STOCK ASSESSMENT AND MANAGEMENT OF DIPLODUS SPECIES IN ABU QIR BAY, ALEXANDRIA, EGYPT

A Thesis

Presented to the Graduate School
Faculty of Sciences, Alexandria University
In Partial fulfilment of the
Requirements for the Degree

of

Master of Science

In

Biological Oceanography (Fish Biology and fisheries)

By

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March, 2010
Presented by

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For the Degree of
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ACKNOWLEDGMENT

I am thankful for the mercy of God, who gave me the power and skill and was behind all the facilities I got for completing the present work.

I would like to express my deep thanks and sincere gratitude to Prof. Dr. Altaf Ezzat for her planning of this work, generous supervision, professional guidance, encouragement and for critically reading and reviewing the manuscript as well as discussion of various parts in the present work.

I also forward my deep thanks and gratitude to Dr. Hatem Mahmoud for his continuous help and professional guidance as well as for doing computer computations, reading and reviewing of this thesis.

I wish to extend my deep thanks to Dr. Amany Osman for her guidance, help, valuable advice and continuous encouragement during this work.

Genuine thanks are also due to Head of Oceanography Dept., Faculty of Science, Alex. Univ., for his continuous moral support, helpful suggestions, and sincere assistance.

I also wish to express my gratitude to my colleagues in Oceanography Dep., Fac. of Science, Alex. Univ. and in National Inst. of Oceanography and fisheries, Alex. for their help during the present work.

Finally I would like to express my gratitude to anybody who might have helped me during this work.
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CHAPTER I

INTRODUCTION

The value of fish as a harvestable crop, in conjunction with their abundance and variety has made them a subject of various scientific investigations. In Egypt, marine and fresh water fish represent a good protein food of high nutritive value which is available at reasonable price for most people. Culture of fresh water and some marine fish started to be a good tool to increase fish production, however most fish species (of commercial importance) are difficult to be cultured on a commercial basis.

Commercial exploitation of marine fish species has been existing since old times. In recent years, overexploitation as well as pollution problems in some areas, hindered the development of marine fish production. Management techniques were introduced in order to improve and sustain marine fisheries. Besides that, various efforts have been done in order to overcome the effects of pollution on fish populations.

Management of commercially important fish species, as well as initiation of programs utilizing artificial propagation of captive fish has been frequently implemented in various countries (Rounsfel, 1975).

Informations on stock composition and population dynamics of various fish species in Egyptian Mediterranean waters become of high importance for fisheries managers in order to increase fish production from marine areas. Egyptian Mediterranean coasts extend from Elsalloum on the west to Elarish on the East.

There are about 64 fish families present in Mediterranean waters of Egypt, which are represented by 202 species. Of these, family Sparidae is the most dominant comprising 21 species (Ibrahim & Soliman, 1996).
There are about twelve species of this family which are considered to be frequent in the landed catch from Alexandria waters. These are *Boops boops*, *Dentex dentex*, *Diplodus annularis*, *Diplodus puntazzo*, *Diplodus sargus*, *Diplodus vulgaris*, *Lithognathus mormyrus*, *Pagellus erythrinus*, *Pagrus pagrus*, *Sarpa salpa*, *Sparus aurata* and *Oblada melanura*.

Seabreams (Sparidae) live in coastal waters world-wide, and sustain important recreational and commercial fisheries (Fischer *et al.*, 1987). They could be found in a wide variety of marine habitats, from rocky to sand bottoms, at depths between 0 to 500 meters, although they are more common at less than 150 meters deep. (Gonçalves, 2000; Gomes *et al.*, 2001; Sousa *et al.*, 2005 and Ribeiro *et al.*, 2006).

Seabreams constitute about 17.13% of the landed catch in 2008 from Abu Qir Bay (GAFRD, 2008). However in the last years a gradual drop in the landed catch is noticed in the Bay. In spite of these problems it is still considered to be productive.

As a part of Alexandria coastal waters, it made the subject of study of various scientists. There are about 14 fish families present in the landed catch from this Bay, for this reason various scientists were interested in the study of the biology and fisheries of fishes present in that Bay. Of these we mention: Ezzat *et al.*, 1982 studied age and growth of Sole fish, *Solea vulgaris*.

Allam, 1995 studied the feeding habits of Sole fish, *Solea vulgaris*, *S. aegyptica*. Faltas, 1997 studied the beach seine fisheries in Abu Qir Bay, he devided fish caught by this gear into two categories these were, economic species (21%) and non economic (79%). Faltas *et al.*, 1998 studied the trash catch of bottom trawl in the Bay. Faltas *et al.*, 2000 studied the fishery biology of gobies captured by beach seine.
Akel, 2005 made a comparative study on the catch characteristics during the daytime in Abu Qir Bay and Elmax Bay. He estimated the growth, mortality and yield per recruit of carangid fish, *Alepes ajedapa*. Allam *et al*., 2005 studied age and growth of two most common species of wrasses, namely *Symphodus tina* and *Xyrichtys novacula*. Farrag, 2008 studied the population dynamics and management of two sparid fish, namely *Pagellus erythrinus* and *Lithognathus mormyrus* in Abu Qir Bay.

Genus *Diplodus* is represented in Abu Qir Bay by two dominant species, namely *Diplodus sargus* (white seabream) and *Diplodus vulgaris* (two saddled seabream), these two species are frequently present in the landed catch from Alexandria coastal waters. Fish genus Diplodus usually live in coastal waters on rocky or sandy bottoms down to a depth of 130 meters (Fischer *et al*., 1987). The youngs usually live in coastal sea grass meadows.

According to the available literature these two species made the subject of study of some authors in the Egyptian Mediterranean coastal waters. Elmaghraby *et al*., 1982 studied the maturation, spawning and fecundity of two sparid fish *D. sargus*, and *D. vulgaris* in the Egyptian Mediterranean waters. They concluded that, the spawning season for *D. sargus* started in January and continued till the end of April, while that of *D. vulgaris* started in November and ended in February, According to these last authors, the two species are characterized by a prolonged spawning rather than a fractional spawning season.

Wassef, 1973 studied some of the biological aspects of these two sparid fish, (*D. sargus* and *D. vulgaris*) in Egyptian Mediterranean waters. Her study included the identification and morphometric characteristics as well as biological characters of both species. Ali, 1996 studied the reproductive biology and physiology of *D. vulgaris* in the Egyptian Mediterranean waters.
Elgreisy, 2000 studied the reproductive biology and physiology of *D. sargus* (Family: sparidae), in the Mediterranean environment. Lahlah, 2004 studied the ecology of *D. sargus* in some sea grass meadows along the Alexandria seashore.

These two species made the subject of study of various scientists, of these we mention; Mariani, 2001 who studied the life history and ecosystem driven variation in composition and residence pattern of seabream species (Sparidae) in two Mediterranean coastal lagoons off the western coast of Italy. Sala & Ballesteros, 1996 indicated that in the Mediterranean Sea, Sparidae mainly *D. sargus* and Labridae are major predators of Sea-urchins therefore playing a major role in controlling their abundance and effects on benthic communities.

Gordoa & Moli, 1997 studied the age and growth of spardid fish *D. sargus*, and *D. vulgaris* in the adult population as well as the differences in their juvenile growth patterns in the North Western Mediterranean Sea. Morato, 2001 studied the length weight-relationship for 21 coastal fish species of Azores, (North Eastern Atlantic), *D. sargus* was included.

Conides & Alhassan, 2000 studied age of *D. vulgaris* by using eye length diameter. The results showed that, this technique could be adopted for determination of the age of that species when the specimens are very young. Gonçalves, 2000 and Gonçalves, *et al*., 2007 studied the population dynamics of *D. vulgaris* sampled from the South coast of Portugal. Palma and Andrades, 2002 studied the morphological characters of the sparid fishes *D. sargus*, in the Eastern Atlantic and the Mediterranean Sea.

A. Area of Study:

A.1. Description of the area of study:

Abu Qir Bay (Figure 1) is a shallow semi secular basin located at about 35 Km east of Alexandria. It lies between latitudes 31° 16′ and 31° 28′ North and longitudes 30° 5′ and 30° 22′ East. The bay has shorelines of about 50 Km, the bay is bordered on the West by Abu Qir Peninsula and East Rosetta Nile Branch. The area of the bay is about 360 Km² with a maximum depth of about 16m (average depth 10m) (Radwan, 1996).

The Bay was considered in the past among the highly fertile marine habitats in Egypt, besides being a relatively shallow sheltered area. The average standing crop of phytoplankton recorded in the Bay reached 906 thousand cells, (Samaan & Makhail, 1990). This is particularly due to its eutrophication by the entering effluents into the Bay, which are rich in nutrients. The most important one being the slightly brackish water flowing from Lake Edku into the bay through Boughaz Elmaadiya at the South Western side of the lake at a rate of about 3.5 million cubic meters per day. The bay receives also at its western margin considerable amounts of drain water intermixed with industrial wastes through Eltabia pumping station. The daily discharge of this station fluctuates between 1.5 and 2 million cubic meter (Samaan & Makhail, 1990).

The North Eastern coast of the bay ends at the opening of Rosetta Nile Branch where it receives water from the Nile branch that average about 3.3x103 million cubic meters per year. Most of this water is mostly confined to a short period between December and February. Other minor effluent is directly discharged at the South Western margin of the Bay from Abu Qir area Fertilizer factory (Samaan & Mikhail, 1990).
During the last decades, the Bay faced the problem of pollution, as a result of waste water discharged into it from different sources; (Eltabia pumping station, the outlet of Lake Edku and the mouth of Rosetta branch of the River Nile (Radwan, 1996).

The bottom of the Bay has in most of its parts many subsurface ridges, which could be detected in the extreme west. Some of these ridges mount over the water surface to form small islands, of these we mention Nelson Island which is the largest one. Many ridges and batches could be found between Abu Qir head and Nelson Island. These ridges cause a rather limited exchange with the open sea in that part of the bay. The bottom nature
inside the bay gradually varies from sandy in the western part to sandy mud and muddy sand in the eastern part (Radwan, 1996).

The water circulation pattern in the Bay is mainly wind dependent. The circulation and hydrographic pattern of the bay causes mixing of inflowing Mediterranean water with water discharged, mainly from Eltabia pumping station, Lake Edku and Rosetta branch of River Nile (Mohamed, 1981).

According to prediction of (Moussa, 1981) which is based on the previous data of the current regime in Abu Qir, the water circulation follows a clockwise direction in the eastern two thirds of the Bay and weaker anticlock currents in the western part.

At the point of contact these two currents join forming a North Western current, with speed of 50cm/sec inside the Bay and 5cm/sec in the outside of the Bay (Elsharkawy & Sharaf Eldin, 1974). At the lake Sea connection, there is an exchange of lake bay water throughout the year, with a maximum speed between 60 and 100 cm/sec along the axis of the channel (Mohammed, 1981).

A.2. Seasonal variations in some physical characteristics of Abu Qir Bay:

The prevailing wind during the year is generally light to moderate, the wind is north westerly throughout the year until December where it blows between south west and north west (Elsharkawy & Sharaf Eldin, 1974).

Water temperature showed marked seasonal variations in the bay. The highest value of surface water temperature was recorded during summer (29.7 C⁰) and the lowest value during winter (15.5 C⁰). Temperature decreases with increasing depth (Said et al., 1995; Elmardany, 2006; Younes, 2005 and Mohamed, 2006).
The salinity of the bay water varied from 6.4 mg/l during winter to 39.3 mg/l during autumn (Nessim *et al*., 1994; Younes, 2005 and Mohamed, 2006). The maximum value of hydrogen ion concentration (pH) was recorded during summer (8.79) and the minimum (7.30) during winter (Dowidar & Elnady, 1984; Elsherif and Mikhail, 2003 and Mohamed, 2006).

The highest value of dissolved oxygen was recorded during winter (10 mg/L) and the lowest (0.73 mg/L) during the summer (Tayel, 1992; Fahmy, 1997 and Younes, 2005). Water alkalinity varied between 1.67 mg/L during March and 4.0 mg/L during January (Mohamed, 2006).

**B. Aim of the Present Study:**

In Abu Qir Bay, Diplodus spp. received less attention from fishery scientists. Hence it was found interesting to reveal some informations on its biology and population dynamics in the Bay. The present work is hoped to give useful informations of the stock of *D. sargus* and *D. vulgaris* in Abu Qir Bay and aims to obtain the basic informations required for assessing and managing the fisheries of the most important and abundant sparid fish in the study area, so the main purposes of the present study are:

- Determine age and growth of the two species, *D. sargus* and *D. vulgaris*.
- Study some parameters of their population dynamics, namely, mortality, maximum age, Exploitation ratio, sex ratio and growth parameters.
- Evaluate the effect of fishing operations on the present stock of the two species under investigation and hence assess the state of their fisheries in the Bay.
CHAPTER II
MATERIALS AND METHODS

Statistical data concerning the annual catch of Sparidae (D. sargus and D. vulgaris) and total catch of Abu Qir Bay, Alexandria and the Egyptian Mediterranean coast in the period from 1998 to 2008 were obtained from the statistical records of the general authority for fish resources development GAFRD (1998 - 2008).

A. Collection of Samples:

Random samples of D. sargus and D. vulgaris were collected every two weeks from the commercial catch in the landing site in Abu Qir Bay during the period from January 2008 to January 2009. Identification of the collected fish samples were carried out and the following data were recorded for each fish sample:

- Name of species.
- Date of capture.
- Type of gear used.
- Total length (from the tip of the snout to the end of the caudal fin) to the nearest mm.
- Total weight to the nearest gm.
- A sample of scales (5 – 8) was taken from the left side of each fish and above the pectoral fin.
- Sex and sexual maturity were determined by macroscopic examination of the gonads.

Scales from each fish were washed out by water and kept dry in an envelope on which is written all the above informations.
B. Growth Studies:

B.1. Length weight relationship:

Length weight relationship was estimated for the two species under study by using the power equation:

\[ W = a L^b \] (Le Cren, 1951)

Where:

- \( W \): is the total weight in gram.
- \( L \): is the total length in cm.
- \( a \) & \( b \): are constants.

The preliminary studies showed no differences in the exponent values between the two sexes, therefore no segregation due to sex was done.

B.2. Condition factor:

The condition factor “K” which is considered another way for expressing the relationship between length and weight was calculated for the two species under study using the following equation:

\[ K = \frac{W}{L^3} \times 100 \] (Hile, 1936)

Where \( W \) is the total body weight (gm) and \( L \) is the total body length (cm) of the fish. Here also segregation due to sex was not adopted.

The mean \( K \) for each length class was determined for the two species under study.

B.3. Age and growth determination:

The study of the age determination and the rate of growth depends on counting annual marks on various hard parts of the fish body such as spines, rays, opercular bones, otoliths and scales.
In the present study scales were used, they were taken from the left side of the fish above the pectoral fin. The location of the scale samples was fixed throughout the whole sampling period to avoid all kinds of bias that might arise during the growth calculations (Joeris, 1957), each scale sample was kept in a special paper envelope on which is recorded the name of the species, date of capture, location, sex and sexual maturity, total fish length in cm and fish weight in gm.

Scales were cleaned in 10% solution of ammonium hydroxide, washed by distilled water then mounted dry between two glass slides. They were then examined under a binocular microscope (X25).

Reading of scales was done using reflected light on a dark back ground to measure the total scale radius and the distance from the focus (center of the scale) to each annulus using an eye piece micrometer. The regenerated or irregular scales were discarded.

**B.3a. Back calculation of length and growth:**

The relationship between scale radius and fish total length for the two species was found to be linear and represented by the following equation:

\[ L = a + b S \]

Where \( L \) is the total body length in cm, \( S \) is the scale radius in micrometer division, ‘a’ is the intercept on the Y-axis and ‘b’ is the slope of the regression line.

For back calculation of fish length at various years of life (Lee, 1920) was used:

\[ L_n = [(S_n / S)*(L - a)] + a \]

Where \( L_n \) is the calculated length at the end of \( n^{th} \) year of life in cm., \( L \) is the total length in cm, \( S_n \) is the scale radius from the nucleus to the \( n^{th} \) annual
mark (in micrometer division), S is the total scale radius in micrometer division from the nucleus to the anterior edge of the scale and a is the intercept on the Y axis in the length scale relationship.

The obtained formula expressing length weight relationship was used to estimate the back calculated total weights at various years of life for each species under study. No segregation due to sex was done, since the values of the two constants (a & b) were nearly the same.

B.3b. Theoretical growth in length and in weight:

The Von Bertalanffy growth model was applied to describe the theoretical growth of the two species understudy. Estimation of Von Bertalanffy parameters ($L_\infty$ the asymptotic length (cm), K the growth coefficient or curvature parameter and ($t_0$) determine the point in time when the fish has zero length) were calculated by applying (Ford, 1933 & Walford, 1946 method) according to the following equation:

$$L_{t+1} = a + b L_t$$  \hspace{1cm} \text{(Sparre & Venema, 1998)}

Where: $a = L_\infty (1 - e^{-k})$ and $b = e^k$

The initial condition parameter ($t_0$) was calculated by applying the inverse Von Bertalanffy growth equation:

$$t_0 = t + [(1/k) (\ln (L_\infty - L_t) / L_\infty)]$$

Theoretical growth in length was calculated according to (Von Bertalanffy equation 1938):

$$L_t = L_\infty (1 - e^{-k (t-t_0)})$$

In order to get the corresponding theoretical growth in weight according to Von Bertalanffy formula, we used the following equation:

$$W_t = W_\infty (1 - e^{-k (t-t_0)})^b$$
Where $L_t$ is the total length at age group $t$ (cm), $W_t$ is the total weight at age group $t$ (gm), $W_\infty$ is the asymptotic weight in gm. $L_\infty$, $K$ and $t_0$ are Von Bertalanffy growth parameters and the constant “$b$” is the exponent in the length weight relationship.

$W_\infty$ is estimated by converting $L_\infty$ to the corresponding weight using the length weight relationship.

**B.3c. Maximum age ($t_{max}$):**

The maximum age was obtained from the equation: $t_{max} = 3/ K$.

According to Pauly & David, 1981 where:

$t_{max}$ is the longevity of fish species and $K$ is the curvature parameter.

**B.3d. Growth performance:**

According to Moreau *et al.*, 1986 the following equations were adopted to estimate the growth performance of length and weight for the two species under study.

Growth performance in length:

$\Phi_L = \log K + 2 \log L_\infty$

Growth performance in weight:

$\Phi_W = \log K + 2/3 \log W_\infty$

**C. Population Structure:**

Length frequency distribution for the two species understudy was determined and the percentage of occurrence of each length class was obtained.
C.1. Survival and instantaneous mortality coefficients:

C.1a. Estimation of instantaneous total mortality coefficient “Z”:

The instantaneous total mortality coefficient (Z) of the two species under study in Abu Qir Bay were obtained by the method of the linearized catch curve with constant time intervals and by using age frequency data (Fish age in years on X axis and Ln the fish frequency of each age group on Y axis) by taking the minus value of the slope (-b) of the straight descending portion of the curve as the value of Z (Ricker, 1975).

C.1b. Estimation of instantaneous natural mortality coefficient “M”:

Natural mortality was calculated using Pauly empirical formula (1980), which requires Von Bertalanfy growth constants and the annual mean water temperature (18.50\degree) in Abu Qir waters.

\[
\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T
\]

Where \( L_\infty \) & K are Von Bertalanfy parameters and T is the annual mean temperature.

C.1c. Estimation of instantaneous fishing mortality coefficient “F”:

Instantaneous fishing mortality (F) was calculated by subtracting the natural mortality coefficient (M) from the total mortality coefficient (Z):

\[
F = Z - M
\]  
(Beverton & Holt, 1957).

C.1d. Estimation of the survival rates “S”:

The estimation of survival rates (S) was given by the equation \( S = e^{-z} \)
Ricker, 1975.
C.2. Exploitation ratio:

The exploitation ratio (E) was calculated for the two species under study. It describes the relation between the instantaneous fishing mortality and the instantaneous total mortality according to Baranov, 1918 formula:

\[ E = \frac{F}{Z} \]

C.3. Length and age at first capture:

Length at first capture (Lc) was investigated from the equation of Beverton & Holt, 1956 which applies the growth constants of Von Bertalanfy:

\[ L_c = L^' - K (L^\infty - L^') / Z \]

Where \( L^' \) is the mean length of the catch, \( K \) & \( L^\infty \) are the constants of Von Bertalanfy equation and \( Z \) is the instantaneous total mortality coefficient.

The corresponding age at first capture (tc) were calculated by the following equation (Beverton & Holt, 1957):

\[ t_c = \left( \frac{-1}{K} \right) \left( \ln \left( \frac{1 - L_c}{L^\infty} \right) + t_o \right) \]

Where \( K \), \( L^\infty \) and \( t_o \) are the Von Bertalanfy constants and \( L_c \) is the length at first capture and \( t_c \) is the age at first capture.

C.4. Length and age at recruitment:

Length at recruitment (Lr) was estimated also in the same manner by applying the growth equation of Von Bertalanfy:

\[ L_r = L^' - K (L^\infty - L') / Z \quad \text{Where:} \]

\( L' \) is the length for which all fish of that length and longer are under full exploitation.
L is the mean length and Z is the instantaneous total mortality coefficient.

The corresponding age at recruitment was calculated by the same equation by using the length at recruitment:

\[ T_r = \left( -1 / K \right) \left( \ln (1 - L_r / L_x) + t_o \right) \]

**D. Management:**

**D.1. Estimation of yield per recruit (Y/R):**

The yield per recruit was estimated by Beverton and Holt yield per recruit model (1957), and written in the form suggested by Gulland, 1969 as follows:

\[ Y/R = F_e^{-M(tc-tr)} W_{\infty} \left[ (1/Z) - (3S/(Z+K)) + (3S^2/(Z+2K)) - (S^3/(Z+3k)) \right] \]

Where: \( S = \exp \left[ -K (t_c-t_o) \right] \)

\( t_c = \) Age at first capture.

\( t_r = \) Age at recruitment.

\( W_{\infty} = \) Asymptotic body weight.

\( F = \) Fishing mortality coefficient.

\( M = \) Natural mortality coefficient.

\( Z = \) Total mortality coefficient.

\( K = \) Von Bertalanfy growth parameter (Curvature parameter).

**D.2. Estimation of biomass per recruit (B/R):**

The average biomass per recruit is the average biomass of the exploited part of the cohort; it considers the weight of the cohort at a particular time. Beverton and Holt biomass per recruit model (1957) expresses the average biomass of survivors as a function of fishing mortality. It was calculated by the equation:

\[ (B/R) = (Y/R) / F \]

**D.3. Estimation of biological reference points (F_{0.1} & F_{max}):**

The extreme values of the fishing level, which might seriously affect the self renovation of the stocks, were defined as biological reference points
(BRP). These values of fishing mortality such as $F_{\text{max}}$ and $F_{0.1}$ were investigated (Cadima, 2003). In order to estimate the value of $F_{\text{max}}$ we computed the value of maximum yield per recruit as a function of fishing mortality at various ‘F’ values. The value of ‘F’ corresponding to the biggest yield per recruit of the two species under study is considered $F_{\text{max}}$ for each.

The virgin biomass per recruit $\overline{B}_0$ or the biomass of the unexploited stock was estimated by considering the value of fishing mortality zero.

According to Cadima, 2003 the values of $F_{0.1}$ for the two species under study were determined by the following equations:

Let the function

$$V = Y - 0.1 \cdot \overline{B}_0 \cdot F$$

Where:

$\overline{B}_0$ is the virgin biomass, ‘Y’ is the yield per recruit and ‘F’ is the fishing mortality. It can be proved that the function $V$ is maximum when $F = F_{0.1}$. Therefore, $F_{0.1}$ can then be calculated by maximizing the function ($V$).

**D.4. Effect of ‘$t_c$’ on ‘Y/R’:**

The effects of age at first capture on yield per recruit at the present value of the fishing mortality and at different fishing mortality values of the two species under study were estimated.

**D.5. Effect of ‘F’ at different values of ‘$t_c$’ on ‘Y/R’:**

This study was examined by estimating the values of yield per recruit as a function of fishing mortality at different values of age at first capture for the two species under study.

**D.6. Effect of ‘F’ at different values of ‘M’ on ‘Y/R’:**

Study of the effect of fishing mortality at different values of natural mortality on yield per recruit is also examined for *D. sargus* and *D. vulgaris*. 
D.7. Virtual population analysis:

The age based cohort analysis (Pope’s cohort analysis 1972) was used to analyze the historical data for estimation of population parameters (Sparre & Venema, 1998). It was estimated by analysing the catch at age in numbers obtained by raising the age frequency samples to the total landed catch of Abu Qir Bay.

The value of the terminal ‘F’ used in that routine was assumed to be equal to ‘F’ of the oldest age group. The number of survivors in the oldest age group was estimated by the equation:

\[ N_t = \frac{C_t}{(F_t/Z_t)(1-e^{-Z_t})} \]

Where: \( N_t \) = number of survivors in the oldest age group.
\( C_t \) = number of fish caught in the oldest age group.
\( F_t \) = The terminal fishing mortality (F of the oldest age group).
\( Z_t \) = The total mortality.

The numbers of survivors in the previous years were estimated by the following equation:

\[ N_{t-1} = \frac{((N_t)(e^{M/2}) + C_{t-1})[e^{M/2}]}{e^{M/2}} \]

Where: \( N_{t-1} \) = number of survivors in the previous age group.
\( C_{t-1} \) = number of fish caught in the previous age group.
\( M \) = the natural mortality.

Estimation of the different values of fishing mortality which corresponded to the previous age groups \( (F_{t-1}) \) were investigated from the following equation:

\[ F_{t-1} = \ln \left( \frac{N_t}{N_{t-1}} \right) - M \]
CHAPTER III
FISHERY STATISTICS

A. Systematic Review:

Fishes of family Sparidae are widely distributed in Atlantic, Indian and Pacific Oceans. This family includes about 29 genera with nearly 100 species (Nelson, 1976). Family sparidae is represented in the Mediterranean Sea by 10 genera and 22 species that usually inhabit coastal areas, and produce pelagic eggs and larvae (Arculeo, 2003).

Sparid fish, or seabreams, are demersal fishes living in coastal waters and occupy a variety of trophic niches; they are generally gregarious, though adults might be solitary in some species (Froese & Pauly, 2000).

In the Mediterranean area, sparids are of great interest for fisheries and aquaculture. Most sparid fish species are usually appreciated as sea food with high commercial value. In the recent years, sea breams have also gained considerable importance for aquaculture. For instance, the gilthead seabream, *Sparus aurata*, has become one of the most important cultured species in the Mediterranean region. Several other sparidae are cultivated in fish farms, they are potential candidates for aquaculture.

Despite the growing interest in this group of fishes, however, few studies on some aspects of their biology are available. This is particularly worrying if we consider that a correct management of biological resource should be based on the most complete informations about the natural genetic diversity of the species involved.

Genus Diplodus (Sea breams) are widespread in Alexandria waters. They comprise five species namely *D. sargus* and *D. vulgaris*, *D. annularis*, *D. puntazzo* and *D. cervinus* (Fischer, et al., 1987). Family Sparidae comprised
about 17.13% of the total landed catch at Abu Qir Bay during 2008 (GAFRD, 2008). *D. sargus* and *D. vulgaris* are the most common in the landed catch of Sparidae in Abu Qir Bay. These species make the subject of the present study and they are shown in figures (2 & 4) together with their geographical distribution around the world (Froese & Pauly, 2000) in figures (3 & 5).

**A.1. Diplodus sargus sargus (Linnaeus, 1758):**

The white seabream (*D. sargus*) is an omnivorous sparid fish species, found in the Mediterranean as well as the eastern Atlantic Ocean, including the archipelagos of Madeira, Cape Verde and the Canary Islands (Fischer *et al.*, 1987).

*Diplodus sargus* species complex includes six subspecies: *D. sargus sargus* in the Mediterranean and Black Sea; *D. sargus cadenat* in the eastern Atlantic (from the Bay of Biscay to Senegal including the islands of the Azores, Madeira and Canaries); *D. sargus lineatus* which is endemic to Cape Verde islands; *D. sargus helenae* in St. Helena island; *D. sargus ascensionis* in Ascension island; and *D. sargus kotschyi* from the Persian Gulf and Northern Indian Ocean. Another subspecies of the complex, *Diplodus sargus capensis*, which occurs from Angola to Mozambique and Southern Madagascar, has been recently considered as a species (*Diplodus capensis*) by Heemstra & Heemstra, 2004.

The White Sea bream is mainly caught by artisanal fisheries and constitutes a valuable fishery resource because of its high price (Harmelin *et al.*, 1995). It is targeted by small scale and sport fisheries (Reina *et al.*, 1994). Hence it is of interest as a potential species for aquaculture.
Fig. (2): *Diplodus sargus sargus* (Linnaeus, 1758).

Fig. (3): Geographical distribution of *Diplodus sargus sargus*  
(After Froese and Pauly, 2000).
Youngs are euryhaline, entering brackish waters and lagoons in the spring. The adults can be found in a diverse range of habitats, including coastal rocky reefs, sandy bottoms, and seagrass beds (*Posidonia oceanica* in the Mediterranean) (Lahlah, 2004). They congregate in schools of 5 – 50 individuals, feeding on polychaetes, mollusks and sea urchins, *D. sargus sargus* have pelagic eggs and larvae (Bauchot & Hureau, 1986).

Together with other species of the genus Diplodus, it dominates fish assemblages in shallow rocky habitats (Sala & Ballesteros, 1997). The rocky areas may potentially contribute more production of white seabream than the sandy coasts (Lioret & Ecole, 2003). It is a protandrous hermaphrodite fish (Pajuelo & Lorenzo, 2004).

The white sea bream is a particularly attractive species for further studies. Different aspects of its biology and ecology were studied by various authors, of these we mention (Harmelin, 1987; Rosecchi, 1987; Harmelin et al., 1995; García & Macpherson, 1995; Gordoa & Moli, 1997; Macpherson et al., 1997; Biagi et al., 1998; Macpherson, 1998; Planes et al., 1999; Vigliola & Harmelin, 2001 and Lanfant, 2003), growth (Pajuelo & Lorenzo, 2002), reproduction (Morato et al., 2003; Pajuelo & Lorenzo, 2004) and feeding (Sala & Ballesteros, 1997; Escoubet et al., 2001; Mariani, 2001 and Zander & Soetje, 2002). Studies of its environmental conditions have also been carried out by (Planes et al., 1997 and Lioret & Ecole, 2003) where they mentioned that it is an omnivorous species it prefers small crustaceans and molluscs, and would also consume algae and small corals. However, up to our knowledge very few studies were done on its fisheries assessment. Such studies were carried in North West Mediterranean (Girardin, 1978) and in Portugal (Gonçalves, 2000).
A.2. *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817):

The species *Diplodus vulgaris* are commercially important demersal fish which are caught in a bathymetric range of 3–100 m. It is distributed in the Mediterranean and along the eastern Atlantic coast from France to Senegal, including the Madeira, the Azores and the Canaries Archipelagogs (Bauchot & Hureau, 1986). It can be found close to rocky and sand bottoms, close to the habitat of the marine plant *Posidonia oceanica* or in lagoons. Juveniles often live in coastal lagoons and estuaries (Monteiro, 1989), it is considered a resident species in artificial reefs (Santos, 1997) and sea weeds (Lahlah, 2004). This species is also caught by artisanal fishery and is targeted by small scale and sport fisheries.

In spite of being one of the most frequent and abundant sparid fish in the coastal waters and in the catch of Southern Europe, there have been few studies published on the fishery biology of *D. vulgaris* (Garcia & Macpherson, 1995 and Harmelin *et al*., 1995). Age and growth studies have been carried out in one particular region of its distribution, the North Western Mediterranean by Girardin, 1978; Man Wai, 1985 and Gordo & Moli, 1997. Reproduction aspects have been restricted to the Mediterranean with the studies done by D’Ancona, 1949; Lissia & Pala, 1968; Elmaghraby *et al*., 1982 and Man Wai, 1985 and the eastern Atlantic (Lozano *et al*., 1990 and Gonçalves, 2000). Feeding habits were studied by Ara, 1937; Bell & Harmelin, 1983; Rosecchi, 1985; Rosecchi & Nouaze, 1987 and Sala, 1996 for the Mediterranean and by Gonçalves & Erzini, 1998 in the eastern Atlantic.
Fig. (4): *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817).

Fig. (5): Geographical distribution of *Diplodus vulgaris*  
(After Froese and Pauly, 2000).
B. Statistical Studies:

B.1. The fishing methods used in Abu Qir Bay:

The used fishing methods in Abu Qir Bay are purse seines, trammel nets, gill nets, long line fishery and beach seine. The long line fishing method is more used in the bay than the other methods (231 boats) it represents 56.62% of all the used fishing methods, followed by trammel and gill nets (126 boats) which represent 30.88% of all the used fishing methods in Abu Qir Bay during the year 2008 (GAFRD 2008).

The numbers of working fishing boats in Abu Qir Bay from 1998 to 2008 are listed in table (1) and graphically represented in figure (6). Up and down fluctuations took place in the number of these boats till 2006 where they reached their highest number (529 boats), after that a progressive decrease in the number of fishing boats occurred from 499 in 2007 to 477 in 2008.

It is to be noted that, the motorized boats working in Abu Qir Bay are much higher in number than the non motorized boats. However both types showed progressive decrease from 1998 to 2008.

B.2. Catch composition in Abu Qir Bay:

The data on the total catch in Abu Qir Bay (Alexandria) and in the Egyptian Mediterranean coasts are shown in table (2). Figure (7) shows the total landed catch in Alexandria, as well as the Egyptian Mediterranean coasts. From this figure we notice that, in the Egyptian Mediterranean coast the total catch was low in the years from 2000 to 2005; after which a progressive increase was noted until 2008. A progressive increase in the total landed catch in Alexandria coasts is also apparent. On the other hand the total landed catch in Abu Qir Bay (Table 2 & figure 8) decreased from 939 tons in 1998 to 572 tons in 2008.
The fish catch from Abu Qir Bay during 2008 was mainly dominated by *Sardinella* spp (37.59%), *Siganus* spp (9.44%), *Boops boops* (6.99%), *Penaeus* spp (5.24%), *D. sargus & D. vulgaris* (4.02%) as well as *Pagrus pagrus*, *Solea vulgaris* and *Epinephelus* spp. which appear to have the same percent abundance 4.02% each (GAFRD, 2008).

**B.3. Catch statistics:**

The catch of *D. sargus* and *D. vulgaris* in Abu Qir Bay, Alexandria and from the Egyptian Mediterranean coasts in the period from 1998 to 2008 are shown in table (3) and graphically represented in figures (9 & 10). We should note that, the catch of both species are always included together in one category in the reported landed catch statistics.

The total landed catch of Abu Qir Bay represents 11.65% of the total landed catch at Alexandria in 1998. This percent decreased progressively till it reached 2.86% in 2008. While the landed catch of Alexandria with respect to that of Mediterranean showed an increasing trend with some fluctuations till it reached a maximum in 2006 (26.13%) after which a decrease in 2007 & 2008 is noticed (20.38% & 22.48%) respectively (table 2).

In Abu Qir Bay the catch of Diplodus spp. have increased in the last few years from 11 tons in 2005 to 23 tons in 2008. If we consider the percent of the landed catch of Diplodus spp. in Abu Qir Bay with respect to that of Alexandria, we notice that this percent decreased from 12.15 to 3.69 with some fluctuations during the whole period (1998 – 2008). This is because of the very low rate of increase in the catch of Diplodus spp. in Abu Qir Bay which is far less than the rate of increase in that catch in Alexandria.

However, if we consider the landed catch of Diplodus spp. with respect to the total landed catch in Abu Qir Bay we can see that, Diplodus spp. catch
also undergoes some up and down variations from 1998 till 2003. A progressive increase in the percent abundance of Diplodus spp. catch can be observed from 2.28% in 2004 to 4.02% in 2008.

Diplodus spp. landed at Alexandria has increased from 107 tons in 1998 progressively till it reached 624 tons in 2008. On the other hand the catch of Diplodus spp. showed up and down variations (from the coasts of Mediterranean) till 2008, with two peaks the first in 2001 and the second in 2006 (Table 3).

The landed catch of *D. sargus* and *D. vulgaris* showed a progressive increase in Abu Qir Bay from 1998 to 2008 while in the same period the total landed catch of the bay decreased progressively till it reached its lowest value in 2008.

The landed catch of Abu Qir Bay during the year 2008 was dominated by 14 fish families beside other species which represent each by less than 2% of the total landed catch (table 4). The two families Engraulidae and Clupeidae are the most dominant, they constitute 37.59% of the total landed catch in Abu Qir Bay, Siganidae (9.44%) and Penaeidae represented 5.24% of the total landed catch. The other families represent less than 5% each.

In the year 2008 family Sparidae represented about 17.13% of the total landed catch of Abu Qir Bay. It was represented by *Boops boops, Sparus aurata, Pagrus pagrus, D. sargus, D. vulgaris, Pagellus erythrinus, Lithognathus mormyrus* and few individuals belonging to other Diplodus spp. The two species under study represented about 23.47% of the Sparid landed catch in Abu Qir Bay during the year 2008.

During the course of the present study, *D. sargus* represented collectively by 62% of the total landed catch of the two species under study, while *D. vulgaris* represented about 38%, in the year 2008.
CHAPTER III

AGE AND GROWTH

Age determination is an important tool in studying fish biology and their fisheries management. It forms the basis for calculations leading to obtain knowledge on growth, life span, mortality, recruitment, reproduction and other fundamental parameters of their populations (Holden et al., 1974).

Age determination can be carried out through different methods such as rearing, tagging, standard statistical methods and determination of year marks from skeletal structures such as otolith, vertebrae, fins, spines, operculae and scales. Scales are the most common structures used for age determination in the teleost fish.

A. Length weight relationship:

The length weight relationship is usually expressed by the power equation: \( W = a L^b \) (Le Cren, 1951) where “W” is the total fish weight, “L” is the total body length and “a & b” are constants. The exponent "b" expresses the degree of fish condition which usually varies from 2.5 to 4 according to the environmental conditions (the high value of "b" indicates a higher ponderal growth rate).

The length weight relationships for each species under study (\( D. sargus \) and \( D. vulgaris \)) in Abu Qir Bay are represented graphically in figures (11 & 12) and expressed by the following equations:

\[
\begin{align*}
\text{for } D. sargus & \quad W = 0.0207 L^{2.9421} \quad R^2 = 0.9844 \\
\text{for } D. vulgaris & \quad W = 0.0178 L^{2.9686} \quad R^2 = 0.9884
\end{align*}
\]

The present data show that, the value of "b" shows slight negative allometry (less than “3”) in the two species under study, (2.9421) for \( D. sargus \) and (2.9686) for \( D. vulgaris \).
This means that, the fish puts on weight at a slightly lower rate than its growth in length.

**B. Condition factor:**

The condition factor “K” has been widely used to express the suitability of an environment to a certain fish species by comparing the value of “k” for a fish species living in a certain locality with individuals belonging to the same species and living in other localities. It is an important indicator of the degree of well being and relative robustness of the fish population. It varies with fish length, weight, season and state of maturity (Lagler, 1956).

Fish with high values of condition factor are considered to be heavier as compared with those having the same length group and with low “k” values. The average (K) values for each length group of the two species under study are given in the table (5) and graphically represented in figures (13 & 14).

It should be noticed that, the small lengths have higher “k” values than the bigger ones. The highest value of “k” (1.96) for *D. sargus* corresponds to length group 11.5 cm, and it is 1.75 corresponding to the same length group 11.5 cm for *D. vulgaris*.

The same results were noticed in the mean values of the condition factor for each age group (Table 6), the smaller ages have higher condition factor than older ones, for the two species under study. The higher values (1.82 & 1.66) in *D. sargus* and *D. vulgaris* respectively were corresponding to age group I and it decreases thereafter as the fish gets older.

The seasonal variations in the condition factor of the two species under study are represented in table (7). We can see that, the average values of the condition factor of *D. sargus* increases in summer and autumn than the other two seasons. In *D. vulgaris* as well, the values of “k” were high in summer
and autumn. This could be explained to be due to the effect of the spawning season in the two species which extends from January and continues till the end of March in *D. sargus* (Lahlah, 2004) and from November to February in *D. vulgaris* (Elmaghraby *et al.*, 1982). Thus, the value of “K” decreases during and after the spawning period.

From table (5) it should be noted that, *D. sargus* has an overall mean value of “k” (1.74) higher than *D. vulgaris* where the overall mean value of “k” is (1.63).

C. **Age determination:**

Age was determined in both species by means of scale readings. Use of scales was adopted as a first choice, they are easy to read and handle. Scales of both species in the present study are of the ctenoid type, annual checks were clear in most examined scales.

C.1. **Length scale relationship:**

The body length scale radius relationship was determined for 746 and 616 specimens of *D. sargus* and *D. vulgaris* respectively. The total length range of specimens studied was 7.5 to 27.5 cm T.L and 8.5 to 26 cm for *D. sargus* and *D. vulgaris* respectively.

Body length scale radius relationship of both species proved to be linear and could be represented by a straight line (Figures 15 & 16) indicating a linear relationship. This relationship was found to be represented by the following equations:

*D. sargus:* \[ T.L = 1.0713 S + 1.316 \quad R^2 = 0.9923 \]

*D. vulgaris:* \[ T.L = 1.0786 S +1.222 \quad R^2 = 0.9815 \]

Where T. L is total fish length in cm, S, is the total scale radius in micrometer division.
C.2. Time of annulus formation:

From table (8) and figures (17 & 18), it is evident that the least values of scale increment for both species was in April, which means that the annual check is formed in the month of April for both species.

C.3. Growth in length:

Lengths at the end of each year of life were back calculated for both species (*D. sargus* and *D. vulgaris*) according to Lee’s formula (1920). The value of “a” for *D. sargus* was 1.316 and for *D. vulgaris* was 1.222. Average back calculated lengths for each age group as well as the mean increments are shown in tables (9 & 10) and represented graphically in figures (19 & 20) for both species.

From these tables and figures, it is clear that linear growth rate reaches its maximum value by the end of the first year of life, where the attained increments were about 11.42 cm and 10.34 cm for *D. sargus* and *D. vulgaris* respectively, after which gradual decrease in annual increments with further increase in age was observed.

We should note that, the average calculated length values of *D. sargus* were higher than those of *D. vulgaris* for each year of life.

C.4. Growth in weight:

The back calculated weights by the end of each year of life for both species are shown in tables (11 &12) and graphically represented in figures (21 & 22).

From these tables and figures the mean weights for *D. sargus* were 26.77, 71.66, 130.58, 193.12, 251.19 and 300.47 gm for age groups I, II, III, IV, V and VI respectively.
The corresponding weights for *D. vulgaris* for age groups I, II, III, IV, V and VI respectively were 18.30, 55.91, 107.46, 165.09, 220.62, and 267.24 gm.

According to the obtained data, it appears that, the annual increment of growth in weight increases with further increase in age until it reaches it’s maximum value at age group IV for both species (62.24 and 57.63 gm for *D. sargus* and *D. vulgaris* respectively), after which the increment shows gradual decrease with further increase in age.

It is noticed that, the back calculated weights at the end of each year of life of *D. sargus* were also higher than those of *D. vulgaris*.

**C.5. Theoretical growth in length:**

The von Bertalanffy growth equation was determined by applying Ford Walford method. Accordingly, the obtained Von Bertalanffy equations for both species are the following:

For *D. sargus* \( L_t = 31.38 \left[ 1 - e^{\left(-0.262 \left( t - (-0.73) \right) \right)} \right] \)

For *D. vulgaris* \( L_t = 31.30 \left[ 1 - e^{\left(-0.258 \left( t - (-0.56) \right) \right)} \right] \)

The theoretical back calculated lengths at the end of each year of life derived from these equations were computed and are shown in the table (13). From this table we notice that, these values are close to those obtained by the back calculation, according to Lee’s formula.

**C.6. Theoretical growth in weight:**

The values of \( W_\infty \) for the two species were obtained by applying the length weight relationship; by using the value of \( L_\infty \) (Pauly, 1981) and were found to be 524 and 490 gm for *D. sargus* and *D. vulgaris* respectively.
Accordingly, the Von Bertalanffy growth formula for ponderal growth, are as follows:

For *D. sargus*: \[ W_t = 524\left[1 - e^{-0.262(t^{(-0.73)})}\right]^{2.9421} \]

For *D. vulgaris*: \[ W_t = 490\left[1 - e^{-0.258(t^{(-0.56)})}\right]^{2.9686} \]

The theoretical weights for each year of life are given in table (14) for both species. It appears that *D. sargus* attains heavier weights than *D. vulgaris* in their different ages. The obtained values of weights agree with the back calculated weights according to Lee’s formula.

**C.7. Maximum age and growth performance:**

It has been pointed out by various authors that the value of “k” (the growth coefficient in Von Bertalanffy growth formula) in fishes is closely linked with longevity. Generally in nature, the oldest fishes of a stock grow to reach about 0.95 in their asymptotic length (Beverton & Holt, 1963)

As is shown in table (15) the maximum age of the two species were found to be 11.45 years for *D. sargus* and 11.62 years for *D. vulgaris*. This means that the two species have nearly the same longevity.

The growth performance values in length (\(\Phi_t\)) of the two species are 2.41 for *D. sargus* and 2.40 for *D. vulgaris*. The growth performance values in weight (\(\Phi_w\)) are 1.231 and 1.205 for *D. sargus* and *D. vulgaris* respectively.
CHAPTER V
DEMOGRAPHIC STRUCTURE

A. Length Frequency:

From table (16), we notice that the smallest fish noted in the catch of *D. sargus* was 7.5 cm TL, while the biggest length was 27.5 cm. Most fish represented in the catch of this species lie within the length range 10.5 and 20.5 cm total length. While the catch of *D. vulgaris* comprises lengths between 8.5 and 26.5 cm. Most abundant length groups lie between 10.5 and 14.5 cm and also between 16.5 and 21.5 cm total length.

From figure (23) which shows the length frequency distribution of *D. sargus*, four modal lengths could be detected. These are; (13.5, 17.5, 21.5 and 23.5 cm). In *D. vulgaris* (Figure 24) three modal lengths are apparent, these are; (13.5, 17.5 and 21.5 cm). We notice here that no concordance is apparent between these modal lengths and the calculated length at age, for both species.

Figures (25 & 26) show that, the length range of different age groups. Overlapping between different length groups at different ages is apparent. This explains the absence of concordance between modal length and length at age for the two species. So here we can say that, this venders it difficult to discriminate between different age groups, by means of length frequency distribution.

B. Age Composition:

Figures (27 and 28) and table (17) show that abundance of different age groups in the landed catch of the two species under study *D. sargus* and *D. vulgaris*. In *D. sargus* we notice that, the most abundant age group is age group II followed by age group I.
Age groups V and VI are of very low abundance. In case of *D. vulgaris* age groups I and II are of equal abundance, while age groups III is nearly two thirds of age group II. Age groups V and VI are of very low abundance in the landed catch.

**C. Sex Ratio:**

According to the present data it was found that the value of sex ratio for *D. sargus* was 1: 4 males to females, while it was 2: 3 males to females for *D. vulgaris*.

**D. Survival and Instantaneous Mortality Coefficients:**

There are separately two causes of mortality, natural and fishing mortalities. The summation of the natural mortality coefficient (M) and the fishing mortality coefficient (F) gives the total mortality coefficient (Z).

**D.1. Instantaneous total mortality coefficient “Z”:**

Figures (29 & 30) Show that, a dome shaped curve is obtained by plotting the natural log of the number of fish in each age group against their corresponding ages. This curve has an ascending part and a descending part.

The ascending part represents the fish which are still small and hence escape from the fishing gear. The vulnerable part of fish populations is included in the descending limb of the catch curve (Pauly, 1980 and Sparre & Venema, 1998).

The slope of the descending limbs (which is a straight line) represents the total mortality coefficients ‘Z’. This was found to be equal to 1.0917 year\(^{-1}\) for *D. sargus* and 1.0487 year\(^{-1}\) for *D. vulgaris*. 
D.2. Instantaneous natural mortality coefficient “M”:

The instantaneous natural mortality coefficient (M) was estimated by applying the empirical equation derived by Pauly, 1980 based on the constants $L_\infty$ and K of Von Bertalanffy growth model and the annual mean temperature of the water in which the fish stock in question lives. The value of the instantaneous natural mortality coefficient for *D. sargus* and *D. vulgaris* were 0.606 and 0.6 year$^{-1}$ respectively.

D.3. Instantaneous fishing mortalities coefficients “F”:

The fishing mortality coefficient of *D. sargus* and *D. vulgaris* in Abu Qir Bay were computed to be 0.486 and 0.449 year$^{-1}$ respectively.

D.4. Estimation of the survival rates “S”:

Ricker, 1975 defines the “survival rate” as the number of fish alive after a specified time interval, divided by the initial number, usually on a yearly basis. In the present study it was 0.34 for *D. sargus* and 0.35 for *D. vulgaris*.

E. Exploitation Ratio “E”:

The rate of exploitation is defined as the ratio of fishing mortality to total mortality, it gives an indication of whether a stock is overfished or not on the assumption that the optimal value of (E) should be about 0.5 (Gulland, 1971).

The values of the exploitation rate of *D. sargus* and *D. vulgaris* in Abu Qir Bay were 0.445 and 0.428 respectively.

F. Length and Age at First Capture:

Length at the first capture ($L_c$) is defined as the length at which the fish may be vulnerable for fishing. The values of $L_c$ as computed in the present
study were found to be 12.51 and 12.52 cm and the corresponding values of \( t_c \) were 1.208 and 1.42 years for \( D. \) \textit{sargus} and \( D. \) \textit{vulgaris} respectively.

**G. Length and Age at Recruitment:**

Recruitment is the process in which young fish enter the exploited area and become liable to contact for the first time with the fishing gear. Length at recruitment (\( L_r \)) was estimated according to Pauly, 1984; it was found to be 10.43 cm for \( D. \) \textit{sargus} and 10.62 cm for \( D. \) \textit{vulgaris}.

As shown in table (18) the corresponding ages at recruitment (\( t_r \)) were 0.81 and 1.05 year for \( D. \) \textit{sargus} and \( D. \) \textit{vulgaris} in Abu Qir Bay respectively.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( D. ) \textit{sargus}</th>
<th>( D. ) \textit{vulgaris}</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_\text{-} )</td>
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<td>16.23</td>
</tr>
<tr>
<td>( M )</td>
<td>0.606</td>
<td>0.600</td>
</tr>
<tr>
<td>( Z )</td>
<td>1.092</td>
<td>1.049</td>
</tr>
<tr>
<td>( F )</td>
<td>0.486</td>
<td>0.449</td>
</tr>
<tr>
<td>( S )</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>( L_c )</td>
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<td>12.52</td>
</tr>
<tr>
<td>( L_r )</td>
<td>10.43</td>
<td>10.62</td>
</tr>
<tr>
<td>( t_c )</td>
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<td>1.420</td>
</tr>
<tr>
<td>( t_r )</td>
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<td>1.05</td>
</tr>
<tr>
<td>( E )</td>
<td>0.445</td>
<td>0.428</td>
</tr>
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</table>
CHAPTER VI
MANAGEMENT

The task of fisheries management is to gather, analyze, plan, consult and decision making. Fisheries management has as a final goal, giving advices to decision makers in order to improve the state of fishery. These decisions are accomplished with enforcement of regulations or rules (as necessary) which govern fisheries activities to ensure the continued productivity of the resources and accomplishment of other fisheries objectives.

Among management objectives is to ensure the economic and social well being of future generations or to protect their habitats.

In fact fisheries managers need scientific advice on the effect of fishing on target fish species. Protection of these species is likely to become a key objective in management plans.

Various models have been proposed to study fish populations and effect of fishing operations on them. The yield per recruit model of Beverton and Holt, 1957 is the most recommended model.

A. Yield per Recruit:

The analytical model derived by Beverton & Holt, 1957 incorporates informations on growth, age (or size) structure, natural mortality rates and harvesting strategy into population dynamics of the species. This model expresses yield on a “per recruit basis”, so the yield is relative to the recruitment. Yield per recruit and biomass per recruit models represent the most appropriate stock assessment models available (Butterworth, 1997).

In this model, it is assumed as a first approximation that, the population is in the steady state described by Beverton & Holt, 1957; i.e. the instantaneous natural mortality coefficient of fishes in the population is (at
any given age) constant. This model incorporates the interplay of somatic growth and the probability of dying in order to predict the life time yield of a cohort and the biomass remaining, under different combinations of fishing mortality and age at first capture (Griffiths, 1997).

The yield per recruit model describes the state of the stock and the yield in a situation when the fishing pattern has been the same for such a long time that all fish alive were exposed to it since they recruited. In the present study the yield per recruit were estimated (according to Beverton and Holt model) to be 27.76 gm and 25.99 gm for *D. sargus* and *D. vulgaris* respectively.

**B. Biomass per Recruit:**

Beverton and Holt biomass per recruit model expresses the average biomass of survivors as a function of fishing mortality and related to the yield per recruit values. According to the present data the biomass per recruit for *D. sargus* and *D. vulgaris* were 57.16 and 57.90 gm respectively.

**C. Estimation of The Biological Target Reference Points (F_{0.1} & F_{max}):**

For the sake of proper management of a fishery, and in order to prevent over exploitation or complete collapse of the fishery, there appears the need to identify some biological points, which might help in this concern. Many technical reference points have been proposed for rational exploitation of fishery resources. There are two types of fishery technical reference points, namely, target reference points (F_{0.1}) and limit reference points (F_{max}).

The limit reference point (LRP) may correspond to some minimum conditions (e.g. a dangerously low spawning biomass) or some maximum conditions (a high rate of decline in stock size, or a high mortality rate) at which point a management response is automatically triggered (Caddy & Mahar, 1995). Then the limit reference point indicate a state of the fishery
which is considered to be undesirable and which management plan should avoid.

The biological target reference points (TRP) indicate a state of a fishery which is considered to be desirable and at which management action should aim. They are defined as the level of fishing mortality (or of the biomass) which permits a long term sustainable exploitation of the stocks, with the best possible catch. They can be characterized as the fishing level (F target) or by the Biomass (B target). The most accepted “F” target is F_{0.1} (Cadima, 2003).

The use of target reference points is now a common practice to do in fisheries management. This helps to define optimum fishing mortalities from a per recruit point of view. The evaluation of the biological reference points has to be updated, taking into consideration the possible changes in the biological parameters or any other necessary corrections of the exploitation pattern. This fact is important because the new biological reference points will be different from the previous ones.

F_{max} is defined as the point on the curve (Y/R against F) where Y/R is maximum. F_{max} only indicates the value of “F” which gives the maximum possible yield per recruit from a cohort during its life for a given exploitation pattern. F_{max} strategy achieves the highest total catch at the expense of severe biomass per recruit reduction (Punt et al., 1993, Booth & Baxton, 1997). Even F_{max} which usually is used as a target-point have been proposed as a Limit Reference Point (LRP) in some cases (Cadima, 2003).

The values of yield per recruit and the biomass per recruit for the two species under study as a function of fishing mortality (by testing various values of fishing mortality) are shown in tables (19 and 20) and figures (31 & 32). The maximum yield per recruit (Y/R_{max}) (according to the present
results) for *D. sargus* was 31.1233 gm which corresponds to maximum fishing mortality value $F_{\text{max}}$ (1.239), while for *D. vulgaris* $Y/R_{\text{max}}$ was 29.7867 gm corresponding to $F_{\text{max}}$ 1.245.

The percentages of biomass per recruit value to the virgin biomass at the maximum fishing value for *D. sargus* and *D. vulgaris* were 16.26 and 16.09 respectively.

Punt *et al.*, 1993 recommended the use of $F_{0.1}$ as a target reference point, since he stated that it could be used with relative safety with the least risk of stock collapse.

The value of the biological target reference point $F_{0.1}$ was estimated for the two species under study in Abu Qir Bay. It was 0.486 for *D. sargus* which is equal to the actual fishing mortality value and 0.484 for *D. vulgaris*.

The percentages of biomass per recruit value to the virgin biomass at the biological reference point ($F_{0.1}$) for *D. sargus* and *D. vulgaris* were 36.99 and 36.90 respectively.

**D. The Effect of variations of $t_c$ on $Y/R$:**

Tables (21 & 22) represent the effect of age at first capture on yield per recruit according to the present values of fishing mortality of each species under study. It is noticed that, the difference between the observed $Y/R$ values and the values of $Y/R_{\text{max}}$ of *D. sargus* is about 0.05gm. For *D. vulgaris* this deference is 0.014 gm. This means that the increase of age at first capture has a little effect on yield per recruit, in both species under a constant value of fishing mortality.

From these tables we notice that, as we go from the low values of $t_c$ (0.1) to the actual value (for the two species under study) a rapid rise in the value
of Y/R occurs. After the observed value of t\textsubscript{c} the rate of increase decreased drastically, so that no big difference occurred between the observed value of t\textsubscript{c} and that corresponding to the maximum value of Y/R.

E. The Effect of ‘F’ on ‘Y/R’ at Different Values of ‘t\textsubscript{c}’:

Yield per recruit model (Dynamic pool model) of Beverton & Holt, 1956 & 1957 has been widely used in the management of marine fisheries, especially reef fisheries. The advantage of this model is that it allows for the easy evaluation of the response of yield to changes in fishing mortality. Restrepo, 1999 stated that, the yield per recruit is the expected yield per fish recruited to the stock at specific age.

The effect of fishing mortality together with age at first capture on the values of yield per recruit were estimated for the two species under study and represented in tables (23 & 24) and figures (33 & 34). Two values of t\textsubscript{c} beside the observed value were used with difference 0.5 year higher and lower than the actual value of t\textsubscript{c}.

As mention before, at a constant fishing mortality (actual value) t\textsubscript{c} values were nearly equal to the maximum t\textsubscript{c} for both species under study. In \textit{D. sargus}, at the lower value of t\textsubscript{c} the maximum yield per recruit (27.5351 gm) corresponds to an “F” value of 0.774 year\textsuperscript{-1}, at the actual value of t\textsubscript{c} the maximum yield per recruit (31.1233 gm) corresponds to an “F” value of 1.239 year\textsuperscript{-1}, while at the higher t\textsubscript{c} the value of maximum yield per recruit (33.6795 gm) was higher than the yield of the previous values of t\textsubscript{c} and corresponding to fishing mortality 2.353 year\textsuperscript{-1}.

In \textit{D. vulgaris}, at the lower value of t\textsubscript{c} the yield per recruit peak corresponds to an “F” value of 0.779 year\textsuperscript{-1}, at the actual value of t\textsubscript{c} the yield per recruit peak corresponds to an “F” value of 1.245 year\textsuperscript{-1}, while at the
higher \( t_c \) the values of yield per recruit were higher than the yield of the previous values of \( t_c \) and reach their peak (32.1695 gm) with fishing mortality value of 2.364 year\(^{-1}\).

These results indicate that, the yield per recruit values were increased with the increase of fishing mortality together with the increase of age at first capture. By another meaning, as \( t_c \) increases the yield per recruit need to increase fishing mortality to reaches a higher maximum value.

**F. The Effect of ‘F’ on ‘Y/R’ at Different Values of ‘M’:**

Yield per recruit at the current age of 1st capture \((t_c = 1.208 \text{ for } D. sargus \text{ and } 1.42 \text{ for } D. vulgaris)\) and at three alternative values of natural mortality with the predicted range \((M = 0.400, 0.600, 0.800)\) are shown in tables (25 and 26) and figures (35 & 36). It is noted that maximum yield per recruit changed widely with “M“. For \( D. sargus \), at \( M = 0.406 \text{ year}^{-1} \), the maximum yield per recruit corresponds to a value of \( F = 0.561 \text{ year}^{-1} \). At the current value of \( M \) the maximum yield per recruit corresponds to a value of \( F = 1.239 \text{ year}^{-1} \) while at the higher value of \( M \) the maximum yield per recruit corresponds to a value of \( F = 2.588 \text{ year}^{-1} \).

In \( D. vulgaris \) it appears that at \( M = 0.400 \text{ year}^{-1} \), the maximum Y/R, corresponds to a fishing mortality 0.618 year\(^{-1}\), while at the current value of \( M \), the maximum value of Y/R corresponds to a value of \( F = 1.245 \text{ year}^{-1} \). At the higher value of \( M \) (0.8 year\(^{-1}\)), the fishing mortality corresponding to the maximum Y/R (24.66 gm) is equal to 2.658 year\(^{-1}\).

From these results, we notice that, as the value of \( M \) increases, the maximum value of Y/R decreases at a constant fishing mortality.

In other words the natural mortality affects the fish production directly. This explains the effect of water pollution on fish populations in Abu Qir
Bay. Also, we can say that a decrease in water pollution in the Bay would increase production of Diplodus spp, and would decrease the fishing effort needed. In this concern a study of the amount of recruited population is needed as well as the chemical characteristics of water in the bay in order to be able to give a good idea on proper management of such a fishery.

**G. Virtual Population Analysis (VPA):**

Cohort analysis or virtual population analysis has its importance in fish population dynamics. It gives important ideas on the fish abundance and instantaneous fishing mortality coefficients of the cohort at different time intervals as the instantaneous natural mortality coefficients are known.

Virtual population analysis uses the numbers of fish caught during commercial fishing operations to estimate historic fishing mortality and stock numbers in a cohort of fish. It estimates how many fish must have been in the sea to account for that catch, under the assumption that natural mortality is constant and the numbers or weights of catch samples during the different years of life were known.

Virtual population or cohort analysis (Pope, 1972) is the most widely applied methodology for estimating stock size and exploitation pattern from catch data.

For age based VPA it is possible to trace each cohort or year class separately through the catch data. Provided an adequate estimate of the natural mortality (M) and terminal fishing mortalities (F) are available the numbers in the stock at each age in each year can be computed.

For length based VPA the cohort cannot necessarily be separated or easily be traced from year to year. Because of this, the population is assumed to be in a steady state having a stable length composition. Age based VPA is
not so constrained to the steady state and can provide informations more applicable for the short term as well as the long term.

Tables (27 & 28) and figures (37 & 38) represent the estimated values of the population numbers, survivors, natural and fishing mortalities for each year of life of *D. sargus* and *D. vulgaris* in Abu Qir Bay.

It is noticed that, the populations of the two species under study decreased gradually with age, this is due to the exposure to the sequence of natural mortality which decrease with age too and fishing mortality which appeared in different trends in the two species.

In both species under study (*D. sargus* and *D. vulgaris*) fishing mortality values of age groups 0 & I are smaller than the other age groups this is because fish at that age are of small size and hence can escape from the mesh in the fishing gear.

In *D. sargus* the maximum value of fishing mortality was in age group III (0.5238 year\(^{-1}\)) then it decreased till it reached 0.4316 year\(^{-1}\) in age group IV and it increased in age group V (0.5038 year\(^{-1}\)), while the terminal fishing mortality value in age group VI is 0.4857 year\(^{-1}\). The high values of “F” at age group V and VI is due to small numbers of individuals in these two age groups. From table (27), the catch of this species seem to depend on age group I and II.

In *D. vulgaris* fishing mortality values increase from the smaller ages to reach the maximum value in age group V (0.6737 year\(^{-1}\)) and decrease to reach the terminal value in age group VI (0.4489 year\(^{-1}\)). Age groups V and VI have the highest fishing mortality. Table 28 shows that, the catch seems to depend on age groups I, II and III.
CHAPTER VII

DISCUSSION

Since the beginning of the eighties in the last century, Abu Qir Bay is facing the problem of pollution from the effluents which are discharged from different sources; Eltabia Pumping Station (TPS), the outlet of Edku Lake and the Rosetta mouth of the Nile River. The estimated amount of untreated sewage and industrial wastes from 22 different factories pumped to Abu Qir Bay through TPS is of about 2 millions m$^3$/day (Zakaria, 2007).

The exchange of water between Abu Qir Bay and Edku Lake occurs through Elmaddiya channel (about 100 m long, 20 m wide and 3 m deep) is controlled by the prevailing wind and the difference in water level between the bay and the lake. Actually, the amount of brackish water discharged from the lake to the bay is at a rate of about 3.3 million m$^3$/day (Zakaria, 2007).

The water coming from Lake Edku and Rashid branch of the River Nile are usually loaded with pesticides, which come with draining waters from the cultivated lands.

As a result of these pollution problems the total landed catch in Abu Qir Bay gradually decreased from 1998 (939 tons) to 2008 (572 tons). On the other hand the landed catch at Alexandria reached its maximum in 2008 (19978 tons) and the landed catch of the Egyptian Mediterranean coast started to increase from 2003 (46973 tons) till 2008 (88882 tons). Another reason from the decrease in the landed catch in the Bay is the decrease in the number of working fishing boats especially during the last two years (2007 - 2008).
The long line fishery is the dominant fishing method used to catch Diplodus spp. among other fish species in Abu Qir Bay. Beside long lines Diplodus spp. might be caught also by trammel and trawl nets. In their study on the size selective characteristics of long line (Erzini et al., 1996 and 1999) claimed that no fish was caught below the minimum landing size by long lines. According to this author the long line fishery is far less detrimental to the stock than other fishing gear.

The present results show that the landed catch of Abu Qir Bay have decreased while that of the two species under study (D. sargus and D. vulgaris) increased from 1999 (11 tons) till it’s highest value in 2008 (23 tons). In spite of the fact that, the rate of increase in Abu Qir Bay is not as high as that in Alexandria coasts. However this means that, the two species under study are able to withstand the pollution of the Bay.

In fisheries studies, length weight relationship has many different uses, including the estimation of weight from length (Beyer, 1995), the estimation of weight at age (Petrakis & Stergiou, 1995) and the conversion of length at age into weight at age (Pauly, 1983). The establishment of length-weight relationship is also fundamental for the calculation of production and biomass of a fish population (Anderson & Gutreuter, 1983). This relationship is an essential biological parameter needed to appreciate the suitability of the environment for good living of fish, which reflects its importance in most fishery biology studies (Le Cren, 1951).

The rate of increase in weight reflects how the ecological factors of a certain habitat affect the fish in which it lives, particularly the amount of available food (Le Cren, 1951). Thus, fish weight is a more important
parameter than fish length to evaluate the suitability of a body of water as a fish habitat.

Growth is a physiological process which results in an increase of length and weight. A vector diagram known as growth curve is obtained, when length or weight of a fish is plotted against a specified period of time. This curve appears as a sigmoid one and may vary for the same species at different seasons or in different localities. The relationship between fish length and weight is considered to be of prime importance. This relationship is often used to compute the standing stock biomass (Smith, 1996 and Taskavak & Bilecenoglu, 2001) and also to estimate fish weight by knowing its length.

Length weight relationship is expressed by the formula of cube law $W = aL^b$. The exponent “$b$” in the length weight relationship was proposed to be “3” and called isometry (Le Cren, 1951). However this value could be higher or lower “3”, in this case the exponent “$b$” is called allometric coefficient. When “$b$” is greater than “3” then it shows positive allometry (The fish increase in weight more than increase in length). If it were less than “3” we call it negative allometry; the fish becomes lighter for its length. According to Bagenal & Tesch, 1978 the value of “$b$” is always between 2 & 4 and often close to “3”.

Length weight regression parameters for the two species understudy were done on the whole sample (combined sexes). In fact, no differences were observed between the two values of the exponent “$b$” of the two sexes. Various authors came to the same conclusion (Osman, 1994 and Mouine et al., 2007).
In the present study, the values of the exponent “b” were found to be negative allometry for *D. sargus* (2.942) and for *D. vulgaris* (2.9686). These values are slightly less than “3”. Length weight relationship of Diplodus spp. made the subject of study of various authors as shown in Table 29.

Table (29): The value “b” of length weight relationship of *D. sargus* and *D. vulgaris*.

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<thead>
<tr>
<th>Author</th>
<th>species</th>
<th>“b”</th>
<th>area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elmaghraby &amp; Botros, 1981</td>
<td><em>D. sargus</em></td>
<td>3.144</td>
<td>Egyptian Mediterranean water</td>
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<td>Gulf of Lion</td>
</tr>
<tr>
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<tr>
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</tr>
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<td>Elmaghraby &amp; Botros, 1981</td>
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<td><strong>Present study</strong></td>
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</tbody>
</table>

Lahlah, 2004 gave a value of “b” (2.859) for *D. sargus* which is also less than (3). On the other hand, Elmaghraby & Botros, 1981; Man Wai & Quignard, 1982; Morato *et al.*, 2003 and Mouine *et al.*, 2007 gave a value of “b” more than “3”, which means that the fish becomes heavier for its length as it grows larger. Elmaghraby & Botros, 1981 working on *D. vulgaris* gave a value of “b” higher than the present result (3.003) for the same species.

According to Planes *et al.*, 1999 growth in weight of Diplodus spp. appears to vary significantly between species and sites, so that ponderal growth rate would show a decrease due to cold water temperature and limited food availability. According to these authors, differences among sites probably are related to currents and water mass temperature that might have an effect on the value of “b”.

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Cushing, 1975 stated that the same species might show very different patterns of growth in different environments. Another cause for the observed differences in length weight relationships for the same species, among different authors might be the sampling procedure, namely sampling size and length range (Morato et al., 2003). From another point of view, Jobling, 1997 stated that thermal regime is known to influence fish growth.

Condition factor (k) has been used to determine the suitability of environment to a certain fish species. Knowledge of this coefficient is useful in fishery studies. Weatherly, 1972 showed that the determination of condition factor of fish species is very useful in comparing two or more fish populations living under similar or different conditions.

The present results show that, the overall mean value of condition factor (k) is higher in *D. sargus* (1.74) than *D. vulgaris* (1.63). It is known that the condition factor varies among species, and for the same species it varies with season and length. In most fish species the value of “k” decreases with fish length.

In case of *D.sargus* the value of “k” had the highest value at length group 11.5 cm and decreased at higher length groups. This is in accordance with the observations given by Lahlah, 2004; Elmaghraby & Botros, 1981 and Wassef, 1985 in Egyptian Mediterranean waters. In the present study, on a seasonal basis, the highest value of “k” was higher in summer and autumn than in winter and spring.

The depression in the value of “k” in winter could be due to the effect of spawning at that time. Lahlah, 2004 gave the same observation on the same species. Upon resumption of feeding in spring, the value of “k” started to increase.
Lahlah, 1999 in his study on *D. sargus*, in Syrian waters, noticed that the highest value of “k” was in summer, while it reached a lower value in autumn. He explained this to be due to its breeding season in Syrian waters where it spawns in autumn. Seasonal variations in condition factor were also recorded by several authors in various fish species (Keys, 1928; Le Cren, 1951; Wooton, 1989 and Abd Elbarr, 2004).

In studying the variation of condition factor with age, we noticed that the value of “k” in *D. sargus* was highest at age group I and decreased with age to reach minimum at age group VI.

Concerning *D. vulgaris* it was found that the value of “k” reached a high value at length group 11.5 cm and decreased thereafter with higher length. Elmaghraby & Botros, 1981 observed that, the highest value of “k” in this species was at length group 18cm, and decreased at length groups greater than that.

Seasonal variations in the value of “k” revealed that its maximum value was in summer and autumn and decreased in winter and spring. This could be explained due to the exhaustion of the fish body due to spawning in the spawning season (end of autumn and winter).

The same observations were given by Elmaghraby & Botros, 1981. From another point of view, condition factor reached its highest value at age group I and decreased with increasing age. Parrish & Mallicoaste, 1995 and Kreiner *et al.*, 2001 stated that condition factor is affected by food availability, physical factors and physiological state of the fish.

In order to properly manage a fishery, it is important to know the age of fish under investigation. Fish age can be determined directly by the
examination and interpretation of the annual checks formed on its different skeletal parts such as scales, otolith, vertebrae, fins, spines and operculae.

One of the main problems facing age and growth studies is how to select a suitable hard part in order to get a more or less valid estimation of fish age. Scales have been used for age estimation in various fish species (Carlander, 1978). However various authors claimed that, scale readings lead to under estimate fish age (in old fish) (Beamish & Mc Farlane, 1983).

Diplodus spp. are among long lived species and hence various authors recommended the use of otolith. Erzini & Lobo, 2001 were of the view that otoliths are preferable for age determination than scales. The stock of Diplodus spp. in Abu Qir Bay comprised fish from I to VI years of age. Scales in these age groups are easy to interpret.

Man Wai & Quignard, 1982 reported that scales of Diplodus spp. were clear to interpret at young age groups (from 1 to 6). Scale reading was adopted in the present study. Abecasis et al., 2008 compared between scales and otoliths for age determination of sea breams. They indicated that scales could be used as alternative non destructive technique with good results for *D. sargus* and *D. vulgaris*.

In Egyptian Mediterranean waters, many authors used the scales for age determination of the two species understudy as Elmaghraby *et al.*, 1982; Wassef, 1985 & Lahlah, 2004. It is important to know the time of annulus formation on fish scale in order to clarify whether growth is continuous throughout the year or not. It is known that, growth is affected by low water temperature in winter. However sometimes growth rate is affected by the physiological status of the fish, e.g. after spawning season when the fish body is exhausted due to spawning. In the two species understudy the annual
check appear to take place in April. This means that, these two species are affected by low winter temperature besides spawning.

According to Wassef, 1985 and Lahlah, 2004; Spawning season for D. vulgaris starts in November and ends in March while for D. sargus it starts in January and ends in April. Man Wai & Quignard, 1982 stated that the breeding period of D. sargus in Lion Gulf (France) started in March and ended in April. Mouine et al., 2007 stated that the spawning season of D. sargus in Tunis started in March and ended in May.

Man Wai & Quignard, 1982 also stated that, the formation of the annual ring took place in April, May and June. They added that, for individuals older than five years, two rings are formed close to each other in one year on the scale, one due to the effect of winter.

Length scale relationships for both species according to the present study were found to be linear. This is in accordance with Elmaghraby & Botros, 1981; Man Wai & Quignard, 1982 and Lahlah, 2004. Back calculations according to scale readings revealed that, the highest rate of growth was observed in the first year of life, linear growth rate decreased thereafter gradually with age. This phenomenon is known in fish growth (Nikolsky, 1963).

Controversy in the values of back calculated lengths of D. sargus are clear in table (30). From this table we notice that the present values for lengths of D. sargus by the end of various years of life are higher than those obtained by Lahlah, 2004 for the same species. However they are lower than those obtained by Elmaghraby & Botros, 1981; Gonçalves, 2000 and Pajuelo & Lorenzo, 2002.
They are comparable to those given by Man Wai & Quingard, 1982 in the gulf de Lion, France. For *D. vulgaris*, the present results are more or less similar to the values obtained by Elmaghraby and Botros, 1981 while they are lower than those obtained by both Gonçalves, 2000 in Portuguese water and Ali, 1996 in Egyptian Mediterranean waters who used the otolith for age determination.

This disagreement among the results given by various authors might be due to interregional variations in growth rates (Elzarka, 1959; Pauly, 1981 & 1984 and Gonçalves, 2002) or different techniques used in age determinations. Elzarka, 1959 and Werder & Gercilia, 1985 stated that, the controversy might be due to the scales might be collected from different parts on the fish body.

In the present results, it appears that the mean back calculated lengths of *D. sargus* are slightly higher than *D. vulgaris*, this is in accordance with Elmaghraby & Botros, 1981. Biological interaction among the two species, especially in getting food could be a cause as well as genetic factors. The two species are known to feed on the same diet (Fischer & Bauchot, 1987).

Growth in weight or ponderal growth has been estimated for both species understudy, the least increment in ponderal growth, was found to be by the end of the first year of life. The same controversy between results given by various authors for back calculated lengths, appear in back calculated weights.

The mean back calculated weight values for *D. sargus* in the present study are much lower than those given by Elmaghraby & Botros, 1981 and Man Wai & Quignard, 1982 in France, while they are higher than those given by Lahlah, 2004.
Concerning *D. vulgaris* the values given by Elmaghraby & Botros, 1981 were lower than the present results. Table (31) shows that the back calculated weights for *D. sargus* are higher than those obtained for *D. vulgaris*.

Asymptotic length and weight according to the present study for *D. sargus* were 31.38 cm T.L. and 524 gm T.Wt. respectively. Various authors gave different values for asymptotic length and weight of *D. sargus* (Table 32), Lahlah, 2004 in his study on *D. sargus* obtained higher values for the asymptotic length and weight than the present results. Abecasis *et al.*, 2008 in Portugal gave also higher value for \( L_\infty \). The estimated parameters vary as a function of a variety of factors (region and methods of age estimation, direct or indirect).

The present results are near to those given by Lahlah, 2004 in the Mediterranean, Man Wai, 1985 and Mann & Buxton, 1997 in South Africa. However they are much lower than those given by other authors. This controversy as said before is expected due to various techniques used in age estimation as well as to interregional differences.

The value of \( L_\infty \) of *D. vulgaris* according to the present results was 31.3 cm. This value is higher than that estimated by Girardin, 1978 in the North Western Mediterranean water (Table 33) and Gonçalves, 2000 in Portugal as well as Abecasis *et al.*, 2008 and Erzini *et al.*, 2001. They are lower than those given by Man Wai, 1985 in the Mediterranean waters (Gulf of Lion).

The value of asymptotic length in the present study is near to that obtained by Ali, 1996 in the Egyptian Mediterranean water. Matsau, 2001 described Sparidae to be long lived fish. According to Whitehead, 1986 the
maximum attainable length for *D. sargus* may be well over 45 cm TL in North Eastern Atlantic and Mediterranean Sea.

The value of growth coefficient “k” in the present study was found to be equal to 0.262 for *D. sargus* and 0.258 for *D. vulgaris*. Hotzhausen & Kirchner, 2001 reported that as the value of “k” increases the rate of growth increases. This would explain the higher growth rate of *D. sargus* than *D. vulgaris* and can explain the superiority of the back calculated lengths in *D. sargus* than *D. vulgaris*.

The same variations and controversy observed in the values given for $L_\infty$, could be easily detected in the values given for “k” by various authors. In the present study the value of “k” for *D. sargus* was higher than those obtained by Lahlah, 2004 (Table 32) and those given by Abecasis et al., 2008. In case of *D. vulgaris*, the present value of k was higher than those given by Ali, 1996 (Table 33) and lower than those obtained by Gonçalves, 2000 in Portuguese waters.

The variations in the value of “k” among different regions are acceptable due to interregional variations among the geographic areas in which these fish live. The same controversy observed in the values of $L_\infty$ and k in the two species studied could be observed also in the values of $t_o$.

From the above discussion, it appears that the values of Von Bertalanffy growth formula parameters show differences among various geographic localities for the same species. Such differences are due to variations in environmental conditions as well as sampling techniques and computations (Hernandez, 1986).
Gonçalves, 2002 suggested that D. vulgaris is a relatively fast growing fish. He added that it was much faster in growth than D. sargus. Man Wai & Quignard, 1982; Man Wai, 1985 and Mann & Buxton, 1997 were of the same view. However the present results have shown that D. sargus has a faster growth rate than D. vulgaris, both in length and weight and the growth performance of D. sargus in Abu Qir bay is higher than D. vulgaris.

In the study on ageing of sea breams, Abecasis et al., 2008 gave value of growth performance of D. sargus to be 2.37 and for D. vulgaris 2.33. The value of L_∞ according to these authors (by using scales for ageing), was 39.55 for D. sargus and 34.49 for D. vulgaris. Moreover if we compare the value of length or weight at the same year of life between the two species, we can see that D. sargus is much faster in growth than D. vulgaris and reaches a higher lengths and weights than it.

The growth performance index is considered to be a convenient and robust tool for the comparison of growth parameters from different data sets (Moreau et al., 1986 and Pauly, 1980). Furthermore the value of growth performance index might represent and quantify the energetic of a given habitat or niche because this index is directly related to metabolism and food consumption (Munro & Pauly, 1983).

In the present study, the value of growth performance parameter for D. sargus, (Φ = 2.41) was higher than those estimated by Lahlah, 2004 (Φ = 2.13). In case of D. vulgaris in the present study, (Φ = 2.40), which is lower than that observed by Man Wai, 1985 (Φ = 2.41) in Portuguese water and higher than Girardin, 1978 in North West Mediterranean (Φ = 2.26). Variations in the values of the parameter of growth performance might
suggest variations in the growth rate. We should note that *D. sargus* in Abu Qir has higher growth rate and higher performance index than *D. vulgaris*.

According to Lahlah, 2004, the longevity of *D. sargus* was 13.4 years, which is higher than the value given in the present study. The longevity of fish species might be affected by the environmental conditions under which a fish lives (Wooton, 1989).

Hence *D. sargus* which was studied by Lahlah, 2004 was living in sea weeds, while that in the present study is living in Abu Qir bay which is known to be affected by pollution. According to Gonçalves, 2000; Morato, *et al.*, 2001 and Man Wai, 1985 *D. vulgaris* could live 10 to 14 years. On the other hand *D. sargus* according to Mann & Buxton, 1997 could reach 21 years of age. The present results gave a higher longevity for *D. vulgaris* (11.62 years) than for *D. sargus* (11.45 years).

The analysis of length composition of the catch of the two species under study from Abu Qir Bay revealed that, the catch of *D. sargus* is composed of 21 length groups the least was length group 7.5 cm and the biggest was 27.5 cm with mean length 16.16 cm, while the catch of *D. vulgaris* is composed of 19 length groups starting from 8.5 cm to 26.5 cm with mean length 16.23 cm. The most abundant length group was 17.5 cm for the two species. It should be noted that, the two species under study have nearly the same mean length.

The length range of *D. sargus* is in agreement with the length range of the fish samples of the same species which were collected by Lahlah, 2004 in front of Alexandria (Egypt), where it ranged from 9 to 29 cm with mean length 15.72 cm. and the most abundant length group was 17 cm.
Elmaghraby & Botros, 1981 in their study on *D. sargus* in the same area of study mentioned that, the length range of this species from 6 to 39 cm, and the dominant length group was 16 cm with mean length 16.77 cm. While Elmaghraby *et al.*, 1982 found the length range of *D. sargus* to be from 19 to 39 cm in the Egyptian Mediterranean waters.

Abecasis *et al.*, 2008 found that, the length range of *D. sargus* was from 4 to 44 cm in South Portugal. In North Western Mediterranean along the Catalan coast, Gordoa and Moli, 1997 collected samples of *D. sargus* varying between length 8 cm to length 40 cm.

The minimum length of the landed catch of *D. vulgaris* in the same area of study at 1981 was 6 cm and the maximum length was 30 cm (Elmaghraby & Botros, 1981) the dominant length groups were 23 and 24 cm with mean length 18.28 cm. On the other hand Elmaghraby *et al.*, 1982 found the length of *D. vulgaris* to be varying between 16 and 29 cm in the Egyptian Mediterranean waters.

Morato, *et al.*, 2001 in their study *D. vulgaris* in South coast of Portugal claimed that their lengths varied between 13.8 and 37.9 cm, with mean length 24.14 cm for males and 23.46 cm for females. Abecasis *et al.*, 2008 stated that, the length range in their studies on *D. vulgaris* varied from 3 to 37 cm in South Portugal. Gordoa & Moli, 1997 found the lengths of *D. vulgaris* to vary between 8 and 28 cm in North Western Mediterranean along the Catalan coast.

Sex ratio is one of the major parameters in the study of fish population. The present study revealed that males were less abundant than females (sex ratio of *D. sargus*, 1:4 males to females while for *D. vulgaris* it was 2:3 males to females).
*D. sargus* and *D. vulgaris* are known to exhibit protandrous hermaphroditism. Study of the hermaphroditism is out of our scope of the present investigation. However there are various postulations for dominance of females in fish populations. Erkoyoucu & Ozdamar, 1989 who were studying anchovy populations, also Milton, 1994 on Clupeid fish, stated that females dominate at bigger sizes. The present results show the same phenomenon in *D. sargus* and *D. vulgaris* in those females predominate in bigger size groups.

Elgreisy, 2000; D’Ancona, 1949; Elmaghraby *et al.*, 1982; Micale, 1985; Zaki *et al.*, 2001 and Lahlah, 2004 showed that *D. sargus* is a protandrous hermaphroditite. Lahlah, 2004 claimed that in *D. sargus* self fertilization may be possible, since he found various individuals with simultaneous ripening in ovary and testis.

If we consider population growth to be a positive aspect of dynamics of fish populations, then mortality can be seen as a negative counterpart (Sparre & Venema, 1998).

The total mortality is defined as the total number of fishes missed by death from a given population during a certain time interval. The total mortality consists of two types: natural mortality (M) and fishing mortality (F).

The total mortality can be estimated by various methods (Sparre & Venema, 1998) in the present study, it was estimated by the analysis of the catch curve which represents the relationship between the Ln the number of fish taken by fishing at the corresponding ages, the descending part of the catch curve was used to estimates the total mortality (Pauly, 1980). The total
mortality as evaluated in the present study was 1.092 / year$^{-1}$ for *D. sargus* and 1.049 / year$^{-1}$ for *D. vulgaris*.

In spite of the wide distribution and importance of these two species under study there are just few publications existing on their mortality and fisheries management. Morato *et al.*, 2001 estimated the value of total mortality for *D. vulgaris* in the South coast of Portugal, which was equal to 0.625 / year$^{-1}$.

Natural mortality is a key factor in the ecology of fish populations and the natural mortality rate is also a basic parameter in the studies of production, biomass ratio in field populations (Mc Gurk, 1986) and the theoretical analysis of size distributions (Peterson, 1984).

The same species may have different natural mortality rates in different areas depending on the density of predators and competitors, whose abundance is influenced by fishing activities (Sparre & Venema, 1998). Natural mortality is also affected by water quality in which the fish lives.

The natural mortality values of the two species under study were nearly the same (0.606 / year$^{-1}$ for *D. sargus* and 0.600 / year$^{-1}$ for *D. vulgaris*). Mennes, 1985 found that, the natural mortality (M) of *D. vulgaris* was 0.660 / year$^{-1}$ which could be related to the high productivity rates of North West African coast.

Erzini *et al.*, 2001 in their study on fisheries biology and assessment of demersal species from South of Portugal stated that, the estimated values of “M” ranged between 0.19 to 0.66 / year$^{-1}$ with mean of 0.36 / year$^{-1}$.

Estimation of fishing mortality for the two species under study revealed that, there was no significant difference between their fishing mortalities.
Fishing mortalities for the two species was 0.486 / year$^{-1}$ for *D. sargus* and 0.449 / year$^{-1}$ for *D. vulgaris* in Abu Qir Bay. The value of “F” for *D. vulgaris* is lower than that given by Gonçalves *et al.*, 2002 (0.625 year$^{-1}$).

Yield per recruit is the expected yield per fish recruited in the stock at a specific age; it plays an important role in advice for management, particularly as it relates to minimum size controls (Restrepo, 1999).

There are various methods proposed to determine yield per recruit (Clark, 1991; Thompson, 1993 and Mace, 1994). The yield per recruit model of Beverton & Holt, 1956 & 1957 has been widely applied in the management of reef fisheries (Huntsman *et al.*, 1983 and Punt *et al.*, 1993).

The average biomass per recruit is defined as the average biomass of the exploited part of the cohort (The biomass of fish of age $t_c$ and older). In the case of $F = 0$, the value of biomass per recruit considered as the virgin biomass per recruit (The biomass of the unexploited stock). We can also express the biomass per recruit as a percentage of the virgin biomass.

Fisheries management needs estimates of harvest levels that provide maximum yield on a long term basis. Beverton & Holt, 1957 model can be used to forecast the effects of development and management measures, such as increase or reduction of fishing fleets, changes in minimum mesh sizes, etc. Therefore this model forms a direct link between fish stock assessment and fishery resource management.

Fisheries for demersal reef fishes in tropical and warm temperate regions are typically multispecies and the fish are harvested using a wide variety of methods (Munro & Williams, 1985). They are of particular importance to many developing countries, where large numbers of coastal people are
dependent on them both for income and as their main protein source. However, owing to their complexity they pose particularly serious management problems.

The Y/R depends on the exploitation pattern or fishing regime and natural mortality. For a given exploitation pattern, rate of growth and natural mortality, an equilibrium value of Y/R can be calculated for each level of F. It increases with F up to a point where the maximum sustainable yield is obtained. Beyond this point overfishing occurs.

Fisheries management of most commercial resources worldwide has historically concentrated on two ways: management of catch or of effort. Management of catch is usually achieved through imposing quotas or gear restrictions, while management of effort can include limitations of numbers of fishermen or vessels, closed seasons (from the beginning of May to the middle of June in Abu Qir Bay during the year 2008), or temporary area closure (Pitcher & Hart, 1982). These approaches have been successful in many cases to prevent overexploitation of stocks or sometimes even collapse of the fishery.

The main objective of fish stock assessment of exploited stocks is to predict what will happen in terms of future yields, biomass levels (sustainability) and value of the catch, if the level of fishing effort remains the same or if it is changed in one way or another.

There is an equilibrium value of yield per recruit which can be calculated for each level of fishing mortalities. Yield per recruit increases with increasing “F” till it reaches a point where the maximum sustainable yield per recruit is obtained, this value corresponds to $F_{\text{max}}$. Beyond that point, there is growth over fishing (Beverton & Holt, 1957).
As shown in the present study, surviving biomass falls continually as F is increased and one needs to select a fishing mortality rate that does not only achieve a good yield per recruit but also leaves a sufficiently high biomass (as indicated by biomass per recruit) in the water to ensure maintaining of a good recruitment. It is commonly accepted that for many stocks the minimum desirable biomass is between 30 and 40% of the biomass in the absence of fishing (Cochrane, 2002).

There is no theoretical basis for the use of the $F_{0.1}$ reference point except that it will always be less than $F_{\text{max}}$ and hence result in a higher biomass after fishing and it has been found, in general, to be quite robust to important uncertainties.

$F_{0.1}$ is considered as a target reference point and $F_{\text{max}}$ as a limit reference point. $F_{0.1}$ of *D. sargus* in the present study was found to be equal to the actual value of fishing mortality in Abu Qir Bay. For *D. vulgaris* $F_{0.1}$ was found to be nearly equal to the actual value of fishing mortality. This means that, there is no need to increase the fishing effort in Abu Qir Bay for these two species.

Since the actual values of fishing mortality of the two species did not reach the values of the limit reference points $F_{\text{max}}$, therefore the fisheries status in Abu Qir Bay for these two species are still in good condition and reach the target reference point.

To determine the most appropriate age at first capture ($t_c$) for both species in Abu Qir Bay, the yield per recruit values were determined as a function of age at first capture. The results show that, there is no significant difference between the value of $t_c$ maximum (which corresponding to the maximum $Y/R$) and the actual values of the two species under study. At the same time,
the values of the maximum yield per recruit (which corresponding to maximum $t_c$) and the actual value of yield per recruit for both species.

Beverton & Holt, 1957 stated that, the age at first capture $t_c$ affects the value of yield per recruit (Sparre & Venema, 1998). According to the present results, the $Y/R$ increases as the value of $t_c$ increases till it reaches $t_c$ maximum then the value of $Y/R$ decreases with the increase of $t_c$.

Abd Elbarr 2004 in his study on Boops Boops stated that, the $Y/R$ increases as the value of $t_c$ decreases. Griffiths, 1997 on Argrosomus inodorus, came to the same conclusion as the present study. Booth & Buxton, 1997 showed that biomass per recruit decreased with increasing fishing mortality.

If we increase the value of natural mortality, the fishing mortality that is needed to produce the maximum yield per recruit increases; this observation was given by Booth & Buxton, 1997 on Pterogymnus laniarus (Sparidae) in the banks of Angola, as well as Miranda et al., 2000 in Brazil.

The present results show that the $Y/R$ is more sensitive to the natural mortality than to age at first capture. Thus a decrease of 0.2 in the value of M causes an increase in the $Y/R$ by about 44.4% of the present value of $Y/R$ ($t_c$ being constant), this is true for the two species under study.

On the other hand as the value of $t_c$ decrease by 0.5 year, the value of $Y/R$ decrease by about 3.38% of it is current value at the present fishing mortality.

Biomass per recruit is also affected by a change in fishing mortality. The present results show this fact, that as the fishing mortality increases the $B/R$ and % $Bv$ decreases. This observation was given before by different authors.
on different fish species (Lehtonen, 1981; Griffiths, 1997 and Booth & Buxton, 1997).

In order to manage exploited ecosystems, one must have knowledge of the resources they contain. For this reason fisheries management has for decades focused on obtaining informations on catches and on stock sizes of the exploited resources in a species -by-species manner.

Some stock assessment methods have been developed to use the length composition or age composition data to analyze the effect that a fishery had on a particular year class of a stock. The methods that deal with the future expectation are called “Predictive methods”, while the methods that look to the past using historic data are called (Virtual population analysis ‘VPA’ or cohort analysis”.

VPA therefore looks at a population in a historic perspective. The advantage of doing a VPA is that; once the history is known it becomes easier to predict the future catches, which is usually one of the most important tasks of fishery scientists. VPA has been widely used in fish stock assessment during the last 20 years (Sparre & Venema, 1998; Nash, 1998 and Abdallah & Elhaweet, 2000).

Virtual population (VPA) and cohort analysis were first developed as age based methods, however, in recent years also length based methods have become available, which are of particular interest to tropical fisheries. The method originated in the USSR, where Derzhavin, 1922 was probably the first to combine age data with catch statistics. The method was rediscovered by Fry 1949 and subsequently modified by many authors including Gulland, 1965 and Pope, 1972. The modification made by Pope is usually referred to as “Pope’s cohort analysis“. The VPA methods were then reviewed by

According to Cushing, 1975 the fluctuation of fish populations may be affected by many factors besides fishing mortality such as water temperature, shift of currents and changes of sea level and wind stress.

The results in the present study which were obtained from VPA analysis could be considered as a base for future studies that help to predict the future catch. These results indicate that, the fish which died by natural mortality is always more than those which die by fishing mortality (this clarified the effect of pollution in the area of study) and the increase in fishing mortality as the fish increases in age was accompanied by the decrease in population numbers in the two species under study in Abu Qir Bay. Also natural mortality decrease as the fish gets older.

Similar results were found by some other authors who applied VPA on data for other species in different locations. Abdallah and Elhaweet, 2000 found that, both catch and stock biomass of *Sardina pilchardus* and *Sardinella aurita* decreased in age with increasing fishing mortality in Alexandria (Abu Qir). The same results were in agreement with Lehtonen, 1984 in his study on Pike perch (*Stizostedion lucioperca L.*) caught from Archipelago Sea and the Gulf of Finland, Parmanne & Sjoblom, 1988 in their study on fishes of Baltic herring & Hudd, 1985 recorded a decrease in the catch and the stock of *Osmerus eperlanus* with the increase of fishing mortality and age in the Northern Quark, Gulf of Bothnia.

Abd Elbarr, 2004 found in his study on *Boops boops* in the Egyptian Mediterranean waters that, age structured VPA showed an increase in
fishing mortality and a decrease in the population as the fish increases in age.

This study concluded that, the fisheries status of *D. sargus* and *D. vulgaris* in Abu Qir Bay reached the target reference point (F_{0.1}) but did not reach the overexploited phase, because they did not reach the limit reference point (F_{max}) for the two species under study. This means that, there is no need to increase the fishing effort or the mesh or hock size in Abu Qir Bay for these two species.
SUMMARY

The present study deals with the fisheries of two Sparid fish species in Abu Qir Bay. Family Sparidae represents about 17% of the landed catch from the Bay. Among the family; genus Diplodus is generally caught by trammel nets, beach and purse seines but mostly by longlines. Two species of this genus were considered here for study. They are namely *D. sargus* and *D. vulgaris* where they represent by about 4.2% of the landed catch during the year 2008 in the Bay (GAFRD, 2008).

The length weight relationship of both species under study showed a value of exponent “b” of very slight negative allometry. Analysis of the catch length structure of the two species revealed that the catch of *D. sargus* is composed of 21 length groups, the least length was 7.5 cm and the biggest was 27.5 cm with mean length 16.16 cm, while the catch of *D. vulgaris* is composed of 19 length groups starting from 8.5 cm to 26.5 cm with mean length 16.23 cm. The most abundant length group was 17.5 cm for the two species and both have nearly the same mean length. Study of the sex ratio showed that the females dominate the population in both species.

The study of condition factor “K” showed that the value of “K” decreases as the fish increases in length and also varies with season. Length scale relationship was found to be linear. Back calculations of the total lengths by the end of each year of life, showed that the rate of growth of *D. sargus* was higher than *D. vulgaris* in both length and weight. Thus *D. sargus* was 11.42 cm total length at age I and reached 25.98 cm total length at the six\(^{th}\) year of age. For *D. vulgaris* it was 10.34 cm total length ate age I and reached 25.52 cm total length at the six\(^{th}\) year of age.
Growth in weight studies show that for \textit{D. sargus}, the fish was 26.77 gm total weight at the end of the first year of life, while it was 300.47 gm at the six\textsuperscript{th} year age of life. For \textit{D. vulgaris}, it reached 18.30 gm total weight at one year old, while it was 267.24 gm by the end of the six\textsuperscript{th} year age of life. No difference in rate of growth between males and females (Linear and Ponderal). This is true for both species. Besides, the values of Von Bertalanffy parameters were estimated and compared for the two species.

\textit{D. sargus} comprises seven age groups from age group 0 to age group VI as well as \textit{D. vulgaris}. The most abundant age groups are I and II for \textit{D. sargus}, while in \textit{D. vulgaris} it was age group II.

The values of total, natural and fishing mortalities for both species were estimated. They were slightly higher in \textit{D. sargus} than in \textit{D. vulgaris}. The same was true for the values of growth performance in length and weight ($\Phi_L$ and $\Phi_w$).

The Survival rate was slightly lower in \textit{D. sargus} (0.34), than in \textit{D. vulgaris} (0.35). The values of exploitation rates were also higher in \textit{D. sargus} (0.445) than in \textit{D. vulgaris} (0.428).

The length at first capture was nearly the same for both species (12.51 cm and 12.52 cm “Total length”) for \textit{D. sargus} and \textit{D. vulgaris} respectively. The corresponding ages were 1.208 year for \textit{D. sargus} and 1.42 year for \textit{D. vulgaris}. Fishes belonging to \textit{D. sargus} reach 10.43 cm TL when they recruit to the population, while \textit{D. vulgaris} reach 10.62 cm TL at recruitment. These correspond to 0.81 years in \textit{D. sargus} and 1.05 years in \textit{D. vulgaris}.

The yield per recruit obtained by the analytical model of Beverton and Holt, 1957 was found to be 27.76 gm for \textit{D. sargus} and 25.99 gm for \textit{D. vulgaris}. 
vulgaris. The biomass per recruit for D. sargus is 57.16 gm, while it is 57.90 gm for D. vulgaris.

The estimated yield per recruit and biomass per recruit at F_{0.1} (Target reference point) were 27.7617 gm and 57.16 gm for D. sargus and were 26.5552 gm and 54.87 gm for D. vulgaris respectively. These values were corresponding to fishing mortality values of 0.486 year^{-1} for D. sargus and 0.484 year^{-1} for D. vulgaris. The maximum yield per recruit (Y/R_{max}) for D. sargus was 31.1233 gm which correspond to a value of F_{max} = 1.239, while for D. vulgaris it was 29.7867 gm corresponding to F_{max} =1.245. At F_{max} the percentage of biomass per recruit value to virgin biomass was 16.26 % for D. sargus and 16.09 % for D. vulgaris.

The effects of fishing mortality together with age at first capture on the values of yield per recruit were estimated for the two species under study. It showed an increase in age at first capture (t_c) has little effect on Y/R in both species under constant value of fishing mortality.

Cohort analysis (VPA, age based) represent the estimated values of the population numbers, Survivors, Natural and fishing mortalities for each year of life of D. sargus and D. vulgaris in Abu Qir Bay. It is noticed that, the populations of the two species under study decreased gradually with age, this is due to the exposure to the sequence of natural mortality (which decrease with age too) and fishing mortality (which appeared in different trends in the two species). It showed that, the catch is based mostly on fish of age groups I, II and III in both species under study.

On the other hand, the effect of F on Y/R at different values of natural mortality (M) showed that the Y/R_{max} value corresponding to higher values of fishing mortality at higher values of natural mortality, for both species.
From another point of view, it was found that the value of Y/R decreases as the value of natural mortality “M” increases. This is true in both species. This shows the effect of water pollution on fish production.

This study concluded that, the fisheries status of *D. sargus* and *D. vulgaris* in Abu Qir Bay reached the target reference point (F₀.₁) but did not reach the overexploited phase, because they did not reach the limit reference point (Fₘₐₓ) for the two species under study.
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