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Mesh Selectivity of the Shrimp Trawl Fishery in the Western Coastal Waters of Sri Lanka

P.A.A.T. JAYAWARDANE[1,2*], R.P.P.K. JAYASINGHE[2] and T. UPASENA[2]

[1]Maliseet Nation Conservation Council (MNCC)
150 Cliffe Street, Suite 8, Fredericton
New Brunswick E3A 0A1 Canada
[2]Marine Biological Resources Division
National Aquatic Resources Research and Development Agency
Crow Island, Mattakkuliya, Colombo 15, Sri Lanka

Abstract

The selection properties of the shrimp trawl gears in the west coast of Sri Lanka were investigated using the covered cod end method. Trawling was conducted using two craft types, non-mechanised and mechanised in the seas north and the south of the sea mouth of the Negombo lagoon, respectively. The cod end mesh sizes experimented with non-mechanised trawls were 16, 18, 20 and 26 mm while with the mechanised trawls along with the above, an additional mesh size of 23 mm was used. Both trawls exploited juveniles of valuable shrimps. The shrimp catch rates of mechanised trawls for depths <5 m were significantly higher than the same estimated for the depths >5 m ($P<0.05$). The estimated 50% retention lengths for shrimps and fish increased with the elevating cod end mesh size for both craft types. For *Metapenaeus dobsoni* minimum and maximum relative yield/recruits were estimated for fishing with 18 and 23mm cod ends, respectively. For *Parapenaeopsis coromandelica* maximum values for relative yield/recruit were estimated for 18 mm cod ends. The estimated optimum exploitation levels were highest for fishing with 23 mm cod ends for two major shrimp species exploited by the trawl fishery. The corresponding relative values/recruit for both species were also highest for the same.

* Corresponding author. Tel.: + 1 506 472 1885, Fax: + 1 506 472 8543
E-mail address: arunajayawardane@yahoo.com.sg

Introduction

As a considerable portion of the continental shelf around Sri Lanka has rocky bottoms, shrimp trawling is restricted to smooth muddy areas especially near the estuarine and coastal waters where influxing rivers bring more nutrients during the rainy season (Jayawardane and Dayaratne 1994).

Off the west coast of Sri Lanka, there are two trawling grounds for shrimps, situated north and south of the sea mouth of the Negombo lagoon, where traditional sail driven large dug out canoes (non-mechanised trawls) and 3.5 t wooden boats (mechanised trawls) are operated (Sanders et al. 2000).

The two types of trawls operating in the seas off west coast, remove substantial quantities of juveniles (Jayawardane et al. 2004). Except for the trawl selectivity studies conducted by Siddeek (1986) for *Penaeus semisulcatus* (Penaeidae), off the northwestern coast of Sri Lanka, no information is available for trawl selection of penaeid shrimps from coastal fisheries of Sri Lanka. The present investigation was undertaken to evaluate the selection properties of the trawl gears used for shrimp fishery in the western coastal waters of Sri Lanka. An analysis to determine the optimum mesh sizes to be used in the cod ends and studies to evaluate the biological impact of trawling on the shrimp resources in the west coast were also undertaken. Information of this calibre would be of immense use for the management of shrimp trawl fishery in the western coastal waters of Sri Lanka.

Materials and Methods

Collection of data

Covered cod end experiments were conducted using non – mechanised trawls in the northern part and mechanised trawls in the southern part of the trawling ground in the western coastal waters of Sri Lanka (Fig. 1) in March/April and November/December 2002, respectively. Commercial shrimp trawlers using nets of similar design and dimensions to gears used in the fishery were employed for the investigation. Four different cod end mesh sizes 16 (the existing cod end mesh size used by both craft types), 18, 20 and 26 mm were used for fishing with the traditional non – mechanised trawls. The same mesh sizes plus a 23 mm mesh size were used during the experimental fishing with mechanised trawls.

Forty-five hauls with non-mechanised and 60 fishing hauls with mechanised trawls were conducted over 11 and 15 fishing days, respectively. Prior to the experimental fishing the cod end protective net or 'chafer' was removed and a fine meshed cover (stretched mesh = 7 mm) was connected to the cod end. After each haul, the shrimp and fish caught inside the cod end and the cover were collected separately, and the total catch and species composition were recorded onboard. In addition, information such as specification of the craft and gear and details of fishing operations (operational depth, position, trawling speed and the duration of fishing hauls) were recorded. Representative samples were drawn separately from the catches of two different venues and taken to the laboratory for further investigations. In the laboratory these samples were sorted by species for fish and by both species and sex for shrimps. The total lengths of all the shrimps and fish in the samples were measured to the nearest 0.1 cm using a measuring board and total weight of the entire sample was determined (kg). These were then raised to the respective total catches.

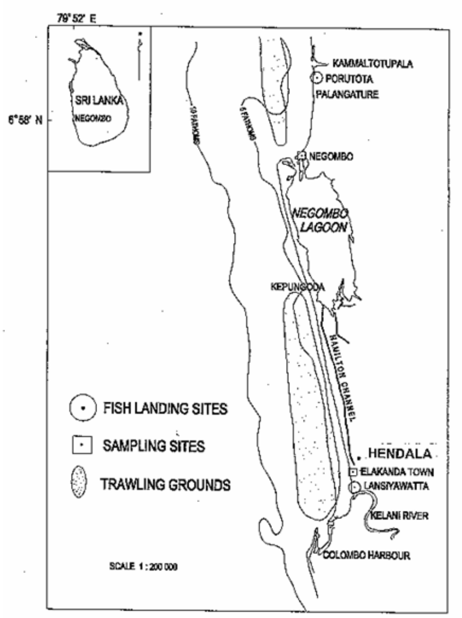


Figure 1. Map showing trawling grounds off the west coast of Sri Lanka

Analysis of data

The mean catch, in kg per trawl hour, was considered as the catch per unit effort with respect to each craft category and also for fishing with the cod ends of different mesh sizes.

The effects of factors other than the fishing effort on shrimp/fish yields from the fishing operations were investigated using the General Linear Model (SPSS 1999).

Trawl selection ogives for different shrimp and finfish varieties for the fishing conducted with the cod ends of different mesh sizes were estimated using the logistic model that resembles the cumulative normal distribution.

$$S_L = 1/[1+ exp\ (S_1 - S_2\ X\ L)]$$

Where,
S_L is the fraction retained in the cod end of fish length L,
L, the length interval midpoint and S_1 and
S_2 are constants (Paloheimo and Cadima 1964; Kimura 1977; Hoydal et al. 1982).

The rearranged version of the above equation, $ln\ [1/\ (S_L - 1)] = S_1 - S_2\ X\ L$ was used to estimate the constants, S_1 and S_2 (using a regression analysis between the $ln\ [1/(S_L - 1)]$ and the mid length), and these values were then used to estimate the fraction of shrimps and fish of different size categories retained by the cod ends of different mesh sizes.

The 25, 50 and the 75% retention lengths ($L_{25\%}$, $L_{50\%}$ *and* $L_{75\%}$) of shrimp/fish species caught were estimated using following equations.

$$L_{25\%} = (S_1 - ln\ 3)/S_2$$
$$L_{50\%} = S_1/\ S_2$$
$$L_{75\%} = (S_1 + ln\ 3)/S_2$$

The relationships between L50% and cod end mesh size were estimated for major shrimp/fish species caught among the trawl catches using regression analysis.

To evaluate the biological impact of trawling on shrimp resources in the western coastal waters of Sri Lanka, a relative yield per recruit analysis was performed using the FiSAT computer program (Gayanilo and Pauly 1997) separately for *Metapenaeus dobsoni* and *Parapenaeopsis coromandelica* (Penaeidae) exploited by mechanised trawls. The following estimated values for population parameters (L∞ and K) and the natural mortality (M) for these two species (Table 1) were used for the analysis.

Since the price of shrimps varies depending on their sizes, a relative value/recruit analysis was also conducted and it was assumed that the value of shrimps caught by the cod ends >20 mm stretched mesh was 50% greater than the value of the shrimps caught by the cod ends <20 mm.

Table 1 Population parameters and natural mortality of shrimps, *M. dobsoni* and *P. coromandelica*

Species	L∞ (cm) , K and M ($year^{-1}$)	Source
M. dobsoni		
Male	11.49, 1.02 and 1.72	
Female	12.8, 1.73 and 2.51	Jayawardane et al. (2003a)
P. coromandelica		
Male	11, 1.2 and 2.75	
Female	11.2, 1.2 and 2.69	Jayawardane (2005)

Results

Fishing crafts, gear and operation

Shrimp trawling is conducted using two types of crafts *viz*. 3.5 t wooden boats (mechanised trawls, 10.4 m in length and powered by 25-40 HP engines) and traditional sail driven large dug out canoes (non-mechanised trawls, 12 m in length and the nets are towed under the sail power) in the shallow seas off the west coast. The use of non-mechanised trawls occurs outside the lagoon, to a distance of around 10-15 km north of the entrance. On the other hand the operations of mechanised trawls were from the Hamilton canal (Fig. 1) on grounds located about 15-20 km south of the entrance of Negombo lagoon.

The trawl net used for experimental fishing with non-mechanised trawls is long, narrow and cone shaped, with a small cod-end about 1m in length and a larger body of about 7 m. The width of the opening of the net was around 5.64 m. The mechanised trawls used a much larger net, with a cod end of about 2.5 m in length and a body of about 12 – 15 m. The width of the opening of the net was around 15 m.

The operational depth varied from 5.4 – 9.9 and 3.5 – 12.6 m for non-mechanised and mechanised crafts, respectively. The estimated mean true fishing time (duration of a haul) for non-mechanised trawls was 27.16 min (SD = 10.98) while for mechanised trawls the same was estimated at 29.56 min (SD = 7.35). The mean trawling speed was estimated at 3.43 km•hr^{-1} (SD = 0.57) for mechanised trawls which was relatively higher when compared to the similar estimation made for non-mechanised trawls which was 1.7 km• hr^{-1} (SD = 0.18).

Catch rates

The estimated mean fish catch rates for non-mechanised trawls had been on a declining trend with the elevating cod end mesh size (Fig. 2a). The maximum and the minimum mean catch rates were recorded for fishing with the cod ends, 16 and 26mm respectively (14.85 and 1.78 kg•hr^{-1}, respectively). Likewise, the estimated mean shrimp catch rates followed almost a similar trend. Under the similar circumstances the mean total catch rates estimated for cover had been on an increasing trend (minimum and the maximum catch rates, 0.02 and 0.53 kg•hr^{-1} were estimated for fishing with the cod ends, 16 and 26 mm, respectively). However, no such clear variation pattern of catch rates was observed with mechanised trawls (Fig. 2b). For both shrimps and fish, minimum catch rates were recorded for fishing with 23 mm cod ends (0.87 and 1.86 kg•hr^{-1}, respectively). Maximum catch rates were recorded for 18 mm cod ends for shrimps (3.58 kg•hr^{-1}) and 26 mm cod ends for fish (9.12 kg•hr^{-1}).

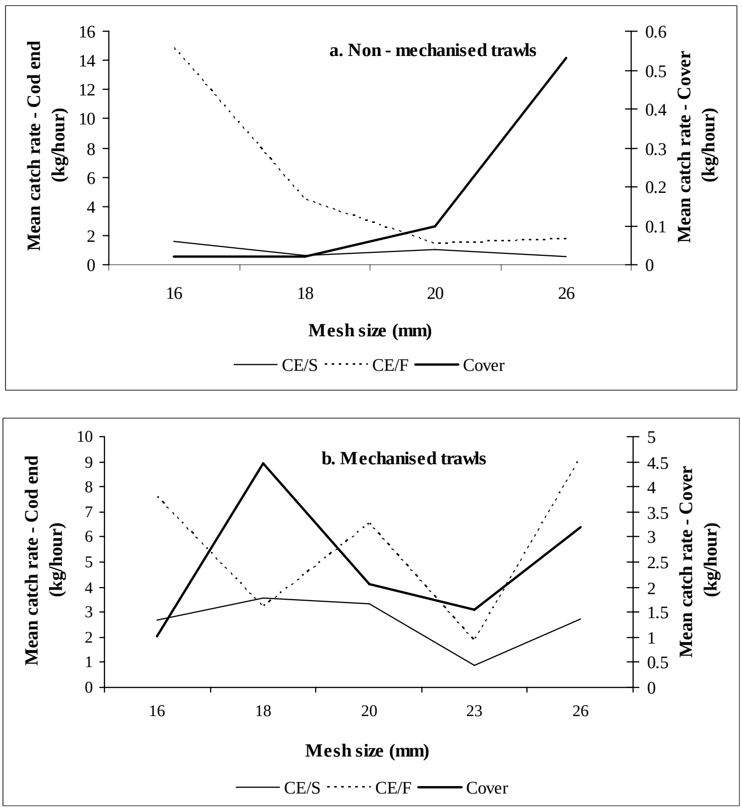


Figure 2. The estimated mean catch rates for fishing with cod ends of different mesh sizes. CE/S - Cod end/shrimps; CE/F - Cod end/fish

The general linear model indicated that there was a significant difference between the estimated mean catch rates of shrimps for fishing with cod ends of different mesh sizes for mechanised trawls (Table 2). The estimated mean catch rate for 23 mm cod end was significantly lower than the rest (P<0.05) (Table 3). The analysis also indicated that the estimated mean shrimp catch rates of mechanised trawls for depths <5 m were significantly higher than the same estimated for the depths >5 m (P<0.05). The reverse was true in terms of fish catch rates of mechanised trawls. For mechanised trawls, the estimated mean shrimp catch rate for different fishing days were also significantly different (P<0.05). However, no such difference was observed in terms of non – mechanised trawls and the interactions were also not significant (Table 2).

Table 2. Summary of the general linear model performed on the estimated catch rates for experimental fishing with cod ends of different mesh sizes

Source	Sums of squares	Degrees of freedom	Means squares	F - value	Level of significance	r^2
Non-mechanised trawls						
Shrimp catch rate						
Corrected model	4.57	18	0.254	1.232	0.34	0.581
Intercept	1.858	1	1.858	9.016	0.008	
Fishing depth	0.901	1	0.901	4.372	0.053	
Mesh size	0	0				
Fishing date	1.057	6	0.176	0.854	0.548	
Fishing depth x Mesh size	0	0				
Fishing depth x Fishing date	1.082	5	0.216	1.05	0.423	
Mesh size x Fishing date	0	0				
Fishing depth x Mesh size x Fishing date	0	0				
Error	3.298	16	0.206			
Total	9.176	35				
Corrected total	7.868	34				
Fish catch rate						
Corrected model	6.905	18	0.384	3.362	0.009	0.791
Intercept	4.655	1	4.655	40.796	0	

Table 2. Summary of the general linear model performed on the estimated catch rates for experimental fishing with cod ends of different mesh sizes (continued)

Source	Sums of squares	Degrees of freedom	Means squares	F - value	Level of significance	r^2
Fishing depth	0.031	1	0.031	0.268	0.612	
Mesh size	0	0				
Fishing date	1.242	6	0.207	1.815	0.159	
Fishing depth x Mesh size	0	0				
Fishing depth x Fishing date	1.063	5	0.213	1.863	0.157	
Mesh size x Fishing date	0	0				
Fishing depth x Mesh size x Fishing date	0	0				
Error	1.825	16	0.114			
Total	16.179	35				
Corrected total	8.731	34				
Mechanised trawls						
Shrimp catch rate						
Corrected model	8.27	17	0.486	6.109	0	0.748
Intercept	0.216	1	0.216	2.713	0.109	
Fishing depth	3.096	1	3.096	38.881	0	
Mesh size	0.366	1	0.366	4.601	0.039	
Fishing date	2.63	10	0.263	3.302	0.004	
Fishing depth x Mesh size	0	0				
Fishing depth x Fishing date	0	0				
Mesh size x Fishing date	0.035	1	0.035	0.438	0.512	
Fishing depth x Mesh size x Fishing date	0	0				
Error	2.787	35	0.08			
Total	13.793	53				
Corrected total	11.058	52				
Fish catch rate						
Corrected model	8.052	17	0.474	4.681	0	0.695

Table 2. Summary of the general linear model performed on the estimated catch rates for experimental fishing with cod ends of different mesh sizes (continued)

Source	Sums of squares	Degrees of freedom	Means squares	F - value	Level of significance	r^2
Intercept	9.958	1	9.958	98.418	0	
Fishing depth	1.466	1	1.466	14.493	0.001	
Mesh size	0.073	1	0.073	0.724	0.401	
Fishing date	1.694	10	0.169	1.674	0.127	
Fishing depth x Mesh size	0	0				
Fishing depth x Fishing date	0	0				
Mesh size x Fishing date	0.034	1	0.034	0.334	0.567	
Fishing depth x Mesh size x Fishing date	0	0				
Error	3.541	35	0.101			
Total	25.466	53				
Corrected total	11.593	52				

Table 3. Summary of the multiple comparisons of catch rates ($kg \bullet hr^{-1}$) for experimental fishing with cod ends of different mesh sizes (mm) - Mechanised trawls

Mesh size 1	Mean catch rate	Mesh size 2	Mean catch rate	Mean difference	Standard error	Level of significance (P)
Shrimp catch rate						
23	1.9	16	4.58	-0.2967	0.1432	0.046
		18	3.06	-0.5325	0.1156	0
		20	1.92	-0.4481	0.1233	0.001
		26	2.51	-0.3376	0.1156	0.006

Species abundance and composition

Of the different shrimps caught among the non-mechanised trawl catch only *M. dobsoni* made a notable contribution accounting for 13% of the above. The finfish groups leiognathids, sciaenids, engraulidids and *Opisthopterus tardoore* (Pristigasteridae) were also found to make a substantial contribution to the non-mechanised trawl catch which together accounted for 77% of the same (Table 4). On the other hand shrimps made around 35% of the mechanised trawl catch. In addition to *M. dobsoni* that made around 27% of the mechanised trawl catch, a substantial contribution

Table 4. The estimated % composition of the catches of two different venues for fishing with cod ends of different mesh sizes (mm)

Species/group	Overall composition	16 Cod end	Cover	18 Cod end	Cover	20 Cod end	Cover	23 Cod end	Cover	26 Cod end	Cover
Non-mechanised trawls											
M. dobsoni	13.15	99.96	0.04	99.1	0.9	98.22	1.78			76.35	23.65
Other shrimps	2.05	100	0	99.79	0.21	99.45	0.55			91.33	8.67
Leiognathids	5.21	98.57	1.43	98.23	1.77	99.43	0.57			93.22	6.78
Sciaenids	7.19	99.87	0.13	99.75	0.25	98.07	1.93			89.45	10.55
O. tardoore	51.45	99.98	0.02	99.82	0.18	99.79	0.21			87.98	12.02
Thryssa spp.	13.32	99.95	0.05	99.88	0.12	96.95	3.05			65.37	34.63
Crabs	1.35	93.66	6.34	99.41	0.59	100	0			100	0
Others	6.28	98.61	1.39	99.61	0.39	92.19	7.81			86.02	13.98
Mechanised trawls											
M. dobsoni	27.08	98.71	1.29	92.89	7.11	77.02	22.98	50.22	49.78	57.13	42.87
P. coromandelica	6.39	91.25	8.75	72.3	27.7	72.14	27.86	55.93	44.07	36.42	63.58
Other shrimps	1.59	100	0	100	0	97.08	2.92	86.15	13.85	99.7	0.3
Leiognathids	8.22	87.61	12.39	78.03	21.97	90.57	9.43	87.03	12.97	45.07	54.93
Sciaenids	10.65	95.77	4.23	94.98	5.02	66.17	33.83	61.21	38.79	56.95	43.05
O. tardoore	2.79	93.74	6.26	73.74	26.26	89.01	10.99	73.56	26.44	43.54	56.46
Thryssa spp.	2.46	84.85	15.15	53.51	46.49	72.36	27.64	53.91	46.09	7.24	92.76
Lepturacanthus savala	30.01	98.37	1.63	96.67	3.33	100	0	96.57	3.43	99.44	0.56
Others	10.81	69.05	30.95	25.14	74.86	51.18	48.82	69.99	30.01	60.45	39.55

was also made by *P. coromandelica* accounting for 6% of the above. The contributions of the finfish groups, leiognathids, sciaenids, engraulidids and *O. tardoore* to the mechanised trawl catch were low with 24%, while much higher contribution was made by ribbon fish making around 30% of the same (Table 4).

For fishing with both craft types, there was a little difference between the catches in the cod end and the cover in terms of species diversity. However, the estimated species compositions for two different venues and also for trials with the cod ends of different mesh sizes varied substantially (Table 4). Though the existing cod ends of the trawl gears (16 mm) of both craft types retained reasonable quantities of shrimps and the finfish caught among the catches, the escapement rite of the trawl gear used by 3.5 t crafts increased substantially with the increasing cod end mesh size. Especially the mesh sizes greater than 20 mm were found to release reasonable quantities of the valuable shrimps (Table 4). However, the trawl gear used by the traditional crafts showed a little improvement under similar circumstances retaining more than 75% of the valuable shrimps caught even after the cod end mesh size was increased up to 20mm stretched mesh.

The estimated selection ogives

The estimated retention lengths for different shrimp and fish species caught among trawl catches had been on an increasing trend with the increasing cod end mesh size (Table 5; Figs. 3 and 4). The study indicated that the estimated 50% retention lengths of two major shrimp species exploited by the trawl fishery (*M. dobsoni* and *P. coromandelica*) for different cod end mesh sizes were less than the estimated mean lengths at maturity of the same (Jayawardane et al. 2003b). During the experimental fishing with non – mechanised trawls, it was only possible to estimate selection parameters for a few species of finfish and crustacea. In contrast the similar exercise performed with mechanised trawls was of great success with estimation of selection parameters for a number of shrimp and finfish species.

The results of the regression analysis performed between the estimated 50% retention lengths and the cod end mesh size (Table 6) indicated that most of the regression equations explained the variability of 50% retention length well. Of the nine equations estimated the equation between the 50% retention length of *Johnius belangerii* (Sciaenidae) and the cod end mesh size explained around 99% of the variability of the retention length (Table 6). On the other hand the estimated regression equation

Table 5. The estimated selection ogives for different shrimp/fish species

Species name/mesh size	S_1	S_2	L_{25} (cm)	L_{50} (cm)	L_{75} (cm)	Selection factor
Non - mechanised trawls						
18mm						
M. dobsoni (female)	7.39	1.61	3.91	4.59	5.27	2.55
S. ruconius	20.52	6.26	3.10	3.28	3.45	1.82
20mm						
M. dobsoni (male)	6.05	1.46	3.39	4.14	4.89	2.07
female	5.48	1.35	3.24	4.05	4.87	2.03
J. belangerii	4.46	0.64	5.24	6.96	8.67	3.48
26mm						
M. dobsoni (male)	5.09	1.03	3.88	4.95	6.02	1.90
female	1.27	0.35	0.49	3.64	6.79	1.40
T. vitirostris	4.15	0.39	7.86	10.69	13.51	4.11
Mechanised trawls						
16mm						
M. dobsoni (male)	2.11	0.87	1.17	2.43	3.69	1.52
female	1.47	0.75	0.50	1.97	3.43	1.23
P. coromandelica (male)	2.56	0.80	1.83	3.20	4.57	2.00
female	2.01	0.73	1.25	2.76	4.29	1.73
O. tardoore	0.88	0.22	0.99	4.03	9.06	2.52
T. dussumieri	3.67	0.54	4.74	6.77	8.79	4.23
S. ruconius	3.55	1.40	1.75	2.53	3.32	1.58
G. achlamys	10.37	1.24	7.45	8.34	9.22	5.21
J. belangerii	4.93	0.79	4.86	6.25	7.64	3.91
J. carouna	2.69	0.56	2.82	4.77	6.72	2.98
18mm						
P. coromandelica (male)	3.53	0.72	3.38	4.91	6.45	2.73
female	3.94	0.79	3.60	4.99	6.38	2.77
O. tardoore	6.15	1.10	4.58	5.58	6.57	3.10
T. dussumieri	8.15	1.39	5.07	5.86	6.65	3.26
S. ruconius	5.81	1.43	3.28	4.05	4.81	2.25
T. setirostris	4.17	0.41	7.59	10.30	13.00	5.72
S. insidiator	5.47	1.04	4.22	5.28	6.34	2.93
J. belangerii	3.58	0.43	5.81	8.38	10.96	4.66
J. carouna	6.58	1.12	4.88	5.86	6.84	3.26
L. savala	3.10	0.12	16.98	26.31	35.64	14.62
20mm						
P. coromandelica (female)	3.37	0.48	4.70	6.97	9.24	3.49
O. tardoore	4.50	0.66	5.16	6.83	8.49	3.42
S. ruconius	3.29	0.53	4.14	6.22	8.30	3.11
J. belangerii	6.44	0.63	8.53	10.28	12.04	5.14

Table 5. The estimated selection ogives for different shrimp/fish species (continued)

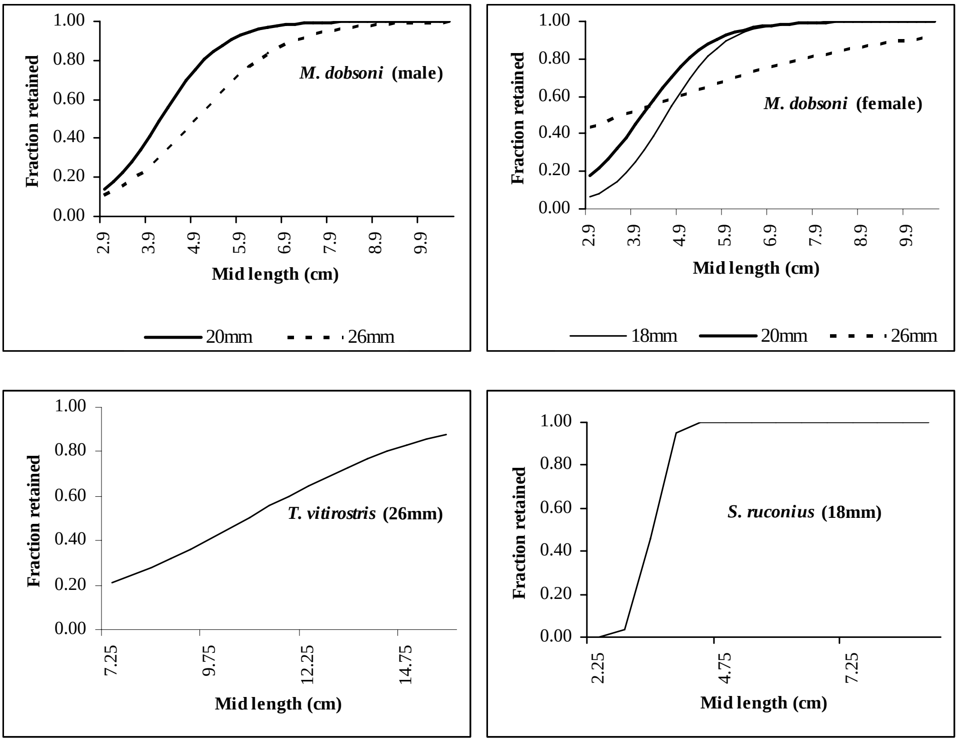
Species name/mesh size	S_1	S_2	L_{25} (cm)	L_{50} (cm)	L_{75} (cm)	Selection factor
J. carouna	6.07	0.70	7.05	8.61	10.17	4.31
23mm						
M. dobsoni (male)	6.72	1.41	3.99	4.77	5.55	2.07
female	5.94	0.90	5.40	6.63	7.85	2.88
P. coromandelica (male)	8.05	1.17	5.96	6.90	7.84	3.00
female	9.00	1.30	6.10	6.95	7.80	3.02
T. setirostris	5.23	0.48	8.62	10.92	13.21	4.75
J. belangerii	9.31	1.13	7.25	8.22	9.19	3.57
J. carouna	8.98	1.06	7.41	8.44	9.47	3.67
26mm						
M. dobsoni (male)	1.56	0.29	1.59	5.36	9.13	2.06
female	3.37	0.52	4.36	6.47	8.58	2.49
P. coromandelica (male)	2.01	0.24	3.78	8.35	12.91	3.21
female	2.59	0.55	4.26	4.71	10.53	1.81
O. tardoore	5.20	0.49	8.38	10.63	12.88	4.09
T. dussumieri	5.33	0.52	8.21	10.34	12.47	3.98
S. ruconius	9.65	1.62	5.29	5.97	6.65	2.30
S. insidiator	10.48	2.35	3.99	4.46	4.93	1.72
G. achlamys	1.22	0.23	0.53	5.26	9.99	2.02
J. belangerii	4.29	0.43	7.51	10.09	12.68	3.88
J. carouna	7.29	0.94	6.59	7.76	8.93	2.98
L. savala	4.11	0.13	23.98	32.72	41.46	12.58

*Trawl selection ogive - $S_L = 1/[1 + \exp(S_1 - S_2 X L)]$

between the similar variables of *P. coromandelica* (female) explained only 18% of the variability of 50% retention length.

Relative yield and value/recruit and optimum exploitation levels

The relative yield per recruit analysis performed with major shrimps caught among the mechanised trawl catches indicated that the estimated optimum exploitation levels increased with the elevating cod end mesh size up to 23mm and decreased again (Figs. 5 and 6). For *M. dobsoni* the minimum and maximum relative yield/recruits were estimated for fishing with 18 and 23 mm cod ends, respectively (Fig. 5). On the other hand for *P. coromandelica* maximum values for relative yield/recruit were estimated for 18mm cod ends. For both species, minimum and maximum optimum exploitation levels were estimated for fishing with 16 and 23 mm cod ends respectively (Fig. 6). The relative value/recruit analysis also indicated that the maximum relative values were recorded for fishing with 23mm cod ends for both species (Fig. 6). For *M. dobsoni* minimum relative values/recruit were estimated for 18mm cod ends while for *P. coromandelica* similar estimations were made for 16 mm cod ends.



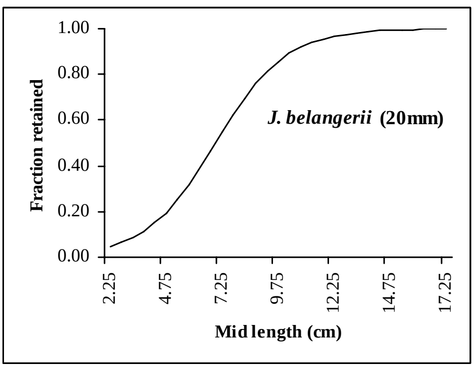
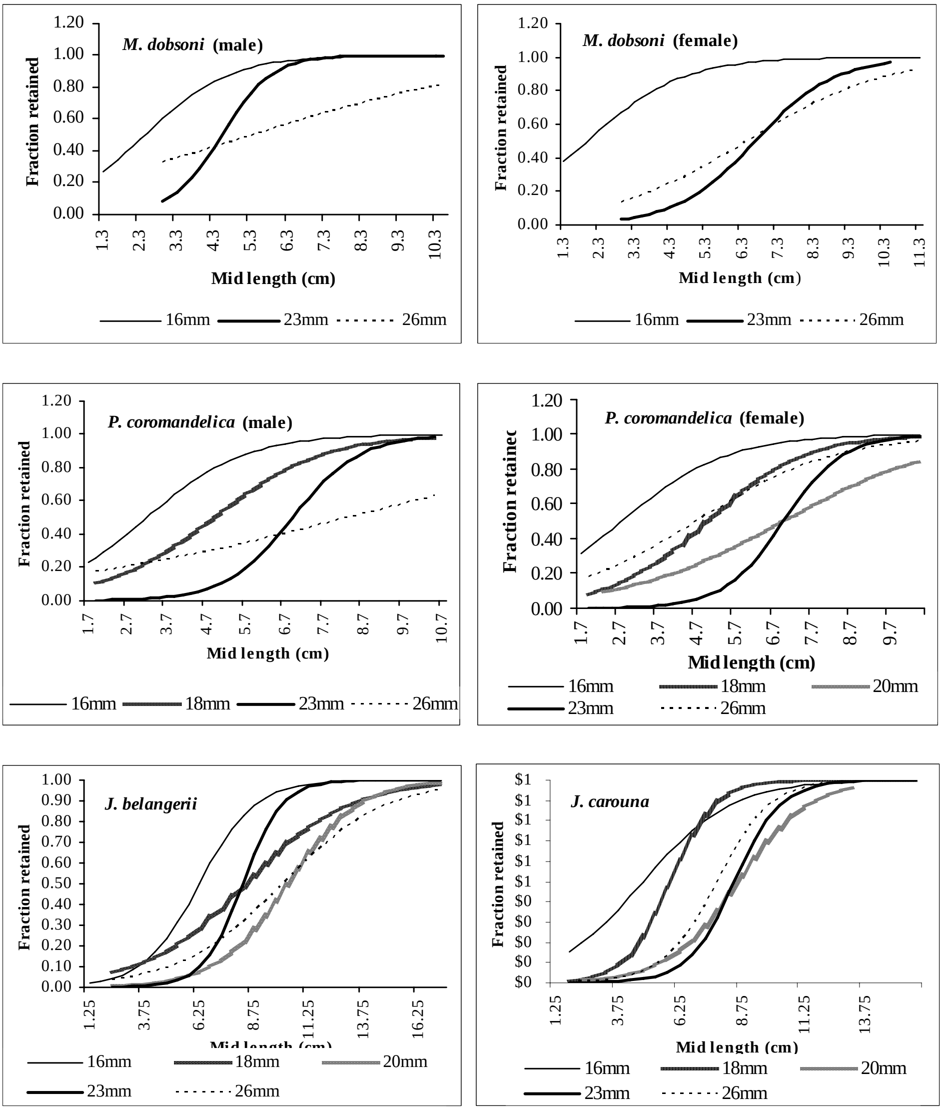


Figure 3. The estimated selection ogives for certain shrimp and fish species caught in the non-mechanized trawl catch



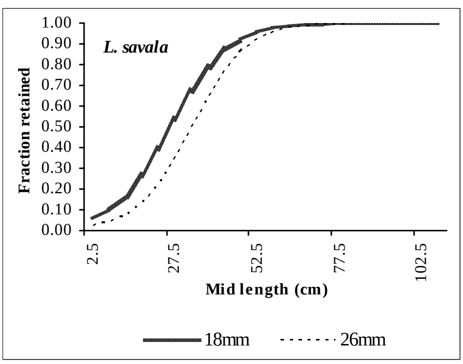
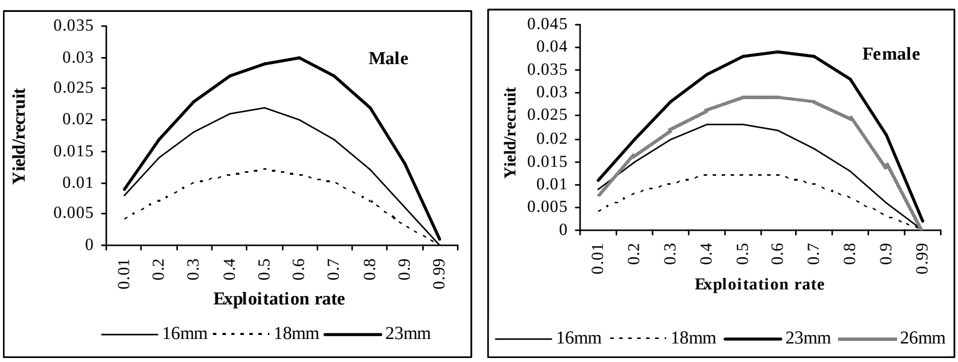


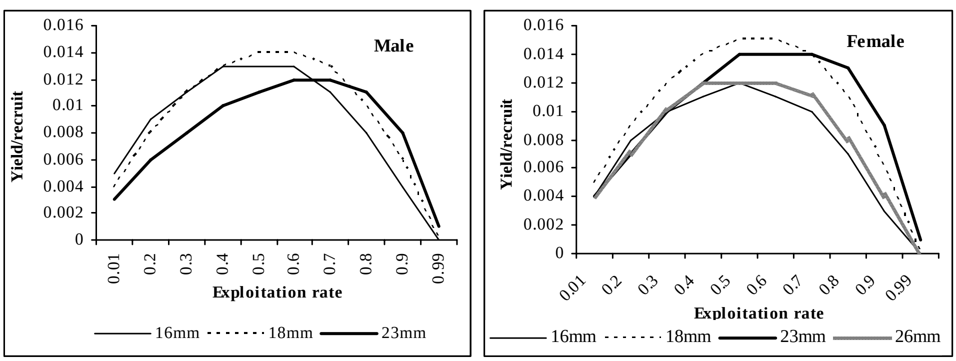
Figure 4. The estimated selection ogives for certain shrimp and fish species caught in the mechanized trawl catch

Table 6. The estimated relationships between 50% retention lengths (L50%) and cod end mesh size (MS) – Mechanized trawls

Shrimp/fish species	Relationship	r^2
M. dobsoni (male)	L_{50} = 0.3003 X MS - 2.3202	0.989
female	L_{50} = 0.4882 X MS - 5.5549	0.8969
P. coromandelica (male)	L_{50} = 0.4886 X MS - 4.2986	0.9818
female	L_{50} = 0.194 X MS + 1.2792	0.1918
O. tardoore	L_{50} = 0.6518 X MS - 6.2682	0.9985
T. dussumieri	L_{50} = 0.415 X MS - 0.6433	0.86
S. ruconius	L_{50} = 0.3143 X MS - 1.5932	0.6109
J. belangerii	L_{50} = 1.0075 X MS - 9.8317	0.9989
J. carouna	L_{50} = 0.96 X MS - 10.867	0.9414



M. dobsoni



P. coromandelica

Figure 5. The estimated yield/recruits of major shrimps caught among mechanized trawl catch for different cod end mesh sizes

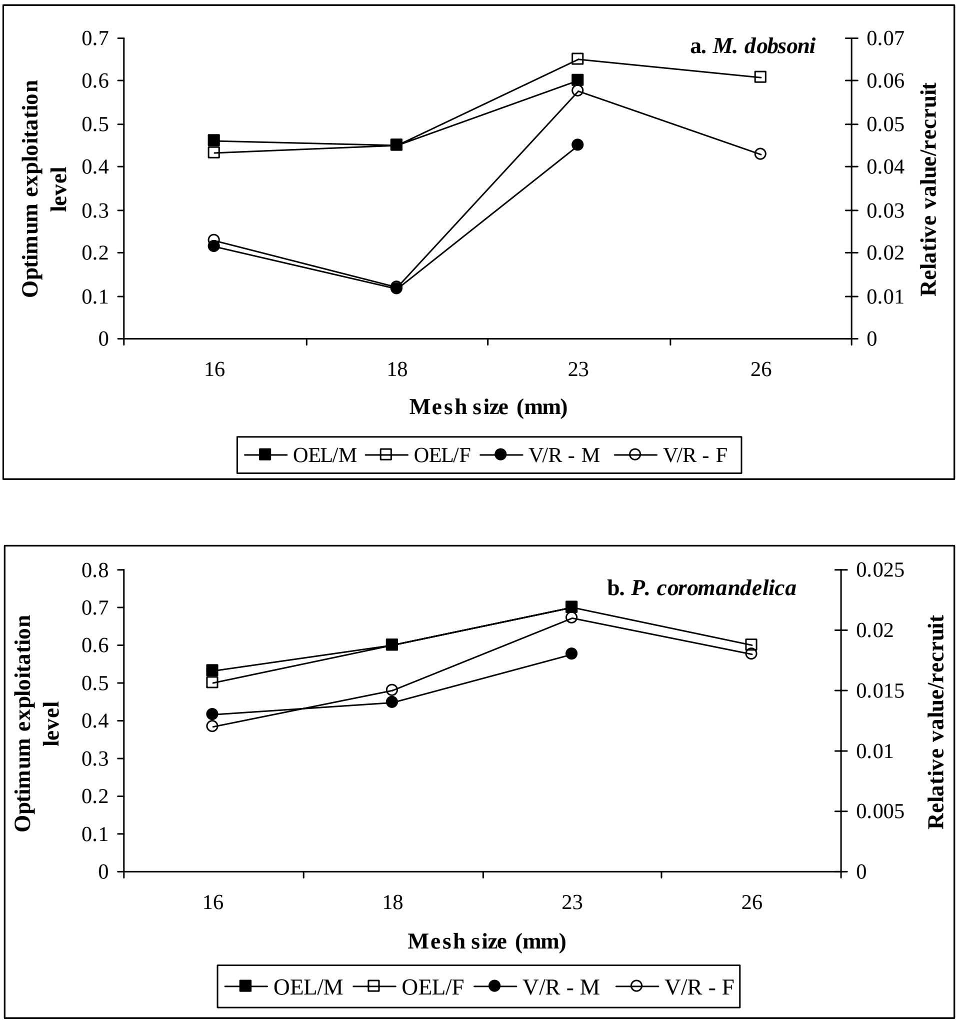


Figure 6. The estimated optimum exploitation levels and the corresponding values of relative value/recruit. OEL – Optimum Exploitation level; V/R – Relative value/recruit; M – Male; F - Female

Discussion

Possession of necessary knowledge over selection properties of fishing gears is useful especially when it is necessary to estimate the real size/age composition of the finfish/crustaceans in a fishing area. The above is also a vital tool for fisheries managers, who by regulating the mesh size of the fishing gear, determine the size of the target species caught. In addition, the gear selectivity is strongly related to the estimation of total mortality, Z, the analysis of trawl survey data and also the prediction of future yields (Sparre and Venema 1992). During the present exercise the selection properties of the trawl gears used in the west coast shrimp trawl fishery of Sri Lanka were evaluated using the covered cod end method (Pope et al 1975; Jones 1976) for possible management of the trawl fishery to ensure the existence of the valuable shrimp fishery resources.

The estimated mean fish and shrimp catch rates for non-mechanised trawls decreased with the elevating cod end mesh size. The reason for the absence of a clear variation pattern in the catch rates of mechanised trawls could presumably be due to the substantial influence of the seasonality of fishing operations on catch rates. The statistical analysis also confirmed the above indicating that there was a significant difference between the mean shrimp catch rates estimated for different fishing days. In addition, the analysis also indicated that the observed shrimp catch rates for depths <5 m were significantly higher than that estimated for depths >5 m and the reverse was true in terms of fish ($P<0.05$). This is an indication of high abundance of shrimps in shallow seas off the west coast where trawling is conducted at depths varying from 3.5 – 12 m (Jayawardane et al 2004).

As revealed during the present investigation, both trawls exploited substantial quantities of under sized individuals of valuable shrimps. Not surprisingly the estimated 50% retention lengths for shrimps exploited by both trawl types increased with the elevating cod end mesh size (Table 5) which is a favourable factor in terms of existence of the shrimp resources in the west coast. Siddeek (1986) also made a similar observation during the experimental fishing conducted with the new fish-cum shrimp trawl in the Palk Bay, Sri Lanka with the highest 50% retention length for *P. semisulcatus* was estimated for 40 mm cod ends (2.27 cm carapace length) while the same estimated for the existing 30mm cod ends was reasonably lower with 1.96 cm. As the existing trawl fishery in the seas off west coast seems to exploit substantial quantities of juveniles, it is advisable to formulate a mechanism for sustainable exploitation of the shrimp resources in the west coast.

The relative yield/recruit analysis performed during the present study also indicated that the estimated optimum exploitation levels were highest for fishing with 23 mm cod ends for both species (Fig. 6). In addition the corresponding values for relative yield/recruit of *M. dobsoni* were also highest for the same (Fig. 5). Similarly, the outcome of the relative value/recruit analysis for both species compares favourably with the above

(Fig. 6). Though the relative yield/recruit analysis performed with *P. coromandelica* produced a slightly different outcome (Fig. 5) with maximum values were estimated for 18 mm cod ends, subject to further investigations it is reasonable to conclude that the 23 mm cod ends are better than the existing 16mm cod ends for the sustainable exploitation of the shrimp resources in the west coast. The analysis of catch rates indicated that the estimated mean catch rates decreased with the elevating cod end mesh size leaving poor economic returns to the trawl fishermen. However, it should also be noted that such initiative (increasing the existing cod end mesh size) would make reasonable contribution to increase the mean size of the shrimp caught among trawl catches result in sustainable growth of both the shrimp yield and also the economy of the shrimp fishermen in the long run. Furthermore, it was also revealed that the estimated exploitation levels for both species by two different trawl types (around 0.4 for both species for two trawl types – Jayawardane et al 2003a; Jayawardane 2005) were less than the estimated optimum exploitation levels for 23 mm cod ends, indicating the possibility of increasing the existing fishing effort over these species without overexploitation of the valuable shrimps caught among trawl catches.

The present exercise did not produce sufficient information with regard to the selection properties of the other valuable shrimps exploited by the trawl fishery, such as *Penaeus indicus* and *P. merguiensis* (Penaeidae). The relatively small contribution of these two species to the trawl catch presumably reflects their low abundance on the grounds being fished, and/or low vulnerability to the gear. Another possible explanation is that the present fishing trials did not coincide with the recruitment seasons of these two shrimps in the west coast. Therefore, prior to make any final conclusion it is vital to initiate a comprehensive study covering different fishing seasons of the trawl fishery with special emphasis over the dynamics of recruitment. The findings of the present investigation provide a basis for such a comprehensive study.

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