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On An Approximation Equation Applicable to the Designing of the Trawl Net-I

On the Net mouth Central Height of the Four Panelled Net

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Abstract

Concerning the shape of the net mouth of the trawl net a theoretical equation applicable to the measuring of the net mouth central height (N. C. H.) was noted after, basing on the following two the hypothesis: —

(1) The net mouth is of the elliptical shape.

(2) The perimeter of ellipse is unvarying, irrespective of the towing speed and the interval between the wing ends.

and we have the following theoretical equation, given; namely

$$h=d\left(\frac{kp-2d}{1.14d}\right)^{\frac{2}{3}}$$

This theoretical equation value in the figure ascertained to be lower, at the low speed side, than the model experimental value, and conversely this was higher, at the high speed side, than the model experimental value. At the same time, it was ascertained that when the towing speed approached to 1 m/sec the theoretical value approximately agreed with the experimental value.

Introduction

It has been confirmed that the shape of the net mouth, usually, covers a range, from like cyclic to elliptical (1959),[1] (1971).[2] Of this, it was ascertained by HAMURO (1959)[1] that provided that the diameter of a twine (d mm)/the mesh size (1 mm) has been set, to be large at the baiting, and small at the side panel, the shape of the net mouth approaches to be cyclic one, making, consequently, the N. C. H., or the short diameter of the ellipticity, rather, enlarged. Furthermore, it was mentioned hydrodynamically, by the previous reports (1974),[3] (1975)[4] that the variations in the shape of the net mouth and the N. C. H. are depending upon those of d/l value. As shown in Fig. 1, these items are to be noted in the photograph taken by GOTOH (1970)[5] basing on the model experiments.

Beyond a certain towing speed, the perimeter of net mouth of a trawl net is assumed to come to be kept approximately unvarying. The justification of this is to be found in a lot of model experimental results showing the fact that when the towing speed comes to be beyond 2 knots, approximately an unvarying value begins to be shown

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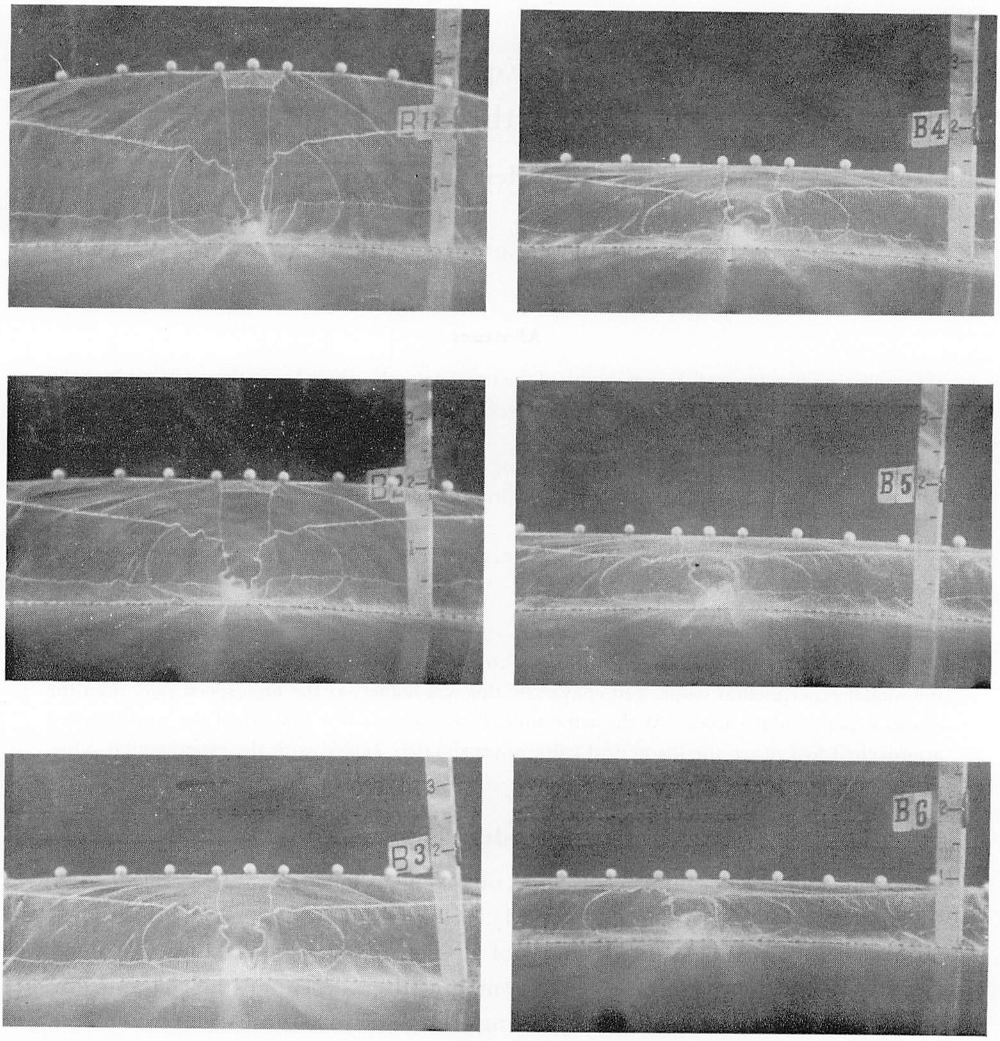

Fig. 1. The front views of the net mouth at the various speed by photograph.
B1: 0.31 knot B2: 0.63 knot B3: 0.94 knot B4: 1.29 knot B5: 1.64 knot B6: 1.95 knot

by the N. C. H. and the crossed area of the net mouth (1953),[6] (1961),[7] (1966).[8] Basing on the above mentioned facts confirmed about the shape of the net mouth, a theoretical equation about the N. C. H. — an equation which was believed by the author to play an important part in designing a highly effective trawl net — was noted after.

Deployment of the theoretical equation

First, let's assume the ellipse, given. Provided that the perimeter of the ellipse (b)

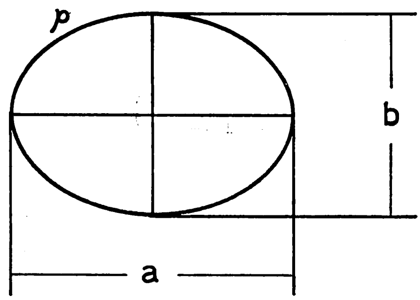

Fig. 2. A ellipse to the use of deployment of the theoretical equation.
p: Perimeter of ellipse a: Major axis of the ellipse b: Minor axis of the ellipse

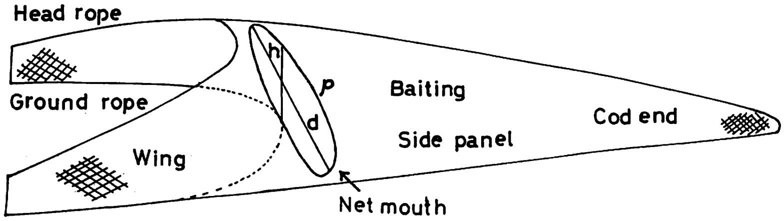

Fig. 3. A net mouth to the use of deployment of the theoretical equation.
p: Perimeter of ellipse h: Net mouth central height d: Width of net mouth

is unvarying, irrespective of the varieties in the major axis (a) and of the minor axis (b), we have following equation (1961),[9] (Fig. 2).

$$p=2a(1+0.57\ (b/a)^{k}) \qquad \cdots\cdots(1)$$

$$k=1.55-0.217\ (b/a) \qquad \cdots\cdots(2)$$

In the equation (1), the error of p value is only 1/8%. If the K value in the equation (2) is fixed to be 3/2, the error of P value in the equation (1) comes to be 7/8%.

Accordingly, if the perimeter of the ellipse is allowed to lie within the error range of approximately 1%, the equation is to be turned into

$$p=2a[1+0.57\ (b/a)^{\frac{3}{2}}] \qquad \cdots\cdots(3)$$

Here, the shape of the net mouth might be substituted for the above mentioned ellipse; and under the application of the two assumptions, namely (1) the net mouth is elliptically shaped (2) perimeter of net mouth is unvarying, irrespective of the towing speed, and the interval between the wing ends, the equation (3) is to be deployed into the following (Fig. 3):

$$P=\frac{2d}{k}[1+0.57\ (h/d)^{\frac{3}{2}}] \qquad \cdots\cdots(4)$$

Here, P is the *total length of the net mouth* ($p=kP$), d is the width of the net mouth, h is the N. C. H. Equation (4) may be deployed further into

$$h=d\left(\frac{kP-2d}{1.14d}\right)^{\frac{2}{3}} \qquad \cdots\cdots(5)$$

Here, the value of h is represented by a functional number which is to be fixed by the relationship between the perimeter of the net mouth and the total length of the net mouth; this is to say that the value is not fixed, but variable in accordance with the variations in the shape of the net.

In dealing with the interval between the wing ends and the towing speed, or the conditions indispensable for the calculation of the N. C. H., the figures representing the width of the net mouth counted from the relationship between the above mentioned 2 items, were substituted for the figures in the equation (5).

Confirmation of the theoretical equation

The confirmation of the theoretical equation was carried out by substituting the values obtained from the model experiments of the typical four panelled net for the figures in the equation (Fig. 4). The majoring measures of the real trawling net

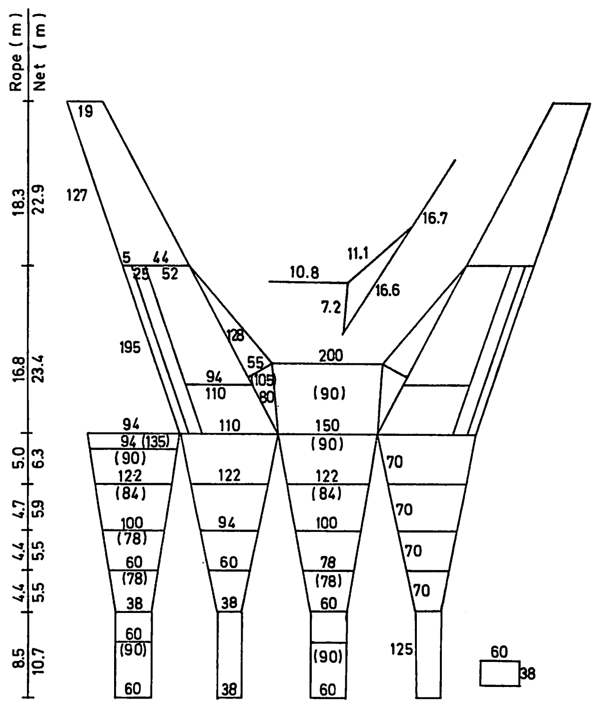

Fig. 4. Plan of the experimental net. Number in figure shows the mesh number, bracket number shows the mesh size (mm).

Table 1. Relationship between the perimeter and total length of the net mouth.

Velocity (m/sec) \ Item	l (m)	P (m)	p (m)	$p/P=k$
0.51	9.8	54.8	33.3	0.61
	21.0		33.9	0.62
	32.2		36.1	0.66
	43.4		36.6	0.67
	53.2		35.8	0.65
1.03	9.8	54.8	34.3	0.63
	21.0		35.9	0.66
	32.2		36.0	0.66
	43.4		36.4	0.66
	53.2		36.2	0.66
1.54	9.8	54.8	32.2	0.59
	21.0		34.3	0.63
	32.2		34.9	0.64
	43.4		35.7	0.65
	53.2		36.6	0.67
1.82	9.8	54.8	34.6	0.63
	21.0		35.4	0.65
	32.2		37.2	0.68
	43.4		37.9	0.69
	53.2		35.7	0.65

l : Interval between the wing ends.
P: Total length of net mouth.
p : Perimeter of net mouth.

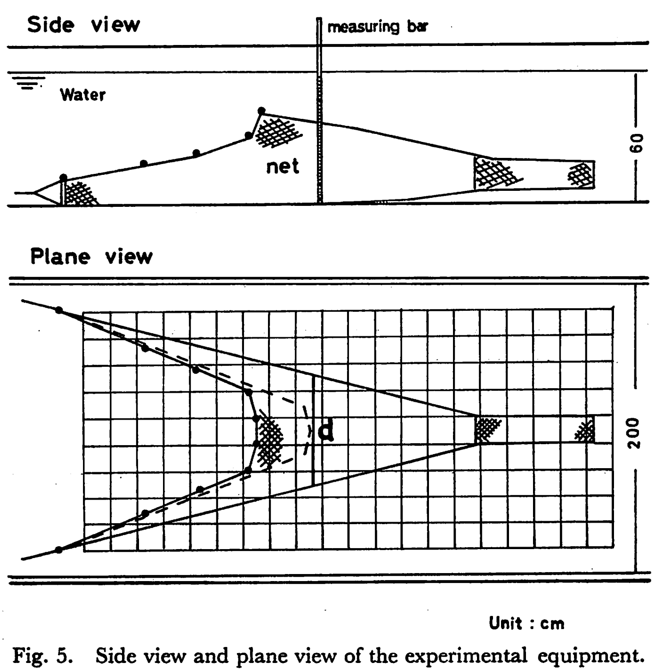

Fig. 5. Side view and plane view of the experimental equipment.
D: Width of net mouth.

Table 2. Showing the width of the net mouth under the various conditions of net-towing.

Interval between the wing ends (m) \ Towing speed (m/sec)	0.51	1.03	1.54	1.80
10	8.2	9.0	9.5	10.1
20	11.0	12.0	12.3	13.0
30	12.4	13.5	13.9	14.5
40	13.0	14.0	14.5	15.0
50	13.3	14.3	14.7	15.0

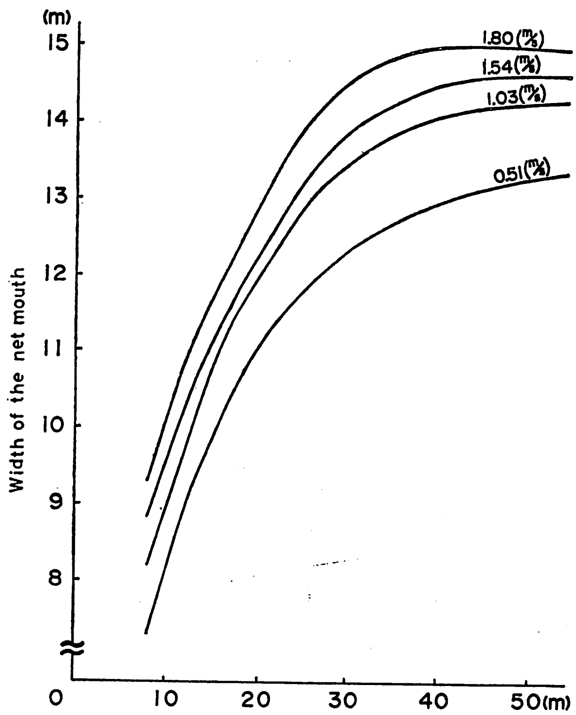

Fig. 6. Relationship between the width of the net mouth and the towing conditions; interval between the wing ends, towing speed.
(m/s): Towing speed.

are as in the following: total length of the net, 62.1 m, head rope, 66.4 m (in total length); ground rope, 73.8 m (in total length); the value of d/l is 0.018 at the wing, 0.023 at the square part, 0.016 at the baiting, respectively; and the mean value at the net mouth is 0.018.

The relationship between the perimeter of the net mouth and the total length of the net mouth under trawling is as shown in table 1. In the value of $p/P=k$, there is a slightly discernible tendency that the slower is the towing speed, the less is the k value.

The range of k value lies within 0.59~0.68, the mean value being 0.6. The value of p was obtained by measuring the wire ring set around the perimeter of the net mouth. The wire is made of the extremely slender pianowire; and during the towing net it was held up from above in order to prevent the shape of the net from being collasped.

The width of the net mouth was measured with the calibrated board, set beneath the net, with the towing speed and the interval between the wing ends kept changing, variously (Fig. 5).

The results obtained are as shown in Table 2 and Fig. 6. The width of the net mouth is to be obtained through the figures showing the interval between the wing ends and the towing speed which are to be obtained from Fig. 6, respectively. By the way, the net used in this experiment is the four panelled net which is the most typical one among the various sorts of net, which makes it applicable to a lot of nets similar to the adopted one.

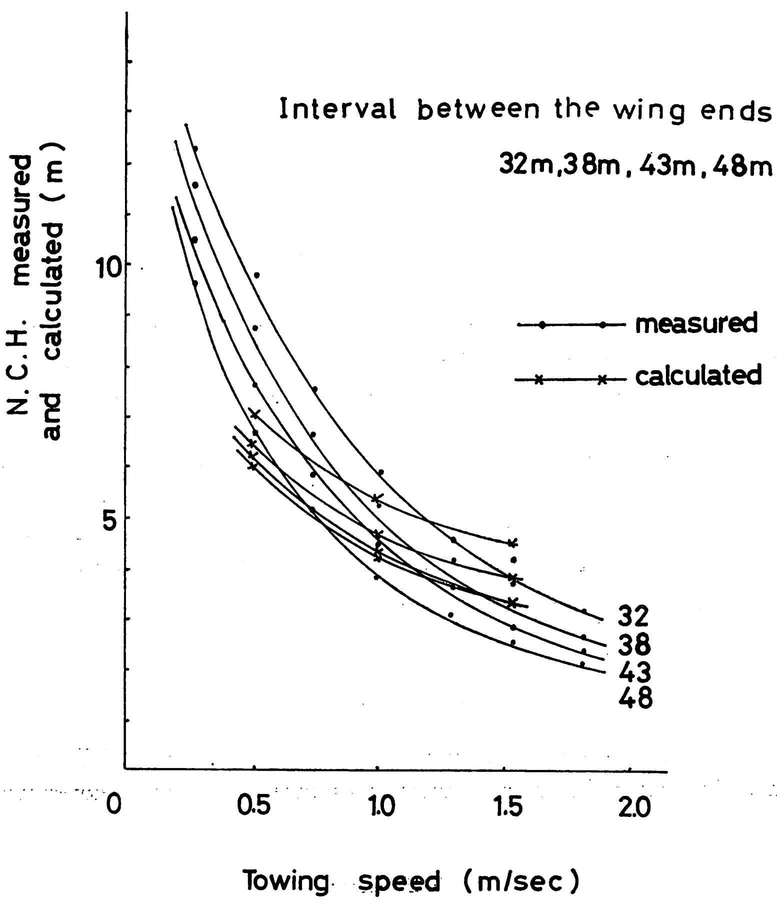

Fig. 7. Showing the net mouth central height (N. C. H.) on measured by the model experiment and calculated by the approximate.

When the value of k obtained from Table 1, and the value of the width of the net mouth obtained from Fig. 6 are substituted for the figures in the equation (5), the N. C. H. with a certain the interval between the wing ends and the towing speed can be got theoretically.

Here, concerning the N. C. H., comparison was made between the theoretical value and the experimental value. The result obtained by the comparison is as shown in Fig. 7. In this figure, firstly, it was noted that the theoretical value was lower than the experimental value, at the side of low speed; and the reverse was noted at the side of high speed; and, secondly, it was noted that theoretical value and the experimental value came to be approximately equal at the towing speed of 1 m/sec. The fact that at the low speed side the theoretical value was lower than the experimental value was lower supposed to be derived from the error of assuming the shape of the net mouth to be perfectly ellipse. The fact that at high speed side the theoretical value was higher than the experimental value suggested that the theoretical value was nearer to the real one than the experimental value.

Discussion

This theoretical equation was induced from the two hypothesis, hence the necessity of discussing the hypothesis, themselves. The first hypothesis that the net mouth is of the elliptical circle offer no significant problem, because there is the ascertained fact that under a certain towing speed — at least 1 m/sec, it shows a shape quite similar to an ellipse.

The hypothesis that the perimeter of the net mouth is unvarying is open to various questions, but it was assumed that the proper arrangement of the d/l expression would allow us to make them negligible. This is to say that, in applying this theoretical equation to the practical cases, it will be necessary for us to assort the nets into groups, in accordance with the shape of the net (varying according to the panelling number) and with d/l value, with the ascertainment of the k value and of the figures representing the relationship among the width of the net mouth, the interval between the wing ends and the towing speed before we can carry out a successful substitution of these value for the figures in the theoretical equation.

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