STUDIES OF POPULATIONS AND EXPLOITATION STATUS OF EGYPTIAN RED SEA ABUNDANT SARDINES

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INTRODUCTION

Light and purse-seine fisheries started in the Egyptian Red sea regions in 1960. The fisheries authorities have been afraid of over-exploitation since the start of the fisheries. They decided to increase the number of fishing boats gradually and recording catches to estimate the effort associated with the optimum yield. Five and four motor boats were permitted in the Gulf of Suez and Ghardaqa regions in 1960 and 1946 respectively. The boats were increased in the Gulf to ten in 1961, 1962; and to fifteen since 1963 while fishing has been prevented in September and October each year. That is, fishing effort was increased to about 1.25 times with respect to 1961-1962 period assuming equal catchability all the year round. It was decided that this last effort would provide the optimum yield.

This work was prepaired to present some studies that may help the proper exploitation of abundant sardines, viz. *Sardinella jussieu* (Lacépéde) and *Sardinella sirm* (Valbaum). *S. jussieu* formed about 80% of the Gulf catch; the two species about 80% of Foul Bay catch, and about 25% of Ghardaqa Catch.

MATERIALS AND METHODS

Samples of *S. jussieu* and *S. sirm* had been collected from Ghardaqa region (27° 02′ latitude, 33° 55′ longitude) since July 1964. At the end of December 1964, the auther had an opportunity to accompany a russian research vessel "Ichthiolog" to Foul Bay (23° 40′ latitude, 35° 40′ longitude) for about two weeks from where he got some samples. Two samples collected from Suez Gulf fishing boats were supplied by the marine biological station at Suez. The total fish lengths from tip of snout to end of longest tip of caudal fin of preserved fish were measured in millimeters and grouping was carried later on. The flesh was cut away from the right half of the body and the back-bone was exposed. The total number of vertebrae, including the hypural, was counted under a low-power binocular. All partially fused vertebrae were counted as separate vertebrae. The catch data of the Gulf were supplied by the marine biological station at Suez, Ghardaqa data by the Red Sea Fisheries company, and Foul Bay data were extracted from Ichthiolog log-book.

Statistical methods :

The chi-square test of homogeneity was employed in evaluating the significance of differences in vertebral numbers. To have an accumulated information from a group of chi-square tests, chi-square values were added and tested with degrees of freedom equal to the sum of corresponding degrees of freedom (Fisher, 1958; Snedecor, 1956). The significance of a difference between two mean fish lengths was tested by the statistic "Z^2" which has a chi-square distribution with one degree of freedom (Lindgren, 1962). A sum of a number of Z^2 tests was tested for significance to have an accumulated information.

DISTRIBUTION

S. sirm was absent from the Gulf fisheries records. It was recorded at Ghardaqa and Foul Bay catches. *S. jussieu* was recorded at the three localities. The absence of *S.sirm* from the Gulf shows that some ecological factors prevailing the Gulf may be responsible for this phenomenon.

POPULATION STUDIES

Introduction ;

The polytypic concept of species in fish was first investigated by Heincke (1898). The morphological characters are determined by heridity and factors in the physical environment, particularly during embryonic and larval developmental stages. The morphological variation of phenotypic or genotypic character is therfore indicative of reproductive isolation, i.e., separate populations. The vertebrae of 2567 and 795 fish belonging to *S. juessieu* and *S. sirm* respectively were counted. They belonged to year classes 1962-1965 and 1963-1964 respectively. Sexual dimporphism, variability of samples within localities, between year classes and between localities were studied to collect evidences about populations.

Sexual dimorphism :

Samples were differentiated according to sex and age into sub-samples. The vertebral number distributions of samples belonging to different sexes, different year clsses and different localities were collected (table 1a). One sample from ten of *S. jussieu* provided a chi-square value approaching the 5% significance level while the accumulative information (χ^2=22.198,d.f.=20,0.5>P>0.3) failed to give evidence of sexual dimorphism as far as the number of vertebrae is concerned. Samples of *S. sirm* provided 8 comparisons (table 1.b). One sample showed a significant difference while the accumulated information showed an insignificant difference (χ^2=15.25, d.f.=13, 0.3 > P > 0.2). For subsequent studies, the vertebral numbers of different sexes were combined (table 2).

Homogeneity of samples within localities ;

Differences between samples within localities and within year classes were studied (tables 3). *S. jussieu* and *S. sirm* samples showed variations expected from homogeneous materials within localities and within year classes. Ghardaqa *S. jussieu* samples approached 5% significance level. Samples within localities and within year classes were pooled.

Differences between year classes :

The variability of vertebral numbers of *S. jussieu* between year classes and within localities was studied from samples collected from Ghardaqa 1962 to 1965 year classes and from the Gulf 1963-1964 year classes (table 3.). The samples showed significant differences and the accumulated information showed highly significant differences ($\chi^2=23.325$, d.f.$=8$, $P<0.005$). The variability of vertebral numbers from year to year may be explained by the variability of factors in the physical environment from year to year during spawning and early developmental stages. The effect of salinity on meristic characters has been discussed by Heuts (1946, 1949) and the effect of light reported by Vlady-kov (1934), McHug (1954) and Lindsey (1958). Oxygen tension as an influencing factor was demonstrated by Toning (1952). The literature dealing with the effect of temperature on vertebral number is vast. Schmidt (1921) reared Salmo trutta at 3 different temperatures. He showed that the lowest vertebral number was produced at intermediate temperature. *S. sirm* samples belonging to year classes 1963 and 1964 from Foul Bay and Ghardaqa were studied (table 3). There were evidences of nonsignificant differences between year classes from the same locality. This may be explained by the relative insensitivity of vertebral number of *S. sirm* to environmental factors during the cricital early stages of development.

Populations in sampled regions :

The comparison between Foul Bay and Ghardaqa samples of *S. jussieu* carried intra-year-class 1963 (table 3), showed a highly significant difference ($\chi^2=393$, d.f.$=3$, $P<0.005$). Therefore it may be concluded that there is evidence of isolated populations between Ghardaqa and Foul Bay. Comparison between samples of *S. jussieu* from Ghardaqa and Gulf carried intra-year-class 1963 and 1964 (table 3.) showed insignificant differences. The accumulated information showed insignificant differences ($\chi^2=9.666$, d.f.$=4$, $0.1>P>0.05$). Chi-square value is large and may indicate partial mixing. The pooled mean vertebral number of 1963 year - class samples were 45.16314, 46.01275, and 46.07894 at Foul Bay, Ghardaqa, and the Gulf respectively. The mean values of 1964 year-class samples were 45.9335, and 45.9422 at Ghardaqa and the Gulf respectively. Therefore we may conclude that *S. jussieu* vertebral number increases with increasing latitude. The persisting smaller mean number at Ghardaqa than the Gulf may show some evidence of partial isolation between the two areas.

Association of temperature or latitude with the number of meristic elements in fishes has been investigated by many workers. Jordan (1896) and Hubbs (1934) postulated an inverse relation. Corroboration of this relation has been documented by Schmidt (1917 a,1917 b,1921) forZ *oarces viviparus*, and by Schmidt (1919) for *Lebistes reticulatus*. This relationship has been studied for flat fish (Dannevig, 1950) ; Cod (Dannevig, 1933) ; Killifish (Gabriel, 1944) ; northern anchovy (Mchugh, 1951) : and for *Lycodes pingelli, Ammodytes lancea, Gadus callarias*, and *Clupea harengus* (Jansen,1944).

S. sirm samples within 1963 and 1964 year classes from Ghardaqa and Foul Bay indicated insignificant differences between localities (table 3) as well as the accumulated information ($\chi^2=1.64$, d.f.$=4$, $P=0.8$). That is, an evidence of an entire population between Ghardaqa and Foul Bay. There is doubt concerning this conclusion because different year classes were homogeneous, i.e., vertebral numbers of *S. sirm* were probably not sensitive enough to reveal variability related to variations in the physical environment and like-wise probably relatively insensitive to differentiate populations and that the number of fish studied was few.

TABLE 1a VERTEBRAL NUMBERS OF *S. Jussieu*

Date	Locality	Year class	Sex	Vertebral Numbers						Total	χ^2 for sex	d. f	P
				4	45	46	47	48	Sum				
2-1-65	Foul Bay	1963	Male	9	72	27	1	—	109	191	1.679	2	0.5–0.3
			Female	3	57	22	—	—	82				
7-1-65	Foul Bay	1963	Male	11	131	39	—	—	181	330	0.537	2	0.8–0.7
			Female	12	107	30	—	—	149				
6 -7-65	Ghardaqa	1963	Male	—	1	15	1	—	17	79	4.898	2	0.1-0.0
			Female	—	9	37	16	—	62				
6-7-65	Ghardaqa	1964	Male	1	66	278	43	1	389	617	0.434	2	0.9–0.8
			Female	—	41	165	21	1	228				
5-8-65	Ghardaaqa	1963	Male	—	14	79	5	—	98	313	5.958	2	0.1–0.05
			Female	—	24	160	31	—	215				
5-8-65	Ghardaqa	1962	Male	—	1	5	—	—	6	100	1.562	2	0.5–0.3
			Female	—	12	69	13	—	94				
3-10-65	Ghardaqa	1965	Male	—	14	111	17	—	142	311	2.196	2	0.5–0.3
			Female	—	18	121	30	—	169				
May or June 65	Gulf:of Suez	1964	Male	—	20	147	18	—	185	420	2.701	2	0.3–0.2
			Female	—	36	183	16	—	235				
May or June 65	Fulf of Suez	1963	Male	—	1	5	2	—	8	38	0.789	2	0.7–0.5
			Female	—	5	18	7	—	30				
15-4-66	Gulf of Suez	1964	Male	1	9	62	8	—	80	168	1.444	2	0.5–0.3
			Female	—	17	63	8	—	88				

TABLE *Ib*. VERTEBRAL NUMBERS OF S. *Sirm*

Date	Locality	Year class	Sex	Vertebral Number				Total	χ^2 for sex	d.f	P
				42	43	44	Sum				
31-12-64	Foul Bay	1963	Male	1	35	2	38	82	0.057	2	0.98–0.90
			Female	1	41	2	44				
31-12-64	Foul Bay	1964	Male	—	9	—	9	13	2.443	1	0.2–0.1
			Female	—	3	1	4				
4-1-65	Foul Bay	1963	Male	—	54	5	59	109	1.287	2	0.7–0.5
			Female	1	44	5	50				
4-1-65	Foul Bay	1964	Male	2	71	7	80	157	0.291	2	0.9-0.8
			Female	3	68	6	77				
18-8-65	Ghardaqa	1964	Male	—	3	3	6	18	7.208	1	Less than 0.01
			Female	—	12	—	12				
18-8-65	Ghardaqa	1963	Male	1	78	3	82	109	0.331	2	0.9–0.8
			Female	—	26	1	27				
24-11-65	Ghardaqa	1964	Male	5	146	12	163	285	2.331	2	0.5–0.3
			Female	3	115	4	122				
24-11-65	Ghardaqa	1963	Male	—	6	—	6	22	1.303	1	0.3–0.2
			Female	—	13	3	16				

TABLE 2 *a*.— VERTEBRAL NUMBERS OF *S. jussieu* (COMBINED SEXES)

Date	Place	Year class	Vertebral numbers					Total
			44	45	46	47	48	
2/1/65	Foul Bay	1963	12	129	49	1	—	191
7/1/65	,,	1963	23	238	69	—	—	330
6/7/65	Ghardaqa	1963	—	10	52	17	—	79
5/8/65	,,	1963	—	38	239	36	—	313
6/7/65	,,	1964	1	107	443	64	2	617
3/10/65	,,	1965	—	32	232	47	—	311
5/8/65	,,	1962	—	13	74	13	—	100
June or July 65	Gulf of Suez	1963	—	6	23	9	—	38
June or July 65	,,	1964	—	56	330	34	—	420
15/4/66	,,	1964	1	26	125	16	—	168

TABLE 2. *b*—VERTEBRAL NUMBERS OF *S. Sirm* (COMBINED SEXES)

Date	Place	Year class	Vertebral numbers			Total
			42	43	44	
31/12/64	Foul Bay	1963	2	76	4	82
,,	,,	1964	—	12	1	13
4/1/65	,,	1963	1	98	10	109
,,	,,	1964	5	139	13	157
18/8/65	Ghardaqa	1964	—	15	3	18
,,	,,	1963	1	104	4	109
24/11/65	,,	1964	8	261	16	285
,,	,,	1963	—	19	3	22

TABLE 3.— COMPARISONS WITHIN SAMPLES OF *S. Jussieu* and *S. sirm*

Comparisons	χ^2	d.f.	P.
1—*S. Jussieu*			
1—Homogeneity of samples within localities and within year classes (Y.C.)			
a—Foul Bay, Y. C. 1963	1.915	2	0.5–0.3
b—Ghardaqa, Y.C. 1963	5.638	2	0.1–0.05
c—Suez Gulf, Y.C. 1964	1.194	2	0.7–0.5
Accumulated information.	8.747	6	0.2–0.1
2—Within locality and between year classes			
a-Ghardaqa; Y.C. 1963, 64, 65, 62: . . .	13.196	6	0.05–0.02
b—Gulf; Y.C. 1964, 63	10.129	2	p< 0.01
3—Within year classes and between localities			
a—Foul Bay and Ghardaqa Y.C. 1963 .	393.079	3	p< 0.005
b—Ghardaqa and Gulf, Y.C. 1963 . . .	3.72	2	0.2 –0.1
c—Ghardaqa and Gulf, Y.C. 1964 . . .	4.946	2	0.1 –0.05
Accumulated information for differences between Ghardaqa and Gulf	8.666	4	0.1 -0.05
2—*S. Sirm*			
1—Homogeneity of samples within lecalities and within Y.C.			
a—Foul Bay, Y.C. 1963	1.907	2	0.5–0.3
b—Foul Bay, Y.C. 1964	0.438	2	0.9–0.8
c—Ghardaqa, Y.C. 1963	3.764	2	0.2–0.1
d—Ghardaqa, Y.C. 1964	3.930	2	0.2 0.1
Accumulative information	10.039	8	0.3 0.2
2—Within localities and between Y.C.			
a—Foul Bay, Y.C. 1963, 64	0.909	2	0.7–0.5
b—Ghardaqa, Y.C. 1963, 64	1.763	2	0.5–0.3
Accumulative information	2.672	4	0.7–0.5
3—Within year classes and between localities .			
a—Foul Bay and Ghardaqa Y.C. 1963 .	0.940	2	0.7–0.5
b—Foul Bay and Ghardaqa, Y.C. 1964: .	0.699	2	0.8–0.7
Accumulative information	1.64	4	0.8

GROWTH STUDIES

Growth was studied from lengths of different age groups recorded in the samples. The differentiation into age groups was done according to scale criteria, i.e., grouping and relative narrowing of spaces between circulii is an indication of a winter ring (fig.1) . Mean lengths, and mean squares were estimated for each sex from different age groups and different localities (table 4).

TABLE 4.—MEANS, MEAN SQUARES OF LENGTHS AND TESTS OF SIGNIFICANCE BETWEEN MALES AND FEMELS LENGTHS (Z^2)

Lecality	Foul Bay					
Growth years	2	3	3	3	—	—
Year class	1963	1963	1962	1962	—	—
Sampling date	2/1/65	7/1/65	2/1/65	7/1/65	—	—
1 — *S. Jussieu*						
Male $\bar{L}$	12.5151	12.5047	—	—	—	—
n	109	181	—	—	—	—
Female $\bar{L}$	12.6817	12.6319	14.433	14.550	—	—
n	82	149	17	2	—	—
Male S^2	0.3206	0.3759	—	—	—	—
Female S^2	0.4814	0.5070	0.0812	—	—	—
Z^2	3.149	2.958	—	—	—	—
P	0.1–0.05	0.1–0.05				

2 — *S. Sirm*

Growth years	1	2	3	1	2	3
Year class	1964	1963	1962	1964	1963	1962
Sampling date	4/1/65	4/1/65	4/1/65	31/12/64	31/12/64	31/1/64
Male $\bar{L}$	12.655	15.977	—	14.172	16.534	19.50
n	80	59	—	9	38	1
Female $\bar{L}$	13.046	16.262	21.50	14.350	16.995	20.70
n	77	50	1	4	44	3
Male S^2	1.0460	0.5896	—	0.4044	0.9747	—
Female S^2	1.0838	0.7416	—	1.8133	1.1754	—
Z^2	5.630	3.267	—	0.063	4.067	—
P	0.02–0.01	0.1–0.05	—	0.8	0.05–0.02	—

TABLE 4.— (*Continue*)

Locality	Ghardaqa				
Growth years	2+	3+	1+	1+	≃1
Year class	1963	1962	1964	1964	1965
Sampling date	27/2/65	27/2/65	6/7/65	5/8/65	3/10/65

1.— *S. jussieu*

Male $\bar{L}$	14.3833	15.45	13.4328	14.350	10.674
n	12	4	389	6	142
Female $\bar{L}$	14.350	15.75	13.9114	14.6166	10.721
n	20	6	228	3	169
Male S^2	0.4206	0.1466	0.1487	0.192	0.4651
Female S^2	0.4547	0.4960	0.1683	0.0533	0.4347
Z^2	0.017	0.745	205.634	1.428	0.387
P	0.9–0.8	0.5–0.3	less than 0.005	0.3–0.2	0.7–0.5

S. jussieu (Continue)

Growth years	2+	3+	4+	2+	—
Year class	1963	1962	1961	1963	—
Sampling date	5/8/65	5/8/65	5/8/65	6/7/65	—
Male $\bar{L}$	15.799	17.2166	17.95	14.9618	—
n	98	6	1	17	—
Female $\bar{L}$	16.0988	17.1715	18.00	14.8726	—
n	215	93	8	62	—
Male S^2	0.2689	0.0267	—	0.3023	—
Female S^2	0.2499	0.1160	0.0657	0.2024	—
Z^2	23.017	0.356	—	0.377	—
P	Less than 0.005	0.7–0.5	—	0.7–0.5	—

TALBE 4.—(*Continue*)

Locality	Ghardaqa				
Growth years	1+	2+	3+	≈ 2	≈ 3
Year class	1964	1963	1962	1964	1963
Sample date	18/8/65	18/8/65	18/8/65	24/11/65	24/11/65
		2—*S. sirm*			
Male $\bar{L}$	13.8167	17.9695	—	15.5107	18.95
n	6	82	—	163	6
Female $\bar{L}$	14.2166	19.1204	21.1	15.5992	18.75
n	12	27	1	122	16
Male S^2	0.6827	0.5227	—	0.3975	0.112
Female S^2	0.9697	0.2329	—	0.2819	0.1707
Z^2	0.821	88.296	—	1.551	1.363
P	0.5–0.3	<0.005	—	0.3-0.2	0.3-0.2

Locality	Gulf of Suez				
Growth years	1+	2+	3+	2+	3+
Year class	1964	1964	1963	1963	1962
Sampling date	May or June 1965	15/4/66	15/4/66	May or June 1965	May or June 1965
		S. jussieu			
Male $\bar{L}$	12.1165	14.7449	16.15	14.6	—
n	185	78	2	8	—
Female $\bar{L}$	12.7857	15.1821	—	14.523	16.492
n	235	87	—	30	7
Male S^2	0.4913	0.4675	—	0.454	—
Female S^2	0.6202	0.4845	—	0.3386	0.3429
Z^2	84.601	16.540	—	0.087	—
P	Less than 0.005	Less than 0.005	—	0.8–0.7	—

Growth of different sexes :

S. jussieu and *S. sirm* provided 14 and 8 comparisons respectively between mean lengths of males and females (table 4). Four samples in each species showed significant differences as well as the accumulated information (*S. jussieu*: $Z^2=339.3$, d.F.$=13$, $P<0.005$, *S. sirm*: $Z^2=105.05$, d.f.$=8$, $P<0.005$). Ten samples from 14 and 7 from 8 showed larger females , i.e., evidence of a higher growth for females.

Locality and fish length :

S. jussieu two samples from Foul Bay and age group 2 showed insignificant differences ($\Sigma Z^2$for females and males$=0.286$, $0.9>P>0.8$). *S. jussieu* males and females, from Foul Bay and Ghardaqa, belonging to age group 2 and year class 1963, showed significant differences between mean lengths with respect to locality (Males : $Z^2=96.5$, $P<0.005$; Females : $Z^2=116.2$, $P<0.005$). Males and females from Ghardaqa were larger. Foul Bay and Ghardaqa samples were collected in January and February 1965 respectively. A lag of about 2 of the coldest months will probably add negligible length to fish. Therefore we may consider that there is evidence of larger fish from Ghardaqa supporting the conclussion derived from vertebral number study, i.e., there are separte population at Foul Bay and Ghardaqa. Dates of samples did not permit a comparison between Ghardaqa and the Gulf.

S. sirm samples from Foul Bay on 4/1/65 and 31/12/64 showed significant differences between mean lengths of females and of males belonging to age groups 1 and 2 (Accumulative information: $Z^2=62.53$, d.f.$=4$, $P<0.005$). Mean length estimates of 31/12/64 samples were larger. Sample dates did not permit a comparison between Foul Bay and Ghardaqa.

Absolute growth :

S. jussieu samples from Foul Bay were pooled with the following estimates :

Age group	Mean length of males	Mean length of females
2	12.51	12.65
3	—	14.45

Samples from age group 1 were not available from Foul Bay. The log book of "Ichthiolog" showed a length frequency of the catch on 7/1/65, based on fork length as follows :

length cm.	8		9		10		11		12		13
Frequency.		5		1		23		60		11	

The first mode at 8.5 cm. probably represented age group 1 with a total length of about 9.43 cm. for mixed sexes. The growth of *S. jussieu*, as extracted from table 4 may be described as follows

Age group	Foul Bay mean length	Ghardaqa Mean length	Gulf Mean length
1	9.34	11	11
2	12.61	14	14
3	14.33	15.5	15.5
4		17	
5		18	

Age group 3 mean length estimate at Foul Bay is for mixed sexes which is expected to be less than the estimate of females shown previously. The preceding estimates show similar growth patterns at Ghardaqa and the Gulf while larger estimates recorded at the Gulf (table 4) are explained by later sampling dates at the Gulf.

S. sirm mean length estimates of Ghardaqa samples show expected differences from the foul Bay estimates, due to different sampling dates and different year classes. The pooled Foul Bay samples provide the following pattern:

Age group	Male mean length	Female mean length	Mixed sexes mean length
1	12.81	13.11	12.95
2	16.19	16.60	16.40
3	19.50	20.90	20.60

Growth parameters :

The commonly accepted von Bertalanffy curve was fitted to *S. jussieu* data from Ghardaqa and Foul Bay. Ghardaqa data were fitted by the least squares as described by Tomlinson and Abramson (1961). The fitted equation was the following:

$$L_t=20.055\ (1 - e^{-0.36103\ (t+1.22142)})$$

Where L_t is fish length in cm.at age t in years (the convention that the end of calender year as the end of growth year is adopted here). Empirical and calculated lengths were as follows:

Age group	1	2	3	4	5
Empirical length	11	14	15.5	17	18
Calcutlated length	11	13.79	15.64	16.96	17.88

Foul Bay data were fitted according to Gulland (1964) method, with the following equation:

$$L_t = 16.6\ (1 - e^{-0.615\ (t+0.308)})$$

Empirical and calculated lengths were the followings:

Age group	1	2	3
Empirical length	9.43	12.61	14.33
Calculated length	9.19	12.61	14.42

Fitting age groups 1 to 3 mean lengths of Ghardaqa to the growth equation by Gulland (1964) method estimate L_∞ and K at 17 cm and 0.69315 respectively. Comparisons between parameters' estimates derived from Ghardaqa and Foul Bay data were as follows:

Parameters	L_∞	K	t_o
Ghardaqa (age group 1-5)	20.055	0.36103	- 1.221
Ghardaqa (age group 1-3)	17	0.69315	
Foul Bay (age group 1-3)	16.6	0.61519	-0.308

If we consider that Ghardaqa parameters' estimates derived from age groups 1-5 are better than corresponding estimates from age groups 1-3, we may conclude that L_∞ decreases while K increases with increasing latitude or temperature. Beverton and holt (1960) pointed out that within populations of the same species living in different areas, food supplies modifies L_∞ while temperature affects both K and L_∞. With increase in water temperature, K increases while L_∞ decreases.

S. sirm growth pattren was not in a suitable form to be fitted to von Bertalanffy equation. The length increment from age group 1 to 2 was less than that from age group 2 to 3.

THE PRESENT EXPLOITATION STATUS

Introduction :

The few available data allowed a limited discussion. Three regions are recognized as far as the Egyptian Red Sea light and purse-seine fisheries are concerned. The Gulf is exploited by a comparatively larger number of boats, Ghardaqa region by a relatively fewer number, and Foul Bay region visited rarely by some boats from the Gulf and Ghardaqa.

Sardinella sirm fisheries :

S. sirm was not recorded in the Gulf fisheries. The records of Foul Bay catches were not available. The discussion will be restricted to Ghardaqa region. Ghardaqa boats usually fished in the neighbourhood of Ghardaqa. Four boats started in 1964 summer. One boat was stopped in 1964. Catch and effort data were obtained from July 1964 to June 1966. The catch-per-unit-effort-as an index of fish abundance, may be estimated by dividing the total catch of a species by the total number of fishing operations or by the number of operations in which a certain species was caught (positive fishing operations). The first method is prefered when the boats are randomly distributed and the second method in case of selecting certain fishing grounds. The boats records showed that certain areas were selected and the second method was adopted. The 3 boats did not work regularly to allow a direct comparison between the years 1964–65 and 1965–66 for each boat.

The total catch and the total number of positive fishing operations by the 3 boats were 2167 kg.,25 ; 4704 kg., and 47 in 1964–65 and 1965–66 respectively, That is, catch and effort were 117% and 88% greater respectively or they were approximately doubled in the next year. The catch-per-unit-effort evidenced an increased abundance in the last year (from 86.6 to 100). The increased catch and abundance with larger effort are evidences of the necessity of much increased effort to direct the fisheries to the optimal yield.

Sardinella Jussieu fisheries :

S. jussieu was caught from Suez Gulf, Ghardaqa and Foul Bay. There are evidences that Foul Bay fish form a separate population while there is partial or complete mixing between Ghardaqa and the Gulf. Foul Bay population can be considered virgin because the effort expended at this region is negligible.

The total catch and total number of positive fishing operations at Ghardaqa were 33007 kg., 33 ; 37718 kg., and 68 in the first and second years respectively. That is, catch and effort were 14% and 106% greater respectively in the last year. The catch-per-unit-effort decreased from 1000 unit in the first year to 554.6 in the second year.

Yearly landings of *S. jussieu* from the Gulf and effort were as follows :

Year	1960	1961	1962	1963	1964	1965
Catch(kg.)	2299972	3361608	6999300	6764300	2176373	725918
No. of boats	5	10	10	15	15	15
Relative effort	5	10	10	12.5	12.5	12.5
Ratio of *S. jussieu*	0.92	0.81	0.91	0.95	0.68	0.28

The mean weight of *S. jussieu* landed by one fishing boat of Suez Gulf was about 145000 kg. in 1964 and 50000 in 1965. All Ghardaqa boats landed about 33000 and 38000 kg. in 1964–65 and 1965–66. That is, all Ghardaqa boats landed about 1/4 and 3/4 of a single boat in the two years approximately. Therefore; the effort expended by Ghardaqa boats was negligible compared with Gulf boats. It may be prefereble to neglect Ghardaqa data as well as sailing boats with unavailable records. There is some doubt about the reliability of the Gulf catch estimates, but it is believed that the data indicate the trend of the yield, i.e., increasing or decreasing. The Gulf statistics are transformed to relative estimates, as a simplification, with the followings:

Year	1960	61	62	63	64	65
Catch	1	1.5	3	2.9	0.9	0.3
Effort	1	2	2	2.5	2.5	2.5
Abundance	1	0.7	1.5	1.2	0.4	0.1

The decrease of Ghardaqa abundance estimate as well as Gulf estimate in 1965 compared with 1964 provides a further evidence of mixing between *S. jussieu* at Gulf and Ghardaqa.

The Gulf catch and abundance decreased from 1962 to 1965 which had been associated with the increased effort since 1963. This apparent association let to the idea that 15 boats may cause over-exploitation. In fact overexploitation has two effects, viz.,a decreased sustainable yield caused by increased fishing mortality, i.e., fishing effort, and decreased recruitments through the decreased number of spawners. The relation between effort, abundance and catch may be shown by the equation "$C = c\ f\ \bar{w}$" (Ricker, 1958); where C=catch, $\bar{w}$= abundance, c= coefficient of catchability and f =fishing effort. Thus logarithms of catches are directly proportional to logarithms of abundance and to logarithms of efforts. The rank correlation was insignificant between effort and catch ($r_s = -0.243$, 5% level = 0.886); and significant between catch and abundance ($r_s = 0.943$, 5% level =0.886, 1% level=1)' Assuming that fishing efficiency was increased with time; due to a probability of larger gears, more lamps of higher intensity and greater number of trips per year; fishing effort in 1962 was given a higher rank than 61, 1964 higher than 63 and 1965 higher than 64. Rank corrlation showed in this case an insignificant association between catch and effort ($r_s = -0.486$, 5% level = 0.886). Therefore, it may be concluded that the variability of catches was mainly due to variations in abundance which masked variability due to fishing effort. That is, decreasing catches in later years were not probably due to increasing effort. Assuming that logarithms of both catch and effort were random variables with a bivariate normal distribution and linear regression, the correlation coefficient would be highly insignificant ($r = -.0325$, n= 4 , 10% level =0.723). About 0.1% of variations in the logarithms of catch would have been due to logarithms of fishing effort ($r^2 = 0.00105$), or about 0.1 % of catch variability was due to effort.

The second effect of overexploitation, i.e., a decreased recruitment through the decreased number of spawners, may be shown by the relation between effort and number of spawners. If effort do not affect number of spawners, it will not consequently affect recruitments. Abundance of *S. jussieu* may be considered as equivalent to abundance of spawners as there are evidences that the fish spawn after their first winter. The absence of association between effort and abundance was evidenced by rank correlation ($r_s = -0.328$, 5% level =0.886), i.e., neither number of spawners nor recruitments were probably affected by fishing effort. The absence of association between effort and catch as well as abundance are evidences that the range of effort expended was probably so small that its effect on the fisheries was negligible, i.e., under-exploitation status. The data of 1966 were not available while the catch of the first half of 1967 gave the impression to many people related to fisheries that it was much superior to preceding years.

DISCUSSION

Zoogeographical regions of the red sea :

It was shown previously that *S. sirm* absence from the Gulf gave evidence of some different factors prevailing the Gulf than other parts of the Egyptian Red Sea regions to be able to explain this distribution. The distribution of *S. jussieu* populations with evidences of isolated populations between Foul Bay and Gulf, support such a conclusion. Therefore, there is evidence of discontinuity of Foul Bay and Suez Gulf regions. Ghardaqa region may be considered as a transitional region where fish from the two regions may be found.

Exploitation status :

The fisheries of *S. jussieu* and *S. sirm* in Egyptian Red Sea regions may be considered to be in an under-exploitation status. The range of fluctuations of *S. jussieu* Gulf catch and abundance were 1 : 10 and 1 : 15 respectively which were probably due to natural causes. Ricker (1958) from theoretical discussion of some reproductive curves have shown that populations with a certain type of reproductive curves (curve-c with population parameter a = 2.678) will have an inherent tendency of fluctuating annual catches if exploitation is stabilized at moderate values'. The fluctuations will increase with decreasing values of exploitation and vise versa.

SUMMARY

The identification of fish populations was carried by vertebral numbers. *Sardinella jussieu* (Lacépède) from Foul Bay region probably formed a distinct population from Ghardaqa and Gulf of Suez region. Samples of *Sardinella sirm* (Walbaum) were homogeneous and vertebral numbers were probably relatively insensitive to environmental factors and identification of populations. The growth patterns of the two sardines were described. Females probably grow better than males. *S.jussieu* probably grow slower at Foul Bay. Some factors prevailing Gulf of Suez probably affect the distribution of the two sardine species and populations. The egyptian Red Sea fisheries of the two sardines were probably in an under-explotitation status.

ACKNOWLEDGMENTS

The auther wishes to express his gratitude to Prof. Dr. A.A. Al Kholy, directer of Al Ghardaqa Institute of Oceanography and Fisheries, for providing facilities of this work; Red Sea Fisheries Company for providing catch data; the staff of the russian research vessel, Ichthiolog, for making, some data available; and Suez Marine Biological station for providing samples and catch data from Gulf of Suez.

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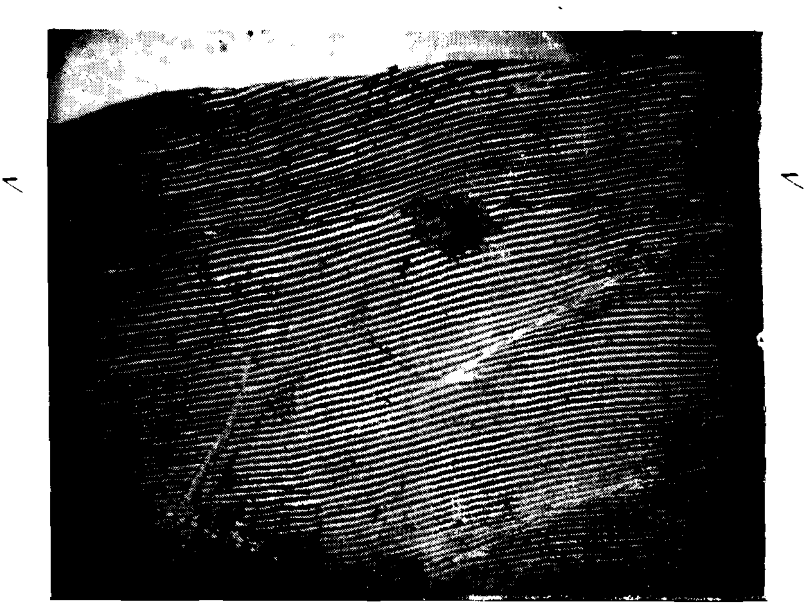

FIG 1A.—*S. jussieu*, 13.4 cm, ripe male, one winter ring marked (↘), fish from Al-Ghardaqa.

FIG. 1B.—*S. jussieu* 13.7 cm. female, true winter ring marked (↘); false winter ring marked (X,) fish from Foul-Bey.

FIG. 1C.—*S. Sirm*, 18.7 cm, mature male, first winter ring marked (I), second winter ring marked (II), fish from Al-Ghardaqa.