International Commission for the Northwest Atlantic Fisheries

ANNUAL MEETING – JUNE 1976

Stock assessment of *Loligo* squid in Subarea 5 and Statistical Area 6 in the 1972/73 and 1973/74 fishing seasons

by

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Introduction

Stock assessment of *Loligo* squid in Subarea 5 and Statistical Area 6 had been made by the areal method for six seasons from 1968/69 to 1973/74 (Ikeda *et al.*, 1973; Ikeda *et al.*, 1975). As was mentioned in these previous papers, the stock size estimated by the areal method must be more or less underestimated because some fraction of the stock outside fishing grounds cannot be taken into account. For better estimation of the stock size, then, Pope's cohort analysis was applied to the 1972/73 season. The results of calculation were listed together with the estimates by the areal method in the latest paper (Ikeda *et al.*, 1975). The present paper describes the stock assessment of *Loligo* by Pope's method on the basis of the data in the 1973/74 and 1972/73 seasons.

Material and Method

Basic data used for the assessment are the mantle length composition of the Japanese catch by month from October to April, the estimated numbers of squids caught by all Member Nations by month and the estimated average mantle length by age in terms of months from birth. Mean mantle length is calculated by the following growth equation:

$$L = 38.3(1-e^{-0.59t})$$

where L is mantle length in cm and t is age in years. The mantle length composition by month are calculated from the monthly catch by size categories and the length frequency of each size category. The frequencies thus obtained are shown in Table 1 (for 1972/73) and Table 2 (for 1973/74). The average weight of squid caught are calculated from the average length by month and the length-weight relationship. The number of squids caught by month are obtained from the monthly catch in the ICNAF Statistical Bulletin and the average weight of squid for each month. The catch of unclassified squids are divided into *Loligo* and *Illex* on the basis of ratio between two species from classified catches.

For applying Pope's cohort analysis, three groups are picked up, squid of 9.8 cm in mantle length, as of October, as April brood, those of 8.3 cm as May brood and those of 6.8 cm as June brood. Frequencies of these size groups are estimated from Table 1 and Table 2 by the following way.

Frequency of each brood mentioned above can be interpolated from those of the nearest four mantle length. For example, the frequency of April brood in October is estimated from Table 1 as follows:

$$f' = a \cdot f_3 + (1-a) \cdot f_2 = 0.3 \times 0.105 + 0.7 \times 0.078 = 0.0861$$

$$f'' = \frac{1}{3} [(1+a) \cdot f_4 + (2-a) \cdot f_1] = \frac{1}{3} (1.3 \times 0.124 + 1.7 \times 0.046) = 0.0798$$

$$f = \frac{1}{2} [(2+a(1-a)f' - a(1-a)f''] = 0.0868$$

where $a = L - L_2 = 9.8 - 9.5 = 0.3$, f_i is frequency at length L_i, $L_1 < L_2 < L < L_3 < L_4$.

Catch in number of each brood is obtained by multiplying the total catch by corresponding frequency. The figure of 1.31 for April brood in October, for instance, is 15.08 (the total catch in October) multiplied by 0.0868 (frequency). Those calculated figures are listed in Table 3 (for 1972/73) and Table 4 (for 1973/74).

Stock sizes of each brood by month are calculated by the following Pope's method with assumed fishing mortality (F) of 0.1 in the last age and natural mortality (M) of 0.03 for each month:

$$N_i = N_{i+1} \ e^M - C_i e^{M/2}$$

As is noted in Table 2, however, monthly mean weight of squid substantially decreases in March and April. This may by caused by either large amounts of smaller squids entered to or larger squids emigrated from the fishing grounds. For calculating the stock size for 1973/74 fishing season, these figures in March and April are excluded.

Results

Estimated stock sizes of each brood by month are shown in Tables 3 and 4. The average rate of exploitation during October is approximately 0.01 in 1972/73 and 0.03 in 1973/74 season. Since the number of squids taken during October in each season amounts to 15.08×10^6 and 42.88×10^6 individuals, the initial stock size in number at the beginning of season (October) must be 1.510×10^6 in 1972/73 and 1.430×10^6 in 1973/74. The biomass in weight is estimated to be 92×10^3 tons and 89×10^3 tons, respectively.

Table 1. Size composition of Loligo squid in Subarea 5 and Statistical Area in 1972/'73 fishing season.

Mantle length in cm	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
3							
4		1	1				
5	1	4	4	2	1	2	3
6	7	19	19	9	3	8	12
7	21	52	55	29	9	25	35
8	46	97	107	65	22	52	72
9	78	134	158	114	44	85	112
10	105	140	174	152	75	110	113
11	124	125	155	167	112	122	129
12	131	101	115	155	143	121	108
13	126	81	78	125	151	110	85
14	109	64	49	83	136	92	63
15	87	50	29	45	108	71	45
16	65	38	18	23	80	54	34
17	43	28	12	12	52	39	27
18	24	19	8	7	30	28	22
19	13	14	6	4	15	20	19
20	7	10	4	3	8	15	16
21	4	7	3	2	5	11	14
22	3	5	2	1	2	8	11
23	2	3	1	1	1	6	10
24	1	2	1	1	1	5	8
25	1	2	1		1	4	7
26	1	1				3	6
27		1				2	6
28		1				2	5
29						2	5
30						1	4
31						1	3
32						1	2
33							1
34							1
Total	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Mean weight per individual (g)	66.6	57.8	47.6	53.1	72.8	73.7	77.4
Total catch in tons	1,004	3,063	3,791	5,828	5,141	4,621	2,131
Catch in number (10^6)	15.08	53.00	79.62	109.69	70.59	62.72	27.55

F 4

Table 2. Size composition of Loligo squid in Subarea 5 and Statistical Area 6 in 1973/'74 fishing season.

Mantle length in cm.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
3							
4	1	1			1	1	2
5	3	4	2	1	3	7	11
6	15	16	8	7	13	31	44
7	45	43	21	20	36	79	112
8	89	82	42	42	65	136	183
9	136	117	64	67	88	165	205
10	159	131	83	88	95	147	159
11	155	130	100	104	98	110	100
12	131	118	114	115	99	76	57
13	99	100	120	118	98	54	34
14	65	78	117	111	92	40	22
15	36	55	104	96	80	30	16
16	20	39	84	77	66	24	12
17	13	27	58	55	49	19	9
18	8	18	35	36	35	16	7
19	6	12	20	23	25	13	6
20	5	8	12	15	18	11	4
21	4	6	7	10	13	9	3
22	3	4	4	6	8	7	3
23	2	3	2	3	5	5	2
24	1	2	1	2	4	4	2
25	1	2	1	1	3	4	1
26	1	1	1	1	2	3	1
27	1	1		1	1	2	1
28	1	1			1	2	1
29					1	2	1
30						1	1
31						1	1
32						1	
33							
Total	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Mean weight per individual (g)	52.1	58.2	73.1	74.2	73.0	55.9	41.5
Total catch in tons	2,234	4,577	7,788	7,051	3,868	5,407	2,793
Catch in number (10^6)	42.88	78.64	106.54	95.03	52.99	96.73	67.30

Table 3. Stock assessment of Loligo squid in 1972/'73 fishing season by Pope's Cohort analysis using the data of some monthly broods.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Total catch in number by member countries(10^6)	15.08	53.00	79.62	109.69	70.59	62.72	27.55
Mean Mantle Length(cm)							
April brood	9.8	11.2	12.5	13.7	14.9	16.0	17.1
May brood	8.3	9.8	11.2	12.5	13.7	14.9	16.0
June brood	6.8	8.3	9.8	11.2	12.5	13.7	14.9
Frequency at Mean Mantle Length							
April brood	0.0868	0.1310	0.1150	0.1170	0.1256	0.0621	0.0295
May brood	0.0403	0.1386	0.1635	0.1550	0.1495	0.0836	0.0388
June brood	0.0102	0.0880	0.1665	0.1652	0.1430	0.1068	0.0552
Catch at Mean Mantle Length(10^6)							
April brood	1.31	6.94	9.16	12.83	8.87	3.90	0.81
May brood	0.61	7.35	13.02	17.00	10.55	5.24	1.07
June brood	0.15	4.66	13.26	18.12	10.09	6.70	1.52
Stock Size at Mean Mantle Length(10^6)							
April brood	57.81	54.81	46.35	35.96	22.26	12.86	8.64
May brood	73.15	70.39	61.07	46.44	28.32	17.08	11.41
June brood	78.29	75.83	69.00	53.90	34.46	23.50	16.21
Rate of Exploitation							
April brood	0.023						
May brood	0.008						
June brood	0.002						

Assumed fishing mortality(F) of 0.1 in the last age with natural mortality(M) of 0.03 for each period.

Table 4. Stock assessment of Loligo squid in 1973/'74 fishing season by Pope's Cohort analysis using the data of some monthly broods.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Total catch in number by member countries(10^6)	42.88	78.64	106.54	95.03	52.99	96.73	67.30
Mean Mantle Length(cm)							
April brood	9.8	11.2	12.5	13.7	14.9	16.0	17.1
May brood	8.3	9.8	11.2	12.5	13.7	14.9	16.0
June brood	6.8	8.3	9.8	11.2	12.5	13.7	14.9
Frequency at Mean Mantle Length							
April brood	0.1456	0.1317	0.1140	0.3331	0.1076	0.0269	0.0101
May brood	0.0791	0.1231	0.0950	0.1150	0.1119	0.0355	0.0139
June brood	0.0223	0.0740	0.0700	0.0996	0.0990	0.0507	0.0191
Catch at Mean Mantle Length(10^6)							
April brood	6.24	10.36	12.15	31.65	5.70	2.60	0.68
May brood	3.39	9.68	10.12	10.93	5.93	3.43	0.94
June brood	0.96	5.82	7.46	9.46	5.25	4.90	1.29
Stock Size at Mean Mantle Length(10^6)							
April brood	133.96	123.85	109.98	94.76	60.79		
May brood	107.91	101.39	88.85	76.26	63.24		
June brood	88.73	85.17	76.92	67.29	55.99		
Rate of Exploitation							
April brood	0.047						
May brood	0.031						
June brood	0.011						

Assumed fishing mortality(F) of 0.1 in the last age with natural mortality(M) of 0.03 for each period.