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Studies on Trawl Net Model Experiment of Three Types of Trawl Net

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Abstract

To obtain some fundamental suggestions on the gear efficiency of the three different types of trawl net, the authors carried out the model experiment, and compared them with each other, basing on the physical characteristics of the net. The first is the two-seam-net was used in 1950's in East China Sea; the second is the four-seam-net was used in 1960's in Bering Sea; the third is the six-seam-net was used on board of the "Nansei Maru". These three nets aimed for catching the demersal fishes. The results obtained in this study are summarized as follows:

(1) The towing speed, when the height of net mouth is stable, differs in each net. The towing speed is about 2.3 knot on the two-seam-net, about 2.6 knot on the four-seam-net and about 3.0 knot on the six-seam-net. On ordinary towing condition, the height of net mouth on the four-seam-net is the highest, marking about 6.0–9.0 percent of the maximum breadth of the net, among the three types of trawl net.

(2) Net resistance is explained by general equation $R=k\ V^n$, and the values (n), the highest values observable in the four-seam-net, marking 1.64–1.99, the second is the values of two-seam-net, marking 1.42–1.64, and the third is those of six-seam-net, marking 1.32–1.53.

Introduction

In otter trawl fishing, there are three types of net design. The first is two-seam-net, constructed of baiting and belley; the second is four-seam-net, constructed by adding two side panels to two-seam-net; the third is six-seam-net constructed by adding two triangled net webbings to four-seam-net. These nets are usualy used to catch demersal fishes.

In this paper authors carried out model experiment and compared the gear efficiency of the net among the three kinds of the trawl net.

The data obtained here are supposed to give us some fundamental informations about the planning of the trawl net.

Material and Method

These nets put under the experiment were three kinds of construction; the net

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consisted of two pieces, the baiting and belley; four-seam-net made by adding two side panels to two-seam-net; six-pieces-constructed-net made by adding triangled nets to four-pieces-net. Two-seam-net was used in 1950's in the East China Sea, four-seam-net was used in 1960's in the Bering Sea, six-seam-net was used on board of "Nansei Maru"*.

These nets used in this experiment are shown in Fig. 1, 2, 3. Summary of the experimental gears is shown in Table 1.

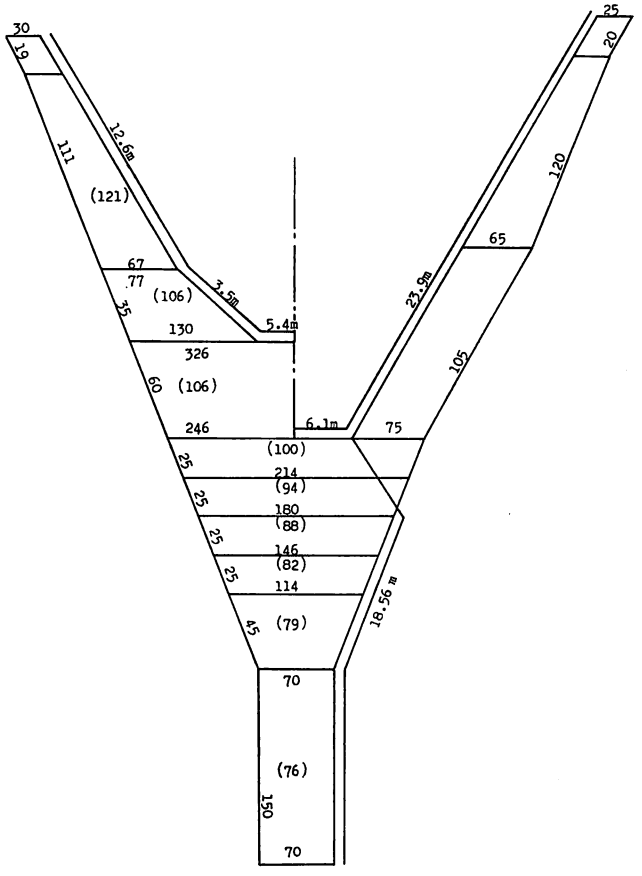

Fig. 1. Net plan of the experimental gear on two-seam-net. Numbers in the figure show the mesh number, bracketed number showing the mesh size (mm).

Field experiments were carried out on the sea off Tanegashima Island. Net-height-meter was attached to the head rope and to the ground rope in order to measure the height of the net mouth in fishing condition. Towing speed was measured by electrical magnectic log. Tension of warp was measured by ten-

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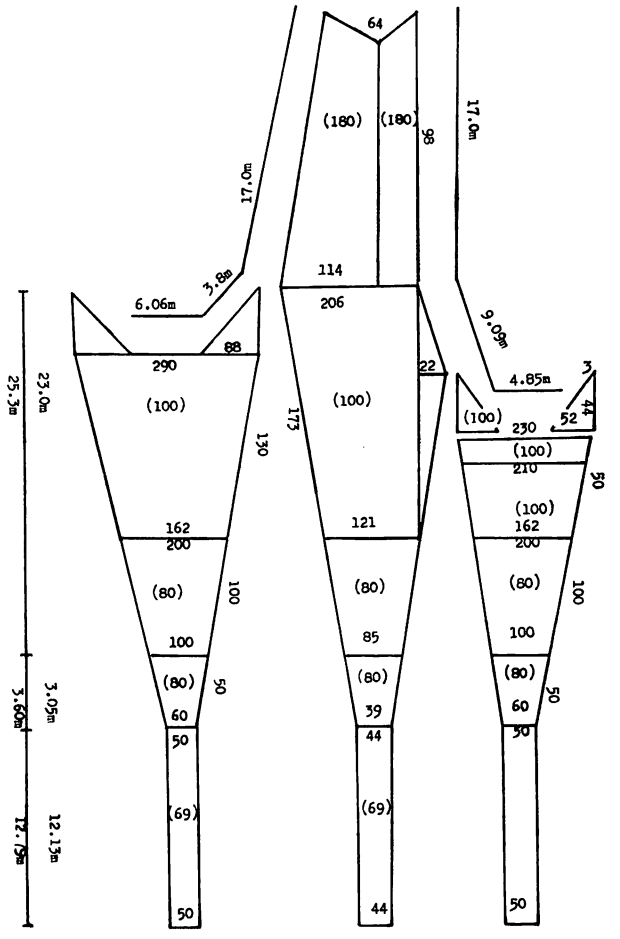

Fig. 2. Net plan of the experimental gear on four-seam-net. Numbers in the figure show the mesh number, bracketed number showing the mesh size (mm).

Table 1. Summary of experimental gear.

		Two-seam-net	Four-seam-net	Six-seam-net
Head rope length	(m)	36.72	47.66	15.20
Ground rope length	(m)	58.14	57.03	18.90
Float total buoyancy	(kg)	224.48	376.2	64.0
Ground rope weight	(kg)	282.14	436.3	79.7

sionmeter on deck. Also, the position of shooting the net and that of hauling the net were fixed by radar equipped in "Nansei Maru."

Model experiment was carried out at the circular tank of this faculty. Tension of model net was measured by UT gauge and recorded by pen recorder. Height of the net was measured by the measuring scale bar, directly. Experimental apparatus is shown in Fig. 4. The experimental model net was made,

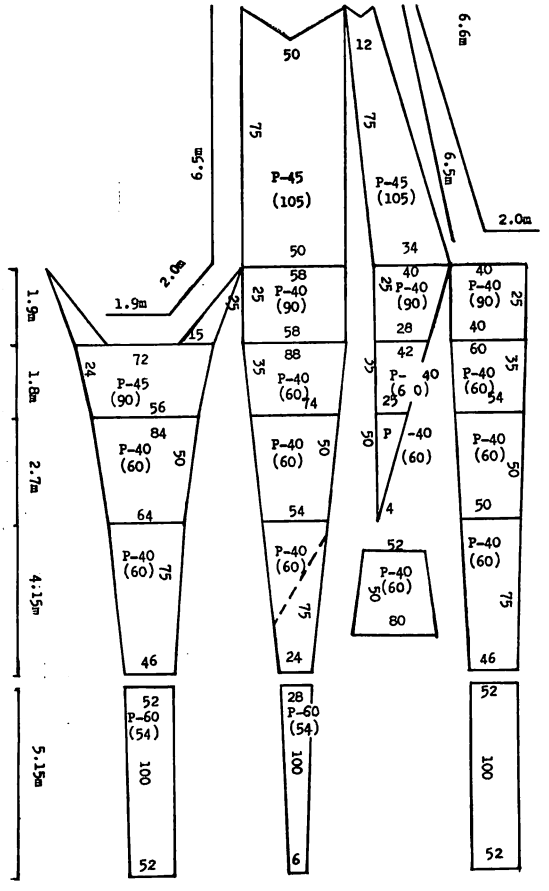

Fig. 3. Net plan of the experimental gear on six-seam-net. Numbers in the figure show the mesh number bracketed number showing the mesh size (mm).

basing on Dr. TTAUTI's comparative methods[1].

As shown in Table 2, the ratio between the model scale (′) and the full scale (″) of experimental net was ascertained to be as in the following;

(1) Reducing scale λ'/λ''

(2) Ratio of twine diameter and mesh size $D'/D''=L'/L''=k$.

(3) Ratio of velocity $V'/V''=\sqrt{D'/D''\cdot(\rho'-1)/(\rho''-1)}$

(4) Ratio of rope diameter

$D_1'/D_1''=\sqrt{\lambda'^2/\lambda''^2\cdot(\rho_1''-1)/(\rho_1'-1)\cdot V'^2/V''^2}$

(5) Ratio of buoyancy and sinker and that of the force acting on the net

$F'/F''=R'/R''=(\lambda'^2/\lambda''^2)(V'^2/V''^2)$

On the field experiment, wing tips distance and otter boards distance were calculated by using KOYAMA's formula[2], as shown in the following:

$$W=\frac{2L_w\cdot L_n}{L_h+L_n}\sin\theta/2+\frac{F\cdot L_n}{L_h+L_n}$$

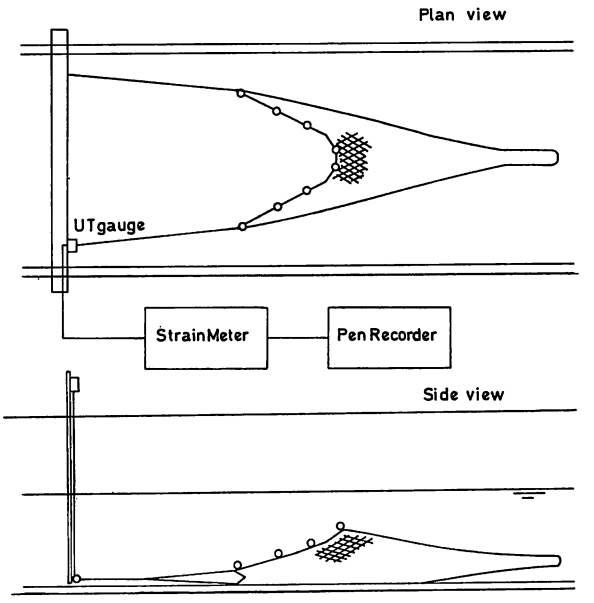

Fig. 4. Side view and plane view of the experimental apparatus.

Table 2. The ratio between the full scale (″) and model scale (′) of the experimental gear.

Ratio	Two-seam-net	Four-seam-net	Six-seam-net
λ'/λ''	1/34	1/35	1/35
$D'/D''=L'/L''$	0.127	0.120	0.168
V'/V''	0.299	0.346	0.409
D_1'/D_1''	0.062	0.234	0.709
$F'/F''=R'/R''$	7.73×10^{-5}	0.98×10^{-4}	1.36×10^{-4}

$$W'=2L_w \cdot \sin\,\theta/2+F$$

where

W=Wing tips distance (m)

W'=Otter Boards distance (m)

L_w=Length of warp (m)

L_h=Length of hand rope (m)

L_n=Length of the net measured between wing tip and cod head (m)

θ=Angle subtended of a pair of warps (degree)

F =Distance between two top rollers (m)

According to the field data wing tips distance of the trawl net was noted to be in the range of 45–55 % of head rope length. In the model experiment, wing tips distance was fixed to be 30, 40, 50, 60 % of head rope length.

Results and Discussion

(A) Height of net mouth

The three types of trawl net examined in this study differ in its size. Accordingly physical characteristics of these nets are not to be compared directly. About the height of net mouth, authors calculated the ratio of the height of net mouth (*H*) to the maximum breadth of net (*B*), and the gear efficiency of the net was compared by using this ratio, results are as follows:

Initial height of net-mouth is about 20 percent of maximum breadth of net-mouth and that two-seam-net is lower than that in any other nets. When the interval between the wing ends is wide, and when the towing speed increases, the height of net mouth is apt to be decreased.

In other words, when the net is towed, owing to the resistance, the webbing near the net-mouth is widened side ways, making the height of head rope reduced; but under the increased speed, the net-shaping near the net mouth becomes stable at the point where a balance is got, between the resitance of the net and the buoyancy of the buoys.

The reducing curves of the ratio (*H/B*) are peculiar in each net. That is considered to be the characteristic curve of the trawl net.

The curves of two-seam-net show that the ratio decrease rapidly in lower towing speed, but when the towing speed is higher than about 2.3 knot, the ratio becomes stable. In the ordinary towing condition, the height of net mouth is about 5.0–7.5 percent of the maximum breadth of the net. In this type of

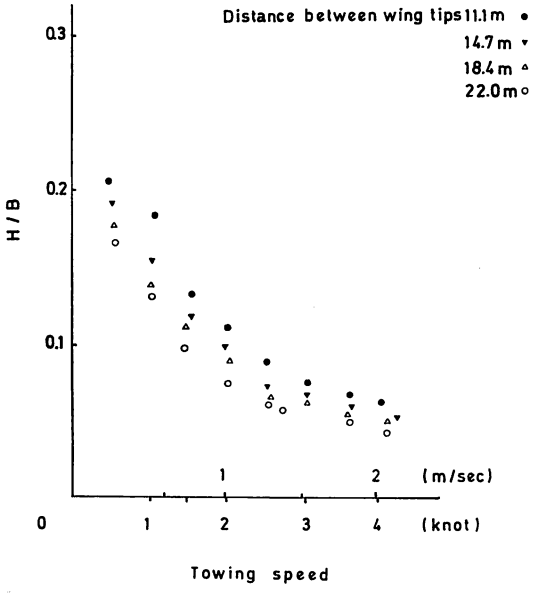

Fig. 5. Relationship between the towing speed and the ratio of the height of net mouth (H) to the maximum breadth of net (B) on two-seam-net.

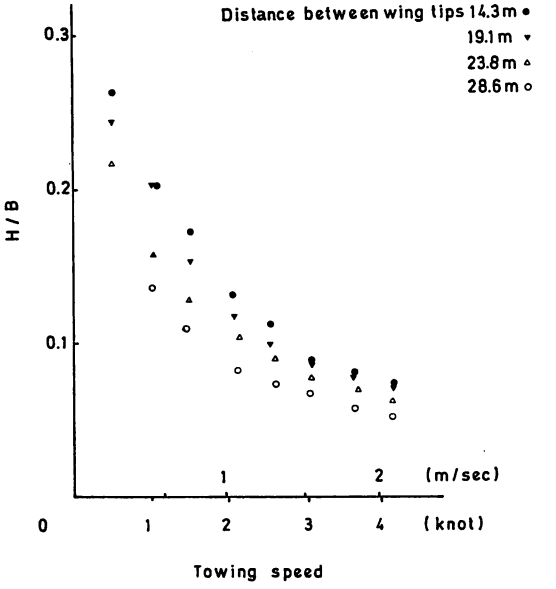

Fig. 6. Relationship between the towing speed and the ratio of the height of net mouth (H) to the maximum breadth of net (B) on four-seam-net.

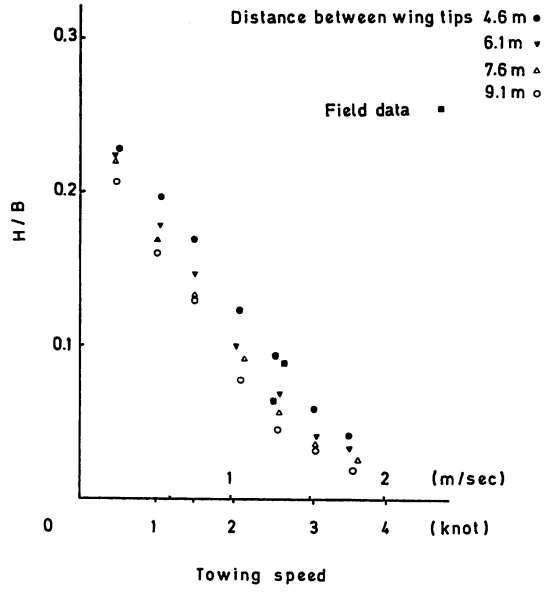

Fig. 7. Relationship between the towing speed and the ratio of the height of net mouth (H) to the maximum breadth of the net (B) on six-seam-net.

net constructed of two panels of net, namely baiting and belley, net webbings near the net mouth are widened to side ways.

The curves of four-seam-net show similar tendency to that two-seam-net, and

the ratio becomes stable when the towing speed is higher than about 2.6 knot. In the ordinary towing condition, the height of net mouth is about 6.0–9.0 percent of the maximum breadth of the net. In this typed net, as the area of the webbing near the net mouth is large enough to add the effect of buoyancy on to the expansive net's power coming from the webbing itself, the height of the net mouth is the highest among three types of nets.

The curves of six-seam-net show a little difference from those of other two types of nets. The ratio of this typed net decreases straightly until the towing speed gets about 3 knot, and it becomes stable when it gets higher than about 3 knot. This shows the results approximately similar to those of other studies [3)4)5)]. This kind of net uses the large triangled webbing near the net mouth, but the buoyancy per unit head-rope-length is smallest in the three, (two-seam-net is 6.10 kg/m, four-seam-net is 7.89 kg/m, six-seam-net is 4.21 kg/m). The front edge of the square part is pushed upward at the time when the towing speed is slow, but when the speed becomes higher, the front edge of the square part is lowered. In the ordinary towing condition, the height of the net mouth is about 2.0–2.4 percent of the maximum breadth of the net. Experimental results of model net fit well to the field data. (Fig. 7) KODERA[6)] mentioned, in his studies, that the construction of the net mouth is to be expected increase in the height of net mouth, by using more rib-lines. HIGO[7)] examined fundamental three sorts of trwaling net, and mentioned that the height of net mouth is subject to the influences of the area of triangled net webbing and the buoyancy of the buoys. In our results, the height of net mouth of six-seam-net is not higher than other nets. This seems to be caused by the fact that the buoyancy of the buoys of six-seam net is not sufficient for the area of the triangled net-webbing.

(B) Net Resistance

The relationship between net resistance and the towing speed is shown in Fig. 8, 9, 10. When the towing speed increases the net resistance increases too. The relationship between the resistance and the towing speed is explained by formula[7)8)]:

$$R=k\,V^{n}$$

where k is constant, n is coefficient, R is resistance and V is towing speed, i. e.

two-seam-net $D=14.7$ m, $R=1654.2\,V^{1.52}$

four-seam-net $D=19.1$ m, $R=1905.5\,V^{1.99}$

six-seam-net $D=6.1$ m, $R=457.1\,V^{1.53}$

The value of n it is the highest in the four-seam-net, marking 1.64–1.99, the second is value of two-seam-net, marking 1.42–1.64, and the third is those of six-seam-net, marking 1.32–1.53.

On the field experiment, the tension of warp was measured, and the resistance of net was calculated from the tension of warp. As shown in Fig. 10,

Table 3. Values of k and n in the equation between the net resistance and the towing speed of two-seam-net.

Distance* (m)	11.1	14.7	18.4	22.0
Values				
k	1396.7	1654.7	1769.7	1988.4
n	1.63	1.52	1.42	1.64

* Distance between both wing tips

Table 4. Values of k and n in the equation between the net resistance and the towing speed of four-seam-net.

Distance* (m)	14.3	19.1	23.8	28.6
Values				
k	114.8	1905.5	2290.9	794.3
n	1.78	1.99	1.60	1.43

* Distance between both wing tips

Table 5. Values of k and n in the equation between the net resistance and the towing speed of six-seam-net.

Distance* (m)	4.6	6.1	7.6	9.1
Values				
k	489.9	457.1	501.2	524.8
n	1.46	1.53	1.32	1.37

* Distance between both wing tips.

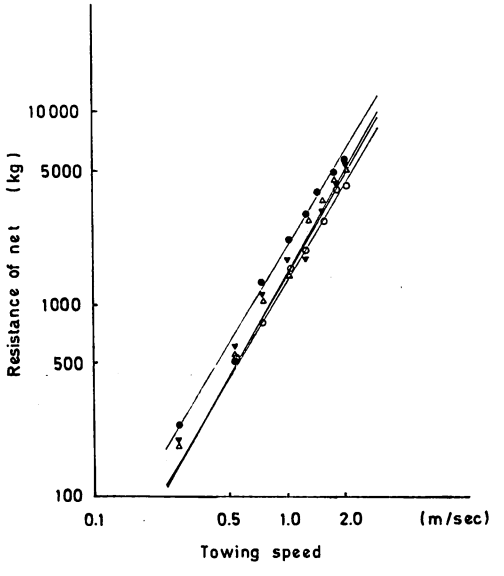

Fig. 8. Relationship between the towing speed and the net resistance on two-seam-net. Symbols in figure show the distance between both wing tips; (○): 11.1m, (▼): 14.7 m, (△): 18.4 m, (●): 22.0 m.

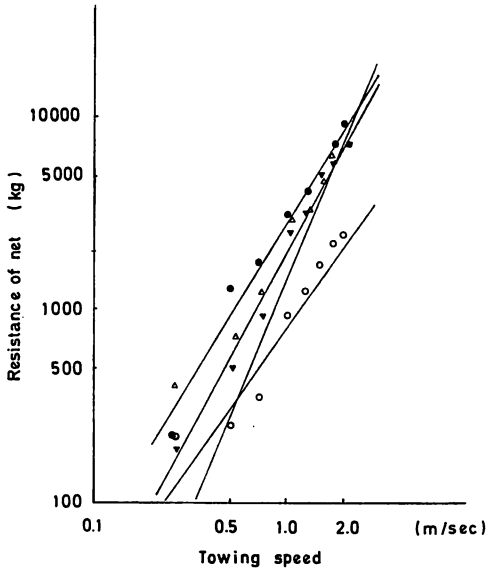

Fig. 9. Relationship between the towing speed and the net resistance on four-seam-net. Symbols in figure show the distance between both wing tips; (○): 14.3m, (▼): 19.1 m, (△): 23.8 m, (●) : 28.6 m.

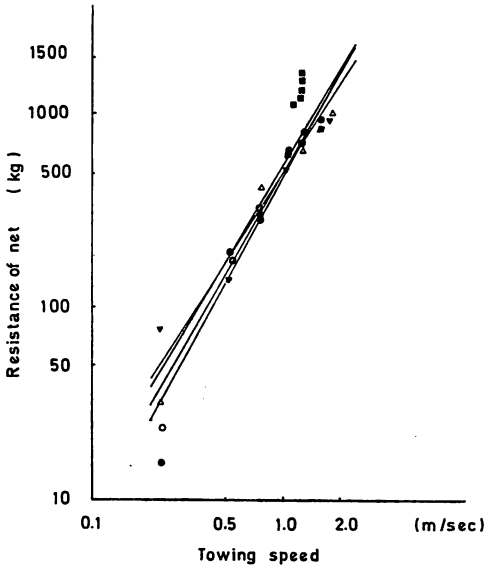

Fig. 10. Relationship between the towing speed and the net resistance on six-seam net. Symbols in figure show the distance between both wing tips; (○): 4.6 m, (▼) :6.1 m, (△) :7.6 m, (●): 9.1 m, (■): Field data.

there are some differences between the net resistance of model experiment and that of field experiment. These differences are about 30-40 % of the resistance

of model experiment. The main cause for the difference may be due to the friction between the net and the bottom of sea.

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