Indian Journal of Marine Sciences
Vol. 31(4), December 2002, pp. 329-333

Gill net selectivity studies for fishing frigate tuna, *Auxis thazard* Lacepede (Perciformes/Scombridae) in Thoothukkudi(Tuticorin)waters, southeast coast of India*

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Received 27 September 2001, revised 21 September 2002

Auxis thazard form commercial fishery in Thoothukkudi coastal waters from June to October in big meshed drift gill nets with the mesh size ranging from 60 to 100 mm. The fishery is mainly constituted by the length group 275-500 mm. The present study deals with the estimation of mesh size to capture the commercially significant length group (326-400 mm) of *A. thazard* and its enmeshing pattern in gill nets with two different mesh sizes. The optimum mesh size for the exploitation of the commercial significant size group of *A. thazard* from Thoothukkudi coastal waters is estimated as 84 mm. As the length at first maturity of this species in Thoothukkudi coast varied from 300 to 310 mm, the nets with proposed mesh size would reduce growth and recruitment over fishing of *A. thazard* in this coast and allow for spawning before first capture. Though the big meshed drift gill net fishery of Thoothukkudi coast is multi species oriented, the study emphasises the need to regulate the mesh size of the nets based on the type of fishes that form fishery and fishing seasons. It is recommended to conduct big meshed gill net fishing from June to October with the nets having the mesh size of 84 mm,as *A.thazard* is the major contributor to the big meshed gill net catch during this season. The use of gill nets with the 60 mm-mesh size should be banned during this season, as this would result in capturing of juveniles of *A.thazard* leading to growth overfishing.

[**Key words**: *Auxis thazard* , frigate tuna, big meshed drift gill nets, mesh size, commercially significant length group, length at first maturity]

Thoothukkudi (lat. 8° 47′ N and long. 78° 9’ E) is one of the important fish landing centres in southeast coast of India and the annual tuna catch from this coast has been estimated at 54 tonnes accounting for 5.38 % of the tuna production of Gulf of Mannar during 1996-97[1].

Tamil Nadu ranks third in the total tuna production in the country followed by Kerala and Gujarat.The mesh size of drift gill nets of Thoothukkudi coast ranges from 60 to150 mm. Along with coastal tuna, seer fishes and sharks are also caught as by catch in the small meshed drift gill nets (popularly called ‘Podivalai’) which have the mesh size ranging from 60 to 115 mm. The fishing season for frigate tuna *Auxis thazard* Lacepede(Perciformes/Scombridae) in this coast is from June to October. This species form fishery in the coastal region, 10 to 14 nautical miles away from the shore at the depth ranging from 40 to 55 m. *Auxis thazard* is caught along with *Ethyunnus affinis,*yet another species of coastal tuna of Thoothukkudi coast.These two species are indiscriminately fished and no attempt has so far been made to optimize the mesh size of gill nets to capture *A. thazard* and *E.affinis* . The present study deals with the estimation of the gill net selection factors of *A. thazard* so as to optimize the mesh size for its commercial exploitation. The enmeshing pattern of *A. thazard* in gill nets with two different mesh sizes are also discussed.

Selectivity of fishing gear has a direct influence on the exploited stock [2]. Gillnet selectivity may be estimated either indirectly or directly. Indirectly, it is inferred by examining the size distributions of gillnet catches or from maximum girth and head girth measurements. By direct method, the selectivity parameters are estimated based on the proportions of fish caught from different size classes of a population with known length frequency distribution[3].

Gillnet selectivity studies in Indian waters are mainly concerned with the optimization of mesh size for the commercial exploitation of important marine and fresh water fishes . Attempts have been made by a few workers to arrive at optimum length of capture of

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certain important fin fishes based on the length at first maturity. Knowledge on the length at first maturity of the species to be captured is essential for optimizing the mesh size for sustained commercial exploitation of any species.

Materials and Methods

The study was carried out for two years from June1998 to October 2000 at Therespuram, the landing center for traditional crafts of Thoothukkudi coast (Tamil Nadu, southeast coast, India.). Nets with the mesh size of 60 and 100 mm were sampled from the fleet of drift gillnets operated from the commercial fishing boats of Thoothukkudi origin, (popularly called 'Vallam'). The nets with the mesh size 60 and 100-mm were named as net 'A' and net 'B' respectively. The features of the net 'A' and 'B' are given in Table 1. Each of 5 nets of 'A' and 'B' had been connected in series for operation along with other nets. The vessel along with the fleet of nets were allowed to drift for about 7 hrs from 0600 to 1300 hrs and then hauled.

On complete removal of fishes from the experimental net, the impressions of twine on the body of each fish were carefully observed. Based on twine impression, the fish caught in the net were grouped as those caught by snagging (held tightly in the front portion of the gill), gilling (exactly at gill) and wedging (around the body). Measurements such as fork length, gill girth, gilled girth and maximum girth were measured to the nearest millimetre for each fish of the sampled net with the help of a measuring tape. Sampling was made thrice a week onboard the vessel. The percentage of snagging, gilling and wedging were separately worked out for each net. All fishes sampled from the experimental nets, except those caught occasionally by tangling were used for the estimation of selectivity. The length frequency data collected in both the nets were grouped with a common interval of 25 mm and the percentage of fish caught in each net under each length group was worked out.

Table 1—Description of the experimental gillnets

Parameters	A	B
Webbing Material	Nylon	Nylon
Twine Specification	210/1/4	210/1/6
No. of meshes in length	1000	1000
No. of meshes in breadth	100	100
Mesh size	60 mm	100 mm
Horizontal hanging coefficient	0..5	0.5
Vertical hanging coefficient	0.86	0.86
No. of floats	12	14
Specification of float	PVC Cylindrical 55 cm ϕ x 50cm	PVC Cylindrical 55 cm ϕ x 50cm
No. of sinkers	8	10
Specification of sinker	Stone -250g	Stone –250g

Size of fish being caught in a gill net depends on the selectivity of the gear. The selection curve and selectivity parameters such as the length of fish at 50% selection on the ascending length of the selectivity curve (l_b), mean selection length (l_c), and the length of fish at 50% selection on the descending length of the selection curve (l_d) were estimated. To derive selection curves, as per the method described by Olsen[4], the percentage of different length groups caught in both the nets were worked based on the length frequency data. These values were converted as natural logarithmic values for easy computation. The functional relationship of the ratios on the mean length of each length stratum was estimated by the curve line as regression, $Y = al^2 + bl + c$. where, $Y = \log_e$ of the ratio of percentage of fish in a length group caught by two different mesh types; l = mean or median length of fish of any length group; and a, b and c are constants, estimated by curvilinear regression method. The ordinates of the selection curves were given by the equation:

$$N_i = \exp\{-u(l - l_c)^3 - v(l - l_c)^2\}$$

The constants k, u and v were solved by using the constants a,b, and c and also the parameters q (= y + x), r (= y-x), and s (= y X x), (where y and x are the sizes of the larger and smaller mesh respectively in a pair combination) for the two different mesh combinations in the following equations[4]

$$v = \frac{3q(b^2 - 4ac) \pm b\sqrt{9b^2q^2 - 24ac(q^2 + 2s)}}{24cr}$$

$$k = \frac{b}{2rv - aq}$$

$$u = \frac{a}{3kr}$$

The catch data of *A.thazard* in terms of both number and weight taken from 10% of the boats were raised to daily catch. The average daily catches were raised to monthly catch based on the number of fishing days and the effort was expressed in boat days.

To estimate optimum length of capture, length at first maturity (length at which 50% of the animals attained maturity) was estimated. About 50 specimens

for each species under each sex covering wide length group were observed for their maturity stages during de-gutting operations in the processing hall for dry curing. Maturity stages were determined and the stages were classified as immature, maturing, mature and spent [5]. Taking the fork length expressed in cm in X-axis and percentage of matured specimens in Y-axis, a graph was drawn. Length at which 50 percent of the animals found matured was taken as length at first maturity (l_m).

The commercially significant size group of *A. thazard* in the fishery was worked out as a percentage of total catch from the pooled catch data. The mid-value of the length group was taken as optimum length of capture and used for the estimation of optimum mesh size.

The optimum mesh sizes for the commercial exploitation of *A. thazard* were worked out based on the relation $m = l_c/k$, where m is the stretched measure of mesh in millimetre and 'l_c'is the mid-value of commercial significant length group in millimetre.

Results and Discussion

Auxis thazard form fishery on commercial scale for five months in a year from June to October in Thoothukkudi coast. The enmeshing pattern of *A. thazard* in net 'A' and 'B' are shown in Table 2. In net 'A', the length group 326-350 mm was found gilled to the extent of 79% and in net 'B' gilled the length group 401-425 mm was gilled to the extent of 69% (Table 2). Therefore, the net 'A' and 'B' have correctly fished the above mentioned length groups with high percentage of gilling. However, the l_c values of *A.thazard* estimated in net 'A' and 'B' were 259 and 431 mm. Though a fish may be caught in gillnet by snagging, gilling, wedging and entangling, gilling would be the appropriate enmeshing pattern as it gives high probability of retention of fish in the net after capture. The difference between 'l_c' and the length group caught with highest percentage of gilling in net 'A' and 'B' reveals the influence of snagging and wedging on 'l_c' besides gilling.

A number of studies have indicated unimodal length distribution curve for gillnets with large mesh sizes in contrast to the bimodal distribution for smaller mesh sizes[6,7]. In the present study also, irrespective of the mesh sizes used, the selectivity curves were found unimodal. Further, the selectivity curves were not much skewed in contrast to that of fishes commonly tangled in the net[7,8]. The selectivity curves of rainbow trout, *Oncorhynchus mykiss* have been reported to be slightly skewed unimodal curve for gillnets and bimodal curve for entangling nets[9].

The smooth-bodied nature of tuna, which does not facilitate tangling, may be quoted as a reason for smooth unimodal selectivity curves of *A. thazard* in the nets 'A' and 'B' in present study. Similar observations have been made with *Amblygaster sirm* in the small meshed gillnet fishery of Srilanka which were caught mainly by gilling and wedging owing to its smooth-bodied nature[10]. The views of the fishermen also agree with this finding that snagging, gilling and wedging and not by tangling in drift gill nets of Thoothukkudi mainly capture tuna.

Selectivity parameters

The selection curves of *A. thazard* are depicted in Fig. 1. The selectivity parameters such as 'l_b', 'l_c' and 'l_d' for the mesh combination AB is given in Table 3. The value of 'l_b', which is otherwise called 'Length at first capture' was low in net 'A' (128 mm) and was high (310 mm) in net 'B' (Fig. 1). The length at first capture (l_b) denotes the length of fish at which 50% of the fish are retained and the remaining 50% pass through the mesh and escape.

The mean selection length of fish 'l_c' in gill nets with a particular mesh size means the length of fish

Table 2 — Enmeshing pattern of various size groups of *Auxis thazard* in nets A , B

Size range (mm)	Percentage of enmeshing		
	Snagged	Gilled	Wedged
		Net A	
276-300	—	50	50
301-325	—	67	33
326-350*****	—	79	21
351-375	18	68	14
376-400	34	60	6
401-425	61	39	—
426-450	84	16	—
451-475	100	—	—
476-500	100	—	—
		Net B	
326-350	—	38	62
351-375	—	51	49
376-400	7	63	30
401-425*****	18	69	13
426-450	41	59	—
451-475	63	37	—
476-500	89	11	—

*****Length groups caught with highest percentage of gilling

Table 3—Selectivity parameters of *Auxis thazard*

Mesh Combinations	Net	l_b (cm)	l_c (cm)	l_d (cm)	k	u	v
BA	A	12.8	25.9	37.3	4.3119	0.0568	0.4792
	B	30.1	43.1	54.3			

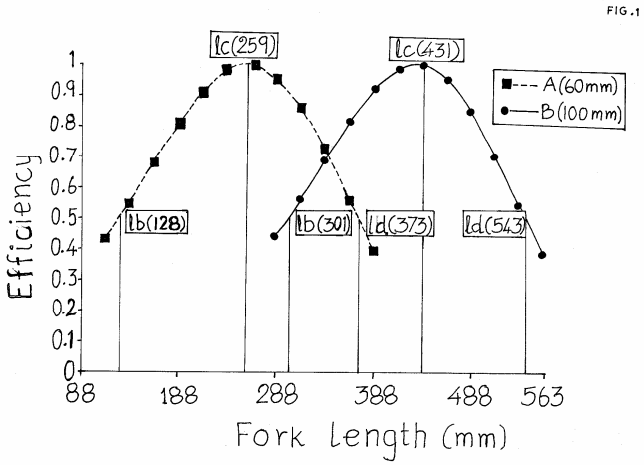

Fig. 1—Selection curves of *Auxis thazard* caught in net A and B

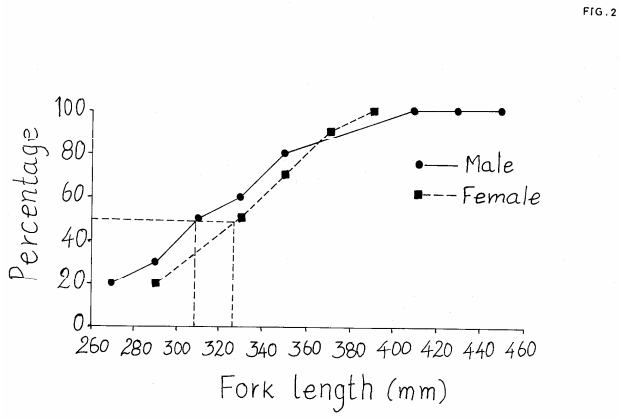

Fig. 2—Estimation of length at first maturity of *Auxis thazard*

which is retained 100% in the net. The 'l_c' fall between 'l_b' and 'l_d' both in net 'A' and 'and were higher in net 'B' than in net 'A'. The mean selection length of *A. thazard* was estimated as 259 mm and 431 mm in net 'A' and 'B' respectively. The escapement length (l_d) which denotes the length of fish, at which 50% of the fish which could not enter into the mesh because of its size. The value of 'Escapement length (l_d) was 373 and 543 mm in net 'A' and 'B' respectively. The average value of estimated 'k' was 4.34 (Table 3).

Gillnets can be considered to be girth-specific rather than species specific. Adopting the method of Olson [4], the 'l_b', 'l_c' and 'l_d' values have been estimated for *Scomberomores commersoni* by Devaraj[11] as 280, 419 and 590 mm based on the catches from the gillnets with the mesh size of 64 mm. The 'l_b', 'l_c' and 'l_d' values estimated in the present study based on the catches from net 'A' (60 mm) were 128, 259 and 373mm. The reason for remarkably low value of selection lengths estimated in the present study may not only be attributed to the marginal difference in mesh size but also to the girth to length ratio which is higher for *A. thazard* than for *S. commerson. Scomberomores commerson* has slender body with relatively lower 'girth to length ratio' in contrast to *A. thazard* with fusiform body.

Table 4—Length frequency distribution of *Auxis thazard* in the fishery

Length group	Total catch in numbers (percentage)
276-300	8.33
301-325	5.56
326-350*	27.78
351-375*	23.15
376-400*	18.52
401-425	9.26
426-450	2.78
451-475	2.78
476-500	1.85

*Commercially significant length groups in the fishery

Length at first maturity

Males and females of *A. thazard* were found to attain maturity at slightly different length. Males attained maturity at slightly smaller length than females. Males attained maturity at 308 mm while females at 328 mm (Fig. 2). The length at first maturity of this species has been reported to vary from 300 to 320 mm in Indian waters[12,13]. The operation of the net 'A' posed serious threat to the fishery as it captured immature and maturing fishes together to the extent of about 30%. In contrast, the net 'B' captured mainly mature animals.

Optimum mesh size

The commercially significant length group of *A. thazard* in the tuna fishery of Thoothukkudi was found to be 326 - 400 mm, which contributed 69.45% of the annual tuna catch (Table 4). The mid length of

the commercially significant size group was 363 mm. Considering the optimum length of capture as 363 mm, the optimum mesh size for the commercial exploitation of *A. thazard* was worked out as 84 mm. Length at first maturity has been considered as a criteria to fix the optimum length of capture[14-17] . As the length range of commercially significant size group was higher than the length at first maturity (308-328 mm) the operation of the proposed net with the mesh size of 84 mm would help to ensure sustainable fishery provided the effort is optimized.

Further, it is suggested that the use of net 'A' (mesh size 60 mm) should be discouraged for fishing tuna in Thoothukkudi waters as it captures mainly juveniles and maturing groups. The nets 'A' and 'B' captured the *A. thazard* by snagging and wedging besides gilling. As the mesh size of the newly proposed gill net, 84 mm falls between the mesh size of net 'A' (mesh size 60 mm) and net 'B' (mesh size 100 mm). The net 'A' captured the commercially significant length group (326 to 400 mm) with a percentage of gilling ranging from 60 to 79 % while the net 'B' captured the same length group by gilling to the extent of 38 to 69 % (Table 2). Therefore, the newly proposed gill net would capture the commercially significant size group of *A. thazard* by gilling to the extent of about 50 to 60 %.

Though the big meshed drift gill net fishery of Thoothukkudi coast is multi species oriented, the study emphasis the need to regulate the mesh size of the nets based on the type of fishes that form fishery and fishing seasons. It is recommended to conduct big meshed gill net fishing from June to October with the nets having the mesh size of 84mm, as *A.thazard* is the major contributor to the big meshed gill net catch during this season. The use of gill nets with the 60mm-mesh size should be banned during this season, as this would result in capturing of juveniles of *A.thazard* leading to growth overfishing.

Acknowledgement

The authors thank Mr. M. Kottaimuniasamy for his assistance in the collection of data and Mr. M. Venice selvam for technical assistance.

References

1 Anon, *Tamil Nadu Fisheries statistics (1996-97) endeavour and achievements*, (Department of Fisheries, Chennai) 1997, pp. 44.

2 Hamely J M, Review of gillnet selectivity, *J Fish Res Bd Can*, 32 (1975) 1943-1969.

3 Sparre P & Venema S C, Introduction to tropical fish stock assessment, Part I Manual, *FAO Fisheries Technical paper* No.3061, (FAO, Rome) 1992, pp. 172-199.

4 Olsen S, Mesh selection in herring gillnets, *J Fish Res Board Can*, 16 (1959) 339-349.

5 Pradhan L B, Mackeral fishery of Karwar, *Indian J Fish*, 3 (1959) 141-185.

6 Ehrhardt N M & Die D J, Size-structured yield –per- recruit for the Florida gill net fishery for Spanish mackerel, *Trans Fish Soc* , 117 (1988) 581-590.

7 Reis E G & Pawson M G, Fish morphology and estimating selectivity by gillnets, *Fish Res*, 39 (1999) 262-273.

8 McCombie A M & Berst A H, Some effects of shape and structure of fish on selectivity of gillnets, *J Fish Res Board Can*, 26 (1969) 2681-2689.

9 Losanes L P, Matuda K & Fujimori Y, Estimation of the entangling effect of trammel and semi-trammel net selectivity on rainbow trout (*Oncorhynchus mykiss*), *Fish Res*, 15 (1992) 229-242.

10 Karunasinhe W P N & Wijeyaratne M J S, Selevity estimates for *Amblygaster sirm* (clupeidae) in the small-meshed gill net fishery on the west coast of Sri Lanka, *Fish Res*, 10(1991) 199-205.

11 Devaraj M, *Fish population dynamics. Course manual*, Bulletin No.3 (CIFE, Mumbai, India) 1983, pp. 38-41.

12 Muthiah C, Maturation and spawning of *Euthynnus affinis, Auxis thazard* and *A.rochei* in the Mangalore inshore area during 1979 to 1982, *Bull Cent Mar Fish Res Inst*, 36 (1985) 71-85.

13 James P S B R, Pillai P P, Pillai N G K, Jayaprakash A A, Gopakumar G, Mohammed Kasim H, Siva-das M & Koya K P S, Fishery biology and stock assessment of small tuna, (Fishery Survey of India ,Mumbai) 1993, pp.123-148.

14 Santos M N Monterro C C & Erxini K, Aspects of the biology and gillnet selectivity of the auxiliary sea bream (*Pagellus acarne*, Risso) and common pandora (*Paagellus orythrinus linnaeus*) from the Algarve (South Portugal) *Fish Res*, 23 (1995) 223-236.

15 Santos M N, Monterino C C, Erzini K & Lasserre G, Maturation and gill-net selectivity of two small sea breams (genus *Diplodus*) from the Algarve Coast (South Porugal), *Fis Res*, 36 (1998) 185-194.

16 Petrakis G & Stergiou K I, Gillnet selectivity for *Diplodues annularis* and M*ullus surmuletus* in Greek waters, *Fish Res*, 21 (1995) 455 – 464.

17 Petrakis G & Stergiou K I, Gill net selectivity for four species (*Mulles barbatus*, *Pagellus erythrinus* and *Spicara flexuosa*) in Greek waters, *Fish Res*, 27(1996) 17-27.