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Report of Standing Committee on Research and Statistics (STACRES)

Special Meeting on Capelin and Squid, February 1979

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REPORT OF STANDING COMMITTEE ON RESEARCH AND STATISTICS (STACRES)

Special Meeting on Capelin and Squid, February 1979

Chairman: G. H. Winters (Acting) Rapporteur: V. M. Hodder

STACRES met at Tokyo, Japan, during 14-21 February 1979 to provide advice on the scientific basis for the management in 1979 of the capelin stocks in Subareas 2 and 3 and the squid (*Illex*) stocks in Subareas 3 and 4. The assessment of the southern capelin stock in Divisions 3LNOPs and the squid stocks were deferred from the 1978 Annual Meeting (*ICNAF Redbook* 1978, page 39 and 48). The reassessment of the northern capelin stock in Subarea 2 and Div. 3K was added to the agenda for this meeting at the request of Canada (Com. Doc. 79/III/1). Following the recent resignation of the Chairman of STACRES (Dr E. C. Lopez-Veiga), it was unanimously agreed that Dr G. H. Winters (Canada) act as Chairman for this meeting. Scientists attended from Canada, Cuba, France, German Democratic Republic, Japan, Norway, Poland and USSR, and an observer from USA.

Meetings of *ad hoc* Working Groups on Capelin (convened by G. H. Winters) and on Squid (convened by F. Nagasaki) were held concurrently during 15-20 February and their reports, as approved by STACRES are given in Appendices I and II. The agenda for the meeting is at Appendix III, the list of participants is at Appendix IV and the list of research documents is at Appendix V.

1. Assessment of Capelin Stocks (App. I)

a) Trends in catch and effort

The nominal catch of capelin in Subareas 2 and 3 declined from a peak level of 366,000 tons in 1975 to 84,000 tons in 1978. The development of the fishery during 1971-75 and the subsequent decline to 1978 followed a similar pattern in both the northern (Subarea 2 and Div. 3K) and the southern (Div. 3LNOPs) stock areas, but the decline was particularly great in Div. 3NO where the nominal catch decreased from 132,000 tons in 1975 to about 5,000 tons in 1978. Stock discrimination studies indicated that the spawning population on the Southeast Shoal (Div. 3N) is distinct from that spawning inshore in Div. 3L but they were unable to demonstrate the possible mixture of these spawning components in the offshore fishery in Div. 3L.

Analysis of catch and effort statistics indicated that the catch per hour fishing of USSR BMRT-A trawlers in Subarea 2 and Div. 3K declined from 6.5 tons in 1975 to 2.3 tons in 1978. Statistics for this vessel type were not available for Div. 3LNOPs, but the catch per day of USSR trawlers (>2000 GRT) declined from 44 tons in 1976 to 28 tons in 1978. Catch per unit effort was considered not to be a reliable index of abundance in Div. 3N, since the catchability coefficient would probably increase with declining abundance, given the distributional characteristics of capelin on the spawning grounds.

b) Subarea 2 and Division 3K

Both Canadian and USSR analytical assessments indicated that the biomass of the northern stock was high during the mid-1970's (up to 4.0 million tons) due to good recruitment of the 1969 and 1973 year-classes but has since declined due to poor recruitment of the 1974-76 year-classes. Biomass estimates for 1978, derived by various methods, ranged from 59,000 tons to 1.25 million tons. Weighting of the various estimates according to the reliability of the data yielded an average biomass estimate of 665,000 tons on 1 September 1978. This estimate was projected forward to 1980, assuming catches of 50,000 and 100,000 tons in 1979 and assuming that recruitment of the 1977 and 1978 year-classes at age 2 was equal to the geometric mean of the strength of previous year-classes. It must be emphasized that the size of the stock in 1980 will depend very greatly on the strengths of the 1976-78 year-classes. In view of the uncertainties about the size of these year-classes, STACRES advises that the TAC for Subarea 2 and Div. 3K in 1979 should be set at 75,000 tons.

c) Divisions 3LNOPs

Tagging studies by Norway in Div. 3N in 1978 indicated that the catch (about 5,000 tons) represented a high proportion of the spawning biomass in that area. An acoustic survey in May indicated a biomass of 310,000 tons in Div. 3L, and a sequential capelin abundance model indicated a biomass of approximately 200,000 tons in Div. 3LNOPs, 98% of which was estimated to be in Div. 3L. The sequential abundance model indicated that biomass levels during the early and mid-1970's were much higher than in 1978, due to recruitment of the strong 1969 and 1973 year-classes, and that the proportion of the stock in Div. 3NO was much higher in earlier years. Recent recruitment (1974-76 year-classes) has been poor. The decline in stock biomass has been much greater in Div. 3NO than in Div. 3L, and, since bottom temperatures on the spawning grounds in Div. 3N in recent years have been within the range suitable for spawning in that area, the possibility of recruitment overfishing should be taken into account.

Projections of stock size, using two different estimates of the strength of the 1976 year-class (860 and 2,134 million fish) and two levels of biomass estimated for 1978 (200,000 and 310,000 tons), indicated that the biomass in 1979 would be lower than the estimates for 1978 and that the strength of the 1976 year-class would have to be much greater than the maximum estimate used in the projections for the biomass in 1979 to exceed the levels estimated for 1978. Since a species like capelin with a short life-cycle usually exhibits large fluctuations in abundance, STACRES concluded that, during periods of poor recruitment, the exploitation rate should be low in order to protect the spawning stock biomass. Using a conservative exploitation rate of 10%, the projections indicate that the TAC for capelin in Div. 3LNO should fall in the range of 9,000-16,000 tons. On the basis of the higher estimate of capelin abundance in 1979, STACRES advises that the 1979 TAC in Div. 3LNO should be set at 16,000 tons. Furthermore, in order to protect the spawning stock in Div. 3N and during its migrations through Div. 3O, STACRES advises that there should be no commercial fishery for capelin in Div. 3NO and that the TAC apply only to Div. 3L.

d) Future research

The uncertainties which continue to exist about the population dynamics of capelin make it important, for future assessments, that all biomass estimates be accompanied by estimates of variance, that methods be investigated for improving the estimation of pre-recruit abundance, that studies on predator-prey interactions and migration patterns be continued, and that research on spawning behaviour and egg mortality in Div. 3N be initiated.

2. Assessment of Squid (*Illex illecebrosus*) Stocks in Subareas 3 and 4 (App. II)

a) Fishery trends

The nominal catch of squid in Subareas 3 and 4 increased rapidly from an annual average of 4,500 tons in 1970-74 to 99,000 tons in 1978, 54% of which were taken in Subarea 4. No estimate of the 1978 catch in Subareas 5 and 6 could be made due to incomplete statistics, but the *Illex* catch was about 25,000 tons in 1976 and 1977.

The overall distribution of *Illex* in Subareas 3 and 4 during 1978 did not change much from that of 1977. Squid appeared on the Scotian Shelf in June and the fishery lasted until November. Offshore occurrence on the Grand Bank was noted in June and the fishery there extended from July to September. In Newfoundland inshore waters, squid appeared in late May and remained available to the fishery until December.

b) Biological studies

When the fishery on the Scotian Shelf began on 15 June 1978, squid were on the average considerably smaller than at the same time in 1977 (mantle length difference of 27 mm), but growth was rapid during the summer so that by September the average size was similar to that for 1977. Studies on maturation indicated that both males and females were approaching full maturity upon their departure from the coastal and shelf areas in late November. In the laboratory, female *Illex* were observed to reach full maturity and to spawn. The eggs hatched in 6-8 days at 13°C and early larval stages were observed for the first time. Further studies on age determination by statoliths confirmed the existence of numerous zones which may represent diurnal or feeding periods. Large numbers of squid were successfully tagged in inshore Newfoundland waters late in the season, and specimens recaptured up to 29 days after tagging showed no apparent adverse effects.

c) Environmental effects

Several sources of information indicated that squid abundance has fluctuated greatly over the past several years. It was noted that prevailing environmental conditions, especially water temperature, seem to be correlated with changes in availability, with possible influence on the arrival and concentration of squid on the fishing grounds. Such conditions may have influenced not only the growth but also the availability of squid on the Scotian Shelf in the early part of the 1978 fishing season.

d) Mesh selection

Various mesh selection studies were conducted in 1977 and 1978, using codend mesh sizes ranging from 45 to 130 mm. Early in the season (June) the 90-mm mesh codend released 20-23% of the catch by weight in contrast to 13-14% for the 45- and 60-mm mesh sizes currently in general use, whereas later in the year (October-November) the 90-mm mesh released 1-2% against no escapement for the 60-mm mesh . It was noted that general use of 90-mm mesh codends would not only reduce the by-catch of small commercially-important finfish species but allow the escapement of small squid early in the season with a consequent increase in the yield per recruit. It was also

pointed out that the yield per recruit of silver hake would be greatest if the size at first capture was increased to about 26 cm which corresponds to the 50% retention length for silver hake with the 90-mm mesh. STACRES agreed that the possibility of having a uniform mesh size for the squid and silver hake fisheries should be deferred until the status of the silver hake fishery is assessed, and it accordingly

recommends

that the codend mesh size for the silver hake and squid fisheries be considered by the Assessments Subcommittee at its April 1979 Meeting.

e) Biomass estimates

STACRES noted that the biomass estimates provided for 1978, based on sequential population analysis and areal expansion methods, varied greatly for both Subareas 3 and 4. After discussion, it as agreed to accept the average of the various estimates of stock size with the result that the biomass (as on 1 September 1978) was estimated to be 97,000 tons in Subarea 3 and 152,000 tons in Subarea 4. Exploitation rates in 1978 were calculated to be 0.29 and 0.18 for Subareas 3 and 4 respectively.

f) Total Allowable Catch for 1979

Due to the very short life-span of *Illex* and the large fluctuations in availability from year to year, its abundance in Subareas 3 and 4 cannot be predicted at this time. The design of an effort regulation for 1979 was not possible due to the many technical problems involved. Consequently, it was agreed that a TAC should be applied to the squid fishery in 1979, accompanied by limitation of effort based on 1978 catch rates to ensure that fishing mortality would not greatly increase in the case of reduced abundance. It was noted that, should the abundance of *Illex* in 1979 be as high or higher than in 1978, a higher exploitation rate than that in 1978 would be appropriate. STACRES therefore advises that the TAC for 1979 should be set at 120,000 tons, with 70,000 tons for Subarea 4 and 50,000 tons for Subarea 3, and that the opening date of the fishery should be 1 July 1979. Since migration patterns are variable from year to year, STACRES

recommends

that the Assessments Subcommittee at its April 1979 Meeting give further consideration to the commencement date for the squid fishery in relation to availability of squid on the fishing grounds and to environmental conditions.

g) Future research

STACRES noted the need for more intensified research on the general biology and distribution of *Illex*, including the effects of environmental factors on migration and abundance, through the extension of research vessel surveys, improved tagging techniques to facilitate studies on stock discrimination and the estimate of population parameters, and continued mesh selection studies to obtain more precise information on *Illex* and by-catch species.

3. Standard Form for Reporting Age-Length Keys

STACRES noted that this item had been deferred from its Special Meeting in November 1978. In view of the absence of representation at this meeting from two of the coastal states involved in the initial design of the form, STACRES agreed that the matter be deferred for consideration at the 1979 Annual Meeting by the Statistics and Sampling Subcommittee.

4. Other Matters

STACRES was informed that the publication of *Statistical Bulletin* Vol. 27 for 1977 was unduly delayed due to the non-receipt of STATLANT 21B statistics for 1977 from three countries, namely Portugal, Spain and United Kingdom, despite several telexed reminders following the reporting deadline of 30 June 1978. The Secretariat has received no response to any of its requests for the data and, consequently, cannot indicate if or when these countries will submit their data. In fact, it was noted that two of the three countries involved did not submit a preliminary monthly statistical report during the whole of 1978. STACRES expressed great concern not only for the invonvenience to the many users of ICNAF statistics caused by the delay in publishing the Statistical Bulletin, but, more important, for the effect that incomplete statistics for 1977 and 1978 will have on the stock assessments to be carried out at the forthcoming meeting of the Assessments Subcommittee in April 1979. Noting that the Secretariat had done all in its power to solicit the appropriate statistics, STACRES

recommends

that the matter of non-reporting of fisheries statistics for the ICNAF Area by certain countries be brought to the attention of the Commission at its forthcoming Special Meeting in March 1979.

5. Adoption of Report

Since time did not permit the final preparation and adoption of the foregoing report before adjournment, STACRES agreed that the Chairman in collaboration with the ICNAF Secretariat prepare the proceedings for immediate distribution as a Summary Document and for later adoption at its 1979 Annual Meeting. It is noted that the reports of the *ad hoc* Working Groups on Capelin (Appendix I) and Squid (Appendix II) were formally adopted by STACRES at this Meeting.

6. Acknowledgements

The Chairman expressed his appreciation on behalf of STACRES to the Japanese hosts for the excellent service and facilities provided for the meeting and for their generous hospitality, he thanked all participants including the conveners of working groups and the rapporteurs for their interest and cooperation during the meeting, and the Secretariat for their usual efficient work. STACRES expressed its gratitude to Dr G. H. Winters for agreeing to preside over this meeting at very short notice.

APPENDIX I. REPORT OF *AD HOC* WORKING GROUP ON CAPELIN

Convener: G. H. Winters Rapporteur: J. E. Carscadden

The *ad hoc* Working Group on Capelin met during 15-19 February 1979 to review the status of the capelin resource and fishery in Subareas 2 and 3. Initially the assessment was intended to cover only the southern stock complex in Div. 3LNOPs (*ICNAF Redbook* 1978, page 39), but the agenda was subsequently amended to include a reassessment of the northern stock in Subarea 2 and Div. 3K at the request of Canada (Com. Doc. 79/III/1). Scientists attended from Canada, Cuba, German Democratic Republic, Japan, Norway, Poland and USSR. During the course of the assessments, the Working Group reviewed Res. Doc. 79/II/1, 7, 9, 10, 23, 29, 30, 31, 32, 33 and 34, and unpublished data.

1. Fishery Trends

The nominal catch of capelin in Subareas 2 and 3 increased greatly from less than 3,000 metric tons in 1971 to 366,000 tons in 1975 and declined rapidly to 84,000 tons in 1978 (Table 1). The development of the fishery during 1971-75 and the subsequent decline followed a similar pattern in both the northern (Subarea 2 + Div. 3K) and the southern (Div. 3LNOPs) stock areas, except that the peak catch occurred a year later in the northern area. From 1976 to 1978, the nominal catch declined by 75% in the northern area and by 80% in the southern area. In Div. 3LNOPs, apart from Subdiv. 3Ps where catches have generally been small, the most drastic decline occurred in Div. 3NO.

Table 1. Nominal catches (metric tons) of capelin by stock area in Subareas 2 and 3, 1971-78.

Year	2+3K	3L	3NO	3Ps	3LNOPs	SA 2+3
1971	242	870	750	999	2,619	2,861
1972	45,623	1,241	21,417	2,522	25,180	70,803
1973	136,422	3,876	126,875	1,356	132,107	268,529
1974	126,939	57,713	100,751	2,248	160,712	287,651
1975	198,501	34,097	131,783	1,583	167,463	365,964
1976	216,326	33,823	110,186	61	144,070	360,396
1977	152,409	26,802	50,092	1,016	77,910	230,319
1978[1]	55,051	23,763	5,164	8	28,935	83,986

[1] Preliminary statistics.

A review of nominal catches by stock area and country during 1971-78 (Table 2) indicates that about 92% of the total catch in the northern area was taken by USSR and that 60% and 23% of the total catch in the southern area were taken by USSR and Norway respectively.

2. Migrations and Stock Interrelationships

Capelin in Div. 3LNOPs exhibited unusual distribution patterns during the 1978 fishing season. Most of the catch was taken in Div. 3L (about 24,000 tons), with only about 5,000 tons being taken on the spawning grounds in Div. 3N. It is likely that this extremely small catch in Div. 3N represented the bulk of the spawning stock (Res. Doc. 79/II/1). Anomalous hydrographic conditions in 1978 may have influenced the distribution of capelin (Res. Doc. 79/II/31). However, bottom temperatures on the spawning grounds (Div. 3N) in recent years, including 1978, were within the range of temperatures considered sufficient for capelin spawning (Res. Doc. 79/II/9). Surface temperatures in the same area were higher in 1978 than in previous years.

A multivariate analysis of meristic characters of spawning capelin (Res. Doc. 79/II/29) suggested that there are three major stocks in the Newfoundland area: the Southeast Shoal stock, the Gulf of St. Lawrence (western Newfoundland) stock, and the insular Newfoundland stock. Although meristics were not considered to be the best characters to discriminate capelin stocks, the Working Group noted that the method offered some promise in stock differentiation and recommended the continuation of such studies in view of the scarcity of knowledge on the subject.

3. Trends in Abundance

a) Commercial catch-effort analyses

Subarea 2 and Division 3K. The catch of capelin in this area has declined greatly following the

Table 2. Nominal catches (metric tons) of capelin by stock area and country, 1971-78.

Area	Country	1971	1972	1973	1974	1975	1976	1977	1978[1]
2+3K	Bulgaria	-	-	-	-	1,394	-	2,892	-
	Canada	242	461	598	1,343	698	1,684	2,136	2,446
	Cuba	-	-	-	-	-	-	5,089	1,340
	GDR	-	11	-	-	7	-	1,014	227
	Japan	-	-	-	-	62	51	870	69
	Norway	-	-	-	16	2	-	-	-
	Poland	-	24	2,356	5,734	20,267	10,494	4,282	1,036
	Portugal	-	-	-	-	175	-	-	-
	Romania	-	-	-	-	-	-	2,610	2,530
	USSR	-	45,127	133,468	119,846	175,896	204,097	133,516	47,403
	Total	242	45,623	136,422	126,939	198,501	216,326	152,409	55,051
3LNOPs	Bulgaria	-	166	-	-	-	1,271	578	25
	Canada	1,869	3,312	5,502	13,693	3,817	7,832	9,715	6,277
	Cuba	-	-	-	-	-	-	700	82
	GDR	-	-	-	-	-	-	-	179
	Iceland	-	-	-	-	15,814	8,839	3,394	354
	Japan	-	-	-	-	2,819	5,063	3,958	789
	Norway	-	653	41,293	43,964	37,477	23,178	21,499	4,238
	Poland	-	-	744	3,742	4,608	4,627	1,018	502
	Portugal	-	-	-	3,500	399	-	-	-
	Romania	-	-	-	-	-	-	-	107
	Spain	-	-	-	4,016	4,284	-	-	-
	USSR	750	21,049	84,568	91,797	98,245	93,030	37,047	16,382
	Others	-	-	-	-	-	230	1	-
	Total	2,619	25,180	132,107	160,712	167,463	144,070	77,910	28,935

[1] Preliminary statistics

peak catch in 1976. In view of the oceanic distribution of capelin during the fishing season in this area, the Working Group concluded that catch per hour trawling of the standard class USSR BMRT-A trawlers would provide a useful index of stock abundance (Res. Doc. 79/II/30). Catch per hour trawling was considered to be a more accurate index than catch per day fished, as the catch during a day can be increased or decreased by fishing for different periods of time. The catch per unit effort was highest in 1975 (6.47 tons per hour) and declined to a low level in 1978 (2.29 tons per hour).

Divisions 3LNOPs. Estimates of catch per unit effort of USSR trawlers (>2000 GRT) in Div. 3L indicate a gradual decline from 1975 to 1977 (46.1 to 39.9 tons per day) and an abrupt decline in 1978 (27.6 tons per day) (Res. Doc. 79/II/33). In Div. 3N, catch per unit effort declined from 50.1 to 37.9 tons per day from 1974 to 1977 with a sharp decline to 0.8 tons per day in 1978. The Working Group noted that, because the capelin occurring in Div. 3N are composed of dense spawning schools, the catchability coefficient would probably increase as the stock declined and the catch per unit effort would remain high. Under these conditions, catch per unit effort would not likely be indicative of the trend in stock abundance until the stock had declined to an extremely low level. The Working Group therefore concluded that the estimates of catch per unit effort (Res. Doc. 79/II/23, 31 and 33) were useful as an index of stock abundance in Div. 3L only.

b) Research vessel survey indices, including acoustic data

Subarea 2 and Division 3K. A USSR acoustic assessment in November 1977 provided a biomass estimate of 59,000 tons (Res. Doc. 79/II/30), but this estimate was considered to be unreliable because the distribution of capelin in 1978 made the photographic estimation of density of the schools difficult and the survey did not include areas inside Canadian territorial waters. A Canadian acoustic assessment in October 1978 provided a biomass estimate of 339,000 tons (Res. Doc. 79/II/34), which is considered to be an underestimate because the capelin were observed to be congregating at the end of the survey.

Divisions 3LNOPs. An acoustic assessment by Cuba in early July 1978 (Res. Doc. 79/II/7) indicated

a biomass of 4,500 tons of immature capelin, which could not be considered as indicative of the abundance of the mature population in 1978. A USSR acoustic survey in Div. 3L during May-June 1978 (Res. Doc. 79/II/31) yielded a biomass estimate of 310,000 tons. Because most of the capelin remained in Div. 3L in 1978, this estimate was considered to be indicative of the relative abundance in comparison with those of previous years but may be an underestimate because the entire area was not surveyed. However, no estimates of variance were provided and the Working Group could not evaluate with statistical validity any range of values around the acoustic estimate. Due to problems in locating capelin concentrations, Canadian scientists could not obtain an acoustic estimate of the capelin biomass in Div. 3N in 1978.

c) Numerical population models

Subarea 2 and Division 3K. A USSR analytical assessment using the Allen model indicated that the biomass of capelin at the end of the 1978 fishery was 598,000 tons (Res. Doc. 79/II/30), implying that the biomass was approximately 700,000 tons at the beginning of the 1978 fishery. No variance estimate was provided, but the Working Group concluded that the major source of error in this method is that the 1978 biomass estimate is dependent on the starting biomass used in earlier years. A Canadian assessment based on a sequential capelin abundance model estimated the capelin biomass at the beginning of the 1978 fishery to range from 1.12 to 1.25 million tons (Res. Doc. 79/II/32). No variance estimates were provided but the major sources of error in the model pertain to the assumptions on spawning mortality and proportions mature at age.

Both the USSR and Canadian assessments indicated that the capelin biomass was high in 1975 and 1976 and declined during 1977 and 1978, such that the 1978 biomass was between one-third and one-half of the 1975 and 1976 levels. The biomass was high in the earlier years of the fishery due to the strong 1969 and 1973 year-classes.

Divisions 3LNOPs. Canadian assessments based on sequential capelin abundance models indicate that the stock in Div. 3LNO has declined since 1972 to a low level of 200,000 tons in 1978, the decline in the Div. 3NO portion of the stock being much greater than that in Div. 3L (Res. Doc. 79/II/33). These declines are also evident from catch per unit effort indices. As a consequence of these dynamics, the Div. 3L portion of the stock has constituted the major part of the total biomass since 1975 such that it made up 98% of the stock in 1978. Although no estimates of variance were provided for these sequential population analyses, the Working Group recognized that the models are sensitive to such input variables as spawning mortality and the proportions mature at age. It was noted that the high biomass levels in the early and mid 1970's were the result of the strong 1969 and 1973 year-classes.

d) Other estimates

Subarea 2 and Division 3K. A Cuban assessment based on the areal expansion technique (Res. Doc. 79/II/10) provided a biomass estimate of 77,000 tons. This was considered to be an underestimate because it was based only on the area fished by the Cuban fleet in 1978.

Divisions 3LNOPs. A tagging experiment conducted by Norway (Res. Doc. 79/II/1) was not successful in providing an estimate of the spawning stock in Div. 3N because of the absence of capelin for tagging before the fishery began and the sudden end to fishing after only two days. Some capelin were tagged and the high number of recaptures indicated that a large proportion of the capelin in the fishing area were caught.

4. Biological Characteristics

The Working Group did not discuss the following sub-items of this agenda item due to the lack of any new information: annual variation in growth, annual variation in maturity and spawning, stock-recruitment considerations, and the importance of capelin as a major prey species in the Grand Bank area.

5. Recruitment Estimation and Prognosis for 1979

a) Subarea 2 and Division 3K

In view of the wide range of biomass estimates provided, the Working Group agreed to take a weighted average (665,000 tons) as the "best" estimate of the biomass on 1 September 1978. The weighting factors were determined after considering the reliability of the data used. The age structure of this estimate was calculated from the population structure derived from the Canadian sequential capelin abundance model. Using this age structure and assuming the size of the 1977 year-class to be the geometric mean of previous year-classes as 2-year-olds, the biomass of the stock on 1 January 1979 was estimated at 1.266 million tons (Table 3). Since this estimate was considered indicative of a low stock level for 1979, the main concern of the Working Group was directed to a reduction in fishing mortality in an attempt to stabilize the stock and perhaps

allow for some recovery. The results of the projections under assumed catches of 50,000 and 100,000 tons in 1979, which corresponds to approximately 10% of the biomass levels at the beginning of the fishing season in 1979 as predicted from the models, are given in Table 3.

Table 3. Capelin in Subarea 2 and Division 3K: projected catches in 1979 and stock sizes in 1980 under assumed catches of 50,000 and 100,000 tons in 1979.

Age	Stock size at start of 1979 (10^6)	1979 catch at 50,000 tons Number (10^6)	1979 catch at 50,000 tons Weight (000 t)	Stock size at start of 1980 (10^6)	1979 catch at 100,000 tons Number (10^6)	1979 catch at 100,000 tons Weight (000 t)	Stock size at start of 1980 (10^6)
2	73,000	980	15.5	73,000	1,874	32.6	73,000
3	17,705	904	23.0	53,231	1,825	46.5	52,296
4	7,014	331	9.9	8,653	601	17.9	7,780
5	1,655	50	1.7	874	91	3.0	619
Total	99,374	2,265	50.1	135,758	4,391	100.0	133,695
F multiplier			0.315			0.670	
Spawn. biomass (000 tons)	460			730			687
Total biomass (000 tons)	1,266			1,902			1,856

The Working Group points out that the size of the capelin biomass in 1980 will depend very much on the strength of the most recent year-classes, 1976 and 1977 in particular. Since the estimated size of the 1976 year-class and the assumed size of the 1977 year-class are subject to substantial errors, a catch of 100,000 tons may be too high and, alternatively, a pessimistic error may result in a low yield of 50,000 tons. Therefore, in view of the uncertainty associated with estimating the sizes of the incoming year-classes, the Working Group advises that the TAC in Subarea 2 and Div. 3K should be set at 75,000 tons for 1979.

b) Divisions 3LNOPs

Estimates of the strength of the 1976 year-class in Div. 3L were obtained from correlations of strengths of year classes in Subarea 2 + Div. 3K with the strengths of corresponding year-classes in Div. 3L. These provided two estimates of year-class strength which were used in the projections based on the Canadian sequential capelin abundance models. These projections indicated that the biomass of capelin in Div. 3L in 1979 would be lower than in 1978 (Table 4). Projections, using the same estimates of the strength of the 1976 year-class and the 1978 biomass estimate from the USSR acoustic survey, also indicated that the biomass in Div. 3L in 1979 would be lower than in 1978 (Table 5).

Table 4. Projections of numbers at age and total biomass for Div. 3L at the start of 1979, based on a biomass of 200,000 tons in 1978 (Canadian SCAM model) assuming two different levels of recruitment at age 3.

Age	Numbers at age (10^6) Option 1	Option 2
3	859.7	2,134.1
4	1,380.1	1,380.1
5	587.1	587.1
6	111.3	111.3
Total number (10^6)	2,938.2	4,212.6
Total biomass (tons)	86,708	114,617

Table 5. Projections of numbers at age and total biomass for Div. 3L at the start of 1979, based on a biomass of 310,000 tons in 1978 (USSR acoustic survey) and assuming two different levels of recruitment at age 3.

Age	Numbers at age (10^6) Option 1	Option 2
3	859.7	2,134.1
4	2,273.6	2,273.6
5	960.7	960.7
6	185.0	185.0
Total number (10^6)	4,279.0	5,553.4
Total biomass (tons)	130,500	158,409

The Working Group points out that the 1976 year-class is apparently weak but that no estimates of variance associated with the recruitment of this year-class were available. However, even if the strength of this year-class was much higher than predicted, the biomass level in 1979 would probably not exceed the calculated biomass level for 1978. Since the Div. 3L portion of the stock has constituted the major part of the total stock (Div. 3LNOPs) in recent years, the biomass projections given in Tables 4 and 5 should reflect the abundance of the total capelin stock in Div. 3LNOPs in 1979. Because of the predicted low abundance of the 1976 year-class, it is expected that the 1974 and 1975 year-classes will be the major components of the population in 1979.

It is the conclusion of the Working Group that no strong year-classes have been evident in the Div. 3LNO population since that of 1973, which constituted only a small proportion of the biomass in 1978 and will virtually disappear in 1979, and that the decline in biomass in recent years has been the result of poor recruitment since 1973. The decline in recruitment in Div. 3NO has been greater than in Div. 3L, although a general trend in declining recruitment of capelin is evident for all stocks in the ICNAF area. The effects of hydrographic conditions on recruitment could not be assessed by the Working Group due to the lack of data. However, since bottom temperatures on the spawning grounds (Div. 3N) in recent years, including 1978, were within the range of temperatures considered sufficient for capelin spawning, unfavorable water temperatures are not likely to be the only cause of recruitment failure in Div. 3N. The intense commercial fishery on the spawning grounds in Div. 3N may have substantially reduced the spawning stock size in recent years, and the possibility of recruitment overfishing should be taken into account.

Because of marked fluctuations in recruitment and the short life cycle of the species, capelin populations will exhibit violent fluctuations in biomass. The Working Group therefore concludes that, during periods of poor recruitment, the exploitation rate should be low to protect the spawning stock. Using a conservative exploitation rate of 10%, the projections for 1979 (Tables 4 and 5) indicate that the TAC should fall in the range of 9,000-16,000 tons. Based on the higher estimate of capelin abundance in 1979, the Working Group advises that the 1979 TAC for capelin in Div. 3LNO be set at 16,000 tons. In order to protect the spawning stock in Div. 3N and since capelin migrating to Div. 3N usually pass through Div. 3O, the Working Group further advises that there be no commercial fishery for capelin in Div. 3N and 3O in 1979 and that the TAC apply only to Div. 3L.

6. Future Research

a) Since most of the assessments of capelin abundance presented at this meeting did not provide estimates of variance, the Working Group recommends that a concerted effort be made in future assessments to provide such estimates of variance in order to better evaluate historical and projected abundance estimates. This is particularly true for acoustic surveys where careful planning of survey tracks and replicate surveys will provide meaningful variance estimates. In addition, the intercalibration of acoustic equipment in joint surveys should be attempted. When designing acoustic surveys, consideration should be given to the issue of errors resulting from incomplete coverage of the survey area, errors from the use of incorrect target strength due to lack of knowledge of fish orientation, and errors resulting from individual fish producing echoes below the threshold level.

b) In analytical models, research should be focused on estimating values of the proportions mature at age and of the spawning mortality. Historical data on weight-at-age and length-at-age of capelin in the commercial fishery would be valuable in this regard.

c) Methods of estimating pre-recruit abundance should continue to be investigated. Surveys conducted shortly after the beginning of capelin spawning will provide estimates of the abundance of the spawning population. Later surveys will provide more accurate estimates of pre-recruit abundance but will offer less precision in estimating the spawning biomass.

d) Studies on predator-prey interactions should continue, and, in this regard, the importance of analyses of cod feeding habits both inshore and offshore to compare with historical feeding patterns of cod is emphasized. Such studies are particularly important during periods of low capelin abundance in order to assess any changes in the feeding habits and the growth of cod.

e) Studies of migration patterns and stock discrimination should be continued. The tagging of capelin in Div. 3L would provide valuable information on the relative importance of inshore and offshore spawners in the fishery of this area.

f) An intense commercial fishery on capelin spawning grounds, such as has occurred in Div. 3N, may affect spawning behaviour and the mortality of capelin eggs. In the absence of such a fishery, it is important that studies on egg mortality and spawning behaviour be initiated to provide baseline data in the event that favorable recruitment of capelin permits a fishery in Div. 3N in the future. Such surveys of egg abundance may also allow the estimation of spawning stock size.

7. Other Matters

a) The Working Group emphasized the need for coordination of acoustic surveys being planned by member countries, and accordingly

recommends

that an ad hoc working group on capelin be convened during the time of the Assessments Subcommittee Meeting, 28 March-10 April 1979, at St. John's, Newfoundland, to evaluate and coordinate capelin research plans for 1979.

b) In view of the short life cycle of capelin and the difficulty of estimating the size of recruiting year-classes, the Working Group strongly

recommends

that future assessments of both the northern and southern capelin stocks be carried out early in the year for which advice on management is required.

c) The Working Group wishes to remind members of STACRES that a joint USA-USSR acoustics symposium will be held at Cambridge, Massachusetts, USA, in July 1979.

APPENDIX II. REPORT OF *AD HOC* WORKING GROUP ON SQUID

Convener: F. Nagasaki

The *ad hoc* Working Group on Squid met during 15-20 February 1979 to assess the status of the squid (*Illex illecebrosus*) stocks in Subareas 3 and 4 in accordance with the STACRES recommendation from the 1978 Annual Meeting (*ICNAF Redbook* 1978, page 39). Scientists attended from Canada, Cuba, German Democratic Republic, Japan, Poland and USSR, and an observer from USA. During the course of its discussions, the Working Group reviewed Res. Doc. 79/II/2, 3, 4, 5, 6, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 35, 36, 37 and 38, and unpublished data.

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 80,000 tons in 1977 (Table 1). Preliminary data indicate that the 1978 catch was about 99,000 tons, an increase of 24% over that of 1977.

Table 1. Nominal catches (metric tons) of short-finned squid (*Illex illecebrosus*) in Subareas 2-4 by country, 1970-78.

	1970	1971	1972	1973	1974	1975	1976	1977	1978[1]
Bulgaria	-	-	-	-	-	25	1,034	2,998	948
Canada (MQ)	6	16	8	11	65	89	943	1,275	26,960
Canada (N)	74	1,606	18	622	17	3,204	9,929	29,733	39,277
Cuba	-	-	-	-	-	-	3,248	4,685	4,056
France (M)	-	-	-	-	-	-	-	775	1,974
France (SP)	-	-	-	-	-	-	442	584	1,730
FRG	-	-	-	-	-	-	27	8,020	1,065
GDR	-	-	-	-	-	17	-	-	-
Italy	-	-	-	-	-	-	1,355	2,467	1,055
Japan	63	58	11	24	5	507	3,055	3,145	4,477
Poland	-	-	-	228	-	-	809	2,939	1,944
Portugal	-	-	-	-	-	-	264	1	580
Romania	-	-	-	-	-	-	-	1,304	980
Spain	-	-	-	-	265	268	934	3,070	4,010
USSR	1,242	7,226	1,831	8,992	85	13,634	16,900	18,953	9,534
Ireland	-	-	-	-	-	13	2,827	-	-
Total	1,385	8,906	1,868	9,877	437	17,757	41,767	79,953	98,590

[1] Preliminary data

A review of *Illex* catches by subarea (Table 2) indicates that only small sporadic catches were taken in Subarea 2, that the yield in Subarea 3 increased greatly from an average of 500 tons during 1970-74 to 45,000 tons in 1978, and that the yield in Subarea 4 increased from an average of 4,000 tons during 1970-74 to 53,000 tons in 1978. In Subareas 5 and 6, the known catch of *Illex* increased from about 2,000 tons in 1970 to nearly 17,000 tons in 1974 and declined to 14,000 tons in 1975. However, 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 available for these years. In 1976 and 1977, the *Illex* catch in Subareas 5 and 6 (including USSR data) was about 25,000 tons, but a reliable estimate for 1978 was not available at the time of this meeting due to incomplete statistics.

In the Northwest Atlantic as a whole, the known catches of *Illex* increased from about 4,000 tons in 1970 to about 32,000 tons in 1975 (Table 2). The overall catch increased significantly to 67,000 tons in 1976 and to 105,000 tons in 1977. During the two most recent years for which statistics are available, the proportion of the total catch taken in Subareas 2 to 4 increased from 62% in 1976 to 77% in 1977.

Preliminary information on overall fishing effort (days fished) in relation to directed squid fisheries on the offshore grounds in Subareas 3 and 4 during 1978 are given in Table 3. The data indicate considerable variation in overall catch per unit effort by the various countries involved in the fisheries.

Table 2. Nominal catches (metric tons) of *Illex* by subareas, 1970-78.

Year	Subareas 2	3	4	Total SA 2-4	Total SA 5-6
1970	-	111	1,274	1,385	2,453[2]
1971	-	1,607	7,299	9,906	4,036[2]
1972	-	26	1,824	1,850	14,713[2]
1973	2	620	9,255	9,877	15,178[2]
1974	31	17	389	437	16,653[2]
1975	-	3,764	13,993	17,757	13,790[2]
1976	-	11,254	30,510	41,764	24,936
1977	6	32,748	47,199	79,953	24,795
1978[1]	-	45,472	53,118	98,590	...

[1] Preliminary data
[2] Excludes USSR catches which have not been reported for *Illex* and *Loligo* separately.

Table 3. Catch (metric tons) and effort data for offshore directed squid fisheries in Subareas 3 and 4 for 1978[1].

Country	Subarea 3 Days fish.	*Illex* catch	C/f	Subarea 4 Days fish.	*Illex* catch	C/f
Canada (MQ)	54	1,560	28.9	862	21,465	24.9
Cuba	79	1,298	16.4	183	2,654	14.5
France (M)	-	-	-	94	1,974	21.0
Italy	-	-	-	120	1,084	9.0
Japan	62	549	8.9	288	3,625	12.6
Poland	-	-	-	84	1,662	19.8
USSR	5	35	7.0	378	9,260	24.5
Totals	200	3,442	17.2	2,009	41,724	20.8
Total catch		45,472[2]			53,118	

[1] Source: Res. Doc. 79/6, 22, 37, and unpublished data.
[2] Newfoundland inshore fishery accounted for 39,122 tons.

2. Biological Characteristics

a) Distribution

The overall distribution of *Illex* in Subarea 4 during 1978 did not change much from that reported for 1977 (*ICNAF Redbook* 1978, page 23). The offshore distribution in 1978, based on observations from all international fisheries on the Scotian Shelf (Res. Doc. 79/II/17, 22), showed three main areas of concentration at depths ranging from 100 to 250 m: Sable Island Bank, Banquereau Bank and Emerald Bank, near the line defined for the regulation of small-meshed gear. The major concentrations occurred in the Emerald Bank area during June and July and in the Sable Island Bank area later in the season (Res. Doc. 79/II/22, 36). Although immigration to the fishing grounds occurred early in June, commercial concentrations did not occur until mid-July. These concentrations lasted until late November. Distribution by depth changed from 75-150 m in June to 150-250 m in October-November (Res. Doc. 79/II/36). A small concentration of large maturing squid was noted at 350-450 m in late October and at 450-550 m in early November. Diurnal vertical migrations were apparent throughout the fishing season.

An unusual extension of *Illex* distribution into the Gulf of St. Lawrence occurred early in October 1978 and prevailed until early November, with large numbers having been washed ashore in the Northumberland Strait area in mid-October. Inshore occurrence along the east coast of Nova Scotia extended from early June to late September.

In Subarea 3, the inshore distribution of *Illex* in 1978 did not change from that of 1977, with squid appearing in late May and remaining available to the fishery until early December. Offshore occurrence on the Grand Bank was observed early in June with the fishery extending from

July to September. In Subdiv. 3Ps the fishery extended from July to early October.

b) Life cycle

Discernible geographic and seasonal patterns in the modal sizes of *Illex*, based on a compilation of data from several published sources, were noted by STACRES at its Special Meeting on Squid in February 1978 (*ICNAF Redbook* 1978, page 23). Further data for Subareas 3 and 4 were reviewed by the Working Group at this meeting (Res. Doc. 79/II/5, 14, 27 and 35, and unpublished data). The mean mantle length of both males and females in April 1978 was 150 mm, approximately the same as in 1977. When the fishery began on 15 June 1978, the average size was 159 mm (157 mm for male and 163 mm for female) in contrast to an average size of 186 mm at the same time in 1977. The difference in size between 1977 and 1978 represents an approximate delay in growth of about five weeks in 1978. However, by mid-September the average length in 1978 was similar to that in 1977 at approximately 225 mm (220 mm for male and 230 mm for female in 1978). Apparent asymptotic growth occurred in October-November of both years at approximately 245 mm (225 mm for male and 255 mm for female). Thus, while the squid were smaller at recruitment to the fishery in 1978 than in 1977, growth during the period from mid-June to mid-September was more rapid in 1978. The length distributions in 1978 were generally unimodal, but some multimodal frequencies were noted. The possibility of *Gonatus fabricii* being misidentified as *Illex illecebrosus* was suggested as an explanation for some of the modes at small size classes.

From a compilation of data on mean weights of *Illex* in samples collected in Subarea 4 during the 1978 season (unpublished data), the average weights in May were 72 g for males and 82 g for females and in November were 269 g for males and 317 g for females. Growth was rather slow up to the end of August after which both sexes showed rapid gains in weight. A statistical analysis of length-weight relationships in squid (Res. Doc. 79/II/4) indicated that a single equation derived from the combination of all samples irrespective of sex, area, season and year is about as precise as using separate equations for each sex, season, area and year.

Maturation indices for male and female *Illex* (Res. Doc. 78/II/5, 79/II/13) were used to trace the progression of maturation throughout the 1978 season. In Subarea 4, 50% of immature males (stage 1) had advanced to stage 2 in mid-July and to stage 3 in September, whereas 50% of the females had advanced to stage 2 in late May and to stage 3 in September. A few females were observed at stage 4 on the Scotian Shelf in late October and November, and two spent females (unconfirmed) were noted at the end of October, in depths of 350-550 m. In Subarea 3 inshore, the maturation of males advanced to stage 2 in September and rapidly to stage 3 in October, with a small percentage of stage 4 males being observed in late November. The sex ratio in Subarea 4 changed throughout the season as shown in Fig. 1, due probably to the greater selection of the larger females by the gear in July, August and September. The sudden decrease in percentage of males in the population from September to October may be due to emigration.

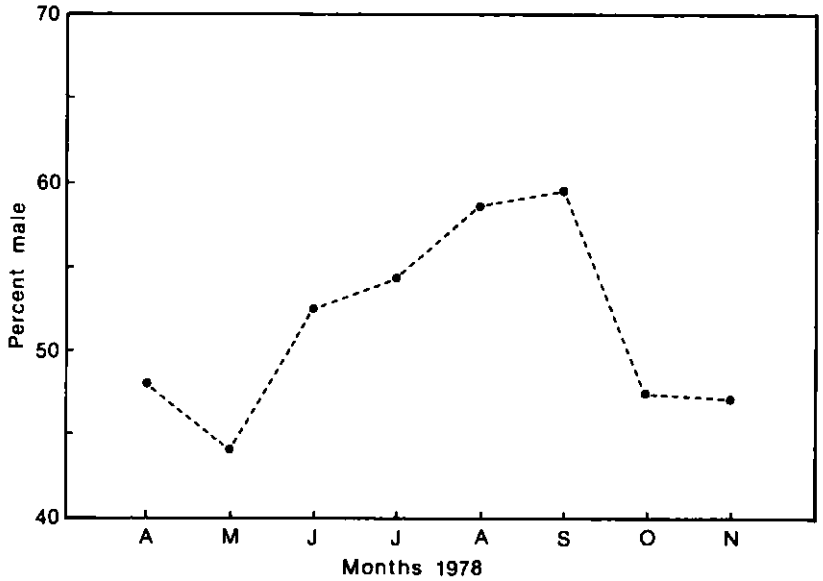

Fig. 1. Monthly percentage of males in the *Illex* stock on the Scotian Shelf during 1978.

c) Spawning (Res. Doc. 79/II/13)

Laboratory observations on stage 4 males showed that greater quantities of spermatophores were produced as maturation progressed through this stage with time. Larger males produced more spermatophores than the smaller ones, the number produced ranging from 200 to 700. The spermatophores release sperm after contact with nidamental gland jelly produced by the females.

Females were brought to maturity in the laboratory and successfully spawned. Egg masses consisted of large neutrally buoyant jelly masses 40-120 cm in diameter containing in the order of 100,000 ova dispersed about 1 cm from each other. One female could produce more than one egg mass. The females died soon after spawning. The tenuous jelly breaks up easily, and hence the collection of egg masses in the field is likely to be difficult.

The eggs hatches in 6-8 days after spawning at 13°C, and the early larval stages were observed for the first time (Res. Doc. 79/II/13). The ellipsoid egg (1.0 × 0.8 mm) enlarged to 1.8 mm in diameter before hatching. Newly hatched larvae had mantle lengths of 1.1 mm and carried a small internal yolk sac. The longest survivor was 8 days old and had a mantle length of 1.25 mm, with characteristic dorsal arms, developing proboscis and chromatophore patterns.

d) Age determination (Res. Doc. 79/II/26)

Age determination in *Illex* was attempted using statoliths from samples taken inshore in Subarea 3. Many difficulties were encountered in preparing the statoliths for examination. The difference in the mean numbers of discernible rings in samples taken on 9 June and 2 August (54 days) is 37, with a 95% confidence interval of 19-55. The indications are that daily rings may be discernible in more detailed studies.

e) Tagging (Res. Doc. 79/II/12, 25)

Laboratory experiments were conducted using different types of tags attached at different locations on the body. The spaghetti-type anchor tag appeared to affect the animal least especially in relation to the mortality observed in animals with skin lesions. In late October and early November 1978 tagging operations were undertaken in Conception Bay, Newfoundland. Of 3,184 squid tagged, 1,011 tags were recovered from the commercial fishery in the time lapse of 2 to 29 days within swimming distance of 10 km. Both anchor-type (32.8% return) and metal-clip (26.4% return) tags were successfully used, and the recovered squid showed no apparent adverse effects.

f) Food and feeding patterns (Res. Doc. 79/II/11, 16)

The diet of *Illex* taken offshore on the Scotian Shelf in June 1978 consisted mainly of euphausiids, whereas the major components were fish and cephalopod remains in October-November. The gut contents were often difficult to identify because squid macerate their food, but such remains as otoliths, squid beaks, vertebrae, scales, lenses, etc., aided in the identification of components. Feeding activity varied with the time of day, the peak occurring between 0000 hours and 0800 hours. The larger squid tended to feed less on crustacea and more on cephalopods (particularly *Illex*) and fish (gadoid species such as silver hake and longfin hake). The composition of food items varied from one location to another on the Scotian Shelf.

Feeding and growth studies, monitored for two months in the laboratory showed that the daily feeding rate for maintenance was about 1% of body weight. Average daily feeding rates ranged from 3.6 to 6.7% and average growth rates from 1.1 to 1.9%. Both rates increased with temperature.

3. Possible Environmental Influence on Abundance

It was indicated at the February 1978 Meeting of STACRES (*ICNAF Redbook* 1978, page 28) 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. This was demonstrated by data available from the Newfoundland inshore fishery and from Canadian surveys in Div. 4VWX. Such changes would seem to be influenced by prevailing environmental conditions, especially temperature, which may affect the arrival and concentration of squid on the fishing grounds.

In 1978, the delay in the arrival and concentration of squid on the Scotian Shelf can apparently be explained by lower bottom temperatures than those which prevailed in the two preceding years (Table 4), whereas in Newfoundland inshore waters the squid fishery occurred where the water temperature ranged from 7 to 15°C (Res. Doc. 79/II/25). Delays in offshore migration and winter spawning related to abnormally low temperatures have also been suggested, with a possible consequence of smaller squid at the beginning of the fishing season and hence smaller catches in June and July due to greater escapement from the trawls (Res. Doc. 79/II/37).

Table 4. Mean bottom temperatures on the Scotian Shelf in July in relation to biomass estimates (Res. Doc. 79/II/14) and nominal catches of *Illex* in Subarea 4, 1970-78.

Year	Temp. (°C)	Biomass (000 t)	Catch (tons)
1970	5.3	1.9	1,274
1971	5.6	14.7	7,299
1972	5.6	3.2	1,824
1973	5.8	8.9	9,255
1974	5.7	9.5	389
1975	5.4	24.8	13,993
1976	6.9	262.5	30,510
1977	6.5	50.5	47,199
1978	5.9	11.5	53,118

Undoubtedly, such a migratory animal as the squid must be influenced by environmental conditions and food availability, but it is difficult, if not impossible, from the data available to clearly understand the effects of these factors on squid behavior and on fishery parameters such as availability and true abundance. Analysis of this phenomenon is largely masked by the setting of a starting time for the fishing season and by fishing strategy, with most of the vessels arriving on the grounds at the peak of the fishing season.

4. Abundance Estimates

The Working Group reviewed a number of papers which provided a variety of estimates of squid abundance in Subareas 3 and 4, based on three different methods of analysis, namely, areal expansion technique using data from commercial fishing activities, sequential abundance analysis, and research vessel random-stratified surveys. It was noted that abundance estimates derived from the research vessel surveys underestimated considerably the actual abundance. However, the importance of these biomass estimates for Div. 4VWX (Res. Doc. 79/II/14) as indicators of year to year relative abundance was stressed. For Subarea 3, an annual predictive index of relative abundance in inshore waters later in the season is generated from the results of a research vessel survey of the Grand Bank in May-June (Res. Doc. 79/II/25).

A summary of all relevant abundance estimates considered by the Working Group is given in Table 5. In Subarea 4, there were 12 estimates derived from research and commercial fishing operations ranging from 6,580 to 434,580 tons, and one estimate based on sequential abundance analysis (212,470 tons). In Subarea 3, there were three estimates based on commercial fishing operations ranging from 29,284 to 76,200 tons, and one estimate based on sequential abundance analysis (216,530 tons).

The means of the estimates of population numbers from the research and commercial surveys and the estimates from sequential abundance analysis for Subareas 3 and 4 are given in Table 6. For the mean survey estimates, the standard deviation, the number of observations and the relative standard error are also given. For the sequential abundance analysis estimates, additional information include the standard error, the relative standard error and the regression estimate of terminal F. The estimates of the population numbers have variances of approximately 50%. However, the relative standard errors indicate that the estimates from sequential analyses have about the same variance as those derived from research and commercial surveys.

Since the sequential method yields the population numbers at the beginning of the season, these estimates are not directly comparable with the mid-season estimates from the research and commercial surveys. Therefore, the population numbers on 1 September (mid-fishing season) generated by the sequential method used in calculating the combined means of the population numbers given for both subareas. The exploitation rates for 1978 could then be derived using the formula $\mu = C/N$. Given the mean population numbers on 1 September and an estimated natural mortality value ($M = 0.06$), the population numbers at the beginning of the season were back-calculated for each subarea. The resulting exploitation rates for 1978 were 0.29 for Subarea 3 and 0.18 for Subarea 4.

Table 5. Summary of abundance estimates for Subareas 3 and 4 in 1978, based on research documents and other information reviewed by the Working Group.

Country	ICNAF area	Documentation	Time period	Population (numbers)	Biomass (tons)	Survey area (km^2)	Comments
Canada	3	Res. Doc. 79/II/25 + Corr.	Fishing season	715×10^6 (1 Sep)	216,530	Inshore Nfld and offshore in SA 3	From sequential abundance analysis
	4VWX	Unpubl. data	Fishing season	584×10^6 (1 Sep)	212,470	Commercial fishing area	From sequential abundance analysis
	4	Res. Doc. 79/II/36	June November	85×10^6 57×10^6	6,580 16,910	3.68×10^6 4.62×10^6	Mesh selection study
Cuba	3	Res. Doc. 79/II/8	July August September	212×10^6 515×10^6 185×10^6	29,280 76,200 41,150	$0.6\text{-}1.3 \times 10^6$	0.004 (F-values) 0.004 0.009
	4	Res. Doc. 79/II/8	July August September October	901×10^6 392×10^6 254×10^6 $1,849 \times 10^6$	124,390 57,990 56,450 434,580	$1.7\text{-}4.0 \times 10^6$	0.003 (F-values) 0.002 0.001 0.001
Japan	4	Res. Doc. 79/II/20	July August September October	559×10^6 $1,627 \times 10^6$ $1,566 \times 10^6$ 632×10^6	80,050 276,510 347,740 153,610	23,241	Commercial fishing activity
Poland	4	Res. Doc. 79/II/37	Fishing season	$1,069 \times 10^6$	138,400	18,600	Commercial fishing activity
USSR	4W	Res. Doc. 79/II/28	July	$3,052 \times 10^6$	354,000	11,548	Commercial fishing activity[1]

[1] Based on catches during 1200-1500 hours (local time)

Table 6. Squid abundance estimates (numbers) for 1978 in Subareas 3 and 4, based on the results given in Table 5.

Method	Parameter	SA 3	SA 4	SA 3+4
Survey estimates:	Mean pop. estimate (10^6)	304	1,004	
	standard deviation (10^6)	183	886	
	number of observations	3	12	
	relative standard error	0.35	0.25	
Squential method:	population estimate (10^6)	715	584	
	standard error of F	0.022	0.016	
	$\hat{F}$	0.070	0.049	
	relative standard error	0.31	0.33	
	Mean population numbers (10^6)	510	794	1,304[1]
	Biomass on 1 September (000 tons)	97	152	249

[1] Relative standard error = 0.16

5. Mesh Selectivity

The Working Group reviewed two research documents relating to mesh selection of *Illex* on the Scotian Shelf during 1977 and 1978. The results of two joint studies, one with Cuba in August 1977 and the other with USSR in October-November 1977 are summarized in Res. Doc. 79/II/3. The author rationalized that the morphology of squid make the 50% retention length too difficult to measure and indicated that results of such studies should be analyzed with respect to the percentage retained by weight. It was indicated that, in late summer and early autumn, 25-30% of the squid entering the trawl would escape through a 90-mm codend. Such a mesh size would allow the escapement of not only small squid which would increase the yield per recruit but also various species of small commercially-important finfish. The proportion of squid released by the 90-mm mesh would decrease with time as the squid increased in size. Since the growth of squid is usually rapid from April to June with increase in size becoming more gradual later in the year, the use of 90-mm mesh codends would allow the cropping of larger squid in the latter part of the year with no substantial reduction in yield relative to that obtained with small mesh sizes. The 50% retention lengths for the 60-, 70-, and 90-mm mesh codends were observed to be 140, 180 and 250 mm respectively.

The mesh selection studies reported in Res. Doc. 79/II/3 also contained the results for silver hake, which were taken concurrently with squid. The study indicated that the 90-mm mesh would, in the long term, give a slight increase in yield of silver hake over that for the 60-mm mesh, with a consequent increase in the average size of fish. The study further indicated that the change from using a 60-mm to a 90-mm mesh would entail an increase in effort in the order of 10-30%, whereas a change from a 90-mm to a 120-mm mesh would entail an increase in effort in the order of 30-100%. The 50% retention length for silver hake in the 90-mm mesh trawl was 260 mm, thus agreeing with earlier studies (*ICNAF Selected Papers* No. 1: 51-58) which indicated that the greatest yield-per-recruit would occur if the length at recruitment was increased to 25.5 cm and that the fishery should not start cropping silver hake until their third year (30-32 cm). The 90-mm mesh codend would therefore seem appropriate for silver hake, but the need for further investigation was noted.

The results of a joint Canada-Japan mesh selection study of squid on the Scotian Shelf in 1978 were reported in Res. Doc. 79/II/35. The experiment was conducted in two periods: (i) June, when codend mesh sizes of 45, 60 and 90 mm were used; and (ii) October-November, when codend mesh sizes of 60, 90, 100 and 130 mm were used. The 50% retention lengths obtained had the following ranges:

45 mm codend	109-148 mm
60 " "	122-134 "
90 " "	107-183 "
100 " "	190-197 "
130 " "	190-234 "

These indicate that selectivity was affected by the morphology and behaviour of squid. Therefore, the percentage released by weight rather than the 50% retention length was used to evaluate the selectivity of each net. In June, 21-23% of the squid catches were released by the 90-mm mesh codend in contrast to 13-14% by the 45- and 60-mm codends. In October-November, the 90-mm mesh codend released 1-2% of the catch, while none were released by the 60-mm mesh codend. The 130-mm codend released 19-43% of the catch depending on the time when fishing occurred.

The Working Group agreed that the possibility of having a uniform mesh size for the squid and silver hake fisheries should be deferred until the status of the silver hake fishery and stock is assessed, and it accordingly

recommends

that the codend mesh size for silver hake and squid fisheries be considered by the Assessments Subcommittee at its April 1979 Meeting.

6. Total Allowable Catch for 1979

In view of the very short life-span of *Illex* and the apparently large fluctuations in abundance and availability, its abundance in Subareas 3 and 4 cannot be predicted at this time, and data from surveys in early 1979 will not be available in sufficient time for effective adjustment of the TAC for 1979. The Working Group still favors, in principle, effort regulation as a means of managing the squid fishery. However, because of the many technical difficulties involved in the design of effort regulation for 1979, the Working Group agreed that a TAC should be applied to the 1979 squid fishery. Should the abundance of *Illex* be much reduced in 1979, the fishing mortality in Subarea 3 is unlikely to increase greatly. Limitation of fishing effort in Subarea 4, by applying 1978 catch rates to the 1979 TAC would ensure that fishing mortality would not increase greatly despite reduced abundance. Data reviewed by the Working Group indicated that a higher exploitation rate than the 1978 level is appropriate should the abundance of *Illex* in 1979 be as high or higher than in 1978.

The Working Group advises that the TAC for 1978 be 120,000 tons, with 70,000 tons for Subarea 4 and 50,000 tons for Subarea 3, based on relative biomass estimates for 1978, and that the opening date of the fishery be 1 July.

Since migration patterns are variable from year to year, the Working Group

recommends

that the Assessments Subcommittee at its April 1979 Meeting give further consideration to the commencement date of the squid fishing in relation to the availability of squid on the fishing grounds and to environmental conditions.

7. Future Research

a) The Working Group noted with interest the progress made in using statoliths as a possible means of ageing *Illex* and urges that such studies be continued.

b) The Working Group noted the results of laboratory and field tagging experiments undertaken in 1978 and emphasized the need for improved tagging techniques to facilitate studies on stock discrimination and the estimation of population parameters.

c) The Working Group noted the need for more extensive research vessel surveys on an annual basis to determine the distribution and abundance of *Illex*.

d) The Working Group noted that intensive mesh selection studies had been carried out in 1978 and indicated that such studies should be continued to provide more precise information on *Illex* and by-catch species.

e) The Working Group emphasized the need for continued studies on the general biology of *Illex*, such as, maturation, larval identification and distribution, and the effects of environmental factors on migration.

f) The Working Group noted some improvement in the reporting of detailed catch and effort data for squid and urged that all countries with directed squid fisheries should comply with the requirements.

APPENDIX III. AGENDA FOR SPECIAL STACRES MEETING ON CAPELIN AND SQUID, FEBRUARY 1979

1. Opening (Chairman: E. C. Lopez-Veiga)

   a) Appointment of rapporteurs
   b) Adoption of agenda
   c) Assignment of work to *ad hoc* working groups

2. *Ad hoc* Working Group on Capelin in Div. 3LNOP and Subarea 2 + Div. 3K (Convener: G. H. Winters) (*Redbook* 1978, page 39 and 48; Com. Doc. 79/III/1)

   a) Migrations and stock interrelationships

   b) Trends in abundance
      i) Commercial catch-effort analyses
      ii) Research vessel survey indices, including acoustic data
      iii) Numerical population models
      iv) Other estimates (e.g. tagging)

   c) Biological characteristics
      i) Annual variation in growth
      ii) Annual variation in maturity and spawning
      iii) Stock-recruitment considerations
      iv) Environment effects on biological characteristics
      v) Importance as a major prey species in the Grand Bank area

   d) Recruitment estimation and prognosis for 1979

   e) Future research

   f) Other matters

3. *Ad hoc* Working Group on Squid in Subareas 3 and 4 (Convener: F. Nagasaki) (*Redbook* 1978, page 39 and 48)

   a) Patterns of distribution and migration
   b) Biological characteristics (growth, maturity, fecundity, spawning, predator-prey relations, etc.)
   c) Trends in abundance (commercial catch rates, research vessel surveys, etc.)
   d) Description of 1978 fishery (grounds, season, depth distribution, gears, mesh sizes, etc.)
   e) Estimation of removals by the fishery (size and sex composition by week)
   f) Estimation of standardized fishing effort by country, vessel glass and gear type
   g) Estimation of exploitation rate in 1978
   h) Mesh selectivity and optimal mesh size for squid
   i) Mixed fishery and by-catch problems
   j) Advice on conservation measures and fishery regulations, including interactions with other fisheries
   k) Other matters

4. Consideration of standard form for reporting age-length keys (Sum. Doc. 79/VI/1, page 5)

5. Other Business

6. Adjournment

APPENDIX IV. LIST OF PARTICIPANTS IN STACRES MEETING, FEBRUARY 1979

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V. M. Hodder	Assistant Executive Secretary, " " "
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APPENDIX V. LIST OF DOCUMENTS PRESENTED TO STACRES MEETING, FEBRUARY 1979

Res.Doc. No.	Serial No.	Title	Author(s)
79/II/1	5324	Norwegian capelin fishery and capelin investigation in Newfoundland waters in 1978	Ø. Ulltang & G. Sangolt
79/II/2	5325	Current mesh selection studies on the Scotian Shelf in relation to historical selectivity data	D. Clay
79/II/3	5326	Mesh selection of silver hake (*Merluccius bilinearis*) in otter trawls on the Scotian Shelf with reference to selection of squid (*Illex illecebrosus*)	D. Clay
79/II/4	5327	Dorsal mantle length - total weight relationships of squid (*Loligo pealei* and *Illex illecebrosus*) from the Northwest Atlantic, off the coast of the United States	Anne M. T. Lange & K. L. Johnson
79/II/5	5328	Distribution and biological characteristics of the squid, *Illex illecebrosus*, off southern Newfoundland (ICNAF Subdiv. 3Ps), in autumn 1978	H. Dupouy
79/II/6 + Addendum	5331	Squid (*Illex*) catches by the French fleet in 1978	R. Letaconnoux
79/II/7 + Corrigendum	5332	An acoustic estimate of capelin biomass in ICNAF Divisions 3LNO	A. Marí
79/II/8	5333	Abundance estimates and fishing mortality rates of squid (*Illex illecebrosus*) in Subareas 3 and 4	A. Marí, E. Valdés & R. Domínguez
79/II/9	5334	Temperature and salinity in Newfoundland in July 1978	J. A. Goméz
79/II/10	5335	Biomass estimates of capelin in Divisions 2J and 3K, 1978	E. Valdés, A. Marí & R. Domínguez
79/II/11	5336	Food and feeding of the short-finned squid, *Illex illecebrosus*, on the Scotian Shelf in 1978	T. Amaratunga, J. D. Neilson, D. J. Gillis & L. G. Valdron
79/II/12	5337	Tagging trials on captive squid (*Illex illecebrosus*)	R. K. O'Dor, R. D. Durward & R. W. M. Hirtle
79/II/13	5338	Aspects of maturation, mating, spawning, and larval development of *Illex illecebrosus* relevant to field studies	R. D. Durward, E. Vessey, T. Amaratunga & R. K. O'Dor
79/II/14	5339	Update of the distribution, biomass estimates and length frequency of *Illex illecebrosus* from Canadian research cruises, 1970-78	R. Dufour
79/II/15	5341	A preliminary review of silver hake (*Merluccius bilinearis*) stock distribution and differentiation on the Scotian Shelf	D. Clay
79/II/16	5342	Feeding and growth in captive squid (*Illex illecebrosus*) and the influence of food availability on growth in the natural population	R. K. O'Dor, R. D. Durward, E. Vessey & T. Amaratunga
79/II/17	5343	Preliminary results of a joint international observer program to evaluate the silver hake small mesh gear line in ICNAF Divisions 4VWX	D. E. Waldron
79/II/18	5344	Catch and effort statistics from the 1978 international squid (*Illex illecebrosus*) fishery in Subarea 4	D. E. Waldron

Res.Doc. No.	Serial No.	Title	Author(s)
79/II/19	5345	Assessment of the 1978 4VWX squid (*Illex illecebrosus*) fishery	D. E. Waldron
79/II/20 + Corrigendum	5346	Estimation of the *Illex* biomass on the edge along the Scotian Shelf	T. Nagai & S. Kawahara
79/II/21	5347	Optimum rate of exploitation and virtual population analysis for short-finned squid, *Illex illecebrosus*, in Subareas 3 and 4	S. Kawahara
79/II/22	5348	Outline of Japanese squid fishery in stock areas 3+4 of the ICNAF waters in 1978	T. Sato
79/II/23	5349	Outline of Japanese capelin fishery	H. Hatanaka
79/II/24	5350	Considerations on the management of the international squid (*Illex*) fishery in ICNAF Subarea 4	G. V. Hurley & R. K. Mohn
79/II/25 + Corrigendum	5351	Assessment of the short-finned squid (*Illex illecebrosus*) in ICNAF Subarea 3 for 1978	G. V. Hurley & P. Beck
79/II/26	5352	A preliminary report on validating age readings from statoliths of the short-finned squid (*Illex illecebrosus*)	G. V. Hurley, P. Beck, J. Drew & R. L. Radtke
79/II/27	5353	Breakdown of squid catches in ICNAF Subarea 3, 1978, with length and sex composition from offshore and Newfoundland inshore samples	G. V. Hurley P. Beck & J. Drew
79/II/28	5354	Biomass estimates of *Illex illecebrosus* (LeSueur, 1821) for ICNAF Div. 4W	Yu. M. Froerman
79/II/29	5355	Multivariate analysis of meristic characters of capelin (*Mallotus villosus*) in the Northwest Atlantic	J. E. Carscadden & R. K. Misra
79/II/30	5356	Status of capelin stocks in Div. 2J and 3K in 1978	
79/II/31	5357	Methods and results of echometric surveys on the assessment of the Grand Newfoundland Bank capelin abundance in spring-summer 1978	V. A. Ermolchev, S. M. Kovalev & A. S. Seliverstov
79/II/32 + Corrigendum	5358	Biological characteristics and biomass estimates of capelin in ICNAF 2J + 3K, using a sequential capelin abundance model	D. S. Miller & J. E. Carscadden
79/II/33	5359	Biological aspects of capelin and a sequential capelin abundance model for the Division 3LNO stock	J. E. Carscadden & D. S. Miller
79/II/34	5360	An acoustic estimate of capelin biomass - ICNAF Div. 2J and 3K, October 1978	D. S. Miller & J. E. Carscadden
79/II/35 + Addendum	5361	Mesh selection of the short-finned squid *Illex illecebrosus*, on the Scotian Shlef, using a bottom trawl: a joint Canada-Japan 1978 research program	T. Amaratunga, A. Kawahara & H. Kono
79/II/36	5362	Abundance estimation of *Illex illecebrosus* during the joint Canada-Japan selectivity research program on the Scotian Shelf in 1978	T. Amaratunga & I. H. McQuinn
79/II/37	5363	Assessment of *Illex illecebrosus* (LeSueur, 1821) stocks in ICNAF Div. 4W determined by area-density method	M. Lipinski
79/II/38	5364	Universal maturity scale for the commercially-important squids (Cephalopoda: Teuthoidea). The results of maturity classification of the *Illex illecebrosus* (LeSueur, 1821) populations for the years 1973-1977	M. Lipinski