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# Effect of Tow Duration and Speed on the Capture Efficiency of Bottom Trawl

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The catching performance of a 34 m High opening bottom trawl (HOBT) was studied with tow durations of 15, 60 and 120 min each and with two towing speeds (0.87± 0.03 and 1.36 ± 0.03 $ms^{-1}$) to find out changes in the species retention and escapement in terms of weight and number from the codend. Variations in the retention and escapement catch per unit effort (CPUE) in terms of weight and number for the different tow durations were compared. Although, the mean catch rate expressed as mean CPUE was found to be consistently higher in the 15-min haul, the difference was not statistically significant from that of 60 and 120-min hauls. Within and between hauls variation in catch rate of six species (as determined by SIMPER analysis) was studied using univariate GLM with tow duration and speed as categorical predictors. The catch rates of three species *Trichiurus lepturus, Lactarius lactarius and Uroteuthis (Photololigo) duvauceli* were found to be significantly different due to tow duration effect, but neither speed nor the interaction effect had any significant effect on the catch rates for these species. The mean diversity, dominance and evenness indices showed no significant difference among the hauls of different tow durations. Based on the results of the study, it is concluded that the short duration tows of 15-min are as effective as the 60 and 120- min tows for estimating catch per unit effort in terms of total weight, number and diversity indices.

*Keywords:* **tow duration, retention, high opening bottom trawl, SIMPER, diversity**

Although trawling has emerged as one of the important methods of capture of aquatic species, the basic knowledge on underwater gear performance as well as fish behaviour in the catching process is limited. Various modifications have been proposed to improve the efficiency of catch, fuel consumption and selectivity. Experimental trawling for trawl efficiency studies carried out along the Indian coast varies from 1 to 3 h, where tow duration can have major impact on the catch per unit effort (CPUE) and diversity of species apart from the design considerations of the gear. Longer tow duration often results in large quantities of catch, with large number of species, which requires extended sorting times and large sub-samples have to be derived for further analysis. One of the methods to reduce this sampling error is to reduce the tow duration and increase the number of tows of shorter duration in the specified ground, which will increase the precision of the experiments to determine CPUE (Cervino & Saborido-Rey, 2006; Folmer & Pennington, 2000; Pennington & Vølstad, 1991; Wieland & Storr-Paulsen, 2006).

Studies on the effect of tow duration on the catch rate showed an increase in the catch rate, when the towing time was reduced from thirty minutes to fifteen minutes or less with no effect on the size composition of the species (Battaglia *et al.*, 2006; Godø *et al.*, 1990; Somerton *et al.*, 2002; Warburton, 1989; Wassenberg et al., 1998). Godø *et al.* (1990) explained the increase in catch per unit effort (CPUE) with short duration hauls as either due to the underestimation of effective swept area or as a result of time-varying trawl catchability, described as the surprise reaction of the

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fishes during the initial phase of the capture when they are near the trawl mouth. This time typically lasts for a few minutes and the fishes thereupon either escape or are trapped in the codend. This phenomenon was hypothesized as 'catching by surprise' by Godø *et al.* (1990). The time before and after the actual tow in which the net continues to fish and which is not taken into consideration for the CPUE calculations called the end-stage effect is also proposed to be one of the reasons for high catch rates in the short duration hauls (Battaglia *et al.*, 2006; Godø *et al.*, 1990). End-stage effects have more impact on the short duration tows due to the error factor (Battaglia *et al.*, 2006).

Studies on impact of varying tow durations on the catch characteristics are scarce in Indian waters. Keeping in consideration of multi-species nature of Indian fisheries, a differential pattern of catch rate of the species is also expected by altering duration of trawling that may have influence on trawl efficiency. Hence, the present study aimed to determine the effect of tow duration and towing speed on the overall retention and escapement CPUE and the individual differences in catch rate of selected species in a standard bottom trawl operated along Veraval coast.

## Materials and methods

The trawling experiments were carried out off Veraval (20°45′-20°55′ N latitude and 70°10′-70°20′ E longitude) situated along North West coast of India. A 15.5 m long stern trawler "MFV Sagarkripa" equipped with 125 hp engine was employed for the trawling operations in the depth range of 40–50 m. A commonly used bottom trawl net i.e. 34 m high opening bottom trawl with 40 mm diamond mesh codend, fabricated with 2.0 mm Ø HDPE twine was used throughout the experimental trawling operations. A codend cover of 20 mm mesh size made up of 1.25 mm Ø PA twine was used to determine the escapement rate from the codend. A pair of V-form otterboards (1.36 m x 0.79m, 80 kg) was used for horizontal opening of the trawlnet. The bridle and sweep lengths were fixed as 10m and 20 m respectively since changes in the sweep lengths can affect the catch rate and species composition (Engås & Godø, 1989; Strange, 1984). The scope ratio (warp:depth) during the entire experiment and at all depths was fixed at 5.0. The mean mesh size of the codend during the operations was 39 mm ± 1.23 (measured using a hand-held wedge type gauge). The speed of the vessel was maintained at 1.67 ± 0.05 and 2.62 ± 0.06 kt (0.87± 0.03 and 1.36 ± 0.03 $ms^{-1}$) respectively for the trials.

The trawling operations were randomly conducted and restricted to the predefined depth zone of 20-40m. Operations with three tow durations were conducted on the same day between 8:00 to 13:00 hours. The trawler after completing an operation in a straight stretch was turned 90° and then steamed for 0.5 h at 5 kt and the next trawling operation (towing time randomly fixed) was carried out parallel to the earlier tow. The order and schedule of tow duration was varied everyday in order to reduce error in the experiments.

The catches when brought to the deck were sorted, weighed, enumerated, and length of individual fish measured to the lowest centimeter below. Data for the study was collected from December 2005 to November 2006, except during the official fishing ban period of May-August. Constant gear settings and retrieval procedures were adopted to reduce variability in the operations.

To stabilize the variance and normalize the data, the CPUE values were log transformed ($\log_{10}$) (Wassenberg et al., 1998; Wieland & Storr-Paulsen, 2006) and one way ANOVA was used to compare variations in CPUE values (catch in $kg.h^{-1}$) for different tow durations. Stations comprising exclusively of *Acetes* sp. and hauls in which juveniles contributed more than 90 % of total catch were not considered for the analysis, since this may skew the results.

SIMPER routines of PRIMER 5.2.8 (Clarke and Warwick, 1994) software was used to identify the species that contributed the highest percentage in terms of abundance and similarity within and between the hauls of different tow durations. The catch in numbers was log (x+1) transformed and used for this analysis.

Univariate General Linear Model (GLM) routines of SPSS ver.12 software was used to compare catch rate variation (expressed as catch per minute) among species due to effect of tow duration, speed and interaction effects of speed and tow duration. The model used for the analysis is $X= \mu + a + b + a.b + \Sigma$, where $\mu$ is the mean CPUE of the species in number, 'a' is the effect due to haul duration, 'b' is the effect due to speed of the vessel, 'a.b' is the interaction effects of speed and haul duration and $\Sigma$ is the error factor. Scheffe's test was carried out for post-hoc comparison of means.

The profile of species in different tow durations were studied by using various diversity indices as per Magurran (2004). Total species (S), Margalef richness (d), Shannon-Weiner Index (H') and Pielou's evenness index (J') were worked out by diversity routines of PRIMER 5.2.8 and reciprocal Simpson's index (1/D) and Smith and Wilson evenness Index ($E_{Var}$) were worked out using MS Excel. In order to prevent variance due to different sample sizes (i.e. the number of tows), the indices were bootstrapped at 95% confidence interval with fixing the number of tows at 100 for the three tow durations.

## Results and Discussions

The mean retention rates in codend and the overall retention (codend and cover catches combined) was higher in the 15min hauls compared to the 60 and 120-min hauls (Table 1). One way ANOVA carried out to find effect of haul durations in mean catch rates, escapement rate and the total catch in terms of weight and number (overall codend and cover catches) showed no significant difference between the hauls ($P$>0.05). Similarly, the escapement rates (in terms of both biomass and number) were higher for the 60-minute hauls, followed by the 15 and 120-min hauls, but were not significantly different ($P$>0.05).

The present results indicate that there are no changes in the overall retention CPUE, both in terms of number and weight due to the haul duration effect. This result is in conformity with the results of earlier works (Battaglia *et al.*, 2006; Godø *et al.*, 1990; Warburton, 1989; Wieland & Storr-Paulsen, 2006). The overall escapement from the codend is also not seen to be changed by the effect of haul duration, but the 60 min hauls was found to have more escapement in terms of weight and number. The reason for this can be that more fishes seem to escape after the initial erratic response during the period of trawl stabilization and this may have continued for this period (Godø *et al.*, 1990). Higher CPUE in the 120-minute hauls can be due to setting in of the trawl geometry and catch stabilization (Warburton, 1989) and a well defined optomotor response

Table 1. Comparison of retention and escapement CPUE ($kg.h^{-1}$) for hauls with different tow durations.

| | 15 min haul (n=13) Mean ± S.E. | 60 min haul (n=32) Mean ± S.E. | 120 min haul (n=22) Mean ± S.E. |
|---|---|---|---|
| Retention Weight ($kg.h^{-1}$) (codend) | 23.63 ± 6.86 | 11.95 ± 2.72 | 10.39 ± 1.55 |
| Retention Number (no. $h^{-1}$) (codend) | 642.39 ± 492.39 | 458.25 ± 175.17 | 514.09 ± 246.10 |
| Escapement Weight ($kg.h^{-1}$) (cover) | 8.94 ± 3.16 | 14.28 ± 7.41 | 5.74 ± 1.18 |
| Escapement Number (no. $h^{-1}$) (cover) | 620.87 ± 285.23 | 2547.13 ± 1727.83 | 452.43 ± 113.84 |
| Total Weight ($kg.h^{-1}$) (codend and cover) | 32.57 ± 8.57 | 26.22 ± 9.23 | 16.13 ± 2.14 |
| Total number (no. $h^{-1}$) (codend and cover) | 1272.08 ± 535.92 | 3005.38 ± 1889.30 | 966.52 ± 286.99 |

* The difference in means for all the findings were not significantly different at P=0.05.

(Breen et al., 2004; Godø et al., 1990; Kim & Wardle, 2003).

The results of SIMPER analysis (Table 2) showed that six species viz. *Lactarius lactarius, Trichiurus lepturus, Sepiella inermis, Otolithes cuvieri, Uroteuthis (Photololigo) duvauceli,* and *Thryssa dussumieri* contributed the maximum to similarity in the catches of different tow duration. Hence these six species were selected to study the individual level contribution to overall catch in different tow durations using univariate GLM.

Average similarity of species within the catches of a particular haul was found to be the lowest for 15 and 60 min hauls (Table 2). The highest was recorded for the species in the 120 min hauls (31.46%), which showed that only a few species were contributing to the catches in this haul, whereas in the 15 and 60 min hauls, the species composition was more even, with the average similarity of 60 min hauls (21.21%) being the least. Pair wise comparison of the average dissimilarity index shows the same trend, the dissimilarity being highest between the catches of 15 and 60 min hauls and lowest between the 60-120 and 15-120 min hauls.

Using haul duration and speed as categorical predictors, the results of GLM (Table 3), showed significant difference ($P$<0.05) in mean catch rates between the hauls for *L. lactarius, T. lepturus,* and *U. (Photololigo) duvauceli.* The catch rate of other species did not vary significantly between different haul durations ($P$>0.05). The speed of the towing and the interaction effect of speed and duration of haul did not have any significant change in the catch rates for the species studied ($P$>0.05). Univariate GLM performed to find the effect of within haul variation due to type of species, speed of the haul and the interaction effects on the catch rates, was found to be significant only for the 120 min haul, whereas, the effect of speed and the interaction was not significant (P>0.05) (Table 3). The speed effect in our experiment (change in the speed of 1.6 to 2.6 kt) was not found to change the catch rate of the six species considered for the study.

In the 120-min hauls, the mean CPUE of *T. lepturus* was significantly higher than the other species. This result again points to some sort of selective capture of fast swimming species in the 120 min hauls. This is contrary to many findings which report high catch rates in the short duration hauls ((Battaglia *et al.,* 2006; Godø *et al.,* 1990; Somerton *et al.,* 2002; Warburton, 1989; Wassenberg *et al.,* 1998). All the experiments were carried out during the same time of the day (8 AM to 12 PM) and the average temperature remained 27± 0.7 $^0$C and hence the effect of light conditions or the temperature affecting the efficiency of capture was nullified (Glass & Wardle, 1989; Ozbilgin and Wardle, 2002). The exact mechanism happening here is not clearly understood.

The mean catch rate for fast swimming species like *T. lepturus* and *O. cuvieri* was lower in the 60- min haul than the 120-min haul (Table 4). These observations when related with the overall escapement rates for the 60-min hauls reveal that more escapements occurs on increasing the tow duration from 15 min to 120 min for these species (Table 4). The reason for higher catches for these species in the 120-min hauls may be due to the catch stabilization effect (Warburton, 1989) or a well developed optomotor response mechanism setting in after the initial period of gear asymmetry, after which the fishes swim parallel to the net and finally gets trapped in the net (Breen *et al.,* 2004; Godø *et al.,* 1990; Kim & Wardle, 2003).

This study was not designed to detect 'catch by surprise' or the end-stage effects (Battaglia et al., 2006; Godø et al., 1990) or the escapement behavior below the footrope (Godø and Walsh, 1992). So the individual fish capture behavior near the vicinity of the trawl could not be quantitatively assessed, but some overall observations were found to be consistent with the findings of Godø *et al.* (1990) and Walsh & Godø (2003) who reported higher proportion of large and fast swimming species caught in the short haul tows of 15 min duration than in 30 min tows.

The bootstrapped mean indices of diversity estimated based on abundance of

Table 2. SIMPER results of different tow durations for species that contributed to at least 90% of differences: average abundance ($\bar{Y}$); average similarity ($\bar{Si}$); s.d. (standard deviation); percentage contribution to similarity (% $\bar{Si}$); average dissimilarity ($\bar{\delta}_i$).

| Species | $\bar{Y}$ | $\bar{Si}$ | $\bar{Si}$/s. d. | % $\bar{Si}$ | $\sum \bar{Si}$ (%) |
|---|---|---|---|---|---|
| - 15 min haul = **22.54** | | | | | |
| *Trichiurus lepturus* | 92.20 | 6.83 | 0.76 | 30.28 | 30.28 |
| *Thryssa dussumieri* | 3.40 | 4.68 | 1.00 | 20.77 | 51.05 |
| *Lactarius lactarius* | 3.90 | 2.96 | 0.43 | 13.14 | 64.19 |
| *Uroteuthis (Photololigo) duvauceli* | 2.80 | 2.09 | 0.49 | 9.25 | 73.44 |
| *Sepiella inermis* | 2.70 | 1.55 | 0.50 | 6.85 | 80.30 |
| *Lagocephalus spadiceus* | 0.90 | 1.13 | 0.36 | 5.03 | 85.33 |
| Jellyfish | 0.50 | 0.86 | 0.38 | 3.81 | 89.13 |
| *Otolithes ruber* | 2.70 | 0.70 | 0.38 | 3.10 | 92.23 |
| $\bar{Si}$- 60 min haul= **21.21** | | | | | |
| *Uroteuthis (Photololigo) duvauceli* | 20.33 | 4.96 | 1.00 | 23.38 | 23.38 |
| *Sepiella inermis* | 8.93 | 4.03 | 0.96 | 19.01 | 42.40 |
| *Trichiurus lepturus* | 13.50 | 2.98 | 0.67 | 14.03 | 56.42 |
| Jellyfish | 2.60 | 2.06 | 0.55 | 9.69 | 66.11 |
| *Otolithes cuvieri* | 226.17 | 1.58 | 0.44 | 7.43 | 73.54 |
| *Otolithes ruber* | 70.37 | 0.62 | 0.29 | 2.93 | 76.47 |
| *Opisthopterus tardoore* | 9.63 | 0.48 | 0.24 | 2.26 | 78.73 |
| *Lactarius lactarius* | 6.10 | 0.46 | 0.25 | 2.17 | 80.90 |
| *Johnius glaucus* | 6.47 | $\bar{\delta}_i$0.43 | 0.21 | 2.01 | 82.91 |
| *Epinephelus dicanthus* | 2.87 | 0.37 | 0.16 | 1.73 | 84.64 |
| *Thryssa dussumieri* | 2.23 | 0.34 | 0.24 | 1.60 | 86.24 |
| *Parapenaeopsis stylifera* | 2.07 | 0.31 | 0.20 | 1.45 | 87.69 |
| *Carangoides talamproides* | 1.50 | 0.28 | 0.28 | 1.33 | 89.02 |
| *Dussumieria acuta* | 3.43 | 0.27 | 0.21 | 1.27 | 90.29 |
| $\bar{Si}$-120 min haul= **31.46** | | | | | |
| *Trichiurus lepturus* | 410.82 | 12.64 | 1.49 | 40.16 | 40.16 |
| *Sepiella inermis* | 44.45 | 4.53 | 0.98 | 14.41 | 54.57 |
| *Uroteuthis (Photololigo) duvauceli* | 37.41 | 2.70 | 0.77 | 8.57 | 63.13 |
| *Johnius glaucus* | 8.50 | 2.12 | 0.55 | 6.73 | 69.86 |
| *Parapenaeus longipes* | 261.64 | 1.50 | 0.38 | 4.76 | 74.63 |
| *Thryssa dussumieri* | 5.73 | 1.31 | 0.48 | 4.17 | 78.80 |
| *Otolithes ruber* | 57.68 | 1.29 | 0.38 | 4.09 | 82.89 |
| *Lagocephalus spadiceus* | 8.59 | 1.10 | 0.37 | 3.51 | 86.40 |
| *Portunus sanguinolentus* | 5.14 | 0.98 | 0.46 | 3.10 | 89.50 |
| *Pampus argenteus* | 2.86 | 0.73 | 0.34 | 2.31 | 91.81 |

| Comparison between different tow durations($\bar{\delta}_i$) | |
|---|---|
| 15 min and 60 min | 82.84 |
| 15 min and 120 min | 78.66 |
| 60 min and 120 min | 78.89 |

Table 3. Univariate GLM results for the change in catch rate (catch per minute) for individual species with time of haul and speed as factors

| Species | Source | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| *Lactarius lactarius* | Haul duration | 2 | 2.255 | 10.612 | 0.002* |
| | Speed | 1 | 0.074 | 0.347 | 0.567 |
| | Haul duration : speed | 2 | 0.137 | 0.644 | 0.542 |
| *Trichiurus lepturus* | Haul duration | 2 | 1.287 | 4.538 | 0.018* |
| | Speed | 1 | 0.004 | 0.012 | 0.912 |
| | Haul duration : speed | 2 | 0.410 | 1.447 | 0.249 |
| *Sepiella inermis* | Haul duration | 2 | 0.606 | 2.379 | 0.106 |
| | Speed | 1 | 0.036 | 0.015 | 0.902 |
| | Haul duration : speed | 2 | 0.255 | 0.140 | 0.869 |
| *Otolithes cuvieri* | Haul duration | 2 | 0.102 | 0.392 | 0.679 |
| | Speed | 1 | 0.050 | 0.192 | 0.664 |
| | Haul duration : speed | 2 | 0.396 | 1.516 | 0.237 |
| *Uroteuthis (Photololigo) duvauceli* | Haul duration | 2 | 1.170 | 3.988 | 0.027* |
| | Speed | 1 | 0.042 | 0.142 | 0.708 |
| | Haul duration : speed | 2 | 0.103 | 0.351 | 0.707 |
| *Thryssa dussumieri* | Haul duration | 2 | 0.487 | 2.051 | 0.146 |
| | Speed | 1 | 0.104 | 0.440 | 0.512 |
| | Haul duration : speed | 2 | 0.114 | 0.479 | 0.624 |
| Univariate GLM results for effect of species and speed on the catch rate (catch per minute) for different haul durations | | | | | |
| Haul duration | | | | | |
| 15 min | Species | 5 | 0.386 | 1.541 | 0.209 |
| | Speed | 1 | 0.001 | 0.003 | 0.956 |
| | Species : Speed | 5 | 0.217 | 0.865 | 0.517 |
| 60 min | Species | 5 | 0.542 | 2.119 | 0.069 |
| | Speed | 1 | 0.462 | 1.806 | 0.182 |
| | Species : Speed | 5 | 0.179 | 0.700 | 0.625 |
| 120 min | Species | 5 | 1.973 | 6.724 | 0.001* |
| | Speed | 1 | 0.128 | 0.436 | 0.511 |
| | Species : Speed | 5 | 0.204 | 0.696 | 0.628 |

* Significant at (P<0.05)

species caught in hauls of three different duration showed no significant difference between the means (*P*>0.05) (Table 5). Total species and reciprocal Simpson's index was lower in the 15-min hauls. The 60-min haul was seen to score over other hauls in all except for the reciprocal Simpson's index but the differences are not significant (*P*>0.05).

The 60 min duration hauls recorded higher values for indices like total species (S), Shannon (H') and Margalef (d), indicating higher diversity in the retained catch (Magurran, 2004). Similarly, out of three evenness indices, Simpson's reciprocal index (1/D) and Smith & Wilson's evenness index ($E_{var}$) was highest for 120-min hauls, whereas Pieolu's evenness index (J') was higher for 60 min hauls. Although it's difficult to ascertain the superiority of any evenness index, the Smith & Wilson's evenness index ($E_{var}$) has been proposed to be the most satisfactory evenness measure (Magurran, 2004). The comparatively lower Simpson's index noted for 15-min hauls can be attributed to the nature of the index itself, which is heavily weighted towards the most abundant species in the sample and less sensitive to species

Table 4. Difference in catch rate (catch per minute) for species contributing more than 90 % in abundance in the hauls of different tow durations

| Species | 15 min hauls Mean (CPUE) | 60 min hauls Mean (CPUE) | 120 min hauls Mean (CPUE) |
|---|---|---|---|
| *Lactarius lactarius* | $31.20 \pm 18.39_1^a$ | $22.875 \pm 5.75_1^a$ | $1.50 \pm 0.65_1^b$ |
| *Trichiurus lepturus* | $54.80 \pm 14.45_1^a$ | $23.75 \pm 7.42_1^b$ | $46.91 \pm 10.15_2^a$ |
| *Sepiella inermis* | $21.60 \pm 10.32_1^a$ | $11.65 \pm 2.14_1^a$ | $7.63 \pm 2.46_1^a$ |
| *Otolithes cuvieri* | $23.20 \pm 16.27_1^a$ | $8.67 \pm 1.80_1^a$ | $11.17 \pm 4.53_1^a$ |
| *Uroteuthis (Photololigo) duvauceli* | $24.67 \pm 9.82_1^a$ | $18.82 \pm 4.57_1^a$ | $7.03 \pm 1.82_1^b$ |
| *Thryssa dussumieri* | $16.00 \pm 5.89_1^a$ | $7.27 \pm 1.97_1^a$ | $6.25 \pm 1.82_1^a$ |

Mean CPUE of species sharing a common superscript in a row are not significantly different due to hauls duration effect ($P>0.05$).
Mean CPUE of species sharing a common subscript in a column are not significantly different in the same haul duration ($P>0.05$).
Scheffe's test used for the posthoc analysis.

Table 5. Diversity indices for the retention catch in hauls of 15, 60 and 120 minute tow duration.

| Tow duration (minute) | Total species (S) | Shannon (H') | Pielou (J') | Simpson's reciprocal (1/D) | Smith & Wilson ($E_{var}$) | Margalef (d) |
|---|---|---|---|---|---|---|
| 15 | 34 ± 2 | 1.273 ± 0.05 | 0.361 ± 0.025 | 1.765 ± 0.056 | 0.449 ± 0.013 | 4.633 ± 0.295 |
| 60 | 65 ± 2 | 2.194 ± 0.014 | 0.515 ± 0.004 | 4.043 ± 0.052 | 0.535 ± 0.003 | 6.676 ± 0.211 |
| 120 | 59 ± 2 | 1.963 ± 0.009 | 0.482 ± 0.004 | 4.172 ± 0.03 | 0.544 ± 0.002 | 5.75 ± 0.204 |

* Bootstrap estimates were calculated at 95% confidence limit and the number of tow durations was fixed at 100.
** No significant difference were found ($P>0.05$) between the means of five diversity indices among different hauls durations.

richness (Magurran, 2004). Although there was variation in the diversity indices among hauls of different tow durations (Table 5) no significant difference was found ($P>0.05$). No significant difference observed in the species profile in the hauls of different tow durations may be attributed to the similar escapement response of the species to the towed gear. This indicates the absence of 'catch by surprise" or the end-stage effects in the 15 min tow duration, and suggests that these effects may be taking place prior to the minimum tow time of 15 min. Stabilization of the trawl geometry also may be taking place before 15 min. Hence more studies are needed with tow timings less than 15 min to study end-stage effects of the gear.

Since the escapement pattern in a trawl net may vary across the sections, whole trawl selectivity studies can help in quantifying the nature of escapement of the different species under consideration (Polet, 2000). The results from these studies will also help in development of target specific trawl systems by taking into effect the behavioral tendencies of the different species.

From the results, it is concluded that the 15 min hauls are as effective as the 60 min or the 120 min hauls for the speed ranges 1.5- 1.8 and 2.5-2.8 kt and in a depth range 40-50m in terms of catch efficiency.

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