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Report of Special ICNAF Meeting of Experts on Effort Limitation
Woods Hole, Massachusetts, 26-30 March 1973

1. The Special Meeting of Experts on Effort Limitation was established by the Commission on recommendation of STACREM to consider, specifically, ten questions posed by STACREM regarding details of effort limitation and, generally, matters related to the establishment of effort limitation schemes (1973 Special Comm.Mtg.Proc.4, App.III and Proc.6).

2. The Special Meeting was held at the Marine Biological Laboratory, Woods Hole, Massachusetts by invitation of the United States Government from 26 to 30 March 1973.

3. The Executive Secretary opened the meeting and, on behalf of the Commission, welcomed the fishery administrators, economists, scientists and technologists from 12 of the 16 Member Countries of the Commission and observers from the German Democratic Republic and FAO (Appendix I).

PROGRAM OF WORK

4. Dr R.L. Edwards (USA) was elected Chairman. The Executive Secretary was appointed Rapporteur. The Chairman welcomed the participants on behalf of the National Marine Fisheries Service and introduced a provisional agenda which included a program of work designed to provide information on which to base answers to the ten questions posed by STACREM (Appendix II). It was further proposed that working groups might be set up to investigate the two major problems: by-catch and control of effort regulation.

Following considerable discussion, the Group agreed to relate the ten STACREM questions to the agenda items, to define the terms contained in STACREM Question 2 as the first item under the program of work and to start through the modified agenda (Appendix III) until it was felt necessary to set up working groups.

DEFINITION OF TERMS

5. STACREM Question 2 reads:

Please define exactly the following terms:

(a) fishing mortality
(b) fishing intensity
(c) fishing power
(d) fishing effort

and specify what are the variables that should be discussed for effort control.

In addition to the four terms listed in STACREM Question 2 for definitions, the Working Group considered it necessary to clarify the term "by-catch" and indicate its meaning in the context of the data available. Somewhat more detailed notes on terms used in fishery assessments are given in Appendices IV and V.

(a) Fishing effort. For practical purposes, fishing effort refers to the amount of fishing by some standardized fishing unit, e.g. days fished, number of hauls, volume of water filtered, etc.

(b) Fishing intensity, as strictly understood, is proportional to the fishing mortality it generates. It is measured by the fishing effort per unit area in a unit of time.

(c) Fishing mortality is a function of fishing effort. The function is generally linear such that the two are related by a constant, the catchability coefficient (q). In a particular fishery, where the unit of effort may vary, the total fishing mortality (F) will be composed of the effect of the sum of the effort of each vessel (f) multiplied by its catchability characteristic (q),

$$F = q_1f_1 + q_2f_2 + q_3f_3 + \ldots\ldots$$

The catchability coefficient of each vessel is the proportion of the stock removed per unit fishing time of that vessel,

$$q = (\text{catch/stock}) \times \text{time}$$

Where the fishing activity (effort) of different vessels is referred to a common unit of time, e.g. hours fishing, fishing power is indicated by the quantity of a standard stock removed per unit fishing time.

(d) Fishing power. For biological and technical reasons, fishing power varies as a function of the vessel characteristics, its gear, its crew, as well as the stock being fished.

In order to approach an estimate of fishing mortality in terms of a single unit of fishing effort, variations of fishing power between vessels/fleets must be taken into account. If one unit of effort and fishing power is selected as the standard, then

$$\text{Fishing Mortality} = q_1 \times (\text{Fishing Effort})_1 + q_2\left[\frac{(\text{Fishing Power})_2}{(\text{Fishing Power})_1}\right] \times (\text{Fishing Effort})_2 + \text{etc.}$$

The fishing power of each vessel will be specific to each species stock but the relative fishing power of particular vessels remain stable over broad categories of resources, e.g. pelagic/demersal or roundfish/flatfish.

Where the fishing power is measured on the same stock size (albeit averaged over a year) and effort is measured in the same unit, then

$$\frac{q_2}{q_1} \times \frac{(\text{Fishing Power})_2}{(\text{Fishing Power})_1} = \frac{(\text{Catch per Unit Effort})_2}{(\text{Catch per Unit Effort})_1}$$

and the summation becomes

$$F = q_1f_1 + q_1f_2\left(\frac{\text{Cpue}_2}{\text{Cpue}_1}\right) + q_1f_3\left(\frac{\text{Cpue}_3}{\text{Cpue}_1}\right) + \ldots\ldots$$

Since the catch per unit effort of each fleet is by definition c/f of that fleet, the above expression simplifies to

$$F = q_1f_1\left(1 + \frac{C_2}{C_1} + \frac{C_3}{C_1} + \ldots\ldots + \frac{C_n}{C_1}\right)$$

(e) By-catch may be defined as the quantity of one or more species caught at the time when fishing is directed primarily toward other specific species. Technically, the by-catch includes not only the quantities of these minor species reported as nominal catches in the statistics but also discards of all species.

Because such data were not available in the statistics, the term "by-catch" as used by the Assessments Subcommittee at the January 1973 Meeting in Rome is not the same as that defined above; rather, the term "subsidiary catch" might be more appropriate. In this context, the Subcommittee examined the monthly catch and effort statistics as reported in Table 4 of the Statistical Bulletin. In cases where no "main species" was indicated or it was shown as "mixed", the effort was allocated to species according to catch on a monthly basis. In nearly all cases, the quantity of the main species designated in this manner was considerably greater than 50% of the total nominal catch of all species. Thus, the monthly "subsidiary" catches in most cases totalled considerably less than 50% of the total for all species.

MANAGEMENT OPTIONS

6. The Group discussed the problem of defining the management options and the associated advantages and disadvantages. Two major options are apparent - continuing with the existing regulatory regime of quotas on major species or introducing regulation to control the total fishing mortality. The latter option arises from the US proposal in January 1973 (Comm.Doc. 73/3). The Assessments Subcommittee Report to the

Special Commission Meeting, January 1973 (Summ.Doc. 73/1) indicated that in 1971 the total catch was probably beyond the maximum sustainable level, and the fishing mortality (as measured by an effort index) probably greater than that corresponding to the MSY. Thus, in order to achieve the objective of maximizing yields from the total biomass, it appears necessary to control fishing mortality at a level lower than that obtained in 1971.

Under the second of the major options - control of total mortality - there are two further options: catch or effort. Discussion by the Group centered mainly on aspects of the direct control of effort because the US proposal generated a STACREM list of ten questions for the Group to answer. However, it was felt that an evaluation of the total effort regulation must be addressed by a relative comparison of catch versus effort control. For example, a reduction in catch must, except under certain circumstances, result in a reduction in fishing effort, so that the two options would have immediate common effects. In the long run, adjustment and monitoring must be considered, and might be somewhat different than in the initial stage. Within either option, the benefits of the regulation of total fishing mortality can be maximized by control of fishing mortality on individual species. This, of course, implies a further set of options that require evaluation.

The Group attempted a first approach to the problem by discussing some of the advantages and disadvantages of management schemes (Table 1). The table does not purport to represent a complete listing, nor, perhaps, is it the best format. However, the Group felt that its inclusion in the report, even though it does not represent an agreed tabulation, would stimulate further comments which would be beneficial to further development of the evaluation of management options.

Table 1. Advantages and disadvantages related to proposed management schemes.

Option I Species (single or group) Catch Quotas → All		Option II Total Catch Quota (a) with some species quotas (b) with all species quotas		Option III Total Effort Limitation with some species quotas	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**	**Advantages**	**Disadvantages**
1. Most precise estimate of MSY in theory	1. Difficult to do (a) Do not know the theory (b) Cannot get data	1. Alleviates by-catch problem	1. Estimating recruitment (stock changes)	1. Alleviates by-catch problem	1. Intercalibration of fishing units
2. Readily understood, hence more acceptable	2. Failure → leads to over-fishing	2. Less precision in assessment required	2. Discard - either tend to increase or require reporting (difficult)	2. Less precision in assessment required	2. Variability in catchability in time (species)
3. Flexibility to adjust quotas	3. Necessity to predict recruitment and rate of by-catch	3. Minimizes probability of over-fishing		3. Minimizes probability of over-fishing	3. New concept (no precedents)
4. National allocation - more readily acceptable	4. Does not prevent excess capitalization per se → difficulty in regulating catch at proper level	4. National allocation easier (historic catch base)		4. Need not be adjusted for variability in stock density and recruitment	4. Difficult in establishing historical basis for national allocation (lack of data)
5. More options for fleet deployment	5. Difficult to set and control appropriate quotas because of by-catch				

The following comments are intended only to clarify the points listed in Table 1.

Option I refers to the case where individual species or species-group assessments are made and catch quotas set. As the number of species covered increases, this scheme approaches Option II(b). However, it is assumed under Option I that the sum of the species quotas will equal the total quota. The advantages listed are (1) that MSY estimates are theoretically more precise because of a knowledge of the individual components, (2) that estimates of yield on a species basis are easiest to grasp conceptually, and thus may be more acceptable, (3) that maximization of yield of a given species is enhanced by the flexibility to adjust quotas based on current conditions, (4) that national allocation may be more acceptable as it could be based on historic species catches, (5) that fleet operators are free to deploy their fleets in any manner in order to catch species quotas, without concern for other regulations. The disadvantages listed are (1) that some assessments are difficult because of the lack of a theoretical basis to adjust for ecological relationships in rapidly changing conditions and because of the lack of available data for many species, (2) that inadequate assessments due to the problems in (1) may lead to overfishing, (3) that the estimation of recruitment and by-catch that is necessary in order to set quotas is difficult because of a lack of developed methods for mixed fisheries and, even when methods are available because of logistics, and (4) that excess effort is not necessarily diverted out of the area, and is difficult to control or monitor.

Option II is the case of a total catch quota with either some or all species under catch quotas. However, since by-catch would not be adjusted for in a species quota, the total quota may be less than the sum of individual quotas depending, of course, on how many species were under quota. The first three advantages of this option are the same as those of the total effort limitation scheme (Option III). They are (1) that the by-catch problem may be attenuated by reducing the overall removals; this would allow the catch of a species to be made in any component of the fishery, provided the sum of the catches does not exceed the quota for that species. Thus, the reduction in species quotas to adjust for by-catch as in Option I would not be necessary and the reduction could be allowed to float to whatever component a country desired. (2) that, with an overall upper limit and no direct adjustment for by-catch, the assessments would require less precision than under Option I, (3) that the probability of overfishing would be minimized by preventing large increases in fishing mortality, particularly on species not under quota or accurately assessed, (4) that overall catch quotas are easier to allocate nationally because there is historical data base of catches upon which to base the allocation. Disadvantages of total quota are (1) that the estimation of recruitment is difficult (see (3) of Option I) and, (2) that precise information on discards is essential to regulating the desired fishing mortality.

Option III refers to the establishment of a level of fishing effort corresponding to the MSY. This Option has the same advantages (1)-(3) of Option II. A further advantage is (4) that yearly adjustments of catch for variability in stock density and recruitment are not required, because, with effort constant, catch should fluctuate with abundance of the stock in the correct proportions. The disadvantages of total effort limitation listed are (1) that the correct intercalibration of fishing units and adjustments for changes are difficult, (2) that variance in catchability with time and shifts between species from year to year may mitigate the effects of effort control because vessels could concentrate on a different mix of species in a different time period, resulting in increased fishing mortality for the same amount of regulated effort, (3) that total effort control, as a new concept, may be difficult to fully understand or accept, (4) that national allocation may be difficult because of the lack of national historical data.

The Group urges countries to investigate the relative importance of these and any other factors that further thought elucidates (Recommendation 1).

STACREM QUESTIONS

7. STACREM Question 1 reads

What are the conversion factors needed to obtain "days on ground" from "days fished" for the various Member Countries? Do countries collect the necessary information to answer this question and, if not, how long will it take to collect the necessary data?

Prior to 1970 some Member Countries submitted "days on ground" as a regular part of their statistical submissions to ICNAF. These data together with "days fished" were published in Tables 4 and 5 of the Statistical Bulletin. The collection and publication of "days on ground" data were discontinued on the recommendation of the Sampling and Statistics Subcommittee at the 1971 Annual Meeting, mainly because nearly all countries provided more refined effort measures, e.g. days fished and hours fished. While the "days on ground" data for 1970 were actually collected, they were not published in Statistical Bulletin Vol. 20 for the year 1970. These data were not a requirement for 1971 and 1972 data submissions from Member Countries and consequently, are not available at the ICNAF Secretariat. Therefore, the conversion factors based on the ratio of "days on ground" to "days fished" for the years 1970 and 1971 cannot be readily calculated at this time.

Information obtained from representatives of countries present at this meeting indicated that most of the Member Countries could provide data on "days on ground" as well as "days fished" from 1973 onwards and some countries could supply the data to fill the gap mentioned above. The following is the result of the survey when representatives were asked if they collected the necessary information (i.e., "days on ground" and "days fished") and when the information would be available:

Member Countries	Remarks
Canada	Data not now available but could be in about one year
Denmark (G)	For OT, data can be supplied for 1972 and onwards; but data for the small-boat fisheries are difficult to obtain and unlikely in the near future
Denmark (F)	It is possible that some data might be available
France (M)	Data are available for 1972 and can be provided for future years
Germany (FR)	Data can be supplied for all years since 1969 if requested
Japan	Such data are collected by the fishing companies but its preparation would require much time
Norway	Data are available for OT, and will be available for LL from 1973
Poland	Data are available from 1971
Portugal	Data will be available from 1973
Spain	Data are available and can be supplied for all years from 1966
USSR	Submitted such data in previous years and can do so again if requested
UK	From 1973 onwards
USA	Basic data are collected and could be supplied if requested
Bulgaria) Iceland) Italy) Romania)	No representative at the meeting
German Democratic Republic	Data are available for 1969 and 1970 and can be provided from 1971 onwards

During the course of the discussion the representatives of some Member Countries indicated that the nature of their fisheries were such that conversion factors obtained from the ratio of "days on ground" to "days fished" would be highly variable with time, area and tonnage class, etc. In this connection, the Group urged Member Countries to analyze their data on "days on ground" and "days fished" and provide estimates of the variance associated with conversion factors obtained from these two effort measures (Recommendation 2).

8. STACREM Question 2 (for answer, see Section 5)

9. STACREM Question 3 reads

The Commission is attempting to control the fishing mortality on the resources and fishing mortality is an abstract quantity which cannot be regulated directly. The Commission may be able to control fishing mortality by regulation of fishing intensity or fishing effort. What is the accuracy with which these quantities can be measured and what is the error involved in using them as a predictor of future fishing mortality?

The statistical errors involved in monitoring a regulatory scheme can only be outlined in general terms at present. The main advantage of catch quotas is that accuracy is independent of variations in the catchability coefficient. But the setting of catch quotas is sensitive to fluctuations in recruitment. Fishing effort quotas are not sensitive to fluctuations in recruitment, but they are sensitive to variations in catchability.

A) Errors involved in setting a catch quota regulation

As currently envisaged catch quotas will be revised annually. Then it is necessary to estimate the stock at the beginning of the year and the amount of catch related to a specified level of mortality. The sources of error are

i) in the size of the exploited stock (errors in data and technique)
ii) in the size of recruitment to the exploited stock (errors in data and technique)
iii) in the fishing mortality achieved when the catch defined with respect to (i) and (ii) is expressed as a proportion of the new stock.

B) Errors involved in setting a fishing effort regulation

If the regulation were set up for an indefinite period, the error would reside in the catchability coefficient caused by

i) the intercalibration of these units between countries
ii) the scope for changes in the pattern of fishing (seasons, species) between countries and change in vessel efficiency, etc.

These two components are described further below.

iii) The choice of effort unit may have a further effect if the choice of unit in a multispecies fishery differs from the unit which would be chosen for each species in a single species fisheries. Also, at the beginning of regulation and if the effort regulation needed to be adjusted, i.e., with reference to the existing state of the fisheries, the A(i) errors will occur.

Very few data are available to quantify all of these errors for single or multiple species fisheries (because of inadequate time series) but some progress has been made with respect to the errors involved in the intercalibration of effort units and the scope for changes in the catchability coefficient with time (B(i) and B(ii)).

For purposes of answering the question, fishing intensity and fishing effort are assumed to be related by a constant area factor and the term "accuracy" was considered to imply two different concepts: variance and bias. The former expresses the uncertainty in a given estimate of the fishing effort, using a specific estimator. For example, if

$$F = q_i \left(\sum_{i=1}^{n} \frac{\text{cpue}_i}{\text{cpue}_1} \cdot f_i \right)$$

where i indicates a fishing unit, then

$$\text{Var (F)} = q_i^2 \sum_{i=1}^{n} \left[f_i^2 \, \text{Var}\left(\frac{\text{cpue}_i}{\text{cpue}_1}\right) + \left(\frac{\text{cpue}_i}{\text{cpue}_1}\right)^2 (\text{Var}(f_i)) + 2\, \frac{\text{cpue}_i}{\text{cpue}_1} f_i \, \text{Cov}\left(\frac{\text{cpue}_i}{\text{cpue}_1}, f_i\right)\right]$$

Thus, leaving aside the accuracy with which a particular reduction in fishing mortality can be specified, one part of the question dealing with determining the probability of achieving the desired reduction, at least initially, may be answered by evaluating the overall variance. It is suggested that the variance of the catchability coefficients for 1971 be estimated to provide some information on this aspect.

The bias term becomes important when considering the control of F in some future year, using the catchability coefficients as estimated, say, in 1971. In general, when Bias > 1.25 $\sqrt{\text{Var (f)}}$, its effect on errors of estimate becomes important.

Many factors may cause bias, or changes in q over time. These include

vessel (type, age, equipment, crew, captain)
density of fish (saturation)
species of fish (demersal, pelagic, bathypelagic)
area (geographic)
time (season, between different gear)
temperature
learning (introduction of new gear, echo sounders, etc.)

Some of these may be asymptotic in effect, and thus, after a period of adjustment may not be a significant factor. Improvement in learning how to cope with variability in catch caused by variations in season, area and other factors would tend to be asymptotic. The change with time in percent of total catch of the principal species sought may provide a measure of the ability to reduce by-catch and may also illustrate the asymptotic nature of learning. Certainly, some factors are more significant than others, and some may produce negative, as well as positive, bias.

The Group suggested that the relative Cpue be examined for 1970 and 1971 to determine, if possible, the effects of vessel class within and between gear and between years, and relate this to pelagic and demersal fish. The seasonal and area components of variation may also be examined by (1) plots of catch against effort by gear-tonnage class, month, species and country to illustrate the internal consistency (see Figs. 1 and 2 for examples), (2) the technique of mean ratio versus ratio of means to examine the degree to which fishing effort can be directed to maximize catch rate (see Fig. 3 for example) and seasonal variations in catch per unit effort (Figs. 4 and 5). Figure 4 includes all finfish, but Fig. 5 excludes the catches of herring, haddock, and flounders which would be under quotas which restrict the opportunities to shift effort. The Group suggested that each country analyze its data with regard to the problem of variance and bias in order to provide some inference on the question of changes in fishing performance (Recommendation 3).

10. STACREM Question 4 reads

If catch quotas are set for several species which imply different percentage reductions in fishing mortality, what problems does this raise in connection with a fixed reduction in fishing effort, especially for countries only interested in some species?

Summaries of catch by fishery (main species sought) and species for each country for 1971 are given in Table 2. It may be observed that most countries harvest a mix of different species, although preferences are evident. Unless the finfish biomass increases, an overall reduction in effort implies a reduction in catch. The problem becomes troublesome when a change in fishing pattern is desired. The table indicates where the problems may be most significant. A problem may arise for countries with a strong species preference which has led to a concentration of effort in certain areas and seasons. An overall reduction in fishing effort could result in the inability to achieve a species quota. Thus, fishing mortality could be reduced unevenly for different species.

Notes on the regulation of total fishing effort and the problem of by-catches (prepared by Captain J.C.E. Cardoso, Portugal) are found at Appendix VI. These were given preliminary consideration by the Group.

Table 2. Nominal catches ('000 tons) in Subareas 5 and 6 by fishery (species sought or main species) and species caught for each country in 1971.

Country	Species sought	Species caught										Total
		Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	
Canada	Cod	2.0	0.7	*	*	0.0	0.1	0.4	0.0	0.0	0.0	3.2
	Had	0.4	0.7	0.1	*	0.0	*	0.1	0.0	0.0	0.0	1.4
	Red	*	*	0.1	*	0.0	*	*	0.0	0.0	0.0	0.2
	O G	0.7	0.3	*	*	0.0	*	2.4	0.0	0.0	0.0	3.5
	Her	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.4	0.0	0.0	28.4
	O F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1
	Total	3.1	1.7	0.3	*	0.0	0.2	2.9	28.4	1.1	0.0	37.7
Ger(FR)	Her	*	*	0.0	0.0	0.0	0.0	0.6	56.5	1.2	*	58.3
	O P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6
	Total	*	*	0.0	0.0	0.0	0.0	0.6	56.5	2.8	*	59.9
Japan	Her	*	*	*	0.0	*	*	*	2.4	*	*	2.5
	O P	0.0	0.0	0.0	0.0	*	*	0.3	*	3.6	*	4.0
	O F	*	0.0	*	0.0	*	0.0	1.2	*	0.1	4.9	6.2
	Total	*	*	*	0.0	*	*	1.5	2.4	3.7	4.9	12.7
Poland	Her	0.1	*	*	0.0	*	0.0	0.1	75.4	16.8	8.1	100.5
	O P	0.1	0.0	0.1	0.0	0.1	*	0.2	12.6	95.4	9.9	118.4
	O F	0.0	0.0	0.0	0.0	0.0	0.0	*	0.3	0.2	0.4	0.9
	Total	0.3	*	0.1	0.0	0.1	*	0.3	88.3	112.3	18.4	219.9
Romania	S H	0.0	0.0	0.0	0.0	*	*	0.0	0.0	0.0	0.0	*
	Her	0.0	0.2	0.0	0.0	0.0	0.2	*	0.5	0.3	0.5	1.7
	O P	*	0.1	0.0	0.0	0.4	0.3	*	0.4	4.2	1.5	7.0
	Total	*	0.2	0.0	0.0	0.4	0.5	*	0.9	4.5	2.1	8.7

..continued

Table 2. Continued

Country	Species sought	Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	Total
						Species caught						
Spain	Cod	7.6	1.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	9.1
	Total	7.6	1.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	9.1
USSR	S H	0.7	0.3	0.2	0.0	59.7	2.3	12.5	10.6	13.0	10.3	109.6
	O G	*	*	0.0	0.0	5.0	0.8	14.2	0.7	2.0	2.5	25.4
	Her	0.3	*	0.6	0.0	6.3	0.3	1.9	52.7	8.0	3.0	73.2
	O P	0.1	*	2.6	0.0	9.3	3.2	6.9	15.3	104.4	12.2	154.0
	O F	*	*	0.0	0.0	8.2	1.2	9.7	2.0	3.0	13.4	37.6
	Total	1.3	0.4	3.4	0.0	88.6	7.9	45.1	81.3	130.5	41.4	399.8
USA	Cod	5.4	0.7	0.2	0.1	0.3	0.8	1.4	*	*	0.1	9.0
	Had	5.4	3.6	0.5	*	*	1.8	2.7	0.0	*	0.0	14.1
	Red	0.9	0.3	11.7	*	0.2	0.4	1.0	0.1	*	*	14.5
	S H	1.1	0.5	0.6	*	7.6	2.3	1.7	2.4	*	0.1	16.2
	Flo	7.7	2.9	2.0	*	1.7	32.8	5.8	0.3	0.5	0.4	54.0
	O G	1.0	0.2	0.1	0.0	0.9	2.3	6.1	0.3	0.1	0.5	11.5
	Her	0.4	0.1	0.5	0.0	2.1	0.6	0.8	27.2	0.2	*	31.9
	O P	*	0.0	0.0	0.0	*	*	*	0.1	2.1	*	2.2
	O F	0.1	*	*	0.0	*	0.1	*	0.0	0.1	3.5	3.7
	Total	21.9	8.3	15.7	0.1	12.9	41.0	19.4	30.3	3.1	4.5	157.2
GDR	O G	0.0	0.0	*	0.0	0.0	0.0	4.8	2.3	0.1	*	7.1
	Her	0.0	0.0	0.0	0.0	0.0	0.0	1.3	15.0	2.1	1.0	19.4
	O P	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.3	66.9	7.3	78.5
	O F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.6	1.8
	Total	0.0	0.0	*	0.0	0.0	0.0	7.1	20.7	69.2	9.9	106.9
Bulgaria	S H	*	*	0.0	0.0	0.3	*	*	0.2	0.2	0.1	0.8
	O G	0.0	0.0	0.0	0.0	0.6	*	1.0	0.1	0.8	0.8	3.3
	Her	*	0.0	*	0.0	0.2	*	0.2	3.5	0.2	0.6	4.7
	O P	*	0.0	*	0.0	0.7	0.1	1.4	0.7	27.3	4.7	35.0
	O F	0.0	0.0	0.0	0.0	0.2	0.1	0.1	*	0.1	0.4	1.0
	Total	*	*	*	0.0	2.0	0.3	2.7	4.6	28.5	6.7	44.8
Cuba	O F	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.7	1.1
	Total	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.7	1.1
All Countries	Cod	15.0	2.7	0.3	0.1	0.3	0.9	2.0	*	*	*	21.4
	Had	5.8	4.3	0.6	*	*	1.8	2.8	0.0	*	0.0	15.5
	Red	0.9	0.3	11.8	*	0.2	0.4	1.0	0.1	*	*	14.7
	S H	1.8	0.8	0.8	*	67.6	4.6	14.1	13.2	13.2	10.5	126.6
	Flo	7.7	2.9	2.0	*	1.7	32.8	5.8	0.3	0.5	0.4	54.0
	O G	1.7	0.5	0.2	*	6.6	3.2	28.5	3.3	3.0	3.8	50.7
	Her	0.9	0.2	1.2	0.0	8.6	1.1	5.0	261.6	28.9	13.3	320.7
	O P	0.3	0.1	2.7	0.0	10.6	3.7	9.8	32.4	305.6	35.7	400.8
	O F	0.1	*	*	0.0	8.8	1.4	11.0	2.5	4.9	25.0	53.5
	Total	34.1	12.0	19.5	0.1	104.4	49.9	79.9	313.3	355.9	88.7	1057.9

* Less than 0.1

11. STACREM Question 5 reads

What is the probable increase of fishing mortality in other Subareas, if a regulation of fishing effort is introduced in Subarea 5 and Statistical Area 6?

Assuming that fishing mortality is proportional to fishing effort, an indication of the magnitude of the surplus effort available for diversion to other areas is shown in Table 3 based on 1971 statistics of nominal catch and days fished for trawlers by ICNAF Subarea and tonnage class (lines 1-7). Line 8 gives the total nominal catches of finfish (all species less shellfish) in Subareas 1 to 4; the total

Table 3. Effort, catch and catch-per-unit-effort by subareas and tonnage classes for trawlers, standardized effort relative to OT 7 vessels, and surplus effort assuming a 25% decrease in effort in Subareas 5 and 6.

Line No.	Gear and tonnage class	Subarea 1			Subarea 2			Subarea 3			Subarea 4			Subareas 5 + 6		
		Days fished	Catch (tons)	C/f (tons)	Days fished	Catch (tons)	C/f (tons)	Days fished	Catch (tons)	C/f (tons)	Days fished	Catch (tons)	C/f (tons)	Days fished	Catch (tons)	C/f (tons)
1	OT 7	818	24,878	28.2	6816	184,262	27.0	8351	211,738	25.4	6963	253,317	36.4	13135	472,845	36.0
2	OT 6	1369	28,489	20.8	2128	43,887	20.6	6945	98,794	14.2	1966	50,862	25.9	2838	87,787	30.9
3	OT 5	262	3,557	13.6	67	1,447	21.6	8005	87,613	10.9	3838	44,159	11.5	12735	104,786	8.2
4	OT 4	193	1,664	8.6	-	-	-	10411	65,469	6.3	13685	118,586	8.7	14837	97,352	6.6
5	OT 3	-	-	-	-	-	-	282	566	2.0	11050	43,376	3.9	13056	71,697	5.5
6	OT 2	-	-	-	-	-	-	21	30	-	8812	20,825	2.4	6572	35,384	5.4
7	PT 4	1345	22,737	16.9	20	477	23.9	9689	155,507	16.0	2668	40,114	15.0	499	9,139	18.3
8	Total Catch[1] (all gears)		140,909			246,184			950,475			1,016,059			1,110,573	
9	Std. effort (days fished)	5000			9120			37420			27915			30850	25%	
10	Surplus effort relative to SA 1-4 (9.7%)	+485			+885			+3635			+2711			+7715		

[1] Excludes shellfish in all subareas and an allowance of 250,000 tons for menhaden and large pelagics in SA 5 and 6.

catch given for Subarea 5 and Statistical Area 6 is the total catch of finfish less an allowance of 250,000 tons for menhaden and large pelagics which are taken in specialized fisheries. The values of standardized fishing effort in days fished (line 9) were obtained by taking OT 7 as the standard fleet and dividing the catches (line 8) by the C/f (catch per day fished) values for OT 7 vessels (line 1). Assuming that the fishing activity in Subarea 5 and Statistical Area 6 is reduced by 25%, a value of 7,715 days fished (standard) represents the surplus effort available for diversion elsewhere. Many options for the diversion of this amount of effort are available: it might be diverted from the ICNAF Area completely, or all or part of it might be diverted in varying proportions to ICNAF Subareas 1-4. If all of the excess effort were diverted to Subareas 1-4, the total effort there would increase by approximately 10%. The values (line 9) for Subareas 1-4 (just one of an infinite number of options) are the amounts by which the standardized effort in these Subareas would increase, if the excess effort were distributed among the Subareas in the same proportions as the values given in line 9.

Calculations, taking (i) OT 6 as the standard, (ii) OT 6 + 7 as the standard, and (iii) OT 5 + 6 + 7 as the standard, gave percentage values ranging from 8.5% to 11.0%, compared with 9.7% for OT 7 as the standard.

12. STACREM Question 6 reads

If you are controlling your vessels at a level of fishing intensity lower than the one you are allowed, how can that be judged by the criterion of days on ground?

The term "fishing intensity", as used in this question, implies a somewhat different sense than that which the Group defined in its reply to STACREM Question 2. It is thought that the STACREM Question 6 raises the problem of the option which should be left to the national authorities of regulating the way in which the fishing effort allocated to them should be applied or distributed as to time and place. Consequently, it involves the definition of days on ground and it is, therefore, to be studied when considering STACREM Question 1.

In order to regulate fishing effort the following difficulty will then have to be faced: when using fishing effort quotas, considerable difficulty may be found in determining the actual days on ground because control might be based on the number of days the vessel stays in the fishing area, when, in some cases, the number of days at the fishing grounds in relation to fishing mortality may be highly variable. Furthermore, directed changes in the relation between days on ground and amount of fishing could mitigate the ability to effect desired changes in fishing mortality through regulation of days on grounds.

The Group suggested that the Coordinating Working Party on Atlantic Fishery Statistics be requested to provide a more precise definition of days on ground than that currently in use (Recommendation 4).

13. STACREM Question 8 reads

What are the opportunities for countries to increase, in response to effort control, the fishing mortality caused by one unit of fishing effort?

a) By changing the <u>time distribution</u> of its effort on a <u>given species</u> (and this may mean greater effort on the spawning stock).

b) By changing the <u>distribution</u> of its effort <u>between species</u> within a given period.

c) Employing only the <u>best skippers and crews</u> and the <u>most efficient vessels</u> within each class.

d) <u>Using most productive techniques and technology</u> that is permitted without, in the short term at least, incurring a change of class.

e) Changing working conditions and increasing spares and, perhaps, crew carried in order to <u>increase hours per day spent fishing.</u>

f) Providing improved knowledge to vessels by better communications between them and more extensive search methods which do not involve the use of fishing vessels themselves so as both to <u>reduce searching time</u> and to <u>concentrate efforts on best fishing areas.</u>

g) Using more extensively support vessels for repairs, refuelling, recrewing, etc., thereby increasing the proportion of the days spent on the grounds actually fishing.

h) Fishing in <u>weather conditions</u> which, in the absence of effort control, would be considered <u>unsafe.</u>

i) Staying on the fish available instead of searching for more suitable (usually larger) sizes, giving rise to what might be a concealed rise in the mortality rate through a rise in unreported discards as well as to a lowering of the average age of the fish caught (with the detrimental effects in the stock that this implies).

14. STACREM Question 7 reads

If both catch and effort quotas are applied to a given stock, what problems are raised in allocating between countries and within a country to ensure that the two quotas are simultaneously met?

In the view of the Group, both catch and effort quotas need not be applied where the regulatory scheme is concerned with one species only. Moreover, an effort quota need not be applied to any country which fishes for only one of the species in a multi-species scheme provided the by-catch can be limited to small proportions. It would be enough to allocate a catch quota for that species to the country concerned and to give it "nil" catch quotas for all other species.

The species catch quotas would likely be allocated to the participating countries based upon some agreed-upon historical basis. The total effort quota might be allocated in several ways, but would likely be based, in some measure, upon country catch-effort relationships which existed in the most recent time period and, of course, calibrated with the catch quotas. Because of (a) the inaccuracies and variations in the effort measurement, the distribution of effort and the mortality rates generated, (b) the opportunities for increasing fishing mortality caused by one unit of fishing effort, and (c) the fact that the effort limitation is designed to be more restrictive than the sum of the catch quotas, there would be no reason to expect that the species quotas and the effort limitation would be met simultaneously by any country or by all countries taken together. Indeed, it is the expressed intention of the proposal that effort quotas should be exhausted before all catch quotas have been fulfilled. Moreover, because of the uncertainties involved, the realization of the desired fishing mortality would be somewhat difficult.

In the opinion of the Group under this plan, those countries which fish for several species would enjoy a greater advantage, by reason of having greater flexibility in achieving their species quotas within the constraint of their effort limitation, than would those countries with fisheries directed to fewer species.

There is a variety of ways in which catch and effort quotas can be allocated within a country and each has its own problems. These are, however, matters for each country to determine for itself. Consequently, the Group feels that it should not comment on this aspect of the matter.

15. STACREM Question 9 reads

Given the present status of stocks and fishing effort in Subarea 5 and Statistical Area 6, assuming that non-member activity does not change, no new entrants arrive and the coastal state stabilizes the catches in the territorial waters outside the Convention Area at the 1972 level, what will be the situation of the stocks in those areas in the years 1974 and 1975 if appropriate catch quotas for those years for mackerel and flounders (other than yellowtail) are added to the quotas already established and the by-catch problem is taken care of by revising MSY's of the regulated species in the area at June 1972 and 1973?

The feasibility of extending catch quotas to the important species depends on both the ability to determine the biological basis for quotas on additional species and the problem of by-catch. The former can be dealt with satisfactorily only when adequate data and theory become available. The latter requires analysis of the amount and distribution of by-catch in the directed fisheries.

The 1971 ICNAF statistics were first examined to determine the feasibility of treating the pelagic and groundfish fisheries separately (Table 4), but no clear-cut distinction was found. To determine the areas where incompatibility might occur between quotas, the pattern of fishing, as shown by the 1971 fishery statistics, was projected to the 1973 quota allocations for each country (Table 5). The conclusions are summarized in Table 6. The method of calculation is outlined in Appendix VII. It should be pointed out that within the definition of by-catch used, individual fleets in their day-to-day operations have more flexibility in directing their efforts towards particular species than it appears in the monthly total catches. If this flexibility is used, it would result in overestimating the 1973 interactions.

National quotas on named species may create subsidiary catch of regulated species by countries which have no allocation. However, these subsidiary catches are allowed for in allocating the "Others" portion of the TAC and the same consideration applies to non-member countries. "Other Groundfish" and "Other Fish" categories were not considered in the summary because of lack of information for 1973. There are some fisheries under national quota allocation which do not have a by-catch problem but for other fisheries, national quota allocation would require close management of the national fishery to control subsidiary catch in order to stay within the quota. Tables 5 and 6 clearly indicate problems for some countries in the flounder and herring allocations. Examination of the total fishing pattern over all countries indicates that it would be difficult as well not to exceed the haddock quota even though it is not allocated nationally. Therefore, adjustments will have to be made in 1973 to avoid exceeding these quotas by:

1) changing fishing practices to avoid exceeding quotas on these species,
2) reducing directed fisheries for these species within national allocations,
3) not achieving the quotas on some species because of the necessity of avoiding catches of species for which quotas have been achieved.

The magnitude of the total by-catch problem over all countries can be illustrated by the simulations of 1973 catches given in Tables 7 and 8. First (Table 7), the individual species quotas were assumed to be taken in the directed fisheries for those species and the incidental catches calculated based on the 1971 overall ratios of by-catch to main species sought catch. It is obvious that significant overharvesting would occur under this regime. Second (Table 8), it was assumed that the total directed and individual catches of 1973 would be the sum of the country values as given in Table 5. The overall total exceeds the sum of the assigned quotas (or 1971 catch of 1973 unregulated fisheries) for flounder, haddock, herring, other fish and other groundfish. It takes less in the cod, redfish, silver hake, and other pelagic fisheries. This is because of the reduced by-catch due to restrictive quotas on some species. If this "underfishing" is compensated for by increased directed fisheries, then the total catch of the flounder, haddock, herring and other fish and other groundfish categories would increase, and exceed the quotas even more. (Recommendations 5 and 6)

Table 4. Distribution of catches of main species sought in 1971 in Subarea 5 and Statistical Area 6.

	Species caught								
Species sought	Cod	Had	Flo	Red	S H	O G	Her	O P	O F
Cod, Haddock, Flounder	+	+	+			+			
Silver hake	+	+	+		+	+	+	+	+
Herring						+	+	+	+
Redfish		+		+		+			
Other pelagic					+	+	+	+	+
Other groundfish					+	+	+	+	+
Other fish			+		+	+		+	+

Table 5. Simulation of 1973 catches ('000 tons) by main species sought categories for Subarea 5 and Statistical Area 6 by country.

Country	Species sought	Catch	Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	Total
Bulgaria	S H	Alloc.	*	*	-	-	0.3	*	*	0.2	0.2	0.1	0.8
		Est.	*	*	-	-	0.3	*	*	0.2	0.2	0.1	0.8
	O G	Alloc.	-	-	-	-	0.6	*	1.0	0.1	0.9	0.8	3.4
		Est.	-	-	-	-	0.6	*	1.0	0.1	0.8	0.8	3.3
	Her	Alloc.	*	-	*	-	0.2	*	0.2	3.5	0.2	0.6	4.7
		Est.	*	-	*	-	0.2	*	0.2	3.5	0.2	0.6	4.7
	O P	Alloc.	*	-	*	-	0.7	0.1	1.4	0.7	31.6	4.8	39.3
		Est.	*	-	*	-	0.8	0.2	1.6	0.8	31.6	5.5	40.5
	O F	Alloc.	-	-	-	-	0.2	0.1	0.1	0.1	0.1	0.4	1.0
		Est.	-	-	-	-	0.2	0.1	0.1	0.1	0.1	0.4	1.0
	Total	Alloc.	*	-	*	-	2.0	0.2	2.7	4.6	33.0	6.7	49.2
		Est.	*	-	*	-	2.1	0.3	2.9	4.7	32.9	7.4	50.3

.. continued

Table 5. Continued

Country	Species sought	Catch	Species caught: Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	Total
Canada	Cod	Alloc.	2.7	0.4	*	*	-	0.1	0.4	-	-	-	3.6
		Est.	2.7	1.0	0.1	*	-	0.2	0.5	-	-	-	4.4
	Had	Alloc.	0.5	0.3	0.1	*	-	0.1	0.2	-	-	-	1.2
		Est.	0.2	0.3	*	*	-	*	0.1	-	-	-	0.6
	Red	Alloc.	*	*	0.2	*	-	*	*	-	-	-	0.2
		Est.	0.1	*	0.2	*	-	*	0.1	-	-	-	0.4
	O G	Alloc.	0.9	0.2	0.1	*	-	*	2.3	-	-	-	3.5
		Est.	0.6	0.3	*	*	-	*	2.3	-	-	-	3.3
	Her	Alloc.	-	-	-	-	-	-	-	9.1	-	-	9.1
		Est.	-	-	-	-	-	-	-	9.1	-	-	9.1
	O P	Alloc.	-	-	-	-	-	-	-	-	22.5	-	22.5
		Est.	-	-	-	-	-	-	-	-	22.5	-	22.5
	Total	Alloc.	4.1	0.9	0.4	0.1	-	0.2	2.9	9.1	22.5	-	40.1
		Est.	3.6	1.6	0.3	*	-	0.2	3.0	9.1	22.5	-	40.3
Cuba	O F	Alloc.	-	-	-	-	0.3	-	-	-	0.1	0.7	1.1
		Est.	-	-	-	-	0.3	-	-	-	0.1	0.7	1.1
	Total	Alloc.	-	-	-	-	0.3	-	-	-	0.1	0.7	1.1
		Est.	-	-	-	-	0.3	-	-	-	0.1	0.7	1.1
Ger(FR)	Her	Alloc.	*	*	-	-	-	-	0.6	32.6	1.5	*	34.7
		Est.	*	*	-	-	-	-	0.4	32.6	0.7	-	33.7
	O P	Alloc.	-	-	-	-	-	-	-	-	2.0	-	2.0
		Est.	-	-	-	-	-	-	-	-	2.0	-	2.0
	Total	Alloc.	*	*	-	-	-	-	0.6	32.6	3.5	*	36.7
		Est.	*	*	-	-	-	-	0.4	32.6	2.7	*	35.7
GDR	O G	Alloc.	-	-	*	-	-	-	4.8	2.3	0.1	*	7.1
		Est.	-	-	*	-	-	-	4.8	2.3	0.1	*	7.1
	Her	Alloc.	-	-	-	-	-	-	1.3	15.0	2.1	1.0	19.4
		Est.	-	-	-	-	-	-	1.3	15.0	2.1	1.0	19.4
	O P	Alloc.	-	-	-	-	-	-	1.0	3.3	66.9	7.3	78.5
		Est.	-	-	-	-	-	-	1.0	3.3	66.9	7.3	78.5
	O F	Alloc.	-	-	-	-	-	-	-	0.1	0.1	1.6	1.8
		Est.	-	-	-	-	-	-	-	0.1	0.1	1.6	1.8
	Total	Alloc.	-	-	*	-	-	-	7.1	20.7	69.2	9.9	106.9
		Est.	-	-	*	-	-	-	7.1	20.7	69.2	9.9	106.9
Japan	Her	Alloc.	*	*	*	-	*	*	*	1.2	*	*	1.2
		Est.	*	*	*	-	*	*	*	1.2	-	*	1.2
	O P	Alloc.	-	-	-	-	*	*	0.3	*	3.6	*	3.9
		Est.	-	-	-	-	*	*	0.3	*	3.6	*	3.9
	O F	Alloc.	*	-	*	-	*	-	1.2	*	0.1	4.9	6.2
		Est.	*	-	*	-	*	-	1.2	-	0.1	4.9	6.2
	Total	Alloc.	-	-	-	-	-	-	1.5	1.2	3.7	4.9	11.3
		Est.	-	-	-	-	-	-	1.5	1.2	3.7	4.9	11.2
Poland	Her	Alloc.	0.2	-	-	-	-	-	0.1	42.2	19.4	8.1	70.0
		Est.	0.1	-	-	-	-	-	0.1	42.2	9.4	4.5	56.3
	O P	Alloc.	0.2	-	0.1	-	0.1	-	0.2	7.1	110.4	9.9	128.0
		Est.	0.1	-	0.1	-	0.1	-	0.2	14.6	110.4	11.5	137.0
	O F	Alloc.	-	-	-	-	-	-	*	*	*	0.4	0.4
		Est.	-	-	-	-	-	-	*	0.3	0.1	0.4	0.8
	Total	Alloc.	0.4	-	0.1	-	0.1	-	0.3	49.3	129.8	18.4	198.4
		Est.	0.2	-	0.1	-	0.1	-	0.3	57.1	119.9	16.4	194.1

Table 5. Continued

Country	Species sought	Catch	Species caught: Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	Total
Romania	S H	Alloc.	-	-	-	-	*	*	-	-	-	-	*
		Est.	-	-	-	-	*	*	-	-	-	-	*
	Her	Alloc.	-	0.1	-	-	-	0.2	*	0.7	1.2	0.5	2.7
		Est.	-	0.2	-	-	-	0.3	*	0.7	0.4	0.8	2.4
	O P	Alloc.	*	*	-	-	0.4	0.3	*	0.6	18.8	1.6	21.7
		Est.	*	0.3	-	-	1.8	1.3	0.1	1.8	18.8	6.8	30.9
	Total	Alloc.	*	0.1	-	-	0.4	0.5	*	1.3	20.0	2.1	24.4
		Est.	*	0.5	-	-	1.8	1.6	0.1	2.5	19.2	7.6	33.3
Spain	Cod	Alloc.	5.8	0.7	-	-	-	-	0.2	-	-	-	6.7
		Est.	5.8	1.0	-	-	-	-	0.2	-	-	-	7.0
	Total	Alloc.	5.8	0.7	-	-	-	-	0.2	-	-	-	6.7
		Est.	5.8	1.0	-	-	-	-	0.2	-	-	-	7.0
USA	Cod	Alloc.	7.2	0.4	0.4	0.1	1.3	0.9	1.4	*	0.1	0.1	11.9
		Est.	7.2	1.0	0.3	0.1	0.4	1.1	1.9	*	*	0.1	12.0
	Had	Alloc.	7.2	1.8	0.8	*	0.1	2.0	2.7	-	*	-	14.6
		Est.	2.7	1.8	0.3	*	*	0.9	1.3	-	*	-	7.0
	Red	Alloc.	1.1	0.1	18.3	*	0.9	0.5	1.0	*	*	*	21.9
		Est.	1.3	0.5	18.3	*	0.3	0.7	1.5	0.1	*	*	22.7
	S H	Alloc.	1.4	0.2	1.0	*	30.3	2.5	1.7	2.0	0.4	0.1	39.6
		Est.	4.2	1.9	2.5	*	30.3	8.9	6.6	9.5	0.2	0.3	64.4
	Flo	Alloc.	10.2	1.4	3.1	*	6.6	36.5	5.8	0.3	4.0	0.4	68.3
		Est.	8.6	3.2	2.2	*	1.9	36.5	6.4	0.4	0.5	0.4	60.2
	O G	Alloc.	1.3	0.1	0.2	-	3.6	2.6	6.1	0.2	0.9	0.5	15.5
		Est.	0.9	0.2	0.1	-	0.9	2.3	6.1	0.3	0.1	0.5	11.4
	Her	Alloc.	0.5	0.1	0.8	-	8.5	0.7	0.8	22.5	2.0	*	35.9
		Est.	0.3	*	0.4	-	1.8	0.5	0.6	22.5	0.2	*	26.3
	O P	Alloc.	*	-	-	-	0.2	*	*	0.1	17.8	*	18.1
		Est.	*	-	-	-	0.4	0.2	0.1	0.5	17.8	*	18.9
	O F	Alloc.	0.1	*	*	-	*	0.1	*	-	0.9	3.5	4.6
		Est.	0.1	*	*	-	*	0.1	*	-	0.1	3.5	3.7
	Total	Alloc.	29.0	4.1	24.6	0.1	51.5	45.7	19.4	25.1	26.2	4.5	230.4
		Est.	28.1	10.5	24.3	0.1	36.0	52.1	25.9	33.3	18.9	4.8	233.9
USSR	S H	Alloc.	1.7	0.2	0.2	0.0	68.7	0.9	12.5	6.3	14.8	10.3	115.6
		Est.	0.9	0.0	0.2	0.0	68.7	2.7	14.3	12.2	15.0	11.9	126.2
	O G	Alloc.	0.1	*	0.0	0.0	5.8	0.3	14.2	0.4	2.3	2.5	25.6
		Est.	0.1	0.0	0.0	0.0	5.1	0.8	14.2	0.7	2.0	2.5	25.4
	Her	Alloc.	0.7	*	0.8	0.0	7.3	0.1	1.9	31.2	9.1	3.0	54.1
		Est.	0.2	0.0	0.4	0.0	3.7	0.2	1.2	31.2	4.8	1.7	43.4
	O P	Alloc.	0.3	*	3.4	0.0	10.7	1.2	6.9	9.1	118.4	12.2	162.2
		Est.	0.1	0.0	3.0	0.0	10.5	3.7	7.8	17.4	118.4	13.9	174.8
	O F	Alloc.	0.1	*	0.0	0.0	9.5	0.5	9.7	1.2	3.4	13.4	37.8
		Est.	0.0	0.1	0.0	0.0	8.3	1.2	9.7	2.0	3.0	13.4	37.7
	Total	Alloc.	2.9	0.2	4.5	0.0	102.0	3.0	45.1	48.2	148.0	41.4	395.3
		Est.	1.2	0.4	3.6	0.0	96.3	8.6	47.2	63.5	143.2	43.4	407.5

* Less than 0.1

Table 6. Quota allocations for 1973 (+) and species for which the quota in Subarea 5 and Statistical Area 6 is exceeded when the national fleet is managed to obtain the quota of the named species according to the 1971 pattern of fishing (e.g. under cod, both Canada and USA would exceed their flounder allowances).

Country	Cod	Had	Flo	Red	S H	O G	Her	O P	O F
Bulgaria								+	
Canada	+ Flo		+	+		+	+	+	
Denmark									
France									
FRG						+	+	+	
Ice									
Italy									
Japan							+		
Norway									
Poland	+			+			+	+ Her	
Portugal									
Romania			+				+	+ Her	
Spain	+					+			
USSR	+		+	+	+ Her Flo	+ Her	+ Flo	+ Her Flo	
UK									
USA	+ Flo		+ Her	+ Her Flo	+	+	+	+	

Table 7. 1973 quotas[1] ('000 tons) for Subarea 5 and Statistical Area 6 with associated by-catch if "quotas" are all caught in the directed fisheries.

Species sought		Species caught (finfish only) Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	Total
Cod	Catch	45.0	8.2	0.8	0.2	0.1	2.7	5.9	<.1	<.1	0.2	63.3
Had	Catch	8.1	6.0	0.8	<.1	<.1	2.5	3.9	0.0	<.1	0.0	21.5
Red	Catch	2.2	0.8	30.0	<.1	0.5	1.1	2.6	0.1	0.0	<.1	37.4
S H	Catch	4.6	2.0	2.0	0.0	170.0	11.6	35.5	33.2	33.2	26.4	318.4
Flo	Catch	12.0	4.5	3.1	0.0	2.6	51.0	9.0	0.5	0.7	0.6	84.0
O G	Catch	4.6	1.4	0.4	0.1	18.4	9.0	80.0	9.4	8.3	10.7	142.5
Her	Catch	0.5	0.2	0.7	0.0	5.8	0.7	3.3	175.0	19.2	8.9	214.4
O P	Catch	0.5	0.0	4.2	0.0	16.4	5.6	15.0	49.8	470.0[2]	55.0	616.6
O F	Catch	0.3	0.2	0.0	0.0	31.7	5.0	39.7	8.8	17.5	90.0	193.0
Total	Catch	77.8	23.3	42.0	0.3	245.5	89.2	194.9	276.8	548.9	191.8	1691.1
	%	100	100	100	100	100	100	100	100	100	100	
Catch/Quota		1.73	3.88	1.40	3.00	1.44	1.75	2.44	1.58	1.17	2.13	
Quota (1973)		45.0	6.0	30.0	0.1	170.0	51.0	80.0	175.0	470.0	90.0	1117.0
Catch minus Quota		-32.8	-17.3	-12.0	-0.2	-75.5	-38.2	-114.9	-101.8	-78.9	-101.8	-574.0

[1] 1971 catches used where no quotas exist.
[2] Mackerel quota of 450,000 tons increased to 470,000 to account for total other pelagic.

Table 8. Simulated 1973 catches based on 1971 catches and 1973 quotas summed over (A) all Member Countries and (B) all Member and Non-member Countries.

	Species sought	Catch	Species caught										Total
			Cod	Had	Red	Hal	S H	Flo	O G	Her	O P	O F	
A.	Cod	Alloc.	15.7	1.5	0.4	0.1	1.3	1.0	2.0	*	0.1	0.1	22.2
		Est.	15.7	1.5	0.4	0.1	0.4	1.3	2.6	*	*	0.1	22.1
	Had	Alloc.	7.7	2.1	0.9	*	0.1	2.1	2.9	-	*	-	15.8
		Est.	2.9	2.1	0.3	*	*	0.9	1.4	-	*	-	7.6
	Red	Alloc.	1.7	0.1	18.4	*	0.9	0.5	1.0	*	*	*	22.6
		Est.	1.3	0.5	18.4	*	0.3	0.7	1.5	0.1	*	*	22.8
	S H	Alloc	3.1	0.4	1.2	*	99.3	3.4	14.2	8.5	15.4	10.5	156.0
		Est.	5.1	2.2	2.7	*	99.3	11.6	20.9	21.9	15.4	12.3	191.4
	Flo	Alloc.	10.2	1.4	3.1	*	6.6	36.5	5.8	0.3	4.0	0.4	68.3
		Est.	8.6	3.2	2.2	*	1.9	36.5	6.4	0.4	0.5	0.4	60.1
	O G	Alloc.	2.3	0.3	0.3	*	10.0	2.9	23.6	0.7	4.1	3.8	48.0
		Est.	1.5	0.5	0.1	*	6.6	3.1	23.6	1.1	2.9	3.8	43.2
	Her	Alloc.	1.4	0.2	1.6	-	16.0	1.0	3.6	143.0	33.4	12.2	212.4
		Est.	0.6	0.2	0.8	-	5.7	1.0	2.5	143.0	15.7	7.6	177.1
	O P	Alloc.	0.2	*	3.5	-	12.1	1.6	8.8	17.6	325.1	28.5	397.4
		Est.	0.2	0.3	0.4	-	13.6	5.4	10.1	35.1	325.1	37.7	427.9
	O F	Alloc.	0.1	*	*	-	9.7	0.7	11.0	1.3	4.5	22.6	49.9
		Est.	0.1	*	*	-	8.5	1.4	9.9	2.4	3.4	22.6	48.3
	Total	Alloc.	42.4	6.0	29.4	0.1	156.0	49.7	72.9	171.4	386.6	78.1	992.6
		Est.	36.0	10.5	25.3	0.1	136.3	61.9	78.9	204.0	363.0	84.5	1000.5
	Quota (1973)		42.7	6.0	29.5	0.1	153.5	49.3	72.9	166.7	383.2	78.1	
	Quota minus Est.		+6.7	-4.5	+4.2	0.0	+17.2	-12.6	-6.0	-37.3	+20.2	-6.4	
B.	Cod	Alloc.	15.7	1.5	0.4	0.1	1.3	1.0	2.0	*	0.1	0.1	22.2
		Est.	15.7	3.0	0.4	0.1	0.4	1.3	2.6	*	*	0.1	23.6
	Had	Alloc	7.7	2.1	0.9	*	0.1	2.1	2.9	-	*	-	15.8
		Est.	2.9	2.1	0.3	*	*	0.9	1.4	-	*	-	7.6
	Red	Alloc.	1.7	0.1	18.4	*	0.9	0.5	1.0	*	*	*	22.6
		Est.	1.3	0.5	18.4	*	0.3	0.7	1.5	0.1	*	*	22.8
	S H	Alloc.	3.1	0.4	1.2	*	99.3	3.4	14.2	8.5	15.4	10.5	156.0
		Est.	5.1	2.2	2.7	*	99.3	11.6	20.9	21.9	15.4	12.3	191.4
	Flo	Alloc.	10.2	1.4	3.1	*	6.6	36.5	5.8	0.3	4.0	0.4	68.3
		Est.	8.6	3.2	2.2	*	1.9	36.5	6.4	0.4	0.5	0.4	60.1
	O G	Alloc.	2.3	0.3	0.3	*	10.0	2.9	28.4	3.0	4.2	3.8	55.2
		Est.	1.5	0.5	0.1	*	6.6	3.1	28.4	3.4	3.0	3.8	50.4
	Her	Alloc.	1.4	0.2	1.6	-	16.0	1.0	4.9	158.0	33.6	12.8	229.5
		Est.	0.6	0.2	0.8	-	5.7	1.0	3.8	158.0	17.8	8.6	196.5
	O P	Alloc.	0.5	*	3.5	-	12.1	1.6	9.8	20.9	392.0	35.8	476.2
		Est.	0.2	0.3	0.4	-	13.6	5.4	11.1	38.4	392.0	45.0	506.4
	O F	Alloc.	0.1	*	*	-	10.0	0.7	11.0	1.4	4.7	24.9	52.8
		Est.	0.1	*	*	-	8.8	1.4	9.9	2.5	3.6	24.9	51.2
	Total	Alloc.	42.7	6.0	29.4	0.1	156.3	49.7	80.0	192.1	454.0	88.3	1098.6
		Est.	36.0	12.0	25.3	0.1	136.6	61.9	80.0	224.7	432.3	95.1	1110.0
	Quota (1973)		45.5	6.0	30.0	0.1	170.0	51.0	80.0	175.0	450.0	88.3	
	Quota minus Est.		+9.5	0.0	+4.7	0.0	+33.4	-10.9	-6.0	-49.7	+17.7	-6.8	

* Less than 0.1

16. STACREM Question 10 reads

Could STACRES look into the question of further regulating mesh size and minimum size of fish in Subarea 5?

Much of the data required to determine the effects of further mesh size regulation may not be readily available. However, certain generalized effects could be determined from data at hand, and advice from STACRES on this question would be useful. It is understood that this advice should be related to the problem of by-catch - both as to the effect on yields of the small fish in the by-catch and the possible alleviation of such effects by mesh regulation.

CARDOSO QUESTIONS

17. CARDOSO Question 1

Could the fishing power coefficients be taken off continuous curves of tonnage which would take into account horsepower, winch power, fishing aids and type of fishing (fresh or frozen)?

For most countries, the information currently available to estimate fishing power coefficients is based on monthly catch and effort data reported by ICNAF tonnage class and ICNAF statistical divisions (or subdivisions where applicable). These data enable the computation of catch-per-unit-effort values by month for each tonnage and gear class of vessel and for each ICNAF division. In cases where "Main Species" is reported, the Cpue's can be calculated for each "Main Species" separately. These Cpue values represent the average performance of the group of vessels within the particular tonnage classes. However, their use for estimation of fishing power would involve inaccuracy owing to the need to assume the vessels fished on the same stock/area with~~in~~ the division.

For most, if not all, countries similar data should be available in logbooks of individual vessels, and Cpue values could be computed for individual vessels of varying tonnages with each ICNAF tonnage class. If this were done, curves could be drawn showing the relationship between Cpue and tonnage and the variance in Cpue could be estimated for any point on the curve. The Group felt that this could best be achieved by national research studies based on detailed knowledge of the activities of the national fleet (Recommendation 7).

18. CARDOSO Question 2

How was the learning factor calculated?

Recorded days fished of the first two years in a fishery by a gear/tonnage class/country were adjusted by a learning function in order to make one day of fishing in the early years in a fishery equivalent to one day of fishing in the third and later years. This was done by estimating what the catch per effort of a gear/tonnage class/country should be had the catch per effort followed the abundance indices recorded by *Albatross IV* for the species concerned, and then adjusting the recorded catch per effort of a fleet to follow the trend of the abundance index. The first year in a fishery was taken to be the first year a fleet recorded twenty percent of its total catch in a particular fishery. Learning was found to be completed by the third year in the fishery. In determining the rate of learning, learning was assumed to increase exponentially with time.

The data used in estimating the rate of learning were as follows:

Species	Subarea	Country	Gear/Tonnage Class	Years
Herring	5Z	Poland	OtSt, 1800+ MT	1966, 1967
Herring	5Z	Romania	OtSt, 1800+ MT	1967, 1968
Cod	5Z	Spain	OtSi, 501-900 MT	1964, 1965
Silver hake	5Z	USSR	OtSi, 501-900 MT	1964, 1965
Silver hake	5Z	USSR	OtSi, 151-500 MT	1963, 1965

These cases (Fig. 6) were used since only they provided sound basis for analysis. Following estimation of the rate of learning, data for other fleets (Table 9) were adjusted using the procedure and rate of learning developed from the above data base. The actual model used is given below. In using this model, learning was considered completed when changes in commercial catch per unit effort paralleled the survey index.

Table 9. Country/gear/tonnage class categories where effort was adjusted for learning.

Species	Subareas 5Y Country	5Y Gear	5Y Tonnage Class	5Y Years Adjusted	5Z Country	5Z Gear	5Z Tonnage Class	5Z Years Adjusted	6 Country	6 Gear	6 Tonnage Class	6 Years Adjusted
Herring	Germany (FR)	OtSt	901-1800	1969, 70	Germany (FR)	OtSt	901-1800	1967, 68	Poland	OtSt	501-900	1968, 69
		OtSt	1801+	1969, 70		OtSt	1801+	1967, 68		OtSt	1800+	1968, 69
	United States	Purse Seine	51+	1965,66	Non-Mbr	OtSt	1801+	1965, 66	USSR	OtSi	151-500	1967, 68
					Poland	OtSi	501-900	1967, 68		OtSi	501-900	1969, 70
						OtSt	901-1800	1967, 68				
						OtSt	1801+	1966, 67				
					Romania	OtSt	1801+	1967, 68				
					USSR	OtSi	151-500	1963				
						OtSi	501-900	1962, 64				
						OtSt	1800+	1961, 62				
						Purse Seine	50+	1968, 69				
						D. Gill Nets	All	1961, 62				
Cod	Spain	Pair Trawl	151-500	1969, 70	Spain	Pair Trawl	151-500	1964, 65				
Haddock					USSR	OtSi	501-900	1965, 66				
Silver Hake					USSR	OtSi	151-500	1963, 65				
						OtSi	501-900	1964, 65				
						OtSt	1800+	1962, 63				
Mackerel					Poland	OtSi	501-900	1969, 70	Poland	OtSi	501-900	1969, 70
						OtSt	1800+	1968, 69		OtSt	1800+	1970, 71
					Romania	OtSt	1800+	1969, 70	USSR	OtSi	151-500	1968, 70
					USSR	OtSi	151-500	1969, 70		OtSi	501-900	1969, 70
						OtSi	501-900	1969, 70		OtSt	1800+	1970, 71

An exponential learning model was assumed thus:

$$\frac{X_i}{Z_i} = [\exp\ (a*i)]\ *e_i$$

where

$$Z_i = X_0 \left(\frac{Y_i}{Y_0}\right),$$

X_i = the observed commercial catch per unit effort in the i^{th} year in the fishery after entrance,

Y_i = the stock abundance in the same year, and

e_i = residual error, where $\ln(e_i)$ has a $N(0, \sigma^2)$ distribution.

Where the catch of a given species was between 20% and 80%, effort was prorated on the basis of the catch and when the catch exceeded 80%, the entire effort was considered to be directed towards that species. The curve was fitted to the logged data by least squares (Fig. 6). It is apparent that learning has been completed by the third year in the fishery (year two after entrance). The parameter a was estimated from all data combined to be 0.70 with an index of determination of 0.82 (proportion of the variation due to regression). (Recommendation 8)

19. CARDOSO Question 3

How was the increase of total effort from 1971 to 1972 calculated?

The United States conducts airplane overflights of the fishing grounds on, generally, a bi-weekly basis. Fishing vessels are identified as to type and also, as far as possible, to individual vessels. These data were summed to estimate vessel days using the assumption that if a vessel was observed during a week, it was present on the grounds for the entire seven days. These data were expanded to a 1972 total using a relationship between days observed and days reported to ICNAF in 1971.

20. CARDOSO Question 4

Could we have data separation on state of stocks, fishing mortality and fishing effort in waters within and outside the Convention Area, as was done for other Subareas?

The Group noted that the USA agreed to make the necessary data available prior to the June 1973 meeting.

RECOMMENDATIONS

21. The Group agreed that the following recommendations be presented to STACREM:

<u>Rec. 1</u> *That Member Countries consider the relative importance of the factors listed in Table 1 and any other factors which would be relevant, and provide comments and revisions for consideration at the June 1973 Annual Meeting (Ref. MANAGEMENT OPTIONS Section 6).*

<u>Rec. 2</u> *That Member Countries analyze their data on "days on ground" and "days fished" and provide estimates of the variance associated with conversion factors obtained from the ratio of days on ground to days fished (Ref. STACREM Question 1).*

<u>Rec. 3</u> *That Member Countries consider the magnitude of the errors associated with factors involved in setting a fishing effort regulation by*

a) estimating variance of the conversion coefficients for 1971,
b) examining the relative Cpue for 1970 and 1971 with a view to determining the possible effects of vessel class within and between gear, years and species,
c) examining the seasonal and area components of variation by the technique of mean ratio versus ratio of the means,
d) estimating the variance of the catchability coefficient q.

(Ref.STACREM Question 3).

<u>Rec. 4</u> *That the CWP (Coordinating Working Party on Atlantic Fishery Statistics) be requested to provide a more precise definition of days on ground than that currently in use (Ref. STACREM Question 6).*

<u>Rec. 5</u> *That Member Countries in their statistical submissions to ICNAF provide*

a) more refined data on the species composition of catches, thus reducing significantly the quantities reported as "species not specified", and
b) more detailed catch and effort data on "main species", thus reducing significantly or eliminating the records for which the "main species" is currently reported as "mixed", and enabling more refined estimates of "by-catch" to be obtained.

(Ref. STACREM Question 9).

<u>Rec. 6</u> *That Member Countries analyze the more detailed data in national archives (logbook records) to estimate more precisely the by-catch and species interaction for 1971 and subsequent years (Ref. STACREM Question 9).*

<u>Rec. 7</u> *That Member Countries undertake studies, using detailed information contained in the logbooks of individual vessels, of the fishing power coefficients of national fleets (Ref. CARDOSO Question 1).*

<u>Rec. 8</u> *That Member Countries undertake analyses of historical data on the fishing activity of their fleets in relation to the determination of learning factors associated with the development of fisheries in the various Subareas or on the various stocks (Ref. CARDOSO Question 2).*

<u>Rec. 9</u> *That, since considerable analyses remain to be done, necessary steps be taken to convene another session of the Group just prior to the June 1973 Annual Meeting of the Commission (Ref. Section 22).*

ADJOURNMENT

22. The Group agreed that, while substantial progress was made during the period allotted for the meeting, considerable analyses remained to be completed and studied. The Group agreed that steps should be taken to convene another session just prior to the June 1973 Annual Meeting of the Commission (Recommendation 9).

23. The Chairman thanked the participants for their interest and contributions. The excellent facilities and hospitality provided by the National Marine Fisheries Service Laboratory and personnel and the Marine Biological Laboratory were recognized by the Executive Secretary on behalf of the participants and the Commission.

24. The meeting adjourned at 1800 hours, 30 March 1973.

Special Meeting of Experts on Effort Limitation
Woods Hole, Massachusetts, 26-30 March 1973

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Questions posed by STACREM regarding details of effort regulation
FAO, Rome, Italy, 24 January 1973

1. What are the conversion factors needed to obtain "days on ground" from "days fished" for the various Member Countries? Do countries collect the necessary information to answer this question and, if not, how long will it take to collect the necessary data?

2. Please define exactly the following terms:

   (a) fishing mortality
   (b) fishing intensity
   (c) fishing power
   (d) fishing effort

   and specify what are the variables that should be discussed for effort control.

3. The Commission is attempting to control the fishing mortality on the resources and fishing mortality is an abstract quantity which cannot be regulated directly. The Commission may be able to control fishing mortality by regulation of fishing intensity or fishing effort. What is the accuracy with which these quantities can be measured and what is the error involved in using them as a predictor of future fishing mortality?

4. If catch quotas are set for several species which imply different percentage reductions in fishing mortality, what problems does this raise in connection with a fixed reduction in fishing effort, especially for countries only interested in some species?

5. What is the probable increase of fishing mortality in other Subareas, if a regulation of fishing effort is introduced in Subarea 5 and Statistical Area 6?

6. If you are controlling your vessels at a level of fishing intensity lower than the one you are allowed, how can that be judged by the criterion of days on ground?

7. If both catch and effort quotas are applied to a given stock, what problems are raised in allocating between countries and within a country to ensure that the two quotas are simultaneously met?

8. What are the opportunities for countries to increase in response to effort control the fishing mortality caused by one unit of fishing effort?

9. Given the present status of stocks and fishing effort in Subarea 5 and Statistical Area 6, assuming that non-member activity does not change, no new entrants arrive and the coastal state stabilizes the catches in the territorial waters outside the Convention Area at the 1972 level, what will be the situation of the stocks in those areas in the years 1974 and 1975 if appropriate catch quotas for those years for mackerel and flounders (other than yellowtail) are added to the quotas already established and the by-catch problem is taken care of by revising MSY's of the regulated species in the area at June 1972 and 1973?

10. Could STACRES look into the question of further regulating mesh size and minimum size of fish in Subarea 5?

Special Meeting of Experts on Effort Limitation
Woods Hole, Massachusetts, 26-30 March 1973

Agenda

I. Opening

II. Election of Chairperson

III. Approval of Agenda

IV. Program of Work (Report of STACREM, Circular Letters 73/17, 73/23)

- A. Definition of terms (STACREM Q. 2)
- B. Problems related to by-catch
    1. Measurement
    2. Relation to directed fishery (STACREM Q. 9)
    3. Assessment of effects of fishing (STACREM Q. 9, 10)
- C. Fishing effort
    1. Factor involved in
        - i) Changes in performance with time (STACREM Q. 3, 8)
        - ii) Inter-calibration of gear (STACREM Q. 1, 3, 6)
    2. Methods of measurement and data requirements (STACREM Q. 1, 3, 6)
- D. Methods of control of catch and effort
    1. Practical and economic problems in application (STACREM Q. 4, 5, 6, 7)
    2. Minimization of by-catch (STACREM Q. 10)
    3. Reporting requirements
    4. Enforcement

V. Other Matters (Cardoso Questions 1-4)

VI. Report

Note on definition of fishing mortality and exploitation rate

Fishing mortality is the mortality generated by fishing, inside a certain group of fish. That group of fish will usually be a stock (of one single species) but can also be a different group, as for example, a single year-class within that stock, age group, sex group, etc.

Natural mortality is the mortality generated by causes other than fishing inside a certain group of fish.

Mortality is the proportion or percentage (in terms of numbers of the fish or members of the group in question) that would be killed by the corresponding cause within the unit of time chosen. This unit of time might be instantaneous or finite. If finite, it may be one hour, one month or, as generally used, one year. Although easily understood when one chooses a finite interval of time, the notion will, for other reasons, be difficult to grasp, as we will see further on.

The instantaneous fishing mortality is the proportion of a stock removed by fishing at that instant during the infinitesimal interval of time dt. During that infinitesimal period of time the stock size or abundance N (number of fish in the stock) may be considered to remain at N and suffer then an infinitesimal change dN. The proportion of stock removed is then dN/N. Consequently, instantaneous fishing mortality, F, is

$$F = \frac{-dN}{N} \cdot \frac{1}{dt} \tag{1}$$

The negative sign only denotes that dN is a quantity removed, not added, during the instantaneous interval dt.

Expression (1) can easily be integrated, assuming no other cause of mortality, if we consider that instantaneous mortality does not vary with time:

$$F = \frac{-dN}{N} \cdot \frac{1}{dt} \qquad -Fdt = \frac{dN}{N} \qquad -Ft = \log N + \text{Constant}$$

When $t = 0$, Constant $= -\log N_0$

Thence, $-Ft = \log N - \log N_0$

and

$$e^{-Ft} = \frac{N}{N_0} \tag{2}$$

which shows that, if F is a constant, the abundance of the stock (i.e., the number of fish in the stock) decreases as a result of fishing with time and mortality in an exponential manner.

If we apply the definition already given, to a finite interval of time, if C is the catch during that interval of time Δt,

$$F_{\Delta} = \frac{C}{\overline{N}} \cdot \frac{1}{\Delta t} \tag{3}$$

where $\overline{N}$ is the mean value of the number of fish N in the stock during the period Δt, taking into account all the gains or losses occurred due to any motive during that period.

Because of all variation causes, N varies with t, so that $N = f(t)$. Then, if $\Delta t = t_1 - t_0$,

$$\overline{N} = \frac{\int_{t_0}^{t_1} f(t)dt}{t_1 - t_0} \tag{4}$$

This expression shows that it is impossible to determine F_{Δ} due to fishing if you do not know the variation of N due to all other causes of mortality during the interval of time considered. It also shows that if a fleet takes 20% of the fish that exists on the grounds fished at the time of fishing, two equal fleets will not take double the amount of fish of one fleet but something less. This is due to the so-called competition between the sources of mortality.

With one fleet operating with a mortality of 20%, we will have approximately

$$F_{\Delta} = \frac{1/2 \cdot 20\%(N_0 + 80\%\ N_0)}{1/2\ (N_0 + 80\%\ N_0)} = 20\%$$

which in relation to N_0 means that the fleet caught approximately

$$1/2 \cdot 20\%(N_0 + 80\%\ N_0) = 18\%\ N_0$$

With two fleets, we will have approximately:

$$F_{\Delta} = \frac{1/2 \cdot 20\%(N_0 + 60\%\ N_0) + 1/2 \cdot 20\%(N_0 + 60\%\ N_0)}{1/2\ (N_0 + 60\%\ N_0)} = 40\%$$

which in relation to N_0 means the fleets caught approximately:

$$10\%\ N_0(1 + 60\%) + 10\%\ N_0(1 + 60\%) = 20\%\ N_0(1 + 60\%) = 32\%\ N_0.$$

Because of the difficulties pointed out, it is far more practical to work with instantaneous fishing mortality and use expression (2). It is customary to designate the fishing mortality coefficient as F. If the time interval is of one unit:

$$N_{t+1} = N_t \cdot e^{-F} \qquad (5)$$

It is obvious that mortality coefficients can be added together and simply multiplied by time units. The most common time unit, as we already said, is one year.

Under identical assumptions, but taking into consideration the natural mortality, defining instantaneous natural mortality in an identical manner, one obtains:

$$N_{t+1} = N_t e^{-(F+M)} \qquad (6)$$

$$N_t = N_0 e^{-(F+M)t} \qquad (7)$$

where M is the natural mortality coefficient. The sum (F+M) which corresponds to the mortality generated both by fishing and all other causes is designated by:

$$Z = F + M \qquad (8)$$

where Z is the total mortality coefficient. From expression (7), it follows that

$$\frac{N_t}{N_0} = e^{-(F+M)t} \qquad \text{and} \qquad N_0 - N_t = N_0 - N_0 e^{-(F+M)t}$$

Hence,

$$\frac{N_0 - N_t}{N_0} = [1 - e^{-(F+M)t}] \qquad (9)$$

which allows an easy calculation of the percentage of fish naturally dying, or fished, or naturally dying and fished, if certain values of mortality coefficients apply.

The following table is an example of the results of that calculation:

Line No.	Total mortality coefficient	Number of time units	Percentage of fish dying
1	0.10	1	10
2	0.10	2	18
3	0.20	1	18
4	0.20	2	33
5	0.40	1	33
6	0.70	1	50
7	1.00	1	63
8	1.50	1	78

It follows from the above table (line 5) that if F = 0.20 and M = 0.20, then, within one year, 33% of the fish will die. In this example, half the total mortality is due to fishing, the other half to other causes. If there had been no fishing mortality, 18% would have died of other sources inside the period regarded (line 3) and not 16-1/2%.

The ratio between numbers of fish removed due to fishing and total numbers of fish dying is referred to as the exploitation rate, denoted by E,

$$E = \frac{F}{F+M} = \frac{F}{Z} . \qquad (10)$$

If F = 0.20 and M - 0.20, then E = 0.5.

Notes on terminology used in fishery assessment

by

Captain J.C.E. Cardoso
Portugal

1. Fishing power of a vessel with a certain equipment, master and crew, working on a certain density of fish of a certain stock, in a certain area of the grounds, at a certain moment, is defined as the amount (weight or number) of fish caught by the vessel per unit fishing time at that moment.

$$FP = \frac{C}{T} \qquad (1)$$

where C is the catch, i.e., the number of fish caught by the vessel in the area, divided by fishing time T. The term C/T is therefore a function of (vessel, equipment, master and crew, density of fish, location of area, season, weather and stock).

Density of fish is defined as the amount (weight or number) of fish of that stock existing in the area per unit volume of water V.

$$\delta = \frac{N}{V} \qquad (2)$$

where N is the number of fish in the volume V.

It is obvious that fishing power of a vessel can only be constant when equipment, master and crew, density of fish, location, occasion, stock are all constant and well determined.

Fishing power may also be defined for a fishing gear. In such a case, if the gear sweeps or encircles a certain volume of water, as the density of fish N/V is a constant, to that volume corresponds the number of fish N which will be caught. That is, in such a case, there is a simple relation of scale between the volume swept V_s and C. Fishing power of the gear may then be defined as

$$FP = \frac{V_s}{T} \qquad (3)$$

where V_s is the volume of water swept by the gear per unit fishing time T, assuming all the parameters mentioned to be constant.

2. Relative fishing power of one vessel (or gear) with a certain equipment (accessories), master and crew, on a certain density of fish, of a certain stock, in a certain area of the grounds, at a certain moment, is the ratio of its corresponding fishing power and the fishing power of a reference or standard vessel (gear) with a certain equipment (accessories), master and crew, operating in the same density of fish of the same stock, in the same area, at the same moment.

$$RFP_1 = \rho_1 = \frac{C_1/T_1}{C_0/T_0} \qquad (4)$$

where C_1 is the catch taken by vessel 1 in fishing time T_1, and C_0 is the catch taken by the reference vessel 0 in fishing time T_0.

It is generally assumed that RFP, once properly determined, i.e., with all fixed necessary parameters, will remain constant even when some or many of these parameters differ.

3. Fishing effort exerted by a fishing vessel or gear is the product of its relative fishing power and its fishing time.

$$X_1 = \rho_1 T_1 \qquad (5)$$

This expression enables the fishing effort of different vessels to be measured in the same unit of effort. It is obvious that the measure of fishing effort is really relative to the reference vessel used to determine ρ_1 and, strictly speaking, is only valid for the parameters fixed to determine ρ.

It is often necessary to determine the total fishing effort exerted by n vessels over an area A.

This will be:

$$X_i = \sum_{i=1}^{i=n} \rho_i T_i \qquad (6)$$

where the total sum of the efforts exerted by vessels 1 to n in the area is calculated. This concept may still be applied to a larger area, where it is known that different densities of fish in the stock apply. This will be considered next when we deal with fishing intensity.

4. Fishing intensity, applied on a stock in a certain area A during the interval of time Δt, is the total fishing effort applied in the area per unit of area and unit of time.

$$\tilde{f} = \frac{\sum_{i=1}^{i=n} X_i}{A \cdot \Delta t} = \frac{\sum_{i=1}^{i=n} \rho_i T_i}{A \cdot \Delta t} \qquad (7)$$

When one is dealing with large areas, it is important to define effective overall fishing intensity:

$$f = \frac{\Sigma \delta \tilde{f}}{\Sigma \delta} \qquad (8)$$

which is a weighted average of the values of fishing intensities applied in different part-areas of the total area considered, δ being the densities of fish occurring in the different part-areas.

Some confusion occurs sometimes between the concept of fishing intensity and fishing effort. This arises because it is many times practical, and usually done, to work with annual values and take the year as the unit of time. In the same manner, if you take the area under study as the unit of area, then fishing intensity is equivalent to fishing effort.

5. Basic relationship between fishing mortality and fishing effort. It is assumed in fisheries that

$$F = qf \qquad (9)$$

The instantaneous fishing mortality in an area on a stock is directly proportional to the effective overall fishing intensity in the area on the stock. If it is assumed that the density of fish and intensity of fishing do not vary significantly within the area, the effective overall fishing intensity will be approximately equal to $\tilde{f}$ or the average of $\tilde{f}$, the fishing intensity. However, as previously explained, in practical population dynamics work, $F \equiv X$. Consequently,

$$F = q\tilde{f} = qX \qquad (10)$$

6. Catchability coefficient. From expression (10) is is easily seen that

$$q = \frac{F}{X} \qquad (11)$$

Consequently, q is the instantaneous fishing mortality induced in the area per unit of fishing effort.

If we introduce the notion that $\frac{dN}{dt} = -FN$, and set $X = 1$ and $dt = 1$, we can then write

$$q = -\frac{dN}{N} \qquad (12)$$

The catchability coefficient in the area is the proportion of stock removed per unit of fishing effort. Applying the notion of a standard vessel, $\rho = 1$, we can state that the catchability coefficient in the area is the proportion of stock removed per unit fishing time of the standard vessel.

7. Catchability coefficient of a ship. In the case of n vessels fishing the same stock in the reference unit area, we can write, from expression (7):

$$F = qX = q \left(\sum_{i=1}^{i=n} X_i \right) \qquad (13)$$

Since fishing mortality coefficients F are additive, we can write:

$$F = \sum_{i=1}^{i=n} F_i = q \sum_{i=1}^{i=n} X_i = q \sum_{i=1}^{i=n} \rho_i T_i = \sum_{i=1}^{i=n} q\rho_i T_i \qquad (14)$$

If we call $$q\rho_i = q_i \qquad (15)$$

we have $$F = \sum_{i=1}^{i=n} F_i = \sum_{i=1}^{i=n} q_i T_i \qquad (16)$$

and consequently $$F_i = q_i T_i \qquad (17)$$

Hence, q_i, the <u>catchability coefficient of a ship</u> fishing in the reference unit area, is the proportion of the stock removed per unit fishing time of that vessel.

8. <u>Relation between fishing power, catchability coefficient and catch per unit fishing time of a vessel.</u> When we have several vessels during the unit year fishing the same stock in the reference unit area, we can average the stock size over the unit year and take it as the unit of stock, which means $\overline{N} = 1$. In such a case, it is evident that the catchability coefficient of a ship is equal to its fishing power and the fishing mortality induced by it.

$$F_i = \frac{dN_i}{1} \times 1 = \frac{C_i}{1} = FP_i = q_i \times 1 \qquad (18)$$

And as we consider that the stock is constant, we have from expression (18):

$$\frac{FP_2}{FP_1} = \frac{C_2/\overline{N}}{C_1/\overline{N}} = \frac{C_2}{C_1} = \frac{F_2}{F_1} = \frac{q_2}{q_1} \qquad (19)$$

which means that the ratio of the fishing power of two vessels is equal to the ratio of the catch per unit fishing time of these vessels.

One should mention that it is common to call the catch per unit fishing time of a vessel cpue (catch per unit effort). This is a slight inexactitude of language resulting from the fact that in absolute for that vessel, a unit time of fishing is a unit of effort, although this vessel may be efficient enough so that one unit of its fishing time may correspond to more than one unit of fishing effort measured in standard units of fishing effort.

9. <u>Mortality of a stock in terms of catch per year of the vessels fishing the stock.</u> From expression (16) we have seen that $F = F_1 + F_2 + \ldots\ldots + F_n$

which can be written $$F = F_1 + F_1\frac{F_2}{F_1} + \ldots\ldots + F_1\frac{F_n}{F_1} \qquad (20)$$

From (19) we conclude that $F = F_1 + F_1\frac{C_2}{C_1} + \ldots\ldots + F_1\frac{C_n}{C_1}$

or $$F = F_1 \left(1 + \frac{C_2}{C_1} + \ldots\ldots \frac{C_n}{C_1}\right)$$

or $$F = q_1 T_1 \left(1 + \frac{C_2}{C_1} + \ldots\ldots \frac{C_n}{C_1}\right) \qquad (21)$$

where F is the instantaneous fishing mortality of a stock of average size $\overline{N}$, during the year, as a result of fishing by a fleet of vessels when the mortality induced by the standard vessel is q_1T_1 and this vessel in that year caught C_1 tons of fish and the other vessels C_2, C_3 ..... C_n tons.

Notes on regulation of total fishing effort and the problem of by-catches

by

Captain J.C.E. Cardoso

Let n_i be the quantity of species n caught as a by-catch of the fishery on species i and n_n the amount of species n caught in the direct fishery of n.

The total quantity of species n fished is $\sum_{i=1}^{i=n} n_i$

The total quantity of all species of fish caught is $\sum_{n=1}^{n=n} \sum_{i=1}^{i=n} n_i$

Two points must be stressed:

a) The concepts of fishing effort and fishing intensity only have scientific value when applied to one definite area and one definite stock and the more restricted the stock (e.g. age group of a definite population) and the area, the greater the possible accuracy.

b) The simple relationship, $F = qf$, will, in many cases, hot hold for several stocks in a large area. For example, it could actually be possible to increase f in an area while reducing F. If increased, f were applied to predator stocks only, thus reducing their numbers, the total number of all fishes in the area might be increased.

It would not be scientifically correct to translate $\sum_{n=1}^{n=n} \sum_{i=1}^{i=n}$ into fishing effort from one year to another. Also in the relationship of one variable to another, many assumptions have to be made which are, in turn, affected by the variability of the parameters.

Let us assume that it is possible with sufficient acçuracy to estimate the conversion of $\sum_{n=1}^{n=n} \sum_{i=1}^{i=n} n_i$ into total fishing effort X, based on historical data. To show that maintaining fishing effort at X has a very low probability of maximizing the sustained catch from the fisheries while allowing proper conservation of the stocks. Let us consider, for simplicity, a binary biomass consisting only of two stocks, stock 1 and stock 2. Using the notation previously suggested, we would consider the following yearly catches:

Catch of direct fishery on 1 is 1_1		2_1 is by-catch of 2 in fishery 1
By-catch of 1 in fishery 2 is 1_2		2_2 is catch of direct fishery on 2
Totals	$1_1 + 1_2$	$2_1 + 2_2$
Overall total	$\underbrace{1_1 + 1_2 \quad + \quad 2_1 + 2_2}$	

Assuming that there is a limitation on maximum catch of stock 1 and that catches on stock 2 are not limited, that I is the maximum sustainable yield for stock 1 and that the maximum catch allowed is I, then for maximization and conservation, $1_1 + 1_2 = I$. But, if there is no limit on 2 and the by-catches of 1 in fishery 2 are important, increasing the catch of 2 will increase 1_2 rapidly. In other words, it is impossible to regulate fishery 1 with a limitation on 1 only. In fact, by increasing 2 without limit, stopping the direct fishery for 1 may not be enough to conserve 1 since 1_2 may become larger than I. If the problem of the by-catch is severe, without fishing for 1, 1_2 may exceed I even before 2_2 reaches its maximum sustainable yield. This is really the argument put forward to justify the necessity of imposing a total fishery effort regulation. However, the argument only proves that in order to regulate I you will have to regulate 2 also. In fact, a total fishery effort regulation may be inadequate to solve the problem.

Another point is that fisheries with large by-catches are not desirable from a conservation point of view, and that the by-catches 1_2 and 2_1 may be quite large with no allocation of fishing effort. In other words, by-catches are catches in which the main assumption, $F = qf$, which allows mortality to be controlled by control of fishing effort, breaks down. It may immediately be concluded that the problem of by-catches can be solved by a careful consideration of maximum allowable catches and an intelligent regulation of indiscriminate fishing, but cannot, in principle, be solved by regulation of fishing effort while respecting the tenets of conservation of stocks at maximum possible yields.

To limit total effort at some arbitrary low level may or may not solve the problem of by-catches, but cannot certainly either lead to maximization of catches or guarantee the conservation of stocks. Assuming that it is possible to convert correctly 1_1 to effort X_1 and 2_2 to effort X_2, then 1_2 and 2_1 in practice correspond to zero fishing effort.

If now an arbitrary limit L is set on total effort, this limit, if "correctly" set, should correspond to the catch, $1_1 + 1_2 + 2_1 + 2_2$.

It is immediately obvious that, when converting $1_1 + 1_2 + 2_1 + 2_2$ into effort as a "lump" stock, the resulting effort could never equal $X_1 + X_2$ since the relationship F to f in stock 1 is different from that applying in stock 2 and either of those two relationships different from that applying in the hypothetical "lump" stock 1 + 2. Thus, arbitrarily or "correctly" calculated, we may always write

$$L = X_1 + X_2 \pm \varepsilon$$

where ε is a positive quantity equal to the absolute value of the difference or error in L relative to $X_1 + X_2$. Since there is a limitation of catch in stock 1, it is now obvious that the termination of fishing on that stock will not coincide with the X_1 effort. This is because X_1 corresponds correctly only to the component 1_1 of the catch in stock 1 while, all the time, another component 1_2 is being added as a result of fishing stock 2 at a rate that has nothing to do with the relation between 1_1 and X_1. If 1_2 is accumulated at a faster rate than 1_1, X_1 will not be fully spent by the time $I = 1_1 + 1_2$ is caught, and vice-versa.

Assuming that I has been caught at the end of application of effort $X_1^1 = X_1 \pm \varepsilon_1$, then the effort available to catch stock 2 will be $L - X_1^1 = X_1 + X_2 \pm \varepsilon - X_1 \pm \varepsilon_1 = X_2 \pm \varepsilon \pm \varepsilon_1$. The effort necessary to catch $II = 2_1 + 2_2$ will similarly be $X_2^1 = X_2 \pm \varepsilon_2$, so that, if stock 2 is to be properly regulated, $X_2 \pm \varepsilon \pm \varepsilon_1 = X_2 \pm \varepsilon_2$ or $\pm \varepsilon \pm \varepsilon_1 \pm \varepsilon_2 = 0$.

If this condition is not fulfilled, stock 2 will not be properly regulated and unless the regulation curtails drastically the fishing time available to fish stock 1 and especially stock 2, as 2 is not regulated, stock 1 will not be regulated either, because as we have seen, with important by-catches, one stock cannot be properly regulated if the other is not.

It is our contention that the condition $\Sigma\varepsilon = 0$, in which the errors ε are so difficult to estimate and control, proves that, especially in a multi-species fishery, total effort regulation will either prohibit maximization of yield or else will not secure proper conservation of stock of species threatened by the existence of large by-catches of those species as a result of fisheries for other species.

It is, therefore, maintained that in a multi-species fishery, total effort regulation may, because of the abundance of one large stock Y, allow a large total effort. This large effort will have a catastrophic result if diverted to an unregulated species Z or be harmful to regulated species R due to by-catches in the fishery on Y alone or on R.

Calculation of projected 1973 catches in Tables 5 and 6

The projected 1973 catches were calculated as follows:

(1) For each country the 1971 catch statistics in Table 5 of the ICNAF Statistical Bulletin were categorized by main species sought by the Assessments Subcommittee (see Table 2). The annual percentage catch distribution of each species caught over the main species sought fisheries was calculated.

(2) The percentage of the species in by-catch to the main species sought within each fishery was calculated for 1971.

(3) The 1973 species quotas or 1971 catches for species or groups of species where no quotas are assigned were partitioned over fisheries on the basis of the percentages as calculated in (1) above and called the allocated catch[1].

(4) The estimated by-catch for 1973 was calculated by applying the percentages in (2) above to the "allocated" directed catch to give a 1973 "estimated" catch (Table 5). The main conclusions are summarized in Table 6.

(5) Where the "estimated" catch exceeded the "allocated", the consequence is overharvest unless there is a change in fishing patterns. Where it is lower than the allocated catch, the result would be an underharvest unless there is an increase in directed effort (with accompanying increased by-catch).

(6) The country values were then summed both for Member Countries only and for Member and Non-Member Countries to illustrate the overall situation (Table 8).

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[1] Haddock was adjusted for the reduced quota. The mackerel quota was used for the other pelagics.

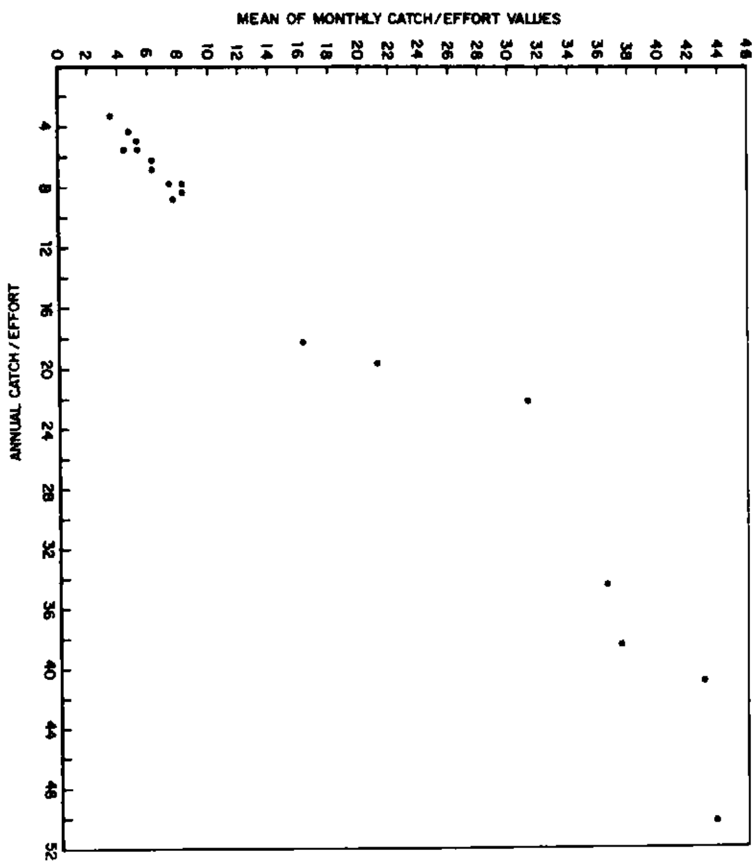

Fig. 3. Annual catch per effort vs mean monthly catch per effort for various tonnage classes, types, nationalities of otter trawlers fishing in ICNAF Subarea 5 and Statistical Area 6 in 1971.

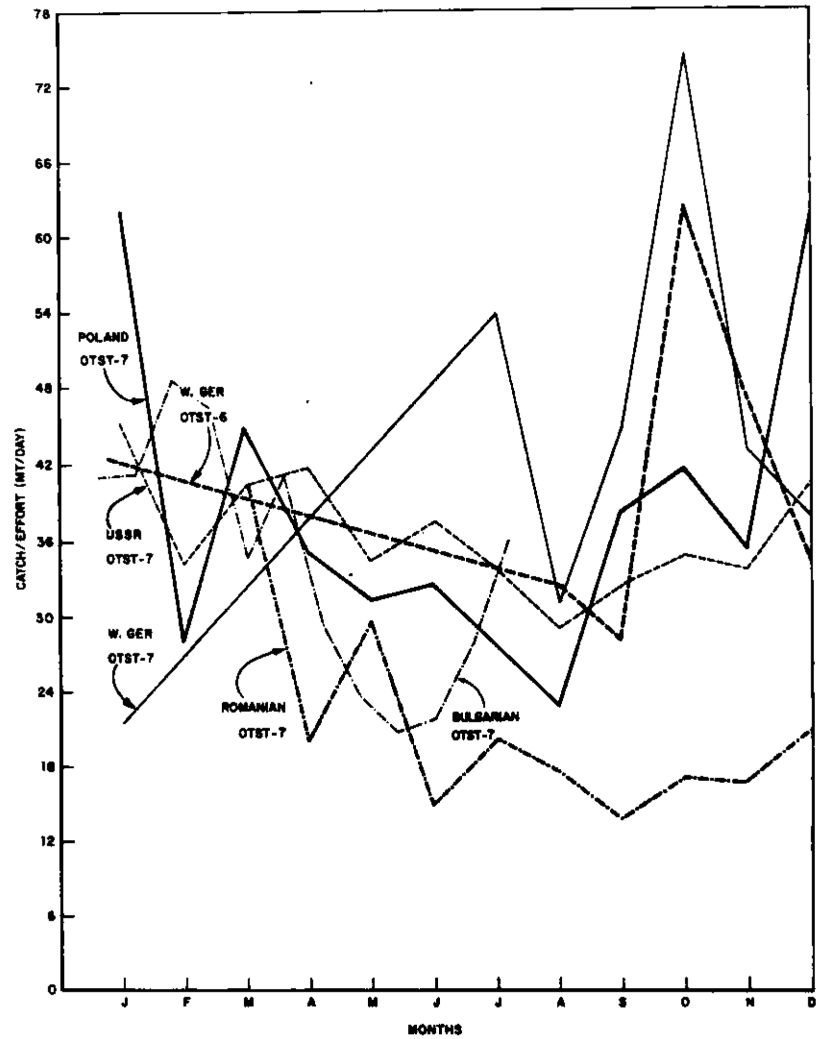

Fig. 4A(1). Monthly catch per unit effort for 1971 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

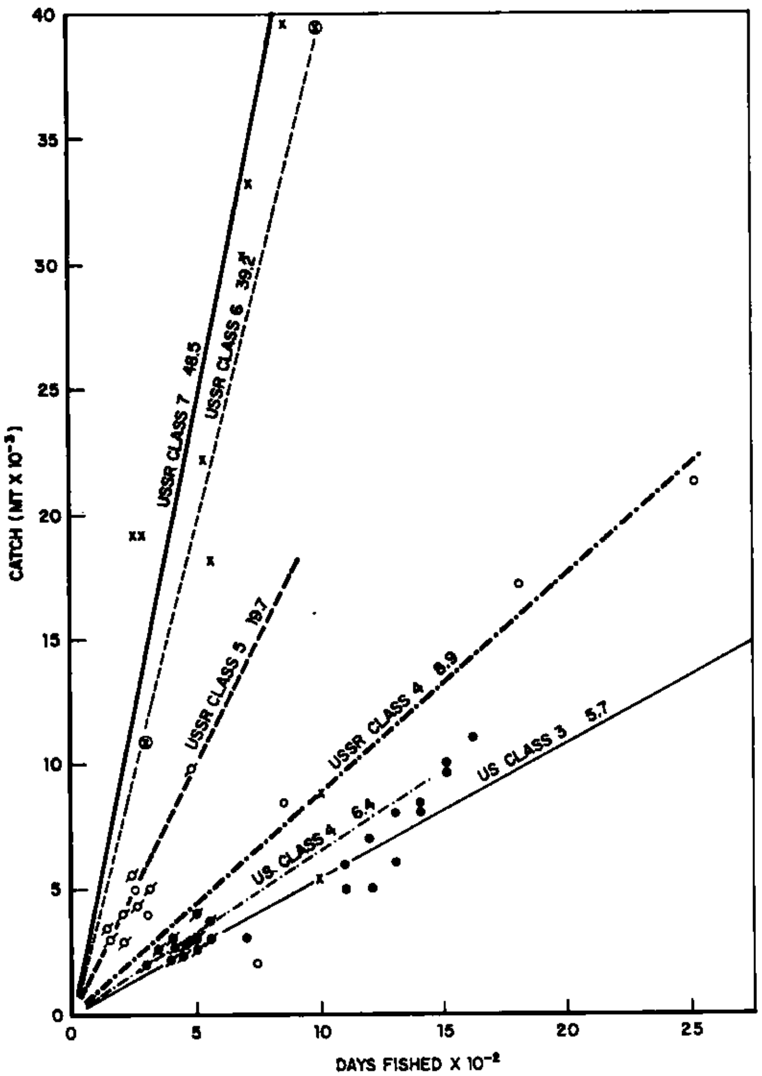

Fig. 1. Plot of total monthly catch against effort for Div. 5Z, 1957 (data from Table 4, ICNAF Statistical Bulletin).

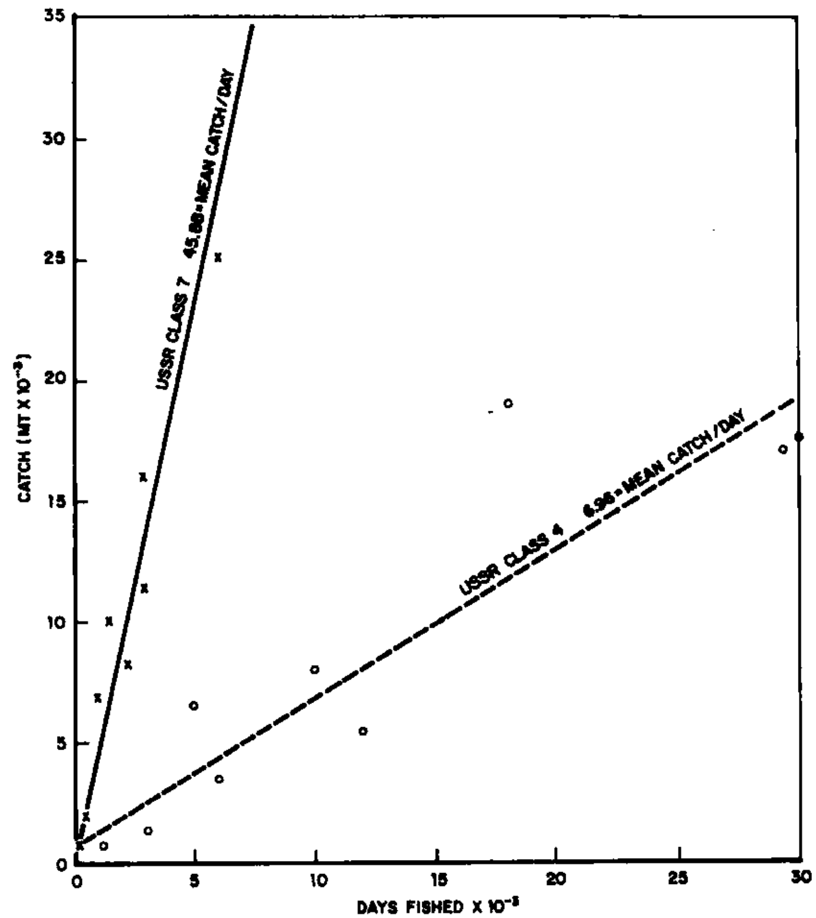

Fig. 2. Plot of total monthly catch against effort for Div. 5Z, 1958 (data from Table 4, ICNAF Statistical Bulletin).

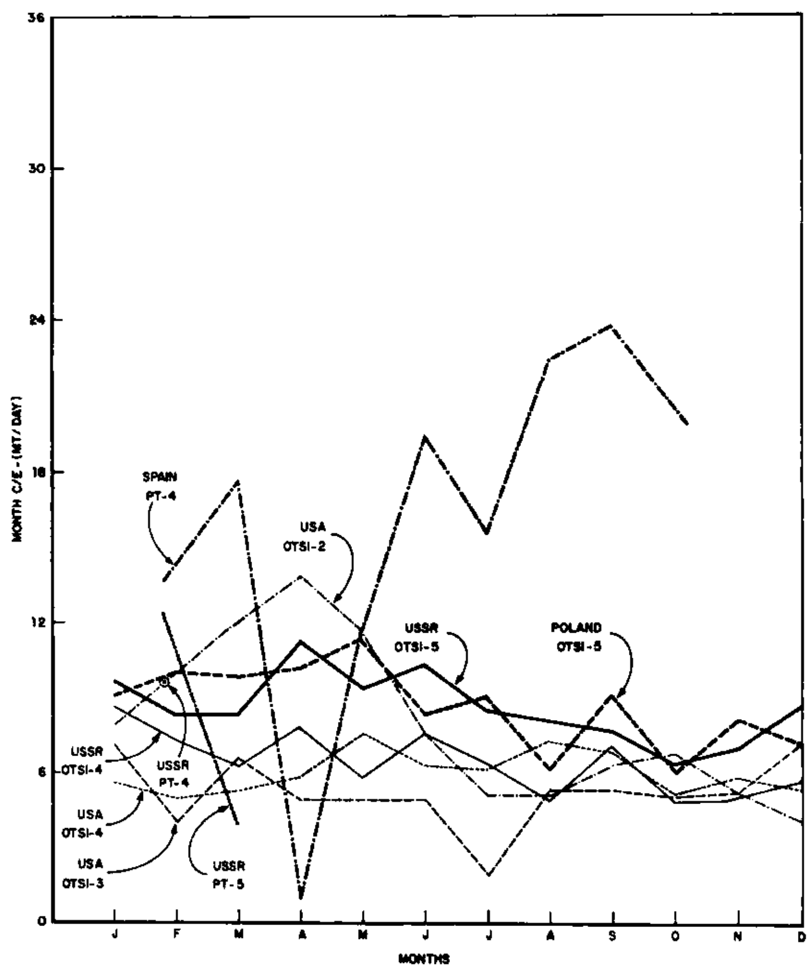

Fig. 4B(2). Monthly catch per unit effort for 1970 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

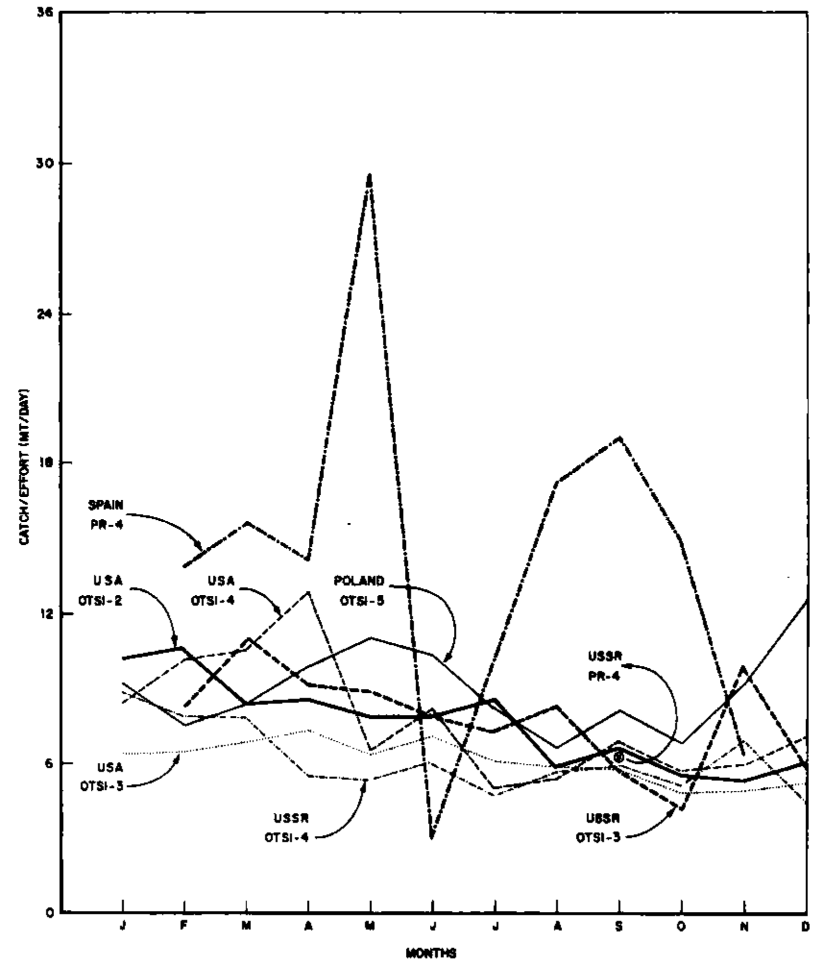

Fig. 4C(1). Monthly catch per unit effort for 1969 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

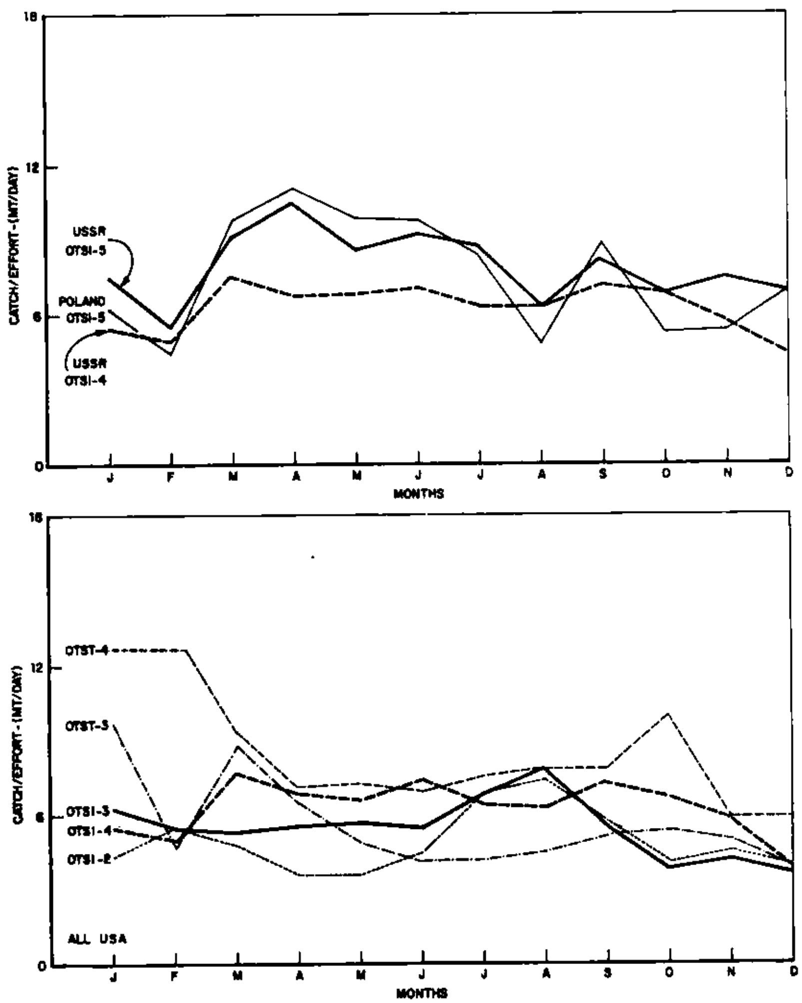

Fig. 4A(2). Monthly catch per unit effort for 1971 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

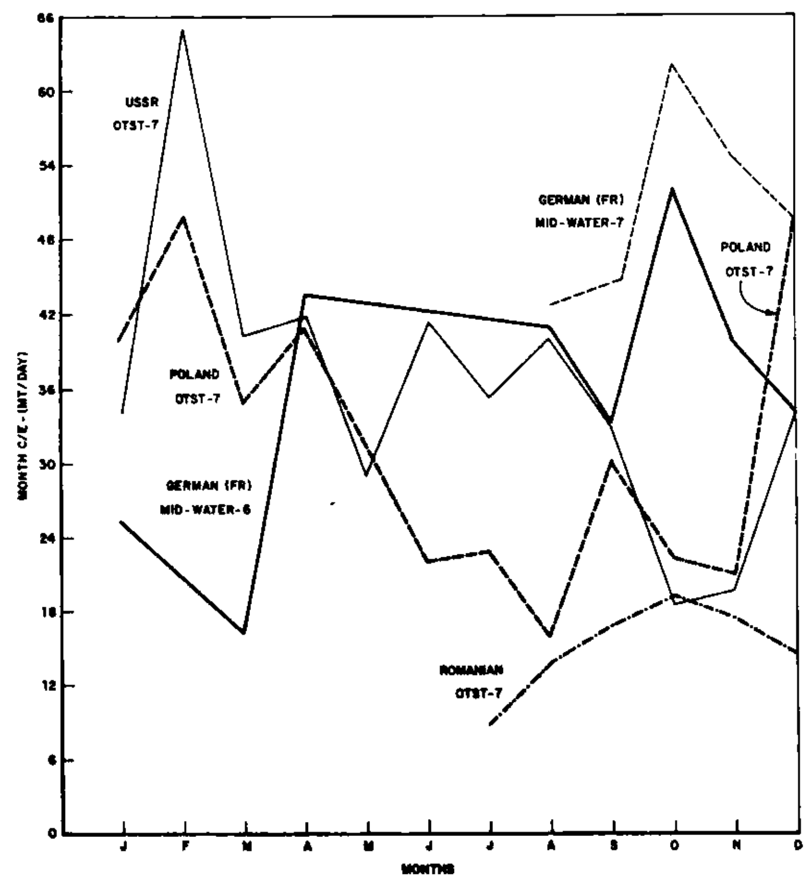

Fig. 4B(1). Monthly catch per unit effort for 1970 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

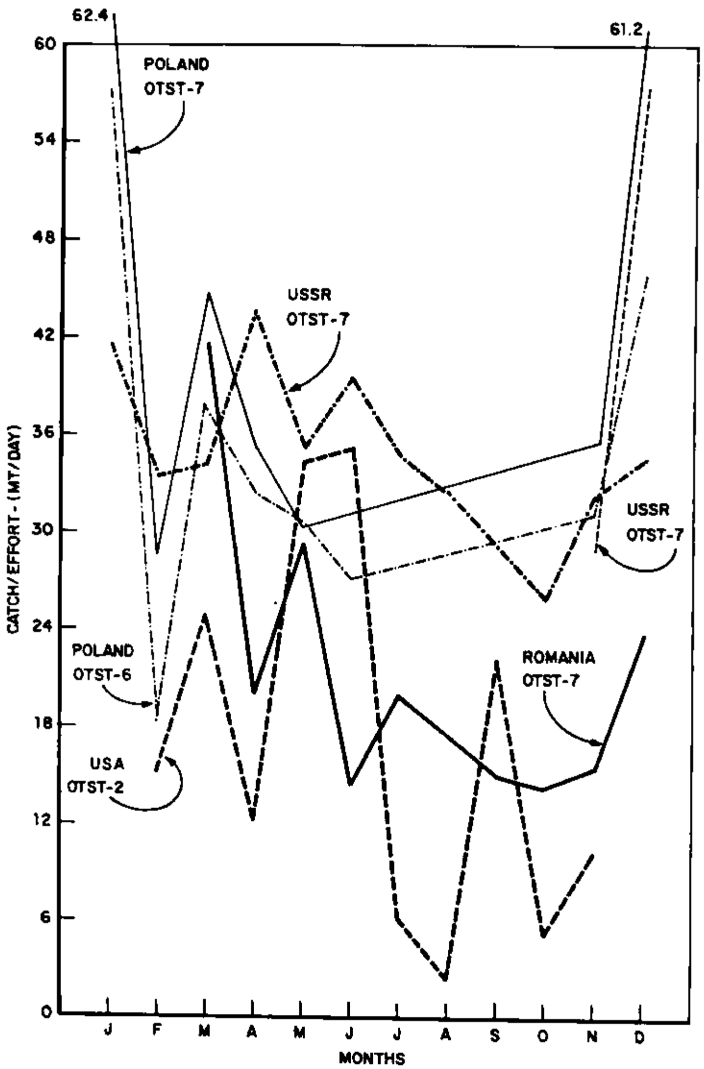

Fig. 5A(2). Monthly catch per unit effort for 1971 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.

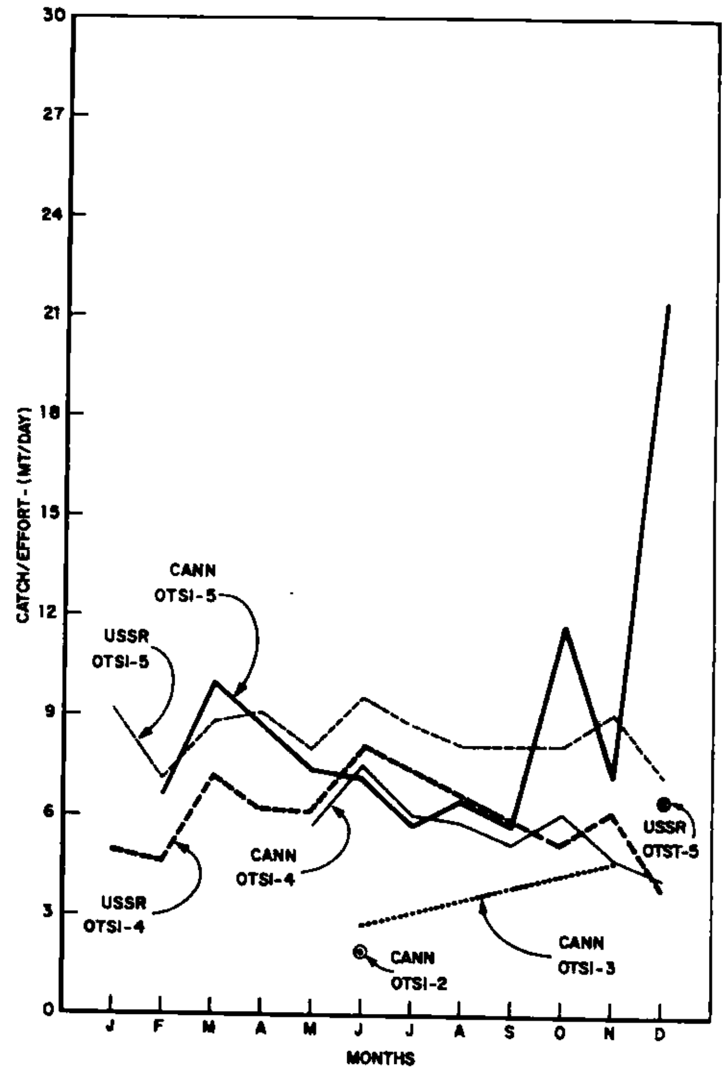

Fig. 5A(3). Monthly catch per unit effort fcr 1971 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.

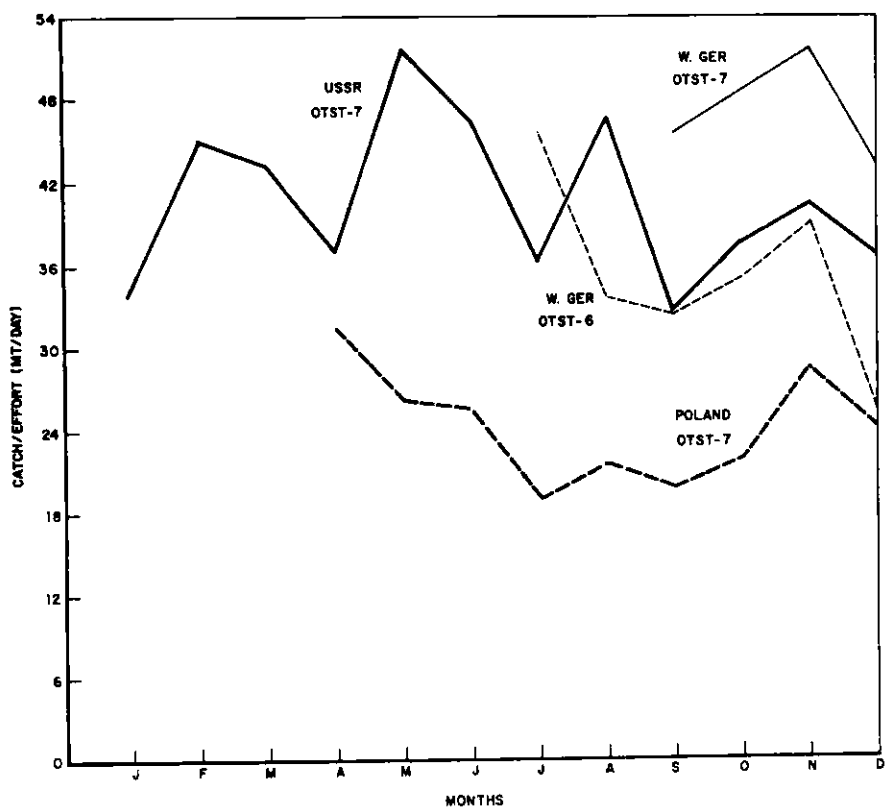

Fig. 4C(2). Monthly catch per unit effort for 1969 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6.

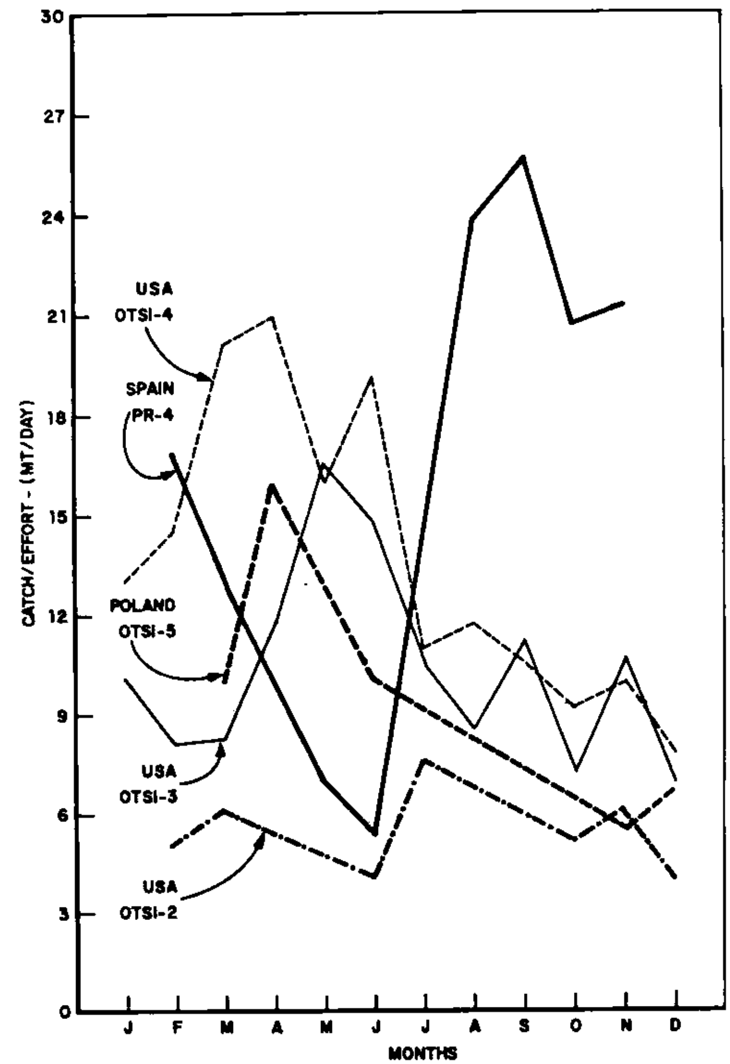

Fig. 5A(1). Monthly catch per unit effort for 1971 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.

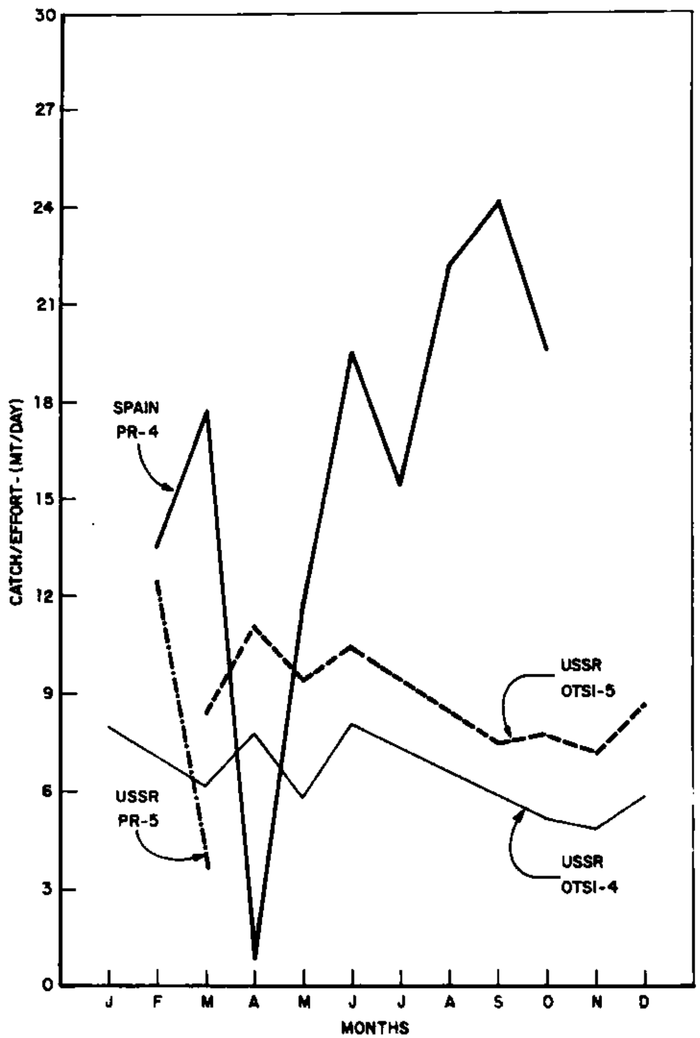

Fig. 5B(3). Monthly catch per unit effort for 1970 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.

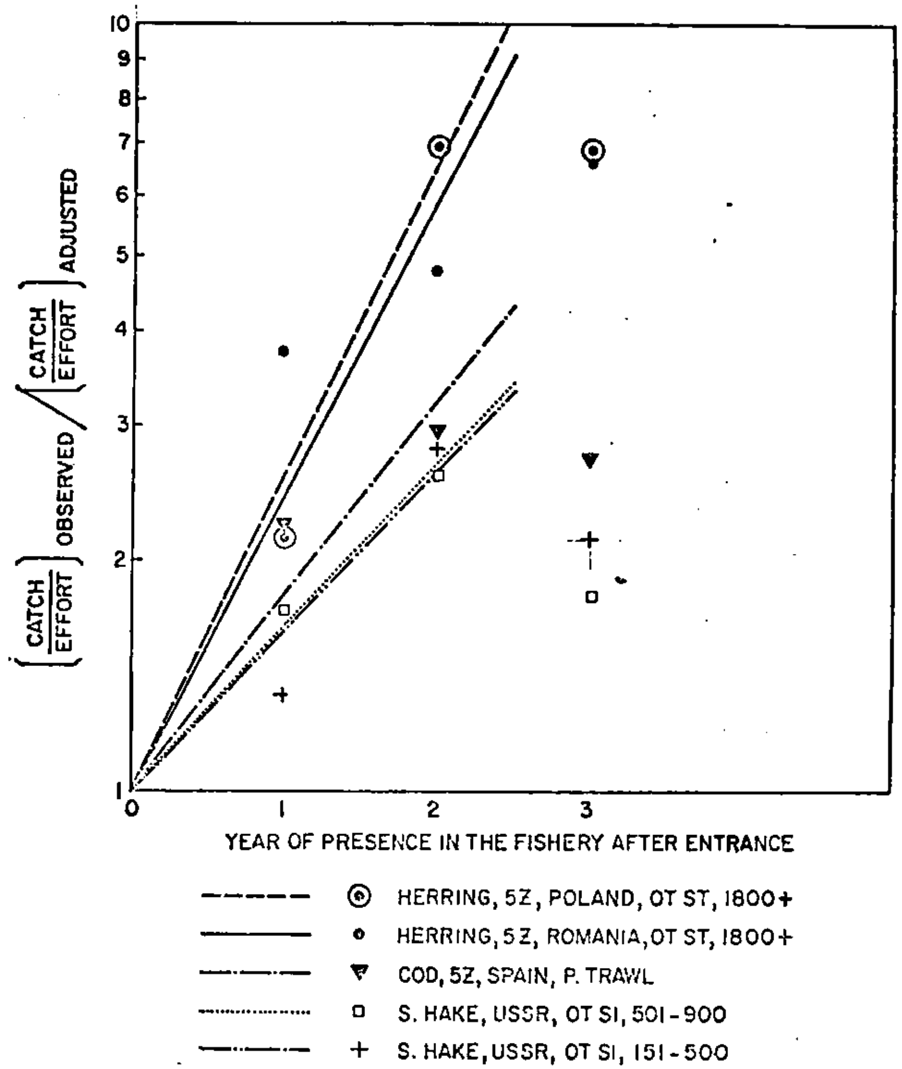

Fig. 6. Relationship of commercial catch per effort to *Albatross IV* survey cruise abundance indices.

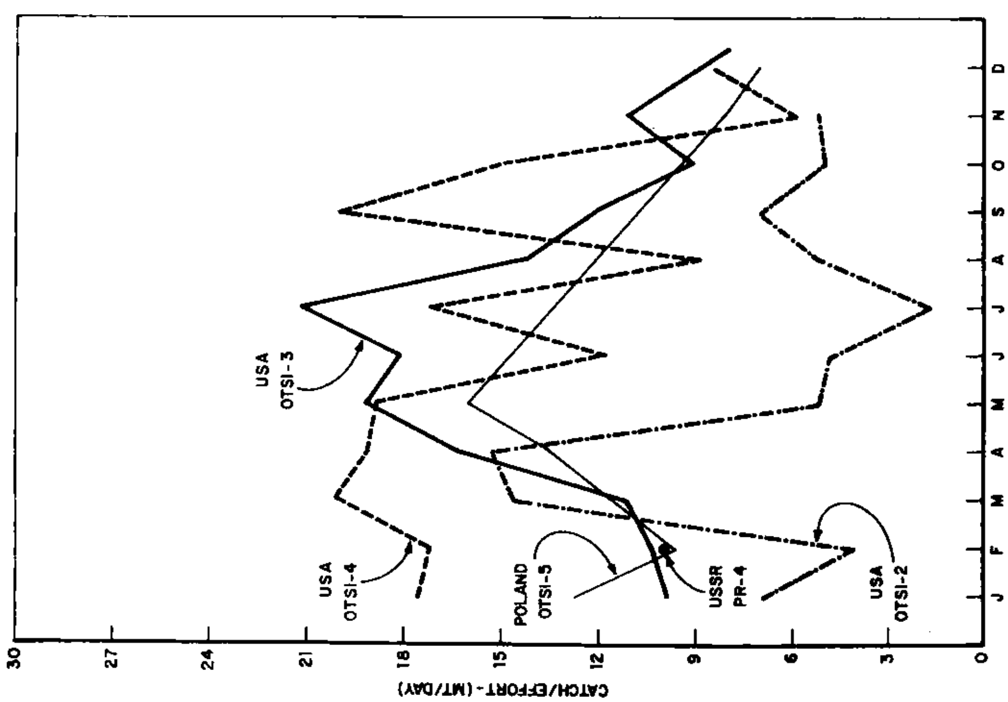

Fig. 5B(1). Monthly catch per unit effort for 1970 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.

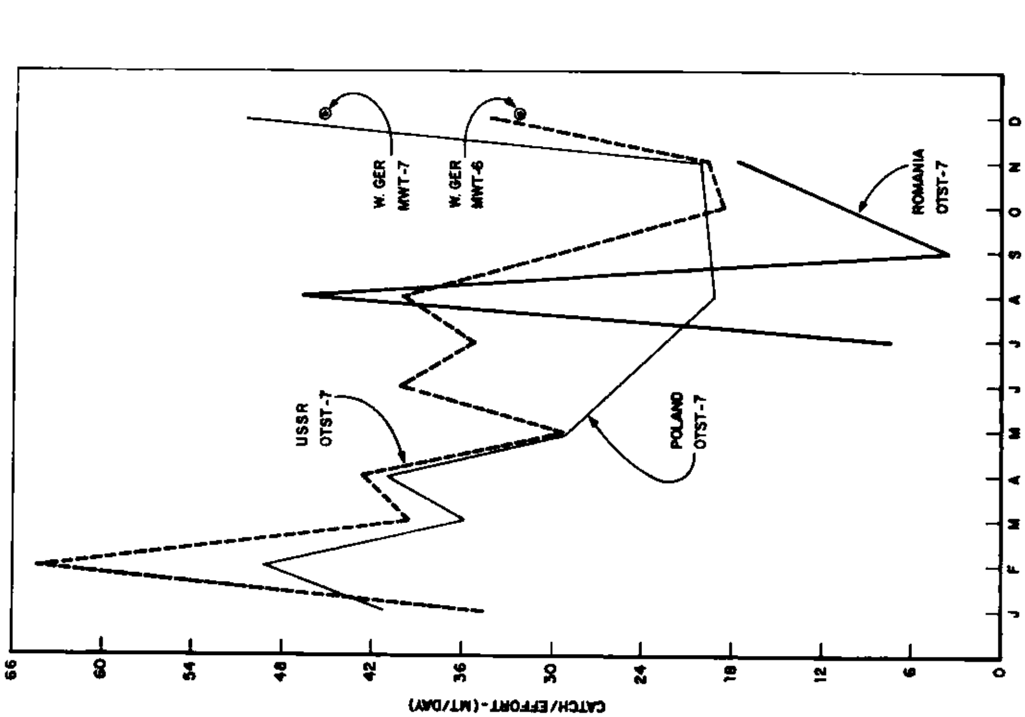

Fig. 5B(2). Monthly catch per unit effort for 1970 by country and vessel class for ICNAF Subarea 5 and Statistical Area 6 with directed catches for flounders, haddock and herring removed.