Fishery Technology
2002, Vol. 39(2) pp : 107 - 113

Standardization of Mesh Size of Gill Nets for the Commercial Exploitation of Kawakawa, *Euthynnus affinis* (Cantor) in Thoothukkudi Coastal Waters, Southeast coast of India

D. Jude, N. Neethiselvan*, P. Gopalakrishnan and G. Sugumar
Fisheries College and Research Institute
Thoothukkudi - 628 008, India

Euthynnus affinis forms notable fishery in Thoothukkudi coastal waters with peak season from June to September. *Euthynnus affinis* is captured in small meshed gillnets popularly called 'PODIVALAI' with mesh size ranging from 60 mm to 115 mm. The present study deals with the standardization of mesh size to capture the commercially significant length group (476-600 mm) of *E. affinis* and its enmeshing pattern in gillnets with three different mesh sizes. The optimum mesh size for the commercial exploitation of *E. affinis* in Thoothukkudy coastal waters is found to be 104.2 mm. Further, the study recommends to discourage the use of gill net with 50 mm mesh size for the capture of *E. affinis* as this net captures the juveniles of *E. affinis*.

Key words: *Euthynnus affinis*, optimum mesh size, length at first maturity, gill nets

During the last decade (1988 to 1998), the tuna landings of India has almost doubled from 20,466 tons to 39,684 tons (Anon, 1998). Southeast coast alone has contributed about 14.4% of tuna catch of the country (Kasim, 1999). In Gulf of Mannar, seven species of tuna viz., *Euthynnus affinis, Auxis thazard, A. rocheri, Sarda orientalis, Kastauvonus pelamis, Thunnus albacares* and *T. tonggol* have been found to be distributed (Siraimeetan, 1985).

During 1966-67, the tuna catch from Thoothukkudi, which is one of the important fish landing centers of Gulf of Mannar (Lat.8° 47'N and long. 78° 9'E) has been estimated as 54 tons accounting for 5.38 percent of the tuna production of Gulf of Mannar. Tuna fishing of Thoothukkudi coast is mainly by drift gill nets mesh size ranging from 60 mm to 155 mm. Coastal tuna along with seer fishes and sharks are caught in small meshed drift gill nets popularly called *'Podivalai'* which have the mesh size ranging from 60mm to 115 mm and in big meshed gill nets called *'Paruvalai'* with the mesh sizes ranging from 122 mm to 155 mm. *Euthynnus affinis*, (Cantor), has been found to be the dominant species constituting more than 45% of the total tuna catch in this region. Drift gillnets have been found responsible for 98% of the total tuna catch of Thoothukkudi coast (Kasim, 2000). No attempt has so far been made to optimize the mesh size of gill nets of this coast to regulate tuna fishery. Therefore, the present study was made to estimate the gillnet selection factors of *E. affinis* in Thoothukkudi waters so as to optimize the mesh size and enmeshing pattern of *E. affinis* in gillnets.

Effect of different mesh on fishing efficiency and optimization of gillnet mesh sizes for several marine species including sardine (Joseph & Sebastian, 1967) *Scomberomorous commersoni*, (Sreekrishna *et al.*, 1972; Sulochanan, 1975), *Hilsa toil* and *Pampus* argenteus (Panicker *et al.*, 1978) and mackerel (Mathai, 1991) have been worked out. Optimization of mesh sizes to capture fresh water fishes in reservoir have also been studied (Sulochanan *et al.*, 1968; Natarajan,

* Corresponding author

1976; Kartha & Rao, 1991). Attempts have been made to fix optimum length of capture of certain important fin fishes based on the length at first maturity (Sreekrishna *et al.*, 1972; Sathyanarayanappa *et al.*, 1990; Santos *et al.*, 1995 and Petrakis & Stergious (1995).

Materials and Methods

The study was carried out for two fishing seasons, from June to November during 1999-2000 and 2000-2001 at Therespuram, the landing centre for traditional crafts of Thoothukkudi coast (Lat. 8° 47'N and Long. 78° 9"E). The nets with the mesh size of 60 mm, 100 mm and 110 mm operated by local fishermen from the traditional plank built boats of Thoothukkudi origin popularly called 'Vallam' were named as net 'A', 'B' and 'C'. The nets were operated at depths ranging from 40 to 55 m. The design features of the nets 'A', 'B' and 'C' are given in Table 1. While fishing, the nets along with the vessel were allowed to drift for six hours and then hauled.

Onboard sampling was made thrice a week. Measurements such as fork length, gill girths, gilled girth and maximum girth were taken for each specimen, with the help of a measuring tape to the nearest millimeter. The sampling covered wide length group. On removal of the fish from the net, twine impression on the fish were carefully observed. Based on twine impressions, the pattern of capture was confirmed and the fishes were classified as snagged (held tightly in the front portion of the gill) or gilled (exactly at gill) or wedged (around the body). The percentage of fish caught by snagging, gilling and wedging were separately worked out for the three nets. Linear regression between gill girth and fork length of *E. affinis* was worked out, taking the fork length in X-axis and gill girth in Y axis. The percentage of capture of each length group of fish in each net were worked out. The length frequency data was grouped with the common interval of 2.5 cm to estimate the gillnet selectivity factors. To obtain the daily average catch the catch data collected both in terms of number and weight were multiplied by the number of boats engaged for fishing on the sampling day and it was multiplied by the number of fishing days for the month to obtain the monthly estimate. The effort was expressed as number of boat days per month.

The selection curve and selectivity parameters such as the length at 50% selection (l_b) on the ascending limb of the selectivity curve, mean selection length (l_c) and the length of fish at 50% selection (l_d) on the descending limb of the selection curve

Table 1. Description of the experimental gill nets

Sl. No.	Parameters	A	B	C
1.	Webbing material	Nylon	Nylon	Nylon
2.	Twine specification	210/1/2	210/1/4	210/1/6
3.	No. of meshes in length	1000	1000	1000
4.	No. of meshes in breadth	100	100	100
5.	Mesh size	60 cm	10 cm	110 cm
6.	Horizontal hanging co-efficient	0.5	0.5	0.5
7.	Vertical hanging co-efficient	0.86	0.86	0.86
8.	No. of flats	14	14	12
9.	Specification of float	PVC cylindrical 55 cm fx 50cm	PVC cylindrical 55 cm fx50 cm	PVC cylindrical 55 cm fx50 cm
10.	No. of sinkers	8	8	10
11.	Specification of sinker	Stone-250 g	Stone-250 g	Stone-300 g

were estimated. To derive selection curves, as per the method of Olsen (1959), the percentage of different length groups caught in different nets were worked out from the length frequency data. The percentage were converted as natural logarithm to avoid laborious computation.

The functional relationship of the ratios on the mean length of each length stratum was estimated by the curvilinear regression, $Y = al^2 + bl + c$. The length of fish and mesh size were expressed in decimeters for easy computations. Where Y + $\log_e$ of the ratio of percentage of fish in a length group caught by two different mesh types; I = 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 are given by 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 different mesh combinations in the following equations (Olson, 1959)

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

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

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

In order to estimate the optimum length of capture, the length at first maturity (length at which 50% of the animals attains maturity) was estimated. Optimum length of capture was fixed based on the commercially significant length group in the total catch and also considering length at first maturity. This was based on the reason that a portion of the matured animal might have spawned already to ensure the recruitment and thereby to sustain the stock. About 50 specimens of *E. affinis* covering both sex of wide length group were observed for maturity stages during degutting operations in the processing hall for dry curing. Maturity stages were fixed as immature, maturing, matured and spent (Pradhan, 1956). Taking the fork length expressed in cm in X-axis and percentage of matured specimens in Y-axis, a graph was drawn. Length corresponding to 50 percent of the animals found matured was taken as length at first maturity (l_m).

The commercially significant length group of *E. affinis* in the fishery was worked out as a percentage of total catch from the pooled catch data of each species, irrespective of the nets used. The mid-value of the length group contributing about 8% and above the total catch was taken as commercially significant size group and was used in the estimation of optimum mesh size. The optimum mesh sizes for the commercial exploitation of each species were worked out based on the relation.

$$m = -\frac{l}{k}$$

Where 'm' is the stretched measure of mesh in cm and 'l' is the mid-value of commercially significant length group in 'cm'.

Results and Discussion

Tuna fishery was notable in the coastal zone upto 14 nautical miles from the shore and at a depth ranging from 40 to 55 m. The average annual catch of *E. affinis* in Thoothukkudi coast was 8,297 numbers weighing 12,428 kg (Table 2).

The percentage of length frequency of *E. affinis* and their ratios in natural logarithms in different nets are given in Table 3. The model length group increased with the increase in mesh size indicating the

Table 2. Monthly average catch and effort of *Euthynnus affinis* during 1999-2000 and 2000-2001

Sl. No.	Month	Total No. of boats operated	Boat days	Tunas landed/boat (in numbers)	Total weight of tunas landed/boat (kg)	Total no of tunas landed (in numbers)	Total weight of tunas landed (kg)
1.	June	6	125	5	7.5	625	937
2.	July	11	275	6	8.52	1562	2343
3.	August	9	220	15	22.84	3350	5025
4.	September	12	298	8	12.17	1860	2791
5.	October	15	375	1	1.50	375	562
6.	November	10	150	4	5.13	525	770
		Total	1443			Total	12428

selectivity of the gears. While analyzing the impact of gillnets on the fishery *E. affinis*, it could be understood that the net 'A' is capturing mostly juveniles and maturing animals. Only 49% of the catches from this net constituted matured length group (42-44 cm). Therefore, the use of net 'A' to capture *E. affinis* in Thoothukkudi waters should be avoided to prevent the capture of juveniles and immature fishes which would otherwise result in over fishing of this species in Thoothukkudi waters. In the case of net 'B', only maturing and matured animals constituted the fishery and in the catch of the net 'C' immature and maturing animals were absent revealing the fact that the nets 'B' and 'C' do not pose any threat to the fishery of *E. affinis*. Good fisheries management requires those fishing gears that could catch large adult fish leaving juveniles to escape as evidenced from the findings of Armstrong *et al.* (1990).

In net 'A', the length group 351-375 mm was found gilled to the highest level of 83% (Table 4). While net 'B' captured the length

Table 3. Percentage of length frequency of *Euthynnus affinis* and their ratios in natural logarithms in different nets

Length (mm)	A	B	C	In (B/A)	In (C/A)	Ln (C/B)
276-300	7.84	—	—	—	—	—
301-325	9.80	—	—	—	—	—
326-350	25.49	—	—	—	—	—
351-375	29.41	—	—	—	—	—
376-400	11.76	4.76	—	-0.9045	—	—
401-425	5.88	7.14	—	0.1942	—	—
426-450	3.92	7.14	2.04	0.5996	-0.6531	-1.2528
451-475	3.92	8.33	2.04	0.7538	-0.6531	-1.4069
476-500	1.96	17.86	4.08	2.2096	0.7332	-1.4765
501-525	—	14.29	8.16	—	—	-0.5603
526-550	—	11.90	16.33	—	—	0.3165
551-575	—	9.52	22.45	—	—	0.8579
576-600	—	7.14	18.37	—	—	0.9450
601-625	—	5.95	12.24	—	—	0.7213
626-650	—	3.57	6.12	—	—	0.5390
651-675	—	2.38	4.08	—	—	0.5390
676-700	—	—	4.08	—	—	—

Table 4. Enmeshing pattern of various size groups of *Euthynus affinis* in 'A' (mesh size 60 mm)

Size range (mm)	Percentage of enmeshing		
	Snagged	Gilled	Wedged
276-300	—	25	75
301-325	—	36	64
326-350	—	75	25
351-375	4	83	13
376-400	49	46	5
401-425	60	40	—
426-450	72	28	—
451-475	81	28	—
476-500	100	—	—

group 451-475 mm to the highest level of 90% in gilled condition (Table 5). In the case of net 'C', the length group 551-575 mm was found gilled to the highest level of 74% (Table 6). The 'l_c' values estimated using the catches of the nets 'A', 'B' and 'C' were 42.3, 51.7 and 60.8 cm respectively.

Table 5. Enmeshing pattern of various size groups of *Euthynus affinis* in 'B' (mesh size 100 mm)

Size range (mm)	Percentage of enmeshing		
	Snagged	Gilled	Wedged
376-400	—	40	60
401-425	—	66	34
426-450	10	74	16
451-475	6	90	4
476-500	15	85	—
501-525	36	64	—
526-550	53	47	—
551-575	75	25	—
576-600	86	14	—
601-625	100	—	—
626-650	100	—	—
651-675	100	—	—

A number of studies have indicated the unimodal length distribution curve of fishes caught in gill nets with large mesh sizes in contrast to the bimodal distribution with that of smaller mesh sizes (Gulland & Harding, 1961; Kawamura, 1972; Ehrhardt & Die, 1988; Hovgard, 1996; Reis & Pawson, 1999). In the present study also, irrespective

Table 6. Enmeshing pattern of various size groups of *Euthynus affinis* in 'C' (mesh size 110 mm)

Size range (mm)	Percentage of enmeshing		
	Snagged	Gilled	Wedged
426-450	—	—	—
451-475	—	14	86
476-500	—	25	75
501-525	—	42	58
526-550	11	68	21
551-575	19	74	7
576-600	51	49	—
601-625	83	17	—
626-650	100	—	—

of the mesh sizes, the selectivity curves of *E. affinis* were found unimodal. Further, the selectivity curves of the present study are not much skewed in contrast to those very much skewed or even multimodal for species of fish that were commonly tangled in the net as observed by Gulland & Harding, (1961); Holt (1963) and McCombie & Berst (1969).

The smooth-bodied nature of *E. affinis*, which does not facilitate tangling is found to be the reason for smooth unimodal selectivity curves of *E. affinis* in various nets. The onboard observations also revealed the capturing of *E. affinis* mainly by gilling, snagging and wedging only and not by tangling.

The reason for the difference between 'lc' and gilled length group of tuna, in net 'A', 'B' and 'C' may be attributed to the capturing of *E. affinis* in net 'A', 'B' and 'C' by snagging and wedging besides gilling. Though, a fish may be caught in gillnet by snagging, gilling, wedging and entangling, gilling would be appropriate which would give high probability of retainment of fish in the net after capture.

The regression equation explaining the relationship between the gill girth and fork length of *E. affinis* is given below.

$$Y = -1.8982+0.6267 \times (r=0.9828)$$

Table 7. Selectivity parameters of *Euthynnus affinis* in different mesh combination

Mesh Combinations	l_b (cm)	l_c (cm)	l_d (cm)	K	u	v
BA	21.6	31.0	40.3	5.2593	0.03331	0.6225
CA	42.3	51.7	60.8	5.1270	0.04056	0.5300
BC	47.3	56.8	66.1	5.1072	-0.0295	1.2065
			Total	5.1645	0.01479	0.78967

The girth of the fish increased with the increase in fork length, however, the relationship was allometric.

The selectivity parameters such as 'l_b', 'l_c' and 'l_d' for the three different mesh combinations are given in Table 7. These values increased with the increase in mesh size. The length at first capture (l_b) of *E. affinis*, which denotes the length at which 50% is retained and remaining 50%,escape ranged between 21.6 and 47.3 cm. The length at first capture (l_c), which denotes the length of fish at which 100% are retained, ranged between 31.0 to 56.8 cm. The lowest 'l_c' value was 21.6 cm for the net combination 'BA' (Table 7). In the present study, the escapement length (l_d) of *E. affinis* varied from 40.3 to 66 cm. The escapement length 'l_d' denotes the length, at which 50% of the fish do not enter into the gillnet and return back because of its bigger body size. The value of 'l_c' fall between 'l_b' and 'l_d' irrespective of the mesh sizes and its value increased with the increase in mesh size. The average value of 'k' estimated for *E. affinis*, was 5.1645.

Table 8. Length frequency distribution of *Euthynnus affinis* in the fishery from June 1999 to November 1999

Length group	Total catch in numbers (percentage)
276-300	2.17
301-325	2.72
326-350	7.07
351-375	8.15
376-400	5.43
401-425	4.89
426-450	4.89
451-475	5.43
476-500	9.78
501-525	8.70
526-550	9.78
551-575	10.33
576-600	8.15
601-625	5.98
626-650	3.26
651-675	2.17
676-700	1.09

In the present study, males and females of *E. affinis* attained maturity at different length. Males attained maturity at 45 cm while females attained maturity at 43 cm. Muthiah (1985) observed the attainment of sexual maturity of males and females at 44 cm and 39 cm respectively. Baissac (1960) has recorded a matured specimen of *E. affinis* at a length of 56.5 cm in Indian coast. Attainment of sexual maturity of females of *E. affinis* at length measuring 48 cm has been reported by Rao & Narayana (1984). As there are regional differences in the attainment of maturity of this species, care need be taken while fixing optimum length of capture of this species in different regions. However, the 'K' value estimated in this study may be adopted for optimizing the mesh size.

The pooled length frequency distribution of *E. affinis* in the total catch irrespective of mesh sizes used are presented in Table 7. The fork length of tuna obtained in the catch varied from 27.6 to 68.0 cm. The mid-length (53.8 cm) of the commercially significant size group (47.6-60.0 cm), which contributed 46.7% of the total catch was well above the length at first maturity of *E. affinis* (i.e. 44 cm). The optimum mesh size worked out using the relation M = 1/k, was 104.2 mm.

It is evident from the study that the net 'A' with the mesh size 60 mm should be discouraged for capturing *E. affinis* in Thoothukkudi waters as it captures mainly juveniles. The newly proposed mesh size for capturing *E. affinis* 104.2 mm falls between the mesh size of net 'B' (mesh size 100 mm) and net 'C' (mesh size 110 mm). Therefore, net with the newly proposed mesh size of 104.2 mm would capture the commercially significant size group mainly by snagging and gilling.

References

Anon (1998) *Annual Report,* Central Marine Fisheries Research Institute, Cochin, India, 70p

Amstrong, D.W., Ferror, R.S.T., MacLennan, D.N. & Reeves, S.A. (1990) *J. Fish. Biol.* **37**, 262

Baissac, J. de B. (1962) Paper presented at the CCTA/CSA symposium on Thunnidae, Dakar, 12-17 December 1960, 2p.

Baranov, F.I. (1914) *Master Posnaniyu Russ. Rybiov.* **36**, 56

Ehrhardt, N.M. & Die, D.J. (1988) *Trans. Fish. Soc.* **117**, 581

Gulland, J.A. & Harding, D. (1961) *J. Cons. Cons. Perma. Int. Explor. Mer.* **26**, 215

Holt, S.J. (1963) KNAF. *Spec. Publ.* **5,** 106

Hovgard, H. (1966) *Can. J. Aquat. Sci.* **53,** 1007

Kartha, K.N. & Rao, K.S. (1991) *Fish. Technol.* **28,** 5

Kasim, H.M. (1999) In *National symposium on sustainable development of fisheries towards 2020 AD –Opportunities and challenges,* Abstract, April, 1999, Kochi, 21

Kawamura, G. (1972) *Bull. Jpn. Soc. Sci. Fish.* **38**, 1119

Mathai, J.T., Vijayan, V., Syed Abbas, M., Manohardoss, R.S. & Krishna Iyer, H. (1991) *Fish. Technol.* **29**, 183

Muthiah, C. (1985) *Bull. Cent. Mar. Fish. Res.* Inst. **36**, 71

Natarajan, A.V. (1976) In *Symposium on the Development utilization of Inland Fishery Resources,* Colombo, Sri Lanka, Proc. IPFC **17**, 1

Olsen, S. (1959) *J. Fish. Res. Board. Can.* **16**, 339

Paniker, P.A., Sivan, T.M., Mhalathkar, H.N. & George Mathai, P. (1978) *Fish. Technol.* **15**, 61

Pradhan, L.B. (1956) *Indian J. Fish.* **3**(1), 141

Rao, K. Narayana, V. (1964) *Proc. Symp. Scombriod Fishes,* Part 2. *Mar. Biol. Assoc. India. Symp. Ser.* **1**, 733

Reis, E.G. & Pawson, M.G. (1999) *Fish. Res.* **39**, 262

Santos, M.N., Monterro, C.C. & Erxini, K. (1995) *Fish. Res.* **23**, 223

Sathanarayanappa, S.N., Sheshappa, D.S., Hanumanthappa, B. & Salian, P.K. (1990) In Proceedings of Second Indian Fisheries Forum, May 27-31,1990, Mangalore, India, 320

Siraimeetan, P. (1985) *Bull. Cent. Mar. Fish. Res. Inst.* **36**, 86

Sreekrishna, Y., Sitarama Rao, J., Percy Dawson, T., Joseph Mathai, T. & Sulochanan, P. (1972) *Fish. Technol.* **9**, 133

Sulochanan, P., George, V.C. & Naidu, R.M. (91968) *Fish. Technol.* **5**, 81

Sulochanan, P. Sadanandan, K.A., Joseph Mathai, T., Syed Abbas, M. (1975) *Fish. Technol.* **12**, 52

Williams, F. (1963) *FAO Fish. Rep.* **62**, 167