

SOME ASPECTS OF THE FISHERY BIOLOGY OF HAKE MERLUCCIUS MERLUCCIUS L. IN THE LIBYAN WATERS.

A. R. MUGAHID* AND M. T. HASHEM**

*Libyan Marine Fisheries Research Center, Tripoli, Libya.

** Institute of Oceanography and Fisheries, Alexandria, Egypt.

ABSTRACT

The abundance and distribution of *Merluccius merluccius* in the Libyan waters are studied from the catches of bottom trawling surveys. The size and age composition of the fish in the catch were analysed. The length-weight relationship and condition factor were calculated. The length and weight of the otolith were studied in relation to fish length and weight. Age determination and growth studies were made for different sexes and were compared with the growth rates in different regions. The size and age at first maturity were also investigated.

INTRODUCTION

The hake *Merluccius merluccius* L. is one of the most common fish species in the Mediterranean and in the eastern Atlantic, from Iceland and Lofoten Islands to Morocco, while rare off Mauritania and Senegal. Separate statistics for this species are found in most of the Mediterranean countries and the catch reported for the Mediterranean in 1970 totalled 17800 tons (Fischer, 1973).

The various biological aspects of this economically important fish species have been studied in many areas (Hickling, 1930 & 1933; Heldt, 1952; Bagenal, 1954; Lataconnoux, 1955; Figueras, 1965.....etc.). However, in the Libyan waters little is known about this fish. So, the present work aims to gain information about the fishery biology of this species as well as to know something about its abundance and distribution in the Libyan waters.

MATERIAL AND METHODS

A bottom trawling survey was carried out by the Japanese vessel (Hoyo-Maru -1500 H.P.), in the period from 18th August, to 19th September 1972, according to the agreement between Libyan and the Taiyo Fisheries Company, Tokyo-Japan (Gorgy, 1972). Another survey was carried out by the research vessel "Al-Muktashef" - 425 H.P., of the Libyan Marine Fisheries Research Center, in the period from September 1973 to September 1974, as a professional research project with "SOGREAH" Company

(Grenoble - France). During these two surveys, the two vessels used one and the same fishing gear, a fish trawl net of the Italian style, with a mesh cod end of 18 mm.

The investigated area is divided into three regions, fig. 1. The first is the Libyan territorial waters off Tripolitania (from Zuara to Sirte), the second is the Libyan-Tunisian continental shelf in the Gulf of Gabes (from $33^{\circ} 30'$ to $36^{\circ} 30'$ N. Latitude), and the third is the Gulf of Sirte (from Sirte to Bengazi).

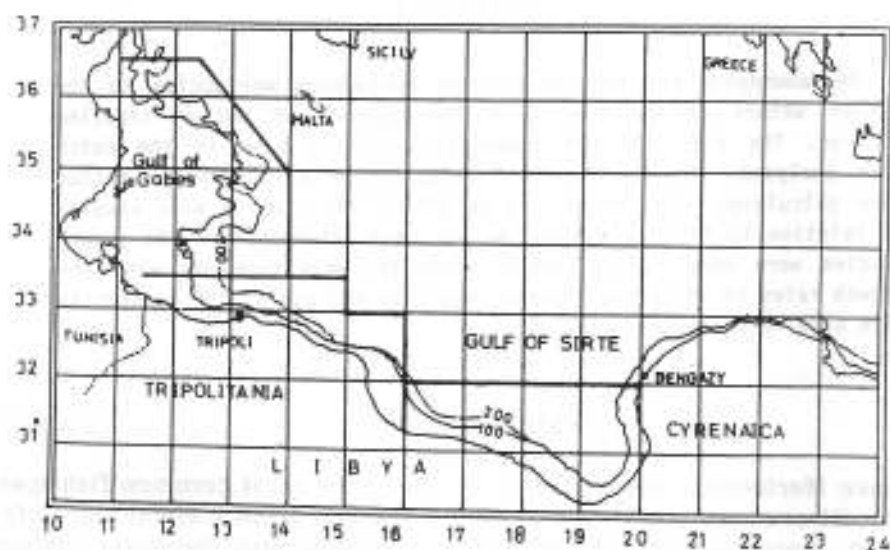


Fig. 1. The surveyed area in the Libyan Waters and Gulf of Gabes.

After each haul, the total catch was sorted into species and the total weight of each species was recorded. The material was analysed according to the size of the yield, i.e. all the individuals were tested in poor catches, but representative samples were taken from abundant catches. Biological analysis involved length measurement, fish weight, determination of sexes and state of maturity. The otoliths of *M. merluccius* were taken for age determination and growth studies.

In addition to the data collected on board during the two surveys, random samples of *M. merluccius* were taken from Tripoli fish market during the period from December 1973 to May 1974, for measuring individual fish weight and recording other necessary biological data together with collecting otoliths. For the examination of otoliths, it was placed with its concave side directed upwards in a small dish filled with xylol. Examinations were carried out by a low power binocular microscope with

black base and reflected light. Under these conditions, opaque zones appear white and hyaline zones dark.

Fish Abundance and Distribution

The relative abundance and distribution of *M. merluccius* in the experimental catches of "Hoyo-Marú" are shown in table 1, (Gorgy, 1972), and that of "Al-Muktashef" in table 2, (Sogreah, 1973-74).

In the two campaigns *M. merluccius* was totally absent in shallow waters (< 50 m), while present in all other depths. In both surveys *M. merluccius* was most abundant in the territorial waters and the Gulf of Gabes, at 100-200 m. depth, while of less importance at other depths. In the Gulf of Sirte, another picture was observed, the *M. merluccius* was less abundant at 100-200 m. depth, than in other depths.

Size Frequency

No special differences were observed in the size distribution of the fish, i.e. during "Al-Muktashef" campaigns, the length frequency of *M. merluccius* in the catches of both the Libyan territorial waters and the Gulf of Gabes were nearly the same. Therefore, the length frequency of *M. merluccius* in the two regions was analysed according to the season, table 3. The data showed a shift in the abundance of certain length groups in the autumn and spring campaigns.

As regards depth, it has to be mentioned that at 50-100 m. depth, the majority of *M. merluccius* were of small sizes, while at 100-200 m. depth the moderate sizes were abundant. At 200-300 m. depth, the catch was mostly composed of small fishes together with some large specimens.

Table 1
Catch per hour and percentage composition of *M. merluccius*
in the catches of "Hoyo - maru", according to depth.

Depth (m.)	50 - 100		100 - 200		200 - 300	
	Kg / h	%	Kg / h	%	Kg / h	%
Territorial waters	0.8	1.4	10.0	19.2	1.1	05.8
Gulf of Gabes	2.3	4.3	05.3	10.6	2.0	04.6
Gulf of Sirte	4.8	5.4	00.4	01.2	2.7	10.0

Table 2
Catch per hour and percentage composition of *M. merluccius* in
the catches of "Al-Muktashef", according to depth.

Region	Territorial Waters						Gulf of Gabes					
	50 - 100		100 - 200		200 - 300		50 - 100		100 - 200		200 - 300	
	Kg/h	%	Kg/h	%	Kg/h	%	Kg/h	%	Kg/h	%	Kg/h	%
Autumn 1973	1.3	1.4	11.4	14.6	3.9	04.7	-	-	23.5	27.9	18.0	12.9
Spring 1974	2.3	5.7	07.8	07.4	-	-	2.8	4.8	11.1	12.2	-	-
Summer 1974	1.8	2.0	07.4	10.2	9.3	15.0	2.3	1.8	09.9	21.5	03.10	6.9

Age Composition

The analysis of age of *M. merluccius* in the catches of "El-Muktashef" showed that its age composition varied according to depth. Taking the catch of the autumn campaign as an example, table 4, we found that at 50-100 m. depth range the majority of the catch was composed of young fish in their first year of life (0-age group). Other young age groups (I and II) were also found, but in small percentages.

In deeper water (100-200 m.) fishes of age group I were the most abundant, while those of the 0, II and III age groups were common, and those of age groups IV, V and VI were represented in small percentages.

At 200-300 m. depth range, the majority of the catch were composed of fishes belonging to the 0- age group. Fishes of the I, II and III age groups were less abundant, while fishes of older ages were only represented by one or two individuals for each age group. It has to be mentioned that fishes older than age group V were only found at this depth, while it was absent in shallower depths (< 200 m.).

It has to be concluded that the young age groups were common at all the investigated depths, while the oldest age groups were only found in waters more than 200 m. depth.

Length - Weight Relationship

The examination of data obtained for the total body weights of *M. merluccius* revealed no significant differences between sexes of the same

Table 3
Length frequency distribution of *M. merluccius* in the catches
of "Al-Muktashef", during Autumn and Spring campaigns.

Fish Length (cm.)	Autumn Camp.		Spring Camp.		Fish Length (cm.)	Autumn Camp.		Spring Camp.	
	No.	%	No.	%		No.	%	No.	%
04	-	-	02	00.4	27	13	2.9	08	1.5
05	-	-	10	01.9	28	13	2.9	08	1.5
06	-	-	12	02.4	29	19	4.2	03	0.5
07	10	2.2	22	04.1	30	12	2.6	07	1.3
08	27	5.9	48	08.8	31	11	2.4	12	2.2
09	19	4.2	33	06.1	32	05	1.1	05	0.9
10	17	3.7	35	06.4	33	05	1.1	05	0.9
11	21	4.6	43	07.9	34	06	1.3	05	0.9
12	16	3.5	65	12.0	35	01	0.2	06	1.1
13	06	1.3	57	10.5	36	02	0.4	03	0.5
14	28	6.1	45	08.3	37	06	1.3	02	0.4
15	16	4.6	19	03.5	38	03	0.7	-	-
16	27	5.9	13	02.4	39	03	0.7	03	0.5
17	27	5.9	15	02.7	40	01	0.2	-	-
18	23	5.1	08	01.5	41	01	0.2	01	0.2
19	20	4.4	05	00.9	42	-	-	01	0.2
20	15	3.3	07	01.3	43	-	-	01	0.2
21	09	2.0	08	01.5	45	01	0.2	-	-
22	03	0.7	06	01.1	49	01	0.2	-	-
23	11	2.4	05	00.9	52	01	0.2	-	-
24	16	4.6	06	01.1	54	01	0.2	-	-
25	19	4.2	03	00.5	61	-	-	01	0.2
26	19	4.2	03	00.5	62	01	0.2	-	-

length in case of immature fish (less than 21 cm.T.L.), but in case of mature fishes the females are somewhat heavier than the males of the same length, table 5.

The equation ($W = c L^n$) is used in the study of length-weight relationship. Using the grouped lengths and the corresponding weights of 198 males, ranging in total length from 13 to 41 cm., and of 81 females ranging from 14 to 44 cm.T.L., led to the following equations

For males :

$$\text{Log } W = -5.6693 + 3.2178 \text{ Log } L.$$

For females :

$$\text{Log } W = -5.5669 + 3.1780 \text{ Log } L.$$

Table 4
Age composition of *M. merluccius* in the catches
of "Al-Buktashev" during 1973, according to depth.

Depth (m.)	50 - 100		100 - 200		200 - 300	
	No. of Fish	%	No. of Fish	%	No. of Fish	%
0	15	75	033	11	128	80.0
I	03	15	111	37	017	11.0
II	01	05	075	25	003	02.0
III	01	05	063	21	004	03.0
IV	-	-	016	05	001	00.6
V	-	-	010	03	001	00.6
VI	-	-	004	01	002	01.3
VII	-	-	-	-	002	01.3
VIII	-	-	-	-	001	00.6
IX	-	-	-	-	001	00.6

However, a length-weight equation, to be most useful, should include fish of both sexes, sampled at various times throughout the year. Bias for seasonal variations, sex differences, maturity and stage of gonads is minimized by this procedure. Therefore the following general equation for the combined sexes would be the most usable for the length-weight relationship of *M. merluccius*;

$$\text{Log } W = - 5.8176 + 3.2767 \log L.$$

Condition Factor

For the purpose of comparing the condition of a fish, the cube relationship of length to weight ($K = W \times 100/L^3$) is usually used. When the data are calculated for separate sexes, according to various length groups (Table 6), it is evident that for both sexes the maximum value of "K" is for the 20-25 cm length range, after which there is a marked decrease in the value of "K". This is most probably due to the attainment of maturation. Then a second decrease is observed for the 35-40 cm length. This may be due to the higher sexual activity at that length. Also, it has to be noted that for all length groups, the females have a higher condition factor than males.

Age Determination and Growth Studies

The otoliths of many fish species consists of alternating concentric layers of opaque and hyaline material. In many fish species it has been found

Table 5
length - weight relationship of *M. merluccius*
during 1972 - 1973.

Fish length (cm.)	Males		Females		Combined Sexes		
	No. of fish	Av. emp. weight	No. of fish	Av. emp. weight	No. of fish	Av. emp. weight	Calculated weight
13	01	012	-	-	01	0012	0012.9
14	-	-	1	0015	01	0015	0016.4
15	01	018	1	0020	02	0019	0020.6
16	-	-	-	-	-	-	0025.4
17	01	030	1	0030	04	0029	0031.0
18	01	040	-	-	01	0040	0037.4
19	01	050	1	0050	04	0048	0044.6
20	01	060	1	0060	03	0060	0052.8
21	06	065	1	0062	09	0065	0062.0
22	06	080	2	0070	09	0076	0072.0
23	10	098	4	0096	18	0094	0083.0
24	12	113	3	0112	17	0111	0096.0
25	22	117	8	0122	30	0118	0110.0
26	21	135	3	0140	25	0135	0125.0
27	14	143	5	0149	19	0145	0141.0
28	19	158	4	0168	23	0160	0159.0
29	23	170	2	0178	25	0170	0178.0
30	09	193	3	0200	13	0195	0199.0
31	11	221	4	0227	15	0221	0222.0
32	08	247	5	0257	13	0232	0246.0
33	07	277	4	0303	12	0284	0272.0
34	07	298	5	0311	12	0303	0300.0
35	03	316	4	0329	07	0323	0330.0
36	03	330	2	0340	05	0334	0362.0
37	-	-	6	0363	06	0363	0396.0
38	01	417	3	0431	05	0426	0432.0
39	-	-	2	0457	02	0457	0470.0
40	-	-	1	0466	01	0466	0571.0
41	01	500	2	0524	03	0509	0554.0
42	-	-	1	0610	02	0600	0600.0
43	01	638	1	0638	01	0638	0648.0
44	02	673	2	0673	02	0673	0699.0
-	-	-	-	-	-	-	-
54	-	-	1	1270	01	1270	1366.0
-	-	-	-	-	-	-	-
62	-	-	1	2000	01	2000	2149.0

that the formation of these opaque and hyaline layers is an annual or seasonal phenomena and thus the otolith structure gives an indication of the age of individual fish (Graham, 1929; Hickling, 1933; Gambell & Messtorff, 1964). Such a pattern of opaque and hyaline zones is found in the otolith of *M. merluccius* (Bagenal, 1954; Lataconnoux, 1955; Figueras, 1965), and so, it provides a very useful method of age determination.

Table 6
The condition factor for males and females of
Merluccius merluccius, during 1972 - 1973.

Length group { cm. }	Males			Females		
	No. of fishes	Average emp. wt.	K	No. of fishes	Average emp. wt.	K
15 - 20	005	039.6	0.739	04	040.0	0.746
20 - 25	057	102.5	0.899	19	103.0	0.904
25 - 30	118	136.1	0.654	25	150.8	0.725
30 - 35	045	247.0	0.719	25	275.0	0.801
35 - 40	007	336.4	0.638	18	380.4	0.721
40 - 45	001	500.0	0.651	07	586.9	0.765

Relation between the growth of fish and its otolith :

Templeman & Squires (1956) found that in case of haddock (*Melanogrammus aeglefinus*), the relation between fish length and otolith length or weight can be used to differentiate between populations. This depends on the fact that they have different growth rates. The author also pointed out that in the cod (*Gadus callorius*) the otolith weight is much more useful than the otolith length in the differentiation between populations.

For *M. merluccius* ranging from 20 to 44 cm.T.L., having otoliths varying from 10.6 to 20.0 mm in length and from 100 to 603 mg. in weight. The relationship between fish length on one hand and the following items on the other were studied:

- 1- otolith length.
- 2- otolith weight.
- 3- percentage length of otolith over fish length.
- 4- percentage weight of otolith over fish weight.

The examination of the data revealed a progressive increase of otolith length with the increase of fish length (Table 7). The relation between these two parameter is a linear one. The percentage length of otolith over fish length shows a slight decrease with the increase of fish length. The data in table 8, agree with the finding of Templeman and Squires (1956) that the otolith weight relative to fish weight decreases considerably with increase of fish size.

Table 7
Fish length, otolith length and percentage of otolith length
to fish length of *Merluccius merluccius*, during 1972 - 1973.

Fish		Otolith	Otolith L.	Fish		Otolith	Otolith L.
Length	No. of	Length	X 100 / Fish	Length	No. of	Length	X 100 / Fish
(cm.)	fishes	(mm.)	Length	(cm.)	fishes	(mm.)	Length
20	01	10.6	5.3	33	3	17.2	5.2
21	03	11.0	5.2	34	5	17.5	5.1
22	04	11.7	5.3	35	3	17.8	5.1
23	03	11.9	5.2	36	4	18.0	5.0
24	03	12.3	5.1	37	2	18.3	4.9
25	07	12.7	5.1	38	4	18.8	4.9
26	12	13.1	5.0	39	2	19.4	5.0
27	09	13.2	4.9	40	3	20.0	5.0
28	08	14.3	5.1	41	2	20.2	4.9
29	11	15.1	5.2	42	2	20.4	4.9
30	07	15.3	5.1	43	1	20.6	4.8
31	06	15.5	5.0	44	2	21.0	4.8
32	04	16.5	5.1	45	-	-	-

Growth Rates

A- Growth in length :

The preliminary examination of the age and length composition of *M. merluccius* showed marked differences in the growth rate of males and females. So the collected data were treated separately according to sex (Table 9).

It is clear that females have a higher rate of growth than males. This may be related to the fact that most males attain their sexual maturity earlier than females. This also shows that the males disappear from the catch at relatively younger ages, with the result that the largest and oldest fish in the catch were always females.

For both sexes, the growth increment in length for the first year is very high (146 & 150 mm. for the males and females respectively). Growth increment shows a marked decrease in the second year, reaching about one third of that in the first year. The minimum annual increment in length is reached during the fourth year of life. After that, the growth increment in length shows a regular increase with the increase of age.

Many investigators (Figueras, 1965; Zupanovic, 1958) have pointed out the presence of three different periods in the growth rate of *M. merluccius*.

Table 8
 Fish length, fish weight, otolith weight and percentage of otolith weight
 to fish weight of *Merluccius merluccius*, during 1972 - 1973.

Fish Length (ca.)	No. of fish	Average		Otolith Wt.		Fish Length (cm.)	No. of fish	Average		Otolith Wt.	
		Fish Wt. (gr.)	otolith Wt. (mg.)	X 100 fish weight	fish weight			Fish otolith Wt. (mg.)	fish (gr.)	X 100 / fish weight	fish weight
20	01	060	100.0	0.167	0.167	33	3	250	287.5	0.111	
21	03	069	113.2	0.164	0.164	34	5	300	315.2	0.105	
22	04	078	123.9	0.185	0.185	35	3	328	333.5	0.102	
23	03	088	124.5	0.142	0.142	36	4	315	365.0	0.116	
24	03	101	141.6	0.140	0.140	37	2	366	365.4	0.100	
25	07	105	138.6	0.132	0.132	38	4	420	405.7	0.097	
26	12	127	152.3	0.120	0.120	39	2	468	448.6	0.096	
27	09	140	175.1	0.126	0.126	40	3	486	498.4	0.103	
28	08	147	208.9	0.142	0.142	41	2	504	624.0	0.104	
29	11	173	232.1	0.134	0.134	42	2	565	547.7	0.097	
30	07	189	226.1	0.120	0.120	43	1	631	587.3	0.093	
31	06	216	264.5	0.123	0.123	44	2	673	502.8	0.090	
32	04	225	259.9	0.116	0.116	45	-	-	-	-	-

Table 9
Growth in length of males and females of
M. merluccius during 1972-1973.

Age group	Males				Females			
	No.	Length mm.	Increment mm.	%	No.	Length mm.	Increment mm.	%
I	05	146	146	36	02	150	150	32
II	14	193	047	12	06	202	052	11
III	39	236	043	11	05	247	045	10
IV	32	274	038	09	15	290	043	09
V	08	314	040	10	10	338	048	10
VI	03	356	042	11	06	398	060	13
VII	01	400	044	11	02	470	072	15
VIII	-	-	-	-	01	540	070	-
IX	-	-	-	-	01	620	080	-

The first period is characterised by rapid growth, the second by slow growth, while the growth rate becomes faster again during the third period. This phenomenon is also observed in the present work. The growth rate is high during the first year, sharply decreases in the second year, reaching minimum value during the fourth year, after which it starts to increase again with the increase of age.

Growth rate in different regions :

According to Belloc (1929), the growth of *M. merluccius* in the Mediterranean is very slow, which is due to the fact that the Mediterranean hake belong to a special variety of dwarf hake. In Lateconnoux (1955) opinion, there is no special dwarf hake in the Mediterranean, where the growth is comparable with that found along the Atlantic coast. This is evident from the following comparison of average length of various age groups of *M. merluccius* living in different areas (Table 10).

Figueras (1965) pointed out the presence of different population, with different rates of growth along the eastern coast of Spain. The growth of individuals living in relatively deeper water was much faster than those living in shallow water. The author tried to explain this phenomena by changes in the environment and feeding conditions.

B- Growth in Weight :

The calculated weight for the different age groups were computed for the males and females (Table 11), from the general length-weight equation. It is clear that the lowest annual increment of weight was during the first

So, it can be concluded that, according to the theory of self-regulation (Nikolskiy, 1965), the Mediterranean hake, having a slower growth rate, attain maturity earlier and at a smaller size than the Atlantic hake, which has a higher rate of growth and attaining maturity at larger sizes and older ages.

Belloc (1929) and other investigators have quoted that the length at maturity for the Atlantic hake is 60 cm, and specimens are fully mature when they attain 80 cm. in length. According to Hickling (1930) these fishes are from 8 to 10 years old. On the other hand, the minimum length of maturity for the Mediterranean hake is 22 cm., and the length of fully mature specimens are 34 cm. These fishes are from 4 to 6 years old.

The present results nearly coincide with that found by Zupanovic (1968) for *M. merluccius* in central Adriatic, where the males attain maturity within length ranging from 20 to 28 cm, and the females from 26 to 33 cm. The author also pointed that the highest maturity percentages for the males were for lengths from 23 to 25 cm, and for the females from 29 to 32 cm.

As regards the age of maturity, it was found that both males and females attain maturity during their fourth year of life, while all fishes are sexually mature by the end of their 6th year of life. Also, it has to be mentioned that in each of these age groups, the percentage of mature males is always higher than that of mature females, table 13.

Among the different sexes of *M. merluccius* some variations are found in the size of first maturity. The smallest male attains maturity at 21 cm.T.L., while the smallest female at 24 cm.T.L. This indicates that the females attain maturity at a body length longer than that of males (Table 12).

For the estimation of size and age at first maturity, it is more subjective to collect the data during the spawning period. It is well known that *M. merluccius* in the Mediterranean has a long spawning period that extends from November to June (Demir, 1959; Kutaygil, 1965; Figueras, 1965). So, our data fit well for estimating the size and age of first maturity.

Sexual Maturity

It is also evident that inspite of the smaller percentage, the annual increment of weight for the females, is always higher than that of males throughout the whole life span. Furthermore the annual increments in weights for females of age-groups VI and VII are nearly double that of males of the corresponding age groups.

In addition, the rate of increase in annual increment of weight is higher in older ages than in younger ones.

year of life, and a progressive increase in weight is observed with the increase of age. In addition, the rate of increase in annual increment

Table 10
Growth Rates (ca.) of the fluke (*M. maritimus*) in different regions.

Region	Author	Sex	Years of Life										
			1	2	3	4	5	6	7	8	9	10	
Scotland	HICKLING (1933)	-	-	19.6	25.4	35.1	43.2	51.4	63.4	68.0	72.9	-	-
Bay of Biscay	Letaconoux(1955)	-	-	-	-	40.0	42.0	45.0	51.0	61.0	68.0	77	-
Catalonia	Ferrer(1965)	-	13.9	18.0	21.5	24.5	25.8	27.8	31.0	32.0	35.0	-	-
		M	15.2	18.8	21.7	24.2	24.7	26.8	30.4	35.8	44.0	-	-
Sea of Marmara	Kucaygil (1965)	F	15.2	20.2	24.8	27.7	31.5	33.8	40.0	47.0	49.5	-	-
		M	09.0	19.0	28.0	35.0	40.0	44.0	49.0	57.0	-	-	-
Central Adriatic	Zupanovic (1968)	-	-	-	-	-	-	-	-	-	-	-	-
Libya	Present Work(1974)	M	14.6	19.3	23.5	27.4	31.4	35.6	40.0	40.0	-	-	-
		F	15.0	20.0	24.7	29.0	33.8	38.8	47.0	54.0	62.0	-	-

Table 11
Growth in weight of Males and Females of
M. merluccius during 1972-1973.

Age group	Males				Females			
	Weight (gm.)	Annual		Weight (gm.)	Annual		Increment	Annual
		Increment	%		Increment	%		
I	017	017	03	0020	020	03		
II	047	030	06	0054	034	04		
III	091	044	09	0105	051	06		
IV	148	057	11	0178	073	08		
V	232	084	16	0294	116	13		
VI	343	111	22	0503	209	24		
VII	511	168	33	0867	364	42		
VIII	-	-	-	1365	498	-		
IX	-	-	-	2148	783	-		

Table 12
Sexual maturity of *M. merluccius* in the Libyan waters during 1972-1973, according to fish length.

Length	Males				Females				
	Immature	Mature	No.	%	Immature	Mature	No.	%	
									No.
20	7	100	-	-	05	100	-	-	
21	9	090	01	010	05	100	-	-	
22	5	083	01	017	04	100	-	-	
23	8	080	02	020	05	100	-	-	
24	9	069	04	031	05	083	1	017	
25	9	069	04	031	06	073	3	027	
26	8	057	06	043	14	067	7	033	
27	3	043	04	057	07	058	5	042	
28	3	023	10	077	07	054	6	046	
29	2	013	13	087	08	050	8	050	
30	1	008	11	092	01	020	4	080	
31	-	-	-	07	100	01	017	5	083
32	-	-	-	04	100	02	022	7	078
33	-	-	-	08	100	01	014	6	086
34	-	-	-	06	100	-	-	6	100
35	-	-	-	03	100	-	-	6	100

Table 13
Sexual maturity of *M. merluccius* in the Libyan waters
during 1972-1973, according to fish ages.

Age Groups	M a l e s				F e m a l e s			
	Immature		Mature		Immature		Mature	
	No.	%	No.	%	No.	%	No.	%
II	43	100	-	-	33	100	-	-
III	31	079	08	021	22	085	04	015
IV	23	049	24	951	36	058	26	042
V	03	008	35	092	05	015	29	085
VI	-	-	18	100	-	-	23	100

SUMMARY AND CONCLUSION

The abundance and distribution of *M. merluccius* in the different regions of the Libyan waters were studied as catch rates and percentage to the total catch, for various depth-ranges down to 300 meters. All trawling surveys indicated that *M. merluccius* was totally absent in shallow waters (< 50 m.), while present in deeper waters. It was most abundant in both the Libyan territorial waters and the Gulf of Gabes at 100-200 and 200-300 m. depth, while of less importance in shallower waters (50-100 m.).

During "Al-Muktashef" campaigns the length frequency of *M. merluccius* in the catches of both the Libyan territorial waters and the Gulf of Gabes showed similar distribution according to depth. At 50-100 m. the majority of hake were of small sizes (5-27 cm.), while at 100-200 m. the moderate sizes (14-39 cm.) were abundant. At 200-300 m. the catch was mostly composed of small fishes (6-20 cm.) together with some large fish of various length groups. Also the age composition of *M. merluccius* in the catch varies according to depth. It was also found that young fish are common at all the investigated depths, while the oldest age groups are only found in deep waters.

Examination of data obtained for individual weights of *M. merluccius* revealed no significant differences between sexes in case of the immature fish. But in case of adult fishes, there are more differences in the length-weight relationship. The females are somewhat heavier than the males.

When the condition factor was calculated for the different sexes, according to various length groups, it was found that the females have always a higher value of "K" than the males of corresponding lengths. Also, it has to be mentioned that for both sexes the value of "K" is high for the 20-25 m length-range, after which a marked decrease is observed and this is most probably due to the attainment of maturity.

Hake ranging from 20 to 44 cm T.L. has otolith varying from 10.6 to 21.0 mm. in length and from 100 to 600 mg. in weight. The relationship between fish length or fish weight on one hand and the various otolith measurements on the other hand, showed a progressive increase of otolith length or weight with the increase of fish length or weight. At the same time, the percentage length or weight shows a slight decrease with the increase of fish length or weight.

The study of growth rate of opposite sexes showed a marked difference between males and females. The females have a higher growth rate than males, this may be related to the fact that most males attain sexual maturity earlier than females.

For both sexes, the growth increment in length for the first year is very high (146 and 150 mm. for the males and females respectively). During the second year the growth increment shows a marked decrease, reaching about one-third that of the first year. The minimum annual increment of length is reached in the fourth year, after which the growth increment shows a more or less regular increase with the progressive increase of age. This coincides with the finding of many authors, who pointed out the presence of three different periods in the growth rate of hake.

Comparison of the growth rate of *M. merluccius* in different regions of the Mediterranean and Atlantic Ocean revealed the high growth rate of Atlantic hake over that of the Mediterranean. Moreover, the *M. merluccius* in different regions of the Mediterranean has different growth rates. According to Figueras (1965), the growth of individuals living in relatively deeper water was much faster than those living in shallow waters and the author tried to explain this phenomenon by changes in environment and feeding conditions.

As regards the growth in weight, the hake gain the lowest annual increment during the first year, after which the annual increment in weight increases with the progressive increase of age. Also, it has to be mentioned that the annual increment of weight for the females is always higher than that of males throughout the whole life span. Furthermore, the annual increment in weight for females of age groups VI and VII are nearly double that of males of the corresponding age groups.

The present data have pointed out that the smallest male attains maturity at 21 cm.T.L., while the smallest female at 24 cm., this indicates that the females of *M. merluccius* in the Libyan waters attains maturity at

a body length longer than the males. As regards the age of maturity, it was also found that both sexes attain maturity during their fourth year and all fishes are sexually mature by the end of their six year of life.

The present results of the size and age at sexual maturity coincide with the data obtained by many investigators for the Mediterranean hake. However, it is far from that obtained for the Atlantic hake, where a different fish population exists. So, it is worth mentioning that the present results confirm the theory of self-regulation in fishes, where the Mediterranean hake population has a lower growth rate, attaining maturity at a smaller size and younger age than the Atlantic population, which has higher growth rate and attains maturity at a larger size and older age.

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