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Original Paper

COMPARATIVE SELECTIVTY AND CATCHABILTY OF POT AND TUBE FOR CONGER EEL (*Conger Myriaster*)

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ABSTRACT

The objective of this experiment was to develop a method to estimate mesh selectivity of pot and comparative catchability between pot and tube for white spotted conger eel (Conger Myriaster). About ten times comparative fishing experiments were carried out off Haneda in Tokyo Bay, during October and November every year from 1997 to 2000. The experiment used collapsible pots of 5 mesh openings (21.0, 18.1, 15.5, 13.6 and 11.6 mm) and tube of 9.06 mm hole diameter as control gear. Result of this experiment indicated that pot of larger mesh size caught larger conger. Significant different was found in in length distributions between the four years (ANOVA Test, $P=1.9x10^{-45}$) and then the data were not combined for the analysis. In term of girth-perimeter ratio, R value of 50% retention and selection range were calculated to be 1.19 and 0.24 from estimated logistic parameters, (α,β)=(-10.67, 8.99). When catchability of tube was assumed to be 1, relative catchability of pot with 21.0, 18.1, 15.5, 13.6 and 11.6 mm mesh openings were 0.62, 0.79, 0.73, 0.63 and 0.51, respectively. This suggested that one tube could catch more conger eel than one pot and pot of larger mesh size was likely to catch of larger size more effectively.

Keywords*:* Selectivity ; catchability ; tube ; pot ; conger eel

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INTRODUCTION

White-spotted conger eel (*Conger myriaster*) is an important species for coastal fisheries in Japan, and caught mainly by pot, and eel-tube. Each year intensity of conger eel increases due to the demand of this commodity (Tokai *et.al*., 2002). Increasing fishing intensity on conger eel results in a serious problem for the sustainability of this species. The annual landings decreased from the peak of 1.8 thousand tons in 1992 and recently maintained one thousand tons (Tokai *et.al*., 2002) .

To prevent further conger eel depletion, it is necessary to control fishing intensity upon conger eel. To control fishing intensity of many fishing gear, it is necessary to asses fishing effort and catchability of fishing gear. However, it is difficult to control fishing intensity directly because size selectivity of fishing gear is different. Size selectivity of fishing gear depends on the length composition of conger eel population which encounter to the fishing gear. Then, the catchability of fishing gear depends on the fishing power of each fishing gear. Mesh size of pot and hole diameter of tube are parameters which affects fishing power of pot. For this reason, the determination of size selectivity of fishing gear is needed to control the fishing intensity. In Kanagawa prefecture, the enlargement of hole diameter to 16 mm in diameter was recommended for fishermen to protect small conger. However, they doubted the effectiveness of holes enlargement as escape holes. Shimizu, (1997) carried out an experiment on size selectivity of pot for conger eel. But the result was unclear, because the catchability of fishing gear was unknown. Size selectivity only estimated length composition of conger eel caught at certain fishing gear. But, number of catch retain on certain fishing gear is unknown.

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SELECT Model (Share Each LEngth's Catch Total) which is a standard analysis method for estimating fishing gear selectivity from comparative fishing experimental data is useful to estimate fishing intensity with size selectivity (Millar, 1992; Millar and Walsh, 1992; Millar and Fryer, 1999). With the use of effort data, Uchida, (2000), Fujimori and Tokai (2001) extended the select model method to analyze relative catchability. This paper propose a method which uses the size-selectivity of multi-fishing gears to provide an estimation of relative catchability. In reference, the relative catchability between the tube and collapsible pots with different mesh sizes will be used as an example of the calculation of this method. Furthermore; we intend to use data of comparative fishing experiments which are moderated for the master curve of mesh selectivity found in the pots for catching the conger eel.

MATERIALS AND METHODS

Sampling Area

The areas for the fishing experiment took place off Tokyo Bay Haneda (**Fig. 1**). The two fishing gears of tube and collapsible pot were used in the experiment twice a day. The fishing gear were usually in use for about two hours in the evening followed by 15 more hours of successive night till early morning. Bait was usually of frozen sardines which were cut roughly and put into string bags and than settled into the pot and tubes.

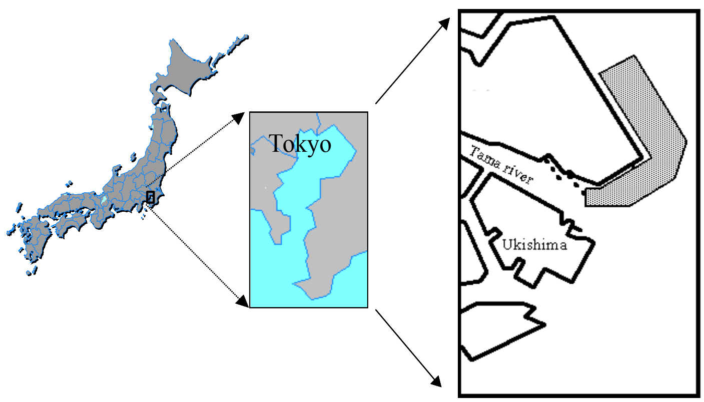

Fig. 1. Area of fishing experiment of the white-spotted conger eel

Fishing Gear

Five mesh opening of collapsible pots; 11.6 mm, 13.6, 15.5 mm, 18.1 mm and 21.0 mm and tubes with drain hole diameter of 9.06 mm were used in this experiment (**Table 1**). Hole diameter of 9.06 mm indicate that the drain hole of tube was small enough to retain the small conger. The tube of 9.06 mm was treated as a control gear.

In this fishing experiment, a total of 10 fishing operations per year were carried out in 1997 to 1999 with another totaled at 9 fishing operations in 2000. In 1997 fishing experiment, the number of tubes was 10, while in the other three years was 30. The number of pots of mesh opening 21.0 and 18.1 mm changed from 1997 to 1999.

In such cases as our comparative fishing experiments related to fishing gear selectivity analysis, there is usually a great need to obtain large data of the length measurement. For this necessity, sometimes the data of several continuous experiments were combined. Uchida *et al.*, (2000) presented the two conditions to combine the data: (1) the ratio of fishing effort, that is the ratio in number of fishing gear used in the experiment are constant, or (2) the fish length distributions in the population were constant during the experiments. If the length size distributions in the population were not the same between the four years (1997 to 2000), the catch data of the four years should not be combined only unless the mentioned takes place.

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Table 1. Number of fishing gear used

Fishing gear		Period			
Pot	Mesh Opening (mm)	6 Oct -21 Nov 1997	10 Oct -6 Nov 1998	25 Oct -9 Nov 1999	17 Oct -14 Nov 2000
	21.0	6	5	3	3
	18.1	6	7	9	9
	15.5	6	6	6	6
	13.6	6	6	6	6
	11.6	6	6	6	6
	Total	30	30	30	30
Tube hole diameter 9.06mm		10	30	30	30
Operation number		10	10	10	9

SELECT Analyses Based On Multinomial Distribution

The total number of conger eel of girth g_j that are caught at period t, C_{tj} was expressed as:

$$C_{tj} = \sum_{i=1}^{k} c_{tij} \qquad (1)$$

At period t, ϕ_{tij} is the proportion of fish of body girth g_j captured by fishing gear i, and is described as:

$$\phi_{tij} = c_{tij} \Big/ \sum_{i=0}^{k} c_{tij} \qquad (2)$$

In each year data, the proportion was plotted against girth.

While conger eel come to contact to the mesh, selection whether the conger eel is retained or not depends strongly on the relationship between mesh perimeter and body girth. On the assumption of geometrical similarity, when a given combination of girth g and mesh perimeter p indicates a value of retention probability, and then, the combination of k times values at both of girth and mesh perimeter has the same retention probability. Instead of the two parameters, girth and mesh perimeter, one perimeter, that is ratio of girth to mesh perimeter; girth-over-perimeter ratio was used to express mesh selectivity.

Master curve of mesh selectivity pot $s(R)$ was described with a logistic function as follows (Willeman *et.al.,* 1996);

$$s(R) = \frac{\exp(\alpha_R + \beta_R R)}{1 + \exp(\alpha_R + \beta_R R)} \qquad (3)$$

Here, α_R and β_R is logistic curve parameter.

By defining π_{ti} as the relative fishing intensity, here $\pi_{ti} = q_i x_{ti}$. Hence number of conger eel of girth g_j that are caught at period t, by fishing gear i was expressed as following equation;

$$c_{tij} = q_i x_{ti}\, t\lambda_{tj}\ \ s(R_{ij}) \qquad (4)$$

where q_i is catchability of i-th fishing gear, x_{ti} is fishing effort of i-th fishing gear at period t, λ_{tj} is body size distribution of conger eel in the population at year t, $s(R_{ij})$ is retention probability of mesh perimeter p_i for conger eel of girth g_j. Therefore, the proportion of conger eel of body girth g_j captured by fishing gear i, is described by the following function;

$$\phi_t(R_{ij}) = q_i x_{ti} s(R_{ij}) \Big/ \sum_{i=0}^{k} q_i x_{ti} \lambda_{tj} s(R_{ij})$$

$$= q_i x_{ti} s(R_{ij}) \Big/ \sum_{i=0}^{k} q_i x_{ti} s(R_{ij})$$

(5)

Here, logistic curve parameter α and β were parameter to be estimated by maximizing the

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log likelihood function as follows:

$$\log_e L = \sum_{t=1}^{T}\sum_{j=1}^{n}\sum_{i=1}^{k}\left(c_{tij}\log_e\left(\pi_{ti}s(R_{ij}) \Big/ \sum_{i=1}^{k}\pi_{ti}s(R_{ij})\right)\right) \quad (6)$$

RESULTS AND DISCUSSION

RESULTS

Size Distribution of Conger Eel

Fig. 2 showed body girth distributions of conger eel caught by each fishing gear in 1997 to 2000. Girth distribution of conger eels caught by 11.6 mm mesh size pots looks the same as the tube catches, but obviously, the pot of larger mesh size caught only larger conger eels. Based on the results of the ANOVA test in girth size distributions of conger eel caught by the tube between the four years experiment, significant differences are found (Anova test, P <0.01). This indicated that, data on each year experiment couldn't be combined. It is essential to deal with the data in each year for the SELECT analysis.

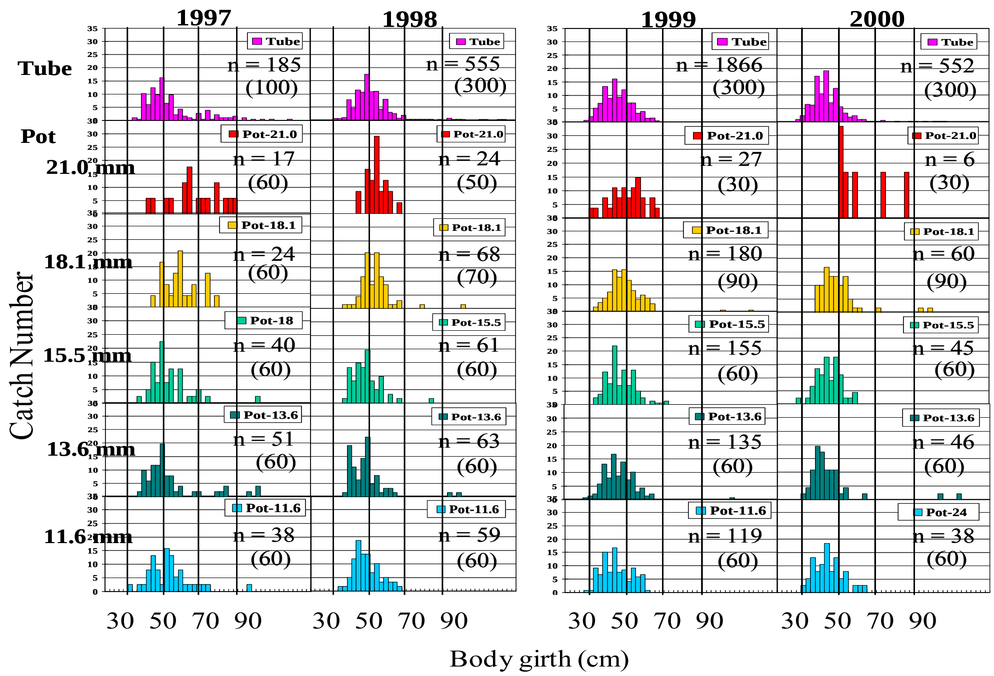

Fig. 2. Body girth distributions of white-spotted conger eel

In 1999 year experiment as the largest sample size, only tubes and pots of 11.6 mm mesh size retained large numbers of small conger eels. Similarly, pots of larger mesh size retained the larger body girth conger eels. The tubes received the largest catches. In contrast, the pot catch numbers were mostly at a 180 congers in mesh size of 18.1 mm. There are two reasons as follow: one is because the total numbers of used fishing gear was 300 in tube, which is larger than those of pots 30, 60 and 90. Another is because tubes have drained holes small enough to retain small size of congers. Thus, by the accumulated girth distributions, the proportion catch of each fishing gear was calculated.

Proportion Retained of Conger Eel

Fig. 3 shows the proportion of conger eel retained by tube and each mesh size of pot in the 1999 year experiment. The diamond shows a proportion of numbered conger eels retained in tubes, the square show a proportion of numbered conger eels retained in pots 21.0 mm mesh size, etc. Solid line shows a proportion curve for tube, dot line shows proportion curve for pot of 21.0 mm mesh size, etc. Of size girth smaller than 3 cm, conger eel was retained by tube and pot mesh size of 11.6 mm mesh opening. In the larger girth size, catches by larger sized meshes increased according to the proportion of decreased tube catches. Plots of catch by pots were scattered, but on the whole, the proportion curves of tube and pots are well fitted to the plots. In particular, the proportion curves of the tubes expressed the decrease in the proportion with an increasing girth. Proportion curve of collapsible pot increases by increasing the girth, then remain constant at a larger size. In this proportion curve fitness process, the parameters qi and logistic parameters α and β were obtained.

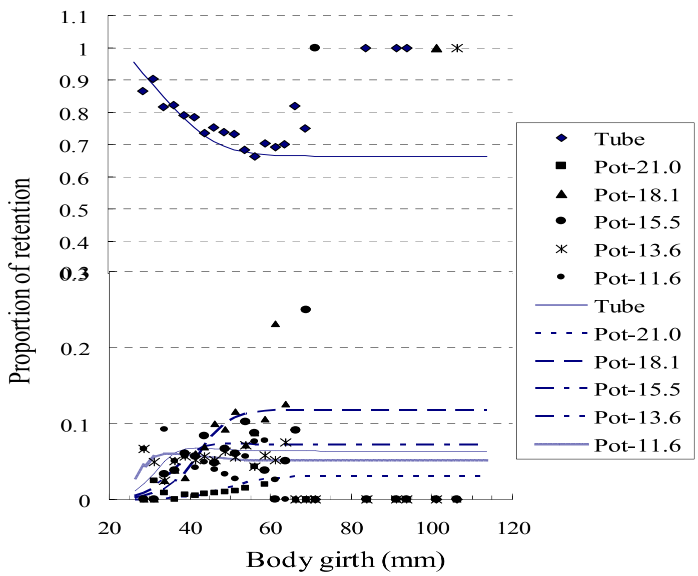

Fig. 3. The proportion of conger eel retained by tube and each mesh size of pot in the 1999 year experiment

Master Curve of Mesh Selectivity

R-values of 50% retention and selection range were calculated to be 1.19 and 0.24 from the estimated logistic parameters α and β of -10.67 and 8.99 respectively (**Table 2**). Mesh selectivity increases at G/P =0.6, reaching 100 % retention at G/P of about 1.8 (**Fig. 4**). It indicates that conger eels can pass through the mesh of smaller size than the girth. This curve is similar to the results indicated by previous studies for trawl and pots selectivity.

Table 2. Parameters of selectivity curve and value of relative catchability (q) for each mesh size of pot

		Mesh Opening (mm)					Tube hole (mm)
Parameters		21.0	18.1	15.5	13.6	11.6	9.06
α	−10.7						
β	8.99						
R_{50}	1.19						
SR	0.24						
π1		0.094	0.118	0.109	0.095	0.077	0.508
π2		0.052	0.092	0.073	0.063	0.051	0.669
π3		0.031	0.118	0.073	0.063	0.051	0.064
π4		0.031	0.118	0.073	0.063	0.051	0.064
q		0.62	0.79	0.73	0.63	0.51	1

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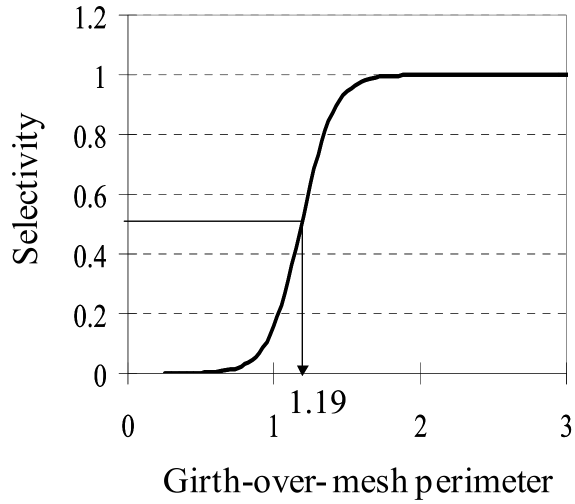

Fig. 4. Master curve of mesh selectivity in terms of girth-over-perimeter

When catchability of tube was assumed to be 1, relative catch ability of pot with mesh size of 21.0, 18.1, 15.5, 13.6 and 11.6 mm, were 0.62, 0.79, 0.73, 0.63 and 0.51, respectively. This suggested that one tube could catch 1.5 times more conger than one pot, while a pot with larger mesh size is likely to catch a conger of larger size more effectively.

DISCUSSION

In the analyses of mesh selectivity for gillnets, methods have often been applied using master curves in terms of girth and mesh perimeter. Then, Tokai *et al*., (1994) also demonstrated that it is possible to express mesh selectivity as a function of the ratio of girth to mesh perimeter. It is well known that at the same mesh size, mesh selectivity is affected by factors other than mesh size and fish size, e.g. the mesh opening (Robertson and Stewart, 1988), the rigidity of the mesh shape due to twine material and tension in the twine due to the catch (Lucas *et al*., 1954) and fish behavior (Engas and Godo, 1989; Godo and Walsh, 1992). In terms of the master curve of mesh selectivity for this experiment, 100 % retention occurred at ratio girth-over-mesh perimeter ratio larger than 1. This result was similar with Nishikawa *et al*., (1994) during an estimation of mesh selectivity of small trawl for conger eel. It was suggested that conger eel could slip through a mesh of perimeter even smaller than its girth because they have smooth bodies coated in mucus with no surface scales and have the capability of skillfully snaking through a narrow space, like a mesh. However, there is difference in the 100 % retention of master curve selectivity between species. Tokai, *et al*., (1990) found that mesh selectivity for rough shrimp increase with an increase in R and each 1 at R of about 0.7 regardless of mesh size. Furthermore, Tokai, *et al.,* (1994) derived 100 % retention in master curve for six species at R close to 1. This could imply that the meshes could not be distorted far enough from their approximately diamond shape to allow fish of a girth equivalent to mesh perimeter to pass through. The R_{100} depended more strongly on the distortion of the mesh shape with respect to the dimensions of the fish body, which was determined by the tension in the meshes and the rigidity of the mesh twine. In this experiment, the flexibility of the mesh which affects the 100 % retention depends on the behavior and swimming ability of the conger eel when it passes through the mesh, as well as on the body type of the species, as well as on the tension in the mesh and the rigidity of the mesh twine.

In this study, the SELECT model was extended with fishing effort data, and we succeeded in obtaining the catch ability, even relative values. One tube could catch more conger than one pot. Furthermore, enlargement of hole diameter of 9 mm also still retained many unmarketable conger eel (Tokai *et al.,* 2000). Because the shape of the tube looks like a hiding place for the conger eel, it offers a habitual it allows it to be attached to the tube. Therefore, after eating the bait, conger eel continuously stay inside and thus offers it difficulty in escaping from out of the tube hole.

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However, a pot of larger mesh size is likely to catch a conger of larger size more effectively.

Smaller-mesh size pot retained many small congers, which is associated with the two explanations: baits were either eaten up by smaller size congers, or they simply occupied the space. And then the probability of large size congers entering becomes difficult. A similar case also occurred in the results investigated by Jeong *et al.,* (2000) which indicated that smaller mesh sized pots caught larger numbers of small snow crab. Larger mesh size is more selective to retain legal catches. Another case also occurred with the pot staged as an escape-vented and non-vented. Non-vented pot catches larger number of sub legal catches. In non-vented pots, sub legal catches occupy space, which might be taken by legal sized catches (Fogarty and Borden, 1980). Hence, size selectivity; here mesh selectivity is an important tool for reducing waste of small fish catches. This analysis method and results are useful for fisheries management, and in particular for controlling fishing intensity in multi-fisheries.

CONCLUSION

In this study, the SELECT model was extended with fishing effort data, and we succeeded in obtaining the catchability, even relative values. Size selectivity, here mesh selectivity is also important tool for reducing by catch of small conger eel. This analysis method and results are useful for fisheries management, in particular for controlling fishing intensity in multi-fisheries.

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Table 1 Number of fishing gear used

Fishing gear		Period			
Pot	Mesh Opening (mm)	6 Oct -21 Nov 1997	10 Oct -6 Nov 1998	25 Oct -9 Nov 1999	17 Oct -14 Nov 2000
	21.0	6	5	3	3
	18.1	6	7	9	9
	15.5	6	6	6	6
	13.6	6	6	6	6
	11.6	6	6	6	6
	Total	30	30	30	30
Tube hole diameter 9.06mm		10	30	30	30
Operation number		10	10	10	9

Table 2 Parameters of selectivity curve and value of relative catchability (q) for each mesh size of pot

		Mesh Opening (mm)					Tube hole (mm)
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$\pi 1$		0.094	0.118	0.109	0.095	0.077	0.508
$\pi 2$		0.052	0.092	0.073	0.063	0.051	0.669
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FIGURE IN CAPTION

Figure 1. Area of fishing experiment of the white-spotted conger eel
Figure 2. Girth distributions of white-spotted conger eel
Figure 3 Girth distribution of conger eel caught in 1999 as the largest sample size
Figure 3. The proportion of conger eel retained by tube and each mesh size of pot in the 1999 year experiment
Figure 4. Master curve of mesh selectivity in terms of girth-over-perimeter

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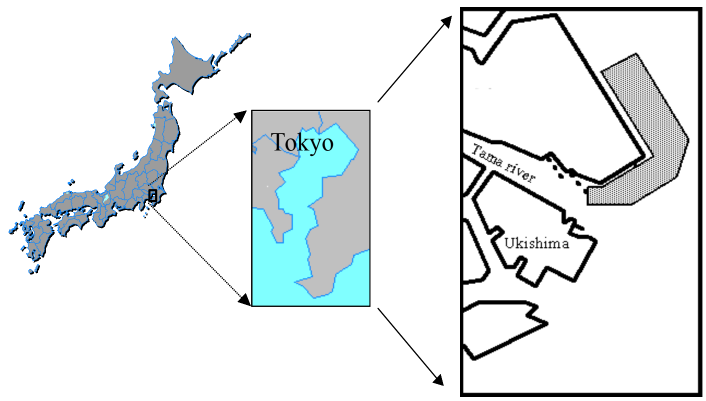

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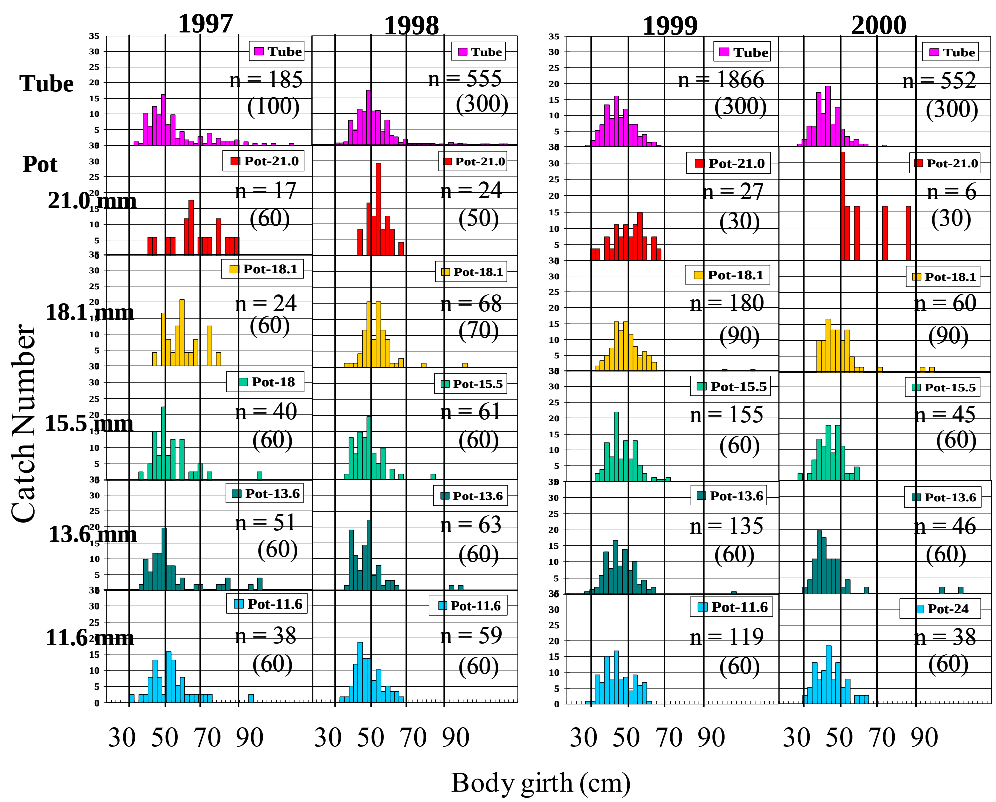

Figure 2. Body girth distributions of white-spotted conger eel

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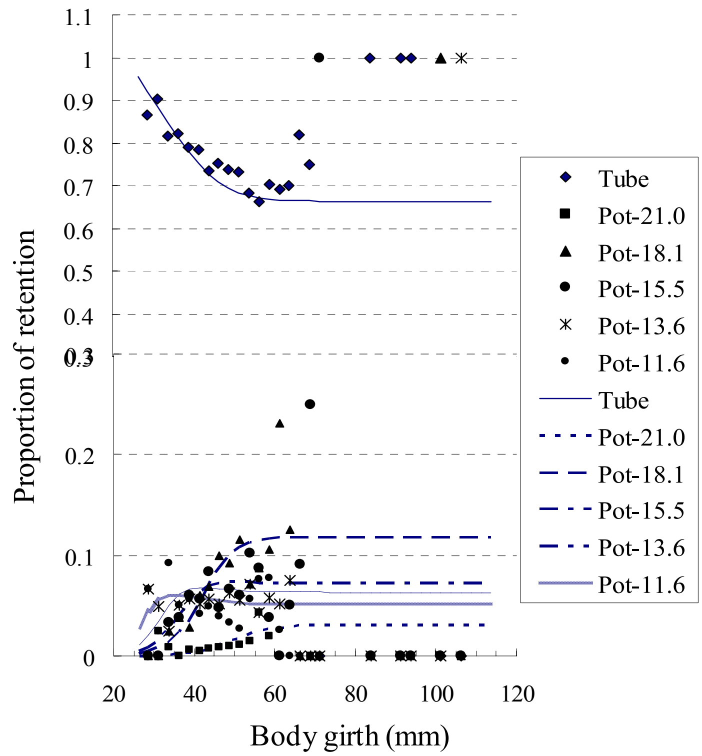

Figure 3. The proportion of conger eel retained by tube and each mesh size of pot in the 1999 year experiment

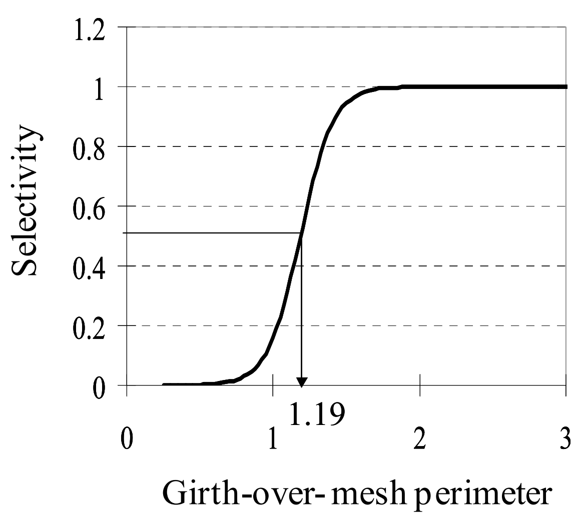

Figure 4. Master curve of mesh selectivity in terms of girth-over-perimeter