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The Catch Per Unit of Swept Area (CPUA) and Estimated Biomass of Large Head Hairtail (*Trichiurus lepturus*) with an Improved Trawl in the Persian Gulf and Gulf of Oman, Iran

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Abstract

The Kish trawler fleet targets large head hairtail (*Trichiurus lepturus*) in the Persian Gulf and the Gulf of Oman. These vessels are equipped with a new improved trawl. The objectives of this study were (i) to estimate the catch per unit area (CPUA) and biomass of *T. lepturus*, (ii) to identify the catch composition and percentage of target and bycatch species in the total catch and (iii) to compare the CPUA between two selected strata using a bottom trawl survey. Surveys were conducted during the periods August to October 2007 in the Persian Gulf and Gulf of Oman. The sampling area was divided into two strata and a stratified random sampling design was used to determine sampling sites. Catch per unit of area varied significantly between the two selected strata ($P<0.001$). Mean CPUA for *T. lepturus* in the total area was 4,308 $kg \cdot nm^{-2}$. The total biomass of *T. lepturus* was estimated to be 842 tonnes in stratum 1 and 1,430 tonnes in stratum 2. *Trichiurus lepturus* made up 74.4% of the total weight in stratum 1 and 70.02% in stratum 2. Among the non-target species in the trawl catches, the species with highest catch rate were *Pampus argenteus* (4.629%), Batoids (2.274%), Carangidae (2.693%) and *Ilisha* sp. (2.672%) in stratum 1 and Carangidae (5.710%), *P. argenteus* (5.245%), Batoids (3.256%) and *Ilisha* sp. (2.995%) in stratum 2.

Introduction

The Persian Gulf and Gulf of Oman consist of subtropical seas lying almost entirely between the latitudes of 24ºN and 30ºN and longitudes of 49ºE to 61º 25´E (Reynolds, 1993). The Persian Gulf is characterized by shallow waters (<100 m) with high nutrient inputs from river outflows, a well mixed layer extending almost to the bottom and high oxygen levels (>5 mL $O_2 \cdot L^{-1}$). Tidal currents are important inside the Persian Gulf as well as in the Hormuz Strait (Taghavi, 2004). The Gulf of Oman connects the Persian Gulf to the north-west Arabian Sea and then to the Indian Ocean.

The fish catches in the Persian Gulf and Gulf of Oman can be divided into four categories: small pelagic, large pelagic, demersal and mesopelagic fishes. Over the last decade catches have varied around an average of 254,500 tonnes (Taghavi, 2004). Catches of demersal species constitute around 30 percent of total catches and large pelagics constitute 50 percent with

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an increasing trend over the last decade. This increasing trend becomes even clearer when considering tuna and tuna-like species (Taghavi, 2004).

Bottom trawls are known to be rather unselective gears. Their use in a multi-species and multi-size fisheries results in catches of bycatch fish species or unwanted size grades of targeted species (Macher et al. 2008). Much of this catch is often discarded with high mortality rates (Alverson et al. 1994). The Kish trawler fleets target *T. lepturus* in the Persian Gulf and Gulf of Oman. These vessels are equipped with new improved trawl design.

Taghavi et al. (2006) has reported a potential catch for *T. lepturus* of around 10,000 tonnes a year in the southern waters of Iran (Persian Gulf and Gulf of Oman). The total catch was approximately 600 tonnes in 2007. Currently there is 3-month open season for the *T. lepturus* fishery in the Persian Gulf and a 5- month season in the Gulf of Oman.

Estimation of abundance and length distribution of commercial fish stocks derived from trawl surveys has become a management necessity in many areas (Godo et al. 1990). Although some investigations have documented the fisheries and biomass of multi-species demersal fish in the Persian Gulf and Oman Sea (Valinassab et al. 2006; Dehghani, 2006) there has been no research on catch composition, CPUA and biomass estimation for this species by Kish vessels.

The objectives of this study are:

(i) To identify the catch composition and fraction of target and by-catch species in the total catch.

(ii) To determine the CPUA and biomass of *T. lepturus*.

(iii) To compare the CPUA between two strata using bottom trawl survey in the Persian Gulf and Oman Sea.

The study was carried out using the stern trawlers *F.V. Kish 708* and *F.V. Kish 611* (43.5 m, 450 kW) during the period August to October 2007 in the Persian Gulf and Gulf of Oman. (Fig. 1). The survey areas were restricted to Iranian waters between the longitudes of 54º 55´E – 56º 20´ E (stratum 1) and 56º 55´E – 57º 25´E (stratum 2). The depth of the two strata was greater than 30 m. A total of 60 hauls were done using a net with a cod-end mesh size of 75 mm and a 45 m headline. The average haul duration was 2.5 hr and towing speed varied from 1.8 to 3.3 $nm \cdot hr^{-1}$, depending on weather and/or bottom conditions. The time and GPS position of start and end of hauling and towing speed were recorded for all tows. The catch was sorted into species or species groups and number and weight of each species (or species group) were recorded. The selection of trawl stations followed a stratified random-sampling design. The total areas of the two strata were calculated using a planimeter (Haff No. 317 E).

CPUA was calculated as the catch weight (W) divided by the estimated swept area (a) for *T. lepturus* in each haul:

CPUA = W/a

The swept area for each hauling was estimated as:

$a = D.H.X$

Where:

D= the distance covered (n.m)

H = head-rope length.

X = fraction of the head-rope length equal to the width of the path swept by the trawl, or the wing spread = 0.66.

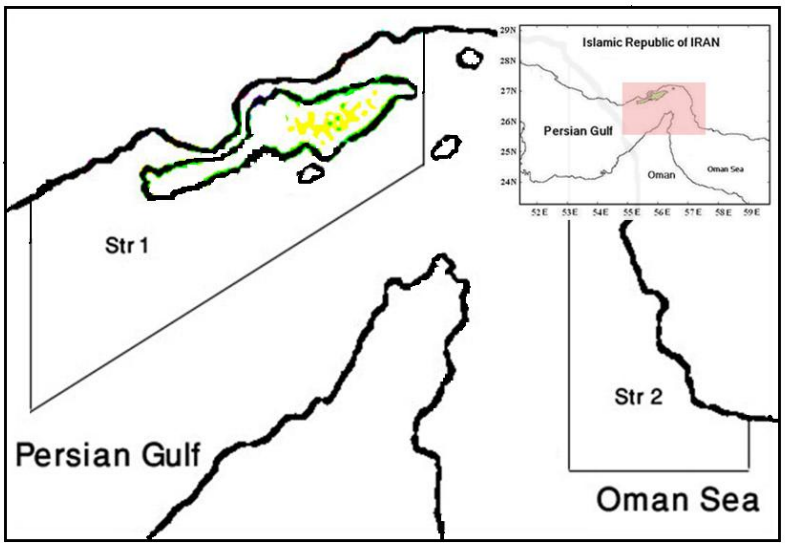

Fig.1. Sampling area (Stratum 1&2) in the Persian Gulf and Gulf of Oman.

The distance covered (D) was estimated for each haul in units of nautical miles (Sparre and Venema, 1992).

$$60x\sqrt{(lat_1 - lat_2)^2 + (lon_1 + lon_2)^2 \cos 0.5^2 (lat_1 + lat_2)}$$

where:

Lat1 = Latitude at the beginning of the haul (degrees)

Lat2 = Latitude at the end of the haul (degrees)

Lon1 = Longitude at the beginning of the haul (degrees)

Lon2 = Longitude at the end of the haul (degrees).

The coefficient of variation (CV) is used to assess the variability of the catch. It was computed for each tow and for all tows by stratum, where the V and are the variances and average of CPUA's in all stations of a stratum:

$$CV = \frac{100 * \sqrt{V}}{\overline{CPUA}}$$

A t-test was used to examine the difference in CPUA for the two strata.

Results

The mean catch per unit area and biomass values for *T. lepturus* for both strata is given in Table 1. Mean CPUA for *T. lepturus* in stratum 2 was significantly higher than stratum 1 ($P<0.001$). Maximum, minimum and mean of CPUA for *T. lepturus* in stratum 2 were higher than stratum 1. However, the variability in stratum 1 was higher than stratum 2 (Table 1, Fig. 2 and Fig. 3). Mean CPUA for *T. lepturus* in the total area was 4,308 $kg \cdot nm^{-2}$. The total biomass of *T. lepturus* was estimated to be 842 tonnes in stratum 1 and 1,430 tonnes in stratum 2. Distributions of catches of *T. lepturus* by tow in the two strata are given in Fig. 2 and Fig. 3.

Table 1. Mean CPUA (±SD) and coefficient of Variation (CV) for strata and total area.

	Min (CPUA)	Max (CPUA)	Mean±SD (CPUA)	CV (%)	Biomass
Stratum 1	73.3	10989	2599.8±2892	111	842 (tonnes)
Stratum 2	274.7	10073.3	4416.3±2918	66	1430 (tonnes)
Total area	73.3	10989	4308±3078	84.57	2272 (tonnes)

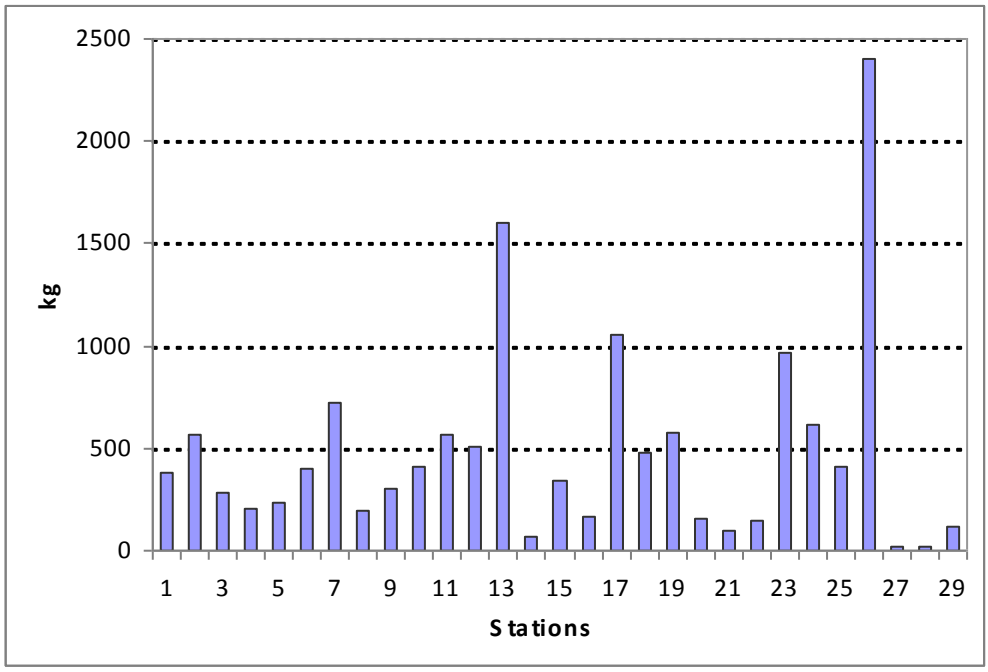

Fig. 2. Distribution of catches of *T. lepturus* by tow, stratum 1.

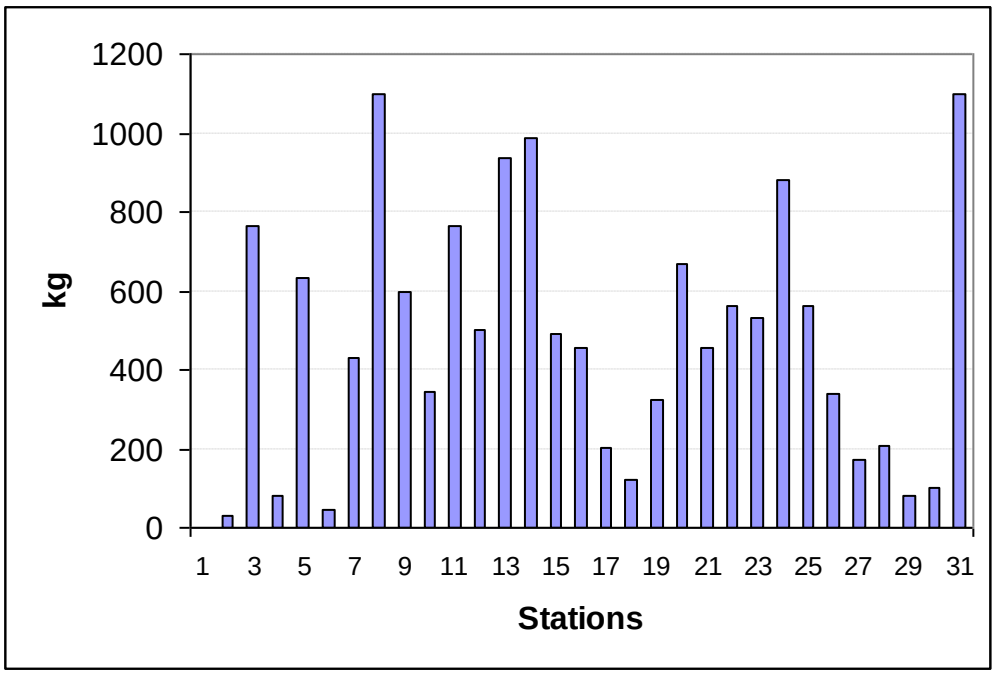

Fig. 3. Distribution of catches of *T. lepturus* by tow, stratum 2.

Table 2 shows the catch composition obtained in the surveys. The composition is given as the total weight of species or species group as a percentage of the total catch during survey. In general, the catch composition differed between the two strata. The *T. lepturus* made up 74.4% of the total weight in stratum 1 and 70% in stratum 2. Among the non-target species in the trawl catches (Table 1), the species with highest catch rate were *P. argenteus* (4.629%), Batoid fishes (2.274%), Carangidae (2.693%) and *Ilisha* sp. (2.672%) in stratum 1 and Carangidae (5.710%), *P. argenteus* (5.245%), Batoid fishes (3.256%) and *Ilisha* sp. (2.995%) in stratum 2.

Discussion

The use of catch per unit effort (CPUA) as a measure of relative fish abundance is a common index used in stock assessment, whether calculated from commercial or research survey data (Haggarty and King, 2006).

Table 2. Checklist of species or species group in 2 strata.

Row	Species or species group	Economic Value	% of total catch	
			Stratum 1	Stratum 2
1	*Trichiurus lepturus*	Commercial	75.470	70.020
2	*Pampus argenteus*	Commercial	4.629	5.245
3	BATOID FISHES	Non-commercial	2.704	3.256
4	CARANGIDAE	Commercial	2.693	5.710
5	*Ilisha* sp.	Non-commercial	2.672	2.995
6	SHARKS	Commercial	2.483	1.925
7	*Scomberomorus guttatus*	Commercial	1.342	1.253
8	*Parastromateus niger*	Commercial	1.085	1.653
9	*Chirocentrus nudus*	Commercial	0.899	1.612
10	*Drepane langimana*	Commercial	0.746	0.985
11	ARIIDAE	Non-commercial	0.693	0.958
12	*Drepane punctata*	Commercial	0.719	0.602
13	*Saurida tumbil*	Commercial	0.588	0.541
14	*Alectis* sp.	Commercial	0.587	0.214
15	*Nemipterus japonicas*	Commercial	0.522	0.652
16	*Polynemus sextarius*	Commercial	0.390	0.245
17	SCIANIDAE	Commercial	0.327	0.000
18	*Sphyraena putnamiae*	Commercial	0.312	0.325
19	*Saurida andosqamis*	Commercial	0.269	0.321
20	*Pomadasys kaakan*	Commercial	0.110	0.135
21	*Upeneus doriae*	Non-commercial	0.108	0.325
22	*Psettidis eruemi*	Commercial	0.191	0.142
23	*Elutheronema tetradactylum*	Commercial	0.097	0.005
24	*Mene maculate*	Non-commercial	0.076	0.352
25	*Muraenesus sinereus*	Non-commercial	0.073	0.099
26	*Rachycentron canadum*	Commercial	0.057	0.053
27	*Sphyraena jello*	Commercial	0.054	0.102
28	*Megalaspis cordyla*	Commercial	0.044	0.023
29	*Scomberomerus commerson*	Commercial	0.043	0.099
30	*Sepia Pharaonis*	Commercial	0.035	0.025
31	*Scomberoides commersoniannus*	Commercial	0.027	0.099
32	*Pseudorhobus arsius*	Commercial	0.011	0.000
33	*Loligo* sp.	Commercial	0.011	0.010
34	*Acanthopagrus latus*	Commercial	0.003	0.002
35	*Grammoplites suppositus*	Commercial	0.002	0.002
36	*Acanthopagrus bifasciatus*	Commercial	0.001	0.000
37	*Otolithes ruber*	Commercial	0.000	0.014

Mean CPUA for *T. lepturus* in stratum 2 were significantly higher than stratum 1 ($P<0.001$). Although no environmental affects were identified or quantified; they may play a role in the species abundance and distribution (Can et al. 2004).

Dehghani (2006) and Valinassab et al. (2005) used a bottom trawl net for surveys in the Persian Gulf and Gulf of Oman. In those surveys, the mean CPUA for *T. lepturus* was determined to be 60.75 and 150.4 $kg \cdot nm^{-2}$ in the Persian Gulf and 533 and 520.7 $kg \cdot nm^{-2}$ in the Gulf of Oman respectively. This value is much smaller than the value found in the present study (2,598 $kg \cdot nm^{-2}$ in Stratum 1: Persian Gulf; 5,626 $kg \cdot nm^{-2}$ in stratum 2: Gulf of Oman). Moreover Valinassab et al. (2005) reported that the mean CPUA in stratum J (similar to stratum 2 in this study) was more than quintuple of its CPUA in stratum I (similar to stratum 1 in this study). However in the present study the ratio (stratum 2/ stratum 1) is 1.6. These studies were conducted in the same area but the results are quite different. Possible reasons for the occurrence of such differences are:

i. Tow duration

In the present study, the duration of the tows was 2.5 hr, whereas for the surveys reported in Dehghani (2006) and Valinassab et al. (2005) it was held constant at 1 hr.

ii. Number of hauls

In the present study, the number of hauls was much higher than in their surveys in the same areas. Pennington and Volstad (1994) suggested that reducing tow duration and increasing appropriately the number of stations would result in an increase in the precision of the survey estimate of, e.g. abundance and biomass, and also of other properties such as mean length. Affects of tow duration on catch rates have been reported by Carothers and Chittenden, 1985; Godo et al. 1990; Somerton et al. 2002)

iii. Survey season

We conducted our surveys during the periods August to October but the studies of Dehghani (2006) and Valinassab et al. (2005) were conducted in December.

iv. Fishing gear and engine powder

Dehghani (2006) and Valinassab et al. (2005) performed their surveys using the *R.V.Ferdows-1* (45.5 m, 1200 kW), which was equipped with a bottom trawl net with a mesh size of 80 mm in the cod-end and a 72 m headline but we conducted our surveys with an improved design with a cod-end mesh size of 75 mm and a 45 m headline.

The coefficient of variation in CPUA in stratum 1 was higher than in stratum 2 (Table 1). The maximum and minimum catches of *T. lepturus* were seen in stratum 1 (Fig. 2 and Fig. 3). This may be a result of the differences in the ecosystems of the two strata. The Persian Gulf is a large area of shallow water that is semi-enclosed while the Gulf of Oman is oceanic in its nature

(Reynolds, 1993) as it is connected to the Indian Ocean by the Arabian Sea. The high coefficients of variation are typical of many trawl surveys (Daug et al. 2002).

In terms of overall catch composition in the surveys, non commercial species made up 7.1% of the total catch, but Valinassab et al. (2006) found that non-commercial species accounted for more than 30% of total biomass. The lower proportion of non-commercial species in this study may reflect a lower bycatch achieved with the improved trawl design for *T. lepturus* in the Persian Gulf and Gulf of Oman.

FAO (1981) reported that the highest percentage of Trichiuridae (17%) in the same area (Strait of Hormoz) has been seen in the depth between 50-100 m. In this study *T. lepturus* made up more than 70% of total catch.

Conclusion

The new improved trawls appear to be more effective in reducing bycatch in the fishery for *T. lepturus* in this area. To achieve sustainable exploitation of this marine resource, this stock should be regularly monitored, and the migration pattern, growth and mortality parameters determined to gain sufficient knowledge to manage these stocks effectively. Thus it is necessary to study these factors for implementing a management strategy.

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