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Original paper

EFFECT OF ESCAPE VENT ON CATCHABILITY AND SELECTIVITY OF POT FOR BLACK DAMSEL (*Neoglyphidodon melas*)

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ABSTRACT

The objective of this study was to investigate the effect of escape vent on catch of black damsel, then size selectivity of escape vent will be estimated to predict the retention probability of escape vent on black damsel. The result of this study indicated that comparison of diversity index between the catches of escape vent pots and non escape vent pots were 3.07 and 3.38 respectively. Installing escape vent pots significantly impove catch of commercial size black damsel i.e 56.6% of total catch. A Kolmogorov-Smirnov two sample test indicated that there is significant difference on the length distribution of black damsel between escape vent pots and unvented pots. The result of size selectivity curve indicated that fish size smaller than 8 cm length have high probability to escape from escape vent pots. Length at 50 % retention occurs at fish length of 14. 67 mm.

Keywords: Escape vent ; pot ; black damsel ; selectivity ; catch

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INTRODUCTION

Black damsel (*Neoglyphidodon melas*) is one of the commercial species in Seribu Islands. This species has been found throughout in the rocky and reef area in Seribu Islands. This fish is commonly caught as bycatch pot that target more profitable species of grouper. Even though it does not support an important fishery it is popular as edible species. People around Seribu Islands consume only large size of black damsel because the small size of black damsel only has small portion of meat. Commercial size of black damsel in Seribu Islands has minimum size of 100 gram per individual (14.9±0.7 cm total length). However, length at first maturity for black damsel in Seribu Islands was 11.8 cm (Yustina, 2005). Undersize of black damsel is returned into the sea or discarded due to low commercial market for undersize black damsel. Although fishermen return the black damsel into the sea in live condition, they are vulnerable to the death because of improper handling, air exposure, predator or unsuitable habitat and environment (Kruse, *et al.*, 1994; Juanes and Hartwick, 1990). This leads to lower yields and lower population egg production level (Brown and Caputi, 1985). Discarded species of black damsel become a serious concern for ecologist in Indonesia. Iskandar (2009) estimated about 30 % of black damsel discarded during pot fishing. This situation will be a serious problem if there is no proper action to prevent increasing of discarded species. Alverson, *et.al*., (1996) predicted that discarded species is one factor which lead to fish stock depletion. Increasing number of discarded species should be minimized to prevent stock depletion of black damsel. These problems can be rectified to a degree by using escape vent that reduce the retention of undersize black damsel in pots (Fogarty and Borden, 1980; Everson, *et al.*, 1992; Treble, *et al.*, 1998). The optimal escape vent size is that which provides the best compromise between low catches of undersize

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fish while maintaining the CPUE of commercial size fish. Instead of using catch rates of commercial size fish, calculations of size selectivity curve provide a universal summary of pot performance.

Black damsel mostly caught by bamboo pot during fishing for targeting grouper. Bamboo pots are traditional method of fishing for coral reef fishes in Seribu Islands. In Seribu Island Waters, pots are generally fished seasonable in depths of 3- 10 m. Typical bamboo pot are setting for targeting grouper without equipped by escape gap for releasing undersize catch. Fishermen worried about reduction of target species if they install escape vent for their pot. For the present there is no regulation for fishermen in Indonesia to install any escape vent for reduction bycatch. In long term, this situation will affect worse condition for sustainability of fisheries resources. For necessity of fisheries management and the conservation of black damsel for future sustainable use, pot should be installed by escape vent. This study describes the effect of escape vent on catch of black damsel, then size selectivity of escape vent will be estimated to predict the retention probability of escape vent on black damsel.

MATERIALS AND METHODS

Study area and data collection

The experiment was carried out for ten fishing trials starting from July 17th 2008 to July 26th 2008 in the fishing ground of Seribu Islands waters (05^o 41' 15'' to 05^o 47' 00'' S and 106^o 19' 30'' to 106^o 44' 50'' E). This area located at northern Jakarta (**Fig. 1**). These areas are characterized by a flat coast, sandy, rocky, gently sloping bottoms and depth ranging from 2 to 15 m.

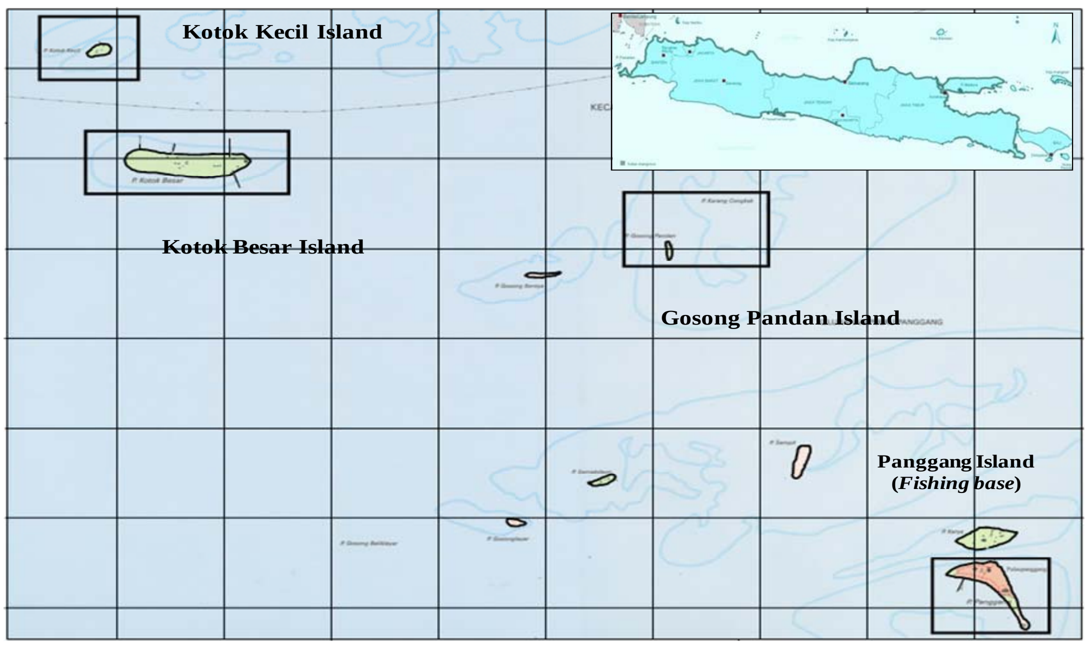

Fig. 1. Map of fishing ground during research activity

Data collection

The pots used in the experiment were of standard size being conventional bamboo pots used by commercial fishermen (66 cm x 51 cm x 20 cm) with arrow head shaped pot. The frame of pots were made from wood covered by bamboo with maximum aperture of 2.5 cm. A horse neck mouth shaped located at the side panel that allowed fish to enter and prevented their escape from pot (**Fig. 2**). A total of 20 pots used in this experiment which consist of 10 pots without escape vents and 10 pots with circle escape vents of 50 mm diameter. Circle escape vent shaped were installed for releasing undersize fish because this shape will provide a large number of non target fish to escape from pot (Miller, 1995).

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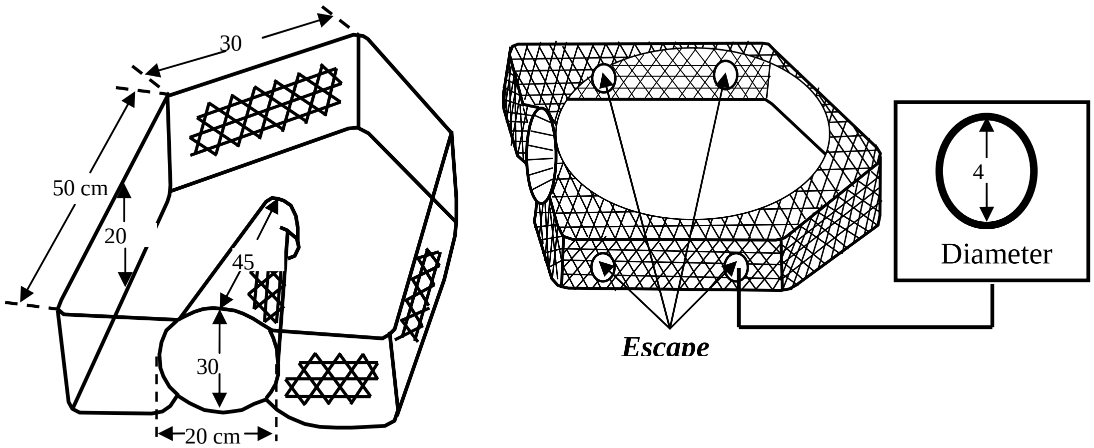

Fig. 2. Dimension of bamboo pot with escape vents located at the side panel

Bamboo pots were transported to the fishing ground by a vessel, 7-m long with a 120 PK engine. The pots were set at low tide to enable the odor of the bait to be most attractive to the fish. Pots were set parallel between escape vent pots and unvented pots at distance 8-10 m apart, allowing an average soaking time of 24 h. All bamboo pots were baited with a *sea urcin* which cut into some pieces placed in the bottom of the pot. All the fish that were retained in the escape vent pot and non escape vent pot were quantified and species identified while black damsel fishes were measured individually for TL to the nearest cm.

Data Analyses

Number of total catch and length distribution between escape vent pots and unvented pots were examined by Kolmogorov-Smirnov test to investigate the effect of escape vent on catch number and size of catch (Steel and Torrie, 1989). Then, inter-specific selectivity is essentially analyzed here in terms of species diversity. As it is suggested by Margalef (1958) the Shanonn on entropy *H'* has been used as measure of diversity (Sacchi, 2002). *H* is measurement of the uncertainty on choice associated with the frequency distribution as:

$$H' = -\sum_{i=1}^{N} P_i * \ln P_i$$

Where *P* is the relative abundance in number of the species and *N* is total number of species. *H'* is maximum (H'_{max}) when the organisms are equally distributed among the species and lower when there is a strong dominance in the sampling unity by a few species.

SELECT Model Analyses

We applied SELECT Model extended by Xu and Millar (1993) to the size frequency data of black damsel caught by pots. The SELECT method uses data from experiments where fishing gear with unknown size-selectivity characteristics is deployed with control gear that is assumed to retain all length classes of fishes that encounter the fishing gear. In this study pots without escape vent were employed as control gear on the assumption that black damsel do not escape through unvented pots. In the comparative experiment, for a given length of individual, l, the proportion of the total catch caught in the experimental gear, $\phi(l)$,is given by the SELECT Eqn (1).

$$\phi(l) = \frac{p(r(l)}{pr(l) + (1-p)} \qquad (1)$$

The size-selectivity function *r(l)* describes the probability of fish retention of length *l*, in the experimental gear given that they encountered this gear. The split parameter *p* in the SELECT model quantifies any possible difference. In this study *p* describes the relative fishing power.

If the experimental and control gears are assumed to have the same fishing power, then *p* is equal to the proportion of the total fishing effort allotted to the experimental gear. However, if the two fishing gear types are suspected of having unequal fishing power, *p* will have some other value, which can be estimated by SELECT procedure. (Millar, 1992). We use two models, one where the values of *p* is regarded as estimates and the other where the values of *p* are fixed by use of the relative total fishing effort with experimental fishing gear. The probability of

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black damsel fish retained in the escape vent pots were analyzed through the length catch distribution by logistic function. This function is the cumulative distribution function of a logistic random variable and is specified by following equation (Wileman, *et.al.*, 1996):

$$r(l) = \frac{\exp(a+bl)}{1+\exp(a+bl)} \quad (2)$$

Where r(*l*) is the probability that fish of length *l* is retained in the escape vent pots while a and b, the two parameters to be estimated, represent the intercept and the slope, after a logit transformation. The length at 50% retention L_{50} is given by

$$L_{50} = \frac{-a}{b} \quad (3)$$

The selectivity curve parameters (a and b) are estimated by maximizing the log likelihood function of Eqn (4) on the assumption that the observed proportion are binomially distributed. The maximization was implemented using add in Software, Solver in MS Excell as follow:

$$LogLi = \sum_l \left[N_l Lnr_l + N_s Ln(1-r_l)\right] \quad (4)$$

Where N_l and N_s are fish number caught in unvented pots and escape vent pots, respectively.

We used Akaike's Information Criterion (AIC) to choose SELECT model with the best fit. AIC value of the fit of each model was calculated using Eqn (5) (Fujimori, *et al.*, 1996):

$$AIC = -2L + 2n \quad (5)$$

Where *L* is sum of log-likelihood of the model fit, *n* is the number parameters in the model.

RESULT

Catch Composition

Number of total catch during a series experiment was 1.097 individuals which consist of 63 species. Dominant catch was black damsel (*Neoglyphidodon crossi*) accounting for 16.5% of total catch. The catches of unvented pots are characterized by a higher number of species and individuals. Among 63 species which were caught by pots during experiment, 61 species caught by unvented pots while 41 species caught by escape vent pots. The comparison of diversity index between the catches of escape vent pots and non escape vents indicated a lower value of Shannon index for the catches of escape vent pot (Shannon index for escape vent pots and unvented pots were 3.07 and 3.38 respectively). A statistically significant difference was examined between escape vent pots *vs* unvented pots on the total catch number of catch (*Kolmogorov-Smirnov* test, $P<0.05$). However, A *Kolmogorov-Smirnov* test failed to indicate a statistically significant difference on catch number of black damsel ($P>0.05$). It means that installing of escape vent did not affect catch number of black damsel.

Length Distribution

The total of 181 individuals of black damsel were caught the experimental fishing operation. Pots without escape vent caught only 25% of commercial size black damsel. Installing escape vent pots significantly impove catch of commercial size black damsel i.e 56,6% of total catch. **Fig. 3** shows length frequency distribution caught in unvented pots and escape vent pots. The Catch number for escape vent pots and unvented pots were relatively similar (i.e 85 and 96 individuals, respectively). *Kolmogorov-Smirnov* two sample test between escape vent pots and unvented pots on the catch number of black damsel did not indicate any significant difference ($P>0.05$).

However, length distribution of black damsel caught in escape vent pots slightly larger than unvented pots. A *Kolmogorov-Smirnov* two sample test indicated that there is significant difference on the length distribution of black damsel between escape vent pots and unvented pots ($P<0.05$).

Proportion Retained of Black Damsel

The estimated curves of $\phi(l)$ in the two models (*p*- fixed and *p*-estimated) were plotted with values of $\phi(l)$ calculated from catch data (**Fig.4**). This figure shows the fit of each SELECT model (*p*-estimated and *p*-fix) to the observed proportion of black damsel in 1 cm total length classes caught in the pots with escape vents. Parameters estimated (a, b, and p), fish length for 50% retention, L_{50}, and Selection Range, *SR*, and *AIC* for two models are shown in **Table 1.**

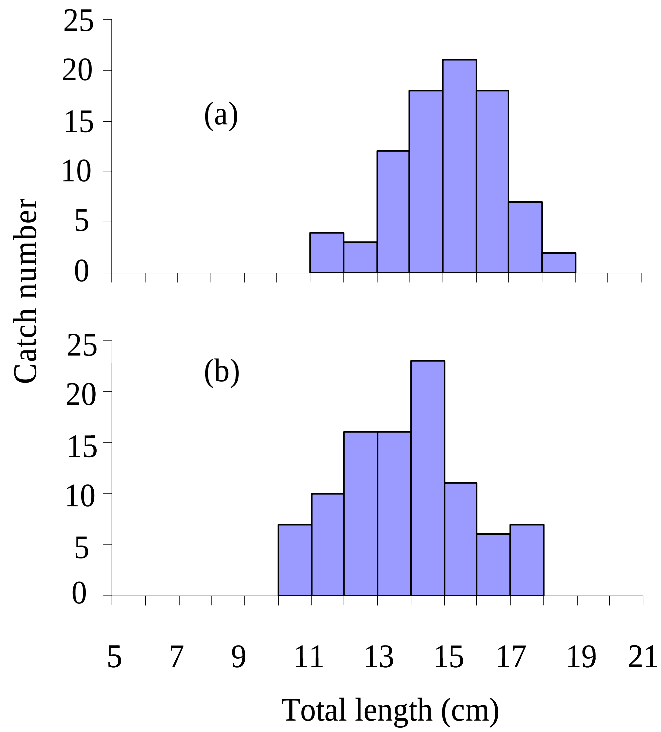

Fig. 3. Length distribution of damsel fish caught by escape vents pots (a) and unvented pots (b)

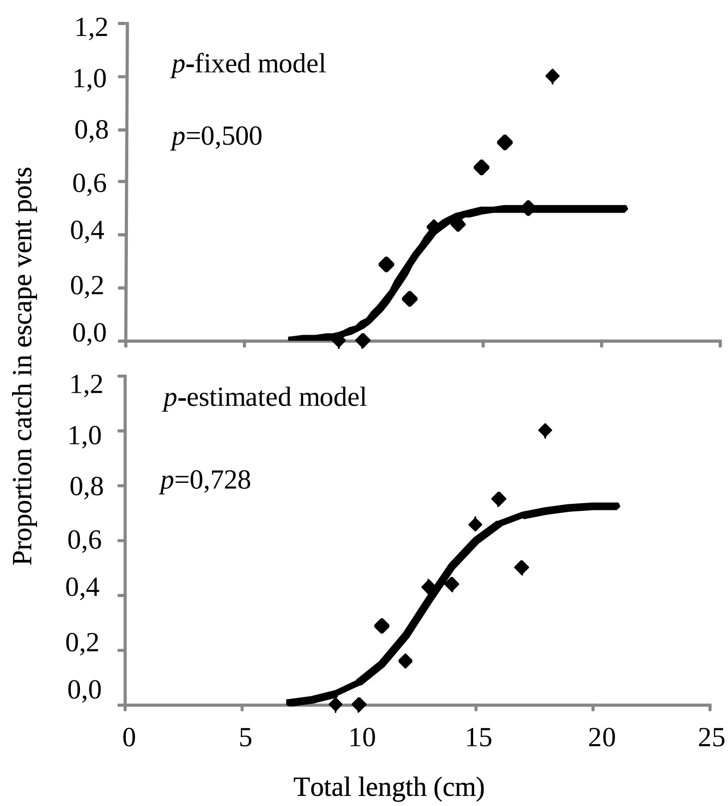

Fig. 4. Plots of the proportion taken in the escape vent pots to the total catch and fitted curves for two models with *p*-fix and *p*-estimated

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Table 1. Parameters estimates of SELECT model for escape vent pots, including using of Akaike's Information Criterion (AIC)

Parameters	*p* -fixed	*p* -estimated
a	-14,57	-10,58
b	1,18	0,72
p	0,500	0,728
L_{50}(cm) *1	12,30	14,67
SR (cm) *2	0,81	1,32
MLL *3	-20,688	-16,938
AIC	-37,38	-27,88

*1 Total length of 50% retention

*2 Selection range defined as L_{75}-L_{25}

*3 Maximum log-likelihood

The proportion of catch data with *p*-estimated model indicated the good fit to the curve. Proportion curves of pots are well fitted to the plot. It can indicate that the applied model is appropriate to express the size selectivity of escape vent pots. The logistic models with *p*-estimated also have lower AIC values than *p*-fix model. Hence, the *p*-estimated model with unequal fishing power was the model with the best fit. We conclude that escape vent increase the fishing power of the pots in this experiment.

Size-Selectivity Curve

Fig. 5 shows the Master Curve of selectivity which describes the probability of black damsel retained by escape vent pots from logistic function with *p*-estimated as the best fit. The result of size selectivity curve indicated that fish size smaller than 8 cm length have high probability to escape from escape vent pots. The probability of fish retained rapidly increased for fish above 11 cm length. Full retention does not occur until 19 to 20 mm total length. Length at 50 % retention occurs at fish length of 14.67 mm. It indicated that escape vent pots caught black damsel fish at 50% retention length larger than length at first maturity (Lm=11.8 cm) but little bit smaller than commercial size.

Discussion

Bycatch in pot fisheries is one of major problem for fisheries in Indonesia. Previous experiment related to pot fisheries stated that commercial pot operated in Seribu Islands caught 66 species while 52 species was non-target species (Iskandar, 2009). However, bycatch is easier to control in baited pots than in most other fishing gear (Miller, 1995). There are four chances to reduce bycatch: (1) select bait with an odor that repels unwanted species. (2) choose the size, shape, location and construction material of the pot entrances to admit only the desirable catch (Hebert, *et al.*, 2001; Stasko, 1975). (3) choose the size, shape, location and construction material of escape opening to retain the desirable catch and release bycatch (Nulk, 1978; Eldridge, *et.al.*, 1979; Krouse, 1978). (4) sort the bycatch on deck and promptly return it to the water (Brown and Caputi, 1985).

The purpose of installing an escape vent at pot is to make fish pot size selective which can reduce bycatch in the pot fishery (Miller, 1995). The result of this study demonstrated that escape vents can significantly alter the quantity and size of the catch compared to unvented pots. In term of total species, unvented pots caught 63 species, after pots were installed by escape vent number of species reduces to be 41 species. Furthermore, the total catch of escape vent pots decreased and the mean length of black damsel increased. However, total catch of black damsel did not decrease significantly indicating that the fishing efficiency of pot for black damsel did not change significantly.

There are several studies on the use of different mechanism to release non target species of pot. Krouse and Thomas (1975) indicated that 44.5 x 152.4 mm escape vent caught fewer sub-legal American lobsters than 41 x 152.4 mm and 38.1 x 152.4 mm. Furthermore, Shepherd, *et.al.*, (2002) concluded that the use of escape vents in wire mesh traps significantly reduced catch of black sea bass below legal size. Pots with escape vents caught more legal size catch than pots without escape vents. This condition may be due to the ability of small species to find escape vents more quickly than larger.

Fig. 5. Master curve of size selectivity escape vent pots from logistic function with *p*-estimated modelThis experiment describe that escape vent does not only release undersize for given species but also reduce non target species of pot which can be indicated by lower Index Shannon *H'* for escape vent pot. This result indicated that escape vent pot relatively selective for species caught in the pot. The use of Index Shannon for describing species selectivity was already done by Sacchi (2002). Sacchi (2002) introduce term of inter-specific selectivity to indicate species diversity and intra-specific selectivity for indicating size selectivity of fish caught by fishing gear.

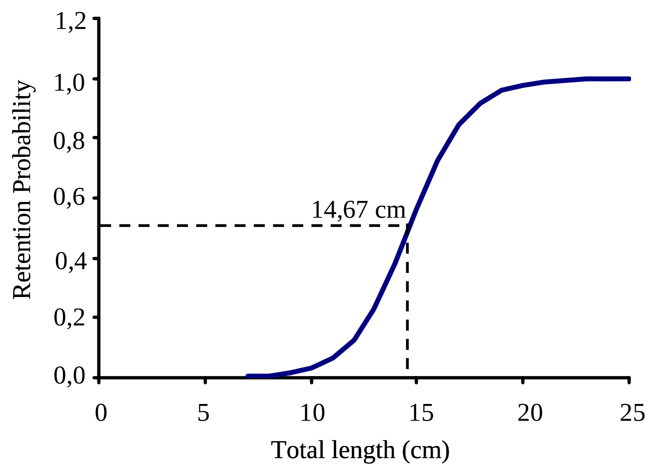

Fig. 5. Master curve of size selectivity escape vent pots from logistic function with *p*-estimated model

The size-selectivity curve support the previous research by Iskandar and Lastari (2008) that escape vent result in selection of fish length. Length of at 50 % retention was 14.67 cm which indicated that escape vent release more than 50% of immature fish because length at first maturity of black damsel in Seribu Islands was 11.8 cm. However, L_{50} of size-selectivity curve of the escape vent pots close to the commercial size of black damsel. Therefore, the escape vent pots were able to demonstrate that 50 % of fish caught in the escape vent pots were in the range of commercial size. This situation will reduce discarded bycatch due to undersize catch of black damsel.

CONCLUSIONS

There are four conclusions from our study. (1) Escape vent pots reduce non target species caught in the pot which indicated by lower Index of Shannon (*H'*) than unvented pots. (2) Length size distributions of black damsel caught in the escape vent pots were significantly larger than those caught in the unvented pots (Kolmogorov-Smirnov two sample test, $P<0.05$).(3) The SELECT model from logistic function with the *p*- estimated model with unequal fishing power was the model with the best fit. (4) Length at 50 % retention occurs at fish length of 14.67 mm. It indicated that escape vent pots caught black damsel fish at 50% retention length larger than length at first maturity (Lm=11.8 cm)

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