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EIGHTH SPECIAL COMMISSION MEETING - JANUARY 1976

Report of Meetings of Standing Committee on Research and Statistics (STACRES)*

Seventh Special Commission Meeting - September 1975

Contents

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REPORT OF STANDING COMMITTEE ON RESEARCH AND STATISTICS (STACRES)

Chairman: A.W. May

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Meetings of STACRES and its Assessment Subcommittee were held at Montreal, Canada, during 17-20 September 1975 to consider matters relative to fisheries management that were deferred from the 1975 Annual Meeting of the Commission. Representatives attended from Canada, Denmark, France, Federal Republic of Germany, Japan, Norway, Poland, Portugal, Spain, Union of Soviet Socialist Republics, United Kingdom and United States of America, and observers were present from Cuba and the International Council for the Exploration of the Sea (ICES).

The principal tasks at these meetings were to (a) consider the implications of possible alternative objectives for fisheries management; (b) review the status of certain cod and redfish stocks in Subarea 3 and 4, for which decisions on management in 1976 were deferred from the 1976 Annual Meeting of the Commission; (c) review the estimates of potential yield of the groundfish resources in Subareas 2 to 4; and (d) consider further the TAC for 1976 of finfish and squids in Subarea 5 and Statistical Area 6 (this item was added to the STACRES Agenda for discussion on account of its presence on the Commission's Agenda for the Seventh Special Meeting). The first item was considered within STACRES and the main points of the discussion are given in Section 1 below. The remaining items were referred to the Assessments Subcommittee, whose report (Appendix I) was discussed by STACRES in meetings held on 22 September 1975 and accepted with the observations given in Section 2 below. The "Remit to STACRES for Seventh Special Commission Meeting, September 1975" is at Appendix II.

1. Possible Alternative Objectives for Fisheries Management

The primary objective, to which the Commission's management measures have so far been directed, and the scientific advice given by STACRES, has been to achieve a fishing mortality rate (F) on the individual resources (or group of resources) exploited in the Convention Area, corresponding with maximizing the long-term catch (termed "maximum sustained catch"[1] in the text of the ICNAF Convention). The Commission has pursued this objective by the adoption of regulatory measures controlling the size (age) at which the fish recruit to the exploited stock (e.g. by mesh regulation) and/or their subsequent rate of exploitation by the fishery. The scientific advice related to this objective has been based on biological data for the individual fish stocks and on assessments of the relationships between catch and fishing mortality (fishing intensity) for them, using appropriate dynamic models describing their biological production processes. Implicit in this advice is that the time-scale of full response to adjustments in exploitation rate is related to the number of years during which a year-class of fish contributes to the fishery.

As a consequence of differences in the nature of the dynamic models used for assessment, two measures of F (F_{max} and F_{MSY}) have been identified as reference points on which to base regulations for achieving the above management objective. F_{max} refers to the fishing mortality rate at which the average catch per recruit is at a maximum. It is a function of the growth and natural mortality processes within the fish stock and of the size (age) at which the fish enter the fishery, and it is therefore independent of changes in recruitment. F_{MSY}, on the other hand, refers to the fishing mortality rate at which the average long-term catch from the fish stock as a whole is highest and is therefore a function of the total production processes within the fish stock, including recruitment. Where the average level of recruitment does not change directly in response to changes in stock size, F_{max} and F_{MSY} will correspond. In the absence of detailed knowledge of the relationship between stock and recruitment for particular stocks exploited in the Convention Area, this correspondence has been assumed in the presentation of previous scientific advice on management action.

STACRES examined the principal features of the F_{max} reference point and identified the following as being of particular importance with regard to its adequacy as a basis for management actions:

a) The form of the relationship between catch per recruit and fishing mortality (F) differs markedly for the various fish stocks according to their growth and natural mortality characteristics. For some stocks, F_{max} occurs at a relatively high level of fishing mortality and it may not be clearly defined. Furthermore, its value for each stock is dependent upon the age and pattern of recruitment to the fishery. These features are illustrated in Fig. 1, showing the kinds of relationships between equilibrium yield per recruit and fishing mortality rate for different species exploited in the ICNAF Area.

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[1] It should be noted that the concept of maximum sustained catch (MSY) is difficult to define precisely and, in fact, cannot be estimated with any precision for many reasons. At best, it is a reference point or goal which the Commission tries to achieve, providing it is consistent with other goals, e.g. economic or social (see Paragraph 1, Article VIII Revised of ICNAF Convention).

b) Although F_{max} defines the fishing mortality rate at which the greatest catch will be obtained from each recruit entering the fishery by taking no account of the relationship between the size of the spawning stock and recruitment, it does not necessarily correspond with that giving the highest average catch (MSY) for the fish stock as a whole (although, as indicated above, it does so if average recruitment does not change with changes in stock size).

c) Because F_{max} takes no account of the stock and recruitment relationship, management measures based on this reference point do not guarantee the maintenance of spawning stock at a level that would ensure the maintenance of an optimum average level of recruitment.

d) The F_{max} level of fishing takes no account of possible economic objectives and factors.

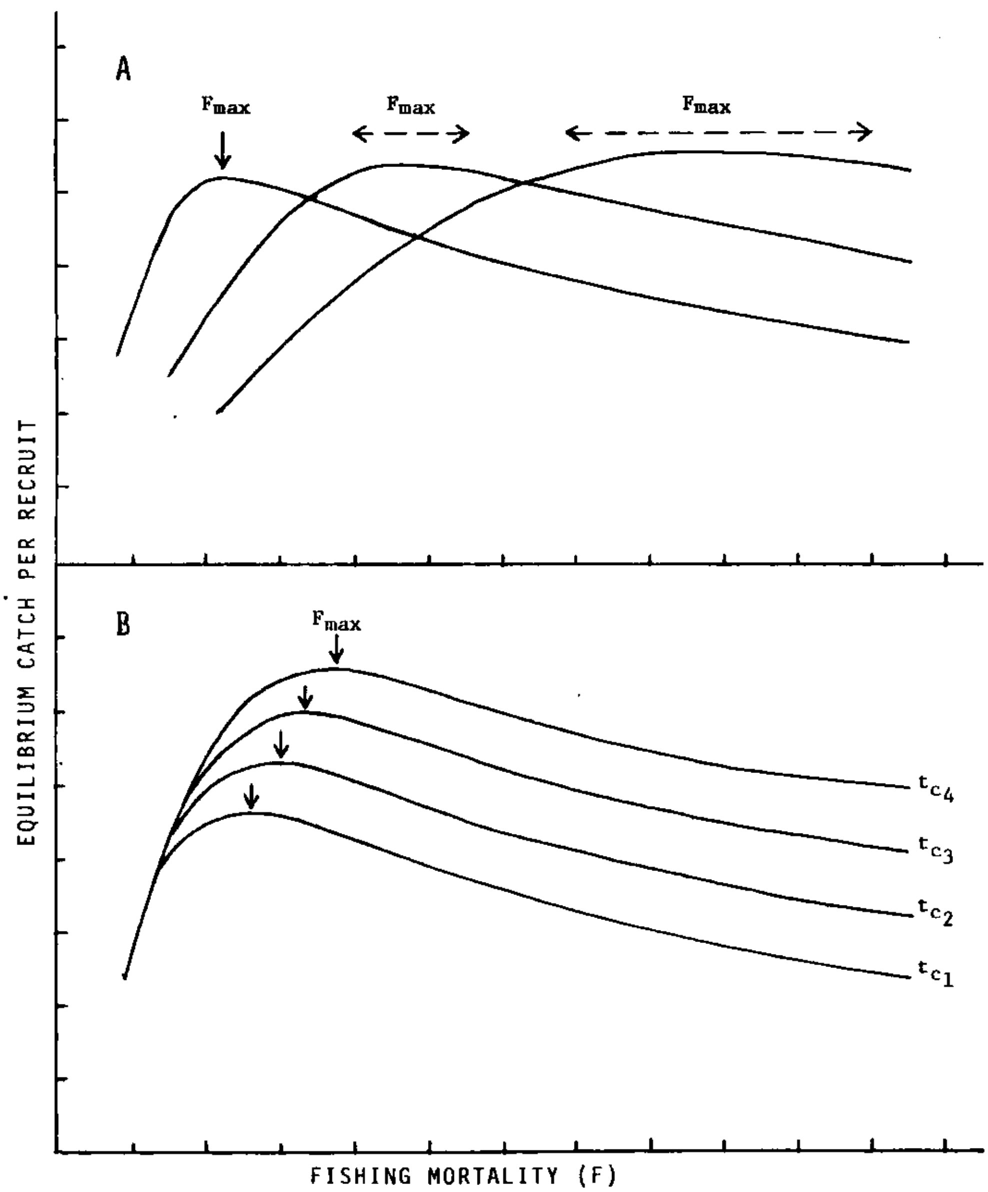

Fig. 1. Examples of equilibrium catch per recruit relationships: (A) for species having different growth and mortality characteristics, and (B) for a stock indicating the effect of different ages of recruitment to the fishery.

The above features indicate that the F_{max} reference point has potential limitations which have to be recognized and evaluated in the provision of scientific advice on management action. They are obviously greatest with respect to fish stocks for which the relationship between catch per recruit and fishing mortality has no clearly defined maximum or, if present, it occurs at a relatively high value of fishing mortality rate. In these situations the setting of TACs for catch quota regulations at the F_{max} level may lead to severe reduction in the stock size, reduction in the number of age-groups in the exploited stock, large short-term changes in catch (and hence in the magnitude of the short-term changes which must be made in the TACs in catch quota regulations), and possible recruitment failures due to the generation of too low spawning stock sizes.

The principal element of the biological system governing the adequacy of F_{max} as a basis for management action is the recruitment process, both its variability due to environmental factors and especially the relationship between recruitment levels and spawning stock size. At present, little is known about the latter relationship, so that the evaluation has usually to be made on a generally qualitative basis using all available information on the size and composition of the stock and the observed variability in recruitment to it together with its relation to other components of the exploited eco-system. However, the relationship is taken into account empirically in some assessment models.

STACRES considered that, in view of the possible large adverse consequences of setting the fishing mortality rate too high in cases where there is doubt about its adequacy, a more restrictive management system than that based on the F_{max} level of fishing mortality rate would be justified. In addition to appropriate measures for controlling the size (age) of recruitment to the fishery (e.g. through mesh regulation), the management system might comprise either, or a combination, of the following elements: (i) fixing the fishing mortality rate in the exploited phase at a level somewhat lower than F_{max}, and (ii) setting a target spawning stock size.

As pointed out previously (*Redbook* 1972, Part I, page 41), for fish stocks in which the relationship between catch per recruit and fishing mortality is a relatively flat-topped curve, a lower fishing mortality rate than F_{max} can be set which would result in only a small loss in average catch but would achieve a substantially higher average stock biomass, greater stock stability due to the presence of a larger number of age-groups in the exploited phase, higher average catch per unit effort, and increased economic efficiency.

The general consequences of adopting such an option (in terms of catch and catch per unit effort) are illustrated in Fig. 2. The average long-term loss in catch relative to the catch at F_{max} (F_{MSY}) is plotted against the average long-term increase in catch per unit effort, both in terms of catch and catch per recruit. The precise form of the relationships (Fig. 2) will, of course, be influenced by many factors. One possible reference for management action is the point on the curves where the slope is unity (i.e. where the rate of change of loss in catch equals the rate of change of gain in catch per unit effort). The actual catches and fishing efforts associated with any point on the curve will be different for different stocks. For example, the catch at F_{MSY} for redfish in Div. 3P is estimated at about 20,000 tons, but the point where the rate of change of loss in catch and the rate of change of gain in catch per unit effort is equal to unity corresponds to a catch of about 12,000 tons. As indicated above, the long-term stability of a fish stock may require a larger stock size (and lower catch) than that corresponding to F_{max} (F_{MSY}) to safeguard against recruitment variations. The implication of this was presented in a study of the cod stock in Subdiv. 4Vn(Jan-Apr)+Div. 4T (Res. Doc. 75/IX/140), where large increases in catch per unit effort would be achieved by regulating the fishery at a level below F_{max} (F_{MSY}) with only small losses in average catch.

The $F_{0.1}$ level, defined as the level at which the change in yield per recruit with respect to change in mortality rate is one-tenth of that of the fishery beginning on the virgin stock, has been specified as another possible reference point below F_{max}, since it is close to the economic optimum (*Redbook* 1972, Part I, page 41), but it does not have the unique merit in necessarily achieving the desired stability of stock size and recruitment. This level of F has already been used as a basis for advice to the Commission on the TACs for some stocks having relatively high values of F_{max}.

The establishment of a minimum spawning stock size constraint, as an element of the management objective, serves to minimize the risks of stock depletion and recruitment failure and hence should be, as far as possible, an integral part of the scientific evaluation leading to the adivce on specific management measures. At present, however, owing to the lack of knowledge on stock and recruitment relationships, the precise value of the limiting stock size cannot be defined for most fish stocks and hence it must be gauged from historical data for each stock in question. Results of a theoretical study presented at this meeting (Res.Doc. 75/IX/134) suggest that, at least for some stocks, an equilibrium spawning stock biomass constraint at a biomass level about two-thirds of that of the virgin stock would provide an adequate biomass buffer for maintaining stock stability and resilience against depletion in the presence of large fluctuations in recruitment.

The risks inherent in a management system based on the exploitation of individual fish stocks at their F_{max} (F_{MSY}) levels are particularly large in fisheries on multi-species resources, in which the exploitation of each stock separately is not possible due to the presence of biological interactions.

In such situations, the objective of fishing each stock at the F_{max} level may lead to its depletion and a possible decrease in the long-term catch of the principal components of the commercial fisheries (although the total fish biomass available for exploitation may not decrease). The adoption of management measures, which maintain an adequate spawning biomass of the desired species, is particularly important in such cases. The second-tier quota system adopted for Subarea 5 and Statistical Area 6 was designed to provide such a safeguard.

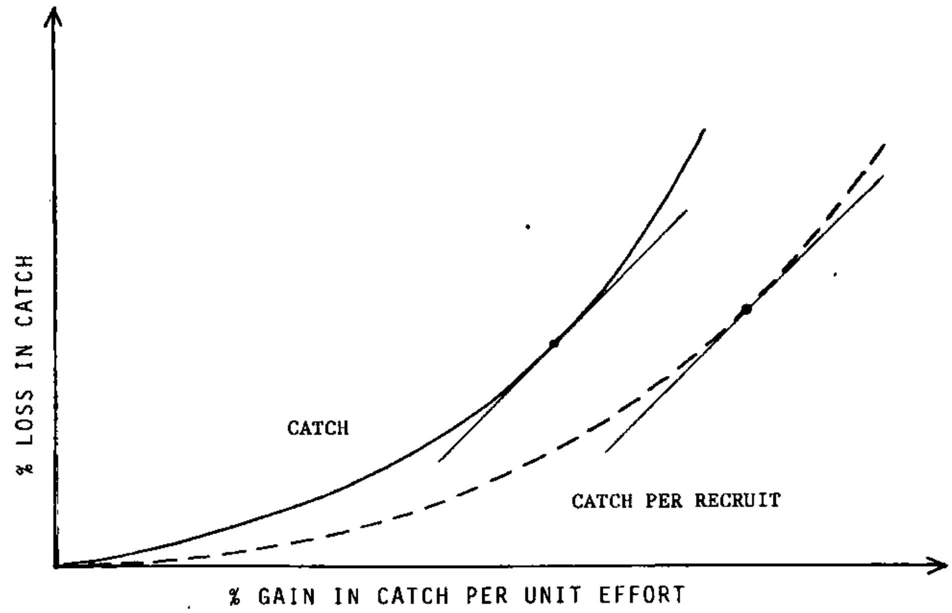

Fig. 2. Example of relationship between loss in average catch relative to that at F_{max} and gain in catch per unit effort.

2. Observations on Report of Assessments Subcommittee (Appendix I)

a) Status of Individual Stocks Deferred from 1975 Annual Meeting

STACRES accepted the conclusions of the Assessments Subcommittee with regard to the six stocks for which the Commission requested further advice on TACs for 1976. These, as set out in Table 1, include 1976 catches for various levels of fishing mortality (F), long term changes in catch and catch rate (stock size) relative to the long-term catch and catch rate for fishing at F_{max}, and the approximate periods of time before the stocks, if fished at the specified levels of F, will essentially reach equilibrium levels associated with those levels of F. However, STACRES considered that further amplification of the advice, regarding the sequence of changes to be expected from the initiation of a management policy in 1976 until the equilibrium condition is reached, would be of interest to the Commission.

All six stocks, listed in Table 1, have had a recent history of exploitation (although to a varying extent) at levels higher than F_{max}. Thus, stock sizes in 1976 are expected to be lower than equilibrium stock sizes associated with F_{max}. The long-term changes, indicated in Table 1, are contingent on F being maintained at the 1976 level for the indicated time period.

Fig. 3 illustrates the changes expected in catch and stock size (catch per unit effort) with time for a management policy of fishing at a constant level of F. If the Commission chooses to allow fishing at F_{max}, both the stock size and the catch would progressively increase with time to the equilibrium level associated with F_{max} (solid lines). If a lower value of F is chosen (say $F_{0.1}$), catch and stock size would again progressively increase with time to the equilibrium level associated with fishing at $F_{0.1}$ (dashed lines). In the latter case, however, the stock size would increase more rapidly than if fishing at F_{max} and reach an equilibrium at the higher stock size, and the catch would also increase but to a slightly lower equilibrium level. The time required, when fishing at $F_{0.1}$, for the stock size to reach the equilibrium level associated with F_{max} would be less than if fishing had occurred at F_{max} (t_1 in Fig. 3). The catch, if fishing at $F_{0.1}$, would also increase at a faster rate than if fishing at F_{max}, and the absolute difference between catches at $F_{0.1}$ and F_{max} would decrease with time. However, the equilibrium catch when fishing at levels of F below F_{max} will always be predicted to be lower than catches associated with F_{max}. It is important to reiterate that yield-per-recruit calculations of this type are dependent on the assumptions of constant recruitment and constant age at entry to the fishery.

Table 1. Implications to long-term catch and catch per unit effort of alternate management options of fishing at or below F_{max} and the 1976 TACs associated with each one. (Average age at first capture and recruitment level of recent years are assumed in all of the predictions.)

Species	Stock area	Fishing mortality (F)	1976 TAC (tons)	Long-term change (%) relative to fishing at F_{max} Catch	Catch/effort	Time scale (years)	Long-term equilibrium catch (tons)
Cod	3NO	0.25 (F_{max})	43,000	0	0	≈ 10	143,000
		0.20	35,000	-2	+15	≈ 10	
		0.15	27,000	-10	+42	≈ 10	
	3Ps	0.30 (F_{max})	48,000	0	0	≈ 6	59,000
		0.25	38,000	-2	+10	≈ 8	
		0.20	31,000	-8	+25	≈ 8	
		0.15	24,000	-20	+45	≈ 8	
	4VsW	0.35 (F_{max})	30,000	0	0	≈ 10	62,000
		0.20	18,000	-8	+50	≈ 10	
	4TVn[1]	0.40 (F_{max})	30,000	0	0	5-10	45,000
		0.35	25,000	-10	+50	5-10	
Redfish	3P	MSY level[2]	18,000	0	0	≈ 10	22,000
		80% MSY[2]	15,000	-5	+20	> 20	
		65% MSY[2]	12,000	-10	+35	> 20	
	4VWX	0.15 (F_{max})	20,000	0	0	> 20	32,000

[1] 4T(Jan-Dec)+4Vn(Jan-Apr).
[2] Fishing effort.

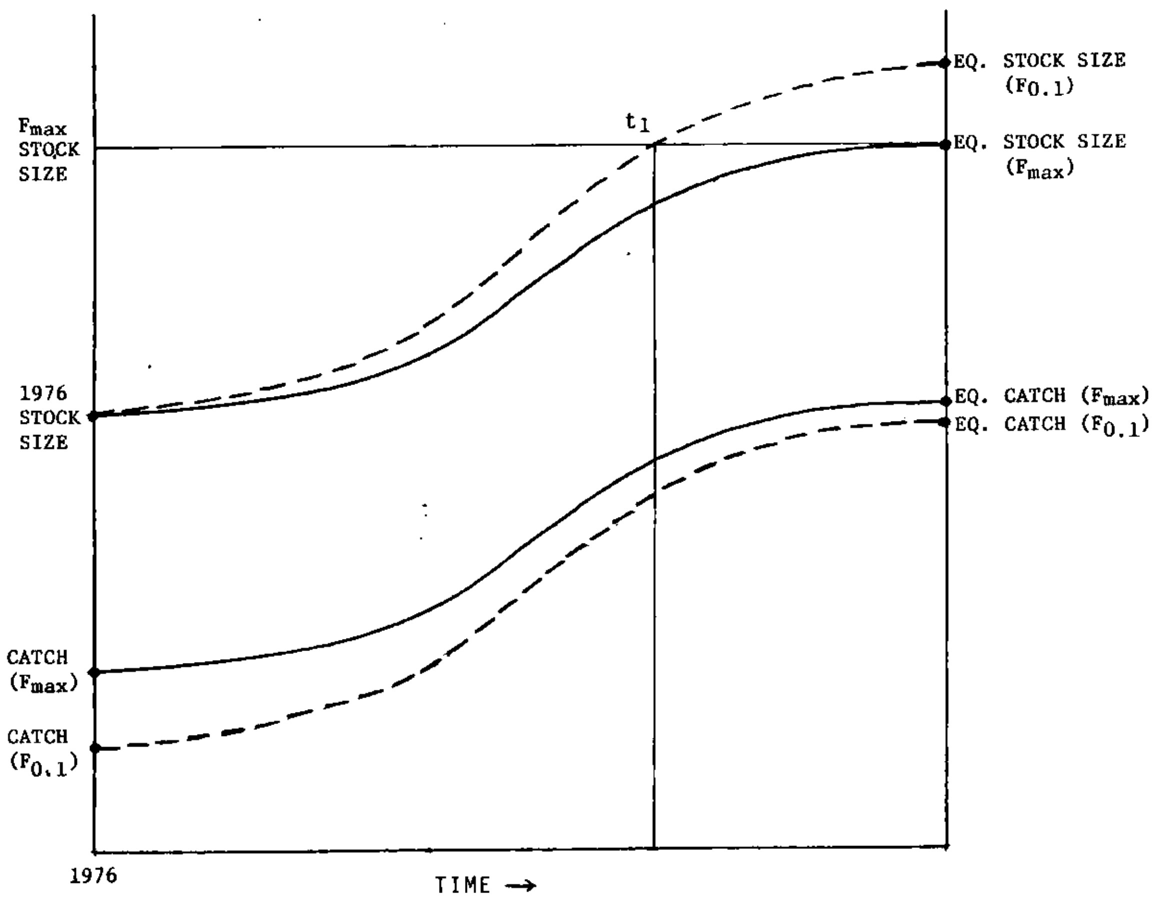

Fig. 3. Changes in stock size and catch with time given a policy of maintaining constant F. (Solid lines refer to fishing at F_{max} and dashed lines to fishing at $F_{0.1}$.)

b) The Overall Level of Fishing in Subareas 2 to 4

At its April 1975 Meeting, STACRES discussed in some detail the effects of specific reductions in fishing mortality on the catch and stock size of various groundfish stocks in Subareas 2, 3, and 4 (*Redbook* 1975, pages 56-62) in relation to the proposals contained in Comm.Doc. 75/8. At the present meeting, STACRES concurred with the views of the Assessment Subcommittee that the analyses carried out at the April 1975 Meeting were still pertinent and that no further advice could usefully be given at this time. It was noted that the appropriateness of "days fished" as a basis for effort regulation had been discussed fully at earlier STACRES meetings, and, although "hours fished" is more closely related to fishing mortality, "days fished" or "days on ground" would be more practical for regulatory purposes ("days fished" is more closely related to F than "days on ground").

c) Further Consideration of Finfish and Squids Within the Second-tier Overall TAC for Subarea 5 and Statistical Area 6

In anticipation of the Commission's request for further advice on this matter (since it appears as an item on the Commission's Agenda for the Seventh Special Meeting), STACRES agreed to include this item on its Agenda and referred the matter to the Assessments Subcommittee for discussion. The Subcommittee's report on the subject (Appendix I, page 9) was accepted by STACRES with the following observations:

i) STACRES noted that it had not previously recommended specifically that squid be included in the second-tier TAC but that its calculations of the second-tier TAC had been based on the inclusion of squid.

ii) Specific recommendations with respect to the species which should be included in the second-tier TAC were not made by STACRES for any other species.

iii) It is not yet possible to estimate the advantages or disadvantages that would be achieved by excluding one or another species from the second-tier TAC.

iv) The squid resources of both species (*Illex* and *Loligo*) have been maintained at a high level under the Commission's management regime of the past.

v) Discussion of the item (Further consideration of finfish and squid within the second-tier overall TAC in Subarea 5 and Statistical Area 6) was not as complete as would have been desirable, since not all Member Countries were represented by experts in this field (in some cases, the discussion of this item had not been anticipated).

3. Adjournment

The Chairman expressed his appreciation for the excellent work of the participants during this Special Meeting of STACRES and its Assessment Subcommittee and adjourned the final session at 2200 hours on 22 September 1975.

APPENDIX I - REPORT OF ASSESSMENTS SUBCOMMITTEE

Chairman: A.T. Pinhorn

The Subcommittee met at Montreal, Canada, during 18-20 September 1975 to consider matters referred to it by STACRES, namely (1) to review the status of certain stocks for which decisions on management in 1976 were deferred from the 1975 Annual Meeting of the Commission; (2) to consider the estimates of potential yield of groundfish resources in Subareas 2, 3 and 4; and (3) to consider further the 1976 TAC for finfish and squids in Subarea 5 and Statistical Area 6. Discussions on the first two points were based on the Commission's request for advice as outlined in "Remit to STACRES for Seventh Special Commission Meeting, September 1975" (see Appendix II, page 14). Consideration of the third point was requested by STACRES because the item appears on the Commission's Agenda for the Seventh Special Meeting.

1. Status of Individual Stocks Deferred from 1975 Annual Meeting

a) Cod in Divisions 3N and 3O

Because of a significant difference in age composition of catches between 1973 and 1974 (apparently caused by differences in age-reading techniques among the countries that submitted samples), a reassessment of this stock was not done at the April 1975 Meeting of the Subcommittee (*Redbook* 1975, page 29). Consequently it was recommended that the TAC for 1976 remain at the 1975 level of 85,000 tons. Since the 1974 fishing effort data were available at the present meeting, it was possible to estimate the fishing mortality (F) for 1974 from a correlation of earlier F-values with fishing effort. This resulted in an F considerably higher than that previously estimated for 1973 and reduced the influence of the suspected differences in age reading on the calculation of the TAC for 1976. A reassessment was therefore possible using 1974 age compositions.

No updating of the previous virtual population analysis using 1959-70 data was possible because of the lack of sampling data for 1971 and 1972. The Subcommittee reviewed the sampling data from the 1973 and 1974 commercial fisheries and examined the catch and effort data from Canadian, Spanish and USSR fisheries, together with catch-rate data from Canadian research vessel surveys. Catches in these divisions declined from a total of 126,000 tons in 1971 to 73,000 tons in 1974. The catch per unit effort in the Spanish pair trawl fishery showed a substantial decline during 1968-74. Abundance indices from research vessel surveys declined significantly between 1971 and 1974. On the basis of changes in the fishing effort of Spanish and USSR fisheries from the late 1960's to 1973 and on the basis of the correlation between total fishing effort and fishing mortalities in the 1960's, an F of 0.7 was estimated for 1974. If the 1975 catch is assumed to be about 75,000 tons, the fishing mortality in 1975 is estimated to be 0.6, a level well in excess of F_{max}. Future yields were estimated for a fishing mortality of 0.25 (F_{max}) and also for values of 0.2 and 0.15 under the assumptions that the 1975 catch would be about 75,000 tons and that recruitment would be about the average level observed in the 1960's.

The total biomass (4+ age-groups) at the beginning of 1975 was estimated to be 234,000 tons, about 60% of the average biomass of the 1960's. The Subcommittee concluded that, in order to safeguard future productivity, it is desirable to restore the total biomass at least to that earlier level as a first step. This could be achieved by 1977 by fishing at F_{max}, provided that the past level of average recruitment continues. Fishing at F_{max} in 1976 implies a catch of 43,000 tons, which is considerably less than that previously recommended. The implications of alternative management options for this cod stock are shown in Table 1.

b) Cod in Subdivision 3Ps

At its April 1975 Meeting, the Subcommittee concluded that fishing at F_{max} (0.3) in 1976 would yield a catch of about 55,000 tons, but, bearing in mind the desire to maintain TACs that had already been agreed for 1975 unless the changes were substantial, it recommended a TAC of 60,000 tons for 1976 (*Redbook* 1975, page 29). Re-examination of the data indicated that the 1974 age compositions, as previously used, over-estimated the 1974 reported catch. Upon making the necessary adjustments in the 1974 age composition of the catch and assuming that the 1975 TAC of 60,000 tons would be taken, the resulting calculation indicated that fishing at F_{max} (0.3) would in fact produce a yield of only 48,000 tons in 1976.

The Subcommittee reviewed the results of the virtual population analysis, which was updated using 1974 sampling data and assuming an F of 0.3 in 1974, and examined catch per unit effort data from the Spanish pair trawl fishery together with data from research vessel surveys. Catches from this stock declined from a peak level of 76,200 tons in 1970 to 46,000 tons in 1974. Estimates of fishing mortality during the 1959-73 period indicated that F was higher than 0.3 (F_{max}) up to 1971 and at about the F_{max} level since then. The catch per unit effort in the Spanish pair trawl fishery has declined steadily since 1968, although the results from Canadian surveys in the area showed no

obvious trend between 1972 and 1974.

The Subcommittee considered the current level of this resource in relation to its long-term potential. The biomass (4+ age-groups) in 1975 was estimated to be somewhat less than the average equilibrium biomass calculated when fishing at F_{max}, but was, however, slightly higher than the average biomass in the 1959-73 period. Since the 1975 level of biomass is at the lower limit of the range of biomass fluctuations that would have been expected during the 1960's if fishing had been consistently at F_{max}, the Subcommittee concluded that there was little evidence of severe reduction in this stock below the MSY level at the present time. Also, the estimate of spawning stock biomass for 1975 is at the upper limit of the range of spawning biomass observed throughout the 1960's and early 1970's but is lower than the estimate of the average long-term biomass when fishing at F_{max}. The higher biomass in 1975, compared with earlier years, may have resulted from the presence in the spawning stock of better-than-average year-classes. These were followed by the generally poorer-than-average year-classes of 1966-69, and this may, to some degree explain the decline in the catch per unit effort of Spanish pair trawlers since 1968, as sampling data indicate that in recent years the catches of Spanish pair trawlers contained significant numbers of small cod.

A range of 1976 TACs associated with various levels of fishing mortality at or below F_{max} is given in Table 1, together with the implications of reduced TACs to long-term catch per unit effort and yield.

c) Cod in Subdivision 4Vn(Jan-Apr) and Division 4T (Res.Doc. 75/IX/140)

Nominal catches from the Gulf of St. Lawrence migrating cod stock were 48,700 tons in 1974, well below the TAC of 63,000 tons for that year. The 1975 TAC of 50,000 tons will generate a fishing mortality of 0.6. Cohort analysis and Canadian research vessel surveys indicate that F ranged between 0.4 and 0.6 during 1971-74 and that the spawning stock biomass ranged between 70,000 and 90,000 tons in 1973-75.

A system simulation based on the detailed biological structure of the stock was presented (Res. Doc. 75/IX/140). Two regions of spawning stock biomass promising high production were noted. Near the 150,000 ton level, the stock was best able to compensate for environmental fluctuation through the stabilizing density-dependent mechanisms of growth rates, egg production and predation of adults on juvenile cod. Stable yields of 40,000-45,000 tons may be anticipated at this level of spawning stock biomass. For spawning stock size of 90,000-100,000 tons, these stabilizing density-dependent factors are substantially weakened, since they have essentially reached their limiting values. Thus, an unbroken series of above-average year-classes, as predicted by the model, would result in slightly higher (about 10%) yields from this lower level of spawning stock size than from a spawning stock biomass of 150,000 tons. It was noted that, while heavily fished cod stocks have been observed to produce higher-than-average recruitment, large fluctuations in recruitment usually occurs. At the lower level of biomass, stability of catches and stock size depends entirely on stable, high levels of recruitment, and the entry of one or two relatively poor year-classes into the fishery would result in a rapid decline in spawning stock biomass below 50,000 tons and the need for severe corrective action. Stable high yields (within 10% of the maximum) would result from the higher biomass level of 150,000 tons, and the robustness of the stock to recruitment variations would increase, thus reducing substantially the need for rapid adjustments of the TAC.

The 1976 TAC of 45,000 tons, recommended at the April 1975 Meeting of the Subcommittee (*Redbook* 1975, page 34), represents a fishing mortality greater than 0.6, with the result that the current stock size would only be maintained or it may even decrease. A TAC of 30,000 tons for 1976 represents a level of F = 0.4 (previously estimated to be F_{max}), and this would allow the spawning stock to increase to the goal of 150,000 tons in 5-10 years, provided that recruitment was favourable during the period (Table 1). A TAC of 25,000 tons, representing an F of 0.35, would have the effect of reducing the dependence of the stock on favourable recruitment during the rebuilding process. The distribution of mortality between the winter fishery in Subdiv. 4Vn and the summer fishery in Div. 4T influences the total yield and the spawning stock biomass, with both tending to increase as the proportion of the annual fishing mortality in the winter fishery decreases.

d) Cod in Subdivision 4Vs and Division 4W (Res.Doc. 75/IX/136)

The status of this cod stock has been re-analyzed, taking into account some new information on the size and age composition of USSR and Spanish catches. Both the catch per unit effort of Spanish trawlers and cohort analysis indicate that a substantial decline in stock size occurred between the late 1960's and 1973. The mean age at recruitment to the fishery also declined from about age 4 in 1969-71 to age 3.5 in 1972-73.

Recent selection patterns (since 1969) indicate that F_{max} is in the range of 0.32-0.38, but the fishing mortality has been above this level since at least 1969, the 1972-73 average being F = 0.80. Yield-per-recruit calculations indicate that a reduction in F (about 60%) to the F_{max} level would

increase yield-per-recruit by about 10%. Substantial increases in yield-per-recruit are also predicted for increases in the mean selection age.

The 1975 TAC of 60,000 tons will generate fishing mortality in the range of 0.75-0.80. A reduction in F in 1976 to the F_{max} level of 0.35 (average value of recent selection patterns) implies a TAC of 30,000 tons. Maintenance of F_{max} and the present age-at-recruitment to the fishery would, in approximately 10 years, allow a predicted average catch of about 60,000 tons (Table 1). The present fishable stock size is approximately 50% of the average stock size corresponding to F_{max}. Lower values of F in 1976 obviously imply lower catches in 1976, but such a lower value, if maintained for up to 10 years, would result in the stock size rapidly approaching and even exceeding the average level of stock size corresponding to F_{max}. For example, fishing at $F_{0.1} = 0.20$ in 1976 implies a 1976 catch of 18,000 tons, but, if this level of F were maintained for several years, the result would be a sustainable catch of 55,000 tons and a stock size 50% larger than that corresponding to F_{max} by about the mid-1980's.

e) Redfish in Division 3P (Res.Doc. 75/IX/137)

Nominal catches from this stock have been at a relatively high level in recent years, averaging about 31,000 tons during 1969-72. The catch declined from 27,500 tons in 1971 to 26,000 tons in 1972 and to 18,000 tons in 1973, but increased slightly to 22,000 tons in 1974, the year when quota regulation was first applied to this stock. The catch per unit effort of Canadian trawlers (151-500 GRT) has exhibited a steady decline from more than 0.9 tons per hour in 1965 to less than 0.5 tons per hour in 1974 and also in 1975, as indicated by preliminary data. The slight increase in catch from 1973 to 1974 was apparently attained by an increase in fishing effort from about 30,000 to 40,000 hours, the latter value being about the level of fishing effort in 1969 and 1971 when catches were considerably higher. This 50% increase in effort between 1973 and 1974 yielded only a 20% increase in catch. At the level of catch per unit effort experienced in 1974 and 1975 (0.5 tons per hour), the 1974 and 1975 TACs of 25,000 tons could only be attained with fishing effort about 30% in excess of that required to attain the MSY under equilibrium conditions.

Commercial catch per unit effort data indicate a high level of redfish abundance in this area during the mid- to late-1960's with above-average recruitment to the fishery. Only about one-half as many redfish older than age 6 were caught in research surveys of the area in 1973, 1974 and 1975 as in a comparable survey in 1965 at the onset of the recent period of increased exploitation. The 1964-66 and adjacent year-classes, which have begun to enter the fishery in 1975 and upon which the fishery will become more dependent during 1976 and 1977, appear to be only one-half as abundant as those of the mid- and late-1950's, which supported the fishery during 1965-74. The yield from these year-classes of the mid-1960's would therefore be expected to be substantially less than (perhaps only one-half) that supported by the earlier level of recruitment. It is possible that these year-classes may already have been exploited at an earlier age than is apparent from the limited sampling data available, if the observations on the sizes of redfish caught in other ICNAF divisions are indicative of the general trend toward the occurrence of relatively more small fish in the catches.

A further general production analysis of this stock, incorporating 1972-74 catch and effort data and using a range of moving averages (6, 8 and 10 years), as previously utilized to establish a range of MSY estimates for other redfish stocks, indicates that the MSY is in the range of about 20,000-23,000 tons as compared with an earlier estimate of 23,000 tons. On the basis of the revised MSY estimate and preliminary indications that the catch per unit effort in 1975 will be at about the same level as in 1974, it would appear that a TAC of 18,000 tons, instead of 20,000 tons as indicated by an earlier analysis, would maintain fishing effort at the MSY level in 1976. Fishing at a level less than that corresponding to the MSY level of fishing effort would result in some immediate loss in yield but would lead to long-term improvement in the catch per unit effort (Table 1). Because of the late age at maturity and the slow growth rate of redfish, benefits from improved catch per unit effort would only be realized in the long-term.

f) Redfish in Divisions 4V, 4W and 4X (Res.Doc. 75/IX/135)

The Scotian Shelf stock of redfish has been exploited since the mid-1930's, with catches during the initial period of exploitation reaching a high of 77,000 tons in 1949. A second substantial peak occurred in 1971 with a catch of 62,000 tons. Subsequently, catches have declined by about 10,000 tons per year to a level of 33,000 tons by 1974.

Commercial catch rates and length frequency data indicate that stock abundance increased in the early 1970's, thus attracting increased fishing effort. A production model using US catch and effort data suggests that both effort and yield declined from 1971 to the level corresponding approximately to the predicted long-term maximum yield by 1974.

At the present age of recruitment to the fishery (age 6), the maximum yield-per-recruit is attained at F of about 0.11-0.16. Mortality estimates for the fishery in 1971-74 are F = 0.30, approximately

twice that which maximizes yield-per-recruit. Substantial increases in yield-per-recruit are predicted for increases in age at recruitment to the fishery. Yield-per-recruit calculations imply that a 1976 TAC of 20,000 tons would reduce exploitation to a level which approximately maximizes the long-term yield (Table 1). Available information is too incomplete to support analyses demonstrating the implications of alternative management options.

Table 1. Implications to long-term catch and catch per unit effort of alternate management options of fishing at or below F_{max} and the 1976 TACs associated with each one. (Average age at first capture and recruitment level of recent years are assumed in all of the predictions.)

Species	Stock area	Fishing mortality (F)	1976 TAC (tons)	Long-term change (%) relative to fishing at F_{max}		Time scale (years)	Long-term equilibrium catch (tons)
				Catch	Catch/effort		
Cod	3NO	0.25 (F_{max})	43,000	0	0	≈ 10	143,000
		0.20	35,000	-2	+15	≈ 10	
		0.15	27,000	-10	+42	≈ 10	
	3Ps	0.30 (F_{max})	48,000	0	0	≈ 6	59,000
		0.25	38,000	-2	+10	≈ 8	
		0.20	31,000	-8	+25	≈ 8	
		0.15	24,000	-20	+45	≈ 8	
	4VsW	0.35 (F_{max})	30,000	0	0	≈ 10	62,000
		0.20	18,000	-8	+50	≈ 10	
	4TVn[1]	0.40 (F_{max})	30,000	0	0	5-10	45,000
		0.35	25,000	-10	+50	5-10	
Redfish	3P	MSY level[2]	18,000	0	0	≈ 10	22,000
		80% MSY[2]	15,000	-5	+20	> 20	
		65% MSY[2]	12,000	-10	+35	> 20	
	4VWX	0.15 (F_{max})	20,000	0	0	> 20	32,000

[1] 4T(Jan-Dec)+4Vn(Jan-Apr).
[2] Fishing effort.

2. Review of Potential Yield of the Groundfish Resources in Subareas 2 to 4 in Comparison with Estimates Based on Individual Resources

The Subcommiteee noted that a discussion on this matter had taken place at its April 1975 Meeting (*Redbook* 1975, pages 56-62). Further consideration at the present meeting indicated that, in view of the uncertainties associated with estimating MSY catch and effort from general production models, particularly Schaefer models (Res.Doc. 75/IX/125, 126, 127), little new evidence could be added to that given earlier (based on general production models) with regard to the need for the overall regulation of the groundfish resources in Subareas 2 to 4. It was pointed out, however, that the fishing mortalities for a number of key stocks, for which 1976 TACs are being considered at the present meeting, are higher than had been previously estimated. Also, it was noted that a number of stocks have shown signs of stress over the past five years (e.g. cod, flatfishes and redfish in Subareas 2 and 3, and cod, haddock, redfish and flatfishes in Div. 4VWX). The application of the Schaefer model to cod and redfish separately in Subarea 2 and Div. 3K (Res.Doc. 75/IX/126) indicates that cod has been fished beyond the MSY level in the 1970's, thus supporting the conclusion from a Schaefer model analysis of the resource as a whole, since cod represents the major portion of the groundfish resource in this area. It was noted that, although the regulation of individual resources has attempted to control the fishing mortality at the F_{max} level since 1973 for those stocks for which TACs were in effect in 1973, the 1976 TACs, as recommended at the April 1975 Meeting of the Subcommittee, for those same stocks add up to 1.3 million tons as compared with 2.1 million tons for 1973. Thus, if the regulation of these stocks in 1973 had effectively controlled the resource at the MSY level, some response might have been evident in 1975, but instead a continued decline is apparent.

If the overall level of exploitation were to have any biological implication, it would be that continued fishing beyond the MSY level might lead to reduction in future recruitment. Although there are some stocks for which the current recruitment levels are low (e.g. cod in Div. 2J+3KL), clear trends in recruitment, which could have resulted from heavy exploitation, cannot be clearly demonstrated generally. The Subcommittee indicated the need for investigation of indices for evaluating the status of stocks from the viewpoint of production/biomass ratios and biomass/recruit relationships.

3. Further Consideration of Finfish and Squids Within the Second-tier Overall TAC for Subarea 5 and Statistical Area 6.

At its Special October 1973 Meeting, the Commission established a TAC regulation for the catch of finfish (excluding menhaden, billfishes, tunas and large sharks other than dogfish) and squids in Subarea 5 and Statistical Area 6. Specified TACs were determined for application in 1974 and 1975, and the 1976 TAC was to be decided at the 1975 Annual Meeting such that it would ensure the restoration of the stocks to a level which would provide the MSY. At its April 1975 Meeting (*Redbook* 1975, page 54), the Subcommittee reviewed all available data pertaining to the determination of the TAC for 1976 to achieve this objective and presented the Commission with a range of values, each associated with a projected time schedule (years) required for the total biomass of finfish and squids to rebuild to the long-term MSY level. At its June 1975 Annual Meeting, the Commission agreed to a second-tier TAC of 650,000 tons for 1976, excluding squids.

The Subcommittee, at the present meeting, reviewed the previous discussions on this subject together with any available new data. The original advice to the Commission by the Subcommittee included squids in the TAC for several reasons. The squids are an integral part of the total community structure, and the significance of this is further supported by new data on the collective feeding habits of the finfish and squid community which shows major overlaps in the existing predator-prey relationships (Res.Doc. 75/IX/130). Furthermore, the second-tier system was intended to include mixed fisheries implications as well as biological considerations. Observations, made by ICNAF inspectors under the Commission's Scheme of Joint Enforcement, have shown that unreported by-catch in the squid fisheries may be substantial, indicating that significant fisheries interactions also exist. Consequently, the Subcommittee agreed that there was no reason to revise its original advice to the Commission.

The Subcommittee then reviewed the table of second-tier TAC options, considered at its April 1975 Meeting (*Redbook* 1975, page 56), and also an extended table of options which was presented to the June 1975 Annual Meeting of Scientific Advisers to Panel 5 for consideration (Res.Doc. 75/117). This latter table (see below) included estimates of the relative probability that recovery of the biomass toward the MSY level would begin in 1976.

TAC (000 tons)	Years to MSY	Probability	Probability (%) relative to that at 650,000 tons
800	13	0.59	74
750	11	0.67	84
650	7	0.80	100
550	5	0.90	113
450	4	0.95	119
350	3	0.98	123

These probabilities can be used to express the relative chance for the start of recovery of the biomass at various TACs. For example, given an exact probability at 650,000 tons, the setting of the TAC at 750,000 tons would reduce the probability to 84% relative to that for 650,000 tons, and setting the TAC at 550,000 tons would increase the probability to 113%.

At its April 1975 Meeting, the Subcommittee considered 650,000 tons to be a realistic minimum level for the second-tier TAC in 1976 in order to correct for the by-catch problem. This value was based on the assumption that the sum of the 1976 TACs for the individual resources in Subarea 5 and Statistical Area 6 would be about 825,000 tons. Further discussion of individual species TACs based on new data took place at the June 1975 Meeting of the Subcommittee without any recommended changes. Taking account of the TACs set by the Commission at its June 1975 Annual Meeting, allowing for one-third of the 1976 TAC for pollock in Div. 4VWX + Subarea 5 to be taken in Subarea 5 and assuming the 1976 herring TACs to be as recommended at its April 1975 Meeting, thus altering the previously summed TAC total to 816,000 tons, the Subcommittee at the present meeting considered it necessary to re-evaluate the resulting reduction required from the summed TACs to arrive at the appropriate second-tier TAC for 1976. The magnitude of the estimated decline in overall biomass in Subarea 5 and Statistical Area 6 was reconfirmed by new data (Res.Doc. 75/IX/139), and further analysis (Res.Doc. 75/IX/132) indicates that the expected catch in 1976 would be 574,000 tons, if the area were fished at MSY effort. The sum of the individual TACs, based on those agreed by the Commission at its June 1975 Annual Meeting, is 747,000 tons, excluding herring whose TACs for 1976 are to be decided at a Special Meeting of the Commission in January 1976. Since the revised sum of the TACs for 1976 is about 9,000 tons less than that assumed at its April 1975 Meeting, the Subcommittee considered that the second-tier TAC for 1976 should also be less than the previously advised TAC of 650,000 tons in order to achieve the same objective.

APPENDIX II - REMIT TO STACRES FOR SEVENTH SPECIAL COMMISSION MEETING, SEPTEMBER 1975

1. The Commission requests further advice on TACs for 1976 for the following stocks for which TACs were not agreed at the June 1975 Annual Meeting: (i) cod in Div. 3NO; (ii) cod in Subdiv. 3Ps; (iii) cod in Subdiv. 4Vn(Jan-Apr) + Div. 4T; (iv) cod in Subdiv. 4Vs + Div. 4W; (v) redfish in Div. 3P; and (vi) redfish in Div. 4VWX. In particular, STACRES is requested to specify possible alternative objectives that might be considered by the Commission, the long-term stock sizes and catches associated with these objectives, and the TACs required to achieve them over specified periods of time.

   In framing its advice, STACRES should

   a) review the present size of the named stocks and longer-term potential when exploited at the level of fishing mortality associated with the maximum sustainable yield per recruit;

   b) redefine the influence of variations in recruitment on estimates of maximum sustainable yield (MSY); and

   c) re-examine the potential effects of a range of levels of exploitation lower than that associated with the MSY, with a view to promoting greater stability of stock sizes and catches, and specify (i) their implications to stock size, (ii) the time scale of changes they imply, and (iii) stock constraints that would assist in attaining an appropriate management objective.

2. STACRES should also review estimates of the potential yield of the groundfish resources of Subareas 2 to 4 in comparison with estimates based on individual resources.