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International Council for the
Exploration of the Sea

C.M.1973/B:4
Gear and Behaviour Committee

CONTENT

REPORT OF MEETING ON FISHING EFFORT MEASUREMENT, IJMUIDEN, 7-8 MAY 1973.

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x) General Secretary
ICES,
Charlottenlund Slot,
2920 Charlottenlund,
Denmark.

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REPORT OF MEETING ON FISHING EFFORT MEASUREMENT
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2920 Charlottenlund, Denmark

REPORT OF MEETING ON FISHING EFFORT MEASUREMENT

IJMUIDEN, 7-8 MAY, 1973

1. Participants

The list of participants is given in Annex I of this report.

2. Background Information

2.1 In a paper presented to the Statistics Committee of ICES at its annual meeting in 1972, Dr S. A. Studenetsky (1972) urged the adoption and application of a standardised international system for the measuring of fishing effort. Dr Studenetsky proposed that the method of measuring fishing effort devised by Dr A. I. Treschev (1970, 1971) should form the basis of such a standardised international system.

2.2 The method of measuring fishing effort proposed by Dr Treschev is based on the acceptance of a definition of fishing power in terms of the concept of a gear's zone of action which is ascertainable from its physical dimensions and characteristics. The expressed aim of such an approach was to allow fishing power to be dissociated from any catches and to relate it simply to the "effective area swept" or "volume of water filtered" by the gear. Dr Treschev proposed that this effective area could, at present, be measured directly only for certain gears such as bottom trawls. It could, however, be determined experimentally for others, e.g. fish pumps, while for a third group for which as yet no precise definition of the volume of water swept has been provided, the fishing power could only be measured indirectly.

2.3 The papers by Treschev and Studenetsky were considered by the Gear and Behaviour Committee in 1972. They asked that Dr Treschev should provide a worked example of his method and that member countries should make trial application of it to their own fisheries and report their results.

2.4 In its discussion of Dr Studenetsky's proposal the Statistics Committee was of the opinion that there was as yet insufficient evidence based on practical evaluation that the system proposed by Dr Treschev did in fact lead to a better determination of fishing effort than currently used systems and that a thorough evaluation of his system was essential. The Statistics Committee recommended that further information should be provided.

3. Terms of Reference

The following resolution (C.Res.1972/2:8), defining the terms of reference of the meeting, was adopted by the Council.

(a) The Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment shall meet again on 3, 4 and 5 May 1973 at IJmuiden to consider especially high-opening bottom trawls, one-boat and pair midwater trawling techniques, engineering aspects of multi-purpose vessels, instrumentation and electric fishing and

(b) the 7 and 8 May be devoted to dealing with the statistical aspects of measuring fishing effort in relation to stock assessments.

the Chairmen of the Gear and Behaviour and Statistics Committees will prepare the plans for this part of the meeting.

assessment experts from member countries will be invited to participate in this part of the meeting.

representatives of ICNAF, FAO (ACMRR) and OECD will be invited to attend.

the Council's Statistician will attend the meeting and present a document outlining the statistical problems in connection with compiling of effort data.

(c) in pursuance of the issues raised by S. A. Studenetsky (Doc.C.M.1972/D:5 referring to A. I. Treschev, Doc.C.M.1971/B:9), Dr A. I. Treschev be asked to submit to the meeting of the Working Group a paper illustrating, by means of worked examples referring to USSR fisheries, the application of his proposed new method of measuring fishing effort, and that other countries evaluate the merits of the method applied to their own fisheries and report their findings to the Working Group.

4. Contributions

4.1 In response to the Council's resolution the following papers were presented to the meeting:

(1)	G. Vanden Broucke, P. Hovart and G. Cleeren	"An application of the Treschev method on fishery effort measurement"
(2)	R. Guichet	"Rélations entre le pouvoir de pêche déterminé expérimentalement, la puissance utilisée en pêche et le volume d'eau filtré par unité de temps"
(3)	W. A. M. Sichone and J. F. de Veen	"Comparison of horse power, propeller thrust and water volume filtered as fishing power parameter of a beam trawl"
(4)	A. I. Treschev	"Engineering aspects of swept volume method (SVM). Definition parameters of fishery"
(5)	A. I. Treschev	"Fishery parameters assessment method (additional comments and clarifications)"
(6)	P. Adam	"Comments on concepts used for fishing effort measurement"

These papers are reproduced as Annexes II - VII of this report.

4.2 In his main paper, (5) above, Dr Treschev repeats his definition of fishing power, namely that it is the volume of water fished. He lists a number of claimed advantages of his measure over others and also gives an example, based on the catches, aggregated over a year, of 16 Russian vessels, 10 bottom trawlers and 6 pelagic trawlers, of the higher correlation between catch per hour and swept volume than between catch per hour and each of three vessel characteristics, namely displacement, length and engine capacity. The values of the correlation ratios (the measure of association chosen by Dr Treschev) are respectively 0.97, 0.82, 0.79 and 0.88. No tests of significance are quoted by Dr Treschev.

Dr Treschev also claims advantages for his method over other methods in determining effort quotas for fishery regulation.

4.3 In their paper, Vanden Broucke et al. study the relationship between the volume swept by a sample of 49 Belgian beam trawlers fishing for flatfish and their catch per hour's fishing. Swept volume is measured as the product of the beam length, height of the trawl heads and the towing speed. There is evidence of a relationship between catch and volume in some of the data but not in others. Correlation with horse power is better than that for swept volume.

4.4 In his contribution (2), Guichet presents the results of a study of catches by two groups of vessels fishing for hake from La Rochelle. The fishing power of the vessels involved, obtained by relating catches to those of of a standard vessel, are considered in relation to (a) engine power and (b) swept volume. The latter is taken as the product of the vertical height of the trawl, the distance between the wing ends and the towing speed. The correlation coefficients between power factor and engine power are significant for both groups of vessel but that between power factor and swept volume is only significant for one group of vessels.

4.5 Sichone and de Veen, paper (3), correlate the logarithms of the total catches of a large number of beam trawlers in five different months in 1971 with engine horse power, propeller thrust and swept volume. In general the coefficients are higher and more often significant when brake horse power and propeller thrust are involved than when catches are correlated with swept volume.

4.6 The contribution by Adam, paper (6), is a review paper on concepts in which the author seeks, among other things, to clarify the various meanings attributed to the term "fishing effort".

5. Discussion

5.1 There was a very full discussion of the contents of all the contributions, particularly of the swept volume method proposed by Dr Treschev.

It was accepted that the swept volume method had certain attractions as a fundamental measurement in determining fishing effort but there were many problems associated with it. For instance, the dimensions to be used to determine the volume of water swept were not generally agreed upon even for a gear such as the demersal trawl. Was the distance between the wing ends or between the otter boards, or some other dimension, the appropriate one? The meeting felt that Dr Treschev had not yet settled this matter.

Furthermore, demersal trawls, as used by different fleets and even by different vessels within fleets, were not at all homogeneous. The use of attachments such as tickler chains could materially affect catch composition and size without in any way altering the swept volume.

In the case of perhaps the easiest gear to which the swept volume method could be applied, namely the beam trawl, the available evidence was that at least as high correlations existed between catch and engine power, as measured by brake horse power or propeller thrust, as between catch and swept volume.

Other factors, such as the skill of the skipper and his crew, were also regarded to be of significance in all types of fishing.

In its application to "passive" gears the meeting was even more sceptical of the method proposed by Dr Treschev. The fishing power of such gears would have to be determined by reference to catch ratios which is not in any way different from a method of evaluating fishing power already in use for many years.

The meeting, in general, could not see any clear advantage in the swept volume method in regulating mixed fisheries, be they fisheries on single stocks using different gears or on several stocks of different species using the same or different gears.

6. Conclusion

The meeting concluded that the swept volume method of measuring fishing effort as proposed by Dr Treschev represented a fresh fundamental approach with scientific potential. The method specifically considers a major factor determining effort for a gear. It seemed most applicable to those trawl fisheries in which the gear is standard, but, even here, other factors also apply with this and other gears and should be brought into consideration. For some gears it may be necessary to estimate rather than measure swept volume.

The meeting considered that the definition of swept volume and methods for its calculation require further development with due consideration of the fish capture process.

Experience with the method has so far been limited but at present it does not seem to be better than methods now in use for purposes of fisheries assessments and its value for mixed fisheries was not generally accepted.

There is need for further experimental results from all countries as a means for comparing methods for fishing effort measurement.

7. Recommendation

The meeting recommends that

> "member countries study the results of applying the swept volume method of effort measurement to their own fisheries and report their findings to ICES."

8. References

Studenetsky, S. A. 1972 Standardisation of the measurement of fishing effort as an important factor in the regulation of the fishery. ICES C.M.1972/D:5.

Treschev, A. I. 1970 Fishing unit measures. ICES Special meeting on measurement of fishing effort. Paper No. 2.

Treschev, A. I. 1971 Fishing unit measures (The second supplemented and revised report). ICES C.M.1971/B:9.

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Meeting on the Measurement of Fishing Effort, IJmuiden, 7-8 May 1973

LIST OF PARTICIPANTS

BELGIUM	Mr G Vanden Broucke, Rijksstation voor Zeevisserij, Ostende 8400.
	Dr P Hovart, Station de Recherche pour la Pêche Maritime, Hôtel de Ville, 4ème étage, 8400 Ostende.
	Mr K Michielsen, Dienst voor de Zeevisserij, 10, rue du Méridien, 1020 Bruxelles.
CANADA (ICNAF)	Mr P J G Carrothers, Fisheries Research Board, Department of the Environment, St Andrews, New Brunswick.
DENMARK	Mr J Møller Christensen, Danish Institute for Fisheries and Marine Research, Charlottenlund Slot, DK-2920 Charlottenlund.
FRANCE	M M Portier, Institut Scientifique et Technique des Pêches Maritimes, Boulogne-sur-Mer,
	M. R J H Guichet, Institut Scientifique et Technique des Pêches Maritimes, 74, Allées du Mail, 17000 La Rochelle.
GERMAN FEDERAL REPUBLIC	Dr J Messtorff, Institut f. Seefischerei, Bremerhaven.
	Dr K Lange, Institut f. Fangtechnik, 2 Hamburg 50, Palmaille 9.
ICELAND	Mr E Ragnarsson, Fisheries Association of Iceland, P.O. Box 20, Reykjavik.
	Mr. A H Augustssón, Fisheries Association of Iceland, P.O.Box 20, Reykjavik.

NETHERLANDS	Mr H B Becker, Mr E J de Boer, Mr I Th. Koldewijn, Mr J F de Veen, Mr J G de Wit,	Netherlands Institute for Fishery Investigations, Postbus 68, Haringkade 1, IJmuiden.
	Mr W Smit, Landbouw Economisch Instituut, 's-Gravenhage.	
NORWAY	Mr P L Mietle, Directorate of Fisheries, P.O.Box 185-186, 5001 Bergen.	
SPAIN	M José A Pereiro, Instituto Español de Oceanografía, Alcalá 27, 4°, Madrid 14.	
SWEDEN	Mr F Billström, National Central Bureau of Statistics, Fack, S-102 50 Stockholm.	
UNITED KINGDOM	Mr M J Holden, Fisheries Laboratory, Lowestoft, Suffolk.	
	Mr A R Margetts, Fisheries Laboratory, Lowestoft, Suffolk.	
	Mr J A Pope, Marine Laboratory, P.O.Box 101, Victoria Road, Aberdeen AB9 8DB.	
U.S.S.R.	Dr A I Treschev, Mr E A Karpenko, Mr V P Simbirov	VNIRO, Verkhne-Krasnoselskaja 17, Moscow B-140.

O.E.C.D.	Mr P Adam, Fisheries Division, 2, rue André Pascal, Paris 16ème, France.	
I.C.N.A.F.	Mr P J G Carrothers (see page 1, Canada)	

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Meeting on Measurement of Fishing Effort, IJmuiden, 7-8 May 1973

AN APPLICATION OF THE TRESCHEV METHOD ON FISHERY EFFORT MEASUREMENT

by

G. Vanden Broucke, P. Hovart and G. Cleeren

Fisheries Research Station,
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Introduction

At the ICES Meeting of 1972 countries were invited to evaluate the merit of the method proposed by Dr A I Treschev in measuring fishing effort.

This method was applied to Belgian beam trawlers fishing for flatfish on the same fishing grounds. A comparison was also made between the catch and the brake horse power.

Material and methods

The statistical material employed relates to the year 1972. Data relating to catches made by 49 trawlers in statistical rectangles IV b, IV c, VII d and VII a, f and g (Figure 1) were available.

Data regarding catches were obtained from the auctions and those concerning the fishing area and hours fishing were taken from the skippers' logbooks.

The length of the beams, the height of the trawl heads and the towing speed were obtained through a questionnaire.

The brake horse power was the power recorded in the ship certificate.

Table 1 gives the characteristics of the vessels and the gear.

The gear used consists of twin beam trawls towed over the port and starboard side of the vessel and measuring approximately 3.5 to 8 m along the beam. The two beam nets are equipped with anti-stome chains.

For the Treschev method the independent variable was the volume of the water swept by the net. This volume (in m^3 per hour) is the product of the total length of the two beams, the height of the trawl heads and the average towing speed as given by the skippers.

The dependent variable was the catch per hour fishing.

As regards the second series of calculations the dependent variable was again the catch per hour fishing whereas the independent variable was the brake horse power.

Using these variables, linear regression equations were calculated for all vessels operating in all areas as well as for the vessels fishing on each of the different grounds.

Results

1. Table 2 shows the linear regressions with the swept volume as independent variable. Figures 2 a-d give the individual distribution of the data.

Rather low correlation coefficients are obtained. For all areas R was 0.529, whereas for the different fishing areas the correlation coefficient varied between 0.631 and 0.259. Only for the areas IV b, IV c and all fishing areas significant regression coefficients were obtained.

2. Table 3 gives the linear regression with the brake horse power as independent variable. Figures 3 a-d show the individual distribution of the data.

Again rather low correlation coefficients are obtained. For all vessels R = 0.673 and for the different areas the correlation coefficients lay between 0.630 and 0.152.

The regression coefficients were significant for all areas, area IV c and VII a, f, g.

3. Comparing Tables 2 and 3 it appears that the correlation coefficients in the Treschev method are smaller than in the second series of calculations, except for area IV b

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Table 1. The characteristics of the vessels and gear.

Fishing areas	No. of vessels	G.T.		H.P.		L of single beam	
		Range	Average	Range	Average	Range	Average
All fishing areas	49	21.04-198.77	94.81	145-610	365.86	3.5-8 m	5.8 m
IV b	15	48.18-143-12	101.34	180-610	372	4-7.3	6.3
IV c	40	21.04-188.49	87.44	145-610	360	3.5-8	5.76
VII d	12	65.47-198.77	101.55	200-500	380	3.5-8	5.9
VII a f and g	36	48.18-198.77	118.39	180-610	408.42	4-8	6.2

Table 2. Regressions: $Y = a + b X$ (X = volume of the water swept).

Fishing area	Regression equation	R
All fishing areas n = 49	$Y = 27{,}138 + 0{,}000404\ X$ (0,000095) (sss) t = 4,253	0,529
IV b n = 15	$Y = 18{,}100 + 0{,}000718\ X$ (0,000238) (ss) t = 3,016	0,631
IV c n = 40	$Y = 27{,}597 + 0{,}000348\ X$ (0,000106) (ss) t = 3,283	0,472
VII d n = 12	$Y = 27{,}797 + 0{,}000330\ X$ (0,000390) (ns) t = 0,846	0,259
VII a, f, g n = 36	$Y = 29{,}925 + 0{,}000370\ X$ (0,000202) (ns) t = 1,832	0,299

(sss = significant $p < 0{,}001$; ss = significant $p < 0{,}01$;
s = significant $p < 0{,}05$; ns = not significant).

Table 3. Regressions: Y = a + bX (X = horse power)

Fishing area	Regression equation	R
All fishing areas n = 49	Y = 12,274 + 0,1003 X (0,0161) (sss) t = 6,235	0,673
IV b n = 15	Y = 50,275 + 0,0320 X (0,0579) (ns) t = 0,56	0,152
IV c n = 40	Y = 13,892 + 0,0891 X (0,0187) (sss) t = 4,755	0,611
VIId n = 12	Y = -10,691 + 0,1454 X (0,0696) (ns) t = 2,088	0,551
VII a, f, g n = 36	Y = 18,280 + 0,0858 X (0,0343) (s) t = 2,503	0,630

(sss = significant $p < 0{,}001$; ss = significant $p < 0{,}01$; s = significant $p < 0{,}05$; ns = not significant).

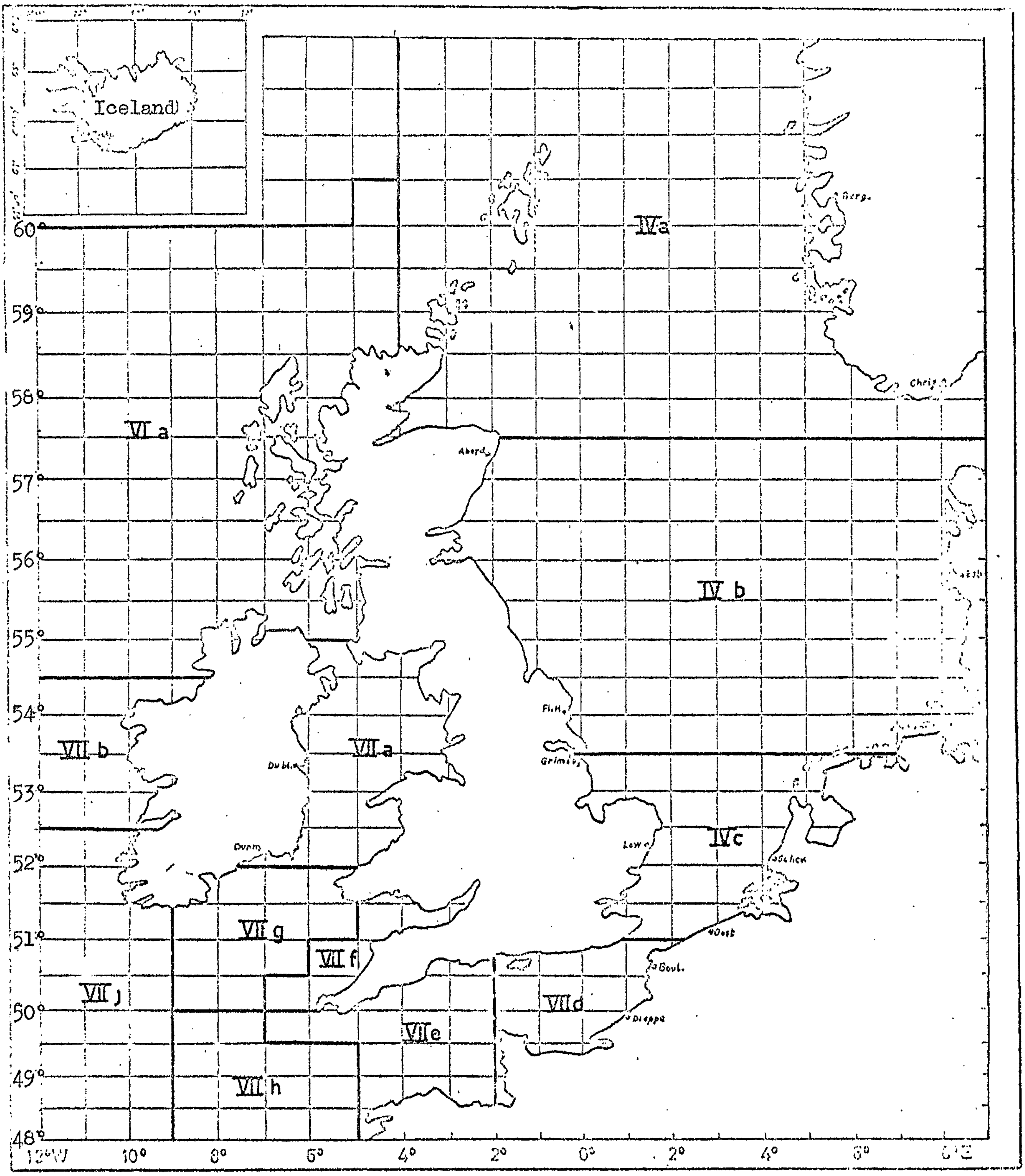


FIGURE 1. FISHING AREAS.

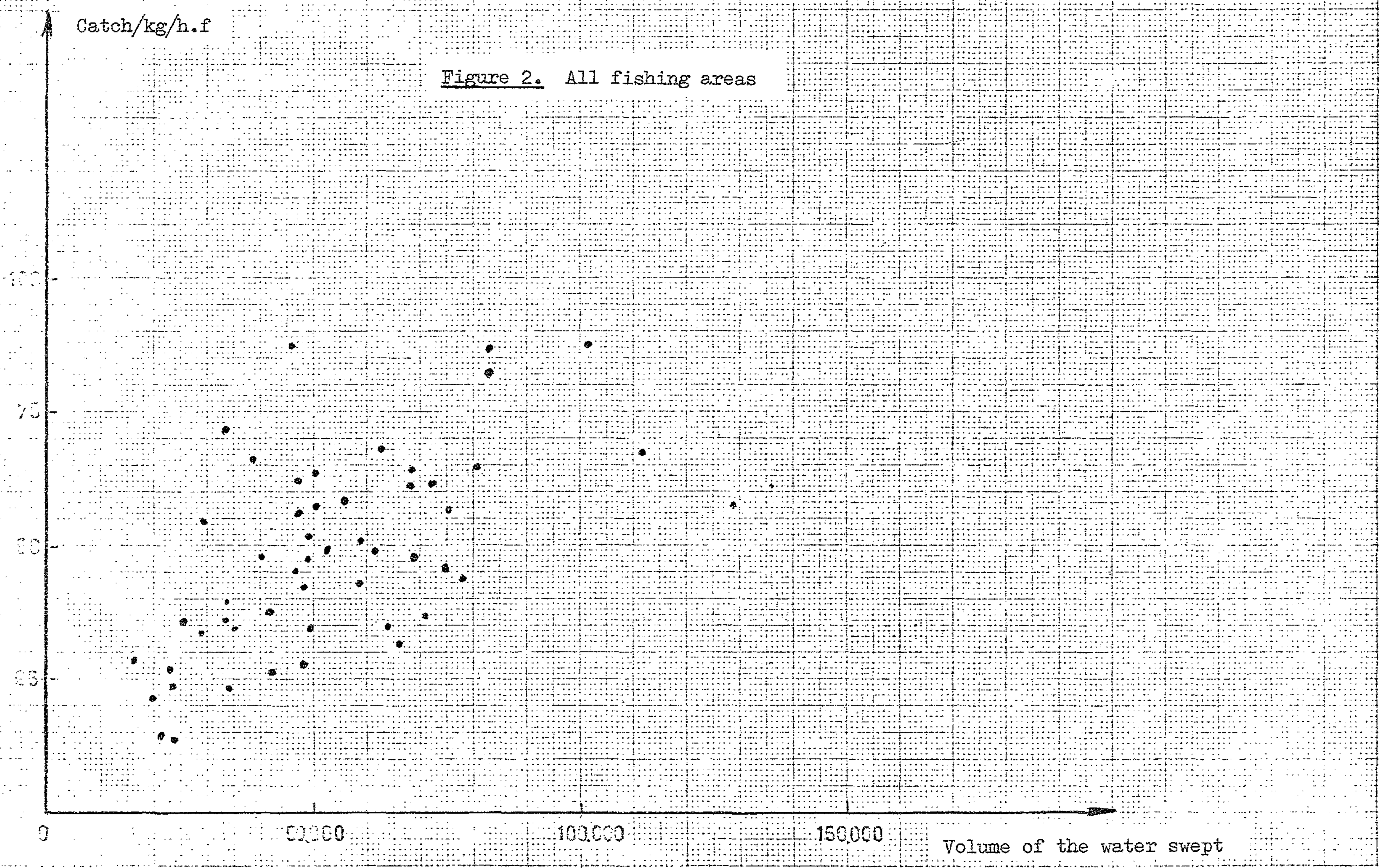


Figure 2. All fishing areas

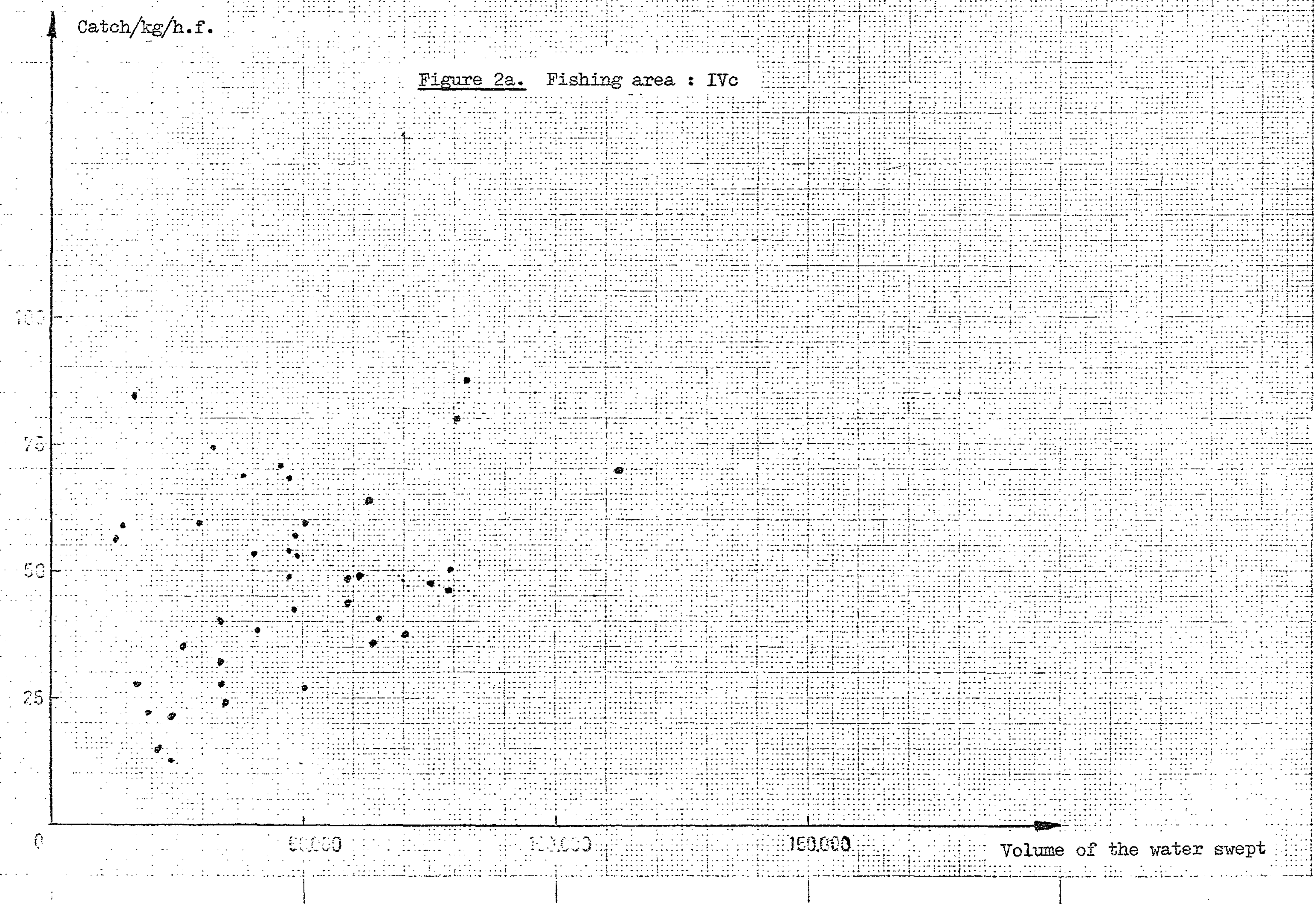


Figure 2a. Fishing area : IVc

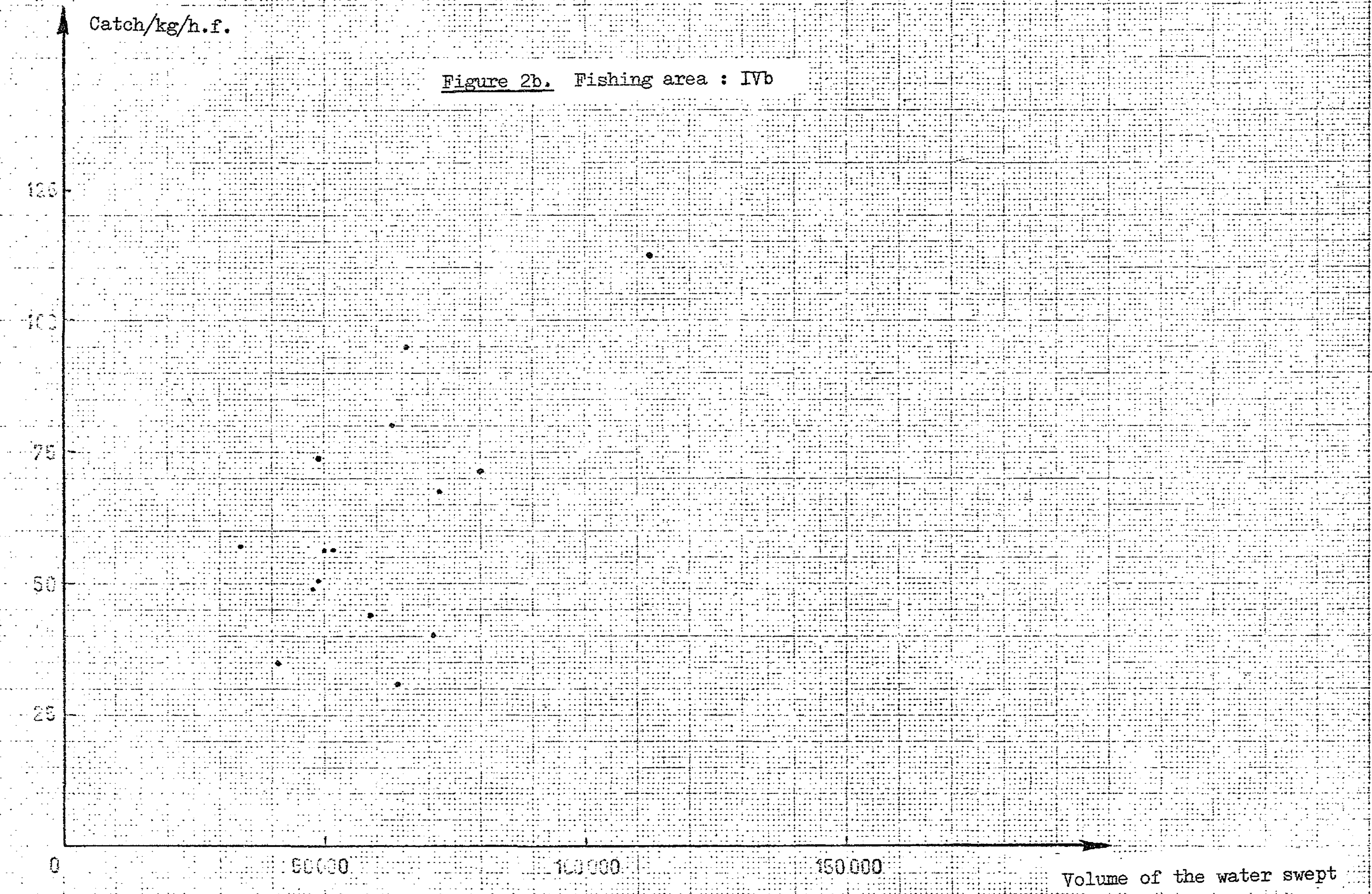


Figure 2b. Fishing area : IVb

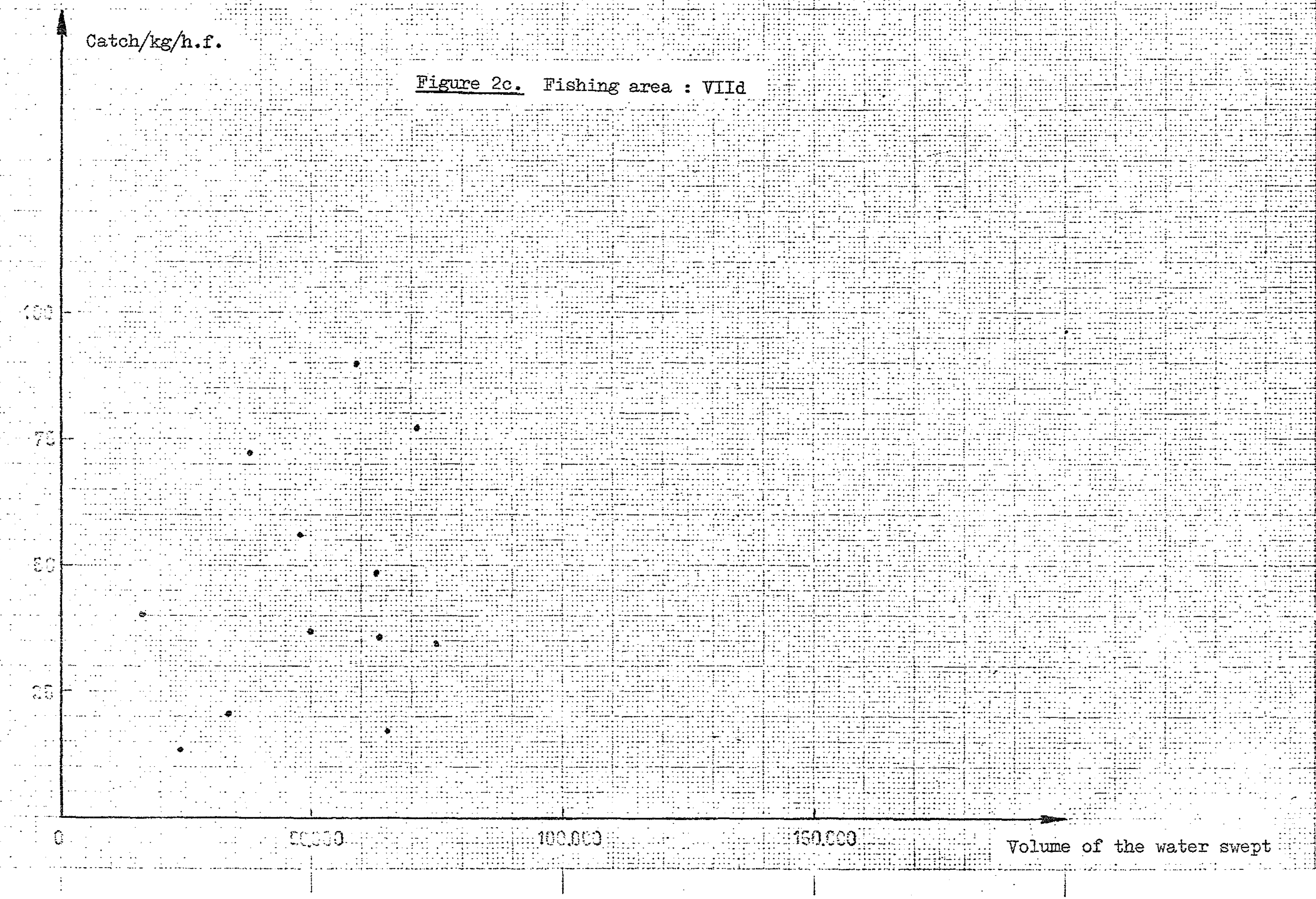
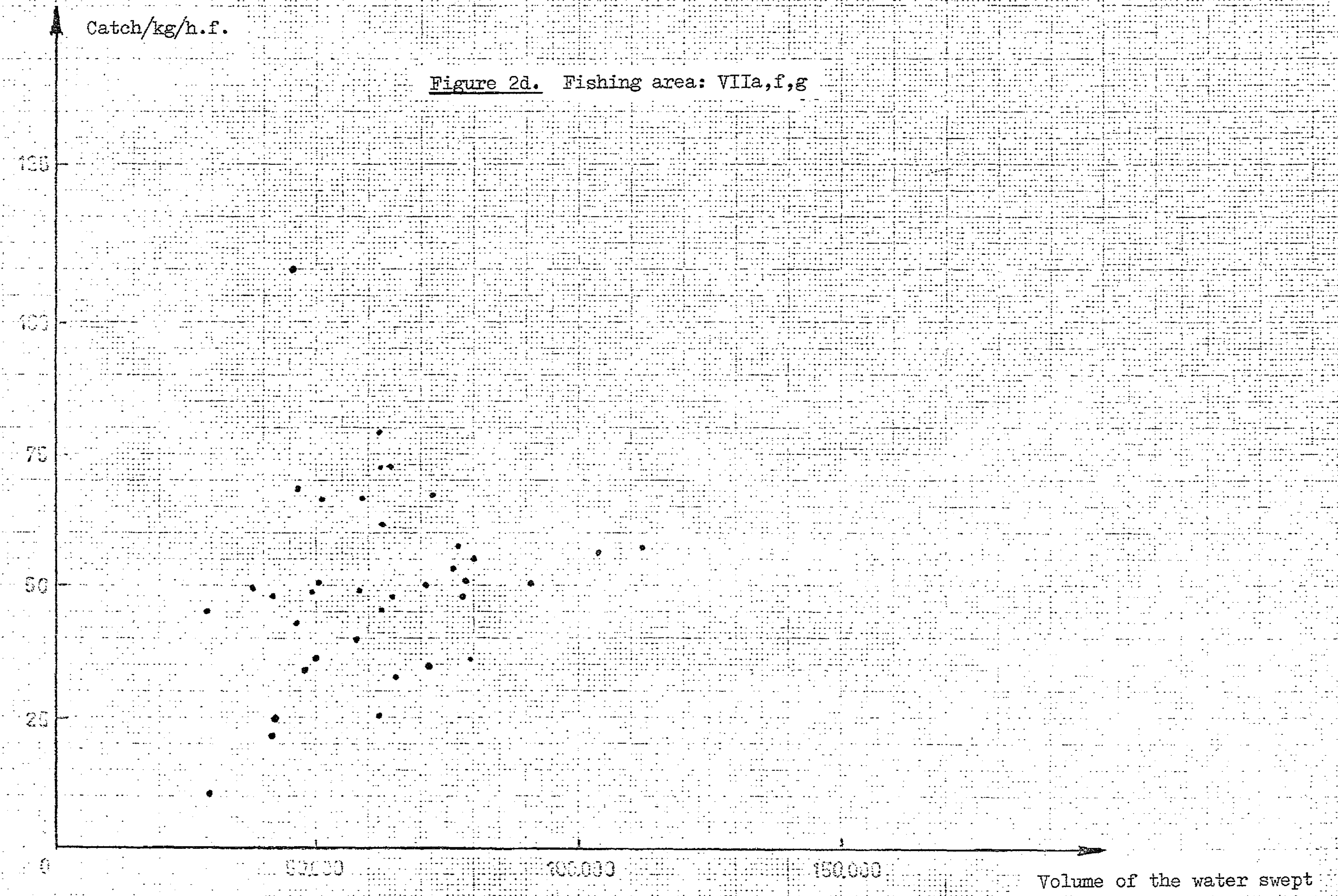


Figure 2c. Fishing area : VIId

Figure 2d. Fishing area: VIIa,f,g



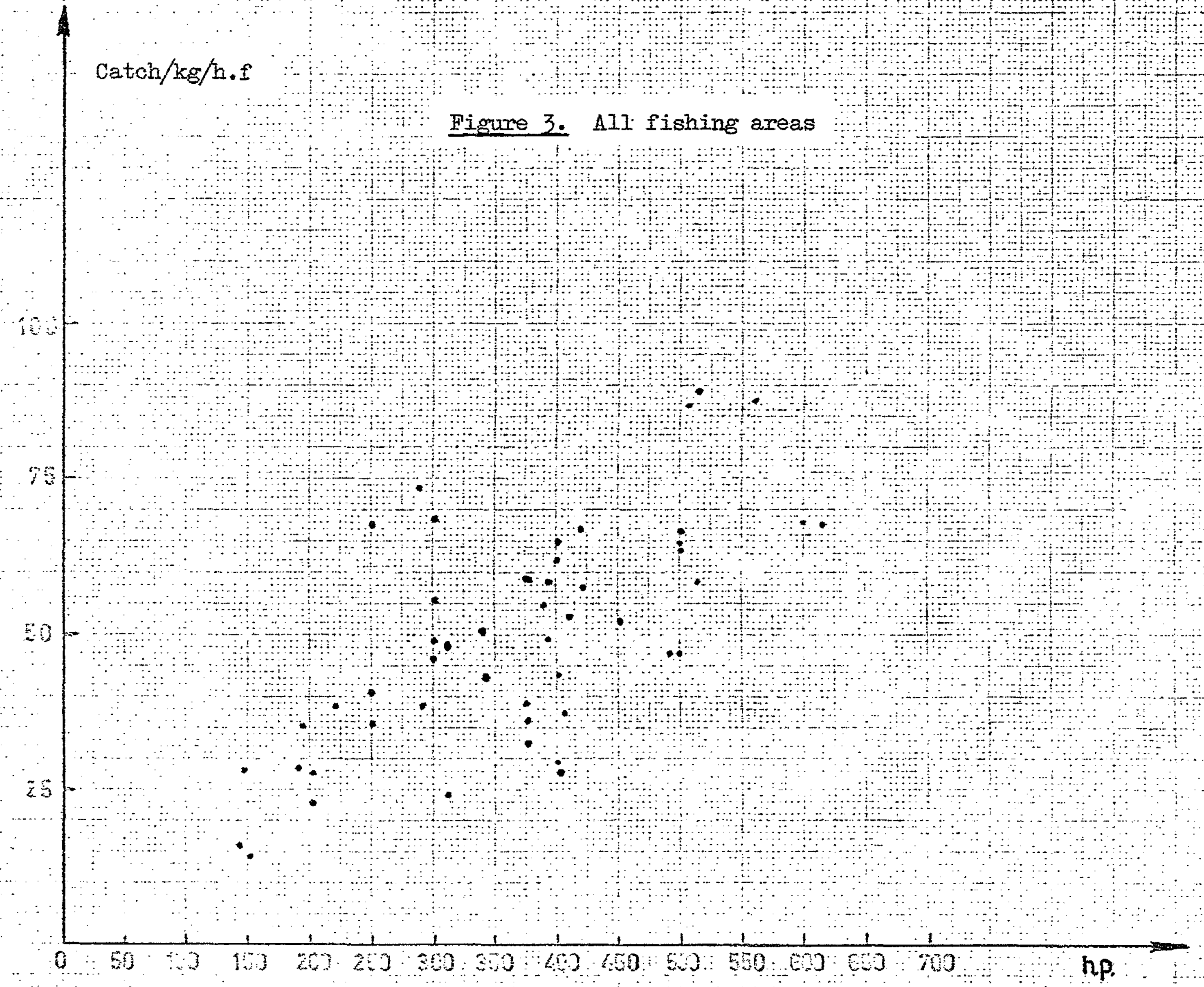


Figure 3. All fishing areas

Figure 3a. Fishing area: IVc

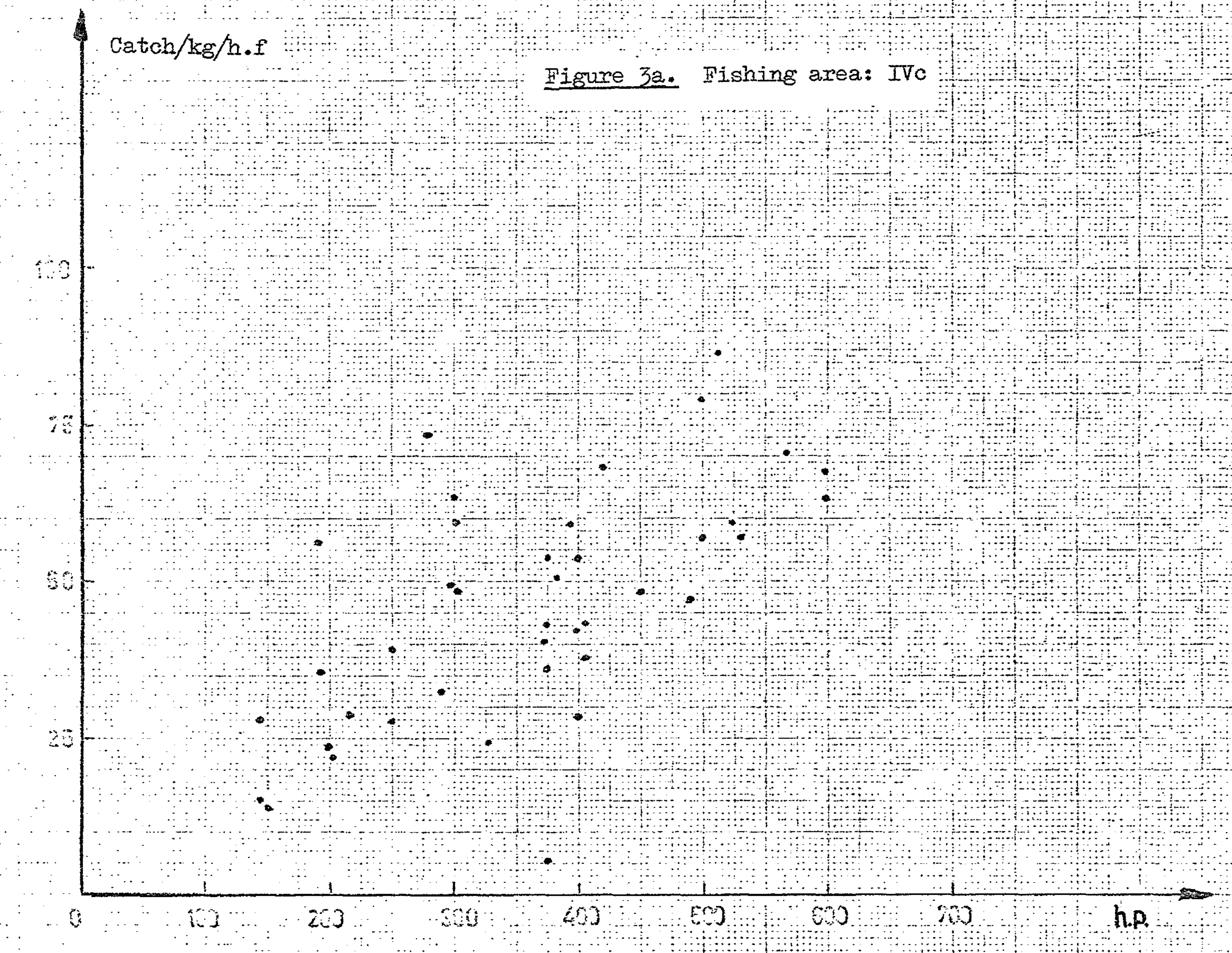


Figure 3b. Fishing area : IVb

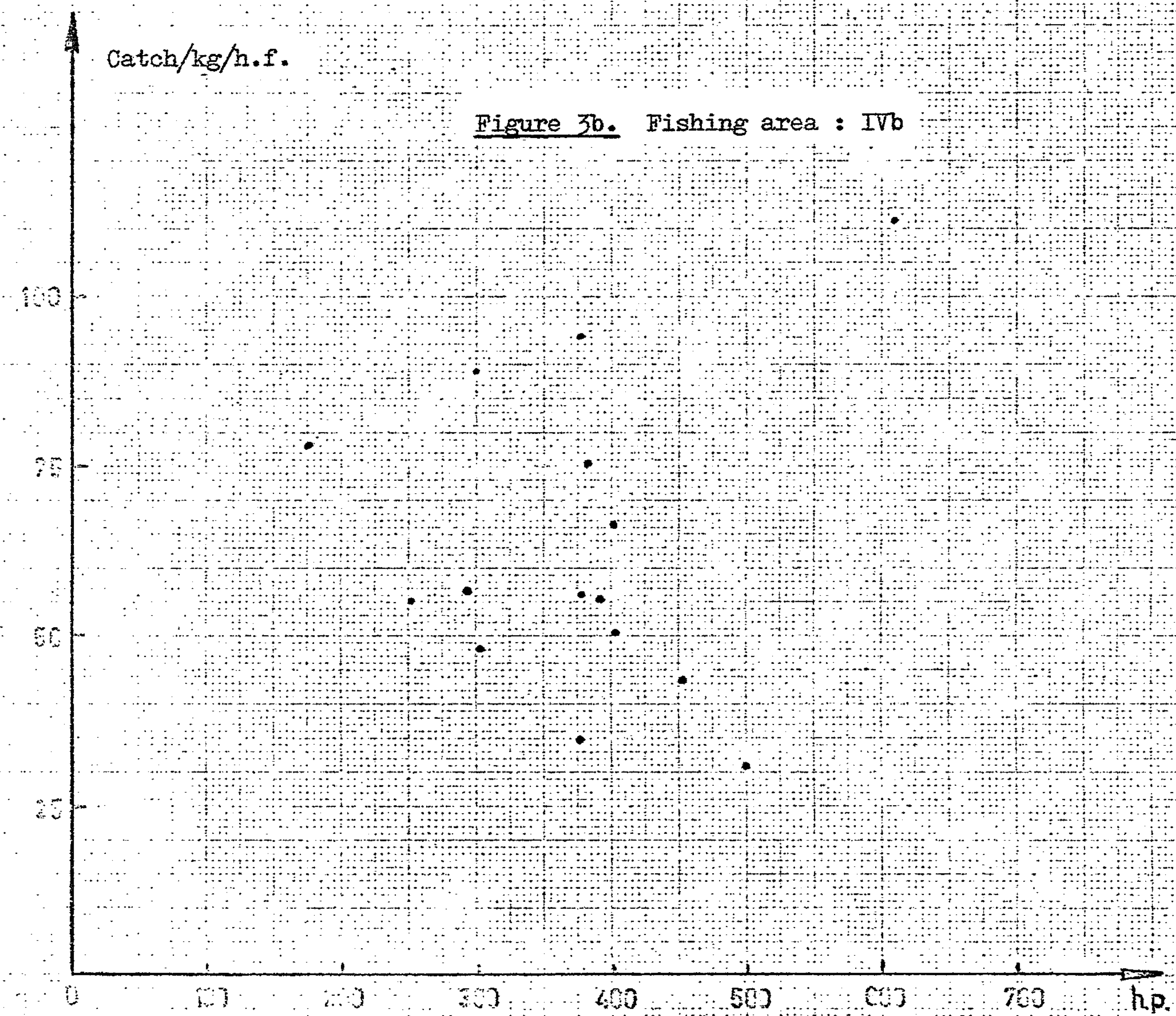


Figure 3c. Fishing area : VIId

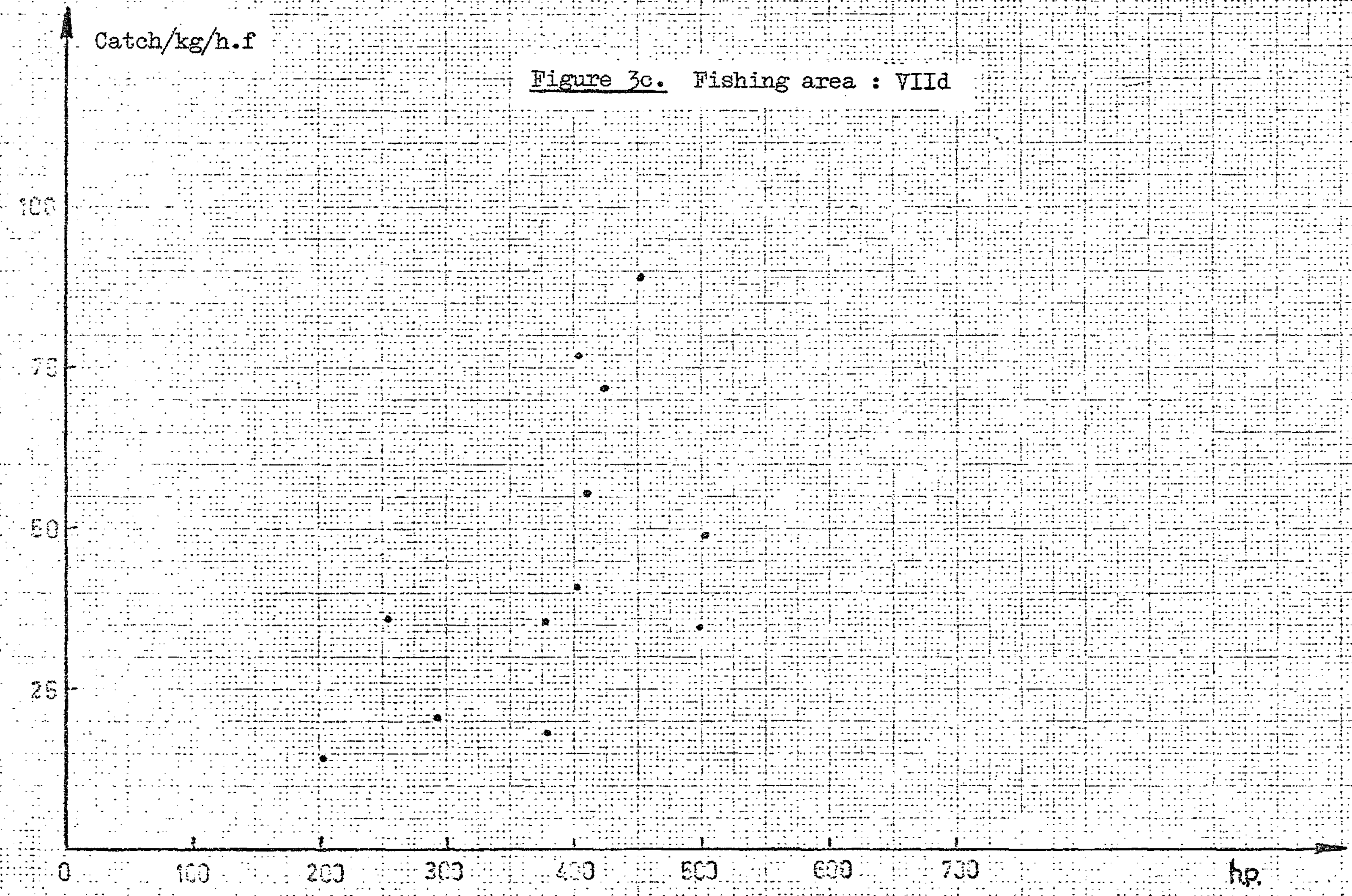
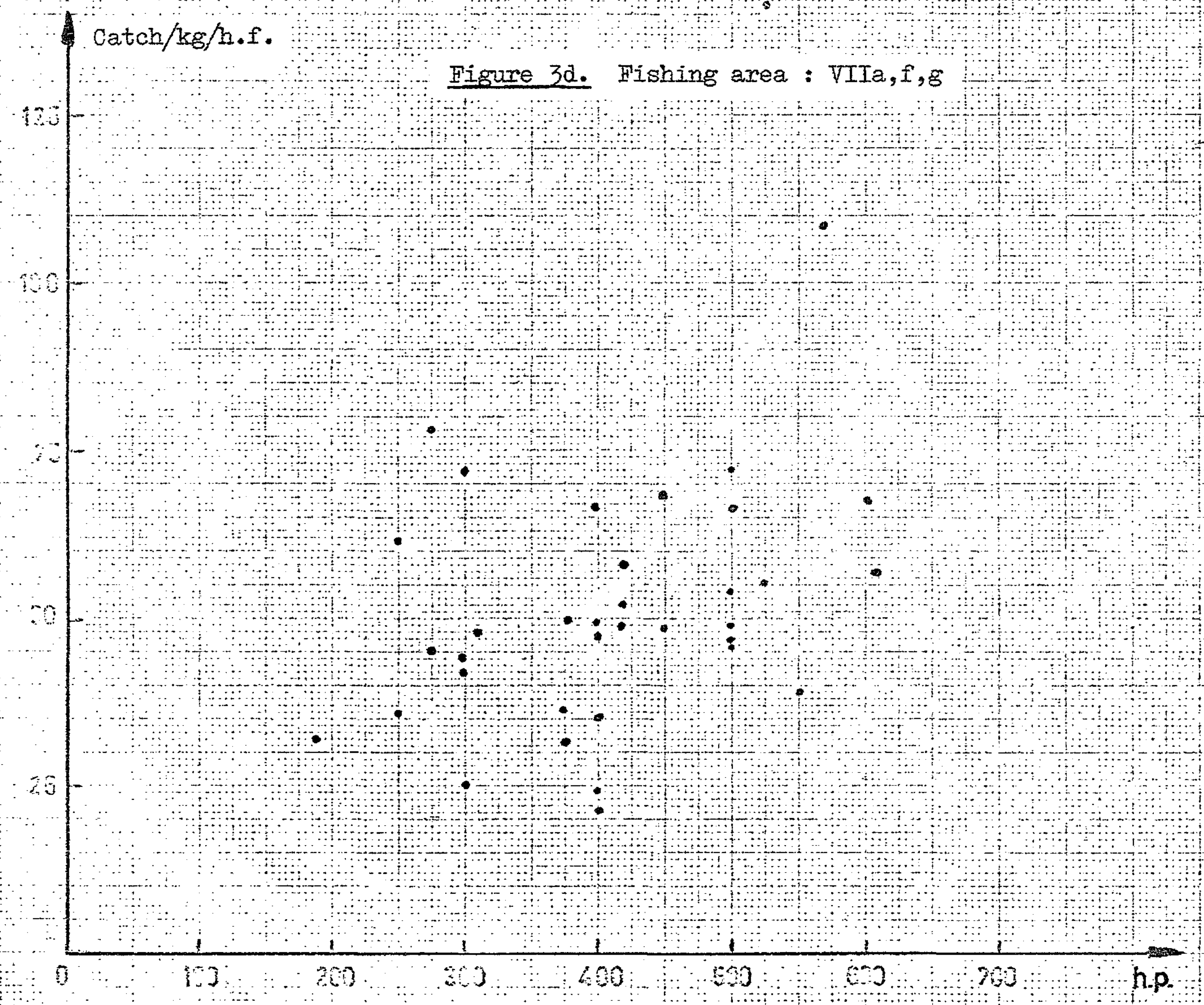


Figure 3d. Fishing area : VIIa,f,g



ANNEX 3

to C.M.1973/B:4

RELATIONS ENTRE LE POUVOIR DE PÊCHE DÉTERMINÉ EXPÉRIMENTALEMENT, LA PUISSANCE UTILISÉE EN PÊCHE ET LE VOLUME D'EAU FILTRÉ PAR UNITÉ DE TEMPS

Exemples calculés sur la pêche du merlu des chalutiers Rochelais

par

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INTRODUCTION

Dans un travail antérieur, nous avons montré les relations qui existent entre le pouvoir de pêche et la puissance des bateaux pratiquant la pêche du merlu à La Rochelle (Réf. : CM 1970, Special Meeting on Measurement of Fishing Effort n° 19).

Dans ce papier nous nous proposons sur des données nouvelles de comparer les relations qui existent entre :

a) le pouvoir de pêche déterminé expérimentalement par rapport à un navire choisi comme standard.

b) deux expressions qui ont été proposées pour remplacer le pouvoir de pêche dans le calcul de l'effort de pêche, à savoir :

- la puissance utilisée en pêche
- le volume d'eau filtré par unité de temps (TRESCHEV)

DONNEES UTILISEES

Evaluation du pouvoir de pêche (F).

Le pouvoir de pêche a été calculé comme précédemment en utilisant la méthode de Beverton et Holt (1954). Les rendements en merlu de 28 chalutiers rochelais au cours de l'année 1972 ont été comparés à ceux de l'un d'eaux choisi comme référence. Nous nous sommes limités à des comparaisons soit directes soit indirectes de la forme $bi/ai \times cj/bj$ c'est-à-dire ne mettant en jeu qu'un seul bateau intermédiaire.

On notera, toutefois les différences suivantes avec notre travail précédent :

a) les rendements sont exprimés en captures par unité de temps de pêche et non par unité de temps d'absence.

b) pour définir l'identité du lieu de pêche, nous subdivisons les divisions de secteurs CIEM précédemment utilisées en unités plus petites.

c) nous considérons que deux navires ont pêché au même moment, si plus de la moitié de leur temps de pêche se situe à l'intérieur de la même quinzaine, alors que deux pêches avaient été jugées simultanées, si elles avaient été vendues au cours du même mois.

Puissance effective (P).

Dans notre première étude nous avions utilisé la puissance totale au frein (BHP). Ici, nous considérons la puissance développée en moyenne par le moteur principal au cours des opérations de pêche. Il est à noter que la majorité des navires utilise presque toute leur puissance pour la traction.

Volume d'eau filtré par unité de temps (F').

Le volume est défini comme le produit de l'ouverture verticale du chalut, de la distance entre les pointes d'ailes et de la vitesse de traction.

La surface pêchante des chaluts a été déterminée par M. PORTIER (Laboratoire de Boulogne). Les écartements aux pointes d'ailes ont été calculés en prenant un angle de travail de 15° pour les ailes inférieures. Cette distance est fonction de la longueur des ailes et de la largeur du carré. L'ouverture verticale qui peut varier avec le gréement a été estimé en tenant compte du nombre de mailles à l'abouture des ailes inférieures est supérieures.

Pour les bateaux considérés il existe deux types de chalut :

- le chalut "cailloux" 25 x 35 possède une corde de dos de 25 m et un bourrelet de 35 m. Au niveau du ventre, le carré est de 6 m de large et les ailes mesurent 14,50 m. Ce type de chalut est utilisé par des bateaux de puissance assez élevée (900 ch environ) pêchant sur les côtes d'Espagne.

- Le chalut 32 m "LR" mesure 32 m de corde de dos et a un bourrelet de 43,5 m. Ce chalut est utilisé par des bateaux plus petits (650 ch environ) et qui travaillent principalement dans le golfe de Gascogne.

RESULTATS

Les régressions et corrélations ont été calculées pour l'ensemble des 30 bateaux ainsi que pour les deux groupes de navires :

(A) pêchant avec le chalut 25 x 35 (N = 12)
(B) pêchant avec le chalut 32 m (N = 16)

Les figures 1 et 2 montrent les diagrammes de dispersion du pouvoir de pêche en fonction de la puissance P et F'. Les équations des droites de régression sont :

Chalutiers (A + B) N = 28

$F = 0,015 + 0,006 F'$

$F = 0,367 + 0,001 P$

X = Swept volume F'

F = 0.015 + 0.006 F'	A + B	28
F = 2.101 − 0.005 F'	A	12
F = −0.319 + 0.008 F'	B	16

- Correlation coefficients :

relative fishing power F/ power P :

			trawlers	N
r_{FP} =	0.70	sss	A + B	28
r_{FP} =	0.90	sss	A	12
r_{FP} =	0.61	ss	B	16

relative fishing power F/ swept volume (Treschev factor) F'

$r_{FF'}$ =	0.50	ss	A + B	28
$r_{FF'}$ =	−0.14	ns	A	12
$r_{FF'}$ =	0.71	sss	B	16

(sss = highly significant ($P < 0.001$) ss = significant $0.01 < P < 0.001$

ns = not significant ($P > 0.05$) -

The correlations between fishing power (F) and the power (P) are always significant. But, the coefficient obtained with fishing power (F) and Treschev's factor (F') is only significant for the vessels (B) using the 32 m trawls.

SUMMARY

In a previous paper (CM 1970, Special meeting on measurement of fishing effort, n° 19), we defined the relationship between fishing power and vessel characteristics of trawlers fishing for hake.

The aim of the present paper is to calculate correlations between the experimental fishing power (F) obtained by the Beverton and Holt method and :

- the power (P) used during fishing operations on one hand.

- The fishing power (F') calculated with Treschev's formula on the other hand.

In this paper we have used statistics of catch and effort of the year 1972. However we have to note some differences vith the first work :

- the catches per effort are calculated using days fishing instead of days on ground.

- to establish the identity of fishing grounds we divided ICES subareas in smaller divisions.

- Power -

The coefficients of correlation are calculated with the power used for fishing instead of the total horsepower.

- Swept volume -

The swept volume of water is defined as the product of the opening area of the trawl (calculated by Mr Portier, Boulogne Laboratory) and the average towing speed given by the shippers.

The fleet of 28 trawlers fishing hake at La Rochelle was divided into two categories :

- A - 12 trawlers using the 25 x 35 trawl on the north coast of Spain

- B - 16 trawlers fishing with the 32 m trawl in the Bay of Biscay.

Results.

Regressions and correlations has been calculated for the totality of the fleet and for the two separate groups.

Regression equations :

X = power P	trawlers	N
$F = 0.367 + 0.001\ P$	A + B	28
$F = -1.100 + 0.002\ P$	A	12
$F = 0.404 + 0.001\ P$	B	16

Chalutiers (A) N = 12

$F = 2,101 - 0,005\ F'$

$F = 1,100 + 0,002\ P$

Chalutiers (B) N = 16

$F = -0,319 + 0,008\ F'$

$F = 0,404 + 0,001\ P$

Les coefficients de corrélation obtenus sont les suivants :

Chalutiers (A + B) N = 28

$r_{FP} = 0,70$ sss =

$r_{FF'} = 0,50$ ss

Le premier coefficient est hautement significatif alors que le second n'est que significatif.

Chalutiers (A) N = 12

$r_{FP} = 0,90$ sss

$r_{FF'} = -0,14$ ns

Le coefficient de corrélation avec la puissance est hautement significatif tandis que celui avec le paramètre F' ne l'est pas.

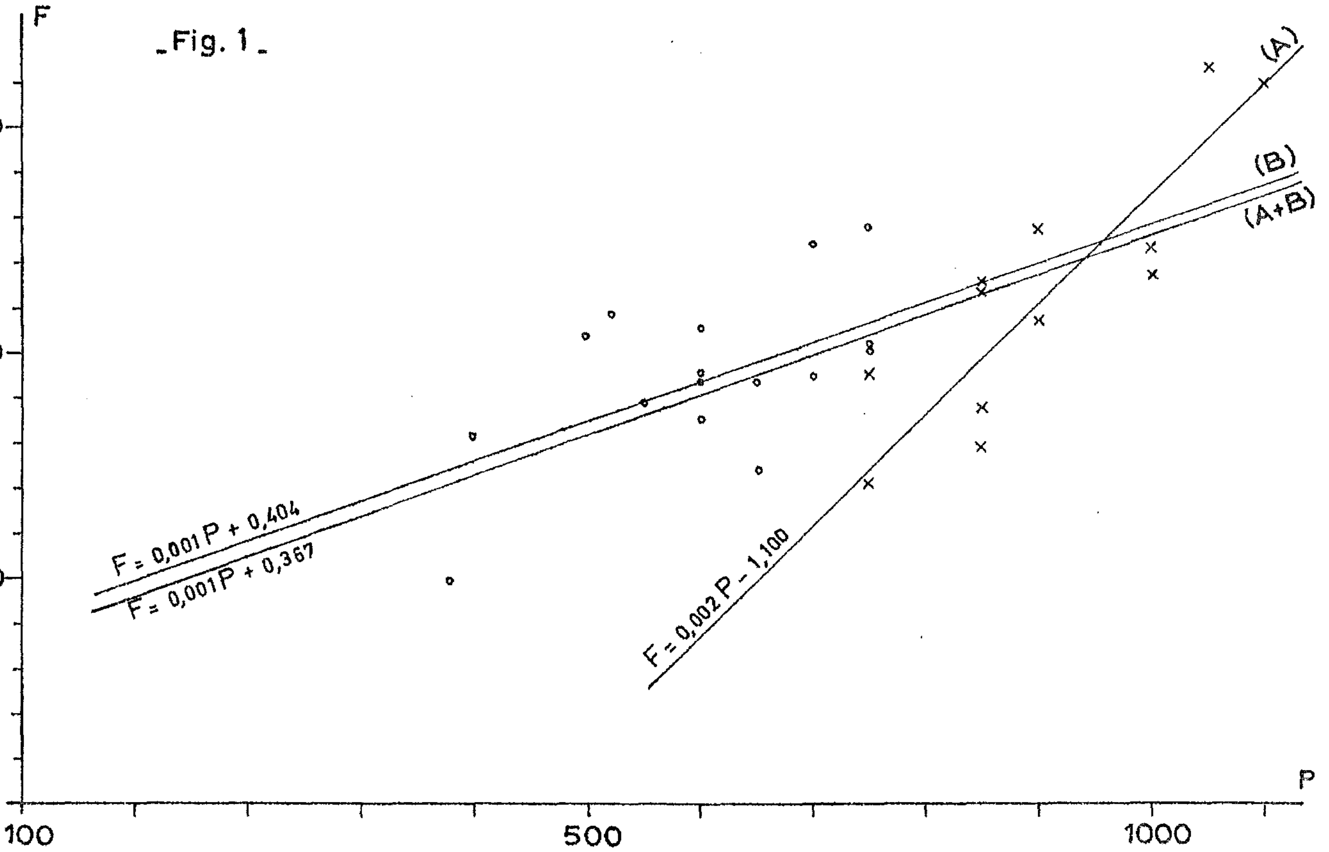
Chalutiers (B) N = 16

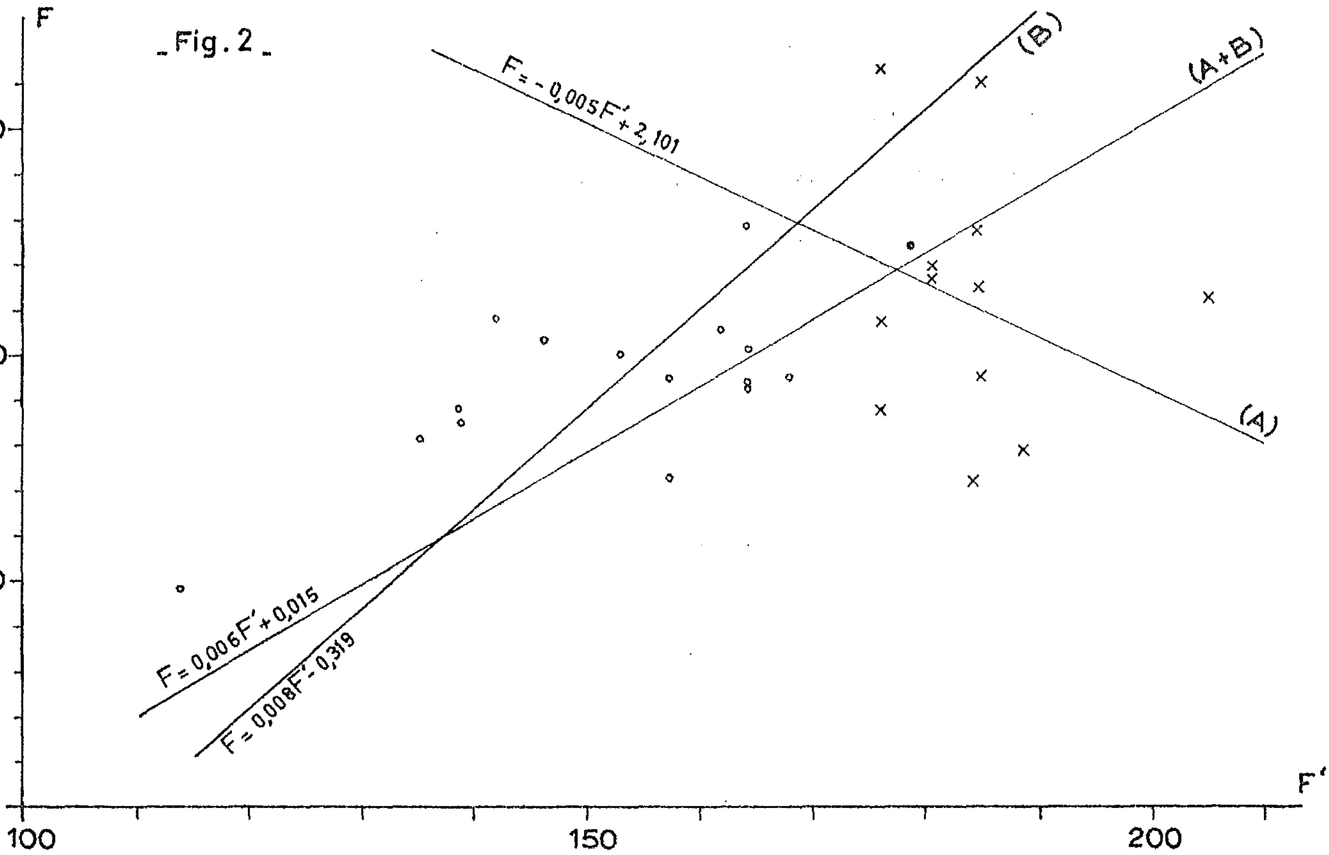
$r_{FP} = 0,61$ ss

$r_{FF'} = 0,71$ sss

Le coefficient de corrélation avec la puissance est significatif : le second est hautement significatif.

(sss indique hautement significatif ($p < 0,001$), ss significatif pour $p < 0,01$ et ns non significatif $p > 0,05$





° Bateaux utilisant le chalut 32 m (A)

× Bateaux " " 25 x 35 (B)

I.C.E.S. Gear and Behaviour Committee.

Meeting on Fishing Effort Measurement, 7-8 May 1973, IJmuiden, Holland

COMPARISON OF HORSEPOWER, PROPELLOR THRUST AND WATER VOLUME FILTERED AS FISHING POWER PARAMETER OF A BEAM TRAWL.

by

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Introduction

In a study on the relative fishing power of Dutch motor trawlers Zijlstra and de Veen (1963) compared a number of ships characteristics such as horsepower, gross tonnage, age of ship and engine and others, using the method described by Gulland (1956). In the gear in use at that time - the otter trawl - brake horsepower appeared to give the highest value for the partial correlation coefficient and for that reason the regression equations of b.h.p. with the relative catch were used for standardizing fishing effort in the Dutch fisheries statistics.

For the beam trawl, introduced in the Dutch demersal fisheries in 1962, it took some years before a study of the fishing power could be undertaken. In this gear too it soon appeared that horsepower was an important factor.

In a paper by de Boer and de Veen (1970) the advantage of using propellor thrust over brake horsepower in defining the fishing power of the beamtrawl was discussed. Although data of a very limited number of ships only could be used at that time it was found that propellor thrust might be a better parameter than horsepower.

At the last ICES meeting (1972) member countries were asked to evaluate the merits of the method proposed by A.I. Treschev (1971). To this end a comparison was made between the Treschev fishing power and horsepower and propellor thrust as fishing power parameter in the Dutch beam trawl fishery.

Methods

The methods used in calculating the fishing power were similar to those described by Gulland (1956).

After assessing the fishing power for a number of standard ships, which all fished together on a number of occasions, the fishing power of other ships were obtained by reference to these standard ships.

The statistical material used in the calculations referred to the Dutch beam trawl fishery in 1971 in selected months and statistical rectangles. For reasons to be explained later the fleet was divided into two categories: 57 ships from Den Helder, Texel and Harlingen and 111 ships from Urk. The months selected were January, April, July, August and October 1971, making it possible to follow possible seasonal trends in the relationships to be studied. Figure 1 gives details on the statistical rectangles used in the different months in which open circles stand dor data from Urk and crosses for data from Den Helder, Texel and Harlingen. In all months, data from the same ships were used.

The reason why we took statistical rectangles and months as units for the calculations is that the Dutch Central Bureau for Statistics does not give more detailed information. As a matter of fact abundance of fish may vary in an area such as a statistical rectangle and also within one month. This will certainly introduce extra variance and for that reason we may not expect high values for the coefficients of correlation.

Propellor thrust was calculated with the aid of propellor diagrams as described in De Boer (1970) and De Boer (1973, this meeting).
The Treschev fishing power was determined by taking the opening of the beamtrawl times two (beamtrawlers fish with two gears at the same time) times 4 knots (the fishing speed of the beamtrawlers when fishing) and expressed in terms of the Treschev standard volume filtered of 10^6 m^3.

We did not account for the different species caught but used the weight of the total catch. The data for the individual trips of the ships were transformed in $\log_e$ catch per 100 hours fishing and for each month and for the two categories of ships correlation coefficients were calculated. In total 1113 trips of the Urk ships and 603 trips of the Den Helder, Texel and Harlingen ships could be used.

Although propellor thrust seems to be a better parameter for the fishing power there is a fairly high correlation between brake horsepower and thrust viz. r = 0.87 (fig. 2a).

The relationship between the Treschev fishing power and thrust of the propellor is different for the two categories of ships (fig. 2b and 2c). It is obvious that for the same value of thrust fishermen from Urk use beamtrawls with a wider opening than their colleagues from the other ports. The correlation between the Treschev fishing power and the propellor thrust is r = 0.57 for Urk and r = 0.48 for the other ships.

In order not to confound the calculations of the Treschev method, owing to these different relationships, the relative fishing power for the data from Urk and for those of the other ports was determined separately.

Results

Correlation-coefficients:

In the following tables the correlation coefficients are given for the relationship relative catch and brake horsepower, propellor thrust and Treschev fishing power for five months and for two categories of ships.

Table 1 - Correlation-coefficients for ships from Urk.

Month	rel. catch-b.h.p.	rel. catch-thrust	rel. catch-Treschev f.p.
Jan. '71	0.214 (67) n.s.	0.187 (58) n.s.	0.031 (67) n.s.
April	0.301 (222) sss	0.313 (185) sss	-0.155 (221) n.s.
July	0.319 (288) sss	0.336 (240) sss	0.242 (288) sss
August	0.366 (297) sss	0.378 (243) sss	0.282 (297) sss
October	0.136 (239) n.s.	0.165 (203) s	0.124 (240) n.s.
Average	0.267 (1113)	0.274 (929)	0.105 (1113)

Table 2 - Correlation-coefficients for ships from Den Helder, Texel and Harlingen.

Month	rel. catch-b.h.p.	rel. catch-thrust	rel. catch-Treschev f.p.
Jan. '71	0.470 (43) sss	0.326 (41) s	0.349 (43) s
April	0.221 (118) sss	0.148 (96) n.s.	0.245 (118) sss
July	0.443 (173) sss	0.418 (131) sss	0.202 (174) s
August	0.441 (129) sss	0.341 (104) sss	0.156 (129) n.s.
October	0.196 (140) s	0.185 (130) s	0.356 (147) sss
Average	0.354 (603)	0.284 (502)	0.262 (611)

The number of trips on which the calculation of the correlation-coefficient is based is given between brackets; sss means highly significant ($p < .001$), s stands for probably significant ($p < 0.05 > 0.01$) and n.s. means not significant ($p > 0.05$).

In general the correlation-coefficients for brake horsepower and thrust were higher than those for the Treschev fishing power. Only in April and October '71 the Treschev f.p. yielded the highest value for r in the case of the Den Helder, Texel and Harlingen ships. Propellor thrust gave the highest correlation coefficients in the ships from Urk, but in the other shipscategory brake horsepower gave the best values. The differences in values of r for thrust and brake horsepower are small, much less than was expected. It is not clear at the moment why the substantial improvement found in the estimation of the fishing power by taking propellor thrust instead of brake horsepower in the beamtrawl in 1969 (De Boer and De Veen, 1970) based on a limited number of ships from Urk, was not reflected in our present results based on a large number of ships. It is possible that in the case of the ships from Den Helder, Texel and Harlingen in 1971 propellors of correct dimensions and the correct number of revolutions in relation to the brake horsepower have been used, whereas this was not completely realized in the Urk ships, where still a number of ships did not have the appropriate propellor or number of revolutions.

The values of the correlation coefficients demonstrate a seasonal trend. They tend to be higher and significant in summer and lower and not significant in winter. This may be a reflection of differences in the proportion of fishspecies caught. In summer most ships concentrate on sole with other species such as plaice and cod as by-catches. In winter, however, smaller ships might shift their attention to plaice, being much more abundant than sole. This may confound the picture of the relative fishing power to such an extent that apparantly the existing relationship is lost. For this reason it would have been better to do the exercise with separate species instead of the total catch. In the time allotted for our calculations this was, however, impossible.

Shape of the curves describing the relationship between relative catch and ships parameters.

In literature the fishing power of vessels is usually given as a linear function of the relative catch and the ships parameter.

For this purpose regression equations are determined. In our case the number of catch data is so large that it is worth while trying to determine the function describing the relationship more precisely. In order to achieve this the data per month were averaged per class of ships parameters. Thereafter these mean values were combined to give one set of data per ships parameter. The average relative catch was more or less the same in April, July, August and October, but twice as high in January. For this reason the data for January were left out of the combination.

In figure 3 the combined mean values for brake horsepower are given; figure 4 gives the data for the propellor thrust and figure 5 those for the Treschev fishing power. Each dot stands on average for a mean value of 17 individual trips.

For each of the diagrams a choice was made between the following functions:

$y = a_o + a_1 x,$ $\quad y = a_o + a_1 x + a_2 x^2,$ $\quad y = a_o x^{a_1}$

In the case of the brake horsepower the best fit with the data was given by the function $y = 348.8\ x^{0.457}$ with $r = 0.547$.
For the propellor thrust the best fit was achieved with the function $y = 268.7\ x^{0.364}$ with $r = 0.435$ and for the Treschev fishing power the regression line $y = 2146 + 54055\ x$ with $r = 0.327$ gave the best fit.

References:

De Boer, E.J. (1970) - "Comment on the use of brake horsepower as a parameter for the fishing power". ICES Spec. Meet. "Meas.o.Fish.Effort" 15, 8 pp.

De Boer, E.J. (1973) - "Diagrams for the determination of the propellor thrust under fishing conditions". This meeting.

De Boer, E,J. and de Veen, J.F. (1970). - "On the fishing power of Dutch beam-trawlers". ICES Spec.Meet. "Meas.o.Fish.Effort" 11, 4 pp.

Gulland, J.A. (1956) - "On the fishing effort in English demersal fisheries". Fish.Invest.Lond., Ser. 2, 20: (5), 41pp.

Treschev, A.I. (1971) - "Fishing unit measures". ICES Council Meeting 1971/B : 9, mimeo, 13 pp.

Zijlstra, J.J. and de Veen, J.F. (1963) - "On the relative fishing power of Dutch trawlers". Journ.d.Cons.Int.Expl.Mer, 28, 2, 241-5.

Acknowledgements:

We wish to thank Mr. H.B. Becker, mathematician at the Fisheries Laboratory in IJmuiden for his help in the calculations, our colleagues Mr. A. Verbaan and Mr. A.Mulder of the Division for Technical Research for their help in assessing the ships characteristics and our colleagues of the Directorate of Fisheries in the different fishing ports for collecting the data on beamtrawls.

/MV

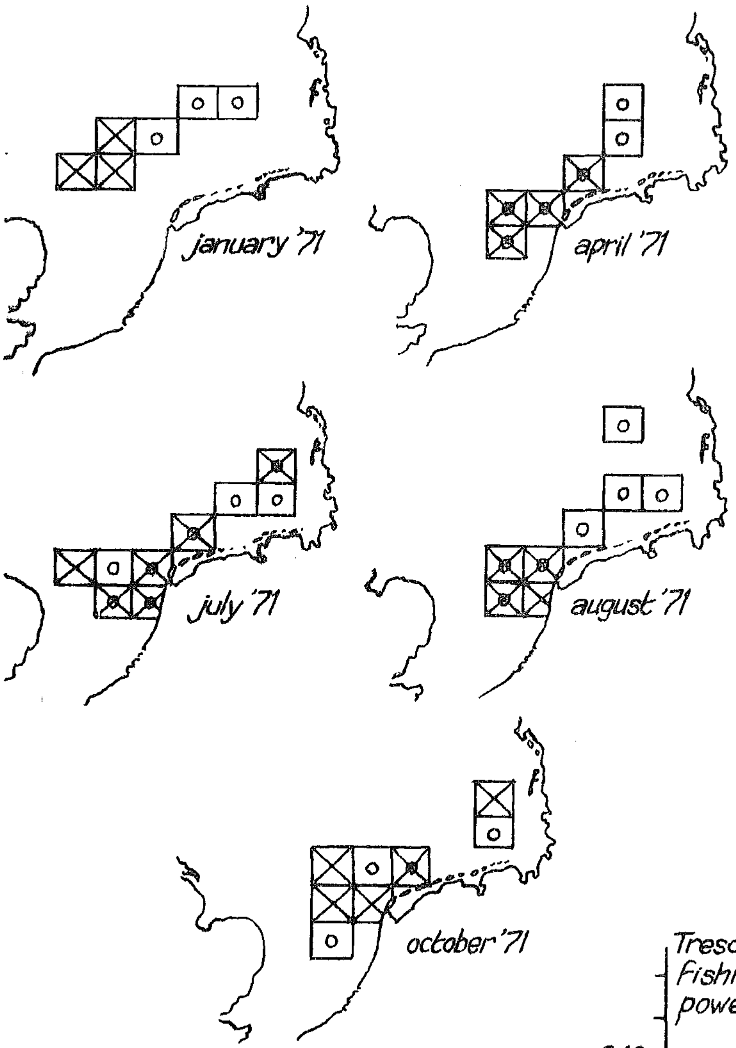


Fig. 1

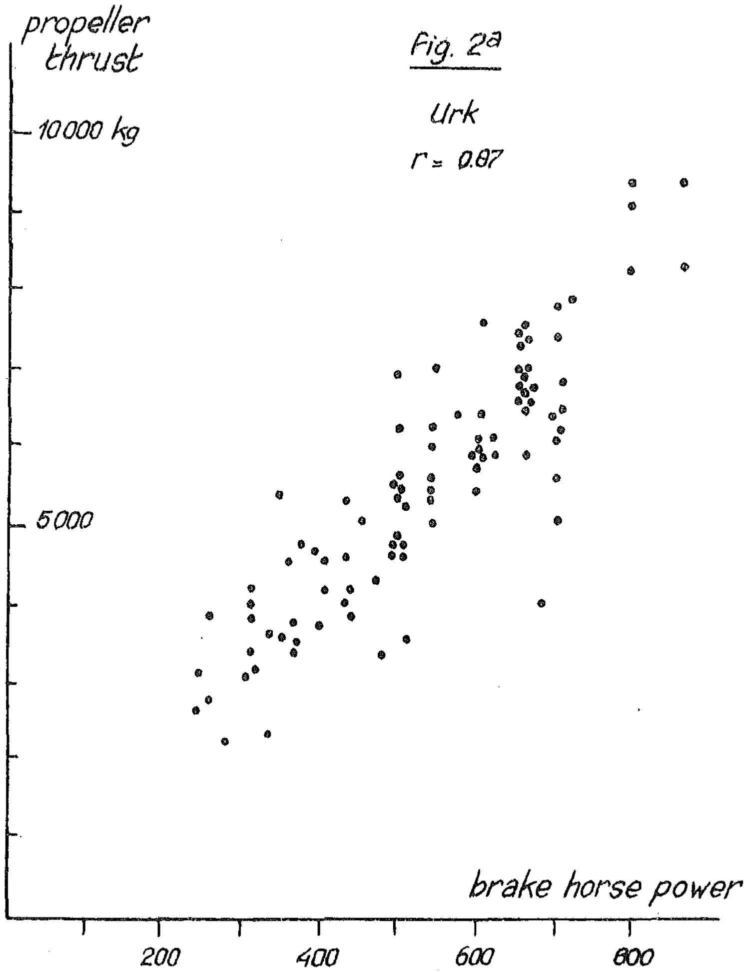


Fig. 2^a

Urk

$r = 0.87$

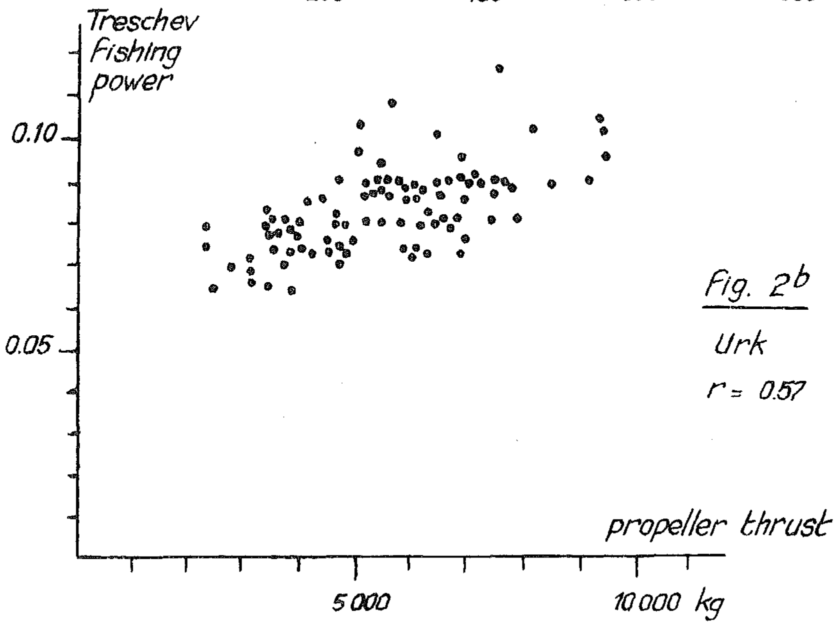


Fig. 2^b

Urk

$r = 0.57$

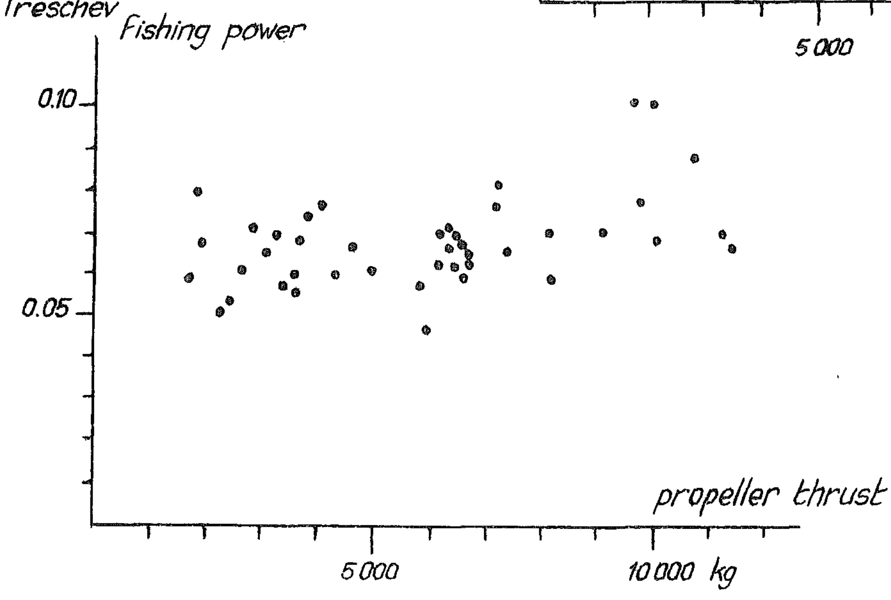


Fig. 2^c

Helder, Texel, Harlingen

$r = 0.48$

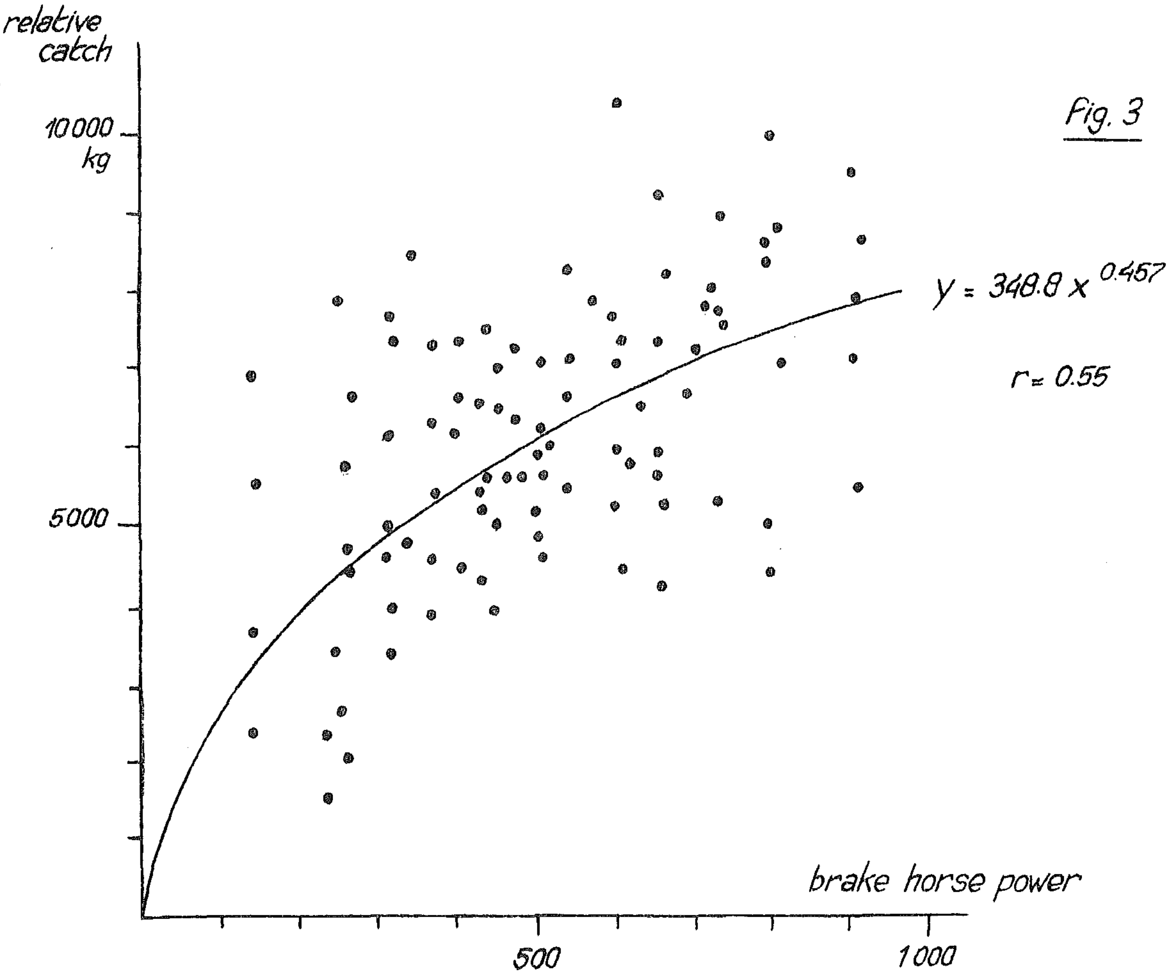

relative catch
10000 kg
5000
brake horse power
500
1000
y = 348.8 x 0.457
r = 0.55

Fig. 3

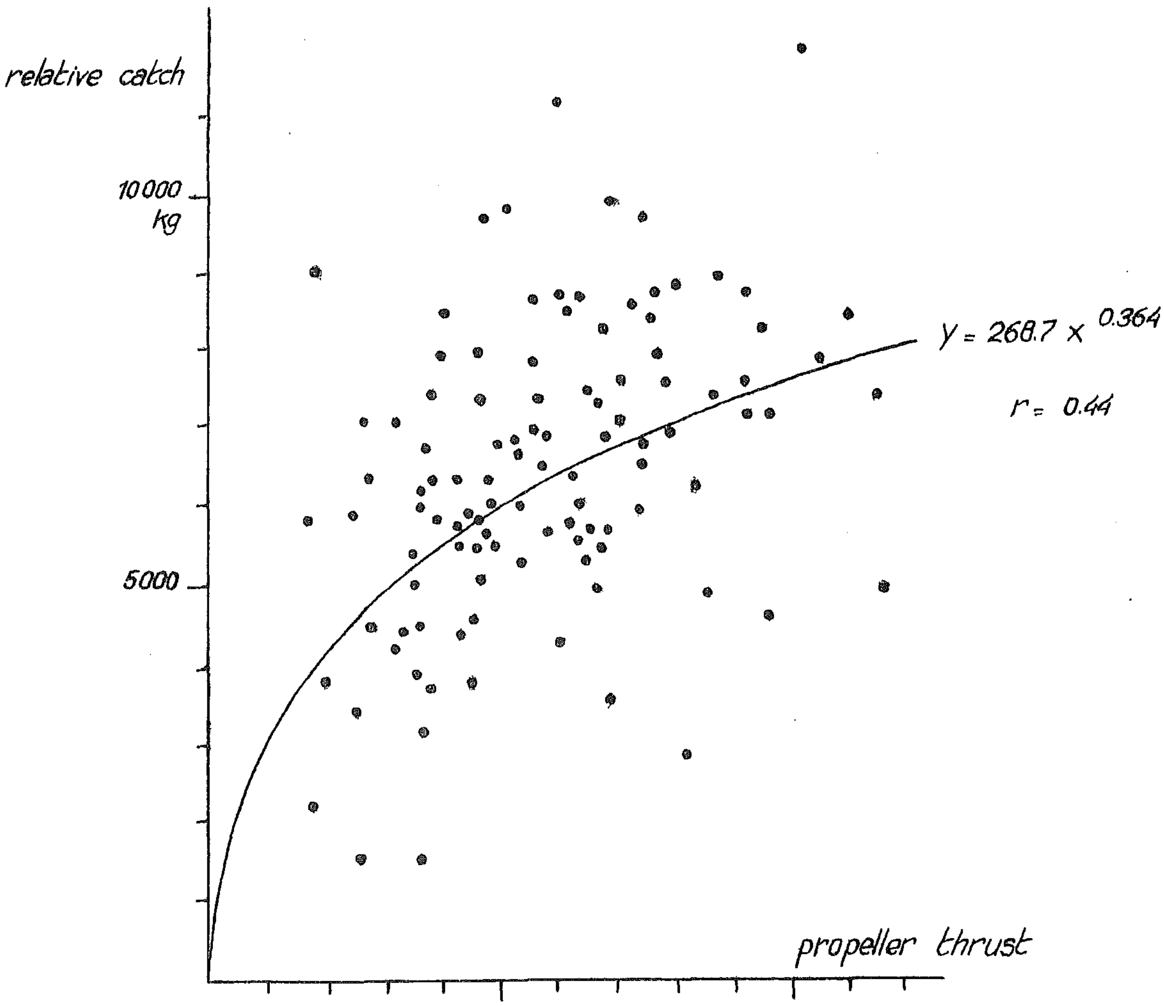
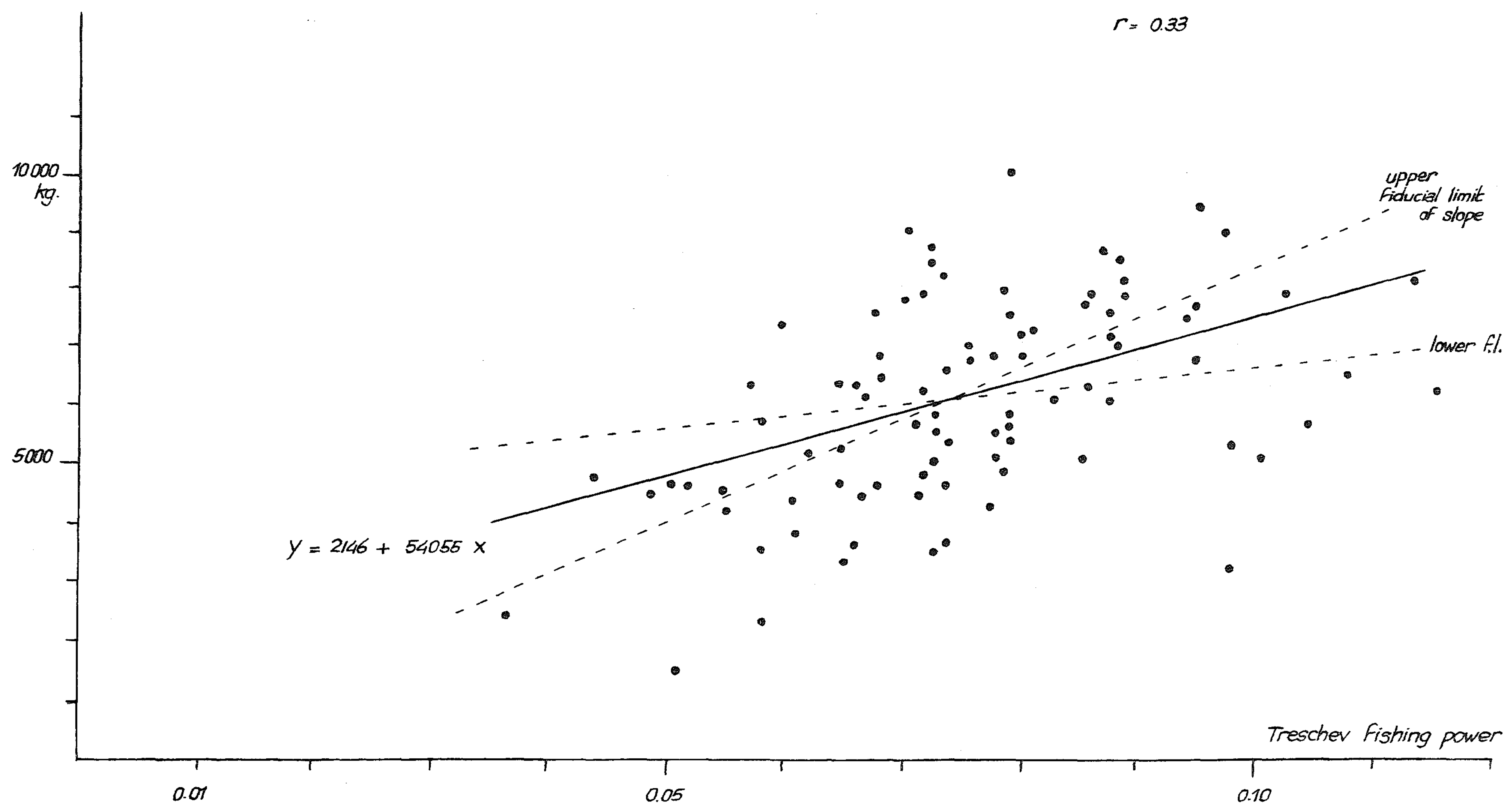

relative catch
10000 kg
5000
propeller thrust
5000
10000 kg
y = 268.7 x 0.364
r = 0.44

Fig. 4

Fig. 5



relative catch
r = 0.33
10.000 kg.
5000
y = 2146 + 54055 x
upper fiducial limit of slope
lower f.l.
Treschev fishing power
0.01
0.05
0.10

Annex V

ENGINEERING ASPECTS OF SWEPT VOLUME METHOD (SVM)

DEFINITION PARAMETERS OF FISHERY

by

A.I. Treschev

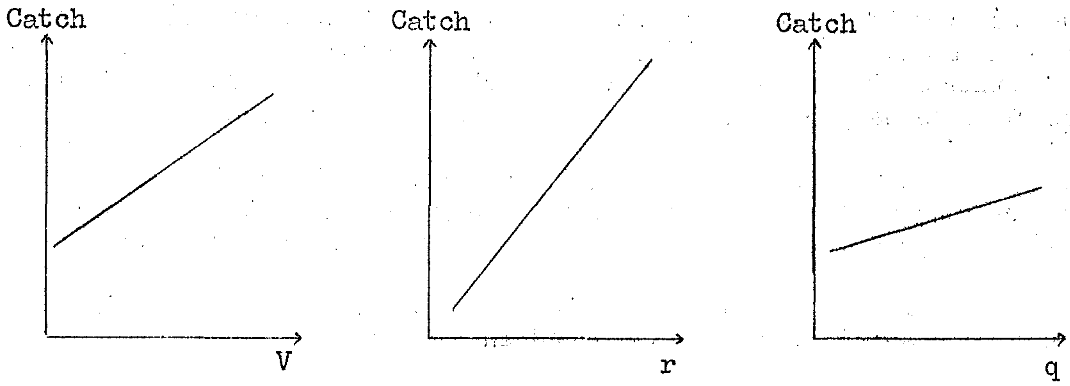
Fishing effectivity (E) depends on three factors:

(1) Swept volume (V). (This is the proportion of total area covered which is fished)

(2) Degree of fish finding (r)

(3) Catchability of fishing gear (q)

These dependences may be described graphically as follows.



Algebraically we have $E = f_1 (V, r, q)$
S.V.M. shows how these factors should be considered.

(1) Swept Volume V depends on the area of the mouth of the gear opening (S), speed (v) and fishing time (t).
In other words

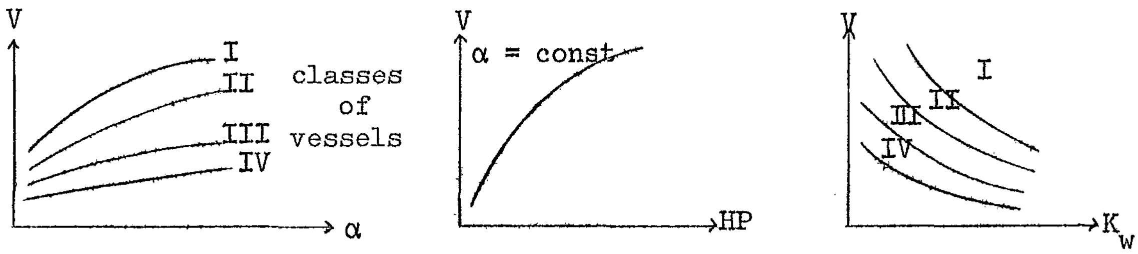
$$V = f_2(S, v, t)$$

On the other hand V also depends on a number of ship's factors

$$V = f_3(HP, \frac{B}{L} \lambda, K_w)$$

where HP = horse power of engine; $\frac{B}{L} \lambda = \alpha$ = hydrodynamic data (B = breadth of vessel, L = length of vessel (overall) and λ is a coefficient which depends on the form of the vessel, its propellor and gear); and Kw is a coefficient which characterises the influence of weather. (It can be the Beaufort scale of the sea state.)

From investigations of these factors, we can obtain the following



Once these relationships are established we will be able to know the influence of all these parameters on fishing efficiency.

(2) Degree of fish finding Here we have

$$r = N_v/N_a$$

where N_v = the number of fish discovered in the fishing area (fish in swept volume) and N_a = total number of fish in the area during fishing time

(3) Catchability of fishing gear This quantity is given by

$$q = N_c/N_v$$

That is, q is the ratio of number of fish in catch (N_c) to number of fish in swept volume (N_v).

As we can see in this analysis there is no Gross Tonnage because it has no direct influence on the fishing efficiency. Sometimes a connection between Gross Tonnage and catches is observed but this only means that in these cases Gross Tonnage is proportional to HP and speed of vessels.

This brief analysis shows how many components should be included in the determination of fishing efficiency and why we cannot take the time on the fishing grounds, HP, Gross Tonnage, standard gear and so on.

Swept volume is much more representative because it includes all real factors of influence and it can be determined in a very simple way.

Annex VI

FISHERY PARAMETERS ASSESSMENT METHOD
(ADDITIONAL COMMENTS AND CLARIFICATIONS)

by

A.I. Treschev

The International Council for the Exploration of the Sea at its 60th Session (C.Res. 1972/2:8/c/) decided to hold in IJmuiden (Holland), May 3 through 8, 1973, a Meeting on Engineering Aspects of Fishing Gear, Vessels and Equipment and on Statistical Problems of Measuring Fishing Effort. Among the Meeting's objectives, it is pointed out that

"in pursuance of the issues raised by S.A. Studenetsky (Doc.C.M. 1972/D:5, referring to A.I. Treschev, Doc. C.M. 1971/B:9, Dr A.I. Treschev be asked to submit to the Meeting of the Working Group a paper illustrating by means of worked examples referring to USSR fisheries the application of his proposed new method of measuring fishing effort, and that other countries evaluate the merits of the method applied to their own fisheries and report their findings to the Working Group".

ESSENCE OF METHOD PROPOSED

The method relies on the following basic assumptions:

Fishing gear capacity (power) W (in conjunction with a certain class of vessel, crew and equipment) is described by the water volume (V_s) fished per unit time (T_1), i.e.

$$W = V_s/T_1$$

where V_s is established for different gear classes by the methods indicated in Doc. C.M. 1971/B:9, and measured in volumetric units and T_1 is the time when a gear is in active (fishing) state and is measured in 24-hour periods and registered either in ship-log or by special-purpose instrumentation.

Fishing effort (U) is the product of the fishing gear capacity (W) multiplied by its active fishing time, for any period, i.e.

$$U = WT_2$$

Here the time T_2 is measured in the same units as are accepted for fishing capacity, i.e. 24-hour periods.

Fishery Efficiency (E_f) is the catch (C) per unit fishing effort, i.e.

$$E_f = C/U$$

where C is the catch in metric tons, and U is the fishing effort in volumetric units.

Since the fishing effort in terms of the accepted measuring system represents

$$U = \frac{V_s}{T_1} T_2$$

that is, the volume of water fished, then the fishery efficiency indicates the catch per unit of the volume fished.

This indicator is essential because, the fishing effort being constant, it describes the productivity of fishing areas in the same way as the harvest per unit of agricultural land provides an index of land fertility in agriculture. Its changes give a measure of evaluating the validity of the quotas set out for catches and efforts.

Under mixed fishery, i.e. with the same object being fished by different gears, the application of the proposed method presents no problem because the fishing effort of different gear classes is measured in the same units and, therefore, may be analysed and limited for all the gears and for each one in particular.

REPRESENTATIVENESS OF METHOD

For the purpose of checking on the method's representativeness, the correlation between the catch and the following parameters has been investigated: volume of the water fished, the length and displacement of vessel and capacity of the main engine.

The degree of interrelation was assessed using correlation ratios. The data used were those of the Soviet fisheries in subareas 2,3,4,5, and 6 north-west Atlantic. Because there was a marked difference in the fishing situation between subareas 2 and 3, on the one hand, and subareas 4,5 and 6, on another, all calculations were made in relative figures*. The actual calculations are given in the appendix and the results were as follows.

Relations	Correlation ratio
Catch per hour - vessel length	0.83
Catch per hour - total displacement	0.82
Catch per hour - master engine capacity	0.88
Catch per hour - fishing capacity	0.98

It follows from these results that the technical parameters of fishing vessels (displacement, length, horse power) are not closely functionally related to fishing success. This is confirmed by the fact that the catches per hour of the same vessels operating at the same time and in the same place may have a coefficient of variation as high as 300%. As measures of fishing effort these technical parameters are not sufficiently accurate. The fact that the correlation ratio for catch per hour and fishing capacity is close to unity (0.98) points to the functional dependence between these quantities being the closest.

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*For every area, the mean catch per hour with a bottom trawl of a BMRT-type vessel was taken as unity (OTST-7).

This is one of the reasons why the author has selected this criterion as the initial value for measuring fishing effort. Besides this, volume fished has the following advantages over all other methods:

1. It permits the most accurate assessment of the effects of fishing on the stocks to be obtained.

2. At a certain productivity of the fishing area (with an established optimal permissible catch per unit of water volume) it permits permanent observation of the relationship between the stocks and the fishery which may serve as an important criterion to assess the validity of the quotas set for catches.

3. Where there has been a preliminary evaluation of the fishing capacity of fishing gear it will be easy to determine fishing effort from only two quantities, namely the number of gears and their time on active duty.

4. It is universal for all fishing gear classes.

5. It lends itself to accurate control and distribution between countries, areas and fishing gears.

6. In a mixed fishery it permits a differential assessment of fishing efficiency to be made with respect to every particular object.

7. Because fishing capacity and fishing effort defined in this way do not depend on the catch but represent, in effect, no more than technical and operational parameters, the uncertainties in the latter, due to variations in fish distribution and behaviour, weather, etc., are avoided.

8. It is no longer necessary to apply any conventional values and calibrated gears which always involves great errors because of large variations in the conditions of fishery, efficiency of fishing gears and equipment, and skill of the crew.

METHOD AS APPLIED TO STOCKS AND FISHERY ANALYSIS

The use of the method for stock and fishery analysis cannot be explained unless we first define the concept of "the intensity of fishery". The latter comprises two values, intensity of yield and intensity of fishing.

Yield intensity (ν) is the ratio of the catch of a certain species (N_c) to its stock size (N), i.e.

$$\nu = \frac{N_c}{N}$$

Fishing intensity (I) in this system of measuring fishery parameters, is the ratio of the water volume fished (V_f) to the volume of the fishing area (V), i.e.

$$I = \frac{V_f}{V}$$

Under rational fishing, the fishing intensity is to be not only known but also properly controlled. To do this one requires the concept of relative fishing intensity.

Relative fishing intensity (j) is the ratio of the actual fishing intensity rate (I), as defined from fishery data, to its optimal value (I_{opt}) derived from the condition of rational relationship between stocks and fishery, i.e. from the biologically determined value of the possible harvest per cubic kilometre of water volume in the given area, i.e.

$$j = I/I_{opt}$$

From this expression one can infer that with j less than unity the fishing intensity is insufficient and should be increased, while j more than unity indicates that the fishing intensity has reached its limit and should be reduced accordingly.

METHOD AS APPLIED TO REGULATION PRACTICES

Let us assume that the fishing effort of country A in area a for the time t is equal to U_1; the fishing effort of country B in area a for the time t is equal to U_2; the fishing effort of the country C in area a for the time t is equal to U_3. The total effort of these three countries $U = U_1 + U_2 + U_3$ and let the countries' catch in the same area for the same time be ΣC. Then the catch per effort has the form:

$$\Sigma C / \Sigma U .$$

Let us assume further that it has been found analytically that the given time period (one year, for example) is such that the total fishing effort in area a has been optimal, i.e. in full accordance with the stock. Also, let it be supposed that x tons of fish have been taken per unit water volume fished (e.g. per one cubic kilometre). Let us assume finally that the general yield quota for a particular fish species, C_q tons, was determined for the same area for the next year by means of a stock assessment.

As a result, the total quota of the effort in the given year may be defined as

$$C_q/x = U \text{ cubic kilometre}$$

Approximately, the total effort quota can be allocated between the countries in the same proportions in which catch quotas are usually distributed. Yet it can be distributed with greater accuracy, i.e. in proportion to the actual fishing effort of every country using the Swept Volume Method. Then the countries with less advanced fishing technology will receive a relatively higher quota of fishing effort per unit of the catch quota than countries with advanced technology. This requires that each country should make preliminary estimates of the fishing capacity of her fishing gear, as described by Treschev (1971), and thereafter enter these into the fishing gear certificates to be kept on board the ships. Whether or not the estimates are accurate can be verified at any time by International Inspection for fishing gear parameters and operation mode.

CONTROL AND STATISTICS

Control of fishing effort using the Swept Volume Method is to be undertaken, in the main, on a national basis. Each country, as it directs its vessels to sea, should supply them with an assignment specifying the value of fishing effort within the bounds of the limit it has established.

The captains are duty-bound to register in the ship logs the actual operation time of a fishing gear and note at the end of each day the total fishing effort consumption.

An international inspector as he pays a routine call to the ship, compares the fishing effort limit issued for the ship with its total consumption as of a certain date.

In order to make it impossible for any particular country to issue more limits than it is entitled to, the limit cards are to carry a stamp of the Fishery Control Commission (Convention) for the given area.

For the purpose of more exact control of fishing effort consumption in the future, use can be made of elementary instruments to record on a sealed film the time of gears operation in the fishing mode (for example, the time when a trawl is at stopper). The list of the necessary instruments is given by Treschev (1971).

Application of the Swept Volume Method of fishery parameter evaluation will cause only a minor change in statistics, such as is being currently submitted by the Conventions Commission countries. Thus, in Table 4 (Statistics of fishing effort and nominal catch by division, month, gear and country) of the ICNAF Statistical Bulletin, under the heading "gear", besides the type of gear, there must be an indication of the latter's fishing capacity in proms, i.e. in the units equal to $10^9 m^3/24$ hr. Thus, instead of "OTST" there should be "OTST - 035" where 035 signifies that a given gear as used by a given ship during 24 hours of continuous fishing is capable of fishing a water volume of 0.035×10^9 cubic metres.

The column "days fished" should contain data on the time of the active gear operation over a year. The column "hours fished" is to be deleted. All other statistics shall be presented in the same form as before.

Table 1

Calculation of Fishing Capacity and Annual Fishing Effort Developed by a Fleet (real data for a USSR Fishing Fleet, 1968).

Vessel type	Trawl	Trawl opening area (m^2)*	Trawl coverage per hour (m)	Fishing capacity of gear in conjunction with vessel	Hours of trawling per annum	Fishing effort of vessel (5)x(6)/24	Number of vessels	Fishing capacity of fleet (5)x(8)	Fleet's fishing effort (7)x(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(OTST-7)PR	no. 396	200	7 400	0.03552	2 446	3.619	16	0.568	57.904
(OTST-7)BMRT	no. 352	150	7 400	0.02664	2 300	2.552	83	2.211	211.816
(OTSI-5)RT	no. 25	94	5 926	0.01337	2 000	1.114	180	2.407	200.520
(OTSI-4)SRT	no. 23	66	5 926	0.00939	540	0.211	189	1.775	39.879
								6.961	510.119

* Approximate trawl opening area for vessels:-

PR - 43m x 4.6m = 200m^2
BMRT - 37.5m x 3.9m = 150m^2
RT - 24.7m x 3.8m = 94m^2
SRT - 17.5m x 3.8m = 66m^2

OTSI - otter trawler with side trawling
OTST - otter trawler with stern trawling
OT - otter trawler
RT - pair trawler (twin fishing)
RS - with purse-seine

Categories of Vessel Tonnage (GRT)

2	0 -	51
3	51 -	150
4	151 -	500
5	501 -	900
6	901 -	1 800
7	over	1 800

APPENDIX

Study of Correlation between Catch per Hour of Trawling and the Following Parameters: Displacement and Overall Length of Ship, Capacity of Main Engine, and Volume of Water Fished (Fishing Capacity).

Determination of Correlation Ratios

Correlation ratio is determined by the formula:

$$\eta = \left\{ \sum_{j=1}^{l} f_j (\bar{y}_j - \bar{y})^2 \Big/ \sum_j \sum_i (y_{ij} - \bar{y})^2 \right\}^{\frac{1}{2}}$$

where:
- l = total number of x classes
- j = ordinal number of j^{th} x-class interval
- $\bar{x}_j$ = mid-point of j^{th} x-class interval
- $\bar{y}_j$ = mean value of y for j^{th} x-class interval
- f_j = number of y values in j^{th} x-class interval

a) Computation of Correlation Ratio of catch per hour on length of vessel [L,m]

Length of vessel, m (x_i)	Catch per hour (relative units) (y_i)
84.7	1.0; 1.21; 1.0; 1.05
82.2	0.98; 1.57; 1.95
79.2	0.9; 1.3; 0.6
54.2	0.26; 0.23; 0.74
50.8	0.24
43.6	0.21; 0.17

Correlation Grid

Interval	j	1	2	3	4-7	8	9
	L	40-45	45-50	50-55	55-75	75-80	80-85
Catches y_j;	x_j;	42.5	47.5	52.5	65.0	77.5	82.5
0.1-0.3	0.2	0.21 0.17		0.24 0.26 0.23			
0.3-0.5	0.4						
0.5-0.7	0.6					0.6	
0.7-0.9	0.8			0.74		0.9	
0.9-1.1	1.0						0.98 1.0 1.0 1.05
1.1-1.3	1.2					1.3	1.21
1.3-1.5	1.4						
1.5-1.7	1.6						1.57
1.7-1.9	1.8						
1.9-2.1	2.0						1.95
	$\sum_{i=1}^{f_j} y_{ij}$	0.38	0	1.47	0	2.8	8.76
	f_j	2	0	4	0	3	7
$\bar{y}_j = \frac{1}{f_j}$	$\sum_{i=1}^{f_j} y_{ij}$	0.19	0	0.37	0	0.93	1.25

Computation: $\sum_{j=1}^{1} f_j (\bar{y}_j - \bar{y})^2$

$\bar{y}_j$	$\bar{y}_j-\bar{y}$	$(\bar{y}_j-\bar{y})^2$	f_j	$f_j(\bar{y}_j-\bar{y})^2$
0.19	-0.65	0.4225	2	0.8450
0	-0.84	0.7056	0	0
0.37	-0.47	0.2209	4	0.8836
0	-0.84	0.7056	0	0
0.93	0.09	0.0081	3	0.0248
1.25	0.41	0.1681	7	1.1767

$\Sigma = 2.9301$

Computation: $\sum_{i=1}^{n} (y_i - \bar{y})^2$

y_i	$y_i-\bar{y}$	$(y_i-\bar{y})^2$
0.17	-0.67	0.4489
0.21	-0.63	0.3969
0.23	-0.61	0.3721
0.24	-0.60	0.3600
0.26	-0.58	0.3364
0.60	-0.24	0.0576
0.74	-0.10	0.0100
0.90	0.06	0.0036
0.98	0.14	0.0196
1.0	0.16	0.0256
1.0	0.16	0.0256
1.05	0.21	0.0441
1.21	0.37	0.1369
1.30	0.46	0.2116
1.57	0.73	0.5329
1.95	1.11	1.2321

$\bar{y} = 0.84$ $\Sigma = 4.2139$

$$\eta = \sqrt{\frac{2.9301}{4.2139}} = 0.83$$

b) Calculation of Correlation Ratio of catch per hour on displacement (D.T)

Displacement Wt. of vessel (light) (x_i)	Catch per hour (relative units) (y_i)			
3 800	1.0 ;	1.0 ;	1.21;	1.05
3 362	0.98;	1.57;	1.95	
3 275	0.9 ;	0.6 ;	1.3	
912	0.26;	0.23;	0.74	
737	0.24			
545	0.21;	0.17		

Correlation Grid:

Interval	j	1	2	3	4-13	14	15	16	
	D	400-600	600-800	800-1 000	1 000-3 200	3 200-3 400	3 400-3 600	3 600-3 800	
Catches	$y_i \backslash x_i$	500	700	900	2 100	3 300	3 500	3 700	
0.1-0.3	0.2	0.21	0.24	0.26					
		0.17		0.23					
0.3-0.5	0.4								
0.5-0.7	0.6					0.6			
0.7-0.9	0.8			0.74					
0.9-1.1	1.0					0.9		1.0	1.05
						0.98		1.0	
1.1-1.3	1.2					1.3		1.21	
1.3-1.5	1.4								
1.5-1.7	1.6					1.57			
1.7-1.9	1.8								
1.9-2.1	2.0					1.95			
	$\sum_{i=1}^{f_j} y_{ij}$	0.38	0.24	1.23	0	7.30		4.26	
	f_j	2	1	3	0	6	0	4	
$\bar{y}_j = \frac{1}{f_j}$	$\sum_{i=1}^{f_j} y_{ij}$	0.19	0.24	0.41	0	1.22	0	1.06	

Computation: $\sum_{j=1}^{l} f_j \, (\bar{y}_j - \bar{y})^2$

$\bar{y}_j$	$\bar{y}_j - \bar{y}$	$(\bar{y}_j - \bar{y})^2$	f_j	$f_j(\bar{y}_j - \bar{y})^2$
0.19	-0.65	0.4225	2	0.8450
0.24	-0.6	0.3600	1	0.3600
0.41	-0.43	0.1849	3	0.5547
0	-0.84	0.7056	0	0
1.22	0.38	0.1444	6	0.8664
0	-0.84	0.7056	0	0
1.06	0.22	0.0484	4	0.1936
				2.8197

$$\eta = \sqrt{\frac{2.8197}{4.2139}} = 0.82$$

c) Computation of Correlation Ratio of catch per hour on main engine capacity (N, h.p.)

Main engine capacity, h.p. (x_i)	Catch per hour (relative units) (y_i)			
2 000	1.0 ;	1.0 ;	1.21;	1.05
2 320	0.98;	1.57;	1.95	
1 340	0.9 ;	0.6 ;	1.3	
800	0.26;	0.23;	0.74	
540	0.24			
400	0.21;	0.17		

Correlation Grid:

Interval	j	1	2	3	4-5	6	7-8	9	10	11
	N	300-500	500-700	700-900	900-1 300	1 300-1 500	1 500-1 900	1 900-2 100	2 100-2 300	2 300-2 500
Catches	y_j \ x_j	400	600	800	1 100	1 400	1 700	2 000	2 200	2 400
0.1-0.3	0.2	0.21	0.24	0.26						
		0.17		0.23						
0.3-0.5	0.4									
0.5-0.7	0.6					0.6				
0.7-0.9	0.8			0.74		0.9				
0.9-1.1	1.0							1.0		0.98
								1.0		
								1.05		
1.1-1.3	1.2					1.3		1.21		
1.3-1.5	1.4									
1.5-1.7	1.6									1.57
1.7-1.9	1.8									
1.9-2.1	2.0									1.95
	$\sum_{i=1}^{f_j} y_{ij}$	0.38	0.24	1.23	0	2.8	0	4.26	0	4.5
	f_j	2	1	3	0	3	0	4	0	3
$\bar{y}_j = \frac{1}{f_j} \sum_{i=1}^{f_j} y_{ij}$		0.19	0.24	0.41	0	0.93	0	1.06	0	1.50

Computation: $\sum_{j=1}^{l} f_j(\bar{y}_j-\bar{y})^2$

$\bar{y}_j$	$\bar{y}_j-\bar{y}$	$(\bar{y}_j-\bar{y})^2$	f_j	$f_j(\bar{y}_j-\bar{y})^2$
0.19	-0.65	0.4225	2	0.8450
0.24	-0.60	0.3600	1	0.3600
0.41	-0.43	0.1849	3	0.5547
0	-0.84	0.7056	0	0
0.93	0.09	0.0081	3	0.0243
0	-0.84	0.7056	0	0
1.06	0.22	0.0484	4	0.1936
0	-0.84	0.7056	0	0
1.50	0.66	0.4356	3	1.3068

Σ = 3.2844

$$\eta = \sqrt{\frac{3.2844}{4.2139}} = 0.88$$

d) Computation of Correlation Ratio of catch per hour on fishing capacity $\left[10^9 \frac{\text{cub.m.}}{\text{24 hr.}}\right]$

Fishing capacity $\left[10^9 \frac{\text{cub.m.}}{\text{24 hr.}}\right]$ (x_i)	Catch per hour (relative units) (y_i)	
0.0173	1.0 ;	1.0
0.0958	1.21;	1.05
0.0162	0.98	
0.2570	1.57;	1.95
0.0152	0.9 ;	0.6
0.0986	1.3	
0.0098	0.26;	0.23
0.0352	0.74	
0.0072	0.24	
0.0068	0.21;	0.17

Correlation Grid:

Interval	j	1	2	3	4	5-8	9	10-24	25
	w	0.00-0.01	0.01-0.02	0.02-0.03	0.03-0.04	0.04-0.09	0.09-0.10	0.10-0.25	0.25-0.26
Catches	y_i \ x_i	0.005	0.015	0.025	0.035	0.065	0.095	0.175	0.255
0.1-0.3	0.2	0.21 0.17 0.24 0.26 0.23							
0.3-0.5	0.4								
0.5-0.7	0.6		0.6						
0.7-0.9	0.8		0.9		0.74				
0.9-1.1	1.0		0.98 1.0 1.0				1.05		
1.1-1.3	1.2						1.3 1.21		
1.3-1.5	1.4								
1.5-1.7	1.6								1.57
1.7-1.9	1.8								
1.9-2.1	2.0								1.95
$\sum_{i=1}^{f_j} y_{ij}$		1.11	4.48	0	0.74	0	3.56	0	3.52
f_j		5	5	0	1	0	3	0	2
$\bar{y}_j = \frac{1}{f_j} \sum_{i=1}^{f_j} y_{ij}$		0.22	0.90	0	0.74	0	1.19	0	1.76

Computation: $\sum_{j=1}^{l} f_j(\bar{y}_j-\bar{y})^2$

$\bar{y}_j$	$\bar{y}_j-\bar{y}$	$(\bar{y}_j-\bar{y})^2$	f_j	$f_j(\bar{y}_j-\bar{y})^2$
0.22	-0.62	0.3844	5	1.9220
0.90	0.06	0.0036	5	0.0180
0	-0.84	0.7056	0	0
0.74	-0.10	0.0100	1	0.0100
0	-0.84	0.7056	0	0
1.19	0.35	0.1225	3	0.3675
0	-0.84	0.7056	0	0
1.76	0.92	0.8464	2	1.6928
				Σ = 4.0103

$$\eta = \sqrt{\frac{4.0103}{4.2139}} = 0.98$$

Meeting on the Measurement of Fishing Effort, IJmuiden, 7-8 May 1973

COMMENTS ON CONCEPTS USED FOR FISHING EFFORT MEASUREMENT

by
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At first sight the terminology used in specialised literature on fisheries, whether it be scientific, technical or otherwise, does not seem to be particularly obscure. The words and expressions are in common usage and in themselves easy to understand. But it is in their application that they become mystifying and when coupled with scientific jargon are easily misunderstood. This is often because the precise and restrictive meaning has been stretched by the specialists so that the common meaning no longer applies.

Among all specialised expressions, fishing effort is surely the one that provokes more discussion than most because it is too often employed without specifying whether it should be understood in a precise scientific manner on in its broad and imprecise meaning.

I. Fishing effort/mortality

The most common confusion arises from the habit of many biologists to shorten to "fishing effort" the "fishing effort/mortality" concept which they very frequently use.

Fishing effort/mortality is a ratio utilising the catch by fishing vessels to measure the percentage of the remaining fish stock and thus expresses the impact of the fishing effort on the stock. It does not reflect the catch by weight and is usually expressed by the biologists in neperian logarithms.

Because the fishing power of the vessels does not usually remain constant, a conversion factor has to be inserted so that technical improvements can be taken into account. Such a conversion factor is very difficult to determine when there is a relatively rapid change in the techniques (e.g. from drift net to purse seine with power block for herring fishing in the North Atlantic) or when the change is complex (e.g. sonar and power block). Similarly when widely different techniques are used on the same stock (e.g. for the Barents Sea cod, trawling on one side and on the other side hand line, drift net etc.) it is very difficult, if not impossible, to find a standard unit permitting the use of a conversion coefficient.

So it could be said that the fishing effort/mortality is a concept having two linked and different aspects:

- where the problem is to assess the reasons for variations in the catch per unit of fishing effort, i.e. the catch per vessel in a given time spent fishing; it must be known whether the fishing techniques and tools have been in any way changed; if they have not, no correction is necessary and bigger or smaller catches indicate a bigger or a smaller stock; if they have changed, a conversion factor has to be inserted before like can be compared with like;

x) The author is solely responsible for the ideas and information presented in this paper.

- in consequence the fishing effort/mortality is proportional to the abundance in the fish stock, but not to the actual catches; in other words, the same fishing effort/mortality can give good catches in the case of good abundance and only poor catches in the case of poor abundance.

2. Overfishing and maximum sustainable yield

The M.S.Y. is the maximum average catch which can be sustained continuously by a fish stock and corresponds to a very precise fishing effort/mortality. There is overfishing when the point of M.S.Y. is overtaken.

The mathematical ways by which are calculated the M.S.Y. and the corresponding fishing effort/mortality should be considered in conjunction with the limits of the computations through which they are arrived at.

First of all, the yields are always given by averages, i.e. erasing fluctuations in abundance. In practice a fish stock exploited at the fishing effort/mortality giving the M.S.Y. would seldom if ever give the same annual yields, but those yields would average at the M.S.Y.

Secondly, calculations to obtain the M.S.Y. take into account the factors which play a role from the side of the increase of the total weight of the stock:

- growth rate of the fish;
- fish availability for the gear which is used;

and from the side of the decrease of the total weight of the stock:

- natural mortality
- fishing mortality.

If the combination of the increasing factors makes it that, in practice the fish begins to be caught around the point of maximum growth (in weight) of the stock, the mathematical computations may lead to very high fishing effort/mortality coefficients for M.S.Y. Of course the selectivity of the gears cannot ensure that the fish below a certain age are never caught. But if such a selectivity is never fully efficient, it is far from being inefficient. Furthermore, some species have their maximum growth rate at a very early age (cf. herring). Other species have dispersion and migration patterns such that a large proportion of the young year classes are hardly touched by the fishing gear. It may also be that the fishermen are making a point of not searching for the too young fishes which would only give poor returns in value terms. In all such cases, it may happen that in practice the fish is only beginning to be caught at or after its point of maximum growth which gives an absurd and theoretical infinite fishing effort/mortality for small or insignificant increases in total average yields.

This is very important in order to stress that the M.S.Y. concept is very useful in giving realistic measures of the maximum average catches that can be taken from a stock, but it often happens that the corresponding fishing effort/mortality measurements are very doubtful or even absurd.

This has led biologists to different kinds of optimum sustainable yield giving a more reasonable fishing effort/mortality. Unfortunately, when they could agree between themselves, it seems that their solutions did not meet the requirements for a better management of the fish resources.

3. Fishing power and fishing effort

Fishing power, in its precise biological meaning, is distinct from fishing effort because it is related to the gear and not to the fish stock.

In other words, before arriving at a standard unit of fishing effort, the biologists must assess the relative fishing powers of the different gears exploiting a stock. And, obviously, while the gear is the catching instrument, it cannot be considered in isolation and should be examined in relation with the boat which allows its utilisation. If three boats, A, B and C using different gears in the same conditions have catches a, b and c their fishing power will be proportional to a, b and c. And when the actual catches of the different boats are varying proportionally to some characteristics of the boats a standard unit of fishing power can be used.

Recognising that many people are already mixing up fishing effort, fishing intensity, fishing capacity, fishing power etc., it would seem opportune to suggest that catching effort, catching power, etc. might be more appropriate expressions as catches form the common yardstick which is sued by the biologists for measuring effort and power.

But such a change of wording would depart from many years practice and could be a source of confusion; furthermore it would not solve the problem.

4. Catching versus fishing

The risk of confusion and the difficulty in wording come from the intricacy of the problem. A fishing vessel is meant to catch fish. But whereas a machine making chewing gum or a chain of car production have a definite output for a given input of material and manpower, the fishing machine, i.e. the fishing vessel, requires a given input (crew, fuel, insurance, etc.) but cannot ensure a guaranteed output.

It is well known that the catching power of the fishing units varies very widely according to the conditions under which the exploitation is conducted. And the variable conditions do not only include physical conditions (ecological conditions, abundance in stock etc.) but also human conditions (skipper ability, etc.).

This leads to the conclusion that it is totally impossible and impracticable to search a single unit of measurement of "fishing effort" when this expression is used in its broadest meaning, i.e. the catching power of fishing units. The only solution is a combination of different measurements.

5. Units of fishing effort measurement

At present the following units of measurements are existing:

- unit of fishing effort/mortality (F of the biologists): it should be stressed that this unit does not allow a comparison between the situations of different stocks: one stock subject to an F of .40 might be exploited at the optimum, when another one, subject to .30 might be running the risk of depletion; in spite of the fact that F is a standard unit, it is only capable of analysing the results of the different fishing efforts exerted on the same stock;

- units of fishing power (standard units of the biologists); the same remark as above applies; such units are only valid for restricted zones. Furthermore, any improvement in technology and wide differences in the techniques used, make it often impossible to arrive at an objective standard unit. For example, the British unit for North Atlantic trawling (correction by tonnage) which was certainly valid for the side trawlers of the 1950's does not seem to be correct for the freezer trawlers of the 1970's. Neither can it accurately cover the activities of hand lines, gill nets or purse seines when such gears are used on the same North Atlantic stocks.

The difficulties in assessing standard units of fishing effort with a view to comparing the catching powers of the different fishing units is an illustration of the difficulties indicated in the above section "catching versus fishing".

It is obvious that no improvement in the catching units could be made by the biologists alone if they cannot dispose of units from the fishing side. Tentatives such as the gear classification (proposed by the CWP and adopted by the North Atlantic bodies), the measurement of gear catchability (studied and proposed by Dr Treschev) the fishing vessels classification (recommended by the CWP and at present studied by OECD and FAO) all go into this direction. The object of the discussions at IJmuiden are of course to analyse those and other similar tentatives and examine the extent to which they could be practicable and linked with the catching units of the biologists.

When boats and gear are classified and measured in a sufficiently sophisticated manner it will be possible to try for the different fisheries the correlations linking the catches and the boats and gear characteristics. For each specific case some of those characteristics have a predominant effect on the efficiency of the fishing operations and should be found.

As a last remark it must be stressed that the improvements in gear and vessels classification and measurement as fishing units may well imply some change in the way the biologists are presenting the results of their work.

Most of the studies on North Atlantic stocks are made with the Beverton and Holt model which is an analytical model. This model is analytical because it takes into account:

- the growth rate of the fish;
- the gear selectivity;
- the seasonal availability;
- the yearly recruitment;
- etc.

But the results presented are usually restricted to an assessment of the fishing effort/mortality and some comments on specific features indispensable to explain the situation and make some forecasts.

If a more comprehensive measurement of fishing effort from the side of the fishing units is introduced, the analytical power of the Beverton and Holt model, which is already used by the biologists as much as allowed by the available data, should lead to a more detailed presentation of the biological results. The work under progress on vessels and gear should be a contribution towards the same purpose.

-o-o-o-