International Commission for the Northwest Atlantic Fisheries

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(Corrigendum)

ANNUAL MEETING - JUNE 1978

Report of Standing Committee on Research and Statistics (STACRES)

Special Meeting on Squid, February 1978

The following errors have been noted in Sum. Doc. 78/VI/3:

1. Page 2, Table 2. The nominal catch for Poland should read "5264" under 1972 and "5050" under 1976. The total under 1976 should read "24936".

2. Page 2, Table 3. The 1976 catch should read "13945" under SA 5 and "66700" under TOTAL.

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CONTENTS

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REPORT OF STANDING COMMITTEE ON RESEARCH AND STATISTICS (STACRES)

Special Meeting of STACRES - February 1978

Chairman: A. W. May Rapporteur: V. M. Hodder

STACRES met at Havana, Cuba, during 13-18 February 1978, at the request of Canada (Com. Doc. 78/II/2), to provide advice on the scientific basis for the management of the stocks of squid (*Illex*) within national fisheries limits of Subareas 3 and 4. The agenda is at Appendix I. Scientists attended from Canada, Cuba, France, Japan, Poland, Spain, Union of Soviet Socialist Republics (USSR), and United States of America (USA) (Appendix II). Research documents presented to the meeting are listed in Appendix III.

Preliminary consideration of agenda items 4 to 9 (Appendix I) was carried out in discussion groups led by E. C. Lopez-Veiga (Spain), A. T. Pinhorn (Canada) and F. Nagasaki (Japan), and *ad hoc* working groups were set up as required to review certain key issues in more detail than was possible in the time available for the plenary sessions. A summary of the proceedings, as adopted by STACRES, are set out in the following sections.

1. Fishery Trends

The nominal catch of *Illex* in Subareas 2 to 4 increased rapidly from an annual average of about 4,500 metric tons during 1970-74 to 18,000 tons in 1975 and to 42,000 tons in 1976 (Table 1). Preliminary data indicate that the 1977 catch was about 81,000 tons, of which 47% was taken by Canada and 24% by USSR.

In Subarea 5 and Statistical Area 6, the known catch of *Illex* increased from about 2,000 tons in 1970 to nearly 17,000 tons in 1974 with a decline to 14,000 tons in 1975 (Table 2). The statistics for 1970-75 do not reflect the true picture, as a breakdown of the USSR squid catches by *Illex* and *Loligo* separately is not yet available for these years. The *Illex* catch (including USSR data) increased to 28,000 tons in 1976, and preliminary data for 1977 indicate a decline to about 23,000 tons. In 1976 and 1977, more than 80% of the total *Illex* catch was taken by Japan, Poland, Spain and USSR.

In the Northwest Atlantic as a whole, the known catches of *Illex* (excluding USSR catches) increased from 4,000 tons in 1970 to about 32,000 tons in 1975 (Table 3). In 1976, the catch (including USSR) increased significantly to nearly 70,000 tons, and preliminary data for 1977 indicate a further increase to 104,000 tons. During the two most recent years in the development of the *Illex* fishery, the proportion of the total catch taken in Subareas 2 to 4 increased from 60% in 1976 to 78% in 1977.

2. Stock Relationships

Relationships among stocks of *Illex* exploited in Subareas 3-5 and Statistical Area 6 are unclear. However, considerable data have been collated on size compositions and maturities which are amenable

Table 1. Nominal catches (metric tons) of short-finned squid (*Illex illecebrosus*) in Subareas 2-4 by country, 1970-77.

Country	1970	1971	1972	1973	1974	1975	1976	1977[1]
Bulgaria	-	-	-	-	-	25	1,034	2,929
Canada (MQ)	6	16	8	11	65	89	943	8,034
Canada (N)	74	1,606	18	622	17	3,204	9,929	29,678
Cuba	-	-	-	-	-	-	3,248	4,668
France (M)	-	-	-	-	-	-	-	455
France (SP)	-	-	-	-	-	-	442	584
F. R. Germany	-	-	-	-	-	-	27	2,774
German D. R.	-	-	-	-	-	17	-	-
Italy	-	-	-	-	-	-	1,355	2,464
Japan	63	58	11	24	5	507	3,055	3,143
Poland	-	-	-	228	-	-	809	2,936
Portugal	-	-	-	-	-	-	264	-
Romania	-	-	-	-	-	-	-	1,054
Spain	-	-	-	-	265	268	934	2,958
USSR	1,242	7,226	1,831	8,992	85	13,634	16,900	18,953
Ireland	-	-	-	-	-	13	2,827	-
TOTAL	1,385	8,906	1,868	9,877	437	17,757	41,767	80,630

[1] Preliminary data

Table 2. Nominal catches (metric tons) of short-finned squid (*Illex illecebrosus*) in Subarea 5 and Statistical Area 6 by country, 1970-77.

Country	1970	1971	1972	1973	1974	1975	1976	1977[1]
Bulgaria	-	80	479	364	420	171	-	33
Canada (MQ)	-	1	-	-	-	-	54	-
Cuba	-	-	14	-	-	121	8	1
France (M)	-	-	8	27	-	-	-	-
F. R. Germany	-	-	-	-	-	-	1,101	-
German D. R.	20	-	-	313	-	882	996	-
Italy	-	-	1,200	805	980	884	1,117	1,958
Japan	389	176	2,398	1,067	3,327	3,237	3,256	4,733
Poland	-	-	5,464	8,288	5,003	3,051	7,831	656
Romania	-	-	-	-	6	48	9	-
Spain	1,636	3,324	4,878	3,784	6,769	2,204	4,063	7,935
USSR[2]	...	...	...	...	...	...	6,812	7,032
USA	408	455	472	530	148	107	229	1,016
Ireland	-	-	-	-	-	3,085	2,241	-
TOTAL	2,453+	4,036+	14,713+	15,178+	16,653+	13,790+	27,717	23,364

[1] Preliminary data
[2] USSR catches of "squid (NS)" in 1970-75 were 1,065, 6,138, 6,976, 8,977, 8,495, and 8,928 tons respectively.

Table 3. Nominal catches (metric tons) of *Illex* by subareas, 1970-77.

Year	SA2	SA 3	SA 4	SA 5	SA 6	TOTAL
1970	-	111	1,274	1,523[1]	930[1]	3,838[1]
1971	-	1,607	7,299	2,216[1]	1,820[1]	12,942[1]
1972	-	26	1,842	8,545[1]	6,168[1]	16,581[1]
1973	2	620	9,255	12,074[1]	3,104[1]	25,055[1]
1974	31	17	389	8,014[1]	8,639[1]	17,090[1]
1975	-	3,764	13,993	5,896[1]	7,894[1]	31,547[1]
1976	-	11,254	30,510	16,726	10,991	69,481
1977[2]	-	31,660	48,970	(23,364)		103,994

[1] Exclude USSR catches in SA 5 and 6 which have not been reported by *Illex* and *Loligo* separately (see Table 2).
[2] Preliminary data.

to interpretation in this regard (Table 4) when considered from the viewpoint of the seasonal and geographic distribution of the species. Although *Illex* occurs throughout the year on the shelf and slope in Subarea 5 and Statistical Area 6, its abundance is very low during the winter months. *Illex* is taken on the Scotian Shelf (Div. 4VWX) from about April to November and on the Grand Bank (Div. 3LNO) from about May to November. Inshore occurrence at Newfoundland, the northern end of the range, is July to November. The migration pattern may comprise north-south and inshore-offshore components with northern and inshore distribution limited seasonally by temperature.

A general pattern is discernable in the modes of length by area and season (Table 4). Unimodal length compositions are more general at the northern end of the range where modal classes are usually at larger sizes than further south. Growth can be followed by a progressive increase in mantle lengths from spring to autumn in all areas. However, a group of small squid with modal length at 6 cm or less appears in late autumn catches in Subarea 5 and Statistical Area 6, and occasionally a group of small squid is taken in Subarea 4 with a modal length approximately twice as great.

Maturing female *Illex* have been taken on the Scotian Shelf in late autumn (Res. Doc. 78/II/1). A mature fertilized female and two maturing females were also taken in this area in May 1973 (Res. Doc. 74/87). Two mature females were taken on the Grand Bank in May 1953 (Squires, 1957)[1]. Small numbers of large *Illex* of sizes, comparable to those taken in late autumn in Subareas 3 and 4, are taken during the spring in Subarea 5 and Statistical Area 6.

[1] SQUIRES, H. J. 1957. Squid, *Illex illecebrosus* (LeSueur), in the Newfoundland fishing area. J. Fish. Res. Bd. Canada 14: 693-728.

The observed data are consistent with the existence of a protracted spawning season, possibly extending from December to June and ranging over an extensive area. However, the total absence of squid in Subarea 3 of modal sizes comparable to the small squid taken in late autumn in Subarea 5 and Statistical Area 6 indicates that spawning does not occur at the northern end of the range, i.e. northeastern Newfoundland. The occurrence of maturing females on the Scotian Shelf in late autumn (Res. Doc. 78/II/1) indicates that spawning probably occurs nearby. It is conceivable that some *Illex* taken in Subareas 3 and 4 are spawned in Subarea 5 and Statistical Area 6.

Table 4. Modal mantle lengths (cm) of *Illex illecebrosus* by sex, season and area[1].

Month	Holyrood Nfld	Rencontre W., Nfld	Grand Banks	Scotian Shelf	Gulf of Maine	Georges Bank	Southern New England	Mid-Atlantic
Male								
Jan	-	-	-	-	-	-	18	-
Feb	-	-	-	-	-	-	17	16
Mar	-	-	-	-	-	-	9,16-17,26	12-15,23-25
Apr	-	-	-	13-14	12	10-13,16-17	14-16,27	-
May	-	-	13	14-16 10,13	-	12,15 14-15	17	-
Jun	-	-	17	18-20 15	-	-	-	-
Jul	17-20	-	16,18	21 19	-	22 19-20	21	10,18-21
Aug	21-22	16-18	-	21-22	24	20	20	-
Sep	22-24	18-22	-	22	-	-	20-21	5-6,18
Oct	24-25	20,22	-	23	-	8-10,20-22 21-22	7-9,19-22	3-6,18,27
Nov	24-25	-	-	23	22-25	22-23 12,23-24	-	18
Dec	-	-	-	-	-	-	-	13,19
Female								
Jan	-	-	-	-	-	-	18	-
Feb	-	-	-	-	-	-	17	16
Mar	-	-	-	-	-	-	9,16-17,26	12-15,23-25
Apr	-	-	-	13-14	12	10-13,16-17	14-16,27	-
May	-	-	12-14	14-16 10,13	-	12 14-15	-	-
Jun	-	-	17	18-20 15	-	-	-	-
Jul	18-21	-	16,18-19	21 20	-	21-22 19-20	21	22
Aug	21-23	17-19	-	22	24	20	20	-
Sep	23-26	18,22-23	-	23	-	-	20-21	5-8,18
Oct	26-28	19,24-25	-	27	-	8-10,20-22 22-23	7-9,19-22	3-6,18,27
Nov	26-28	-	-	26	25	24 12,26-28	-	18
Dec	-	-	-	-	-	-	-	13,19

[1] Data sources: inshore Nfld (Res. Doc. 75/27), Grand Banks (Res. Doc. 73/79), Scotian Shelf (Res. Doc. 73/79, 74/87, 78/II/2), Gulf of Maine to Mid-Atlantic (Res. Doc. 76/VI/65, 77/VI/4, and unpublished data (A. M. Tibbetts-Lange)). All samples from research catches by lined otter trawl, except inshore Newfoundland samples which were jigged and January, February and December samples which were by commercial otter trawl. Most of the samples from the Scotian Shelf in April to June and from the Gulf of Maine to the Mid-Atlantic were unsexed and the modal lengths are listed under both male and female. Underlining indicates the dominant mode in multimodal frequencies.

3. Stock-recruitment Relationships

The major offshore fishery for *Illex* in the ICNAF Area has developed only recently and no data are yet available to demonstrate a relationship between stock size and recruitment. Because of the short life-span of the species, and hence no significant overlap between generations, intraspecific competition and density-dependent mortality is apparently minimized. It is assumed, therefore, that recruitment should increase gradually with stock size and that the stock-recruitment curve is of the Beverton-Holt rather than the Ricker type, i.e. recruitment would be expected to increase with increasing stock size and level off at some point irrespective of further increases in stock size (Res. Doc. 75/61). A stock with such a stock-recruitment relationship may be strongly influenced by the abiotic environment. It is very difficult, therefore, to predict the magnitude of recruitment in advance of the fishing season unless the relative abundance of pre-recruits can be assessed.

4. Yield-per-recruit

It is considered that *Illex* has a life span of approximately one year at which time spawning takes place with very high post-spawning mortality. Growth and maturation is thus rapid, with full development of gonads being reached within a year. From analysis of mantle length frequency distributions, Mercer (1969)[1] suggested the presence of mixed age-groups within a single year-class, possibly related to a protracted spawning season and area. Squires (1957)[2] suggested that spawning occurred from January to June and that the animals spawned when they had reached an age of about one year. Mesnil (Res. Doc. 76/VI/65) proposed winter-born and summer-born groups with a life-span of 1½ years.

Au (Res. Doc. 75/61) estimated the natural mortality rate from the life expectancy and the growth coefficient from length frequencies by month prepared by Squires (1957)[2]. On the basis of these parameters, an exploitation rate (E_{MSY}) of 0.65 was calculated to achieve the maximum yield-per-recruit. If a moderate degree of density-dependence is assumed, the E_{MSY} is likely to be about 0.50. Sissenwine and Tibbetts (Res. Doc. 76/VI/30), assuming a monthly natural mortality of 0.1, calculated E_{MSY} to be about 0.65, if there is no relationship between stock size and recruitment, and about 0.4, when a moderate stock-recruitment relationship is considered.

Analysis of length frequency data from the commercial fisheries in Div. 4VWX allows estimation of removals by number in each 2-week period. Removals of individuals per 100 metric tons decreased from 2.7 million in the period starting on 17 April 1977 to 0.64 million in mid-June and to 0.32 million in November, reflecting rapid growth during the season. It is likely that growth substantially exceeds mortality early in the season, and that an increase in yield-per-recruit could be achieved by delaying the start of the fishing season until at least the middle of June.

5. Abundance Trends over Time

a) Fluctuations in Newfoundland inshore squid catches, 1955-77

Newfoundland inshore fishermen have traditionally fished squid as bait for the cod fishery with longline gear. Bait was the main use of squid until 1977 when a market for squid as food became available to the inshore fishermen. Thus, the fluctuations in catch of squid by Newfoundland fishermen may be considered as a measure of the abundance of squid in inshore waters during the summer months (Table 5). Between 1955 and 1976, the catches fluctuated in the range of 13 to 11,300 tons. Catches were generally in the range of 2,500-10,000 tons during 1955-67, except for 1958 and 1962 when they were 718 and 482 tons respectively. However, during the 1968-74 period catches exceeded 26 tons only in 1970 (111 tons), 1971 (1,607 tons) and 1973 (600 tons). The catch increased to 3,800 tons in 1975, to 11,300 tons in 1976 and to 29,700 tons in 1977, the last being partly due to an increase in effort in the inshore fishery for squid as food. It should be noted that, although these sharp fluctuations in catch may reflect changes in squid abundance, they may also reflect changes in the availability of squid in the inshore areas.

b) Abundance indices from research vessel surveys

Canadian research vessel surveys in Div. 4VWX during July of 1970-77 indicated fluctuations in squid biomass from a low of 1,900 tons in 1970 to a high of 262,500 tons in 1976 (Table 5). Estimates were in the range of 1,900-14,700 tons during 1970-74, increased to 24,800 tons in 1975 and 262,500 tons in 1976, and decreased to 50,500 tons in 1977. USA research vessel surveys in Subarea 5 and Statistical Area 6 indicated fluctuations in biomass from a low of 400 tons in 1969 to a high of 42,900 tons in 1976. Estimates were in the range of 400-2,500 tons during 1968-74, increased to 8,300 tons in 1975 and 42,900 tons in 1976, and decreased to 23,000 tons in 1977. USSR surveys, mostly in Subarea 5 but with some coverage of Statistical Area 6 and Div. 4X in

[1] MERCER, M. D. 1969. Biological characteristics of migrant ommastrephid squid, *Illex illecebrosus* (LeSueur), in the Newfoundland area. Amer. J. Zool. 9: 618-619.

[2] SQUIRES, H. J. 1957. Growth and hypothetical age of the Newfoundland bait squid, *Illex illecebrosus*. J. Fish. Res. Bd. Canada 14: 1209-1217.

Table 5. Indices of trends in squid (*Illex*) abundance from various sources, 1955-77.

Year	Newfoundland inshore catch (tons)	Biomass estimates: Canadian surveys in Div. 4VWX (000 tons)	Biomass estimates: USA surveys in SA 5+6 (000 tons)	Biomass estimates: USSR surveys in SA 5+6 (000 tons)[1]	Research vessel surveys by Japan in SA 3-6 (kg/day)
1955	7,019				
1956	7,779				
1957	2,634				
1958	718				
1959	2,853				
1960	5,067				
1961	8,971				
1962	482				
1963	2,119				
1964	10,408				
1965	7,831				
1966	5,017				
1967	6,917				
1968	13		1.8		
1969	21		0.4		
1970	111	1.9	1.5		
1971	1,607	14.7	2.0	100	
1972	26	3.2	1.7	58	
1973	600	8.9	1.9		738
1974	17	9.5	2.5		1,001
1975	3,751	24.8	8.3	197	2,315
1976	11,257	262.5	42.9	258	3,817
1977	29,678	50.5	23.0		

[1] The surveys covered part of Div. 4X in 1971 and 1975.

some years, indicated biomass estimates of 100,000 tons in 1971, 58,000 tons in 1972, 197,000 tons in 1975 and 258,000 tons in 1976. Japanese research vessel surveys in Subareas 3-5 and Statistical Area 6 indicated changes in abundance indices from 738 kg per day fished in 1973 to 3,817 kg per day fished in 1976. It should be noted that, although the biomass estimates from these research vessel surveys cannot be considered as representing absolute measures of squid abundance because the catchability of the trawls used was less than 1.0, they nevertheless should be representative of trends in abundance from year to year.

c) Conclusion

The abundance indices shown in Table 5 indicate that squid abundance may vary greatly over a period of years and may fluctuate by a factor of several times from one year to the next. In general, it seems that a period of high abundance in 1955-67 was followed by a period of low abundance in 1968-74 and that this was followed by another period of high abundance in 1975-77.

6. Current Stock Status and Exploitation Rate

The various abundance estimates available for 1977, based on the area expansion method, were reviewed in relation to catches. Given the uncertainties of stock inter-relationships and migration patterns, it was agreed that the status of the *Illex* stock in Subareas 3 and 4 should be assessed separately for each subarea.

In Subarea 3, a biomass estimate of 116,000 tons in July 1977 for Div. 3LNO is available from Cuban commercial fishery data. An estimate of 48,000 tons in October-November 1977 for Subdiv. 3Ps is available from a stratified-random survey by a French research vessel. Preliminary nominal catches for Subarea 3 in 1977 are approximately 32,000 tons, of which 29,700 tons were taken in inshore Newfoundland waters primarily during August to November. The July biomass estimate is based on data collected at the same time of the year as that used for biomass estimates in Subarea 4. Hence, this estimate and those for Subarea 4 can be considered as estimates of different groups of squid. The inshore catches in Subarea 3 were made subsequent to the biomass estimate and hence cannot be considered additive. The Subdiv. 3Ps squid biomass, estimated in October-November, may or may not represent double counting. However, taking a conservative approach, the estimate for Subdiv. 3Ps was not added to the estimate for Div. 3LNO. If the July biomass estimate of 116,000 tons for Div. 3LNO is taken as representative of squid abundance in Subarea 3, the 1977 catch of 32,000 tons represents an exploitation rate of 28%. If the biomass estimate of squid for Subdiv. 3Ps were considered to be

additional to that estimated in Div. 3LNO in July, the exploitation rate would be 20%.

Three biomass estimates are available for June-August 1977 from commercial fisheries data for Div. 4W. Both the USSR estimate of 60,000 tons and the Polish estimate of 205,000 tons were derived from statistics on directed fisheries for squid. The Cuban estimate of 133,000 tons, derived from statistics for the directed silver hake fishery, since it coincided with the mean of the USSR and Polish estimates, was considered the most suitable for calculation of the exploitation rate. Preliminary nominal catches from Subarea 4 in 1977 were approximately 50,000 tons, and thus the estimated exploitation rate is 38%.

A wide variety of factors affect the accuracy of the biomass estimates used and these are summarized in Res. Doc. 76/VI/31 and 78/II/17. These potential biases cannot be quantified with the data available, and hence it must be recognized that the above calculations of exploitation rate cannot be accredited with high reliability. The Cuban estimates, since they are based on squid by-catches in fisheries directed to other species, are likely to be underestimates.

No new data or analyses are available to indicate the appropriate exploitation rate for *Illex*. One possible management strategy would be to ensure a certain minimum biomass escapement for spawning, and hence the exploitation rate would vary from year to year. However, this would require more detailed knowledge of the biology of the resource than presently available and very accurate management of the fishery. STACRES, at its 1976 Annual Meeting, concluded: "Analysis of yield-per-recruit and stock-recruitment considerations indicated that removals could be about 40% of the stock biomass" (*ICNAF Redbook* 1976, page 112).

7. Mechanisms and Approaches to *Illex* Management

The most direct methods of controlling the exploitation rate are by the imposition of catch and fishing effort regulations. The advantages and disadvantages of these methods have been thoroughly discussed by the Commission in recent years, particularly in reference to proposals for effort control of fisheries in Subarea 5 and Statistical Area 6.

In the particular case of the *Illex* fisheries, catch controls present specialized problems. The short life-span of *Illex* of approximately one year results in the fishery being conducted each year on new recruits. A mechanism has not yet been developed for predicting the quantity of recruits each year, with the result that previous advice has been given in terms of a precautionary TAC (total allowable catch) which was considered to provide adequate spawning escapement even in years of very low recruitment. However, in years of high abundance, such a TAC is very restrictive and results in substantial losses in potential yield. Pre-fishery surveys provide a potential solution to this problem if recruitment can be measured with sufficient accuracy. However, the evaluation of the accuracy of survey indices requires several years of research and presents no solution for the immediate future. Furthermore, the squid migrations may be sufficiently protracted and variable that surveys would not achieve the accuracy required. In summary, the control of exploitation rate through catch control to achieve an optimal exploitation rate is not technically feasible at present and will not be for several years.

Fishing effort controls are theoretically attractive, in that, once the fishing effort and the exploitation rate are calibrated for one year, the fishing effort can be set and maintained at the same level for succeeding years, with the catch varying with abundance as the exploitation rate remains constant. However, there are a number of practical considerations which could be classed as immediate and long-term difficulties. Effective fishing effort is influenced by a wide variety of factors which change with time, e.g. crew experience, vessel size and power, gear size and type, etc., and these factors would have to be continually monitored and calibrated. In the short term (and the long-term), different country-vessel-gear combinations must be inter-calibrated and the complexities of inshore and by-catch fishing effort taken into account.

For countries which conduct only a directed fishery for *Illex*, inter-calibration based on relative catch rates is straightforward. Squid by-catch problems occur mainly in the silver hake fishery and involve primarily Cuba and USSR. Cuban scientists indicate that all squid catches by Cuban vessels are by-catches in the silver hake fishery and that these by-catches are well documented. Thus, it would be possible to calculate effective by-catch effort by the Cuban fleet, based on the ratio of catch rates. In the case of USSR, which has directed fisheries for both squid and silver hake, sufficient data are available from the international observer program to calculate by-catches in each directed fishery. However, the criteria for defining directed fisheries would be somewhat arbitrary, introducing additional sources of error. Such a scheme would require close regulation of the silver hake fishery and trade-offs between the squid and the silver hake directed fisheries may prove to be necessary.

Inshore fisheries, conducted by many small-boat fishermen present serious practical problems for direct effort measurement. However, if the assumption is made that the same stocks are being fished both offshore and inshore, the inshore fishing effort can be expressed in terms of offshore fishing

effort equivalents. (The problems of control of inshore fishing effort are outside the scope of this Committee.)

In summary, there are many potential sources of error in the implementation of fishing effort regulation. However, given the extreme difficulties in setting catch regulations to achieve a particular objective in terms of exploitation rate, effort regulation offers a substantially greater probability of effective management. Squid are widespread in Subareas 3 and 4 and stock inter-relationships are uncertain. Under the circumstances, it would be wise to spread fishing effort throughout the area of distribution to prevent possible over-exploitation of particular stock components. Therefore, consideration should be given to regulating the exploitation rate of *Illex* in Subareas 3 and 4 separately.

8. By-catch Problem and Alternatives for Minimizing By-catch in the Directed Fishery for *Illex*

a) Season

A major constraint encountered in the analysis of Subarea 4 data was in determining the species to which the fishery of certain vessels was directed. However, relatively high by-catches (up to 30%) were recorded early in the fishing season (Res. Doc. 78/II/4). By-catches decreased by mid-July (0-8%) and remained relatively low for the remainder of the season (Res. Doc. 78/II/4; 10). Silver hake was the most predominant by-catch species, with small percentages of cod, flounders, mackerel, haddock, herring and argentine (Res. Doc. 78/II/10, 13, 16, and unpublished data for the Cuban fisheries in 1976 and 1977).

In Subarea 5 and Statistical Area 6, the 1977 catches of *Illex* were low prior to mid-June (Res. Doc. 78/II/8). In the period from mid-June to mid-September, catches were larger (up to 3,000 tons) with by-catches in the range of 0-3%. Silver hake and red hake were the most predominant by-catch species. Subsequent relatively low catches (total of 2,000 tons) had high by-catches of up to 55%.

b) Gear

The fisheries for *Illex* were conducted with both bottom and midwater trawls. By-catches were lower in midwater than in bottom trawls. For species other than silver hake and squid, small-mesh bottom-trawl by-catches varied between 3.5 and 4.8%, while the by-catches in midwater trawls varied between 0.1 and 1.8%. By- catches of squid in the directed fishery for silver hake were very high in the Cuban fishery (>30%) for both gear types (Res. Doc. 78/II/9). In the USSR silver hake fishery, by-catches of squid were 6.3% in bottom trawls and 22.8% in midwater trawls (which were used experimentally in the silver hake fishery). In the directed fishery for *Illex* by USSR, silver hake by-catches were 10.5% in bottom trawls and 1.2% in midwater trawls. The Polish directed fishery for *Illex* with midwater trawls resulted in by-catches of silver hake from 0.1 to 3.0% (Res. Doc. 78/II/10).

Three types of gear were compared in a Canada-Japan research program: bottom trawl, bobbin-type off-bottom trawl, and dangling-chain off-bottom trawl. The bottom trawl was the most efficient in catching squid, while the chain-type was the least efficient (Res. Doc. 78/II/14, 16). However, by-catches in the chain-type off-bottom trawl were much less than in the other two types. This experiment indicated that it would be possible to fish selectively for squid (Res. Doc. 78/II/9).

There is no mesh size regulation for *Illex* in Subareas 3 and 4, but the 60-mm minimum mesh size for silver hake resulted in some countries using this mesh size for *Illex* also. The countries fishing only for *Illex* used codends with mesh sizes in the range of 40-48 mm.

c) Area

Canadian observations in Subarea 4, based on 15% of fishing days, showed that the majority of the fishing activity for *Illex* took place at depths between 100 and 200 m (Res. Doc. 78/II/9) near the area defined for the international regulation of small-meshed bottom-trawl fisheries in Div. 4VWX. Most of the Canadian squid catches (about 4,000 tons) were taken in the Western Gully (42°52'N, 62°50'W) with 0-3% by-catches (Res. Doc. 78/II/4). The Canadian-Japanese research in 3 areas on the Scotian Shelf showed higher by-catches on the Shelf than along the slope in the area designated for small-meshed bottom-trawl fishing (Res. Doc. 78/II/16).

The overall distribution of *Illex* fishing grounds in the Northwest Atlantic is shown in Fig. 1.

9. Review of Existing Regulations

Fisheries for squid in the ICNAF Convention Area and Statistical Area 6 are regulated by mesh size, fishing gear type, open seasons and areas, and catch quotas.

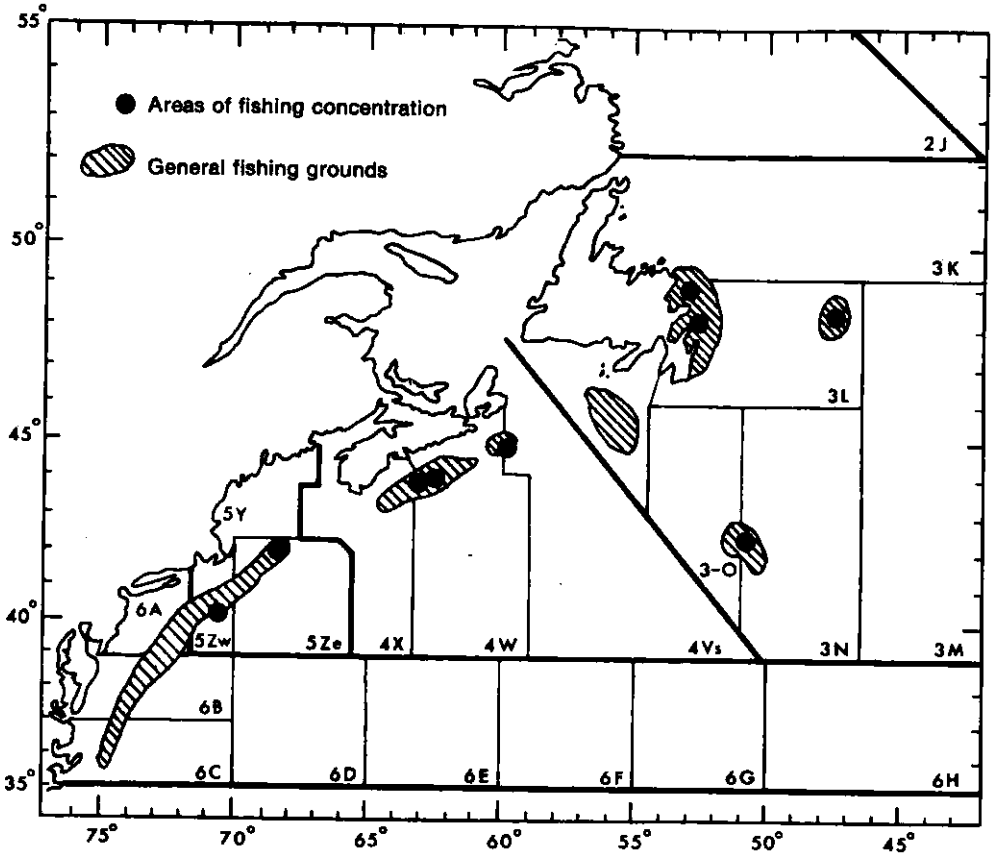

Fig. 1. Chart depicting squid fishing areas, as indicated by information in research documents considered at the meeting.

a) Mesh size regulations

A mesh size regulation of 60 mm exists for squid fishing by bottom trawls in Subarea 5 and Statistical Area 6. There are four authorized topside chafers for use on otter trawl codends (Com. Doc. 78/VI/1, pages 55-59).

b) Fishing gear regulations

Effective from 17 June 1977, no fishing in Div. 4VWX is allowed with bottom trawls, in which the mesh size is less than 130 mm, except in an area defined along the slope of the Scotian Shelf during the period from 15 April to 15 November. Pelagic gear may be used at all times and in all parts of Div. 4VWX (Com. Doc. 78/VI/1, pages 7 and 8).

In Div. 5Z and Statistical Area 6, effective from 17 June 1977, the Commission adopted 6 open areas ("windows") in which fishing could take place as defined in the regulations seasonally along the slope of the continental shelf between Cape Cod and Cape Hatteras (Com. Doc. 78/VI/1, pages 35-37). The regulation also includes an exemption of 1% by weight of all fish on board when fishing for other species and squid is caught by a vessel whose country has no specific allocation. The restrictions on areas of fishing ("windows") and the exemption clause do not apply to the coastal state. These regulations have subsequently been altered and are subject to further change within the US Fishery Conservation Zone.

c) Catch quota regulations

Total allowable catches (TACs) were allocated nationally for *Illex* in Subareas 3 and 4 and for both *Illex* and *Loligo* in Subarea 5 and Statistical Area 6 for 1977 as follows (Com. Doc. 78/VI/1, pages 13-19):

i) For *Illex* in Subareas 3 and 4, the TAC was set at 25,000+ tons, of which 10,000 tons was allocated for Canada, 15,000 tons for USSR, and 3,000 tons for each country without a specific allocation.

ii) For *Illex* in Subarea 5 and Statistical Area 6, the TAC was set at 35,000 tons, with allocations for Bulgaria, Canada, Italy, Japan, Poland, Spain, USSR and USA, and 490 tons for "Others" to cover by-catches only.

iii) For *Loligo* in Subarea 5 and Statistical Area 6, the TAC was set at 44,000 tons, with allocations for Canada, Cuba, Federal Republic of Germany, Italy, Japan, Poland, Spain, USSR and USA, and 300 tons for "Others".

iv) The Commission adopted a second-tier quota in the amount of 520,000 tons for all finfish and squids in Subarea 5 and Statistical Area 6. This overall TAC was allocated nationally to all member countries, except Denmark, Iceland, Norway, Portugal and UK, with a token amount of 50 tons for "Others".

Total allowable catches of *Illex* and *Loligo* in the US Fishery Conservation Zone are 30,000 tons and 44,000 tons respectively for 1978.

10. Specific Advice on Management Alternatives for 1978

a) TAC versus effort regulation

In view of the very short life-span of *Illex* and the apparently large fluctuations in abundance, together with uncertainties about stock identity and migration patterns, it is difficult to specify the effects of alternative management measures in 1978 upon future squid abundance. It is not possible at this time to predict the level of stock abundance which will occur in 1978. Based upon the available estimates of minimum biomass in Subareas 3 and 4 in 1977, it would appear that the exploitation rate in that year was less than 0.4. For the reasons discussed earlier, STACRES favours, in principle, effort regulation as a means of controlling the exploitation rate in the *Illex* fishery. However, it was concluded that effort regulation *per se* would be difficult to design for 1978 because of the practical difficulties of (i) inter-calibration of effort among the different types of vessels and gears, (ii) estimation of effort for *Illex* in mixed fisheries, and (iii) estimation of effort for the relatively large inshore catch. STACRES therefore

recommends

that the feasibility of an effort regulation in 1979 be further examined, requiring the submission by all countries of detailed catch and effort data for Illex in Subareas 3 and 4 with a view to further analysis and discussion at the April 1978 Meeting of the Assessments Subcommittee.

On the basis of the available estimates of minimum biomass from commercial and research trawling, it appears that the minimum biomass in Subareas 3 and 4 was about 250,000 tons in 1977, depending on assumptions about the inter-relationship of *Illex* taken in November in Subdiv. 3Ps and those fished in Div. 3LNO during the summer. With a target exploitation rate of 0.4, the TAC in 1977 could have been about 100,000 tons. If it is assumed that *Illex* will be as abundant in 1978 as observed in 1977, such a TAC could be applied to the 1978 fishery. If such a TAC were adopted, it should be conditional upon licencing of fishing effort based on catch rates achieved in 1977, with no increase in the number of fishing days from the number originally calculated for 1978 if the catch rates are lower than those experienced in 1977. This would provide a safeguard against over-exploitation if the abundance of *Illex* is lower in 1978 than in 1977.

b) Adjustment on the basis of pre-season surveys

Ideally, for such a short-lived species as *Illex*, any catch quota should be determined on the basis of the abundance of the resource in the season under regulation. Pre-season research surveys of the fishing areas would assist greatly in defining the biomass that is likely to be available to the fishery later in the year. If a catch quota is applied for 1978, it should be subject to adjustment on the basis of the results of pre-season surveys.

c) Fishing season

There is some evidence which indicates that by-catches of other species in the directed squid fisheries are relatively high during the early part of the fishing season. Furthermore, observations on the growth rate of *Illex* throughout its life cycle indicate that, if the fishery were concentrated in the latter part of the year, removals would consist of relatively fewer squid per ton caught. For example, it has been calculated that the number of animals removed per 100 tons decreased from 2.7 million in the period starting on 17 April to 0.64 million in mid-June and to 0.32 million in November. It was noted that, in practice, the directed offshore fisheries for *Illex* in recent years have seldom commenced before 1 July. Therefore, STACRES

recommends

i) that the directed fishery for Illex not commence before 15 June; and

ii) that some measures be taken to limit the by-catch of Illex in other fisheries before 15 June.

Concern was expressed by some scientists that severe limits on by-catch could create practical difficulties in mixed fishery situations.

d) Mesh size

There is at present no minimum mesh size regulation for the *Illex* fishery in Subareas 3 and 4. It was noted that in 1977 vessels fishing silver hake with bottom and midwater trawls used 60-mm mesh in the codends. Most of the directed fisheries for *Illex* used trawls with 40-48-mm mesh in the codends. Mesh selection studies have been carried out primarily on *Loligo*. Some preliminary information from 1977 mesh selection experiments aimed at silver hake indicated that trawls with 60-mm meshed codends caught 98% as much *Illex* as those with 40-mm meshed codends. However, it was noted that the implementation of a minimum 60-mm codend mesh size for the directed squid fishery might have an effect on fishing success; also, it was not clear that any substantive benefit would be derived from the introduction of a 60-mm minimum mesh size regulation for *Illex*. However, it has been demonstrated that by-catch effects would be reduced with the application of a 60-mm minimum mesh size as opposed to the use of smaller mesh sizes. It was agreed that mesh selection experiments for *Illex* should be carried out in 1978 and that the question of a minimum mesh size should be reviewed on the basis of the results of these experiments.

e) Gear type

STACRES noted that by-catches in bottom trawling for silver hake were higher than those recorded in midwater trawling, and that by-catches in the Japanese chain-type off-bottom trawl were much less than in the conventional bottom trawl.

f) Management areas

Although it is not clear to what extent the squid occurring in Subarea 3 are related to those fished in Subarea 4, the conservative approach to management of the *Illex* stock would be to spread the fishing effort among the areas of known abundance. STACRES therefore

recommends

that, if a TAC of 100,000 tons is set for Subareas 3 and 4 in 1978, it be partitioned between Subareas 3 and 4.

Based on the relative magnitude of the minimum biomass estimates for Subareas 3 and 4, and using a target exploitation rate of 0.4, an appropriate partition of the TAC of 100,000 tons would be 45,000 tons for Subarea 3 and 55,000 tons for Subarea 4. It was emphasized that the implementation of a TAC should be conditional upon the control of fishing effort, as discussed in section 10(a) above.

11. Future Research Requirements

a) Age determination

STACRES noted with great interest the work being undertaken to determine the age of squid from statoliths (Res. Doc. 78/II/15), and indicated validation studies of the method would be required. It was suggested that the east coast of Newfoundland would be a choice sampling area, as the length frequencies of samples taken there are usually unimodal and leptokurtic throughout the season. It was indicated that statolith readings should be obtained for modal length classes which can be followed from July to November. Accordingly, STACRES

recommends

that studies on the ageing of squid from statoliths be vigorously pursued, and that an effort be made to validate the age readings by following the progression of modal length groups throughout the season.

b) Stock discrimination

In view of the present uncertainties about stock identity and migration patterns, STACRES

recommends

that studies aimed at stock discrimination be intensified through the use of tagging experiments, biochemical techniques and morphometric studies.

It was considered that particular emphasis should be placed on tagging as a means to elucidate migration patterns.

c) Biomass estimates from surveys

It was noted that attempts at estimating the minimum biomass from commercial data and research vessel surveys, although fraught with potential sources of error, had been made in 1977 to provide first approximations of the minimum biomass. STACRES

recommends

that research vessel surveys and the use of commercial data for estimating the biomass should be broadened to encompass the entire area of Illex distribution on a regular basis, using standardized techniques.

d) Mesh selection studies

In view of the urgent need for information on the selectivity of *Illex* in trawls, STACRES

recommends

that mesh selection experiments be conducted in 1978 to determine the selection curves for Illex over the range of mesh sizes (40-60 mm) currently used in the Illex fishery.

e) Larval identification and distribution

It was noted that larval squid had been caught in Subareas 3 and 4 but that the identification of the species had proved to be difficult. It was suggested that the rearing of *Illex* larvae in the laboratory might serve to assist in the field identification of larvae. Studies on larval distribution are required to elucidate spawning areas, and further data are required on the occurrence of mature and maturing females.

f) Biological sampling

STACRES agreed to the adoption of the standards and procedures outlined in Res. Doc. 78/II/5 as a general guide for the biological sampling of *Illex*, involving the collection of data on mantle length, weight, sex determination, maturity stages and stomach fullness. In particular, STACRES

recommends

that length composition data for Illex, both commercial and research samples, be reported by ½-cm intervals for males and females separately, and that data on maturity stages should be collected where possible.

It was recognized that all countries may find it difficult to fully implement this recommendation immediately, as the persons involved in sampling would have to be trained to recognize the sex and maturity stages of the specimens examined.

g) Detailed catch and effort data

STACRES noted that there had been very little response to its request for detailed catch and effort data for *Illex* as set forth in Circular Letter 77/46 (issued 2 August 1977). STACRES reiterated the need for the collection and analysis of such detailed data on the directed squid fisheries, with a view to its possible use in monitoring abundance trends and the estimation of biomass, and urged that every effort be made by all countries fishing for squid in Subareas 3 and 4 to comply with Recommendation (4) of the 1977 Annual Meeting (*ICNAF Redbook* 1977, page 37), the requirements of which were specified in Circular Letter 77/46.

12. Acknowledgement

The Chairman expressed his appreciation to the Cuban authorities for the excellent facilities provided for the meeting and for their generous hospitality, to the Secretariat for their usual efficient work, to all participants for their interest and cooperation and finally to those who assisted in recording the proceedings of the meeting.

APPENDIX I. AGENDA FOR STACRES MEETING, FEBRUARY 1978

1. Opening (Chairman: A. W. May)

   a) Rapporteur
   b) Adoption of agenda and plan of work

2. Review of advice requested in Com. Doc. 78/II/2.

3. Review of available data on *Illex*

4. Identity of unit stocks of *Illex*

5. Life history and biology as related to management

6. Abundance trends over time and current stock status

7. Mechanisms and approaches to the long-term management of *Illex* (e.g. catch quota *versus* fishing effort control, fishing season, etc.)

8. By-catch problem and alternatives for minimizing by-catch

9. Review of existing regulations

10. Specific advice on management alternatives for 1978

11. Future research requirements

12. Adjournment

APPENDIX II. LIST OF PARTICIPANTS IN STACRES MEETING, FEBRUARY 1978

CANADA

A. W. May	Dept. of Fisheries and Environment, Resource Services, 240 Sparks St., Ottawa, Ont.
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A. Perez	" " " "
E. Valdes	" " " "
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A. M. Tibbetts-Lange	National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole, Mass.

APPENDIX III. LIST OF DOCUMENTS PRESENTED TO STACRES MEETING, FEBRUARY 1978

Research Documents

Doc. No.	Ser. No.	Title	Author
78/II/1 (Revised)	5153	Maturation index and fecundity for female *Illex illecebrosus* (LeSueur, 1821)	R. D. Durward, T. Amaratunga & R. K. O'Dor
78/II/2	5154	Population structure of *Illex illecebrosus* in the Scotian Shelf fishing areas in 1977	T. Amaratunga, R. D. Durward, M. Roberge & L. Wood
78/II/3 (Revised)	5155	A study of the 1977 international catch statistics for the squid, *Illex illecebrosus*, fishery in ICNAF Subareas 3 and 4	T. Amaratunga, M. Roberge & L. Wood
78/II/4 (Revised)	5156	The 1977 Canadian offshore catch statistics of the squid, *Illex illecebrosus*, fishery in ICNAF Subareas 3 and 4	T. Amaratunga, M. Roberge & L. Wood
78/II/5	5157	A guide for data collection in the field for the squid, *Illex illecebrosus*	T. Amaratunga & R. D. Durward
78/II/6	5158	Breakdown of inshore Newfoundland squid catches, 1975-77, with length and sex composition from commercial samples	P. W. Collins & G. P. Ennis
78/II/7	5159	Food and feeding of the short-finned squid (*Illex illecebrosus*) during its seasonal occurrence inshore at Newfoundland and a brief review of the trophic relationships of the species	G. P. Ennis & P. W. Collins
78/II/8	5160	Catch, effort, and biological data from the 1977 directed squid fishery in the US Fishery Conservation Zone	A. M. Tibbetts-Lange
78/II/9	5161	Catch compositions during the 1977 Scotian Shelf international fishery with emphasis on the silver hake and squid (*Illex*) fisheries	D. E. Waldron
78/II/10	5162	Stock assessment of *Illex illecebrosus* (LeSueur, 1821) in ICNAF Div. 4W determined by area-density method	M. Lipinski
78/II/11	5163	On the state of short-finned squid (*Illex illecebrosus*) stocks in some areas of the Northwest Atlantic in 1977	R. N. Burukovsky & Y. M. Froerman
78/II/12	5164	Biomass estimates of squid, *Illex illecebrosus*, in Subdiv. 3Ps	R. Chevalier
78/II/13	5165	Observations on the Spanish *Illex* fishery in Subarea 4	D. Lloris
78/II/14	5166	The effects of gear type on the Japanese squid (*Illex illecebrosus*) fishery	D. E. Waldron & D. F. Gray
78/II/15	5167	The age of squids, *Illex illecebrosus* (LeSueur, 1821), from their statoliths	M. Lipinski
78/II/16	5168	Report of the joint survey on by-catch in the Japanese *Illex* trawl fishery, 1977	H. Kono
78/II/17	5169	Stock assessment of *Illex illecebrosus* in ICNAF Subareas 3 and 4	A. Mari, J. J. Terré & R. Dominguez