PERFORMANCE OF GILLNET-MESH SIZE SELECTIVITY FOR THREE FLYINGFISH SPECIES IN AMBON WATERS, MOLUCCAS PROVINCE

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ABSTRACT

The gillnets' performance for capturing flying fish was obtained from the selectivity parameters of each mesh size. Gillnet selectivity parameters for flying fish were estimated using multi-panel drift gillnets with four different mesh sizes in southern Ambon Island. The black-spot flying fish *Cheilopogon suttoni* reached peak selectivity at 20.34 cm for mesh size of 1.25", 24.37 cm (1.5") and 28.47 cm (1.75"). Peak selectivity occurred at 22.16 cm for the 1,25" mesh size in the yellow-spot flying fish *Cheilopogon abei*, with the maximum size selectivity at 31.61cm for the 1.75" mesh. The optimum size for the black-plain flying fish *Hirundichthys oxycephalus* was 18.67 cm for the 1.25" mesh size, and 22.37 cm for 1.50" mesh size. Selectivity was highest at 26.12 cm for the 1.75" mesh size. Gillnet used in this study was constructed specifically for targeting flying fish suggesting that information on mesh selectivity examined here should has direct applicability to local flying fish fishery.

Keywords: Flying fish, gillnet, selectivity, mesh size, optimum size

INTRODUCTION

Mollucas Province as an archipelago in eastern Indonesia covered 658,299.69 km^2 has abundance of fish resources including flyingfish, which have been exploited in the southern part of Ambon Island by a drift gillnet fishery.

The gillnet fishery for flyingfish has operated traditionally on the south coast of Ambon Island since the 1970's. Drift gillnets used are usually monofilament, ranging from 186 to 380 m in length; from 1.5 to 1.81 m in depth, and from 3.125 to 3.750 cm (1.25 to 1.5 inch) in stretched mesh size (Hutubessy *et al.*, 2006). Currently, the number of vessels active in this fishery has reduced due to fewer occurrences of flyingfish in this waters. Fishermen have tended to catch other kinds of fish such as Indian mackerel *Rastrelliger kanagurta* (Souhoka, 2006). Interestingly, eight species of flyingfishes have been recorded from this waters (Hutubessy *et al.*, 2006), dominated by *Cheilopogon suttoni*, *Cheilopogon abei,* and *Hirundichthys oxycephalus*. In addition, comprehensive studies on flyingfish have been conducted (Storey 1983; Mahon *et al.,* 1986; Davenport, 1994; Fahri, 2001; Ali, 2005), and these have mostly focused on their biology. However gear selectivity to catch them is poorly understood. A previous study was focused on two different mesh sizes (Hutubessy *et al.*, 2006).

Due to the similar mesh size used in a piece of gillnet, thus gillnets have been found to be highly selective for fish of a certain size (Fridman and Carrothers, 1986), and knowledge of the size selection of gillnets is effective for regulating their use and for population assessment (Hamley, 1975). Gillnet selectivity has been studied and applied to a wide variety of fish species such as spanish mackerel *Scomberomorus maculatus* (Ehrhardt and Dis, 1988), spotted seatrout *Cynoscion nebulosus* (Helser *et al.*, 1991), lake trout *Salvelinus namaycush* (Hansen *et al.*, 1997),

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coastal sharks *Rhizoprionodon terraenovae*, *Carcharhinus acronotus*, *Carcharhinus isodon* and *Sphyrna tiburo* (Carlson and Cortes, 2003) and flyingfish *Cheilopogon suttoni* and *Hirundichthys oxycephalus* (Hutubessy *et al.*, 2006). Therefore, knowledge of the selectivity of mesh sizes used could support recommendations to minimize the catch of undersized fishes.

The purpose of this study is to examine selectivity coefficients for three species of flyingfish using local drift gillnet in the village of Naku, southern Ambon. In this study, we compare body length of fish gilled onto nets using multi-panel gillnets with four different mesh sizes to determine the optimum mesh size for fishing.

METHODS

Fish were collected employing a 160 m long gillnet consisting of panels of 4 different mesh sizes. Multi-panels of nets with stretched mesh sizes included 2.54 cm (1.0 inch), 3.18 cm (1.25 inch), 3.81 cm (1,5 inch), and 4.45 cm (1.75 inch) was connected at the head rope. Using rubber floats and lead sinker, hanging ratio for all nets were 40%, and the depth of the panels when fishing was 1.5 m. Webbing for all panels were monofilament. When set, the nets were freely drifted to block the swimming direction of fish.

Sampling was conducted from August to November 2006 in waters adjacent to the village of Naku, south Ambon Island (Figure 1). The gillnets were randomly set over a couple hours within an area depending on the occurrence of fish. Fish captured were categorized into gilled (head caught initially in a single mesh) or "entangled" (body caught in multi-meshes), and were pooled for analysis.

Mesh selectivities were estimated following the method of Holt (1963). This method was appropriate for the process of fish captured onto gillnets (Sparre and Venema, 1999). The model was:

$$S_L = \exp\left[-\frac{(L - Lm)^2}{2 * s^2}\right]$$

where S_L was the relative selectivity of fish in length. The value of S_L ranged from 0 to 1. Lm was the optimum length of fish which could be caught, and s^2 was the variance from a normal distribution.

$Lm_a = SF * m_a$ for mesh size a and $Lm_b = SF * m_b$ for mesh size b

where SF is the selectivity factor and m_a and m_b is the mesh size.

$$SF = - 2 * a / b * (m_a + m_b)$$

$$s^2 = SF * (m_b - m_a) / b$$

The values of a (intercept) and b (slope) were calculated from the linear equation between the natural logarithm transformation of ratio of fish caught number at different mesh size (CaL and CbL), and at the certain length interval against the mid point of the length interval (L).

$$\text{Ln}\left[\frac{CbL}{CaL}\right] = a + b * L$$

The assumptions of the model (Holt, 1963) are (1) the shape of the selectivity curve is represented by a normal distribution; (2) the length at maximum selectivity is proportional to the mesh size; (3) the variance is constant for each mesh size; (4) all mesh sizes have equal fishing power.

RESULTS

In total, 402 flyingfish specimen from three species in the coastal aggregation were used for estimating gillnet selectivity. The species of *H. oxycephalus* (n = 189) was the most abundant species captured. The remaining species captured in lower abundance were *C. abei* (n = 133) and *C. suttoni* (n = 80).

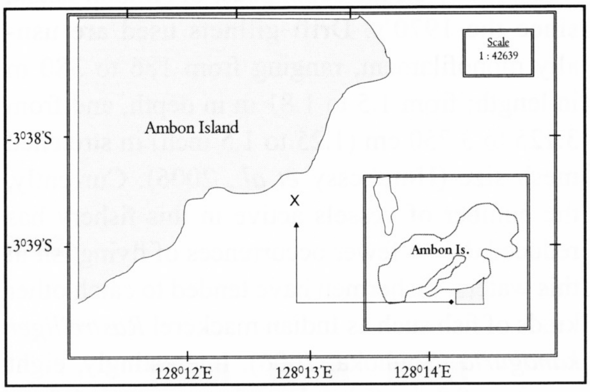

Figure 1. Map of the study site in waters adjacent to Naku village where the multi-panel drift gillnet was set 7 times.

The shape of the length frequency distribution varied in accordance to mesh size and species (Figure 2).

The fish length distribution by mesh size for 1.50" and 1.75" tended to be normal, however, fish caught on the 1.25" mesh size panel did not follow a normal distribution. Many fish were captured by entanglement with the 1.25" mesh size compared to those of 1.50" and 1.75". The length frequency distribution for black plain flyingfish and black spot flyingfish exhibited a similar pattern, the 1.25" mesh size panel caught 17–30 cm TL. For yellow

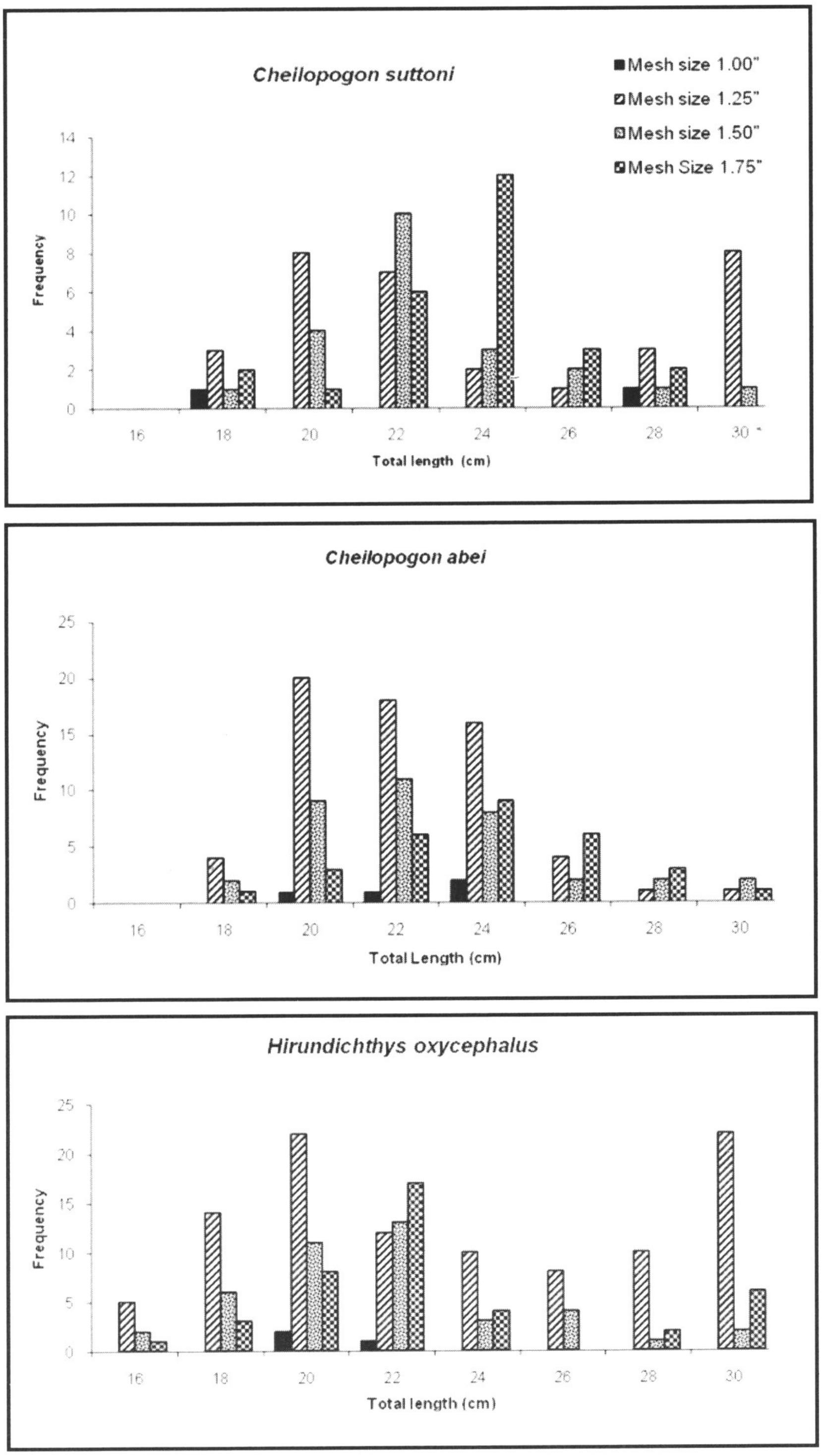

Figure 2. Length-frequency distribution of 402 flying fish by species and mesh size panel (inches) used for estimating gillnet selectivity

spot flyingfish, the distribution was approximately normal for mesh size 1.50" and 1.75" and negative skewed for mesh size 1.25". Only small numbers were caught on the smallest mesh size (1.00"). Therefore, the fish caught by this panel was excluded from the selectivity estimation.

The relative selectivity by species seems to be varied. All species showed broad selectivity curves (Figure 3).

Black spot (*Cheilopogon suttoni*) reached peak selectivity at 20.34 cm for the 1.25" mesh size increasing to 24.37 cm for 1.50" mesh size,

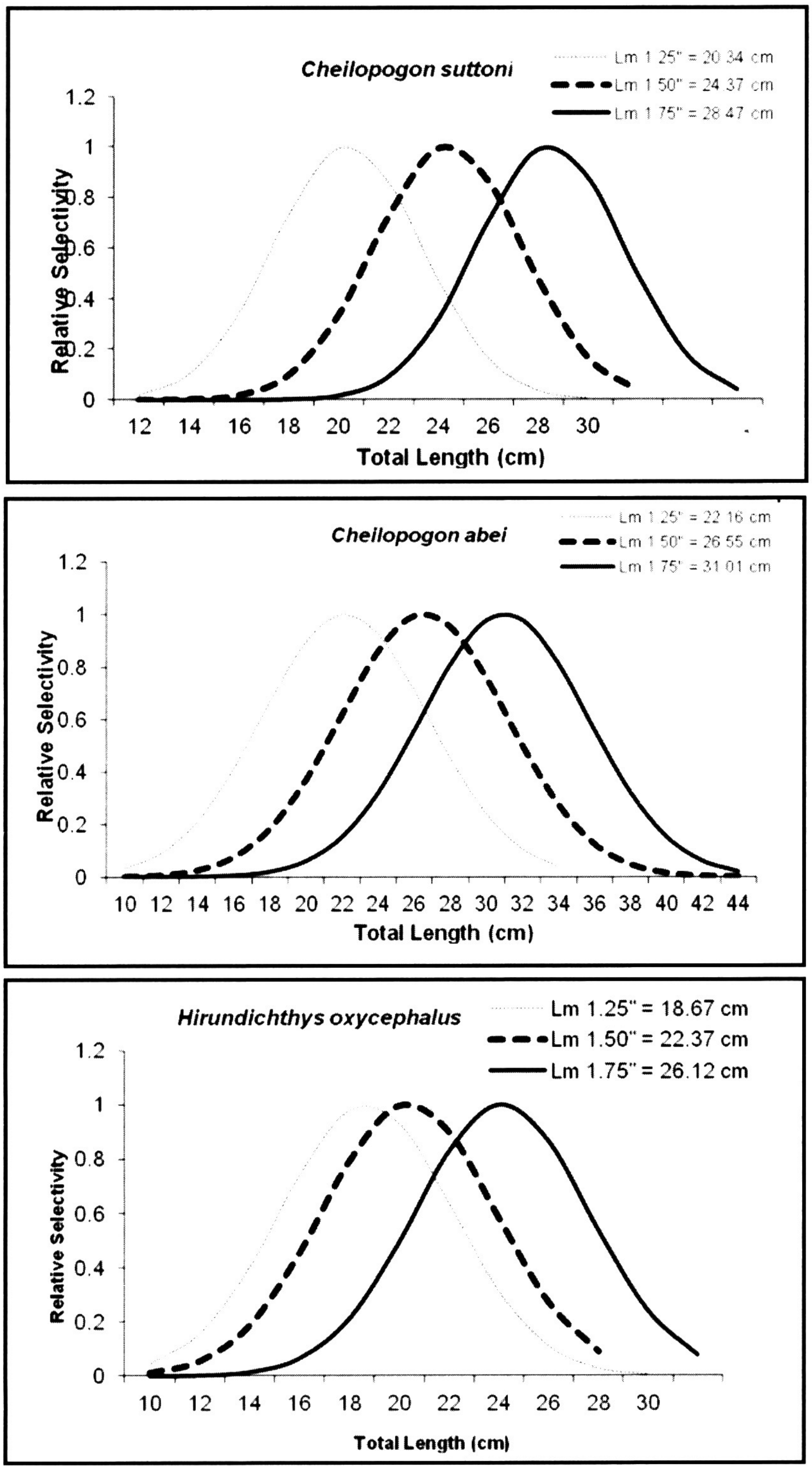

Figure 3. Estimated relative selectivity by panel mesh size as a function of total length

40 mm total length increments per mesh size. Peak selectivity occurred at 22.16 cm for 1,25" for yellow spot (*Cheilopogon abei*) and the maximum selectivity was 31.61 cm for 1.75" mesh size. Peak selectivity for black plain (*Hirundichthys oxycephalus*) reached 18.67 cm for 1.25" mesh size, 22.37 cm for 1.50" mesh size. Selectivity was highest at 26.12 cm for the 1.75" mesh size.

The estimated size-frequency distribution varied depending on species (Figure 4). Predicted numbers of black spot was highest at 17 and 30 cm total length, with numbers decreasing between

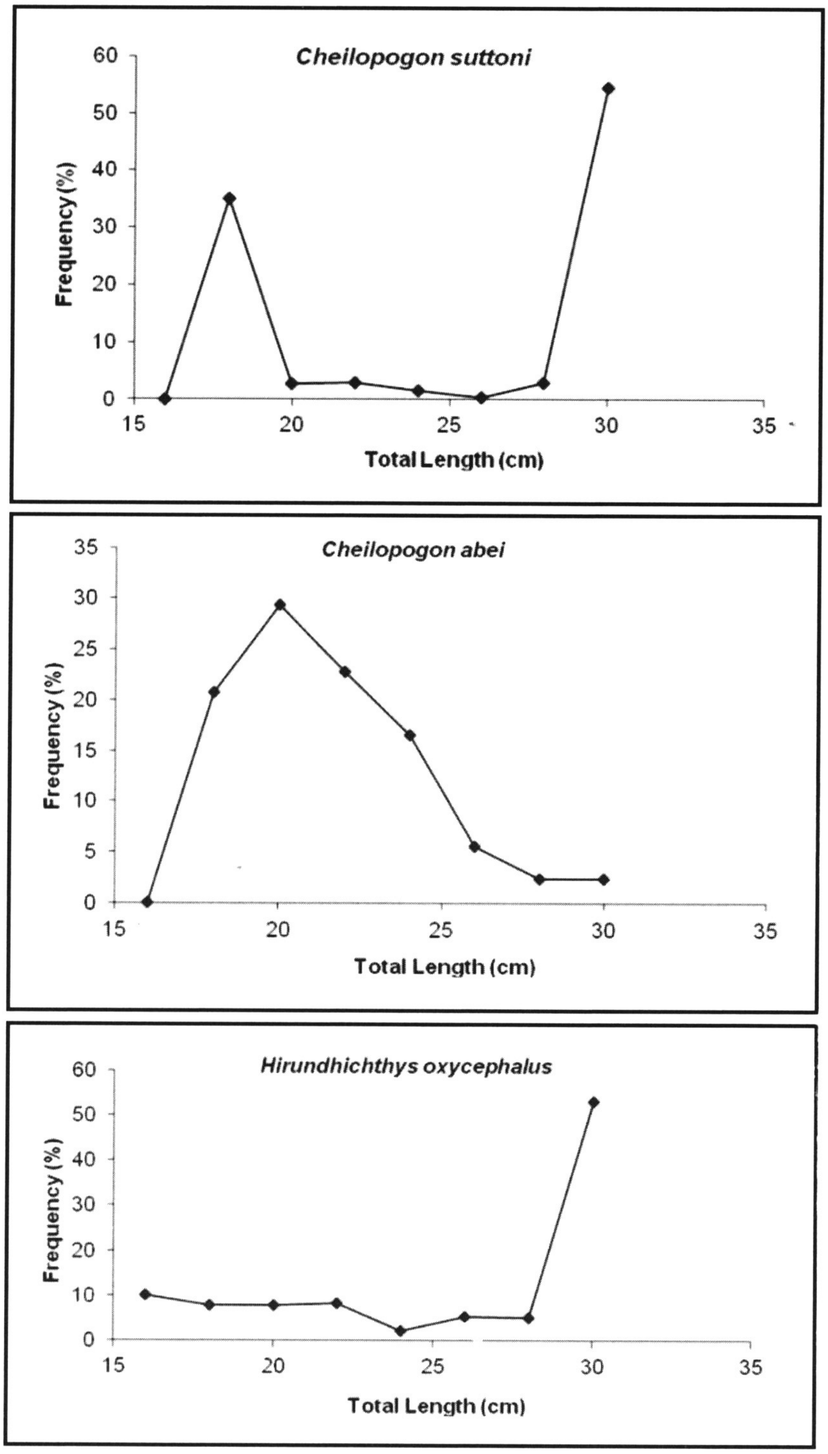

Figure 4. Estimated population size distribution of flyingfish caught by gillnet derived from the gillnet selectivity

both limits of this interval. The size frequency for yellow spot exhibited peaks at 20 cm total length. Exception to black plain flyingfish, the size distribution was constant and decreased to the lowest frequency at 24 cm total length.

DISCUSSION

It is important to examine the assumption of the model in order to achieve valid estimation of selectivity parameters. The assumption that length at maximum selectivity is proportional to mesh size seems to have been met through the relationship between total length and girth for flyingfish. For *Hirundichthys oxycephalus*, girth = 1.5487 + 0.381TL ($P < 0.01$, $r^2 = 0.76$, n = 134), for *Cheilopogon abei*, girth = 2.0997 + 0.362TL ($P < 0.001$, $r^2 = 0.76$, n = 106), and for *Cheilopogon suttoni*, girth = 1.536 + 0.383TL ($P < 0.05$, $r^2 = 0.796$, n = 63). As girth is expected to be the primary variable in determining net retention, it follows that length at maximum selectivity was proportional to mesh size. Moreover, in plots of observed and predicted catches of each size class in each mesh panel (Figure 5), a good correlation

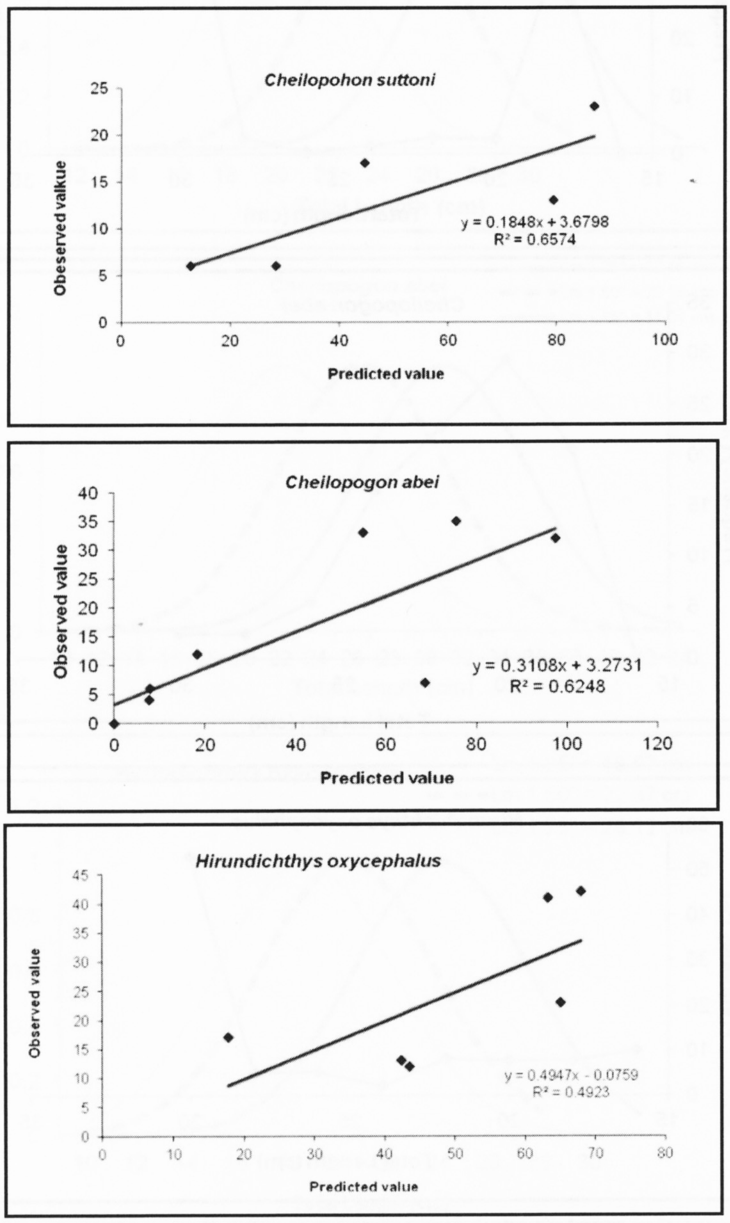

Figure 5. Observed values as a function of predicted values of the number of flyingfish caught by panel mesh size

(r^2 = 0.70 – 0.81) was observed, indicating low residuals. This indicated that individual catches were independent to mesh size which meant the fish were randomly distributed throughout the meshes.

Assumption of equal fishing effort at maximum selectivity was not too difficult to assess directly. In this study, the nets were constructed by local fisherman who have been always targeting flyingfish. With special net shortening (60%), the mesh panels were designed exactly similar to each mesh. Therefore, all panels captured fish in the process of gilled and entangled.

Assessment of the normal distribution and constant variance for all mesh sizes was unlikely to be successfully answered. The length frequency distribution has not been represented to be normally distributed, especially for the mesh size of 1.25". More fish were captured on this panel, and the size of fish was more varied compared to the other 3 mesh sizes used in this study. The process of fish capture was dominated by entangled fish, while all fish were gilled to the biggest mesh size (1.75"). The different processes of fish captured to each panels cause varied sizes of fish, and as a consequence variance among mesh sizes was unlikely to be constant. Simpfendorfer and Unsworth (1998) suggested to analyze the data separately between gilled and entangled fish in order to achieve more accurate estimations of gillnet selectivity. However, we pooled all fish data for analysis because our objective was to provide information that could represent the catch in local fisheries that use gillnet for harvesting flyingfish.

Although fish were caught in the process of gilled or entangled, selectivity estimation showed that there was no overlap among optimum lengths for all meshes and species.

Mesh size and flyingfish morphology are major factors affecting selectivity, as well as elasticity, hanging ratio, twine strength, and fish behavior (Hamley, 1975). To catch flyingfishes with their particulars behavior and morphology requires particular construction of the net. The broad pectoral fins which functions in balancing/ to balance the fish before taking off from the water/surface (Davenport, 1994) affected the fins entangled at the top part of the net for all sizes of fish. This result showed that the nets and method used in this study were sufficiently appropriate and the optimum length estimation could be applied for local fishermen in order to avoid the stock of fish becoming overfished.

The morphology of flyingfish in terms of body shape is depressed. The ratio of body length and depth ranged between 10% to13% for these 3 species (Hutubessy *et al.*, 2006). Fish with a depressed body shape were mostly caught by becoming gilled on the net. By blocking their direction of swimming, some fishes were also entangled in the net by their wings (pectoral fins). If more fish were entangled in nets, the distribution of length could be bi-modal (Hansen *et al.*, 1997). Fish which become entangled by the teeth and maxillaries will generally cause selectivity curves to be broadly domed and skewed to the right (Sbrana *et al.*, 2007; Carol and Garcia-Berthou, 2007). This study showed that 21% of flyingfish were entangled at the net and 79% were gilled. Therefore, its size selectivity curves were a uni-modal normal curve.

For the purpose of fisheries management, it is important to provide a comparison of the increasing optimum length and the minimum size of fish that could be captured although there is no regulation for it. The optimum size for black spot, *C. suttoni*, increased from 20.34 to 28.37 cm following the increasing of mesh size. The minimum size of maturity of this species was 21.45 cm (Hutubessy, unpublished data). The black plain, *H. oxycephalus* and yellow spot, *C. abei* reached minimum size of maturity at 20.49 cm and 24.37 cm, respectively (Hutubessy, unpublished data). This suggests that mesh size of 1.50" and 1.75" were safe to be used in the flyingfish fishery. Moreover, the prediction of flyingfish population size distribution from gillnet selectivity (Figure 4) showed that *C. Suttoni* and *H. oxycephalus* were caught as immature fish or juveniles (25.80% and 37.63%, respectively), whereas *C. abei*, adult fish (> 24 cm) were less than 27% of the catch. Recommendations for minimum size or maximum mesh sizes could be an effective tool to maintain the population of these species of flyingfishes.

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REFERENCES

Ali, S.A. 2005. *Kondisi Sediaan dan Keragaman Populasi Ikan Terbang, Hirundichthys Oxycephalus (Bleeker, 1852) di Laut Flores dan Selat Makasar*. Disertasi. Pascasarjana Universitas Hasanuddin Makasar.

Ayodhya, S. 1981. *Metode Penangkapan Ikan*. Yayasan Dewi Sri Bogor. Bogor

Carol J. and E. García-Berthou. 2007. Gillnet Selectivity and Its Relationship with Body Shape for Eight Freshwater Fish Species. *Journal of Applied Ichthyology*, 23: 654–660.

Carlson, J.K. and E. Cortes. 2003. Gillnet Selectivity of Small Coastal Sharks off the Southern United states. *Fish.Res*. 60: 405–414.

Davenport, J. 1994. How and Why Flying Fish Fly (Review). *J.Fish Biol. And Fish*. 4: 184–214.

Ehrhardt, N.M. and D.J. Die. 1988. Selectivity of Gill Nets used in the Commercial Spanish Mackerel Fishery off Florida. *Trans. Am. Fish. Soc*. 117: 574–580.

Fahri, S. 2001. *Keragaman Genetic Ikan Terbang, Cypselurus Opisthopus, di Perairan Teluk Mandar, Teluk manado, dan Teluk Tomini Sulawesi Selatan*. Program Pascasarjana IPB, Bogor. P.53.

Fridman, A.L. and P.J.G. Carrothers. 1986. *Calculation for Fishing Gear Designs*. FAO By Fishing News Books, Ltd Farnham, England.

Hamley, J.M. 1975. Review of Gillnet Selectivity. *J.Fish. Res. Board Can*. 32: 1943–1969.

Hansen, M.J. C.P. Madenjian, J.H. Selgeby, and T.E. Helser. 1997. Gillnet Selectivity for Lake Trout (*Salvelinus namaycush)* in lake Superior. *Can.J. Fis. Aquat. Sci. 54: 2483–3490.*

Helser, T.E., R.E. Condrey, and J.P. Geaghan. 1991. A New Method of Estimating Gillnet Selectivity, with an Example for Spotted Sea Trout, *Cynoscion nebulosus*. *Can. J. Fis. Aquat. Sci. 57: 507–511.*

Holt, S.J. 1963. Method for Determining Gear Selectivity and Its Application. Spec. Publ. Int. Comn. Northwest Fish 5: Interest to fishers. *FAO Synop*. 125 (1): 27.

Hutubessy, B.G., J.W. Mosse, dan A. Syahailatua. 2006. Selektifitas Gillnet dalam Penangkapan Ikan Terbang di Perairan Naku, Pulau Ambon. Torani vol. 15(6). Edisi suplemen: Ikan Terbang. *Jurnal Ilmu Kelautan dan Perikanan Universitas Hasannudin*, Makasar. Hal 356–360.

Mahon, R., H. Oxenford, and W. Hunte (eds). 1986. Development Strategies for Flying Fish Fisheries of the Eastern Caribbean. Workshop Proceedings. IDRC-MR128e. International Development Research Centre, Ottawa.

Sbrana, M., P. Belcari, S. de Ranieri, P. Sartor, and C. Viva. 2007. Comparison of the Catches of European Hake (*Merluccius merluccius*, L. 1758) Taken with Experimental Gillnets of Different Mesh Sizes in the Northern Tyrrhenian Sea (Western Mediterranean*), Scientia Marina*, 71: 47–56.

Simpfendorfer, C.A. and P. Unsworth. 1998. Gillnet Mesh Selectivity of Dusky Shark (*Carcharhinus obscurus)* and Whiskery Shark (*Furgaleus macki*) from South–Western Australia. *Mar. Freshwater Res*. 49: 713–718.

Souhoka, C. 2006. *Pengaruh Ukuran Mata Jaring Insang Hanyut terhadap Komposisi Ukuran Hasil Tangkapan Ikan Lema (Rastreliger sp*). Skripsi. Fakultas Perikanan dan Ilmu Kelautan, Universitas Pattimura, Ambon.

Sparre, P. and S.C. Venema. 1999. *Introduksi Pengkajian Stok Ikan Tropis*. Buku I. Manual. Pusat Penelitian dan Pengkajian Perikanan Jakarta. 438 pp.

Storey, K.W. 1983. *Aspect of the Biology and Fishery of the Flying Fish, Hirundichthys Affinis, at Barbados*. M.Phil. Thesis, University of the West Indies, Barbados.