in our study, only two of the more abundant species *S. tumbil* and *D. bennetti* had different catch rates during the seasons.

In a previous study, bycatch-to-target species ratio in shrimp trawl fisheries was 6:1 to 15:1 (Thonks et al., 2008). Also, in studies conducted on bottom shrimp trawl bycatch in the Persian gulf, bycatch-to-target species ratio was estimated 6.78 to 15.32 (Yimin et al., 1999). But, Considering the total bycatch value by weight 97.24 kg h^{-1} and by number 492.43 n h^{-1} and since about 10 commercial fishing vessels operate in this area for 6

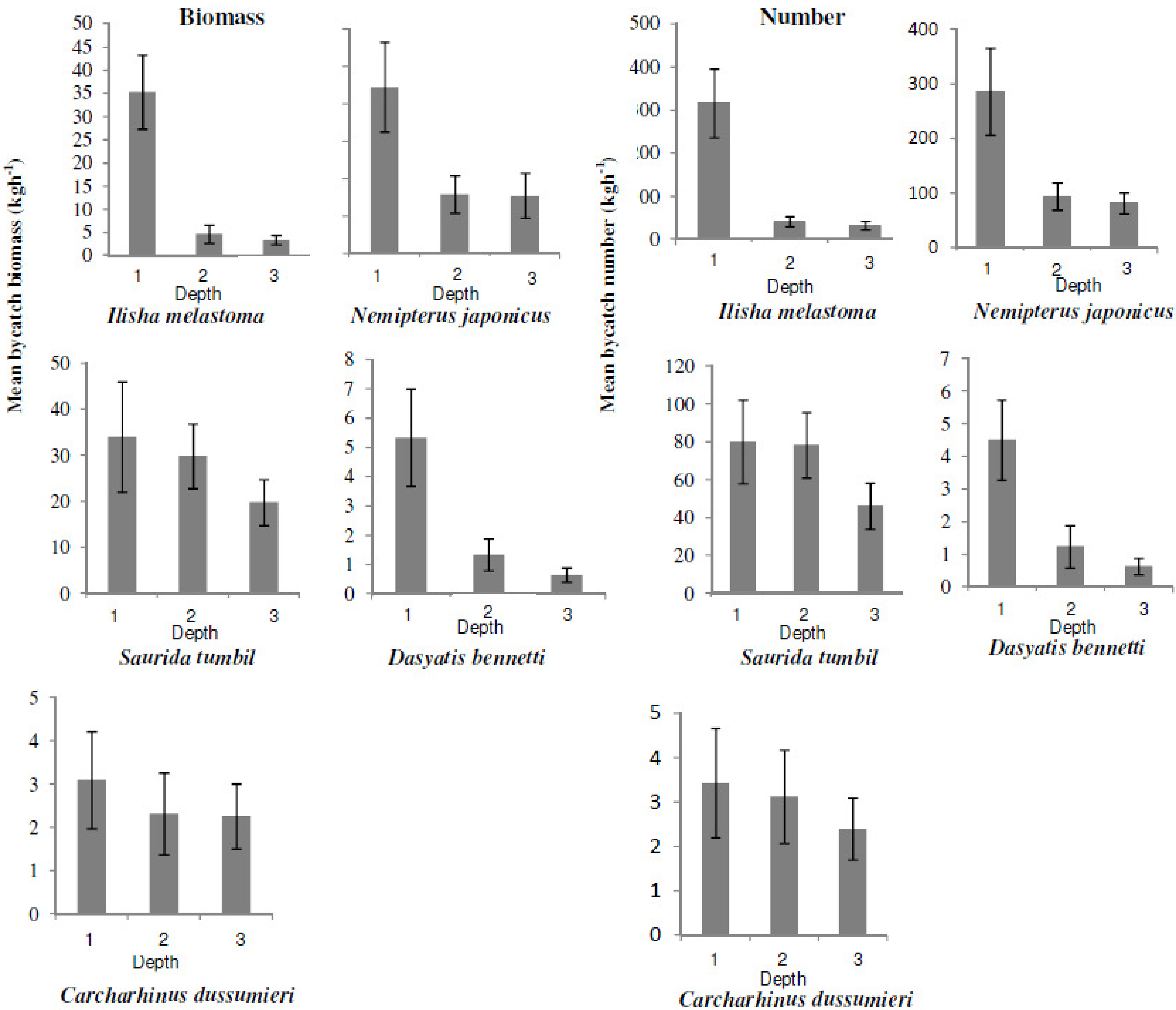

Figure 5. Comparative depth of the mean total bycatch for 5 most bycatch species. For both mean number individuals and biomass. There is, depth1: 40 – 50 m, depth 2: 50 – 60 m and depth 3: 50 - 60 m. Means that have different significance are denoted *.

months per year at fisheries season, this problem can negatively impact on commercial and non-commercial species.

Regarding to the existence of fish juveniles in the bycatch of cutlassfish trawl fisheries, the highest proportion of discarded juveniles to sea belonged to the juveniles of *T. lepturus* with biomass of 5.33 kgh^{-1} (and individuals 82.67 nh^{-1}), which is of important to note. Mean of discarded juveniles of *N. japonicas, S. tumbil, C. malabaricus and Grammoplites suppositus* with 2.11 kgh^{-1} by weight and 41 nh^{-1} by number of the whole and also, mean total discarded species of elasmobranch species like rays and sharks with 8.37 kgh^{-1} for mean discard by biomass and 7.41 nh^{-1} for mean discard by number shows that these values are significant. In the Australian shrimp trawl, fisheries amount of bycatch significantly declined due to use of Bycatch Reduction Device (BRD_S) since 2000 (Brewer et al., 2006; Kuhnert et al., 2010). Lack of application of BRDs in cutlassfish trawl fisheries cause the high mean of total bycatch per trawl, and amount of discard in this fishing gears may declined by using this application, which it needs further investigation.

Table 3. Summary of the two-factor fixed ANOVAs of weight and number of individuals for the five most abundant species bycatch in the Persian Gulf; testing for differences between seasons and depth.

Species	Season (1)	Depth (2)	Season × depth (1)
Biomass			
I. melastoma	0.442	17.136***	5.258*
S. tumbil	15.001***	30.548***	19.40***
N. japonicus	0.228	22.634***	0.955
C. dussumieri	0.006	3.139	0.049
D. bennetti	2.317	6.147**	1.160
Number			
I. melastoma	0.501	5.01*	4.05*
S. tumbil	10.138***	26.522***	4.601*
N. japonicus	2.53	47.494***	3.26
C. dussumieri	0.083	2.114	0.397
D. bennetti	4.769*	3.599*	2.981

Degrees of freedom are shown in parentheses. Significant results are shown in significance levels shown as *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Implications for bycatch management

Due to short duration of this study, spatial variations and species composition obtained for mean total bycatch were not conclusive. Despite this problem, this study has provided the first comprehensive study of the species composition of cutlassfish trawl in fishing grounds of Bushehr waters of the Persian Gulf. The data collected in this study can be used in the quantitative assessments of pressured fisheries on bycatch stocks in the Persian Gulf.

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