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Report of ICES Working Group on Vessel Characteristics and Fishing Effort Measurement

IJmuiden, 30 June-1 July 1969

Introduction

This meeting was held at the Laboratory of R.I.V.O. IJmuiden on 30th June and 1st July. Members of the group and observers present were

Dipl. Ing. W. Karger	- Institut für Fangtechnik	- Hamburg, Germany
M. Dardignac	- Institut des Pêches	- La Rochelle, France
Dr. P. Hovart	- Proefstation voor Zeevisserij	- Oostende, Belgium
Van Den Broucke	- Proefstation voor Zeevisserij	- Oostende, Belgium
H. Frimannsson	- Fisheries Ass. of Iceland	- Reykjavik
A.R. Margetts	- Fisheries Laboratory	- Lowestoft, Un.Kingd.
J.G. de Wit	- Technical Research Dept.	- IJmuiden
W. Doucet	- F.A.O.	- Rome
J.O. Traung	- F.A.O.	- Rome
J.A. Gulland	- F.A.O.	- Rome
P. Adam	- O.E.C.D. (Fisheries Division)	- Paris
Observers:		
P.D. Chaplin	- Industrial Developm.Unit (WFA)	- Hull
H.C. Besançon	- Technical Research Dept.	- IJmuiden
E.J. de Boer	- Technical Research Dept.	- IJmuiden
J.F. de Veen	- R.I.V.O.	- IJmuiden
L.R. v.d. Vlist	- Institute for Preventive Medicine	- Leiden

The origins of the working group were outlined by the convenor J.G. de Wit. Though the studies of the relation of vessel characteristics to catch rates were of rather wide interest to technologists, economists and others, the group was primarily concerned with the use of fishing effort data for population studies and the benefit to those studies of better measures of fishing effort. The general problems involved were reviewed by the convenor in a document circulated before the meeting (See Annex).

J.A. Gulland assisted in editing the report.

Fishing time

The fishing effort exerted by a vessel may be considered as the product of its fishing power, and the fishing time. The choice of the measure used for fishing time therefore influences the measure of fishing power. For gears such as the ordinary bottom trawl in which catching is a continious operation, the best measure of fishing time is the time the gear is actually operating e.g. the time from blocking up to knocking out.

For other gears an important element is the time searching for fish and the gear may only be in operation for a short time after the fish have been located. This question of searching time is particularly important for such gears as purse-seines, but with the increasing use of advanced acoustic devices is also becoming significant in some trawl fisheries, especially in mid-water.

In most trawl fisheries the best measure of fishing time is still however the time the trawl is on the bottom. However, this is not always available; also for economic and other studies the time of interest is the time away from port, or on the grounds. If one of these measures of fishing time is used, then the corresponding measure of fishing power will be increased by anything which increases the real fishing time per day at sea or per day on the grounds, e.g. the ability to fish in bad weather, or increased freezing capacity, giving less time lost while waiting for earlier catches to be frozen. The unit of fishing time used therefore effects the vessel characteristics that are important in the studies.

Skill of crew

The most important single factor in determining the catch in a particular trip is the skill of the skipper and his crew. The group saw no way by which this could be measured, though some preliminary studies on the skill of fishermen and the tactics used by skippers were reported to it. It has generally been assumed that the average ability remains constant from year to year. It was noted, however, that the younger skippers tended to be the best at using new equipment, e.g. sonar, so that the full impact of such equipment in increasing fishing power may occur only after a period during which a new generation of skippers enter the fishery. Also relatively minor instruments, e.g. for measuring headline height may enable the poorer skippers to bring their efficiency up to the average by eliminating errors in rigging the gear.
The group believes that a more careful examination should be made of possible improvements in average skill, especially when extensive training programmes have been introduced.

Size of vessel

Bigger ships with bigger engines usually catch more fish. Also, because of this, the ships in many, if not most, fisheries have increased in size, and have more powerful engines, as well as better equipment (echo-sounders, etc.).

Thus the trend in the catch per vessel per unit fishing time is likely to be at best a poor measure of the trend in fish abundance. The hope of the biologists is that some simple, readily observed measure of fishing power (and fishing time) can be obtained such that the trend in catch per unit effort (fishing power multiplied by fishing time) is the same as the trend in fish abundance.

The group concluded that no such single measure could be determined from the presently available information, nor was there much optimism that in the near future one would be determined which would be generally applicable in all fisheries, and which could be obtained from readily available vessel characteristics (e.g. did not involve complex measurements at sea).

Most features studied (length, gross tonnage, horse power) usually gave good correlation with estimated fishing power, but failed in some situations to describe the changes in fishing power e.g. because only a fraction of the available horse power is actually used when fishing.

The group therefore believed that separate studies were required for each group of vessels. Further discussion was concerned almost entirely with trawlers, for which the following divisions were proposed.

stern- or side trawler.

fresh fish; semi-freezer; freezer salting.

bottom trawl; midwater trawl; bottom pair trawl; midwater pair trawl; beam trawl.

Fishing power of trawlers

The basic factors influencing the fishing power of trawlers are the size and specification of the trawl net, and the engine power actually used to tow it. Both these are difficult to measure, particularly without special observations at sea. After some of the more readily observed parameters have been examined, further studies have been proposed as follows.

a. bottom trawl

Dutch studies showed a higher partial correlation with horse power than with tonnage. Analyses of the Aberdeen fleet showed a high correlation with length. (In using length the Group agreed that the best measure was length overall). Other studies might be made before the 1970 I.C.E.S. meeting by Iceland and U.K. It was believed that Canadian data were also available (with Mr. J. Proskie) and should be requested.

The results when presented should include confidence limits about any regression. These regressions should be of fishing power against (a) length, (b) size (G.R.T. or cubic number = length x beam x depth, or length x beam x half beam -) and (c) horse power. The partial correlation coefficients should also be calculated if possible.

b. midwater trawling

This presents more difficulties than bottom trawling because the techniques are still developing, and the real fishing time probably includes an important element of searching time. Of the countries represented at the meeting Germany has the biggest midwater fishery, and Dipl.Ing. Karger was asked to prepare a report on the relation of fishing power in midwater trawling to vessel characteristics for discussion. I.C.E.S. should also invite Poland, Canada and U.S.S.R. to submit similar reports from their fisheries.

c. beam trawling

Belgium and the Netherlands were invited to collaborate in a study on beam trawling. In the first instance this should deal with fish, and not with shrimp.

d. pair trawling (bottom)

This might be omitted from present studies, though Spain might be invited to submit a report on its fisheries, and, through F.A.O. or otherwise, information could be collected on the pair-trawl fisheries in the Far East.

e. pair-trawl (midwater)

Horse power was believed to be very important - two boats are often used because the power in one boat is insufficient for the very large net. Other equipment - netsonde, active rudder (for good manoeuvrability), and powerful winch (to maintain net speed when beginning to haul) - were also mentioned as being important.

Germany, the Netherlands and U.K. (England and Scotland) were invited to collaborate in further studies.

Other fishing methods

a. Gillnetting

Driftnetting and stationary gillnets on the sea bed were discussed. In general the group thought the vessel's influence to be of very little influence on the fishing power.

Perhaps some influence might be expected for stationary gillnetting on the sea bed for cod. Mr. Frimannsson (Iceland) shall report on this point.

b. Line fishery

The group found the vessel's influence of very little importance.

c. Line fishery with dories

The group decided to leave this fishing method undiscussed.

d. Danish seine fishery

This fishing method has been discussed under three aspects:

- with an anchor
- with long ropes
- with strong wires and a strong winch (fly dragging)

For the second and third method the horse power of the engine might be expected to have an influence. The group found, however, that there is no need to introduce a vessel factor for this fishing method.

e. Purse seining

The group felt that the skipper's and the crew's skill and the equipment are much more important than the vessel characteristics.

f. Pot fishing

The group decided to leave this item out.

Other equipment

Modern fishing vessels have a great variety of advanced and often expensive equipment - Decca navigator, echo-sounders, sonar, etc. - which undoubtedly improve the real fishing power. No precise figures for this improvement, or indeed methods for estimating it, are available. Similarly relatively minor changes in the gear, e.g. adding tickler chains, have added considerably to the fishing power, though the effect of some of these changes can be estimated moderately easily by comparative fishing trials. The group emphasized the importance of very close contact between biologists, economists, technologists and fishermen, so that the users of fishing effort data will be aware of such developments and can attempt, at least qualitatively, to correct for them when analysing the data.

Further work

In previous sections items for further studies have been outlined. Some of these will involve some time, but the group expects that the results will be available for circulation and study before the 1970 I.C.E.S.-meeting. About this time - summer 1970 - might therefore be a suitable time for the group to meet again, if this is desired, to review these later studies as well as the general work of the group.

30th July, 1969

ANNEX

On the problems of evaluating the various characteristics of fishing vessels in terms of their effect on fishing effort measurements

by

J.G. de Wit (Chief Technical Fisheries Research Dept. - IJmuiden, Netherlands)

1. Introduction

The aim of this paper is to provide a base for the discussions at the first meeting of the I.C.E.S. C.Res. 1968/2:11 - Working Group on 30th of June and the 1st of July, 1969 in IJmuiden.

2. Definitions

According to Beverton and Parrish (1954) fishing effort has to be defined as the product of fishing power and fishing time.

The fishing power of a vessel is defined in relative terms as the ratio of its catch per unit fishing time or per unit fishing operation (e.g. per hour's towing, per shot, etc.) to that of a vessel and gear selected as a standard and fishing on the same density of fish. Also called: relative fishing power.

The same authors mentioned still another approach. Instead of using a vessel characteristic as an index of fishing power the other approach is to determine an individual fishing power factor for each vessel, or group of similar vessels, in arbitrary units that depend only on the particular ship chosen as standard. They state, however, that this refinement may eventually prove worthwhile but there is nothing in the results they have obtained so far to suggest that gross tonnage would not be an entirely satisfactory - and much simpler - index, provided the smallest vessels are assigned an extra factor.

Treschev (1963) gives a definition of fishing intensity of trawling in which the fishing effort also appears.

According to this definition the:
"fishing intensity is the relation of catch to fishing effort".

$$i = \frac{C}{S \cdot v \cdot t}$$

i = intensity of fishing operations
C = catch
S = product of horizontal and vertical opening of a trawl
v = trawling speed
t = total duration of trawling
(S . v . t) is the fishing effort and accordingly (S . v) is the fishing power.

Furthermore Treschev (1963) states that this definition is not sufficient from a theoretical point of view, since live objects are involved in catching operations. He suggests that trawling intensity may be expressed as follows:

$$i = f\ (d,\ g,\ k_s,\ t)$$

i = intensity of fishing operation
d = density of fish concentrations
g = criterion of the trawl's catchability
k_s = selectivity factor representing the relation between the quantity of fish escaped and the quantity of fish caught in the trawl
t = duration of trawling

Remark: The first definition of Beverton and Parrish (1954) defines fishing power in general terms. It can be applied to different types of vessels and different fishing methods (trawling, gill-netting, long lining, purse seining, seining, etc.). The second one of Treschev (1963) is related to trawling exclusively. The terms fishing effort and fishing power are very much used in relation to trawling. For this reason it might be advisable to confine the discussions to the vessel's influence on the fishing power for trawling first for the time being.

3. Vessel's parameters in use

Hickling (1946) used gross tonnage as a vessel's characteristic when studying the fishing power of Milfordhaven steam trawlers catching hake.

Beverton and Holt (1954) used the same characteristic as an index of fishing power for English North Sea motor trawlers. They found that the average fishing power per ton of a motor trawler is some 40% greater than that of a steam trawler.

Gulland (1956) found that in the case of the English trawler fleet fishing power is approximately proportional to the gross tonnage of the vessel in the range 150 - 800 gross tons.

Lundbeck (1963) states, however, that the fishing power in relation to vessel size (grt) is not a simple linear correlation. The rise of a fishing power curve is steepest between 200 and 400 gross tons.

He mentions that, generally, the bigger vessels may be favoured additionally in propulsive strength, other technical, nautical and communication equipment, by the more experienced skipper, a more skilled crew, etc.

Propulsive strength in terms of horse power is also used to express the fishing power of a trawler (Boerema 1950, Beverton and Holt 1954, Zijlstra and de Veen 1963).

According to Beverton and Holt (1954) the plot of the fishing power factor against Brake Horse Power shows a roughly linear trend but plots scatter widely.

Zijlstra and de Veen (1963) found linear relations between fishing power and horse power, but also that the fishing power of a motor trawler of m.BHP can be said to be roughly equivalent to that of a steam trawler of about 1.3 m.IHP.

The third vessel's characteristic used is the vessel's length. Plot of the fishing power factor against length gives a non- linear trend, so that length is a less convenient index of fishing power than gross-tonnage according to Beverton and Holt (1954).

It is worthwhile to give a closer attention to these three characteristics from a more technical point of view.

3.1 Gross tonnage

The origin of tonnage measurement goes back to the middle ages to define the size of vessels in terms of loading capacity. Three different lines of thinking can be discovered for the calculation of the volume in history: a British, a French and a Hanseatic. This resulted into quite different tonnage measurements of vessels of the same size. Around the beginning of this century the situation was rather chaotic. Only in 1939 the League of Nations issued International Regulations for Tonnage Measurement of Ships.

In 1947 the Governments of Belgium, Denmark, Finland, France, Iceland, the Netherlands, Norway and Sweden resolved to conclude a convention for a uniform system of tonnage measurement of ships (Oslo-convention 1947). These governments considered that differences in the regulations for Tonnage Measurement of ships and in the application of such regulations may lead to serious inconveniences consisting in unequal treatment of ships.

Later on the Federal Republic of Germany, Israel and Poland and some other countries agreed to this convention. Denmark and Sweden on the other hand withdrew a couple of years ago.

From a personal communication with the Netherlands tonnage authorities it became clear that the United Kingdom though not being a member of the Oslo-convention 1947, follows the rules of this convention to a very big extent.

In Belgium the Oslo-Convention 1947 never came into operation.

The latest modification of the calculation rules of this Convention stems from 1965.

According to the Oslo-convention 1947 the gross tonnage of a vessel comprises:

- the volume of the space below the tonnage deck
- the volume of the space between tonnage deck and upperdeck
- the volume of the superstructures
- excess volume of hatches.

The upperdeck is the uppermost exposed and complete deck. The tonnage deck is the deck below the upperdeck in vessels with more than one complete deck.

In single deck side trawlers the upperdeck and the tonnage deck are the same deck. In slipway-sterntrawlers the uppermost complete deck over the working space is the upperdeck and the working deck is the tonnage deck.

For the volume calculation a tonnage-length is used. This length differs in general from length over all, length between perpendiculars or length of waterline. The tonnage-breadths for the calculation are measured between the innersides of the frames c.q. the linings thereon. The tonnage-depths for the calculation are measured at the centreline of the vessel from the top of the floors or double bottom to the underside of deck.

When calculating the gross tonnage a number of spaces above the upperdeck are exempted e.g.

- spaces for machinery other than the propulsive machinery
- tweendeck spaces for conveyor belts, gutting tables, machinery for treatment of the catch and fishing gear repair (in case the vessel has a tonnage mark at her sides)
- navigation and radio spaces, galleys, washrooms;
- casings of propulsion machinery spaces;
- waterballasttanks;
- stores (excluding provision stores).

The calculation breadths may differ importantly from the moulded breadths in case of deep web-frames or a heavy insulation (deep freeze holds). The fish hold insulation is excempted from the grosstonnage for a thickness of 3".
The calculation depths diverge so much from the moulded depth that a comparison is nearly impossible. Due to the differences in internal contruction and internal arrangements two hulls with identical main dimensions may show different gross tonnages. These differences may be important (abt 5 - 7%).

<u>Examples</u>

	L_{pp} x B x D x d	Displacement motr.t	C_b	Propulsion	Fish hold baskets	Grt
<u>a. Schleswig</u>						
Kieler Howaldts-werke 1950	52 x 8.60 x 5 x 4.4	1080	0,565	steam 850 IHP	5000	568
Mőretrål Kieler Howaldts-werke 1951	52 x 8.60 x 4.75 x 4.2	1136	0,586	diesel 1000 BHP	4330	631
<u>b. Bremerhaven</u> 1961	64 x 11 x 7.3/5 x 4.8	----	-----	diesel 2050	----	941
<u>Vikingbank</u> 1961	64 x 11 x 7.3/5 x 4.8	----	-----	diesel 2160	----	[illegible]

(From C. Boie in Handbuch der Werften 1956 and E. Strohbusch in Handbuch der Werften IX-1967)

The example <u>a.</u> shows two hulls with nearly identical main dimensions.
The Mőretrål has a slightly smaller depth (D) so that a smaller grt should be expected. Due to the fact that this vessel has no insulated fish hold the grt is nearly 11% more than that of the Schleswig.
Due to the smaller depth one could have expected a grt of
$\frac{4.75}{5}$ x 568 = ~540 grt.

Therefore the difference amounts to 91 grt or 16% compared to the Schleswig. This is mainly due to the elimination of the fish hold insulation and a change in the German tonnage rules due to the German agreement to the Oslo-convention (1947) in 1956.

For example b. it can be noted that the Bremerhaven has a fish hold to store the whole catch completely deep frozen, capacity 604 m^3. The Vikingbank on the contrary has a deep freeze-hold of 85 m^3 and a hold to store the fish on ice of 580 m^3. It is obvious that this difference in internal construction is mainly responsible for the difference in grt of 6%.

Especially when legal obligations are based on a gross tonnage limit and when there is a tendency to make vessels of a certain gross tonnage bigger and bigger builders apply the measurements-rules in a very sophisticated way. The result is that the length, beam and depth of the vessels increase and that the gross tonnage does not pass the legal limits.

Examples of such a process are not only found in coasters but in fishing vessels as well. Until recently 50 gross tons was a legal limit for fishing vessels in one of the shipping laws of the Netherlands. The following table indicates the steady length increase of this category of small trawlers since 1946.

year of built	gross tonnage	length (m)	
1946	49.68	18,73	100%
1954	49.98	19.02	103%
1958	49.91	19.56	104.5%
1960	49.14	20,36	108.5%
1960	49.82	20.40	108.5%
1966	49.49	21.35	114%

During the same period the superstructure increased from a small wheelhouse to a deckhouse contributing in 1966 more to the gross tonnage than in 1946. Also for this reason the increase in length is the more remarkable.

As said, due to the possibilities to use the calculation rules more or less intelligently it is possible to create different gross tonnage values for vessels having the same main dimensions. Though this may not hurt very much if the gross tonnage is used for the account of harbour duties, etc. its value is some what doubtful for use as a fishing power parameter.

It seems that even the shipping authorities are not quite happy with the existing system. During May 1969 the IMCO organizes a big conference on tonnage measurement. Proposals are submitted to review the measurement-system and to replace it either by displacement (or weight) of the vessel or by a simple measurement of all closed spaces.

The latter measurement was proposed to be done according to moulded dimensions to measure real volumes in this way. Keeping also in mind that the tonnage measurement-system was subject to alternations - this has occurred a couple of times since 1939 - and also taking into consideration the possibility of a mayor change in future the best thing one can say about gross tonnage as a fishing power characteristic is: it is a rather flexible and uncertain yard-stick.

3.2.Horse power

As mentioned before another parameter to establish the fishing power of a vessel is horse power.

When comparing the catch/grt correlation of British steam trawlers and motor trawlers it was found that one-ton-(gross)-hour fished by a diesel trawler is equivalent to about 1.4 ton-(gross)-hours fished by a steam trawler. A probable explanation for this phenomenon could perhaps be found in a comparison of steam trawlers and diesel trawlers.

But on the assumption that steam and diesel trawlers in the fifties had about the same engine output and about the same fish hold capacity the engine room of a dieseltrawler was smaller than the engine plus boiler room of a steam trawler. In other words due to extra length of the machinery of steam trawlers the gross tonnage of this type must have been bigger than that of a diesel trawler with the same fish hold capacity.

Zijlstra and de Veen (1963) give figures on the Dutch fishing fleet.

	Grt range	Grt average	Grt range	Grt average
steam trawlers	250 - 550	365	450 - 800 IHP	625 IHP
diesel trawlers	120 - 400	221	150 - 900 BHP	450 BHP

To have a basis for comparison IHP's and BHP's the output has to be reduced to the number of horse powers delivered to the propeller or DHP.

To arrive at DHP from IHP or BHP the following relationship is applicable:

DHP = abt 0.8 IHP (reciprocating steam engines)
DHP = abt 0.97 BHP (direct diesel drive)
DHP = abt 0.94 BHP (geared diesel drive)

	Grt range	Grt average	DHP range	DHP average
steam trawlers	250 - 550	365 (100%)	360 - 640	500 (100%)
diesel trawlers	120 - 400	221 (60%)	141 - 850	423 (85%)

If a linearity is assumed for the grt/DHP ratio of diesel trawlers the average grt for a 500 DHP will be $\frac{500}{423} \cdot 221 = 261$ grt.

When this figure is taken as 100% the average grt of steam trawlers of 365 becomes 140%. In other words: on the basis of equal propulsive power (DHP) (generally speaking) the gross tonnage of a steam trawler is about 1.4 times the gross tonnage of a motor trawler.

These figures from the Dutch fishing fleet agreed well with the findings about the British fleet, as mentioned in the beginning of par. 3.2, at that time. The general assumption must be that there is a well defined ratio between DHP and GRT.

Zijlstra and de Veen (1963) found the following relationship: the fishing power of a Dutch diesel trawler of m.BHP can be said to be roughly equivalent with the fishing power of a Dutch steam trawler of about 1.3 m.IHP.

When again BHP and IHP are realted to DHP the relation becomes m.DHP (diesel) equivalent to $1.3\frac{0.8}{0,955}$ m.DHP or 1.09 m.DHP.

From the Dutch figures it is clear that for the same number of DHP a steam trawler is bigger than a motor trawler. For this reason a steam trawler requires some more output to propel the vessel at the same speed as a motor trawler generally speaking. This closes the gap between

m.DHP (diesel) and 1,09 m.DHP (steam)

still further.

These considerations might lead to the conclusion that it does not make so much difference when either gross tonnage or horse power are used as fishing power yard sticks if everybody uses the same horse power i.e. the horse power delivered to the propeller (DHP).

Some other problems, however, inhibit the use of horse power, e.g. BHP. Traung (1957) points out that there are different methods to define the rating of BHP rendering very different results. Or in other words the one BHP is not the same as the other BHP. This makes this measure equally flexible and uncertain as was stated before about the gross tonnage.

The horse power picture was further troubled when a couple of years ago a number of big trawlers was built with more emphasize on speed.

Fairtry, built 1954, $\frac{v}{\sqrt{L}} = 0.8$ (L_{pp} = 74.6 m (242'))

Weser, built 1965, $\frac{v}{\sqrt{L}} = 1.04$ (L_{pp} = 70.2 m (230'))

For the speed increase from 12.5 kn (Fairtry) to 15.7 (Weser) the engine output had to be raised from 1900 SHP to 3000 SHP.

In the beginning of this period the high number of HP was only used for a higher free-running speed. Nowadays, when using a midwater trawl the gap between HP for fishing and HP for running free becomes narrower.

3.3 Length

The third factor mentioned by Beverton and Holt (1954) is the vessel's length. Though a use of this factor could not be found in literature some remarks can be made on it. First of all what is the length of a vessel?

Length over all: This length is the easiest to determine and is given in L_{OA} the tonnage certificate. It is doubtful whether it represents a vessel's characteristic meaningful. A raking stem contributes sometimes to the L_{OA} but nothing whatsoever to the fishing power.

Identification Length : Measured from the aftside of the sternpost to foremost point of the stem. This length is also given in the tonnage certificate.

Length between perpendiculars: L_{PP} Measured from aftside of sternpost to foreside of stem on the construction waterline. The construction waterline is in reality difficult to determine on fishing vessels. The loading conditions vary. Sometimes this waterline is taken at 0.85 D. In this case it is more specifically defined, but still difficult to use in practice.

Length of waterline : L_{WL} Used to calculate the displacement more accurate. Mostly used for tanktesting.

As a compromise L_{PP} could be used as is mostly done in naval architecture. But whichever a length is chosen it must be clear that everybody uses the same length.

4. Other factors governing fishing power

According to a paper by FAO, Parrish and Keir (1959) the possible factors might be grouped in the following categories:

1. Vessel characteristics
2. Gear characteristics
3. Crew characteristics (e.g. number, skill in operating gear, etc.).

The authors further state: "In practice the various factors in either the same or different categories, will not vary independently. For example, size and power of vessel and type or size of gear often vary together. In such instances, the fishing power might be expressed in terms of that factor which is most easily measured".

As shown before the vessel characteristics "most easily measured" e.g. gross tonnage, BHP or IHP are very often not standardized and sufficiently reliable measure.

Traung (1957) correctly states: "When trawling, there is a balance between thethrust developed by the engine and the resistance of the hull, due to the weather (water, wind, waves) and because of the trawl gear. If the resistance of any of these factors changes, a new balance is obtained at another speed. This speed determines to a great extent the screening capacity of the net and thereby the fishing power.

Thrust alone is not sufficient as a parameter for plotting the fishing power. In order to have the work defined, speed must be introduced. Boerema (1957) found differences in catches of flat fish at different average towing speeds of 2.8 and 3 kn.

In this connection Treschev's (1963) approach may be recalled: $i = \frac{C}{S \cdot v \cdot t}$. In this expression the "gape" of the net (S) and the speed (v) are used.

For a bottom trawl the "gape" is not so difficult to estimate if the foot rope length in known. Bridles, however, will have an improving effect in many cases. A correction factor should be applied based on bridle length and or otter board spread. Most types of bottom trawls have an optimum speed. Increases or decreases from this optimum result in a decrease of the "gape" and consequently of the catch.

Therefore, to a net of a known "gape" an optimum speed of the net over the bottom can perhaps be attached.

The "gape" of midwater trawls and the otterboard spread in relation to the bridle length can also be estimated to a rather high degree of accuracy. The speed of a midwater trawl varies between certain limits.

The most difficult of the three characteristics as mentioned by FAO, Parrish and Keir (1959) are the crew characteristics. It will be very difficult, if not impossible, to measure the skill of skipper and crew. Nevertheless, it is felt that these characteristics contribute very much, if not most, to the relative fishing power of the unit consisting of ship, gear and crew.

5. Items to be discussed

A. General discussion of this paper

B. Trawling

1. Vessel characteristics
   a. gross tonnage
   b. displacement
   c. length
   d. horse power (BHP, IHP, SHP)
   e. propeller thrust
   f. others

2. Gear characteristics
   a. "gape" of net
   b. speed of net
   c. catchability of net (netlength, netform, waterflow)
   d. bridle length
   e. otterboard spread
   f. number of tickler chains and their weight
   g. others

3. Crew characteristics
   a. number of crew
   b. skill of skipper
   c. skill of crew
   d. remuneration system
   e. subsidies or grants
   f. motivation
   g. others

4. Electronic equipment, radio, etc.
   a. echosounders
   b. sonar
   c. netsounder
   d. radar
   e. radiotelephony) wireless operator yes or no
   f. telegraphy
   g. decca/loran
   h. decca track-plotter
   i. air reconnaissance
   j. others

C. Gillnetting

D. Seining

E. Line fishing

F. Purse seining

G. Other fishing methods

H. Desireability and possibilities to design a more complex but more reliable yard stick to measure relative fishing power

I. Further studies needed and offers to undertake these studies

MAY, 1969
(Revised July, 1969)

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