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Stock assessment of cuttlefish off the coast of the People's Democratic Republic of Yemen

by
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CONTENTS

INTRODUCTION

The cuttlefish resource of the Gulf of Aden was discovered by the trawler Sekishu-Maru (Nichiro Gyogyo Kaisha, Ltd., 996.98 tons, 1840 HP) during experimental operations offshore of Fartak in November 1966. Three trawlers began the exploitation of the fishing ground with permission of the English Government in 1968. The operation had been continued until 1980, by permission of the Government of the People's Democratic Republic of Yemen (hereafter abbreviated FDRY).

During the early period of exploitation, the fishing sphere extended from the Gulf of Oman to the Gulf of Aden and southward to the middle part of the Somalian coast and it has concentrated mainly around the coast of the PDRY from 50° to 58° E after 1974.

Several commercially important fish species are abundant in this region, but cuttlefish are the main target of fishing because of their stable catch and high price. The yearly change of fishing condition is substantial based upon the data of Nichiro Gyogyo Kaisha Ltd. (abbreviated as Nichiro's data hereafter), a marked change in yearly catch is noticed. The catch in years 1972, 1976 and 1977 were favorable in contrast with the poor catch in 1970, 1978 and the succeeding two years.

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It is commonly known for cuttlefish that their stock size depends on the yearly developmental stock size. Because of their short life span, the phenomenon of the prevailing population of a specific year sustaining the resources for many years has not been seen. The primary factors dominating the recruit stock size are mainly the number of spawners and the environmental conditions which affect spawning and development. In this region, the important factors affecting the recruitment are the scale of upwelling caused by monsoons, the population size, and distribution patterns of predators and prey for juveniles. Detailed information on these matters is generally lacking, however.

This region is suitable for the cuttlefish fishing ground due to the very high productivity because of its rich nutrients provided by upwelling during the southwest monsoon. If this high productivity is successfully linked with production of edible marine animals there would be a promising fishing ground. Although the life span of the cuttlefish is rather short, the high primay productivity and high sea water temperature may lead to high production of the cuttlefish. If their reproduction can be usefully managed, great hopes are entertained on the contribution of this region to the fishing resources.

In order to analyse the variation in fishing condition and the population size, informations on catch and environment are required for a long term. It is unfortunate that information on climate and sea conditions is very scarce. Information on catch was collected from Nichiro's data from 1969 to 1978, and biological information was obtained from the examination of the catch. The tagging experiment were carried out by Nichiro in 1978 along with the ecological observations. Information on sea conditions was obtained from the daily reports of fishing boats and from the observation records of training vessels. The stock assessement was carried out based on these data sources. Moreover, since *Sepia pharaonis* is the main species of cuttlefish in this region, the biological information examined herein is for this species.

I. BIOLOGICAL INFORMATION

1. Identification of species

According to Sato* four species of cuttlefish are commonly found in the fishing grounds off the coast of the PDRY. They include three species of *Sepia*, namely, *Sepia pharaonis* EHRENBERG, *Sepia savignyi* BLAINVILLE and *Sepia prashadi* WINCKWORTH, and one *Sepiella* species, *Sepiella inermis*-(FERUSSAC et D'ORBIGNY).

Some distinguishing features of the three species of *Sepia* are shown in Table 1. The patterns on the mantle of three species show minor distinguishing characters, but the arrangement of suckers on the tentacular club(Fig.1) and features of shell(Fig.2) show striking differences.

Among the 1798 speciemens examined by Sato*, 1715 specimens were identified as *Sepia pharaonis*(96%), 4 specimens as *S.savignyi*(0.2%), and only one specimen as *S.prashadi*. As these specimens were caught by trawlers; their composition may not be distinctly representative that of this region, but *S.pharaonis* may be regarded as the main constituent. Unless noted otherwise, the discussion hereafter is restricted to *S.pharaonis*.

2. Materials

The catch was divided into 9 market sizes (cf.definition in section 4 of this chapter), packed

* T.Sato: Tentative stock assessement of cuttlefish off the coast of the People's Democratic Republic of Yemen. 4 pp.(unpublished).

Table 1. Features of three species of *Sepia*

Species	ML	Mantle	Shell	Hectocotylized arm	Tentacular club
S. pharaonis EHRENBERG	40	tiger-like tranverse stripes commonly with spots	striated zone large, ledge of inner cone thickened, spine with lateral expansions	normal suckers at base + transformed suckers 7～16+4～15	suckers unequal 2-3 middle ones enlarged
S. prashadi WINCKWORTH	13	pale spots	rather thick, ledge of inner cone V-shaped, spine strong with dorsal and lateral keels	2～4+12～14	suckers unequal, 3rd suckers of 2nd and 4th series enormous developed
S. savignyi BLAINVILLE	13	no markings	broadly oval; striated zone separated from outer cone by 2 broad nearly smooth, marginal areas		suckers subequal (the middle ones slightly larger)

ML: mantle length of large specimen in cm
One part of this table is translated from Okutani 1973[1)]

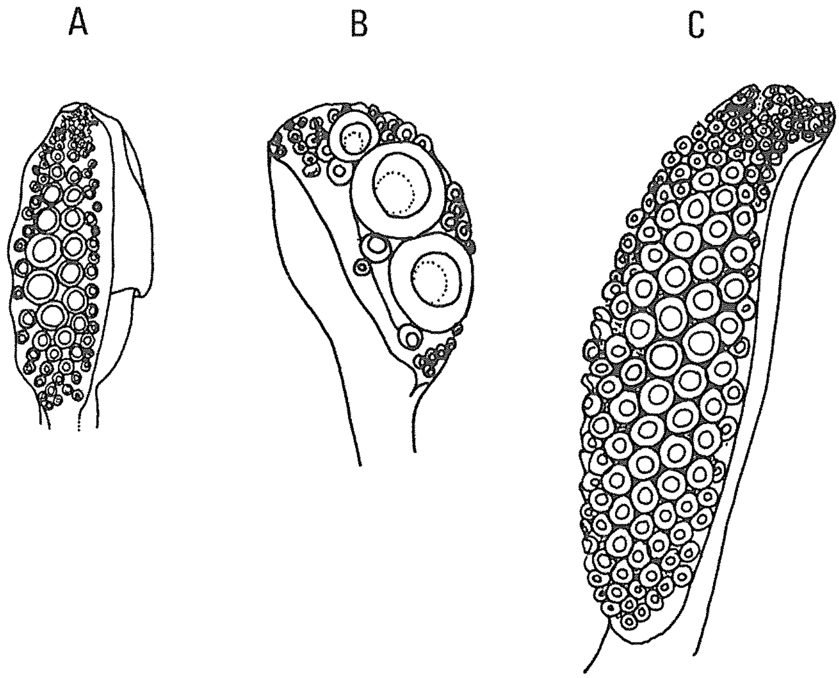


Fig. 1. Tentacular clubs: A, *Sepia pharaonis* (drawn from Voss 1963[2)])
B, *S.prashadi* (drawn from ADAM & REES 1966[3)])
C, *S.savignyi* (drawn from ADAM & REES 1966)

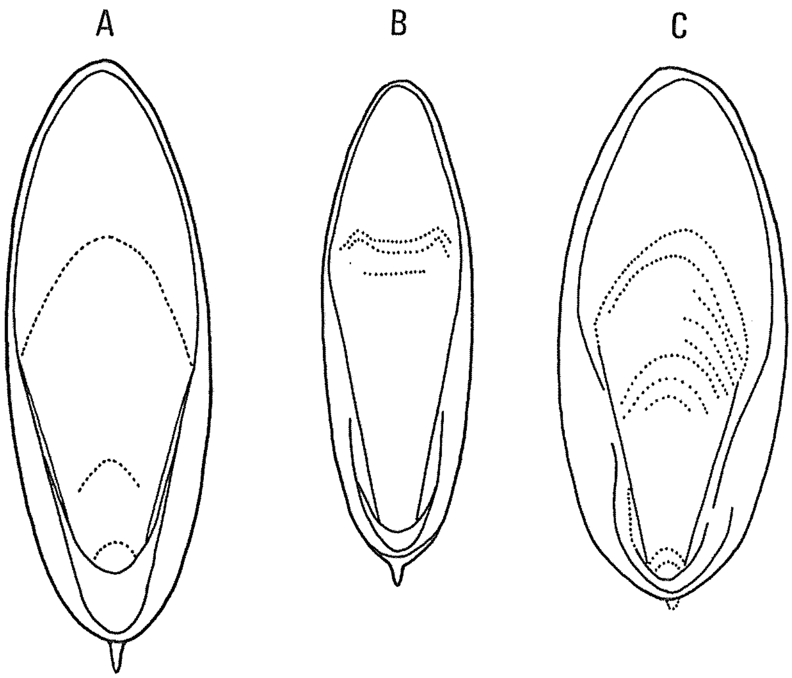


Fig. 2. Shells: A, *Sepia pharaonis*; B, *S.prashadi*; C, *S.savignyi* (drawn from ADAM & REES 1966)

into cases 12kg in weight, and then frozen. Two frozen cases were then packed into a carton and then sent for merchandising.

The specimens used for biological study were selected from these merchandised cartons landed in Japan.

The recaptured specimens from a tagging experiment carried out during 1978 were also examined. Table 2 shows the number of measured individuals by month.

3. Morphological measurements

Measurements were carried out on the defrosted specimens following the terms and dimensions of measurement given in Fig.3. Some relations between important morphological dimensions were found to be as follows.

Fig.4 shows the relationship between mantle length and body weight, both on a logarithmic graph. The relation fits a straight line, written as

Table 2. Number of specimens measured

Month	Apr.	May	June	July	Aug.	Oct.	Nov.	Dec.	Total
No. of specimens	544	245	263	229	253	79	237	6	1856

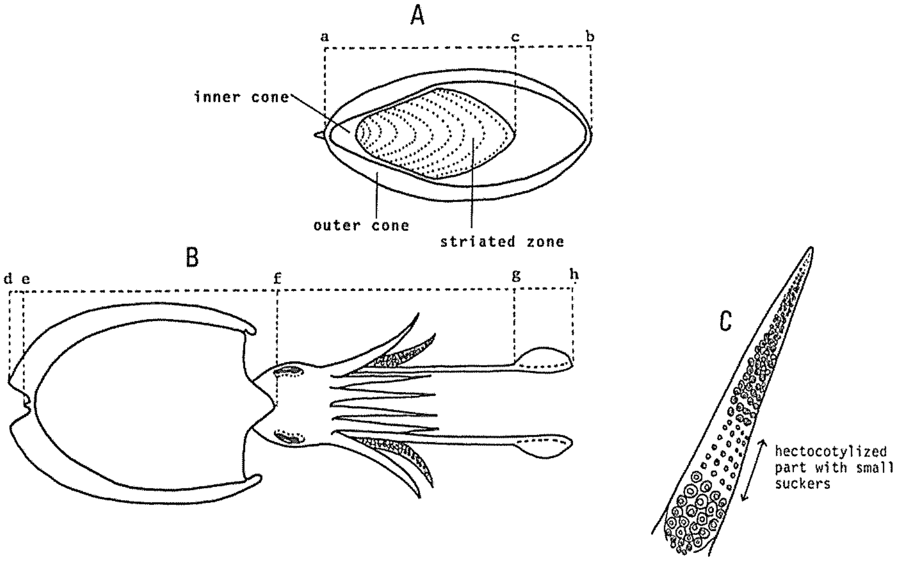


Fig. 3. Terms and dimensions of measurment
A, ventral view of shell; B, dorsal view of cuttlefish; C, hectocotylized arm;
a-b, shell length; d-h, total length; e-f, mantle length;
g-h, tentacular-club length

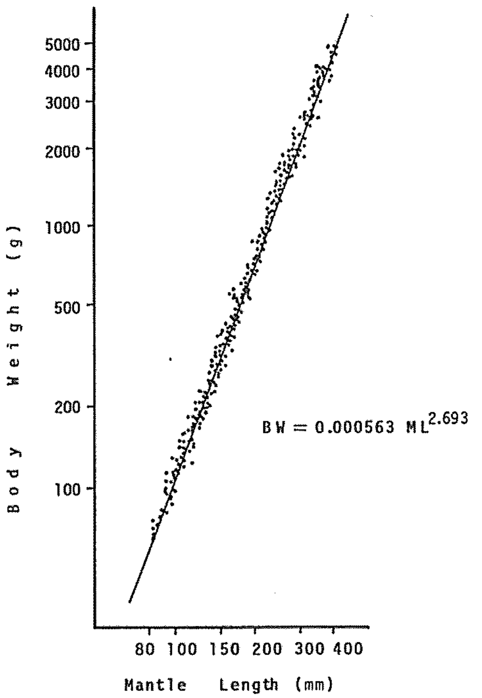


Fig. 4. Relation between mantle length and body weight

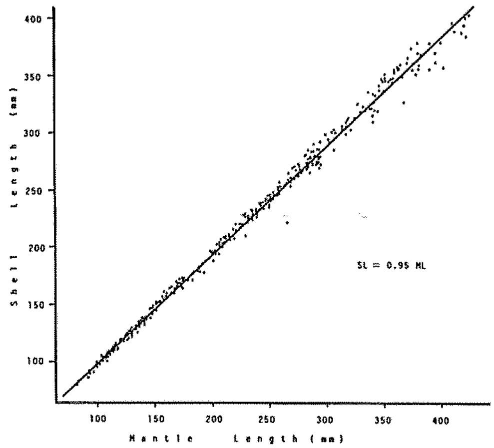


Fig. 5. Relation between mantle length and shell length

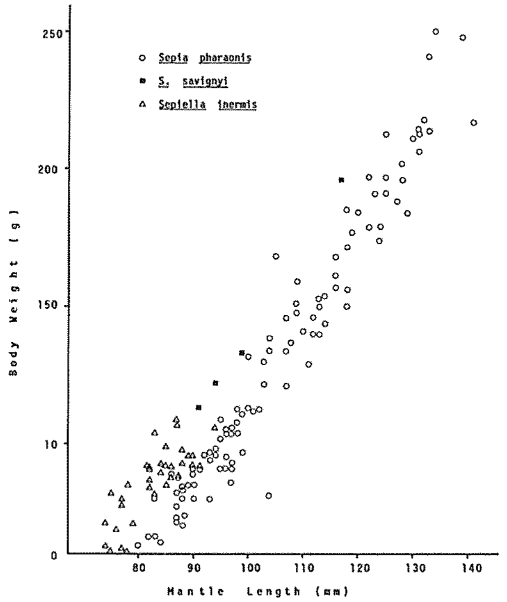


Fig. 6. Relation between body weight and mantle length of three species, *Sepia pharaonis*, *Sepia savignyi* and *Sepiella inermis*, measured in November 1978

the following:

$$BW=0.00056ML^{2.69}$$

Fig.5 shows the relationship between mantle length and shell lenght. It shows good proportional relationship with the following equation:

$$SL=0.95ML$$

The shell length of cuttlefish is a good index for the mantle length.

Fig.6 shows the relationship between mantle length and body wight for two species of *Sepia* and *Sepiella inermis*. *Sepiella inermis* and *Sepia savignyi* are both relatively heavier than *Sepia pharaonis*.

4. Monthly changes in mantle lenght composition.

If the spawning occured during a limited period in a year and if the growth rate was not highly variable, then a mode would be expected to appear in the mantle length composition.

The cuttlefish caught were selected and categorized by fishermen on board to nine market sizes, with average mantle lenghts decreasing in the order: large-3(3L). large-2(2L), large(L), medium (M), small-1 (S), small-2 (2S), dead small-1 (D), dead small-2 (2D), and dead small-3 (3D); the mantle length frequency distribution of each size is indicated in Table 3. The sizes were well categorized for M to 2D with small standard deviations. But the overlap of mantle length between neighboring size classes is rather large because of the too detailed categorization. The 3D group is fully recruited to the fishery.

5. Monthly change in market-size composition

The monthly change in market-size frequency distributions of ten fishing seasons from 1969 to 1978 is shown in Fig.7. The market-size statistics were prepared by case-unit, but there is a substantial difference in numbers of individuals per case among market-sizes as shown in Table 3. The distribution patterns shown in Fig.7 are amended by considering the number of individuals in each case. The longitudinal lines tracing modes are drawn by free hand. These lines for ten years are shown in Fig.8 which shows three flows, and these three lines are seen with every fishing season. The 3D recruit during winter and spring, grow up to 2S at about the end of the year (flow A), then to L by the end of the following year (flow B). One part of L survives till next autumn and grow up to 3L.

6. Sex ratio, maturation, reproduction, and development

Fig.9 shows the monthly frequency distribution of mantle length by sex. The sex ratio of those with mantle length below 30 cm is nearly 1:1, while, all those larger than 30 cm are male and the largest one is about 43 cm. The reasons for the absence of large females may possibly be

Table. 3. Mantle lengh frequency distribution of cuttlefish *Sepia pharaonis* by market sizes

Market size ML (cm)	3L	2L	L	M	S	2S	D	2D	3D
2-3									2
3									4
4									13
5									31
6									62
7									104
8									148
9								1	168
10								11	163
11								57	131
12						2	4	170	88
13						12	44	281	50
14						52	204	274	23
15						138	377	149	9
16					1	241	279	48	4
17					13	261	82	9	
18					69	185	10		
19					197	81			
20				17	306	23			
21			1	38	257	5			
22			5	66	121				
23			19	230	31				
24			54	280	5				
25			113	196					
26			182	118					
27		2	217	55					
28		8	191						
29		26	126						
30		64	61						
31	2	123	23						
32	7	182	6						
33	26	201	2						
34	71	179							
35	140	120							
36	206	62							
37	217	24							
38	171	7							
39	101	2							
40	42								
41	13								
42	4								
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000
Individuals per carton (2 c.)	4	9	14	21	33	51	71	100	150
Mean ML	37.22	33.47	27.58	24.11	20.73	17.21	15.67	13.93	9.82
Standard deviation	1.776	1.928	1.826	1.321	1.254	1.460	0.998	1.306	2.313

market sizes:
3L, large-3
2L, large-2
L, large-1
M, medium
S, small-1
2S, small-2
D, dead small-1
2D, dead small-2
3D, dead small-3

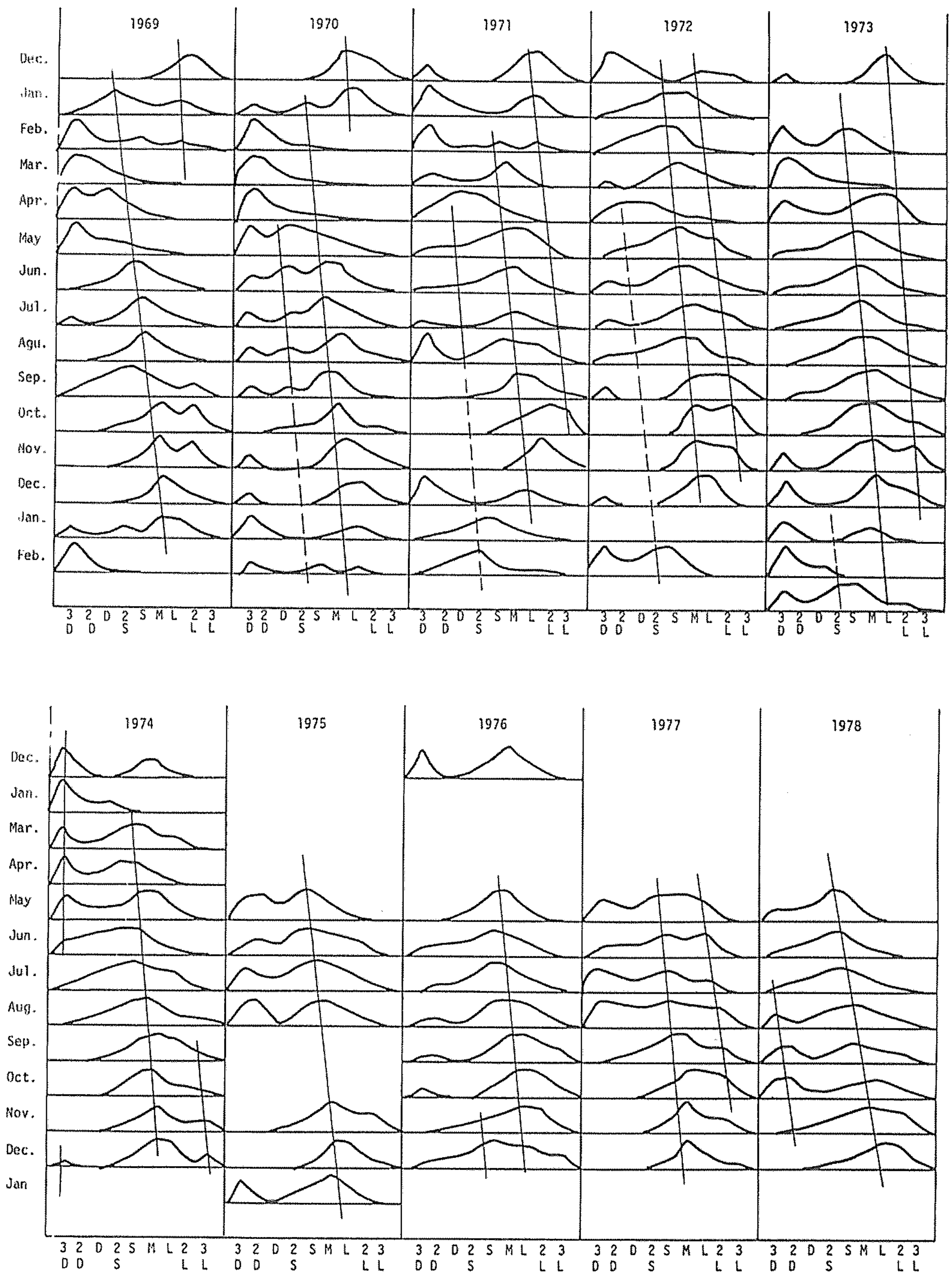


Fig. 7. Monthly change of market size frequency distribution of catch

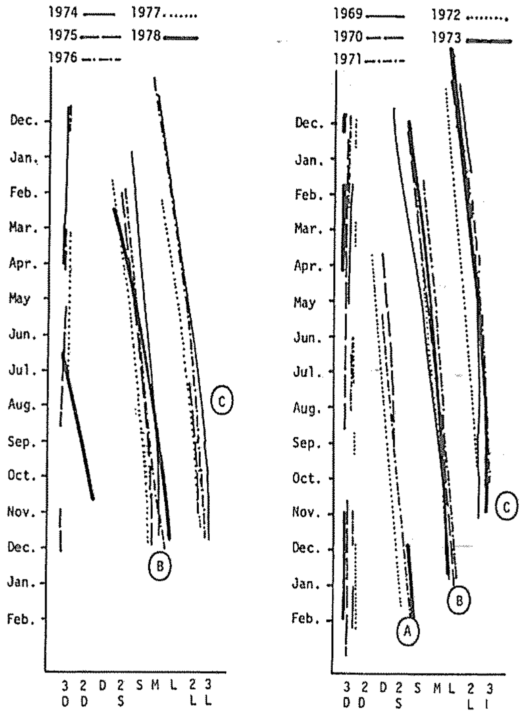


Fig. 8. Traces of modes of market size frequency distibution

the differences of growth rate and the shorter life span. Based on the results obtained in this study, we conclude that the latter is the main reason, but further study is needed.

The maturation process of males can be analyzed through the occurrence of spermatophores produced. Fig.10 shows the mantle length composition based upon different quantities of spermatophores. The fully matured individuals are seen from June to November, during this period those larger than 25 cm are mature.

The relationship between mantle length and gonad weight is shown in Fig.11. The gonad weight is very low in May, increases in June and reaches its peak from August to November, then decreases in December. Although individuals larger than 29 cm were not available, all individuals caught during April were immature.

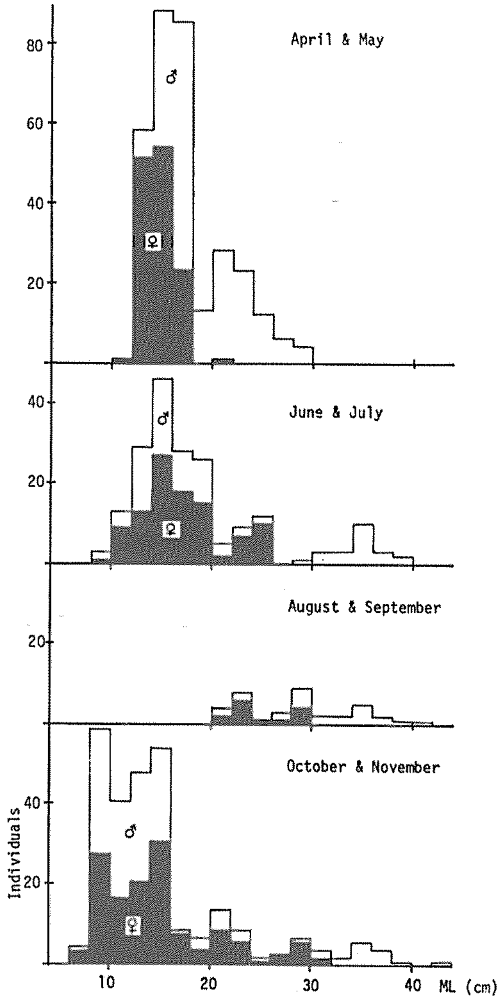


Fig. 9. Seasonal aspect of mantle length frequency distribution by sex

There is no change in May. In June, the males larger than 31 cm are filled with spermatophores. Also, in this month, females of 21-24 cm in ML occur with matured eggs, but the majority are still immature. In July, all the males larger than 24 cm are filled with spermatophores and females larger than 22 cm with matured eggs. In August, all the females larger than 22 cm are mature. By October, the maturation of

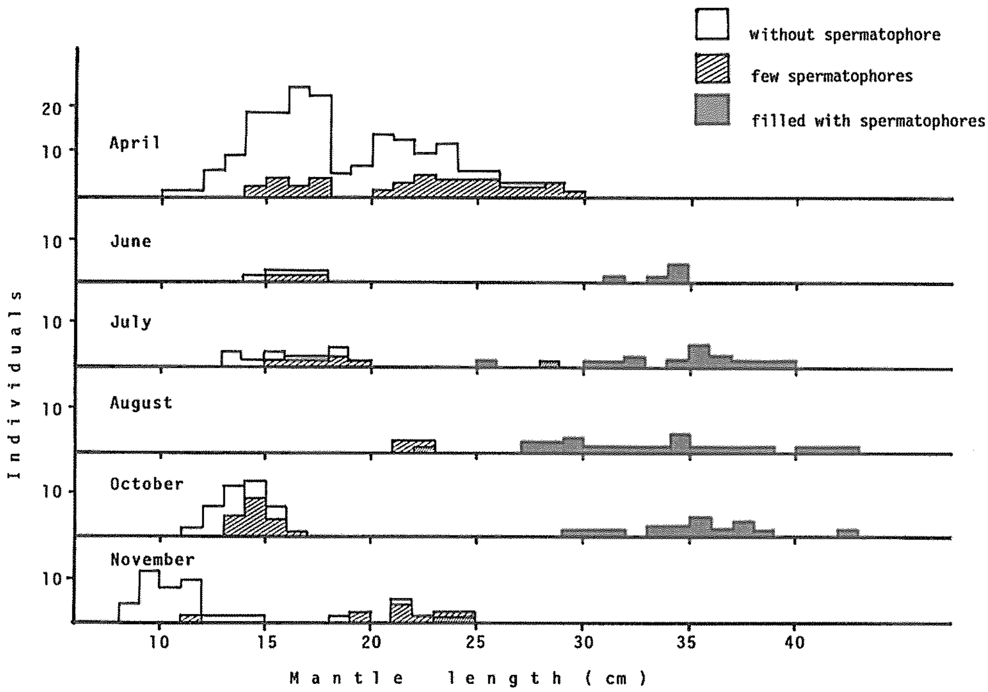


Fig. 10. Monthly aspect of mantle length frequency distribution by the presence of spermatophore in spermatophore sac of *Sepia pharaonis*

females goes on but that of the males shows no change.

Table.4 indicates the rate of maturation of females of different mantle lengths during July to August and October. Based on the above results, the spawning season is estimated to be from autumn, after the monsoon, to the early winter. The proportion of females mature from 15 cm to 20 cm in ML is roughly 1/4, and for those larger than 20 cm is 1. Expressed in market size, individuals of 2S and smaller are immature, part of S and larger are mature, and 2L and 3L are all male.

In this region, cuttlefish of 20-30 cm in ML concentrate in large numbers near the bottom (40-70 m in depth) from March to May and they move up into shallow water (0-40 m in depth) during June and July. During this period, mating can often seen near the shore. Starting in August, the eggs are laid on the rocky, gravelly bottom. It appears that after spawning, the cuttlefish migrate to deeper water. The spawning season lasts untill the end of November. The required days to hatch vary according to water temperature. There are no observations recorded for this species, but referring to the experimental results on other closely related species, this species is estimated to require 30-50 days to hatch. Consequently, fry should occur from early September to mid-January.

The relationship among market sizes, sex ratio and maturation rate is summarized in Fig.12.

7. Summary of life history

Based upon above mentioned results, the life

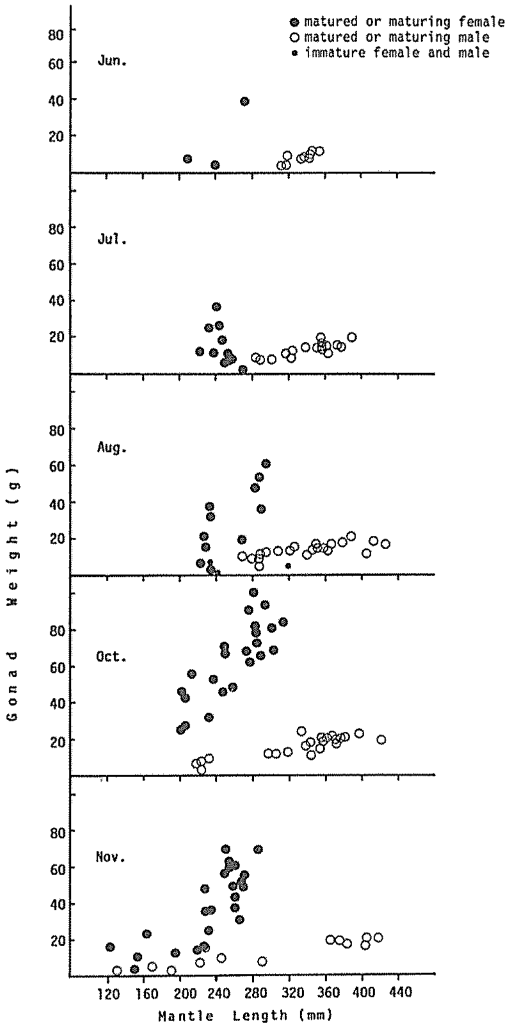


Fig. 11. Relation between mantle length and gonad weight

Table 4. Rate of maturation of females

Month	July to August		October	
Maturation / Mantle length	Mature	Immature	Mature	Immature
(cm)				
9~10		3		
10~		5		
11~		13		
12~		21		
13~		38		2
14~		38		6
15~		32	4	11
16~		13	2	11
17~		17	2	6
18~		10	1	2
19~		11	2	4
20~		10		5
21~	2	5	2	
22~	4	3	1	
23~	5	4	1	1
24~	4	3	3	
25~	4	2	5	
26~	1		4	
27~	2	2	3	
28~	2		6	
29~	2		1	
30~			2	
Total	26	230	39	48

history of this species is summarized in Fig.13. The cuttlefish hatch out from autumn to winter, then spend their immature life offshore in deep water. They become the main object of fisheries after their first year and then mature and join the spawning activities in autumn. Most females apparently die after spawning at the age of two years. Some males survive to the following year and rejoin the reproductive activities, then die before autumn.

According to the above summary, the average life span of the species is considered two years, although the hypotheses of one-year life span has been adopted in some cases. In the latter case, more than one developmental stocks should appear in a year, and the growth of these stocks would correspond to the movement of each peak shown in Fig.7. At any rate, the biological survey of age composition is insufficient and needs more detailed study.*

*The authors and Dr.T.Oba, Professor of Kanazawa University, tried to establish the method of age determination of this species by means of chemical analysis of the shell based upon the oxygen isotopic composition. The results suggest the validity of the two year life span hypothesis.

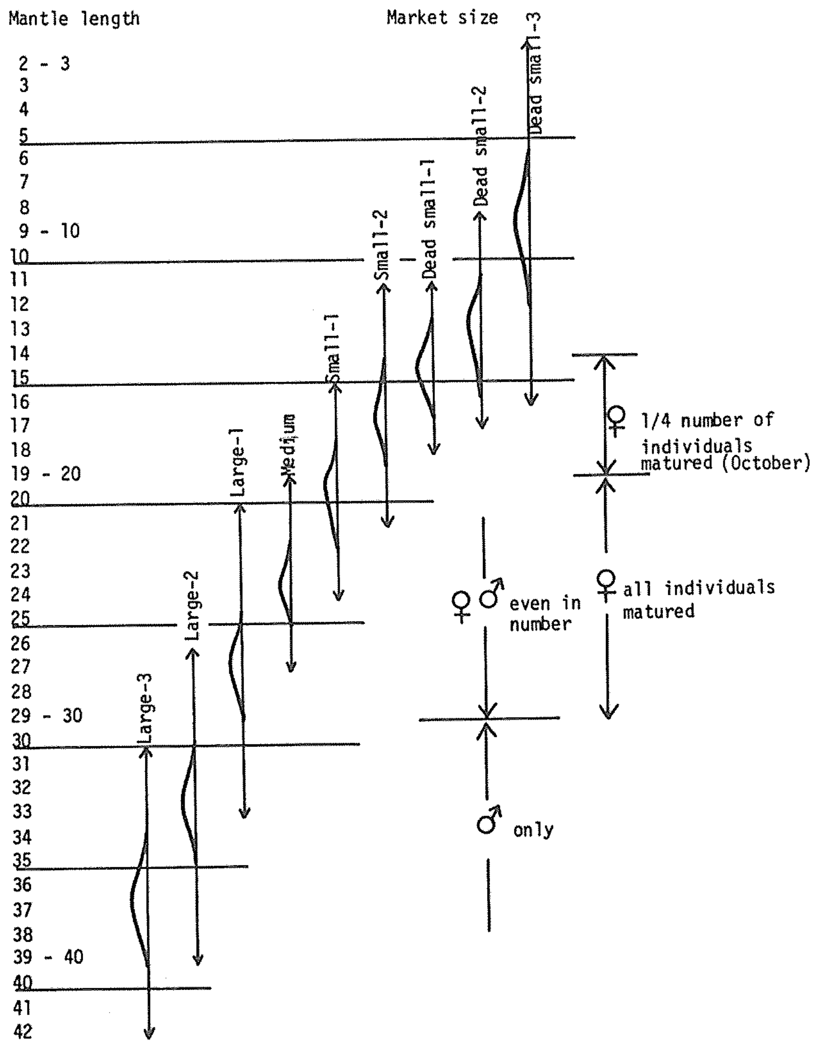


Fig. 12. Relation between market size and sexual maturation

II. ENVIRONMENT OF FISHING GROUNDS

1. Topography

The distribution of the fishing grounds from 46° to 54° E, in relation to the 50m and 200m isobaths are drawn from navigation charts are shown in Fig.14. The area within dotted lines is not favourable to trawling and therefore information is limited for this part.

The region from the northern area off Cape Fartak to the southern area off Sayhut is the best trawling ground. The western coast of Sayhut

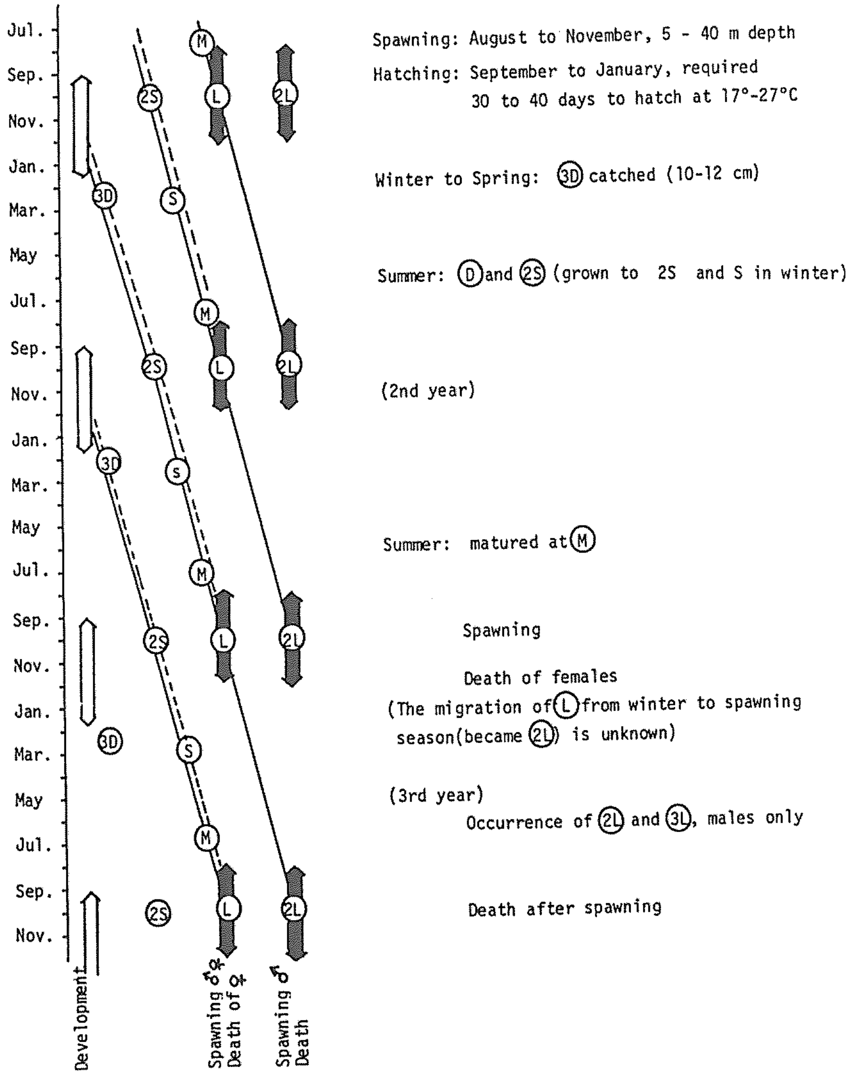


Fig. 13. Life history of *Sepia pharaonis*

has narrow continental shelf with rough bottom and is not suitable for trawling. It is suitable for spawning ground because of its rocky and gravelly bottom.

2. Climate

The air temperature in the coastal area is rather high, and often exceeds 20°C in winter. The average air temperature in Aden is 28.9°C. The rainfall in the eastern land is extremely low. The mountainous area of the western land gets some rainfall in summer, but the runoff hardly reaches the sea.

The climate of this region is characterized

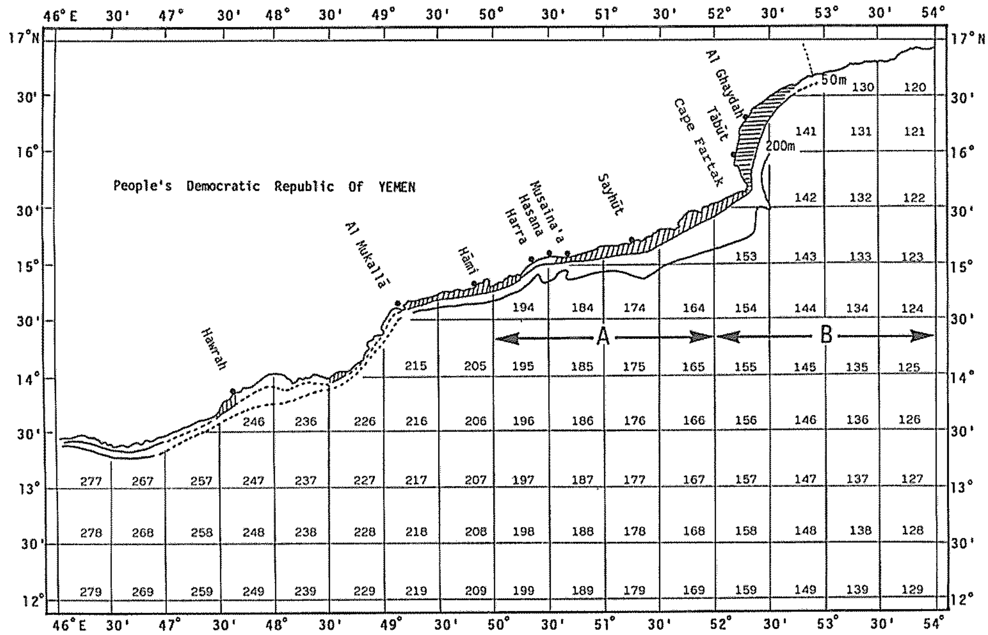


Fig. 14. Distribution of fishing grounds

by two monsoons, the southwest monson from June to August and the northeast monson from December to March; April-May and September-November are transitional periods.

The wind force and direction at noon were recorded on the daily operation records of the Nichiro fleet. The monthly wind direction and force that were derived from the operation record are given in Appendix I. "Area A" represents the area from 50° to 52°E and "Area B" from 52° to 54°E (Fig.14). The wind directions are mainly distributed from E to SW in spring, SE to SW in summer, E to S in autumn and E in winter. There were no significant differences in wind direction between areas A and B. In May, June and October, the wind were gentle, especially in area A during the spring and summer of 1977.

The two monsoons prevailling on the continent were not seen in the data of Appendix I. The reason for this may be the prominency of the so-called marine winds from the sea toward the continent.

Based upon the distribution of wind force given in Appendix I-3,4, the Beaufort's wind scales are generally lower than 4, usually 1-3. Exceptionally stormy weather was seen only in August and September 1975, and May and June 1977. Many rough days were observed in 1975 and 1978 and calm days in 1976 and 1977.

As mentioned above, because the observations were carried out at noon when the influence of marine winds were prominent, the data from the daily report of the Nichiro fleet may not be an adequate index of the strength and the phase of monsoons.

3. Oceanographic phenomena

The general distribution and circulation of water masses were taken up from the reports of

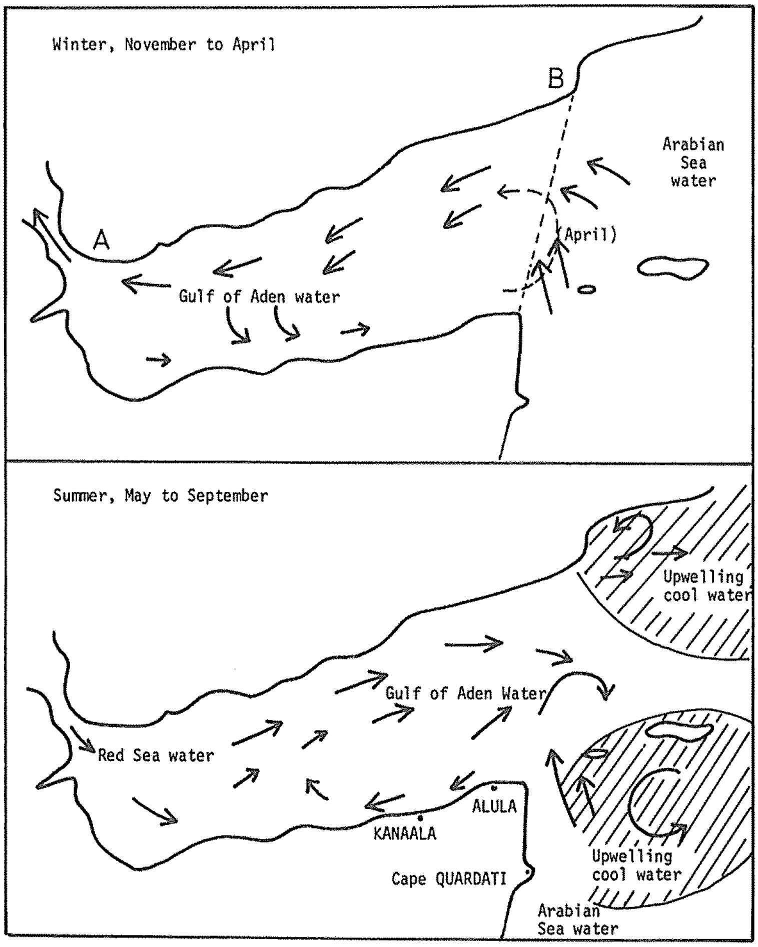


Fig. 15. Schematic showing of the distribution of water masses and the currents in the surface of the Gulf of Aden

Wooster et al.[4] and Taguchi.[5] The schematic diagrams of the distribution and circulation of water masses during the winter and summer monsoon seasons are shown in Fig.15, and their vertical distributions in Fig.16. The circlation (current) patterns in this region alternate regularly owing to the influence of the monsoons, which leads to the differences in distribution of water masses. During the northeast monson season from November to April, the surface water mainly flows southwestwards, and one part flows into the Red Sea through the surface layer of the Bab el Mandeb Straights, and the other part changes direction southwards before reaching the Strait and flows eastwards. By the inflow of Arabian Sea water from western to northern Socotra, a counterclockwise current is established in the Gulf of Aden.

Against the inflow of Gulf of Aden water to the Red Sea, the mid-layer water of the Red Sea flows into the Gulf of Aden through the bottom layer of the Straight, mixes with the Gulf water and finally sinks along the continental slope of the Arabian Sea after passing the entrance of the

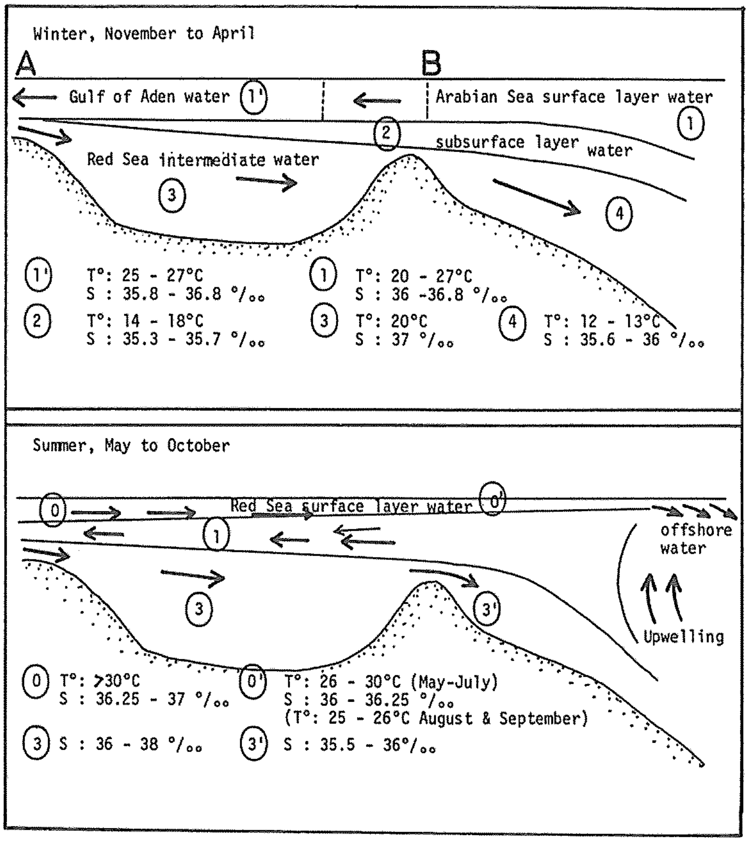


Fig. 16. Schematic showing of the vertical distribution of water masses in the Gulf of Aden

Gulf. Since there is low-temperature and low-salinity subsurface water between the westward flowing surface water and the Red Sea water, the distribution of water masses is stratified.

On the other hand, the current reverses during the southwest monson season from June to August, the surface water of the Culf of Aden shows northeastward flow, and becomes offshore flow after passing the entrance of the Gulf. This offshore flow causes a large scale upwelling of the Indian Sea bottom water off eastern area of Cape Fartak. The Red Sea surface water flows into the Gulf of Aden through the surface layer of the Strait. Another large scale upwelling by the monsoon is also developed in the region between the corner of north African coast and southern Socotra. Because the low salinity and low oxygen upwelling water, the cuttlefish are driven out temporarily from the upwelling region.

III. TAGGING EXPERIMENT

To obtain the biological information of migration, growth and mortality, a tagging experiment was carried out in 1978.

1. Experimental methods

Capture of cuttlefish for experiment Various methods of capture, including cuttlefish traps, angling and trawls were used to collect the materials. One hundred cuttlefish traps which were commonly used along the Japanese coast were prepared. Bamboo and metal traps were alternately connected together by a single rope, setting with brushwood inside. The traps were laid out at noon and hauld up early in the following morning.

The angling was carried out during the autumn season. The individuals caught in good condition by the trawl net used also. During the poor fishing season, the vigorous individuals were often found in the catch in the morning and evening.

Tags Figure 17 illustrates the two kinds of tag used: uncolored aluminum strap (A) and identification tag (B) in red and yellow colors. The alminum straps which were made specially for common squid appear to be too small for this species.

Treatement for recaptured cvttlefish The recaptured cuttlefish were recorded with tag number, recapture condition, mantle length and body weight at the time of recapture, and then freezed for detailed study.

The experiments were carried out twice in the year before and after the southwestern monsoon. In May of 1978, only 35 individuals trapped were released from small boats. From May to July, 1513 individuals were caught and from September to October 123 individuals were caught, and released. Another 156 individuals caught by traps and angling were released during October and November. In October, 553 individuals of *Sepia* sp. caught by traps were also released. The details of the experiment are shown in Appendix Ⅱ. The number of cuttlefish released by month is shown in Table 5.

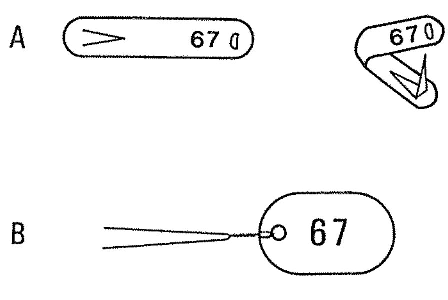


Fig. 17. Tags; A, alminium strap; B, plastic identification tag

Table 5. Number of released cuttlefishes

Fishing method / Month	Small boat		Trawl
	Trap	Angling	
May	35		184
June			1110
July			219
Subtotal	35		1513
Sept.			57
Oct.	* (553) 75		66
Nov.	5	76	
Subtotal	* (553) 80	76	123
Total	* (553) 115	76	1636

* *Sepia* sp.

2. Recapture results

A total of 110 individuals were recaptured during 1978. Their condition at the time of release and recapture are given Appendix Ⅲ. Table 6 shows the rate of recapture and movement of released cuttlefish by month and region. The results are summarized in Table 7. The relationship between the release and recapture locations is shown in Appendix Ⅳ by arrows. All individuals captured by trap released from small boats and those released in autumn were not recaptured. Among 184 individuals released in May off Fartak, 14 individuals were recaptured within an average of 7.3 days close to the release location. In June, those released off Mukalla had a higher recapture rate (11.4%) than off Sayhut (4.2%). The cuttlefish released during June

Table 6. Rate of recapture of released cuttlefishes and their movement

Released			Number of individuals			Days after released		Distance of move		Distance per day	
Month	Area	Gear	Release	Recap.	Rate	Max.	Mean	Max.	Mean	Max	Mean
May	Fartak	Trawl	184	14	7.6	22	7.3	29.5	12.1	3.7	2.0
〃	Hawrah	Trap	35	0	0						
	Subtotal		219	14	6.4		7.3		12.1		2.0
June	Fartak	Trawl	421	26	6.2	17	6.0	190.4	19.4	11.2	3.7
〃	Sayhut	〃	259	11	4.2	19	6.6	56.7	40.6	6.3	4.7
〃	Mukalla	〃	430	49	11.4	34	6.4	56.7	19.0	28.4	3.8
	Subtotal		1110	86	7.7		6.3		21.8		3.9
July	Tabut	Trawl	1	0	0						
〃	Musaina	〃	133	0	0						
〃	Hami	〃	40	0	0						
〃	Mukalla	〃	45	10	22.2	39	11.9	444.2	58.6	35.9	3.4
	Subtotal		219	10	4.6		11.9		58.6		3.4
Sep.		Trawl	57	0	0						
Oct.		〃	66	0	0						
〃		Trap	75	0	0						
Nov.		〃	5	0	0						
〃		Angling	76	0	0						
May-July			1458	110	7.1		6.9				
Sep.-Nov.			279	0	0						

Table 7. Summarized results of releasing experiment

Released			Recapture			
Month	Location	No. of block (A)	Fishing (D)	days (D)/(A)	Recapture rate %	Average days after release
May	Fartak	1	42	42	6.4	7.3
June	〃	3	22	7	5.4 } 7.7	6.2 } 6.3
〃	Mukalla	6	54	9	11.4	6.4
July	Hami	3	12	4	4.6	11.9
Total					7.1	6.9

tween Ghaydah and Fartak moved Southward and southwestward with one part moving eastward. Contrary to the above two groups, those released between Harra and Mukalla moved toward the shore and eastward. Among 45 individuals released in July off Mukalla, 10 individuals (22.2%) were recaptured with a mean of 11.9 days at liberty. This shows that during this period the majority of the cuttlefish approached the shore and remained there. However, the biggest individual (238 mm in ML) moved 444 km and was captured in eastern Ghaydah 24 days after release.

There was no difference in depths between release and recapture stations for those released in May; however, those released in June and July were recaptured 20 to 40 m deeper than the release site and it appears that the distribution of cuttlefish extended offshore at that time.

The cuttlefish released in May showed little movement but those released in June showed considerable movement which may be related to the beginning of upwelling accompanied by the monsoon from off southern Cape Fartak and Mukalla. However, those released off Mukalla in July stayed in the same region for a fairly long time when the upwelling off Mukalla was supposed to be a temporary and small in magnitude. Although the average elasped time before recapture is only 7 days, the average recapture rate is 7.1% which is very high for this kind of experiment. There was no relationship between number of operation days and recapture rate as well as between numbers of operation days per block and recapture rate. This means that the recapture rate, about 5.12 %, is not related to the fishing intensity. Consequently, the released cuttlefish were expected to stay on the fishing grounds for a short time, and most seemed to move to deeper water within only 10 days after release.

IV. STOCK ASSESSMENT

1. Statistics used

The statistics analysed were mainly from the reports of the Nichiro's trawlers. Some other values gathered from other sources were also given but those are suspected to be only rough estimates.

The total number of fishing days and total catch statistics hereafter called "A statistics" were compiled based on the daily and trip records of the trawlers. In addition to these, statistics as different fishing areas and blocks, different market sizes, and numbers of individuals, are usually necessary for detailed analysis. Statistics hereafter called "B statistics" were compiled from daily operation and processing records of trawlers after 1969. The value of "B statistics" are sometimes smaller than those of "A statistics" due to the omission of some daily records; in these cases, the "B statistics" were adjusted by using the ratio of fishing days.

2. Yearly change in fishing grounds

The "center" of fishing grounds of cuttlefish has consistently been located along the coast of the PDRY, although it was dispersed from the southern coast of Iran to the Somalian coast until 1972. During 1969, the main fishing ground stretched from Oman to the PDRY, with its center concentrated from off Ghaydah to Sayhut. Some operation were also done in the Gulf of Oman during summer and along the Somalian coast during spring. The distribution of fishing grounds in 1970 was similar to that of the preceding year with increasing importance of the fishing ground off the PDRY. Fishing was also done along the Somalian coast during summer.

Beginning in 1971, the fishery operated in the Gulf of Oman and along Somalian coast during winter to early spring and also one period of summer, but the main fishing ground continued to be located in the PDRY region. In 1972, there was a good catch, and the fishing ground in the main fishing season from May to December was concentrated along the coast of the PDRY. In the areas near Oman, Somalia and Socotra, operations were carried out only between January to May. During 1973, fishing was mostly carried out along the PDRY coast, some operations were done along the Somalian coast in February and October and in southern Omani coast during the summer. Since 1974, the fishing has been carried out only along the PDRY coast, except for a few operations done around Socotra in 1978.

The above mentioned movements of the fishery have been summarized in Table 8, in which the fishing grounds by month and the proportion of fishing days (D) and total catch (C) for each year in different regions are given in percentages.

Fishing was carried out along Iranian coast in the Gulf of Oman during summers of 1967 and 1968 but with almost no catch of cuttlefish. The area along the Omani coast was seperated into northern and southern fishing grounds by Cape Madrakah. Fishing was carried until 1972 in the northern area and untill 1973 in the southern area. During the summer or before the main fishing season in the PDRY region, the

Table 8. The yearly change of fishing ground for cuttlefish

Year	IRAN, Gulf of Oman			OMAN, North			OMAN, South			P.D.R.Y			SOCOTRA and SOMALIA		
	Month	D	C	Month	D	C	Month	D	C	Month	D	C	Month	D	C
1969	Aug.	5.1	0.1	Apr. –July	17.6	12.7	excluded June, Oct. & Nov.	30.2	1.7	Mar. –Dec. ex. Apr., Jun.& Aug.	43.1	85.4	Mar. –May	3.4	0
1970	July & Aug.	4.6	0.4	Jan., Feb., & Jun–Aug.	16.3	5.8	Feb., Jul., Aug., & Oct.	5.0	2.1	ex. July	66.4	90.9	Feb., Jul.– Oct.	7.7	0.8
1971				Jan. –July ex. May	23.8	1.2	Jan., Feb., Apr., & Jul.	1.7	0.1	ex. Aug.	54.5	97.4	ex. Jan., Apr., May, & Oct.	20.0	1.3
1972				Jan. –July ex. Apr.	12.4	0.5	Mar. –July ex. Apr.	0.6	0.4	May–Dec.	66.9	98.8	Feb. –Jun.	20.1	0.3
1973							July & Aug.	4.2	0.3	Feb. –Dec.	93.9	99.7	Jan., Sep., & Oct.	1.9	0
1974										Jan. –Nov.	100	100			
1975										Apr. –Dec. ex. Aug.	100	100			
1976										Apr. –Nov.	100	100			
1977										Apr. –Nov.	100	100			
1978										Apr. –Nov.	97.2	99.9	Apr. & Nov.	2.8	0.1

D, days operated in %; C, catch in %

catch of cuttlefish was very low since 1971. The fishery along the Somalian coast has been non-existent since April 1974.

The proportions of fishing days in the PDRY region gradually increased from 43 % in 1969 to 100 % after 1974. Most of the catch was trawled from the coast of the PDRY except 85 % in 1969 and 91 % in 1970.

3. Monthly changes in fishing grounds

The fishing grounds during early spring extended from off Fartak to Sayhut and only medium and smaller sized cuttlefish were seen. During April and May, the fishing ground enlarged westward to the vicinity of Hasana and northward to off Ghaydah and large cuttlefish appeared throughout the whole region. This westward enlargement lasted until August and eventually reached Mukalla. At this time the shoals of cuttlefish disappeared from the vicinity of Cape Fartak which had been the main fishing ground during the early period of fishing season. This may be related to the occurrence of cool water caused by unwelling. During September to the fishing ground began to retreat from the west to the east.

An example of the distribution of the fishing grounds in 1977 is shown in Fig. 18, and a schematic pattern of its movement in Fig. 19.

4. Standardization of fishing ability

The data used for this analysis were not obtained from a single boat, but from rather many boats with different fishing abilities. Therefore, the fishing ability of each boat was standardized and the year-by-year mean fishing ability was then calculated. Using statistics obtained during 1967-1977, the yearly catch per unit effort (CPUE, or catch per day) of each boat was calculated and its coefficient compared with the value of the trawler 53-Akebono-maru is shown in Table 9. The yearly coefficient of

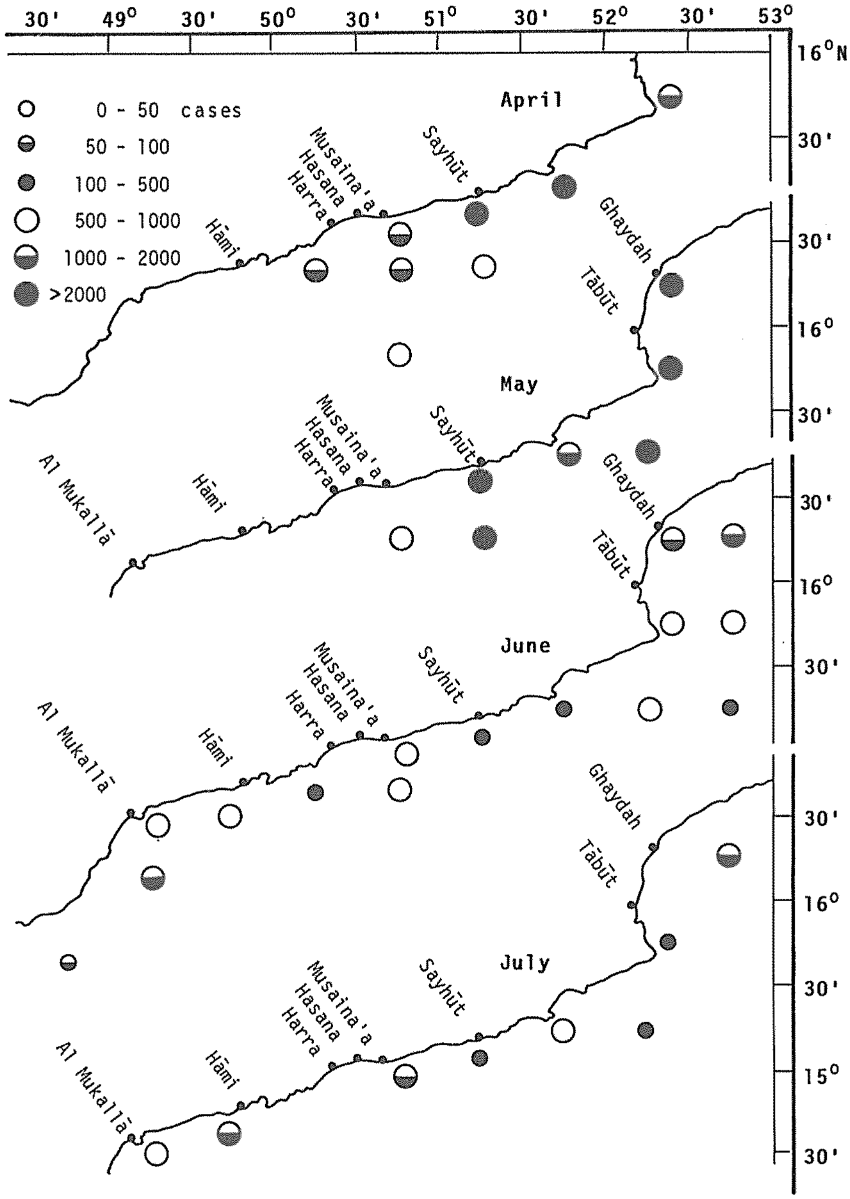
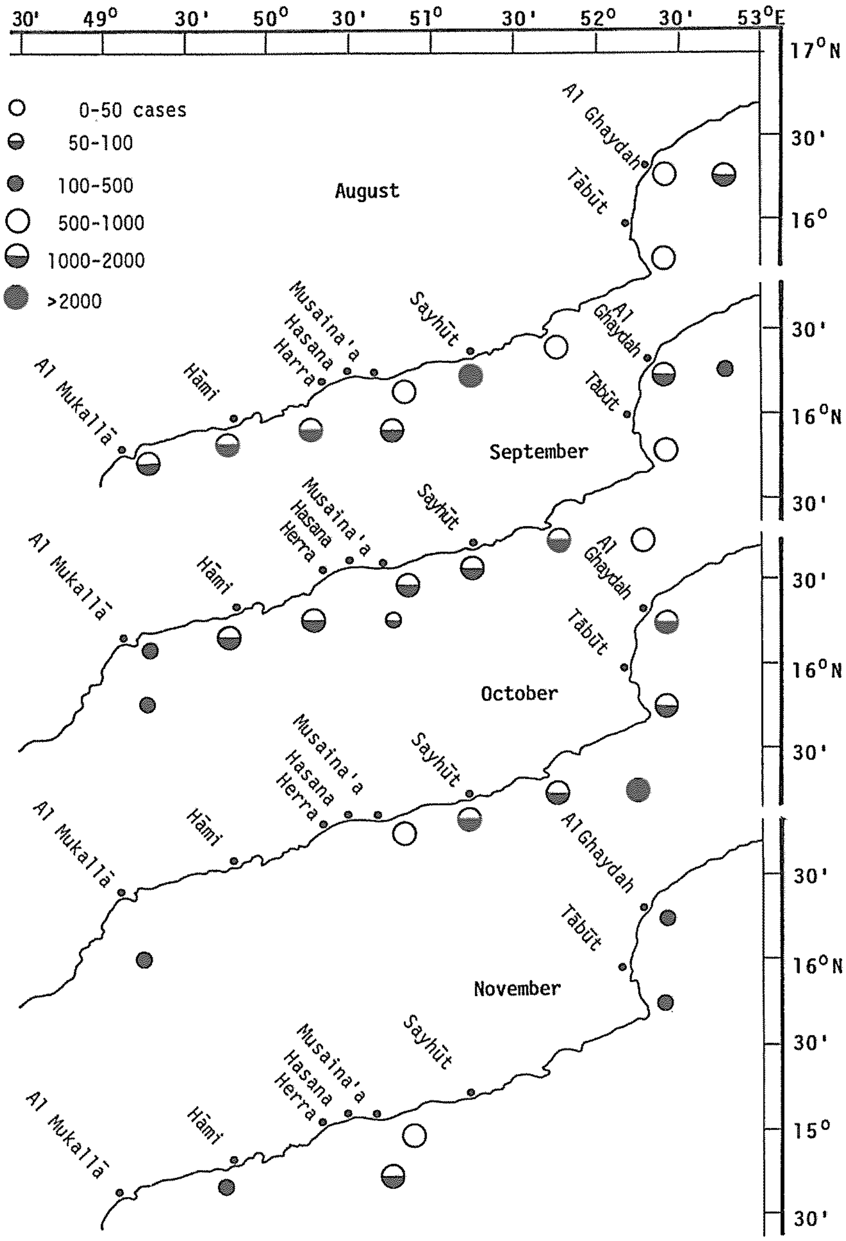


Fig. 18. The change of fishing conditions shown by the catch per day in 1977


30' 49° 30' 50° 30' 51° 30' 52° 30' 53°E
17°N
30'
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16°N
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15°
30'
0-50 cases
50-100
100-500
500-1000
1000-2000
>2000
August
September
October
November
Al Ghaydah
Tābūt
Sayhūt
Musaina'a
Hasana
Harra
Herra
Hāmi
Al Mukallā

Fig. 18. cont.

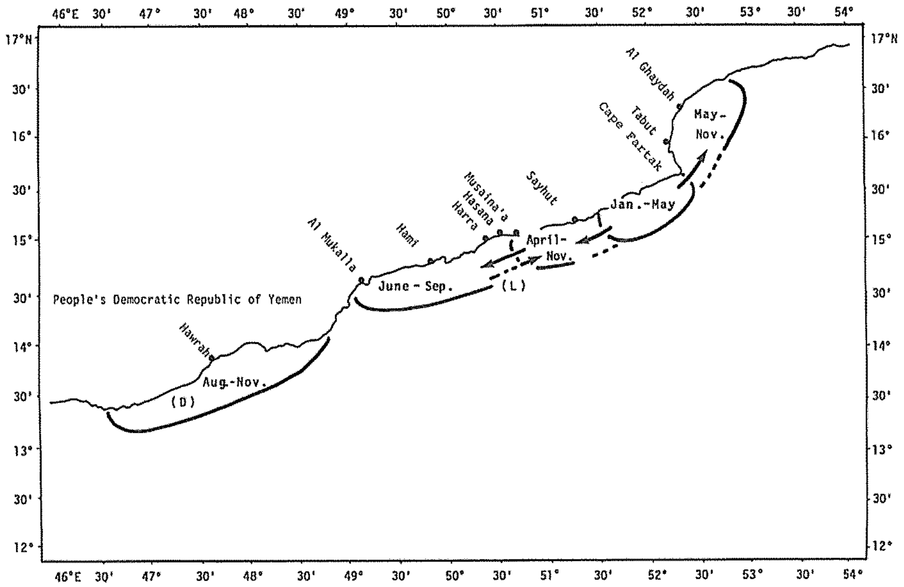

Fig. 19. Schematic showing of the movement of fishing area
(L), market sizes L,2L & 3L;
(D), market sizes D,2D & 3D

fishing ability is 1.0 for the years 1967 to 1973 and 1.3 after 1974.

5. Yearly and seasonal fishing condition

The yearly change of fishing codition is given in Table 10. The values given in the table were based on the "A statistics" of Nichiro with some estimates from various information sources other than that of Nichiro. The yearly change in fishing days and catch are given in Table 11 which include the values from the regions outside the PDRY. Then, the values in Table 11 are adjusted by the ratios given in Table 8 and are shown in Table 10. Because of a lack of detailed data, the values of years 1967 and 1968 were revised by the value of 1969. Furthermore, the fishing days were revised by the coefficient of fishing ability given in Table 9. The total fishing days were estimated by next equation:

$$X = Xn \cdot Ct/Cn$$

where, X ······total standardized days

Xn ·····fishing days of Nichiro fleet

Ct······total catch

Cn ·····catch by Nichiro

The fishing days incresed year by year from 300-400 days in 1967-1969 to more than 1000 days in 1974, and peaked at 1700 days in 1978, accompanied by the increase of total catch which showed a sharp fall in 1978 ignoring the large increase of fishing effort. The resource condition indicated by CPUE (C/D) showed great fluctuations around the 10-ton axis, and a 4-year cycle can be seen in the resources condition. The years can be divided as follows:

High level resources

1968,1969,1971,1972,1976,1977

Low level resources

1967,1970,1973,1974,1975,1978

Fig.20 shows the monthly change in fishing conditions exp essed by catch, fishing days, and catch per day, in which, the fishing days were amended based on the change of fishing ability.

Table 9. The yearly change of coefficient in fishing ability of Nichiro fleet

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	Mean
50-Akebono-Maru	1.12	1.06	0.97	0.87	0.88	*0.81						0.98
51-Akebono-Maru	0.96	0.90				*1.21	0.98					0.98
52-Akebono-Maru				1.03								1.03
55-Akebono-Maru	1.26	1.27	1.07	0.95	0.93	1.19	*1.17					1.11
53-Akebono-Maru	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shizuoka-Maru	1.09	1.03										1.06
Sekishu-Maru	1.14	1.02										1.08
71-Akebono-Maru							1.12	1.27	1.38	1.15	1.28	1.24
73-Akebono-Maru							*1.04	1.54	1.63	1.51	1.51	1.55
Rounded mean	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.3	1.3	1.3	

* excluded from the calculation of mean, for the reason of discrepancy of season operated

Table 10. The yearly change in fishing condition after 1967

Year	Catch in 1000 tons					Fishing effort in days***	CPUE in tons per day
	Nichiro	*PDRY	*USSR	*Taiyo	Total		
**1967	*3.8				3.8	*428	8.9
**1968	*5.6				5.6	*444	12.6
1969	4.53				4.5	353	12.7
1970	3.43				3.4	539	6.4
1971	5.33		0.5		5.8	479	12.1
1972	8.05	0.5	0.5		9.1	546	16.7
1973	5.01	0.5	0.5		6.0	764	7.9
1974	5.91	1.0	0.5		7.4	1232	6.0
1975	4.16	1.0	0.8		6.0	864	6.9
1976	10.29	2.5	2.0		14.8	1083	13.7
1977	9.48	4.0	2.0		15.5	1122	13.8
1978	2.33	1.0	1.0	1.0	5.3	1710	3.1

* estimated values

** detailed value is absent

*** X=Xn. Ct/Cn; X, total fishing days; Xn, fishing days by Nichiro fleet;
Ct, total catch; Cn, catch by Nichiro

Table 11. The yearly change in fishing days and catch (included regions outside PDRY)

Year	Fishing days	Total catch	
		in tons	in 1000 individuals
1967	992	4383	—
1968	1031	6531	—
1969	818	5305	5523
1970	811	3771	7493
1971	804	5476	4874
1972	726	8152	10384
1973	678	5024	6909
1974	755	5907	7121
1975	465	4156	6182
1976	580	10291	10246
1977	529	9476	10608
1978	592	2325	4596

The operation had been done throughout year during early several years succeeding the exploitation period. The fishing effort in winter season had been declining since 1971 and was suspended from 1974 on.

Generally, the catch and CPUE changed in parallel, that is, the fishing conditions appear to be dominated by the change of stock density. At the earlier stage of fishing season, the operations were strengthened following the increase of the stock density and brought about a rapid increase of catch. At the later stages, the stock density passed its peak yet the intensive operations were

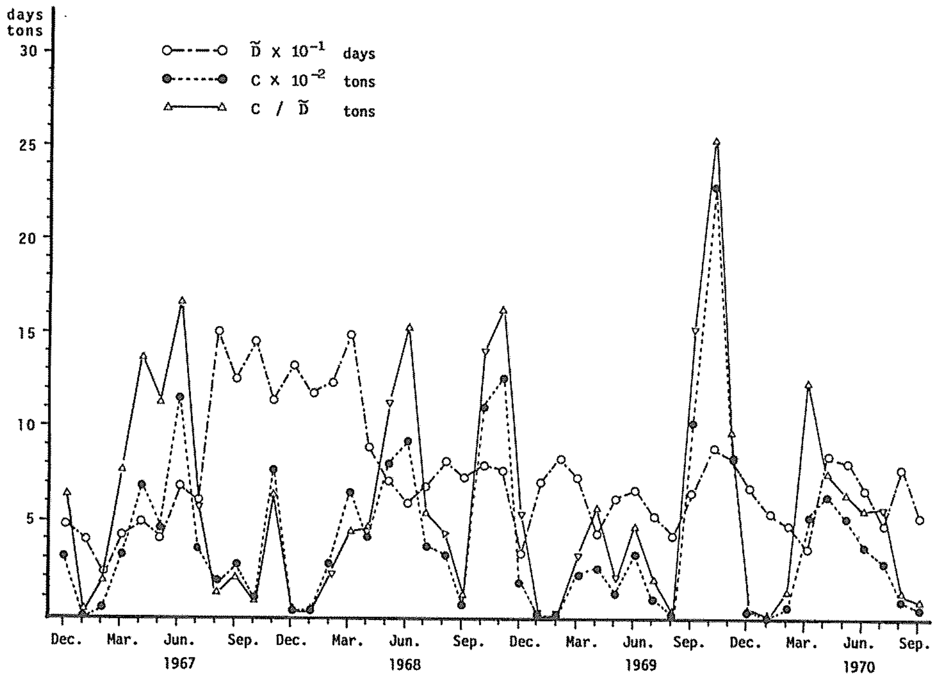

Fig. 20. The monthly change in catch, fishing days and catch per day

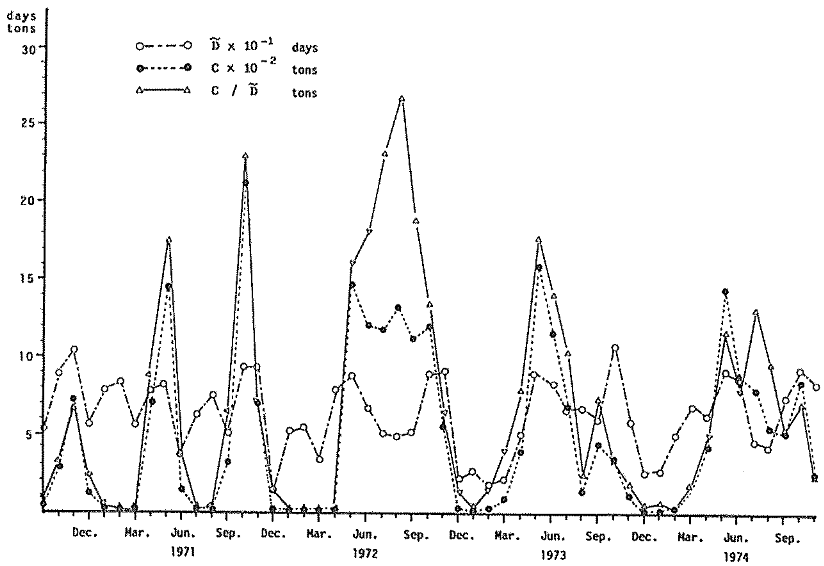

Fig. 20. cont.

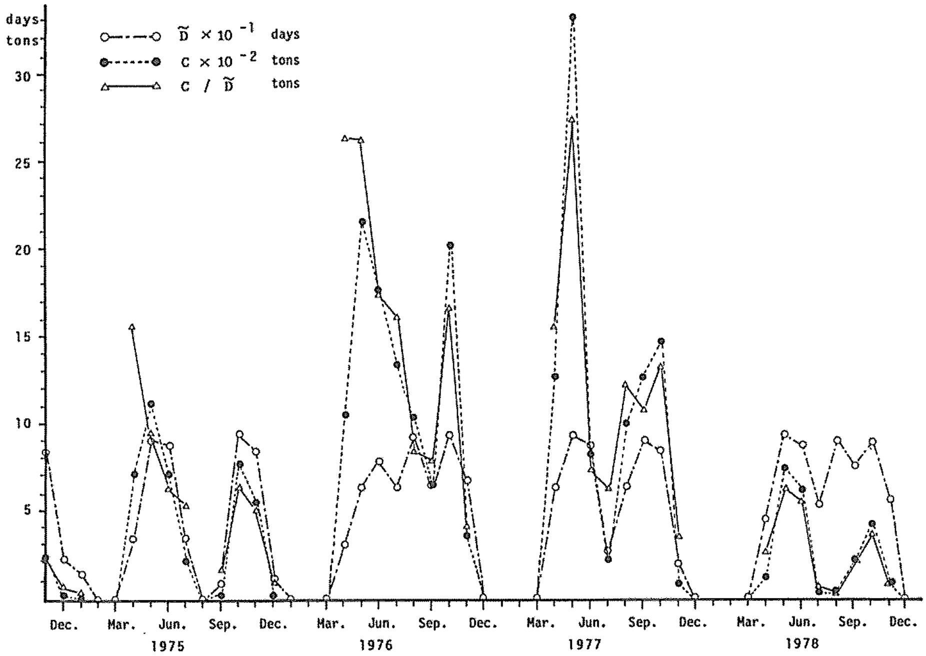

Fig. 20. cont.

still continued, followed then a fast decrease of stock density resulted and the catch decreased suddenly.

Fishing season can be divided into spring and autumn seasons. The decrease of catches in summer may possibly be caused by the dispersion and offshore migration of the schools due to the occurrence of cool water caused by upwelling, as well as mortality of large adults.

The relationship between the fishing conditions in the spring and autumn seasons had been unstable untill 1969, but since 1970, the spring season has had some fishing. However, the autumn season of 1971 had a favorable catch, and the decrease of the catch during summer was not seen during 1972. Generally, the decline in the fishing condition in summer does not appear to be extreme in the favorable catch years.

Secondly, there appears to be a change in stock density index of different market sizes (Fig.7). The smallest group (3D,2D,D), which appears only during the first half of the season is a limited in quantity and cannot sustain the fishing pressure. The medium group (2S,S,M) dominates in the first half of the season and dominates the entire fishing codition. It was also abundant during the second half during 1969. The large group (L, 2L,3L) dominates the fishing codition during the second half. It also showed high densities during the first half of the very favorable years of 1976 and 1977.

The features of fishing conditions were outlined during the years of favorable catches (with high stock density index) and unfavorable catches (with low stock density index). On the years having very favorable catches (1972, 1976, 1977), S-M sizes appeared in high density during the first half and M-L sizes in the second half. During favorable catch years (1969,1971), 2S-3L appeared in high density during the second half season, but did not appear abundant during the first half. As to years of unfavorable catches (1973,1974,1975) 2S-M appeared numerously in the first half, but disappeared during the second half. During extremely unfavorable catch years (1970,1978), very low density was seen in both halves, and L-3L almost disappeared during the second half.

6. Change in stock size of recruits

The stock of short lived animals is dominated by the size of new year class recurits, and this recruit stock size is dependent on both the number of parents and the environmental conditions at the time of spawning and development. Because of the short life span of cuttlefish, one must pay attention to the change of recruit stock size when assessing their stock.

There are two problems involving the environmental conditions at the early developmental stage of the species. First is the abundance of prey organisms. In the case when spawning occurs after upwelling, nutrients are abundant and the prey organisms generally should be abundant, but they might also be influenced by the strength of the monsoon and its time lag. The second is the problem of a sudden change of water temperature, salinity, and concentration of dissolved oxygen, etc... The weter temperature in the upwelling zone decreased to about 10°C accompanied with an increase in salinity and decrease in dissolved oxigen. If this upwelling water covers the spawning grounds, then, it might cause the death of great number of eggs. As the actual state of upwelling is still unclear, a definite consideration of this problem is impossible in this study.

Accordingly, in the present report an analysis is carried out on the relationship between numbers of spawners and recruits based on catch statistics. The quantitative relationship between parents and offspring is shown by the relationship between catch and stock density of spawners in year i and stock density of O-year old recruits in year $i+1$ and of 1-year old recurits in year $i+2$, where, the CPUE is used as an index of stock density.

The analysis is based on the "B statistics" and the stock density indices of spawners and recruits are calculated as follows:

a) Spawners: $(S+2S)/8+M/2+0.45L$ after Section I-7.

Where, S,2S,M and L are market sizes

P_i......catch during August-November of i-th year

b) Recruits

R_{i+1}......sum of 2S,D,2D and 3D in $i+1$ year

R_{i+2}......sum of L,M and S in $i+2$ year

c) Fishing days. This value is adjusted by the fishing ability.

D'_i......sum during August-November of i-th year

D_i......yearly sum of i-th year.

Table 12 shows the change in numbers of spawners and recruits, where the values of $D'_i, D_i, P_i, R_{i+1}, R_{i+2}$ do involve only those regions of the PDRY. From the values in this table, the relationship between numbers of spawners and recruits is considered as follows:

(A) relationship between P_i and R_{i+1}/D_{i+1}
(B) 〃 P_i and $R_{i+2}D_{i+2}$
(C) 〃 P_i and sum of R_{i+1}/D_{i+1} and R_{i+2}/D_{i+2}
(D) 〃 P_i/D'_i and R_{i+1}/D_{i+1}
(E) 〃 P_i/D'_i and R_{i+2}/D_{i+2}
(F) 〃 P_i/D'_i and sum of R_{i+1}/D_{i+1} and R_{i+2}/D_{i+2}

Fig.21 shows the relationship between catch of spawners and stock density index of recruits in the following year (A), the next year (B), and total stock density index of all recruits (C). Fig.22 shows the relationship between stock density index of spawners and that of recruits (D,E,F). From these figures, it can be seen that

Table 12. Fishing days(D), number of spauners(P) and number of recruits(R) in 1000 individuals.

Year i	Di	D'i	Pi	Ri+1/Di+1 (a)	Ri+2/Di+2 (b)	(a)+(b)	Pi/D'i
1969	346	122	669	10.09	7.26	17.35	5.48
1970	532	201	229	5.92	11.30	17.22	1.14
1971	325	236	454	8.54	6.14	14.68	1.92
1972	484	279	902	4.39	3.64	8.03	3.23
1973	633	288	353	3.21	4.36	7.57	1.23
1974	982	295	385	6.51	8.56	15.07	1.31
1975	585	177	368	4.78	8.75	13.53	2.08
1976	729	300	715	6.36	1.65	8.01	2.38
1977	673	248	809	4.45	—	—	3.26
1978	748	310	211	—	—	—	0.68

D′: standardized fishing days

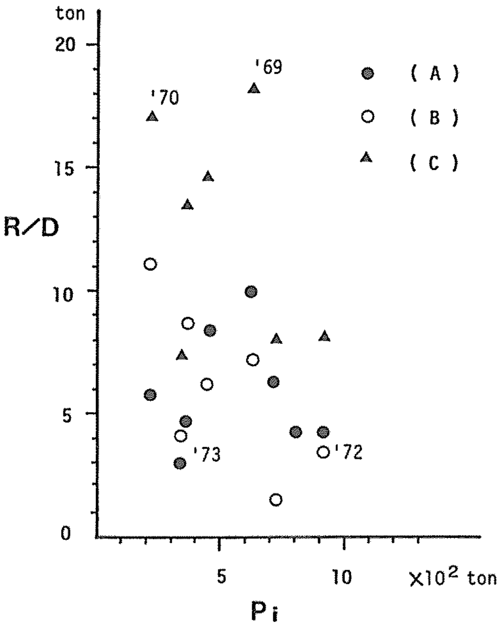

Fig. 21. Relation between the catch of spawner and the stock density index of recruits

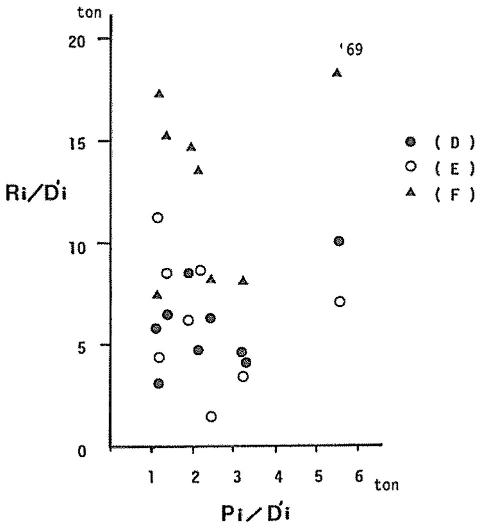

Fig. 22. Relation between the stock density index of spawner and that of recruits

the fluctuations in stock density of recruits are very large and that the aspect of the fluctuations of stock density of recruits owing to the fluctuations of catch or stock size of spawners are rather obscure.

7. Stock size

The CPUE, used as the yearly mean stock density index, is given by the yearly total catch divided by yearly total fishing days. From the values given in Table 10, the relationship between yearly fishing days (D) and yearly CPUE

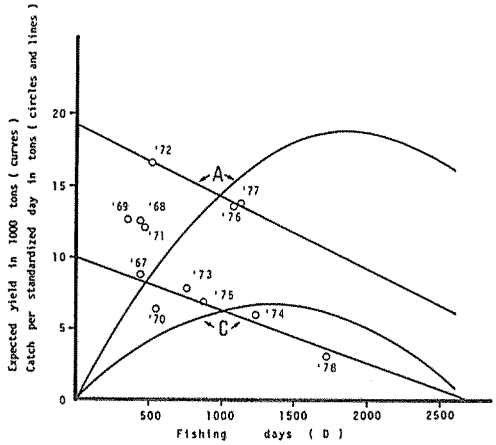

Fig. 23. Relation between catch per standerdized day and standerdized fishing days

(C/D) was expressed in Fig.23 where, the fishing effort is calculated based on the total standardized fishing days. It appears to show a weak inverse correlation. Next, the years were classified into three groups on the basis of the state of resources as follows:

(A) very high level resources
1972,1976,1977

(B) high level resources
1968,1969,1971

(C) low level resources
1967,1970,1973,1974,1975,1978

An inverse correlation is observed in each case of (A),(C) and (B+C) and the relation is written as $Y = a - bD$, where, Y equals C/D. The total catch is written as $C = aD - bD^2$, which is represented by a parabola. Then the maximum C occurs when $D = a/2b$. The results of each case is as follows:

(A) Years with very high level resources.
As we have only three available years, no definite conclusion can be made without acquiring further information. The calculated result fits for these three points gives

$$Y = 19.23 - 0.005D$$

The maximum yield expected from this line is about 18500 tons with a corresponding effort of 1900 days.

(C) Years with low level resources.
The regression is written as

$$Y = 9.94 - 0.0037D$$

with correlation coefficient of -0.89.

The expected maximum yeild is 6700 tons with an effort of 1300 days. The assumption that the regression line of (B) lies between those of (A) and (C) is regarded as being appropriate.

From the above mentioned considerations, the expected maximum yield is estimated at about 18500 tons with an effort of 1900 days for the years with very high level resources, and 6700 tons with the effort of about 1300 days for the years with low level resources. When the resources level is between these two levels, the values may be taken between the curves A and C in Fig.23.

V. CONCLUSIONS

On the basis of the results obtained from the studies on the ecology of the cuttlefish *Sepia pharaonis* in the PDRY waters off the PDRY and on their stock assessement, the following conclusions are derived.

1. Two hypotheses on the life history of this species, that is, a one-year and two-year life span have been proposed. According to the results obtained from the ayalysis of monthly change of market-size composition, statistics of catch, and the observations on gonadal development, the "two-year life span" hypotheses was regarded as appropriate in this study. But the accumulation of further information on life history would be desirable.

2. The spawning occurs during in late summer and early autumn, after the disappear of upwelling, and hatching during winter. The immature animals inhabit offshore deep water. Age groups older than one year appear in the catch and participate in spawning activity in autumn.

Most females die after spawning in autumn at the age of just two years. Some proportion of males were assumed to survive to the following year, then die after participating again in reproductive activity.

3. The environment of the fishing ground in the region is influenced by the reciprocation of the two monsoons and the development of upwelling accompanied by southwest monsoon. The change of currents, the exchange of water masses, and especially the size of cool water masses caused by monsoon dominate the migration, the aggregation and dispersal of cuttlefish, and the change of spawning ground and season as well as the survival rate of juveniles. Accordingly, additional information on the monsoons, which dominate not only the formation of fishing grounds but also the stock density of the recruits, must be collected.

4. Uninterrupted and precise statistics on fishing days and catch for a long time are necessary for the analysis of the resources. The statistics used in this analysis are only available from Nichiro Company. From the analysis of these statistics, the stock assessement of cuttlefish in this region is summarized as follows.

The yearly change in CPUE calculated from standardized fishing days show a periodic fluctuation around 10 tons in a 4 year cycle. The level of resources level is most easily divided by year into:

High level resources 1968, 1969, 1971, 1972, 1976, 1977

Low level resources 1967, 1970, 1973, 1974, 1975, 1978

The stock density of any species having a short life apan is dominated by the stock size of recruits. The fluctuations of stock density of recruits are influenced mainly by the stock density of spawners and the developmental conditions. The relationship between stock density as well as catch of spawners and stock density of recruits derived from the spawners was studied. The results show a slight inverse correlation.

The relationship between the total standardized fishing days (D) and the yearly mean CPUE (Y) show an inverse correlation when the years were classified into; years with very high level resources and other years as follows:

$Y = 19.23 - 0.005\ D$ for very high level resources

$Y = 9.94 - 0.0037\ D$ for low level resources.

From these regressions, the expected maximum yield is estimated to be about 18500 tons with standardized effort of 1900 days in years with very high level resources and about 6700 tons with the standardized effort of about 1300 days in years with comparably low level resources. When the resources level falls between these two levels, the expected maximum yield should take an intermediate value.

The resources level shows a tendency fluctuate yearly. When we consider that this species lives two years before maturing, it may be suggested that a heavy catch of spawners may result a poor recruitment. But, the assumption that the level of recruitment is dominated mainly by the environmental conditions must be taken into consideration. It is desirable that the investigation on this problem is carried out systematically in the future.

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Appendix Ⅰ. Distributions of wind direction and force

Ⅰ—1. Wind directions, A area

Year	1974												1975												1976					
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Calm	70	24	45		5						19						4	7				7							1	
N			22	4													2												1	
NNE			11								3	14																		
NE		34			2		8				6	14							18									19	1	13
ENE				4			8				6		14				2	4												3
E	20	12		4	3	10	4		10	11	43	14	30				4	11	23			21						43	1	
ESE		12	11		6	5			30	2		30						18	18											3
SE			11	15	14	32	43	100	50	36	17	14				8	13	20	23										13	
SSE				15	17	10	21			13		14	14			12	28	5				21							1	23
S	10			35	48	41	8		10	24	6		14			24	47	22	18	100		30							59	58
SSW				17	2		4			4			14			32		4			50	21							1	
SW		6		6	3	2	4			7			14			24		2			50		100					38	4	
WSW																														
W																		2												
WNW																														
NW		12																												
NNW																														

App. Ⅰ—1.(continued)

Year	1976						1977												1978											
Month	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Calm				5								11				4							6	4	3					
N																									3	2				
NNE		33														9							2			2			14	
NE	15			12								2													7	2			3	
ENE										9				21		17							4	2	7	13		3	6	
E	10	26	73	14	14					27	5	2		51	6	35	33						6	12		20	20	7	20	
ESE												2	8	7		13							4				13	25	20	
SE	30	11	18	24	72					18	13	7		21	94	9	67					4	6	6	25	18	20	22	3	
SSE											16	24	23			9						26	13	4	25	20		3	14	
S	45	30	9	38	14					37	40	20	31									35	45	52	17	8	27	10	3	
SSW											16	15										13	4	2		8	20	17	8	
SW				7						9	8	17	38			4						22	12	10		2		3	3	
WSW																								2				7		
W											2												2	2		5				
WNW																														
NW																									10			3	6	
NNW																									3					

Appendix I —2. Wind direction, B area

Year	1974												1975												1976					
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Calm	25		20	12	12						5						4					8								
N	13																													
NNE																														
NE		17	4							3			20															20		2
ENE			4						3	3			20									3	4							
E	49	17	34	18	12				63	28	30		40						5		33	5	20	44				20	24	7
ESE		17	5	18	8	3		15	16	8	20		20				12		5		17	11	21	21						
SE	13	32	11	12	8	3	41	15	11	32	30						12	5	5		33	27	14	21					6	9
SSE			2	34		13		4	2	8							8		9	50	17	7	9							
S			11		29	53	25	27	3	10	9					17	44	52	9	50		34	31	14				30	35	50
SSW			2	6	8	6				5	3					32	12	33	9			5						20		
SW		17	7		19	13	17	39	2	3	3					17	8	10	48				1					10	29	32
WSW						3	17												5											
W					4	6																								
WNW																														
NW																17													6	
NNW																17														

App. I —2. (continued)

Year	1976						1977												1978											
Month	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Calm	4									22	20	5	22	34		5							5			7	2			
N					3											3														
NNE																														
NE		3	3		6																								5	
ENE										2						3														
E			30	40	24					17						21	14					9					11	14	26	
ESE				4											19	3	14										17	27	11	
SE	4	19	51	22	46					13	8	5	11	20	74	23	29						28	24	14	7	40	8	21	
SSE										23	16	5		13		8						9	13	6	14		2	4	16	
S	63	67	16	24	21					19	44	19	11	13	7	23	14					64	26	40	14	31	11	31	5	
SSW	4									2	12	10				8	29					9		12	30	7	15	14		
SW	21	11		10						2		56	56	20		3						9	28	18	14	45	2	2	11	
WSW																													5	
W	4																								14	3				
WNW																														
NW																														
NNW																														

Appendix Ⅰ—3. Wind force, A area

Year	1974											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0	4		11	2	3						2	
1	6	4	22	6	9	10	2	1	11	14	6	
2	4	2	20	8	11	11	7	11	35	25	20	
3			3	1	2	9	3	14	14	1	10	
4	2				1	1			1		5	
5												
6												
Total	16	6	56	17	26	31	12	26	61	40	43	—

Year	1975											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0					1					6		
1	1			2	3	4	3			10	13	
2	3			3	10	6	11		2	33	26	6
3	1			1	11	3	7		3	23	14	6
4						7	1		1	3	13	2
5						1					5	
6								2				
Total	5	—	—	6	25	21	22	2	6	75	70	14

Year	1976											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0							1					
1				1	6	12	8	10	9	21	7	
2				9	11	21	11	22	17	14	18	
3					1	10	8	5	7	11	8	
4						1			3	3		
5									1			
6												
Total	—	—	—	10	17	44	28	37	37	49	33	—

Year	1977											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0				12	5	1	2	5		2		
1				31	13	4	2	7	7	21	1	
2				8	6	8	3	3	13	13	4	
3				2	1	5	2		7			
4						1				1	2	
5						2				1		
6										1		
Total	—	—	—	53	25	21	9	15	27	39	7	—

Year	1978											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0					2			2	1			
1				2	9	3	1	7	26	3	3	
2				5	21	10	5	16	15	22	6	
3				3	7	4	1	4	4	22	10	
4				1						4		
5												
6												
Total				11	39	17	7	29	46	51	19	

Beaufort's wind scale

Appendix I —4. Wind force, B area

Year	1974											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0	7	4	4		3						7	
1	1	8	2	6	29	11	1		3	13	7	
2	1	4	2	22	23	15	10	1	6	29	17	6
3	1	1	1	14	8	13	10	3	1	3	2	1
4				6	3	2	2				3	
5							1					
7～												
Total	10	17	9	48	66	41	24	4	10	45	36	7

Year	1975											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0					2	4				1		
1	5			1	4	7			1	1		
2	1			7	7	20	9			9	1	
3	1			12	19	17	8			3		
4				5	8	8						
5					6				1			
7～								1	2			
Total	7	—	—	25	46	55	17	1	4	14	1	—

Year	1976											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0					1					2		
1				6	17	8	5	12	6	19	2	
2				10	39	16	10	10	4	14	5	
3					18	5	4	5	1	6		
4					1	1	1			1		
5												
6												
Total	—	—	—	16	76	30	19	27	11	42	7	—

Year	1977											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0						5				1		
1				4	14	9	4	8	6	8		
2				3	20	16	2	5	9	7	3	
3				2	13	8	5	1	2	3		
4				2	10	4	1			4		
5					1		1					
6					4	4						
Total	—	—	—	11	62	46	13	14	17	23	3	—

Year	1978											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Scale 0				1	3	2	1			1		
1				4	14	8	8	12	2	2	8	
2				16	21	17	9	19	7	15	12	
3				3	13	13	7	9	6	10	12	
4					1	10	4			2	4	
5												
6												
Total	—	—	—	24	52	50	29	40	15	30	36	—

Beaufort's wind scale

Appendix Ⅱ. Record of tagging experiment of cuttlefish *S.pharaonis* in 1978

Released				Sea depth	Released no.	Mantle length [mm]	Body weight [g]	Method of catch	Sepia sp. released no.
		Time	Position						
May	18	07:40-08:00	246-d	12	13	70-130	40-200	Cuttle	
	19	16:25	246-g	15	1	110	100	trap	
	20	08:15-11:20	246-a,d	10-11	20	90-160	50-450	〃	
	21	07:40	246-d	10	1	110	150	〃	
					(35)			〃	
June	21	17:40	204-b	52	6	105-200	130-720	Trawl	
	22	10:30	184-a	60	22	110-190	195-800	〃	
		16:20-20:00	173-f,i,c,	50-67	65	110-195	160-730	〃	
	23	09:00-10:00	173-i,f	58-61	50	100-185	120-600	〃	
		20:00	194-a	70-74	26	120-193	220-580	〃	
	24	18:00	194-e	55	25	133-220	230-1000	〃	
	25	09:00-09:30	214-f	49-61	45	128-225	200-980	〃	
		16:00-17:00	214-c,204-i	57-62	65	118-205	120-760	〃	
	26	11:00	214-c	55-58	41	118-202	160-760	〃	
		18:00-21:30	204-i,e	56-63	54	128-215	210-890	〃	
	27	13:00	204-e	59	4	150-215	360-740	〃	
	28	06:00	163-h	61	15	133-200	170-650	〃	
	29	18:00	163-d	55	16	130-240	410-1230	〃	
	30	17:00-17:30	163-a	54-57	57	110-195	160-670	〃	
					(491)				
July	1	10:00-10:45	184-a,d	80-81	62	118-190	110-540	Trawl	
		17:00-19:30	184-a,g	81-82	61	112-185	120-620	〃	
	2	16:30	194-h	58	8	123-180	160-540	〃	
	3	15:00	204-b	48	4	120-153	140-370	〃	
	5	13:00	152-d	46	1	150	320	〃	
					(136)				
May	18	17:00	163-h	82	11	125-253	260-1460	Trawl	
	21	18:00	163-e	82	12	141-200	340-930	〃	
	22	19:30	152-f	42	6	147-210	400-1020	〃	
	23	20:30	142-e	178	13	165-227	480-1360	〃	
	24	20:30	152-a	56	15	145-232	360-1360	〃	
	25	20:10	153-g		20	162-227	280-1060	〃	
	26		152-a	86	21	152-225	410-1420	〃	
	27	18:00	152-a	82	18	140-224	390-1110	〃	
	28	18:30	152-b	90	33	172-227	510-1200	〃	
	30	19:30	152-a		35	151-188	310-1040	〃	
					(184)				
June	4	18:40	151-c	55	39	154-230	310-1280	Trawl	
	5	19:15	152-b	74	55	114-236	130-1290	〃	
	6	19:20	152-e	61	72	122-217	110-1180	〃	
	7	17:10	152-a	50	51	122-207	140-710	〃	
	11	19:00	151-c	56	12	158-214	370-1060	〃	
	12	19:00	152-e		20	135-227	210-1080	〃	

Released				Sea depth	Released no.	Mantle length [mm]	Body weight [g]	Method of catch	Sepia sp. released no.
		Time	Position						
June	13	19:30	152-f	64	25	130-214	210-1010	Trawl	
	14	19:30	151-c	41	35	142-223	280-1090	〃	
	15	18:30	151-b	40	13	171-222	560-1140	〃	
	16	19:20	152-a	60	44	148-243	310-1370	〃	
	17	18:45	152-a	64	55	137-212	190-1000	〃	
	19	18:40	204-h		23	152-243	260-1250	〃	
	20	18:00	204-b	25	36	132-254	180-1480	〃	
	22	19:00	214-f	41	40	117-215	110- 800	〃	
	23	18:50	214-f	42	28	109-228	180-1310	〃	
	24	19:00	214-c	50	37	150-226	270-1240	〃	
	30	18:45	163-a	55	34	147-229	210-1200	〃	
					(619)				
July	1	18:45	184-a	91	10	128-193	130-580	〃	
	4	19:00	204-b	32	28	174-228	470-1130	〃	
	5	19:00	214-c	30	22	154-232	270-1120	〃	
	6	19:15	214-f	30	23	158-238	360-1280	〃	
					(83)				
Oct	4	06:45	277-g	13	2	125, 130	130, 180	Trap	
	10	07:00	204-h	15	1	260	2350	〃	
	11	06:30	204-b	12	1	225	1950	〃	
	14	09:40	214-i	4	1	115	150	〃	
	15	10:00	214-i	90-100	10	190-315	550-2850	〃	
	16	09:00	214-i	200	16	185-335	570-2550	〃	
	17	09:30	214-b	230	8	128-270	230-1550	〃	
	18	10:00	183-f	10	1	100	130	〃	
	20	09:40	163-e	85	4	230-245	1100-1400	〃	58
	21	08:30, 09:40	163-e,d	85, 16	9	230-275	1000-1780	〃	42
	22	15:30	163-a	26	5	205-250	730-1350	〃	150
	23	09:45	163- 3	17	0				14
	24	09:00-09:30	173-b	8	12	183-295	580-1730	〃	108
	25	10:30	173-e	9	2	220, 235	1200, 1260	〃	83
	26				0			〃	7
	27				0			〃	5
	28	11:00	214-i	6	2	90, 100	160, 190	〃	2
	29	15:00	214-i	6	4	75-305	120-2200	〃	3
	31	11:00	204-a	16	1	260	1350	〃	4
					(79)				(476)
Nov	1				0			〃	6
	2	10:10	163-d	16	2	185, 235	865, 1170	〃	10
	3	10:40	163-d	11	1	195	570	〃	10
	4	08:30	163-d	18	0			〃	37
	5	09:30	163-d	23	2	215, 230	1750, 1960	〃	15
	6	10:10	173-e	3	26	215-380	840-3800	Angling	

Released				Sea depth	Released no.	Mantle length 〔mm〕	Body weight 〔g〕	Method of catch	Sepia sp. released no.
		Time	Position						
Nov	7	08 : 00	173-e	8	40	220-365	1040-3900	Angling	
	11	15 : 00	214-i	6	1	85	125	〃	
	12	07 : 30	214-i	10	3	255-270	1250-1400	〃	
	13	06 : 30	214-i	15	6	160-240	580-1130	〃	
					(81)				(78)
Sep	17	19 : 30	152-i	37	10	159-218	340-970	Trawl	
	19	19 : 10	163-h	35	16	164-220	385-1095	〃	
	20	19 : 15	163-h	39	16	158-222	390-1090	〃	
	23	19 : 00	151-b	38	15	159-200	370-710	〃	
					(57)				
Oct	2	19 : 30	163-h	40	13	147-226	300-1100	Trawl	
	8	18 : 30	163-a	30	20	165-215	420-770	〃	
	9	19 : 00	153-h	50	15	150-225	270-90	〃	
	11	19 : 00	163-h	30	18	182-219	630-1090	〃	
					(66)				

Appendix Ⅲ. Recaptured results of tagging experiment in 1978

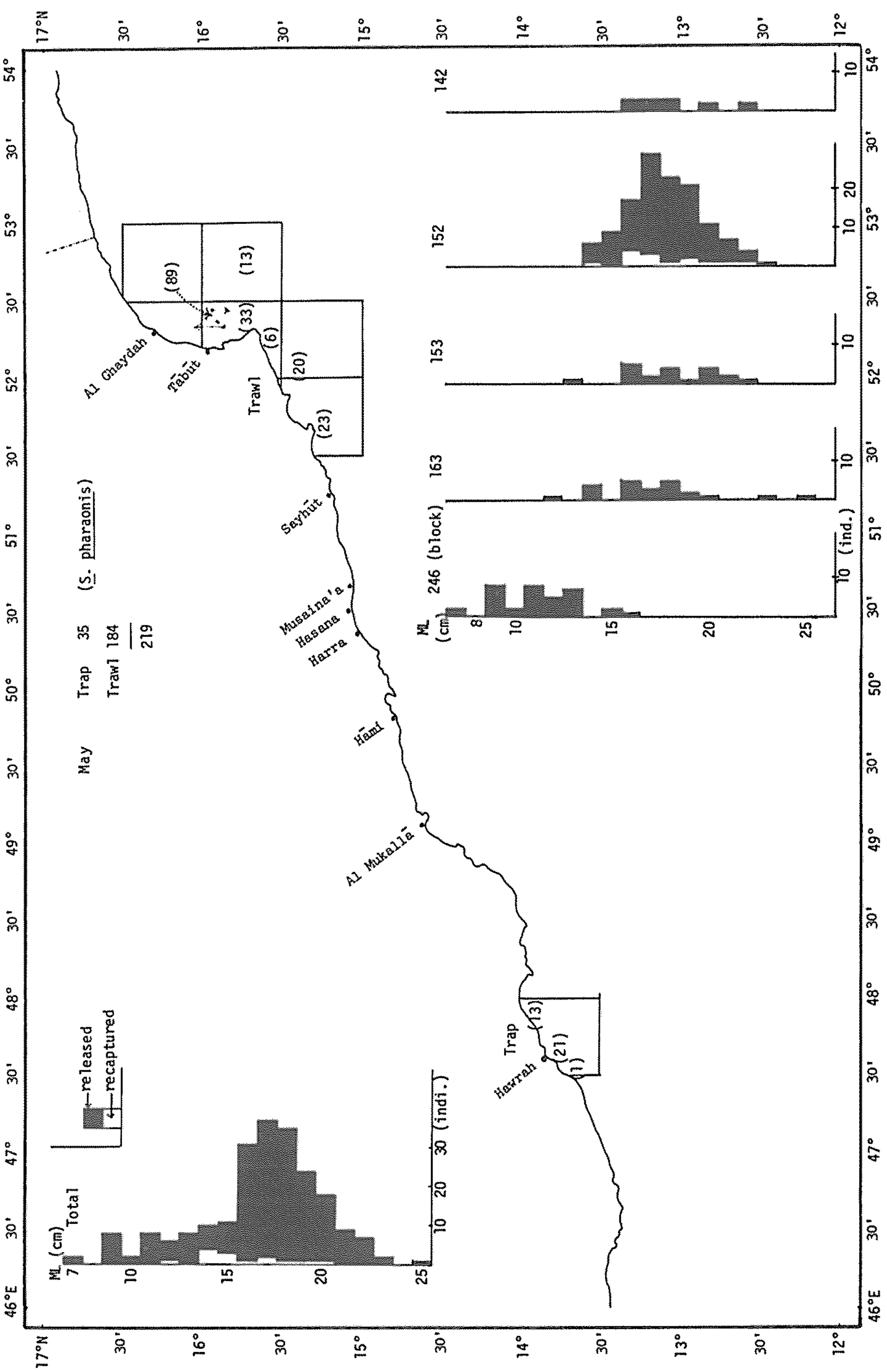
Tag no.	Time released / recaptured	days	Location(N,E) released / recaptured	dist. (km)	Mantle length at relea. (mm)	Body weight at relea. (g)	Depth (m)	Bottom water temp. recap. (℃)	Catch at time of recap. (ton)	Sex
51	May 24,20：30		152-A		165	560	56			
	May 29,21：50	5	152-B	18.6			80	18	0.9	
60	May 24,20：30		15°50′,52°21′		145	360	56			f
	May 29,07：00	5	15°50′,52°25′	7.1			86	16.5	0.7	
66	May 28,18：30		15°47′,52°24′		200	860	90			f
	Jun.10,12：00	13	16°00′,52°19′	29.8			58	18.0	1.2	
86	May 26,		15°50′,52°25′		161	460	86			f
	May 28,18：00	2	15°49′,52°24′	2.4			85	17.5	0.6	
90	May 26,		15°50′,52°25′		172	530	86			m
	Jun. 4 ,21：55	9	15°54′,52°23′	8.5			60	18.5	0.4	
104	May 27,18：00		15°50′,52°24′		190	680	82			f
	Jun.10,14：00	14	16°06′,52°25′	29.6			58	18.0	0.5	
109	May 27,18：00		15°50′,52°24′		224	1110	82			m
	May 30,11：05	3	15°45′,52°22′	10.9			85	17.5	0.9	
121	May 28,18：30		15°47′,52°24′		192	700	90			f
	May 30,10：30	2	15°50′,52°25′	6.0			100	17.0	0.1	
123	May 28,18：30		15°47′,52°24′		183	660	90			f
	Jun.19,15：10	22	15°53′,52°25′	11.7			90	15.3	0.6	
128	May 28,18：30		15°47′,52°24′		210	980	90			f
	Jun. 5 ,17：30	8	15°48′,52°21′	5.7			76	22.0	0.1	
133	May 28,18：30		15°47′,52°24′		175	660	90			f
	May 30,17：30	2	15°44′,52°24′	5.7			103	17.5	0.7	
180	May 30,19：30		15°55′,52°22′		162	430				f
	Jun.11,18：15	12	15°48′,52°23′	22.2			75	15.2	2.9	
184	May 30,19：30		15°55′,52°22′		166	440				m
	Jun. 2 ,01：50	3	15°50′,52°23′	9.4			75	17.8	0.5	
189	Jun. 4 ,18：40		16°03′,52°24′		183	650	55			
	Jun. 9 ,14：10	5	16°08′,52°25′	9.9			48	18.8	2.5	
193	Jun. 4 ,18：40		16°03,52°24′		167	480	55			m
	Jun.10,14：20	6	16°05′,52°26′	5.4			60	16.6	1.5	
83	May 27,18：00		15°50′,52°24′		172	640	82			f
	May 29,08：15	2	15°50′,52°23′	18.0			73	17.5	0.5	
195	Jun. 4 ,18：40		16°03′,52°24′		188	740	55			m
	Jun.12,07：35	8	16°16′,52°28′	24.6			52	17.5	0.7	
225	Jun. 4 ,18：40		16°03′,52°24′		195	910	55			f
	Jun.11,23：40	7	16°07′,52°25′	9.7			40	18.8	0.2	
254	Jun. 5 ,19：15		15°45′,52°20′		149	280	74			f
	Jun. 6 ,17：00	1	15°43′,52°19′	4.3			82	18.0	0.1	
262	Jun. 5 ,19：15		15°45′,52°20′		176	570	74			
	Jun.13	8	15°45′,52°22′	3.6			98-144			
294	Jun. 6 ,19：20		15°46′,52°19′		202	690	61			f
	Jun.13,05：20	7	15°42′,52°24′	12.1			112	14.5	2.9	
297	Jun. 6 ,19：20		15°46′,52°19′		158	430	61			f
	Jun.13,08：25	7	15°43′,52°23′	8.2			100	17.5	8.9	
301	Jun. 6 ,19：20		15°46′,52°19′		183	630	61			m
	Jun.13,07：30	7	15°42′,52°24′	12.1			110	14.4	2.1	
309	Jun. 6 ,19：20		15°46′,52°19′		195	700	61			m
	Jun. 7 ,03：25	1	15°48′,52°21′	5.1			60	18.0	0.6	
321	Jun. 6 ,19：20		15°46′,52°19′		200	690	61			f
	Jun.13,15：40	7	15°42′,52°24′	12.1			112	14.0	2.0	

Tag no.	Time released / recaptured	days	Location(N,E) released / recaptured	dist. (km)	Mantle length at relea. (mm)	Body weight at relea. (g)	Depth (m)	Bottom water temp. recap. (℃)	Catch at time of recap. (ton)	Sex
326	Jun. 6 ,19：20		15°46′,52°19′		184	500	61			f
	Jun.12,14：05	6	15°44′,52°25′	11.5			110	14.8	3.0	
329	Jun. 6 ,19：20		15°46′,52°19′		156	500	61			f
	Jun.13,11：20	7	15°46′,52°23′	7.2			86	17.5	0.3	
338	Jun. 6 ,19：20		15°46′,52°19′		170	360	61			f
	Jun.13,07：30	7	15°42′,52°24′	12.1			110	14.4	2.1	
353	Jun. 6 ,19：20		15°46′,52°19′		175	410	61			m
	Jun.13,13：55	7	15°41′,52°24′	13.0			115	16.5	0.1	
360	Jun. 7 ,17：10		15°54′,52°21′		207	930	50			
	Jun.12,11：40	5	15°42′,52°23′	18.6			110	14.5	3.7	
368	Jun. 7 ,17：10		15°54′,52°21′		167	390	50			m
	Jun.14,09：15	7	15°41,52°24′	24.6			116	14.5	2.1	
370	Jun. 7 ,17：10		15°54′,52°21′		155	410	50			f
	Jun. 9 ,04：30	2	15°47′,52°20′	13.3			70	18.0	0.3	
389	Jun. 7 ,17：10		15°54′,52°21′		164	360	50			f
	Jun.12,22：30	5	15°50′,52°24′	9.4			60	16.0	0.4	
396	Jun. 7 ,17：10		15°54′,52°21′		172	570	50			f
	Jun.13,01：00	6	15°50′,52°24′	9.4			65	16.1	0.4	
449	Jun.13,19：30		15°37′,52°18′		219	1010	64			
	Jun.30	17	15°02′,50°48′	190.4			64			
469	Jun.14,19：30		16°06′,52°24′		155	280	41			m
	Jun.16,14：05	2	16°02,52°24′	7.7			56	17.5		
472	Jun.14,19：30		16°06′,52°24′		163	480	41			f
	Jun.16,17：30	2	15°55′,52°21′	20.7			62	19.0	0.3	
485	Jun.14,19：30		151-C		171	570	41			
	Jun.15,16：00	1	151-B	18.8			64	14.8		
542	Jun.16,19：20		15°53′,52°22′		213	1010	60			f
	Jun.19,09：30	3	15°51′,52°25′	8.3			87	15.5	1.2	
568	Jun.17,18：45		15°53′,52°23′		190	600	64			
	Jul. 2 ,08：50	15	15°37′,52°15′	31.2			30	23.0		
618	Jun.19,18：40		14°41′,49°38′		152	260				f
625	Jun.19,18：40		204-H		166	320				
	Jun.26,22：00	7	204-E	18.0			36	21.5	0.3	
636	Jun.20,18：00		204-B		191	810	25			
	Jun.29	9	204-B	0			40			
649	Jun.20,18：00		14°45′,49°54′		186	620	25			
	Jul. 2 ,17：00	12	14°46′,49°54′	1.9			30			
656	Jun.20,18：00		14°45′,49°54′		254	1480	25			
	Jul. 1	11	14°45′,49°55′	1.9			40			
658	Jun.20,18：00		14°45′,49°54′		161	310	25			f
	Jun.27,18：40	7	14°48′,49°58′	8.0			36	19.5	0.6	
662	Jun.20,18：00		14°45′,49°54′		132	180	25			
	Jul. 3 ,15：00	13	14°47′,49°55′	4.3			45			
678	Jun.22,19：00		14°32′,49°15′		144	290	41			
	Jun.24	2	14°35′,49°20′	10.4			55			
687	Jun.22,19：00		14°32′,49°15′	6.1	180	610	41			f
	Jun.26,08：30	4	14°35′,49°14′				62	21.0	1.6	
694	Jun.22,19：00		14°32′,49°15′	3.8	167	410	41			
	Jul.26,15：00	34	14°30′,49°15′				55			

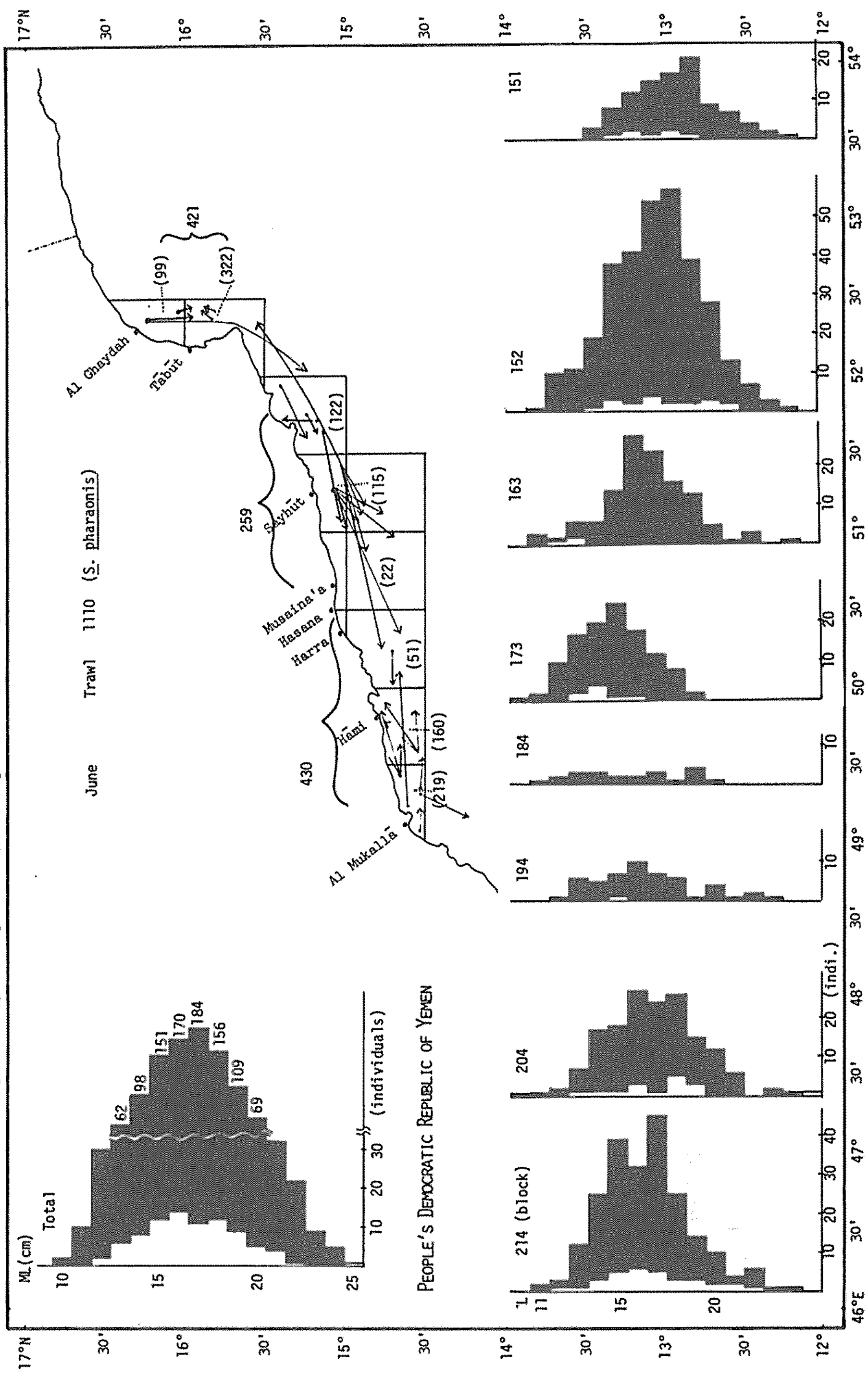
Tag no.	Time released / recaptured	days	Location(N,E) released / recaptured	dist. (km)	Mantle length at relea. (mm)	Body weight at relea. (g)	Depth (m)	Bottom water temp. recap. (℃)	Catch at time of recap. (ton)	Sex
697	Jun.22,19：00 Jun.26,09：50	4	214-F 214-F	0	197	600	41 50	17.5	7.3	
705	Jun.22,19：00 Jun.26,08：30	4	14°32′,49°15′ 14°35′,49°14′	1.8	159	390	41 62	21.0	1.3	f
713	Jun.23,18：50 Jun.25,10：30	2	214-F 214-F	0	193	690	42 57	15.8	0.6	
719	Jun.23,18：50 Jun.26,08：30	3	14°34′,49°18′ 14°35′,49°14′	8.4	151	310	42 62	21.0	1.3	f
736	Jun.23,18：50 Jun.26,08：30	3	14°34′,49°18′ 14°35′,49°14′	8.4	153	300	42 62	21.0	1.6	m
738	Jun.23,18：50 Jun.26,08：30	3	14°34′,49°18′ 14°35′,49°14′	8.4	161	390	42 62	21.0	1.3	
739	Jun.23,18：50		14°34′,49°18′		166	490	42			m
744	Jun.24,19：00		14°37′,49°29′		225	1210	50			f
746	Jun.24,19：00		14°37′,49°29′		184	640	50			f
754	Jun.24,19：00 Jun.25,03：30	1	14°37′,49°29′ 14°40′,49°41′	22.2	161	310	50 42	17.5	1.5	m
759	Jun.24,19：00 Jun.25,12：00	1	14°37′,49°29′ 14°30′,49°26′	13.9	210	1000	50 40	19.0	0.7	f
760	Jun.24,19：00 Jun.25,10：00	1	214-C 214-C	0	183	660	50 38	19.5	0.7	f
765	Jun.24,19：00 Jun.25,03：30	1	14°37′,49°29′ 14°40′,49°41′	22.2	170	440	50 42	17.5	1.5	f
774	Jun.24,19：00 Jul.16,16：00	22	14°37′,49°29′ 14°35′,49°26′	6.9	194	690	50 40	17.0		f
775	Jun.24,19：00		14°37′,49°29′		211	780	50			m
776	Jun.24,19：00 Jun.25,11：50	1	14°37′,49°29′ 214-C	0	208	780	50 38	19.5	0.1	f
831	Jul. 4 ,19：00 Jul.15,13：00	11	14°48′,49°52′ 14°40′,49°40′	25.5	201	920	32 32			
841	Jul. 4 ,19：00		14°48′,49°52′		163	610	32			
844	Jul. 4 ,19：00 Aug.12,19：00	39	14°48′,49°52′ 14°43′,49°43′	18,9	202	830	32 45	13.5	0.2	
847	Jul. 4 ,19：00 Jul.17,19：00	13	14°48′,49°52′ 14°39′,49°40′	40.8	178	580	32 50	15.0		
872	Jul. 6 ,19：15 Jul.18,11：20	12	14°34′,49°18′ 14°30′,49°13′	11.5	197	760	30 55			
879	Jul. 6 ,19：15 Jul.16,09：30	10	14°34′,49°18′ 14°30′,49°12′	12.8	179	540	30 55			
884	Jul. 6 ,19：15 Jul.15,10：30	9	14°34′,49°18′ 14°20′,49°12′	27.9	205	750	30 60			
885	Jul. 6 ,19：15 Jul. 7 ,14：25	1	14°34′,49°18′ 14°33′,49°16′	4.3	213	880	30 40		1.3	m
894	Jul. 6 ,19：15 Jul.30	24	14°34′,49°18′ 16°15′,52°25′	444.2	238	1280	30 20			

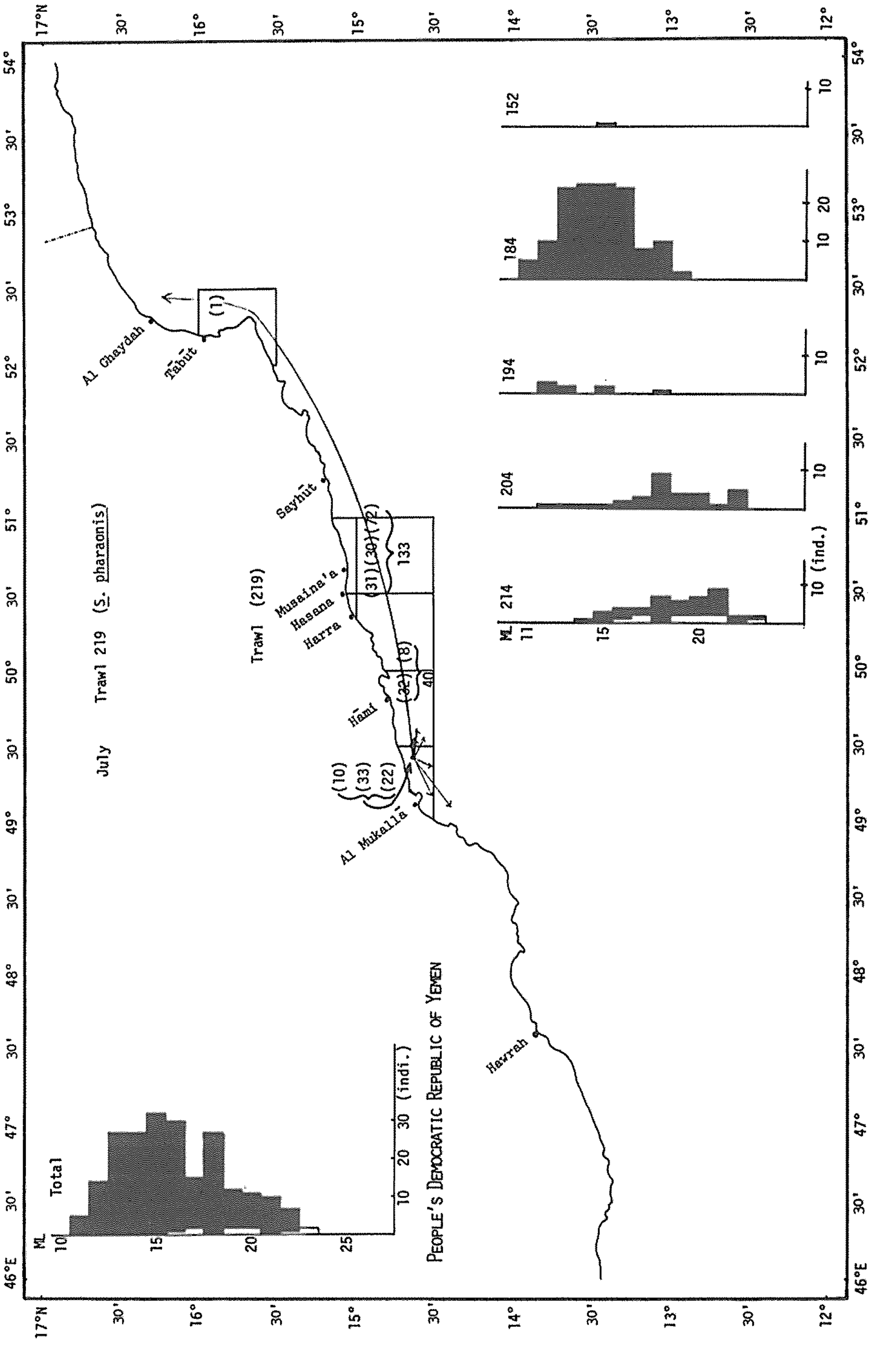
Tag no.	Time		Location(N,E)		Mantle length at relea. (mm)	Body weight at relea. (g)	Depth (m)	Bottom water temp. recap. (℃)	Catch at time of recap. (ton)	Sex
	released / recaptured	days	released / recaptured	dist. (km)						
1043										
	Jul.17,19:00		14°39′,49°40′				50	15.0		
1067	Jun.22,16:30		173-F		155	300	67			m
	Jul. 1 ,20:20	9	14°59′,51°05′	21.1			68	16.5	0.02	
1112	Jun.22,19:55		173-C		165	410	57			
	Jul.13?	19?	15°45′,52°22′	73.8			98-114			
1123	Jun.22,19:55		173-C		145	350	57			f
	Jul. 1 ,12:00	9	184-A	56.7			86	14.2	1.2	
1131	Jul.22,20:00		173-C		143	320	52			f
	Jul. 1 ,18:00	9	14°59′,51°01′	44.2			88	16.5	0.4	
1132	Jun.22,20:00		173-C		140	300	50			
	Jul. 1 ,07:15	9	174-G	40.6			74	16.5	0.5	
1135	Jun.22,20:00		173-C		140	310	52			
	Jun.30	8	15°03′,51°03′	39.3			68-62			
1137	Jun.22,20:00		173-C		130	220	50			f
1187	Jun.23,10:00		173-F		138	340	61			f
1238	Jun.24,18:00		194-E		155	360	55			
	Jul.13	19	14°45′,49°55′	37.8			45			
1275	Jun.25,09:30		214-F		128	200	61			
	Jul. 1 ,13:00	6	14°39′,49°37′	40.0			40			
1279	Jun.25,09:30		214-F		158	400	61			
	Jul. 1 ,13:00	6	14°40′,49°41′	47.3			50			
1282	Jun.25,09:30		214-F		153	360	61			m
	Jun.25,09:40	0	14°40′,49°41′	35.9			42	16.5	0.4	
1294	Jun.25,16:00		214-C		205	760	62			
	Jun.29	4	14°45′,49°57′	56.7			40			
1304	Jun.25,16:00		214-C		170	540	61			m
	Jul. 2 ,11:00	7	14°44′,49°42′	25.8			42	17.5	0.2	
1311	Jun.25,16:00		214-C		140	280	58			
1313	Jun.25,17:00		214-C		160	410	58			
	Jul. 2 ,17:00	7	14°46′,49°54′	56.7			30			
1335	Jun.25,17:00		204-I		142	280	57			
	Jul. 2 ,17:00	7	14°49′,49°54′	40.2			30			
1343	Jun.25,17:00		204-I		189	620	57			m
1346	Jun.25,17:00		204-I		180	510	57			m
	Jun.27,16:30	2	14°48′,49°53′	40.2			36	19.0	0.6	
1348	Jun.25,17:00		204-I		180	510	57			
	Jul. 6	11	14°46′,49°50′	40.2			48			
1355	Jun.26,11:00		214-C		163	440	55			m
	Jul. 7 ,11:30	11	14°33′,49°16′	18.0			40	17.0	1.1	
1361	Jun.26,11:00		214-C		178	520	55			
	Jul. 7 ,06:00	11	214-F	18.0			40	17.0	0.7	
1369	Jun.26,11:00		214-C		170	470	58			
	Jul. 7 ,06:00	11	214-F	18.0			40	17.0	0.7	
1372	Jun.26,11:00		214-C		170	440	58			
	Jul.15,10:30	19	14°20′,49°12′	25.5			60			

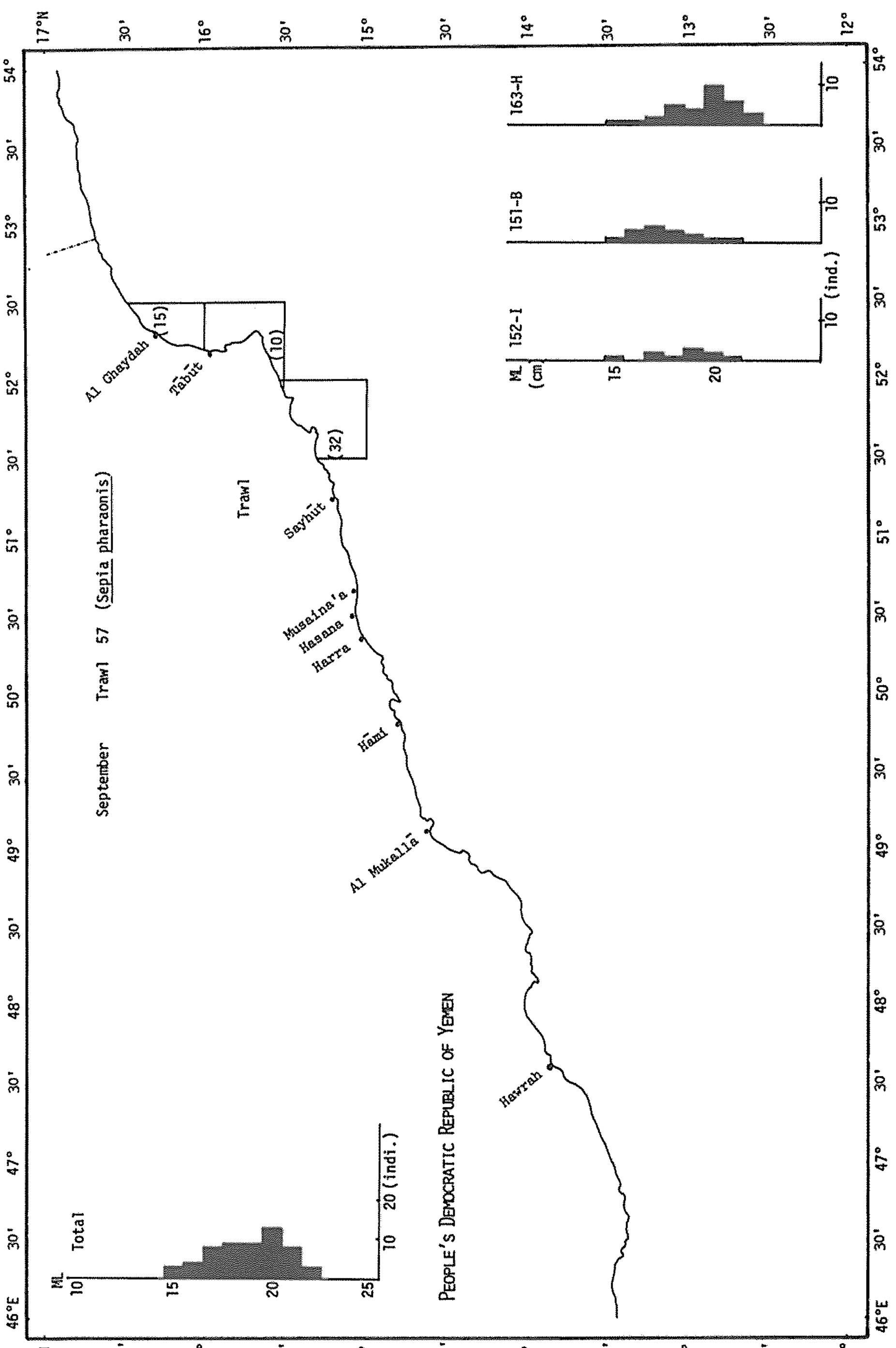
Tag no.	Time released / recaptured	days	Location(N,E) released / recaptured	dist. (km)	Mantle length at relea. (mm)	Body weight at relea. (g)	Depth (m)	Bottom water temp. recap. (℃)	Catch at time of recap. (ton)	Sex
1385	Jun.26, 11：00		214-C		148	330	56			
	Jul. 5, 13：30	9	214-F	18.0			40	18.0	1.3	
1388	Jun.26, 11：00		214-C	0	135	260	56			
	Jul. 5, 12：00	9	214-C				35			
1392	Jun.26, 18：00		204-I		168	420	56			
	Jul. 1, 13：00	5	204-I	0			40			
1396	Jun.26, 18：00		204-I		195	690	56			
	Jun.28	2	14°47′, 50°02′	56.7			64-58			
1425	Jun.26, 21：30		204-E		178	540	62			f
	Jul.17, 12：00	21	14°39′, 49°40′	18.2			53	15.1		
1429	Jun.26, 21：30		204-E		180	630	62			
	Jun.27,	1	14°46′, 49°49′	0			38			
1446	Jun.27, 13：00		204-E		190	660	59			
	Jun.30,	3	14°45′, 49°55′	18.0			45			
1450	Jun.28, 06：00		163-H		135	240	61			
	Jul. 5	7	14°47′, 50°07′	170.6			60-58			
1457	Jun.28, 06：00		163-H		125	290	61			f
	Jun.29, 06：30	1	15°17′, 51°33′	0			24	19.0	0.8	
1458	Jun.28, 06：00		163-H		133	210	61			f
	Jun.29, 06：30	1	15°17′, 51°33′	0			24	19.0	0.8	
NO tag.					(205)	(710)				f

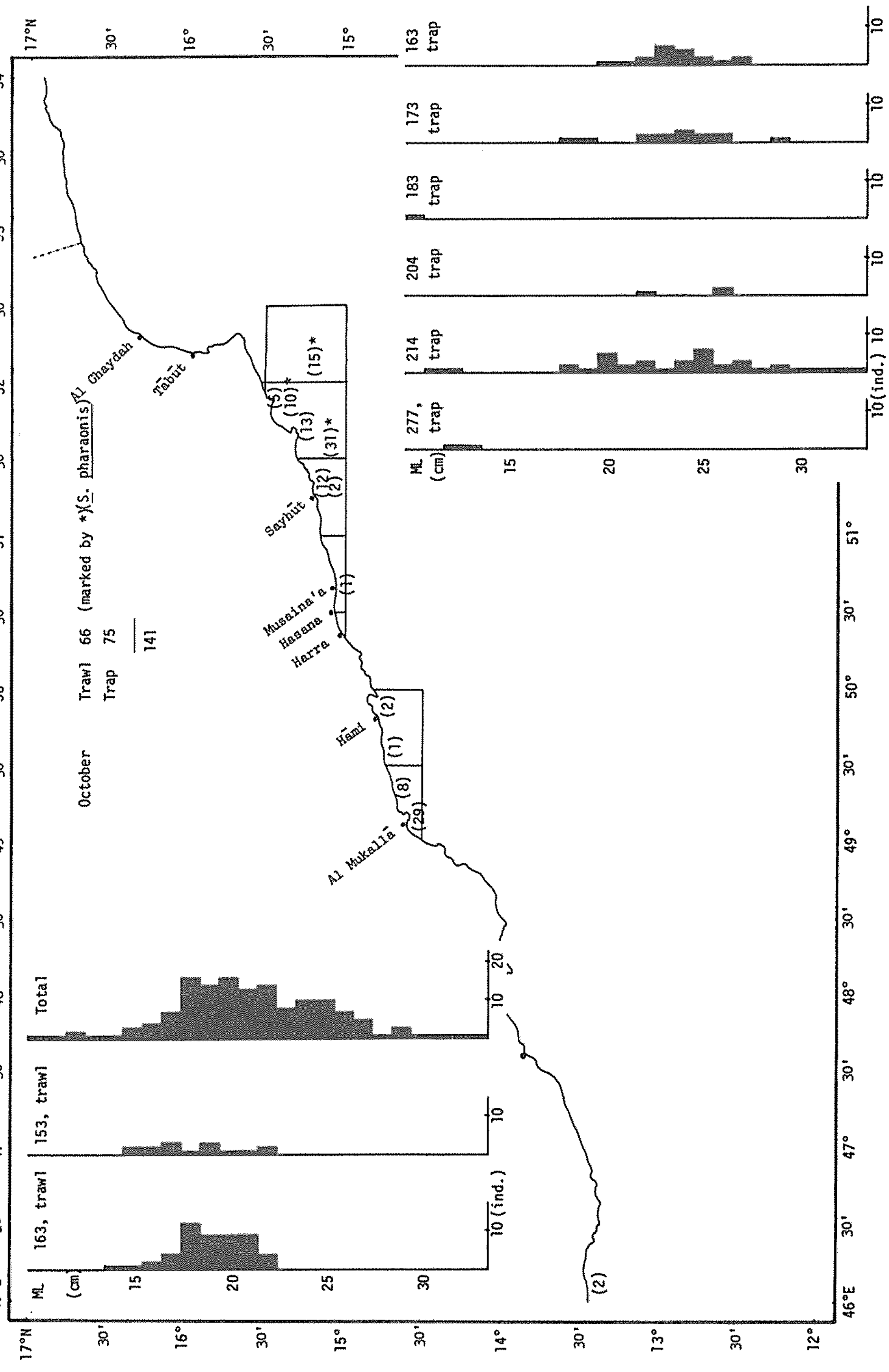


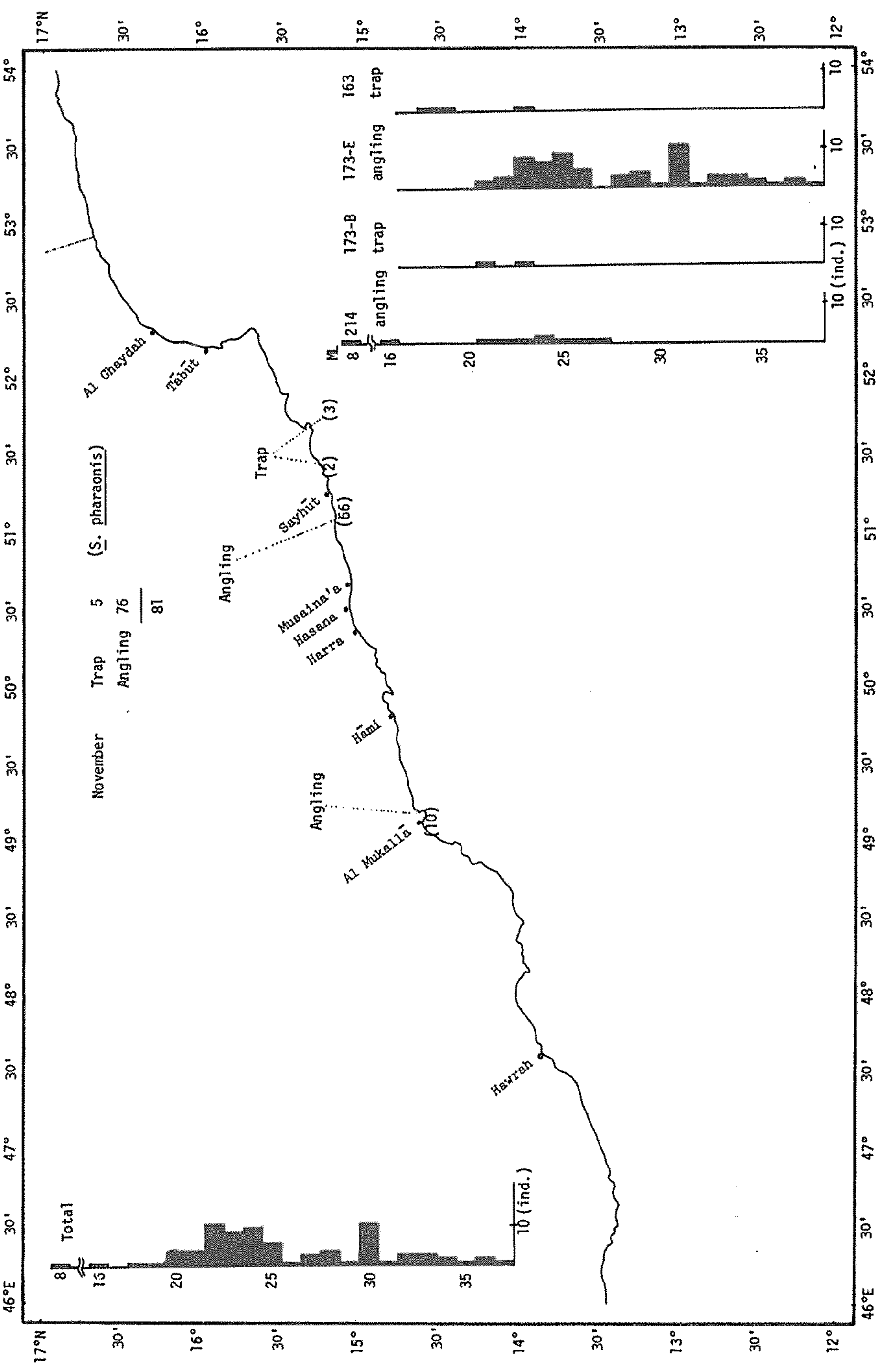
Appendix IV. Releasing and recapturing locations, and monthly mantle-length composition in 1978

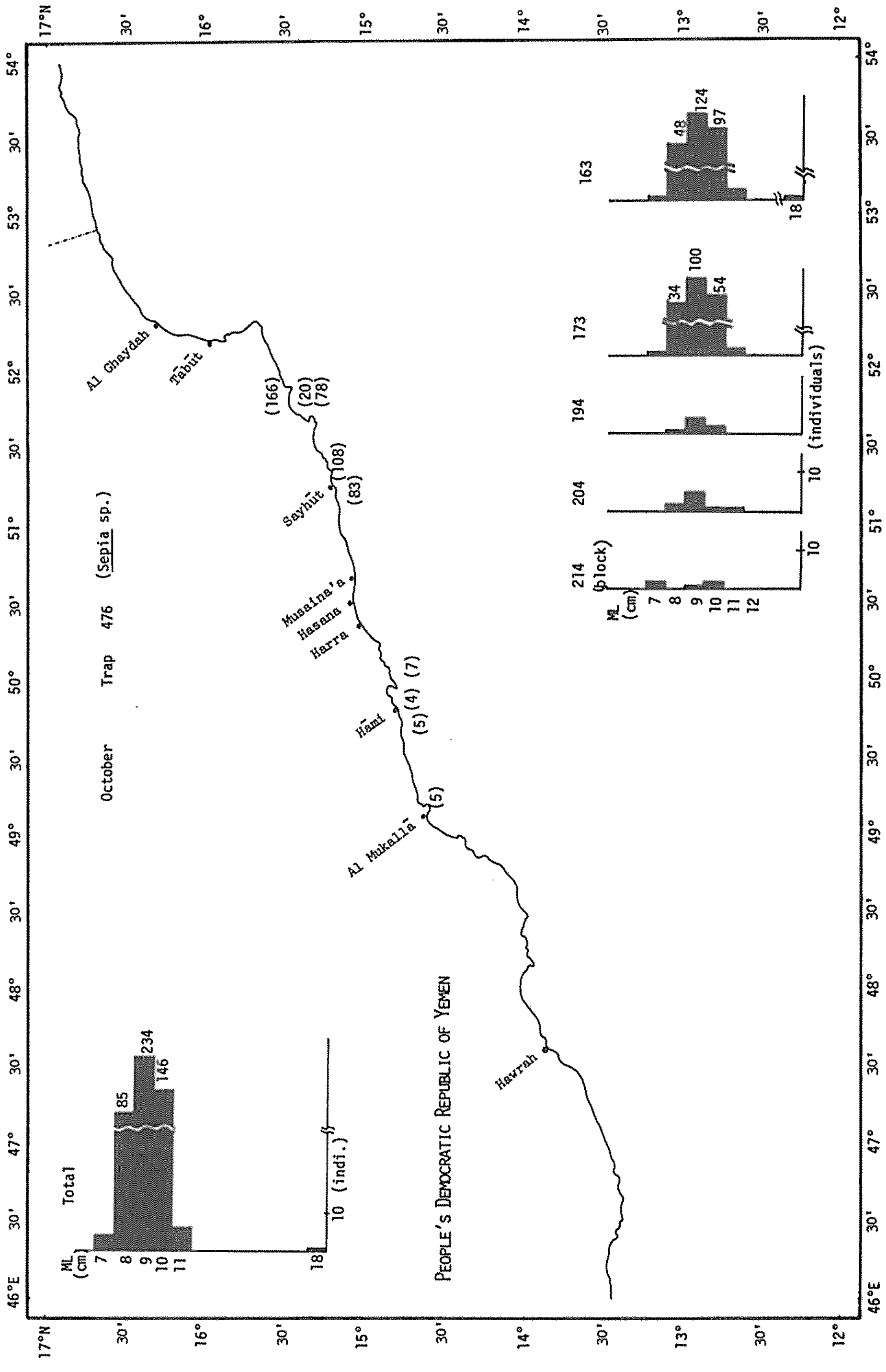

June
Trawl
1110 (S. pharaonis)
People's Democratic Republic of Yemen
Al Ghaydah
Tabut
Sayhut
Musaina'a
Hasana
Harra
Hami
Al Mukalla
421
(99)
(322)
(122)
(115)
(22)
(51)
(160)
(219)
259
430
ML(cm)
Total
(individuals)
214 (block)
204
194
184
173
163
152
151
(indi.)

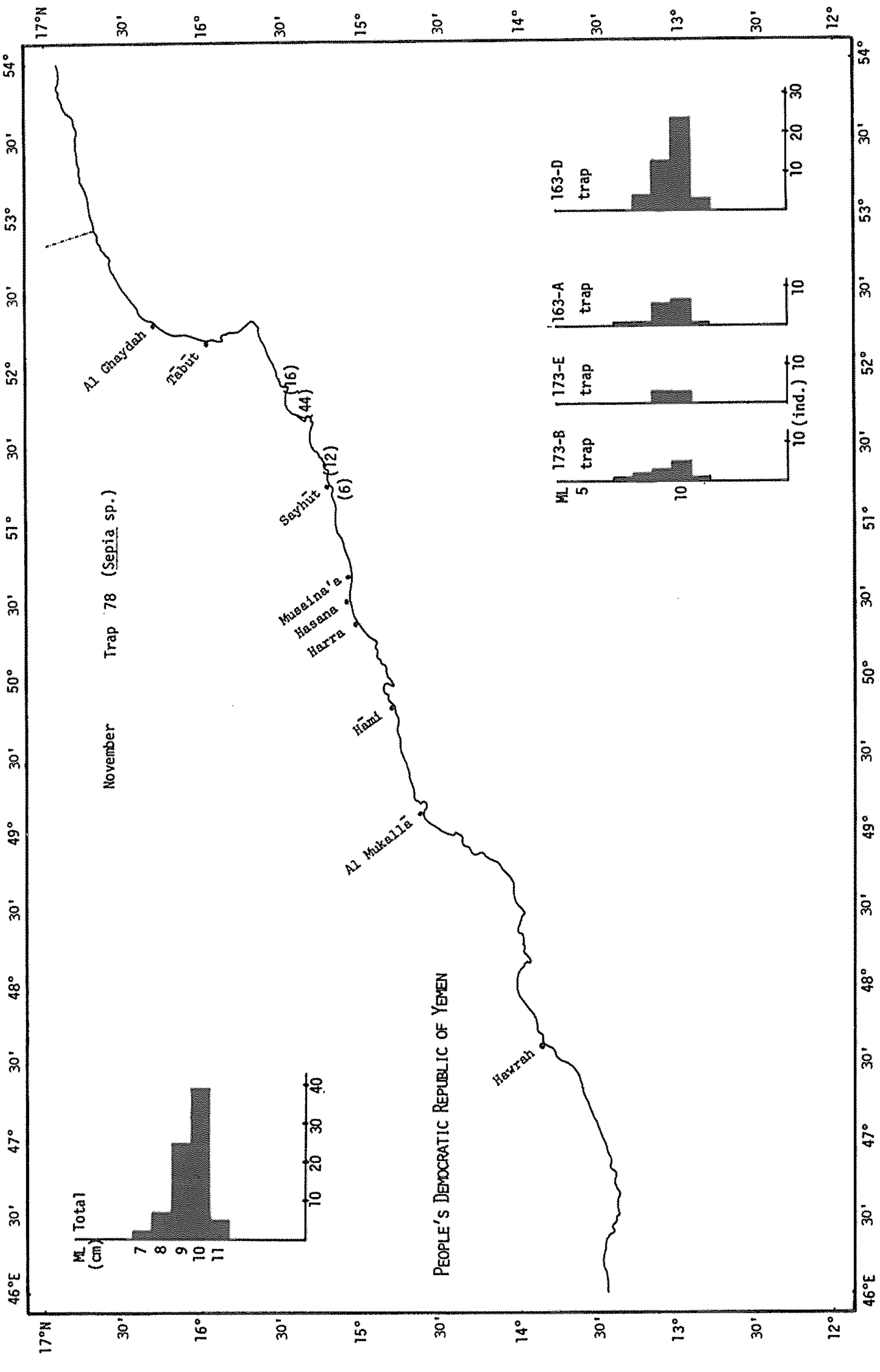

July
Trawl 219 (S. pharaonis)
Trawl (219)
Al Ghaydah
Tabut
Seyhut
Musaine'a
Hasana
Harra
Hami
Al Mukalla
Hawrah
People's Democratic Republic of Yemen
Total
ML
(indi.)
(ind.)
214
204
194
184
152
133
40
17°N
16°
15°
14°
13°
12°
46°E
47°
48°
49°
50°
51°
52°
53°
54°


September Trawl 57 (Sepia pharaonis)
Trawl
Al Ghaydah
Tabut
Sayhut
Musaina'a
Hasana
Harra
Hami
Al Mukalla
Hawrah
People's Democratic Republic of Yemen
(15)
(10)
(32)
152-I
151-B
163-H
ML (cm)
10 (ind.)
Total
20 (indi.)


October
Trawl 66 (marked by *)(S. pharaonis)
Trap 75
141
Al Ghaydah
Tabut
Sayhut
Musaina'a
Hasana
Harra
Hami
Al Mukalla
(15)*
(5)
(10)*
(13)
(31)*
(12)
(2)
(1)
(2)
(1)
(8)
(29)
(2)
163, trawl
153, trawl
Total
ML
(cm)
15
20
25
30
10 (ind.)
10
20
277, trap
214, trap
204 trap
183 trap
173 trap
163 trap
10(ind.)
46°E
47°
48°
49°
50°
51°
52°
53°
54°
30'
17°N
16°
15°
14°
13°
12°


November
Trap 5
Angling 76
81
(S. pharaonis)
Al Ghaydah
Tabut
Trap
(3)
(2)
Sayhut
(66)
Angling
Mussaina'a
Hasana
Harra
Hami
Angling
(10)
Al Mukalla
Hawrah
Total
10 (ind.)
214 angling
173-B trap
173-E angling
163 trap
ML
17°N
16°
15°
14°
13°
12°
46°E
47°
48°
49°
50°
51°
52°
53°
54°


October
Trap 476
(Sepia sp.)
Total
ML (cm)
(indi.)
(block)
(individuals)
214
204
194
173
163
Al Gheydah
Tabut
Seyhut
Musaina'a
Hasena
Harra
Hami
Al Mukalla
Hawrah
People's Democratic Republic of Yemen


November
Trap '78 (Sepia sp.)
People's Democratic Republic of Yemen
Al Ghaydah
Tabut
Sayhut
Mussaina'a
Hasana
Harra
Hami
Al Mukalla
Hawrah
(16)
(44)
(12)
(6)
ML (cm)
Total
7
8
9
10
11
10
20
30
40
ML
5
10
173-B trap
173-E trap
163-A trap
163-D trap
10 (ind.)
17°N
16°
15°
14°
13°
12°
30'
46°E
47°
48°
49°
50°
51°
52°
53°
54°

南イエメン産トラフコウイカ*Sepia Pharaonis*の資源に関する研究

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1966年に日魯漁業株式会社のトロール船石州丸により発見された，南イエメン沿岸産トラフコウイカは，わが国南方トロール漁業の重要資源の一つとなったが，各国の相つぐ漁業参入もあって，やがて漁況が低下し，日魯漁業も1980年代になり出漁をとり止めた。

本報告では，日魯漁業の操業記録と標本個体調査に基づき，トラフコウイカの生態と漁況の変遷を明らかにし，資源変動の解析を行った。本種は2年生であり，発生の好不良を反復しながら，傾向として資源量は低下した。