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Stock assessment of common American squid in ICNAF Subarea 5 and Statistical Area 6

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In the ICNAF Subarea 5 and 6, Japanese trawl fleet first fished common American squid in January, 1968. The first year of operation was on experimental basis and yielded about 170 tons of squid. The fishery developed rather rapidly and almost all of the wintering area of this species were covered by Japanese fleet in the 1968-69 season when the total of 4,446 tons were landed. Fishing season extends from November to May. Since the 1969-70 season, fishing operation has been well stable with annual catch between 10,000 and 15,000 tons.

Fairly detailed catch statistics of squid from the ICNAF waters are given in the ICNAF Statistical Bulletin for 1971. In 1971, about 22,000 tons were caught in the subarea 5 and 6 combined, 48 percent by Japan, 28 percent by USSR, 19 percent by Spain and 5 percent by USA. In commercial sense, however, two species of squid are observed in this area, common American squid, Loligo pealeii, and shortfinned squid, Illéx illecebresus. The catch figures in the Bulletin have not yet been broken down into two species. Almost all of the squid taken by the Japanese trawlers are common American squid.

In the present report, stock assessment of common American squid in this area are made on the basis of daily catch records by Japanese trawlers throughout four seasons from 1968-69 to 1971-72. Almost all of the catch records are used for this anlysis.

Materials and Method

Daily catch record by vessel include the location where fished, fishing effort in term of the number of hauls operated and the catch in weight by size categories. These daily records are lumped up by 10'X10' square and by ten days. The catches were carefully sorted into each size category aboard vessel, so that size classification does not change between different seasons, locations and vessels. The catch in weight, therefore, can easily be converted to that in number of squid on the basis of the appended table which shows number of individuals per case for each category.

Stock size in number and other parameters are estimated by two different method, indirectly by the De Lury's method and directly by areal estimate (density-area method). Owing to the De Lury's, the following equation can be applied to the relationship between the number of squid caught by haul and the accumulated catch up to that time :

$$C_t = q\,(N_0 - K_t)$$

where C_t ; Number of squid caught by haul during the time period t

q ; Catchability coefficient

N_0 ; Stock size in number at the beginning of the season

K_t ; Accumulated catch up to the period t

Result

(1) Seasonal change in the catch and the catch per haul, both in number of squid

The catch of squid and the catch per haul by ten days, both in number, in the Subarea 5 and 6 combined are described in Figure 1. The figure indicates the pattern of fishing season, that is, the time of beginning, closing and the height of operations, varies considerably year by year. It is also shown that when the catch by ten days is larger, the catch-per-haul value during that period is also high and vice versa.

(2) Estimation by the De Lury's

The catch per haul by ten days are plotted against the accumulated catch in Figure 2. Since the catch per haul increases during the first half of the fishing season, the data up to the period when half of the total annual catch was reached and those in the end of the season when the catch per haul drops sharply, are omitted from calculation for the regression between two series of gigures. The results thus obtained are given below :

1968-69 season $C_t = 1.06 \cdot 10^{-3} (35.9 \cdot 10^{6} - K_t)$

1969-70 " $C_t = 0.43 \cdot 10^{-3} (44.4 \cdot 10^{6} - K_t)$

1970-71 " $C_t = 0.31 \cdot 10^{-3} (87.6 \cdot 10^{6} - K_t)$

1971-72 " $C_t = 0.34 \cdot 10^{-3} (101.4 \cdot 10^{6} - K_t)$

The initial stock sizes given in the above equations are those at the period from which regression equations are applied. These estimated stock sizes appear to be more or less underestimated, because that for the 1971-72 season, for instance, is less than the actual catch. The catchability coefficients estimated, on the other hand, are quite identical for three years, the 1969-70 season and on, but they are probably overestimated because of considerable emigration from the fishing grounds which can not be separated from the reduction by fishing.

(3) Estimation by areal method

Relative stock size on the fishong grounds can be obtained from the catch-per-haul value multiplied by area of the grounds. The values thus calculated by ten days for each season are indicated in Figure 3. Intra-seasonal change in relative abundance suggests that the abundance increases through immigration during the first half of the season and decreases not only through fishing but also through emigration during the latter half. It is assumed, therefore, that immigration may be completed at the time when the estimated relative abundance becomes largest.

As is shown in the figure, the time of full immigration varies year by year, say, in the middle of February for the 1968-69 season, in the last ten days of January for the 1969-70, in the early ten days of February for the 1970-71 and in the last ten days of December for the 1971-72. Based on the highest value of relative abundance, absolute number of squid on the fishing grounds are estimated as are given in the Table1. In order to obtain the initial stock size, the accumulated catch to that period are added to the stock size on the grounds.

Table 1. Estimated abundance in number of squid in the Subarea 5 and 6

Season	1968-69	1969-70	1970-71	1971-72
Area of fishing grounds (Km^2)	5,145	6,688	7,974	5,917
Catch per haul in number (10^3)	33.41	29.07	21.28	32,75
Hours per haul	1.61	1.72	1.64	1.82
Speed of net (Kt)	3.75	3.75	3.75	3.75
Width of the wing (m)	25	25	25	25
Area covered by one haul (Km^2)	0.280	0.299	0.285	0.317
Density ($10^3/Km^2$)	119.3	97.2	74.7	103.3
Stock size on the grounds (10^6)	613.8	649.4	595.7	611.2
Initial stock size (10^6)	628.6	693.1	641.7	634.6

The results obtained show that almost same number of squid immigrated into the fishing grounds every year. In the estimations mentioned above, however, effective area covered by net is calculated from the width at the mouth of wing. It is likely that the density of squid thus calculated seem to be more or less overestimated. Although the trawl net used by the Japanese vessels covers waters up to about 7 meters from the bottom, echo reflection reveals that school of squid distributes up to 10 meters from the bottom. Taking these evidences into acount together with the fact that the group of this species moves upward at night, it is quite reasonable to accept that the estimated values tend to be higher than the real ones. Bias from various other sources might be included in the estimates. However, these estimated values may be accepted as a first approximation at least at the present stage of study.

(4) Fishing and catchability coefficient

The fishing rate and the catchability coefficient by Japanese trawlers are calculated from the estimated stock size in number together with the total catch and the catch per haul. The fishing rate and the catchablity coefficient for recent years are estimated to be 10-20 percent and $2.2\text{-}3.4 \times 10^{-5}$, respectively.

Table 2. Fishing rate and catchability coefficient by Japanese trawlers

Season	Stock size in number(10^6)	Catch in number(10^6)	Fishing rate	Number of hauls(10^3)	Catchability
1968-69	628.6	47.9	0.08	3.3	2.5×10^{-5}
1969-70	693.1	112.2	0.16	5.4	3.4x "
1970-71	641.7	64.5	0.10	5.2	2.2x "
1971-72	634.6	130.9	0.21	7.2	2.9x "

Discussion

Although the catchability estimated by the De Lury's method may be biased by dispersion from the fishing grounds, the values for recent three seasons since 1969-70 are proportional to those obtained by direct method. This implies that the pattern of dispersion is rather same for three seasons. It should be noted, however, that the apparent dispersion may also reflect the pattern of operations. This is particularly true in the operations during the 1968-69 season which is supported by lower fishing rate estimated by the direct method.

The direct estimate stands on the assumption that the immigration to the fishing grounds is completed at the time when the relative abundance becomes largest. However, commercial operations are not carried out on the grounds where the density of squid is lower than a certain level. There must be some groups of squid in less density outside the fishing grounds. Therefore, the stock size estimated by the direct method must be of minimum value. Assuming that the squid catch of 22,000 tons from the Subarea 5 and 6 during the 1970-71 season did not include any other species than common American squid, the Japanese catch amounted to about 50 percent of the total which is estimated to be about 0.1 in the fishing rate(see Table 2). Therefore, the over-all fishing rate must be 0.2. Although no information is available for the stock-recruitment relationship of this species, it is thought that 20 percent of the initial stock size can produce sufficient recruit. If this is the case, four times of the 1971 catch, that is about 80,000 tons, can be expected as allowable catch from the squid stock in this area.

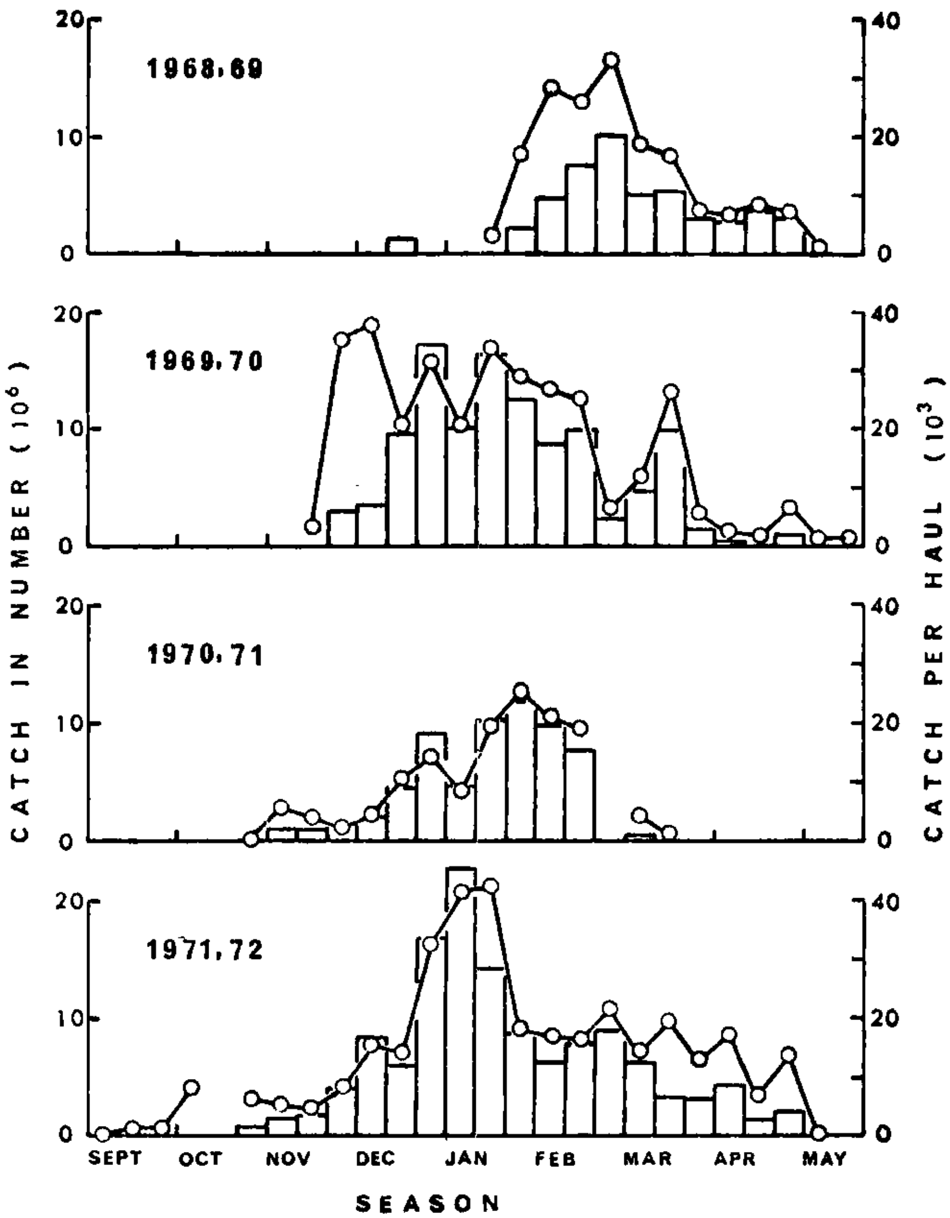

Figure 1. Seasonal change in the catch and the catch per haul of common American squid in the ICNAF subarea 5 and 6 by ten days
The catch by bar graph and the catch per haul by circle.

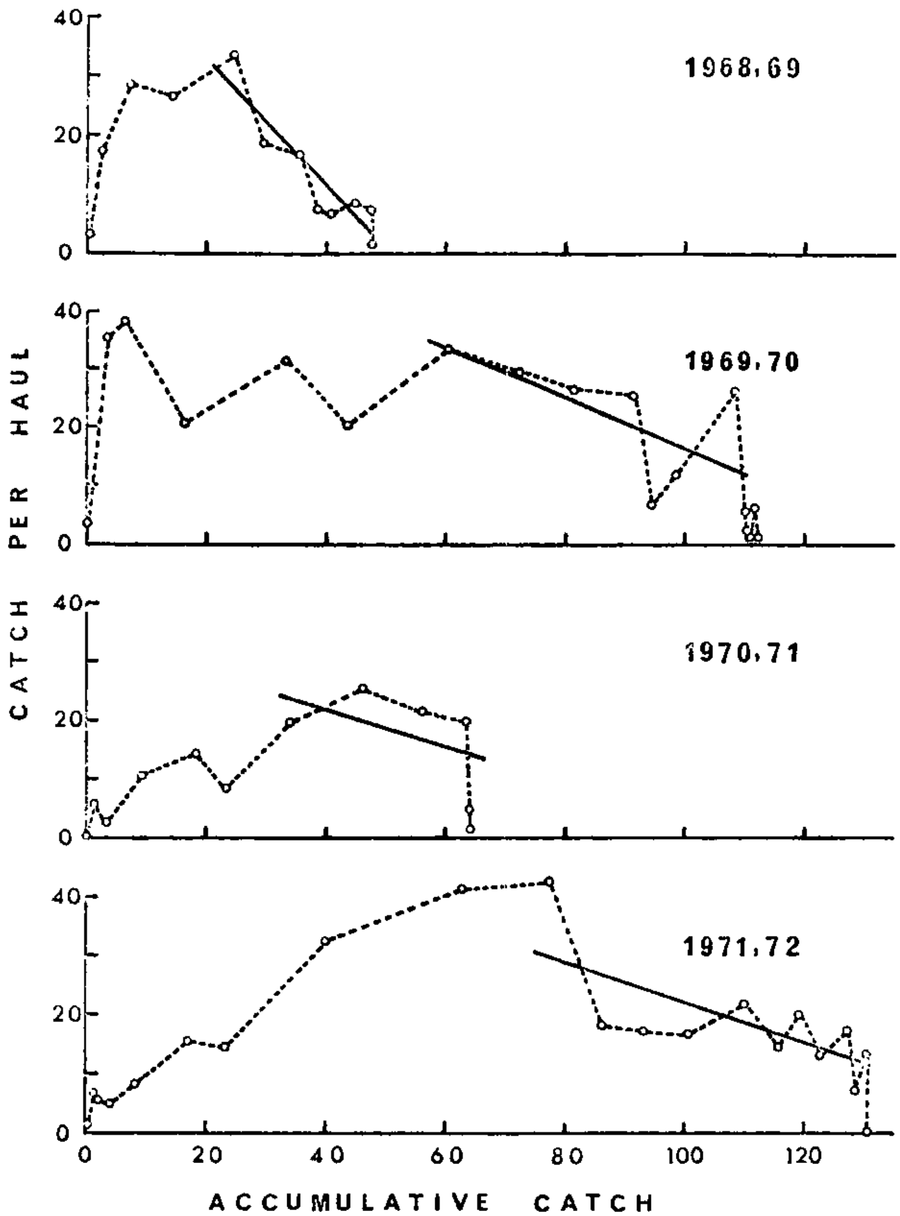

Figure 2. Relationship between the catch per haul and the accumulated catch
The catch per haul in 10^3 and the accumulated catch in 10^6

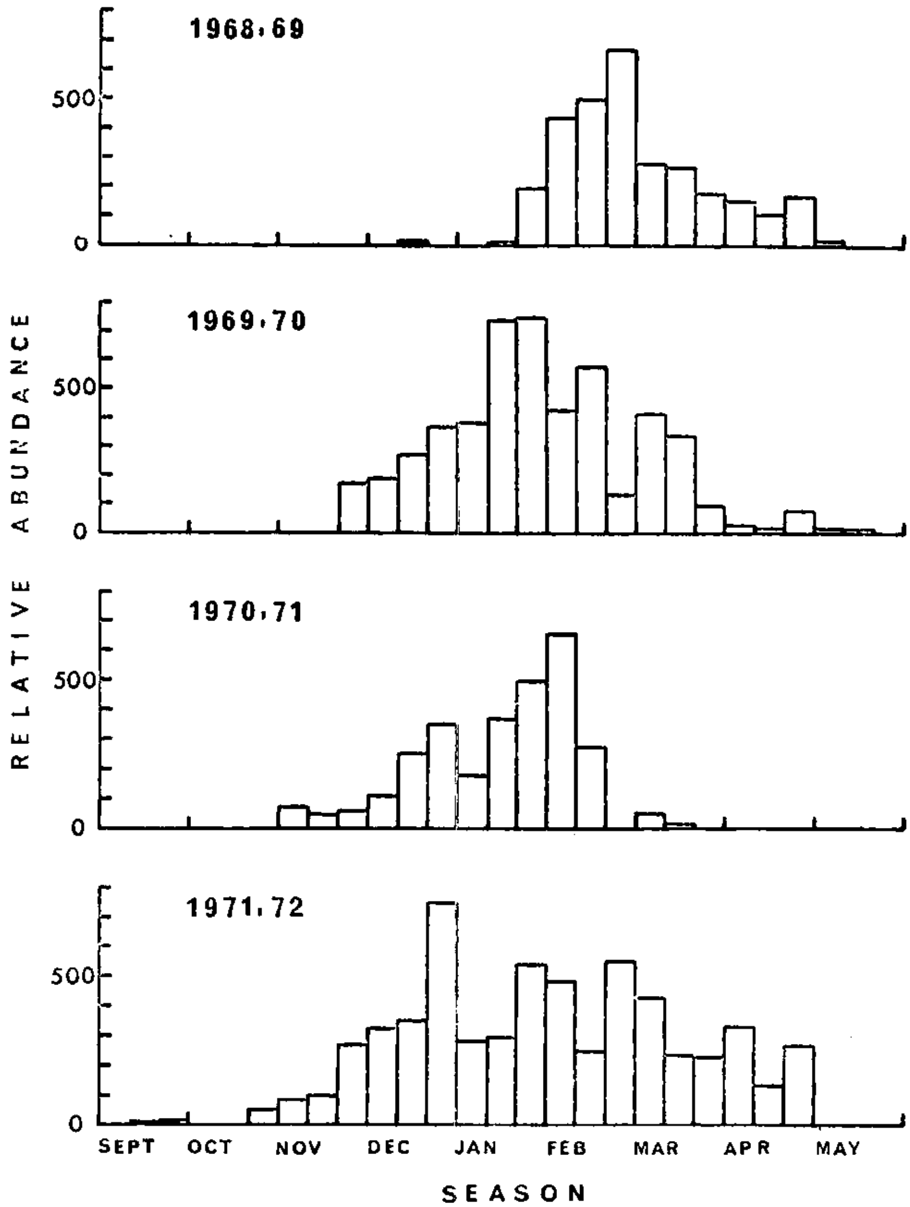

Figure 3. Seasonal change in the relative abundance (catch per haul X area of fishing grounds) of common American squid in the subarea 5 and 6

Appendix Table **Length compositions by size categories of Common American Squid in the ICNAF Subareas 5 and 6.**

Mantle Length in cm	Body Weight in g *	Size Category							
		5L	4L	3L	LL	L	M	S	SS
3- 4	3								
4- 5	5								3
5- 6	8							1	17
6- 7	12							9	68
7- 8	17						1	38	166
8- 9	23						6	103	257
9-10	29					1	27	197	255
10-11	37					5	81	250	155
11-12	46					18	166	215	61
12-13	55				1	50	235	122	15
13-14	66				3	108	229	49	2
14-15	78				11	174	156	13	
15-16	91			1	30	212	70	2	
16-17	105			2	69	194	22		
17-18	120		1	7	123	133	5		
18-19	137		2	21	173	69	1		
19-20	155		5	47	194	27			
20-21	174		14	86	171	8			
21-22	194	1	30	135	119	2			
22-23	216	3	56	170	66				
23-24	236	8	93	173	29				
24-25	262	20	130	150	10				
25-26	288	40	150	103	3				
26-27	315	73	157	61	1				
27-28	351	107	137	29					
28-29	372	138	100	11					
29-30	403	158	65	4					
30-31	436	147	36	1					
31-32	469	124	16						
32-33	505	85	7						
33-34	541	51	2						
34-35	579	27	1						
35-36	619	12							
36-37	660	5							
37-38	703	2							
38-39	747								
39-40	795								
Mean Weight per individual (g)		415	310	234	157	95	61	39	25
Number of individuals per case		30	40	53	80	132	205	321	500

* Calculated from the formula, $W = 7.766 \cdot ML^{2.314} \cdot 10^{-4}$, where W is the body weight in g and ML is the mantle length in mm.