The Effect of Towing Duration on the Catch per Unit of Swept Area (CPUA) from the Bottom Trawl Surveys in the Persian Gulf

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This study was conducted to record best towing duration for bottom trawl surveys to stock assessment in the Persian Gulf. Shannon-Wiener, Margalef and evenness index were calculated for four towing duration (60, 90, 120 and 150 minutes) in fishing grounds of Persian Gulf. A stratified random procedure was used for the survey sampling. The mean CPUA differed significantly with towing duration (P< 0.05) for the T. lepturus. The mean Shannon-Wiener diversity index differed significantly between four towing duration with higher Shannon-Wiener diversity index for 120 minutes (2.81±0.44) (F=5.38; P=0.03. The mean CPUA differed significantly between towing durations with lowest CPUA at 150 minutes (P<0/05). Results showed that 120 minutes towing duration was the best for scientific surveys. 150 minutes towing duration was not suitable for scientific surveys in the Persian Gulf. The present research provided the first comprehensive study on the effect of trawl duration on diversity index and CPUA in Persian Gulf.

Key words: Trawl, Diversity index, Trichiurus lepturus, Persian Gulf

1. INTRODUCTION

The Persian Gulf is in subtropical zone that lying between 24° and 30°latitude. The maximum width of the Persian Gulf is 640 km and average depth is 36m (Reynolds, 1993).

Cutlass fish as a predator fish (Martins and Haimovici, 1996; Bitter and Benneditto, 2009) reported in the Indian Ocean, particularly Persian Gulf. The most abundant species of Cutlassfish in the Persian Gulf is Trichiurus lepturus. The cutlassfish fisheries of the Persian Gulf are the most lucrative fisheries in the recent years (Raeisi et al., 2011). High population of this species has been connected with reduced catch rate of important commercial shrimps, such as Penaeus semisulcatus, Metapenaeus stebbingi, and Metapenaeus affinis, by southern Iranian fisherman which proposed Cutlassfish has a significant impact on the stock of shrimps (Martins and Haimovici, 1996; Raeisi et al., 2011). Some study have been conducted to investigate the environmental condition impact on the distribution of this species (Lee, 1979, Baik and Park, 1986; Dekun and Cungen, 1987; Munekiyo, 1990; Martins and Haimovici, 1996; Raeisi et al., 2011; Meriem et al., 2011) which indicated that the abundant of this species is in subtropical zone.

Some research has been reported the bycatch and CPUA in Persian Gulf (Valinasab et al., 2006; Raeisi et al., 2011; Raeisi et al., 2012; Paighambari and Daliri, 2012; Daliri et al., 2012). But no study has been conducted about towing duration on CPUA and diversity index in Persian Gulf.

Estimation of the CPUA diversity index in commercial fish stocks based on trawl surveys is a management necessity in many fishing areas (Godø et al., 1990; Can and dimirci; 2004). Thus, the standard towing duration for many trawl researches usually vary from 60 minutes to 150 minutes at each selected station.

This paper presents the first quantitative data on the effect of towing duration on CPUA and diversity index in Persian Gulf also based on these data, discusses their applications in fisheries management.

2. MATERIALS AND METHODS

2-1. Data collection

Data were collected by scientific observers that were sent on board of commercial operating vessels in the fishing grounds of T. lepturus in Bushehr and Hormozgan province (North of the Persian Gulf) since May 1st 2009 to 10th November 2010 (Fig. 1).
The total area was calculated with a planimeter. A total of 40 trawl stations were selected following a stratified random procedure.

The cruises were carried out using Commercial vessel. Kish 811 that is a stern trawler (43.5m length, 450 kW) equipped (GPS), echo sounders and a bottom-trawl net with a cod-end mesh size of 75mm and a 45m headline.

In this research, 50, 65, and 75-minute tows of hauling considered as 60 minutes tows of duration; 85, 95 and 105-minute tows of duration, for 90 minutes; and 115 and 135-minute tows, for 120 minutes; and 145, 155, 190 and 170-minute tows, for 150 minutes. Sampling operation was conducted in daytime. During the sampling, duration of trawling, GPS position, towing distance and towing speed were recorded.

The end of each hauling, total catch unloaded on the deck then bycatch were separated from the target species (cutlassfish). Target species was spilling to trays then weighed and counted. The biomass and CPUA were estimated based on Sparre and Venema (1992). The towing distance at a given station (D in nautical miles, n.m.) was measured by GPS or using the formula:

\[ D = 60 \times \sqrt{(\text{Lat}_1 - \text{Lat}_2)^2 + (\text{Lon}_1 - \text{Lon}_2)^2 \cos^2(0.5(\text{Lat}_1 + \text{Lat}_2))} \]  

(1)

Where:
\( \text{Lat}_1 = \) latitude at start of haul (degrees).
\( \text{Lat}_2 = \) latitude at end of haul (degrees).
\( \text{Lon}_1 = \) longitude at start of haul (degrees).
\( \text{Lon}_2 = \) longitude at end of haul (degrees).
Swept area \( (a, \text{n.m}^2) \) at each station was estimated as:

\[
  a_j = D \cdot h \cdot X^2
\]  

(2)

Where \( h \) is the length of the head-rope and \( D \) is the cover of distance, \( X \) is the wing spread coefficient (= 0.66 according to Sparre and Venema, 1992).

The catch per unit area (CPUA, kg n.m\(^{-2}\)) for each station is given by:

\[
  \text{CPUA}_j = \frac{C_w}{a} \text{kg/nm}^2
\]  

(3)

Where \( C_w \) is the catch in weight of a haul and \( a \) is the swept area (n.m.\(^2\)) for each haul.

The total biomass estimated as:

\[
  B = \frac{\text{CPUA}}{0.5} \times A
\]  

(4)

Where \( A \) is the total area \( N \) is the number of stations and 0.5 is the catch coefficient (using the value proposed by Sparre and Venema, 1992, for demersal group in tropical and subtropical areas).

Diversity: A wide variety of diversity indices are available; each variant is sensitive to different aspects of the catch.

\[
  H = \sum_{i=1}^{s} \frac{N_i}{N} \ln \frac{N_i}{N}
\]  

(6)

Where \( H \) is the Shannon-Wiener index, \( N_i \) is the number of individuals of species \( I \) and \( N \) is the total number of individuals of all species. Shannon's index is 0 if there is only one species in the sample, and is maximum, when all \( s \) species are equally represented. Exponentiation of \( H' \) gives the number of species that would, if each were equally common, produce the same \( H' \) as the sample.

\[
  R = \frac{S - 1}{L_n \cdot N}
\]  

(7)

Where \( R \) is the species richness index, \( S \) is the number of species and is the total number of individuals of all species.

Evenness: Evenness indices measure the extent to which species catch is distributed over the species present in the sample. If all species are equally abundant, evenness is maximum.

\[
  \text{Pielou's evenness} = \frac{H}{\log S}
\]  

(8)
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Where H is the Shannon-Wiener index and S is the number of species.

2-2. Data analysis

To analyze normality of the data and homogeneity of variances, Kolmogorov-Smirnov and Levene tests were used (Zar, 1999). The one-way analysis of variance (ANOVA) was used to investigate whether the mean CPUA differed among the towing durations. Correlation between swept area and period of towing was examined using Pearson correlation coefficient.

2-2-1. GLM

The general linear model (GLM) was used for analysis of variance by four factors, area, month, towing duration and depth to investigate their main effects and interactions. In all cases only main effects were tested in order to undertake a wide range of exploratory analyses. To calculate diversity index was used PRIMAR software.

3. RESULTS

Results for sample size, Swept area and depth are shown in table 1. Results indicated positive correlation between towing duration and swept area (R = 0.98).

Table 1: Number of hauls (N), swept area (a±S.E) and towing depths (Depth±S.E) by towing durations

<table>
<thead>
<tr>
<th>Towing Duration</th>
<th>N</th>
<th>a ± S.E (NM²)</th>
<th>Depth ± S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>11</td>
<td>0.1170±0.008</td>
<td>63.72±7.47</td>
</tr>
<tr>
<td>90</td>
<td>9</td>
<td>0.1285±0.007</td>
<td>59.33±6.32</td>
</tr>
<tr>
<td>120</td>
<td>21</td>
<td>0.1372±0.006</td>
<td>64.14±5.94</td>
</tr>
<tr>
<td>150</td>
<td>6</td>
<td>0.1734±0.011</td>
<td>63.87±5.54</td>
</tr>
</tbody>
</table>

3-1. CPUA trend

During in this study, a total of 70,429.3 kg catch was recorded. *Trichiurus lepturus*, constituted approximately 60% the total catch. Non-target species comprised about 40% of the total catch. Mean CPUA values differed significantly between the towing durations with highest CPUA for 120minutes towing of duration (p<0.05).

For the *T. lepturus*, CPUA values increased for durations 60 and 120 minutes but then suddenly decreased at 150 minutes of towing and longer durations. The mean CPUA values differed significantly between various towing durations with highest CPUA for 150minutes duration.

3-2. Diversity index

The mean numbers of individuals were greater in 120minute compared in 60, 90 and 150minutes towing of durations (Fig 2). The mean Shannon-Weiner diversity index differed significantly between four towing duration with higher Shannon-Weiner diversity index for 120minutes of towing (2.81±0.34) (F=5.38; P=0.03). (Fig 3). Margalef’s richness index was higher in 120minutes of towing (1.632±0.38) in comparison to 60, 90 and 150minutes of towing (F=3.22; P=0.025). Pielous evenness index was higher in 120 and 90minutes compared to 60 and 150minutes of towing (F=2.892; P=0.046) (Fig. 3).
Table 2: The mean catch per unit swept area (CPUA ± SE) number of observed haul (N) for four towing durations in fishing grounds of Persian Gulf

<table>
<thead>
<tr>
<th>Towing duration (minutes)</th>
<th>Trichiurus lepturus</th>
<th>Non-target species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CPUA±S.E</td>
<td>CPUA±S.E</td>
</tr>
<tr>
<td>60</td>
<td>2441.44±323.3</td>
<td>3056.4±597.2</td>
</tr>
<tr>
<td>90</td>
<td>7705±3376.9</td>
<td>4286.5±193.5</td>
</tr>
<tr>
<td>120</td>
<td>10619±2262</td>
<td>3875.7±10893</td>
</tr>
<tr>
<td>150</td>
<td>3890±2624.7</td>
<td>9597±217.9</td>
</tr>
</tbody>
</table>

Fig. 2: Number of species and individuals at each station in fishing grounds of Persian Gulf
3-3. GLM model

GLM model showed that diversity index was affected by towing duration and month (P<0.05). But diversity index did not differ significantly between fishing area and seasons (P>0.05).

**Fig. 3:** Diversity indices for each haul in both sampling sites

**Fig. 4:** Dependent variable is species diversity (N2 index, see Table 1). N.S. indicates non-significant (P>0.05) factor. Month*towing duration indicated a significant Month*towing effect (P<0.05).
4. DISCUSSION

In this study, towing duration was the most important factor that changed diversity and CPUA. Murawski (1991) noted that factors such as towing duration may integrate patchy distributions of more-or-less segregated resources into what appear to be composition of species. Thus, the implication is that shorter tow times may consequence in less diverse catches, and perhaps a higher proportion of target species.

Diversity index was significantly different between four towing duration. Some studies also reported effect of towing duration on diversity index (Can and dimirci; 2004, Murwaski, 2000; Cladatoox, 2005). For example, diversity index in USA affected by towing duration. Diversity index reduced in 150 minutes towing of duration. These changes are due to variation in trawl catching capacity over the time (Can and dimirci, 2004). On longer taws, the net make full or close up during towing and sweep out a narrower path, consequence in mobile organisms avoiding capture.

The 120 minutes towing duration had highest CPUA and diversity index in this study. Can and dimirci (2004) reported 120minutes towing duration had highest CPUA in trawl surveys. This suggests 120 minutes is the best duration for scientific surveys.

The gradually decrease in the CPUA rates with increasing in the towing duration in T. lepturus illustrated predation and also escapes from the mesh due to gear saturation for this species.

The CPUA of the bycatch increased when towing duration passed the 150 minute. Other study has also reported increasing in CPUA of bycatch in longer taws (Can and dimirci, 2004; Murwaski, 2000; Cladatoox, 2005).

An important question in designing mitigation measures for by-catch and discard is the extent to which various operational characteristics of the fishery may affect the catch of non-target species. By limiting directed fishing to times and places where resources are segregated, the quantity of unintended catch could potentially be reduced.

Results showed temporal changes in diversity index. Several studies reported temporal changes in diversity index in tropical regions (Can and dimirci, 2004; Murwaski, 2000; Cladatoox, 2005). These differences may be interpreted by wet and dry seasons, seasonal movement of water masses and seasonal temperature changes (Watson et al., 1990; Vinna and Ameida, 2005; Thonks et al., 2008).

5. CONCLUSION

Results showed that diversity index were lower in short taws (60 and 90 minutes) and long taws (150minutes of towing) in comparison with 120minutes towing duration. These results proposed that 120minutes towing duration is the best duration for scientific research.

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