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STUDIES ON THE ESTIMATION OF FISHING EFFICIENCY OF DRIFT NETS AND STATIONARY FISHING GEAR

By V.F. Mytsul (USSR,VNIRO,Moscow)

In this paper the author endeavours to elucidate the method of estimating the efficiency of a line of drift gill nets; this efficiency in general terms is determined by A.I.Treshov according to the formula as follows:

$$W = \frac{V}{T} \qquad (1)$$

where:
- W - efficiency of fishing gear,cum/day;
- V - volume of water swept by fishing gear,cum;
- T - time of fishing gear being in action,days

The volume of water swept by a drift line,in general terms, according to A.I.Treshov is estimated with the formula as follows:

$$V = alns \qquad (2)$$

where:
- V - water volume swept,cum;
- a - height of drift nets in hanging,m;
- l - length of drift net in hanging,m;
- n - number of drift nets in a line,pcs;
- s - drift route of the line,m.

The values of a,l,n (parameters of a drift line) are given.Consequently,the problem reduces to the determination of interconnection between the movement of fish and of the nets.

There are basically two methods of applying drift gill nets in world fisheries.The first method: the line drifts together with the vessel. (Herring fishing wihh drift nets in Northern Atlantics).The second method: the line drifts separately (Japanese open sea fishing for salmon in North-West part of the Pacific Oceann).

In the first case the vessel (drifter) is connected with the line by means of a lead line and the whole fishing arrangement drifts due to surface current and sailing of the vessel,the above-water portion of which undergoes the pressure of wind; and as a result of this the drift line is maintained in spread-out condition.

In the second case the drift line moves mainly under the influence of current,because sailing of the drift buoys and corks is insignificant as compared to the hydrodynamic resistance of the nets.

Below we shall consider several methods of estimating the efficiency of a drift line for the most frequent cases in fishing practice.

1.Suppose,that a line drifts under the influence of wind, current and engine operation parallel with its own level.Let the speed of drifter movement,depending on its sailing and wind velocity,be equal to V_d , current speed $V_{cur.}$,angle between the current direction and nets position - α (Fig.1).

From Fig.1:
we can see that fishing system: vessel-drift line will move at a speed and in the direction of V_{net}. Where V_{net} is the resultant of the speeds of drifter movement under the influence of wind V_d and current V_{cur}.

Suppose,drift line AB = L during a short period of time Δt moved to the position of A'B'. Elementary fishing area Δf during this time will be:

$$\Delta f = L.\Delta z \tag{3}$$

where: Δz - height of parallelogram AA'B'B.

From right triangle AA'N we find:

$$\Delta z = \Delta s \; . \; \sin(\lambda - B) \tag{4}$$

Introducing the obtained value into (3) and passing to the limits,we have:

$$df = L \; . \; \sin(\alpha - B) \; . \; ds \tag{5}$$

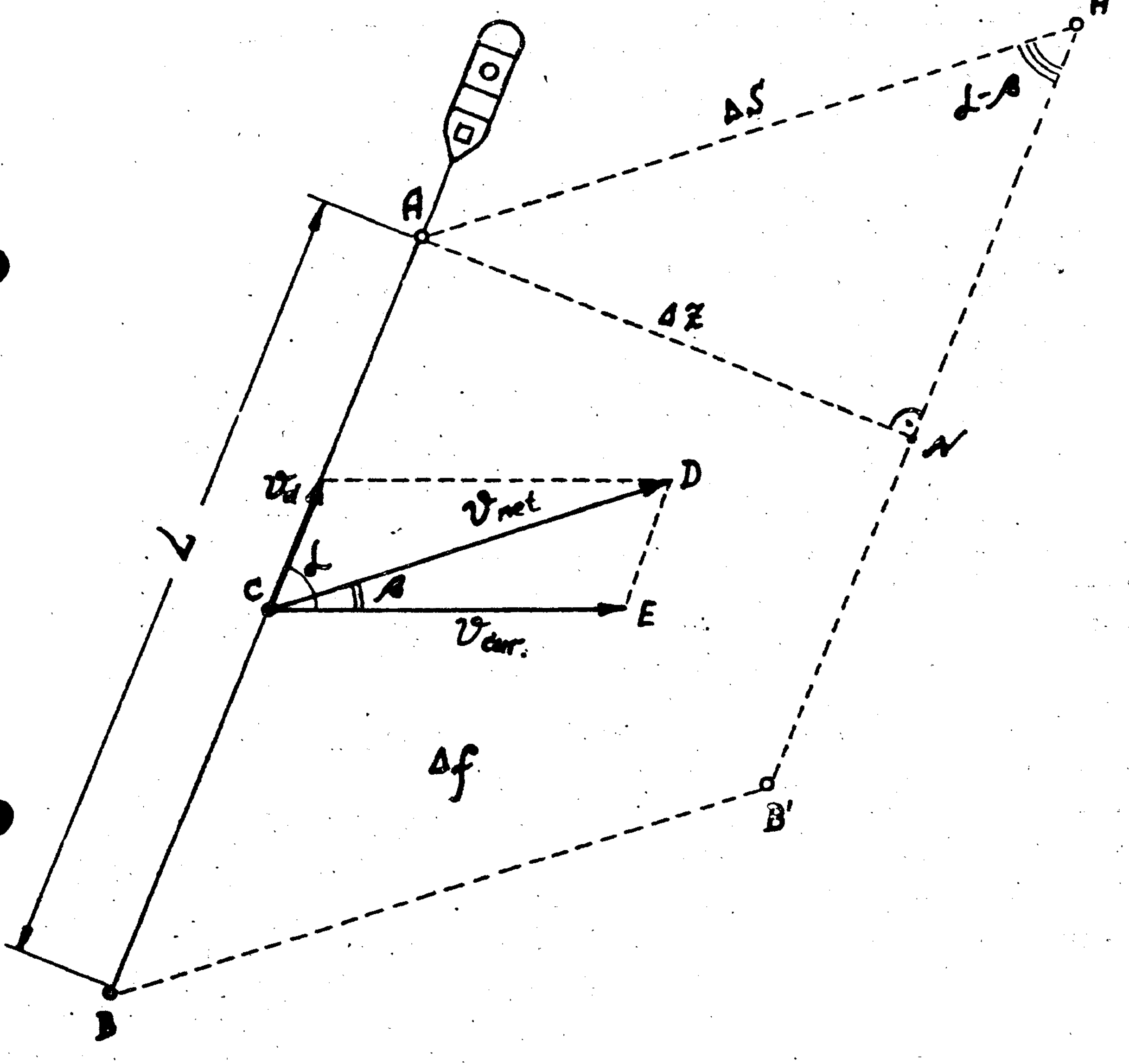

Fig. 1.

After dividing and multiplying the right side of the equality by dt and taking into consideration, that

$$\frac{ds}{dt} = V_{net} \quad \text{we receive:}$$

$$df = L \cdot V_{net} \cdot \sin(a - \beta) \cdot dt \qquad (6)$$

After integrating this expression within the limits of $0:T_d$ we receive:

$$f = L \cdot V_{net} \cdot T_d \sin(a - \beta) \qquad (7)$$

where:

T_d - duration of drift line movement.

From the triangle of speeds CDE we have:

$$V_{net} = \sqrt{V^2_{cur.} + V^2_d + 2V_{cur} \cdot V_d \cdot \cos a} \qquad (8)$$

and:

$$\beta = \arcsin \frac{V_d \cdot \sin a}{\sqrt{V^2_{cur} + V^2_d + 2 V_{cur} - V_d \cdot \cos a}} \qquad (9)$$

Inasmuch as the total length of the drift line is equal to the sum of the lengths of the nets in the line, and the swept volume is equal to the product of fishing area by the height of nets, we have:

$$V_1 = a\, l\, n\, T_d \cdot V_{net} \cdot \sin(a - \beta) \qquad (10)$$

It is known, that in the course of drift when the lead line is used, the nets become deformed, i.e. net dimensions are distorted in height and therefore the height from Formula 10 is not in conformity with the estimated height of the net in hanging. So, for the estimation of the actual, real working height a_{real} one should apply the following well-known formula by A.V.Zasosov:

$$a_{real} = \frac{a}{\sqrt{1 + \left(\frac{P}{2q}\right)^2}} \qquad (11)$$

where:

- a_{real} - real height of drift net in operation condition;
- a - height of net in hanging;
- P - traction equal to drift net resistance;
- q - weight force (in water) of the lead line and lead link in the drift net.

In other words, the real height of net a_{real} is the function of wind drift speed V_d.

For the estimation of speed of drifter movement V_d depending on theinfluence of wind force and speed, it is possible to apply another well-known formula by A.V.Zasosov:

$$P = k\ f_1\ V_w^2 \qquad (12)$$

where: P - wind pressure force on the vessel (traction);
f_1 - projection area of the above-water portion onto middle rib, for vessels of SRT type about 55 sq.m.
V_w - wind velocity, m/sec.;
k - 0.12 coefficient.

However, in case of fixed uniform movement, the vessel traction depending on the wind influence onto the above-water portion of the vessel, is equal to the resistance of nets in the drift line, which for the gill nets is calculated according to the following formula:

$$R_{net} = 1.8\ f_2\ V_d^2 \qquad (13)$$

where: f_2 - area of the nets, sq.m;
V_d - speed of net movement, m/sec. (or speed of vessel drift under the influence of wind only)

Consequently, equations 12 & 13 are equalities:

$$P = R_{net} \quad \text{or} \quad kf_1\ V_w^2 = 1.8\ f_2\ V_d^2 \qquad (14)$$

From where we find:

$$V_d = \sqrt{\frac{k \cdot f_1 \cdot V_w^2}{1.8\ f_2}} \qquad (15)$$

where all symbols are the same as in Formulas 12 & 13.

2. Let us assume that a drift line is motionless and stays in one place and the fishes move towards the drift line at different speeds from different directions, i.e. angles of direction of fish movement and that of the net location are different.

Suppose, Fig.2 shows the amount and direction of speed vectors of the fishes moving towards the nets. Then by means of summing up the vectors we can find the resultant direction and fish speed V_{fish} (Fig.3). Knowing the amount of speed resultant and the general direction of fish movement, it is possible to determine the conventional water volume swept by a line of motionless nets.

Suppose, that during a short period of time Δt the fishes moved from position A'B' into position AB and covered the distance of Δs (Fig.4). Then conventional elementary swept area Δf of the nets will be prsented by:

$$\Delta f = L . \Delta z \qquad (16)$$

but from triangle BB'C we find:

$$\Delta z = \Delta s \;.\; \sin\gamma \qquad (17)$$

Introducing the obtained value into (16) and passing to the limits we find:

$$df = L \;.\; ds \;.\; \sin\gamma \qquad (18)$$

After dividing and multiplying the right side by dt and taking into consideration that $\frac{ds}{dt} = V_{fish}$, we receive:

$$df = L \;.\; V_{fish} \;.\; \sin\gamma \;.\; dt \qquad (19)$$

Having integrated this expression within $0:T_d$ limits, we have:

$$f = L \;.\; V_{fish} \;.\; T_d \;.\sin\gamma \qquad (20)$$

where: f - conventional area of water swept by the nets, sq.m;

L - length of nets, m;

V_{fish} - resultant speed or migration speed of fish movement, m/s

T_d - duration of nets stay in water;

γ - angle between the general direction of fish movement and position of nets.

Similar to formula (10) we use the sum of lengths of separate nets in place of total length of nets, include height of the nets into calculations also, and finally come to conventional water volume swept by motionless nets:

$$V_2 = a l n \; V_{fish} \; T_d . \sin\gamma \qquad (21)$$

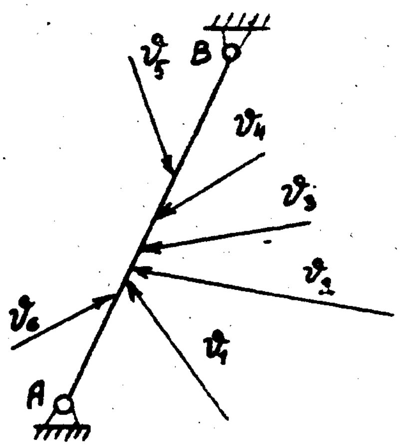

Fig.2.

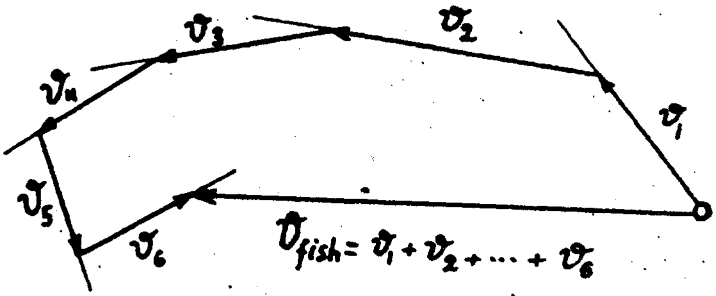

Fig.3.

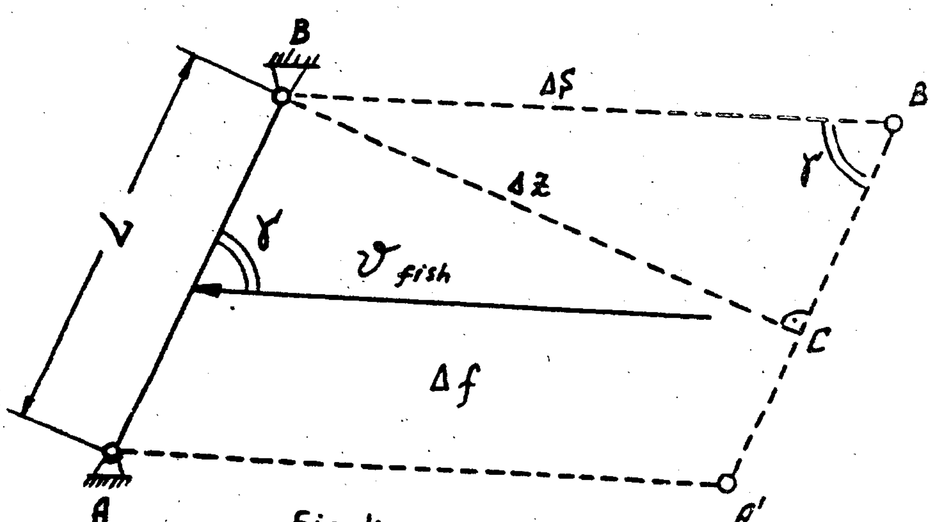

Fig. 4.

3. With the help of formula (10) we determined the volume of water filtered through a drift line during drift period of T_d without taking into consideration the interconnection between fishing object (fishes) and fishing gear. On the other part, according to formula (21) it is possible to determine conventional volume of water filtered through motionless drift line. However, in the course of drift fishing fish and nets are in motion and therefore water volume swept by the drift nets will be equal to the sum of equations (10) & (21).

$$V = V_1 + V_2$$

or:

$$V = aln\, V_{net} \cdot T_d \cdot \sin(a-\beta) + aln\, V_{fish} \cdot T_d \cdot \sin\gamma$$

or:

$$V = aln\, T_d \left[V_{net} \cdot \sin(a-\beta) + V_{fish} \cdot \sin\gamma \right] \qquad (22)$$

So, equation (22) is a general equation for the calculation of water volume swept by a drift line.

It is feasible to note, that in case of drift line moving separately (without drifter) it will run lengthwise towards the center under the influence of forces from load weight of the ground rope and that of the inertia forces, i.e. the line length L, equal to the product of number of nets by their length nl, - will be a function from time: $L = f(t)$.

Besides, one should remember, that many research workers record the following: with the prsence of sea surface current fishes have basically general direction of movement against the current. Consequently, in cases when fishing object is known and it is evident that it moves against the current, then in formula (22) angle γ - the angle of fish meeting the net, - will be equal to angle a - the angle between current direction and netting.

General equation (22) gives rise to peculiar cases of swept volume determination.

1st case: The line moves under the influence of current only. It means that $V_d = 0$ and $\angle a = \angle \gamma$. From (8) and (9) we find $V_{net} = V_{cur}$. $\beta = 0$.

Then: $V_{(at\ V_d=0)} = alnT_d\ (V_{cur} + V_{fish}) \cdot \sin a$ (23)

2nd case: The line moves under the influence of wind pressure onto the above-water portion of the vessel, i.e. $V_{cur}=0$, $V_d = 0$. It means that $V_{net} = V_d$; $\angle a=0$; $\angle \beta=0$; $\angle \gamma \neq 0$.

Then: $V_{(at\ V_{cur}=0)} = alnT_d \cdot V_{fish} \cdot \sin\gamma$ (24)

3rd case: The drift line is stationary, i.e. $V_d=0$, $V_{cur}=0$.

It means that: $V_{net}=0$, $\angle a=0$; $\angle \beta=0$; $\angle \gamma \neq 0$.

Then: $V(_{at V_d=0, at\ V_{cur}=0}) = alnT_d \cdot V_{fish} \cdot \sin\gamma$ (25)

4th case: Fishes are scattered evenly over the fishing area, they stay in the same place as related to the bottom and the drift line moves under the influence of current and wind, i.e. $V_{fish}=0$ and $\angle \gamma = 0°$.

Then: $V_{(at\ V_{fish}=0)} = alnT_d \cdot V_{net} \cdot \sin(a-\beta)$ (26)

It means that in such case the fishing area is equal to the swept volume of water divided by the time period of fishing, i.e. $W = \frac{V}{T_d}$ Proceeding from this, fishing efficiency of a drift line, in general terms, will be as follows:

$$W = 8.64 \cdot 10^{-5} aln \left[V_{net} \cdot \sin(a-\beta) + V_{fish} \cdot \sin\gamma \right] \quad (27)$$

where: n - number of nets in a line, pcs;
l - length of net, m
a - height of net in the course of drift, m;
V_{net} - resultant speed of line movement, m/sec;

V_{fish} - resultant speed of general movement of fish, m/sec;
a - angle between the diraction of current & position of nets;
ß - angle between the direction of nets movement and direction of current;
γ - angle between general direction of fish movement and position of nets;
W - fishing efficiency in promms (1 promm= $\frac{10^9 \text{cum}}{\text{day}}$)

Using general formula (27) for the estimation of fishing efficiency of a drift line it is possible to find fishing efficiency for individual cases by means of including values of swept water volume, determined from equations (23), (24), (25) & (26) into this formula.

So, fishing efficiency of a drift line moving only under the influence of current will be as follows:

$$W_{(at\ V_d=0)} = 8.64 \cdot 10^{-5} a l n (V_{cur} + V_{fish}) \cdot \sin a \qquad (28)$$

Fishing efficiency of a drift line moving only under the influence of wind pressure on the above-water portion of the vessel will be as follows:

$$W_{(at\ V_{cur}=0)} = 8.64 \cdot 10^{-5} a l n \cdot V_{fish} \cdot \sin\gamma \qquad (29)$$

Fishing efficiency of a stationary drift line is equal to:

$$W_{(at\ V_d=0\ \&\ V_{cur}=0)} = 8.64 \cdot 10^{-5} a l n \cdot V_{fish} \cdot \sin\gamma \qquad (30)$$

Fishing efficiency of a drift line, moving under the influence of current and wind with even distribution of fishes over the fishing area and staying in one place as related to the bottom, will be equal to:

$$W_{(at\ V_{fish}=0)} = 8.64 \cdot 10^{-5} a l n \cdot V_{net} \cdot \sin(a-ß) \qquad (31)$$

Analysing equation (27) one can find that maximal value of drift line fishing efficiency will occur at $\sin(a-\beta)=1$ and at $\sin\gamma=1$, i.e. when $\angle a=90°$, and $\angle\beta=0°$ and $\angle\gamma=90°$.

Minimal value of fishing efficiency will occur at $\sin(a-\beta)=0$, i.e. when $\angle a=0°$, $\angle\beta=0°$ and $\angle\gamma=0$.

Average value of fishing efficiency will be at $\sin(a-\beta)=\frac{1}{2}$ and $\sin\gamma=\frac{1}{2}$ i.e. when $\angle a=30°$, and $\angle\beta=0°$ and $\angle\gamma=30°$.

The equations for the estimation of drift line fishing efficiency, obtained for individual cases, are also applicable for the determination of fishing efficiency of trap nets and trap gill nets - equation (30), in this equation the length of trap nets are used accordingly instead of the lengths of drift line (aln), same with floating gill nets - equation (28), in which the length of floating nets is used instead of the length of drift line.

N O T E: Comparing equations (24) and (25) as well as (29) and (30) we can notice that the filtered water volume (and accordingly fishing efficiency of a drift line, moving under the influence of wind due to sailing of the above-water portion of the vessel) is equal to the swept water volume (fishing efficiency) of a stationary fishing gear.

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