THE BIOLOGY AND POPULATION PARAMETERS OF THE WHITING (*Merlangius merlangus euxinus* NORDMANN) IN THE TURKISH COAST OF THE BLACK SEA

A THESIS PRESENTED
BY
ALİ İŞMEN

TO
THE MIDDLE EAST TECHNİCAL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY
IN
MARINE SCIENCES

İÇEL - TÜRKİYE

MAY 1995

I certify that I have read this thesis and in my opinion it is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Supervisor
Prof.Dr. Ferit BİNGEL

Member of
Examining Committee
Prof.Dr. İlkay SALİHOĞLU

Member of
Examining Committee
Prof.Dr. Ercan SARUHAN

Member of
Examining Committee
Prof.Dr. Mustafa ÜNSAL

Member of
Examining Committee
Asst.Prof.Dr. Ahmet E. KIDEYŞ

Certified that this thesis conforms to the formal standards of the institute.

Office of the President
Prof.Dr. Ümit ÜNLÜATA

ABSTRACT

THE BIOLOGY AND POPULATION PARAMETERS OF THE WHITING (*Merlangius merlangus euxinus* NORDMANN) IN THE TURKISH COAST OF THE BLACK SEA

İŞMEN, Ali
Ph.D. in Marine Biology and Fisheries
Supervisor : Prof. Dr. Ferit BINGEL
Middle East Technical University
May 1995. 215 pages

Stock identification of whiting from the Turkish coast of the Black Sea was carried out morphometrically and meristically applying the generalized distance of Mahalanobis. Insufficient differences (P>0.01) in general phenotypic and genotypic characteristics implied the existence of a single unit stock.

Females were dominant in all sampling periods; the overall male to female ratio was 1 (43%) : 1.2 (57%). The maximum age of the fish examined during the sampling period was 9 years. The stock in the investigated area consisted mainly of fish in age groups I, II, and III, with mean lengths lying between 10.8 and 17.8 cm. The smallest Fulton's condition factor (0.0088) was found in winter (spawning period), and the highest condition (0.0105) in summer. Length-weight relationship and von Bertalanffy growth constants were estimated as $W=0.0042*L^{3.24}$, $L_{\infty}=39.1$ cm, K = 0.15, t_0 = -1.53 year. Total mortality and its components were estimated as Z=1.63, M = 0.39 and F = 1.24. The exploitation rates indicated over-exploitation of the stock (E=0.79 in 1990; E=0.73 in 1991; E=0.72 in 1992). The highest trawlable biomass was found in the region between Çaltı and Sarp which is a closed area to trawl fishing in the eastern part of the Turkish Black Sea coast, where the whiting was dominant fish in the trawl catches.

Yield per recruit model of Beverton & Holt (1957) also implied an overfishing on the whiting stock. This negative development on the whiting stock was based on the increasing fishing effort spent on demersal fishes after the decrease in pelagic stocks. It was concluded that a decrease in fishing intensity (F = 0.45) or the enforcement of a minumum allowable total length (17.5 cm) is necessary to allow optimum exploitation of the whiting stock at present.

Whiting fed mostly on fish, crustaceans and polychaetes. The occurrence of the main food items in the stomachs was clearly related to the size (or age) of the whiting and also to their seasonal abundance. With increasing length (or age) of the whiting, fish became dominant while the importance of crustaceans and polychaetes decreased in diet. There was considerable seasonal variation in both the quantity and the type of food eaten. Whiting fed intensively during spring and autumn. The length of prey fish increased with the length of the predator. Daily food consumption rate was estimated as 2.4% (1.6%-2.9%) of body weight, taking into account empty stomachs. Predation on sprat was estimated to be 78,690 tonnes in 1991 and 137,922 tonnes in 1992.

The spawning time of whiting extended from October to July, with a maximum in January-February. The larger fish matured earlier in the spawning season than the small fish. The length at which 50% of the fish were mature, was estimated to be 12.5 cm for males and 14.7 cm for females.The fecundity of whiting was highly correlated with length and to a lesser extent with age. Fecundity-length relationship was $F=aL^{2.19}$ (r=0.75), $F=aL^{2.20}$ (r=075), $F=aL^{3.36}$ (r=0.85) and $F=aL^{2.74}$ (r=0.80) between 1990 and 1993, respectively. Annual variation in fecundity was not evident in the data for the years 1991-93 from the eastern Turkish Black Sea Coast.

Although the externaly visible ectoparasites were not detected, an endoparasite (Nematode-*Hysterothylacium aduncum*) existed in all visceral organs. Infection with this nematodes increased with age of the fish.

Key words: Turkish Black Sea Coast, Whiting (*Merlangius merlangus euxinus*), Stock differentiation, Population parameters, stomach content, maturity, fecundity, parasite.

ÖZET

KARADENİZ' İN TÜRKİYE KIYILARINDAKİ MEZGİT (*Merlangius merlangus euxinus* NORDMANN) BALIĞININ BİYOLOJİSİ VE POPULASYON PARAMETRELERİ

İŞMEN, Ali
Doktora Tezi, Deniz Biyolojisi ve Balıkçılık
Tez yöneticisi: Prof. Dr. Ferit BINGEL
Orta Doğu Teknik Üniversitesi
Mayıs 1995, 215 sayfa

Karadeniz' in Türkiye kıyılarındaki mezgit stoklarının ayırımı, morfometrik ve meristik karakterlerden Mahalanobis' in genelleştirilmiş aralığı uygulanarak yapıldı. Fenotipik ve genotipik karakterlerdeki farklılıkların yetersizliği ($P>0.01$) tek bir stokun mevcudiyetini gösterdi.

Dişiler tüm örnekleme peryotlarında daha baskındı. Erkek-dişi oranı, 1 (43%) : 1.2 (57%) idi. İncelenen balıklar içerisinde maksimum 9 yaş bulundu. Çalışma alanındaki stok, ortalama uzunlukları 10.8 cm ile 17.8 cm arasında değişen I, II ve III yaş gruplarını kapsadı. En küçük Fulton kondüsyon faktörü (0.0088) kışın (yumurtlama peryodunda), en yüksek (0.0105) yazın bulundu. Boy-ağırlık ilişkisi ve von Bertalanffy büyüme sabitleri $W=0.0042*L^{3.24}$, L_∞ =39.1 cm, $K = 0.15$, $t_0 = -1.53$ olarak tahmin edildi. Toplam ölüm ve bileşenlerinin, $Z=1.63$, $M = 0.39$ ve $F = 1.24$ olduğu bulundu. Yararlanma oranları (1990, $E=0.79$; 1991, $E=0.73$; 1992, $E=0.72$) stokun aşırı sömürüldüğünü gösterdi. Trolle elde edilebilir en yüksek biyokitle, Doğu Karadeniz' de trol avcılığına kapalı Çaltı-Sarp arasındaki bölgede bulundu.

Beverton & Holt (1957)' un ürün modeli, mezgit stokları üzerinde aşırı avcılığın olduğunu gösterdi. Stok üzerindeki bu olumsuz gelişme, pelajik stokların azalmasından sonra demersal stoklar üzerinde artan av gücüne bağlandı. Halihazırda mezgit stoklarından optimum yararlanmak, avcılık baskısının azaltılmasını ($F=0.45$) ya da minumum avlanılabilir total boyun 17.5 cm olmasını gerektirmekdir.

Mezgitin çoğunlukla balık, kabuklular and deniz kurtları (polychaete) ile beslendiği görüldü. Mide içeriğindeki ana gıdalar, balığın boyu (ya da yaşı) ve mevsimsel bollukları ile ilişkiliydi. Mide içeriğinde, boy artarken kabuklular ve deniz kurtlarının önemi azaldı ve balığın önemi arttı. Yenilen gıdanın miktar ve çeşidi, mevsimsel olarak değişim gösterdi. Mezgitin yoğun olarak ilkbahar ve sonbaharda beslendiği gözlendi. Yenilen gıdanın boyu, balığın boyu ile arttı. Günlük gıda tüketim oranı, boş mideler de göz önüne alındığında vücut ağırlığının %2.4 (%1.6-%2.9) olarak tahmin edildi. Mezgit tarafından tüketilen çaça miktarının 1991 de 78.690 ton ve 1992 de 137.922 ton olduğu tahmin edildi.

Mezgitin yumurtlama döneminin Ekim'den Temmuz'a kadar yayıldığı, bununla birlikte maksimum düzeyde Ocak-Şubat arasında yumurtladığı görüldü. Büyük bireyler yumurtlama mevsiminde küçüklerden daha erken olgunlaştı. İlk eşeysel olgunluğa erişme boyu (%50) erkekler için 12.5 cm, dişiler için 14.7 cm olarak tespit edildi. Doğurganlık yaşa kıyasla boyla daha fazla ilişkiliydi. 1990-1993 yılları arasında doğurganlık-boy ilişkisi, $F=aL^{2.19}$ (r=0.75), $F=aL^{2.20}$ (r=075), $F=aL^{3.36}$ (r=0.85) ve $F=aL^{2.74}$ (r=0.80) olarak tahmin edildi. Doğu Karadenizin 1991-93 yılları arasındaki doğurganlık değerlerinde yıllık değişimler görülmedi.

Dış parazit görülmemesine rağmen tüm sindirim sisteminde iç parazit (Nematode-*Hysterothylacium aduncum)* bulundu. Nematodlarla enfeksiyon balığın yaşı ile arttı.

Anahtar kelimeler: Türkiye'nin Karadeniz Kıyısı, Mezgit (*Merlangius merlangus euxinus*), stok ayırımı, populasyon parametreleri, mide içeriği, eşeysel olgunluk, doğurganlık, parazit.

ACKNOWLEDGEMENT

I owe my advisor, Prof. Ferit BINGEL, my deepest gratitude for his supervision and encouragement throughout the course of this work. Thanks is also due to Prof. Mustafa UNSAL who helped me by his valuable review and suggestions.

The study was carried out within the framework of the project " Stock Assessment Studies for the Turkish Black Sea Coast " sponsored by NATO-Science for Stability Programme, Turkish Scientific and Technical Research Council (TUBITAK) and Turkish State Planning Office.

I would like to extend my sincere thanks to Professor Ümit ÜNLÜATA, director of Institute of Marine Sciences, and to Mr. Yılmaz Bekiroğlu, director of the Aquatic Resources Research Institute of the Ministry of Agriculture in Trabzon, for providing easy access to all the facilities in this research.

I would also like to thank Assist. Prof. A.C.GUCU, Assist. Prof. Dursun AVSAR and Assist. Prof. Ahmet E. KIDEYS for their supports and helps throughout the study. I am also obliged to Mr. Erhan MUTLU for his helps in using statistical programs.

I am deeply thankful to Mrs. Alison M. KIDEYS for the correction of the English text .

I also thank the captain and their crews of the research vessels of R/V Bilim and R/V Surat-1 and my colleagues at the Institute of Fisheries in Trabzon.

Mostly, I would like to thank my wife and my son for their patience, moral support and help me during the preparation of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

As a consequence of the ever increasing nutritional demand of the world's population, nations are directing their search towards the marine living resources. However, these resources are mostly over-exploited. Supply of this increasing nutritional demand, depends on the rational utilization of marine living resources. Therefore, their past and present potential must be known well.

Fishing countries continuously increased fish production during the 20'th century compared with earlier years by using new improved fishing technology. The fishing activities of such countries concentrated on the world's major fish resources, which are now heavily exploited. This resulted in the depletion of stocks. Famous examples are the Peruvian anchovita, cod and herring stocks of the Northwest Atlantic and the multispecies fishery in the Gulf of Thailand (THUROW, 1982).

The annual fish production of Turkey from its inland waters and surrounding seas increased steadily from 200.000 tonnes in 1970 to 676.000 tonnes (the Black Sea coast of Turkey provided 82% of this production) in 1988 (DPT,1989), However, the total yield (consumption per capita is around 7.6 kg per year) is still insufficient. Since 1988/89, the sudden decrease of the anchovy catch, the largest contributor to the fish yield (over 70% since 1970) influenced the per capita consumption negatively. Therefore, skillful prediction and management of the present stocks of the Black Sea is important and necessary.

The primary purpose of fish population dynamical investigations is to illuminate the positive and negative factors influencing the abundance of stocks. Furthermore, prediction of optimum exploitation measures is necessary for stock management. Naturally, stock assessment and population dynamical studies generally have focused on the biology of commercial species and have been aimed at evaluating or assessing their current and future conditions relative to specific resource management decisions. Earlier studies are generally oriented towards the development of fisheries in the Turkish Black Sea coast (KARA, 1980; DBT-DEU, 1986; SUAE, 1992). A few studies (UYSAL, 1994 and BINGEL et.al. 1991, 1993) are related to the distribution, abundance and stock assessment of whiting. No detailed information about its biology e.g., food, fecundity, parasite, and the unity of whiting stocks along the Turkish Black Sea coast are available yet. Additionally, previous studies were focused mainly on the fishing areas between Sinop and Çaltı cape and there was a deficiency of data covering the whole Turkish Black Sea coast.

1.1. SCOPE AND AIM OF THE STUDY

The decrease in most of the traditional fish stocks, caused by increased fishing levels and by influences of natural and man-made factors, and additionally, the lack of a pertinent data-base meant that information on the effective regulation of fishing activities was deficient.

The fisheries along the Turkish Black Sea coast is currently being managed as one unit; that is, controls on mesh size, fishing effort, seasonal fishing time, and minimum saleable sizes are applied in a blanket policy, without regional distinction of the parameters. Furthermore, management measures established were not based on the results of research.

There are a few studies carried out on the identification of (local) fish stocks (DEMIR, 1963; MENGI, 1971; PAYZA, 1983; AVSAR, 1987; AVSAR et. al. 1988a, b; 1990 and AVSAR, 1993) along the Turkish coasts. Similarities or dissimilarities and geographical distribution of the stocks are very important for the achievement of a rational exploitation policy. The genetic and/or geographic isolation of stocks are the mechanisms which affect the growth rate, morphometric and meristic characteristics, and regenerative capacity. Therefore, it is one of the primary tasks of fisheries biologists to investigate and determine the unit stocks, i.e. examine whether there is one or more unit stock of a particular fish species. In this study, first an endeavor is made to separate the whiting stocks in the Turkish Black Sea coast using both morphometric and meristic characteristics. After a possible classification of the problem of the unity of the whiting stock(s), its biology and population parameters are evaluated so that its current and future condition may be assessed in relation to its management.

The present study is further supported by the information on the biology of the Black Sea whiting by examination of stomach content, maturity, fecundity, and parasites.

1.2. EARLIER STUDIES ON WHITING IN THE BLACK SEA

Excluding the Turkish coasts, studies on whiting in the other regions of the Black Sea started intensively at the beginning of the 20th century. However, especially in the Turkish Black Sea coast the biology, migration and distribution of whiting stock(s) have not yet been sufficiently studied. The oldest record on the existence of whiting in the Black Sea was published by NORDMANN in 1830 (c.f. UYSAL 1994). In the years 1908 and 1913, zoogeographical studies on this fish were published by KISELEVICH and ZERNOV respectively. Later, DURUNISKI (1929) re-evaluated the zoogeography of the whiting (c.f. IVANOV & BEVERTON,1985). During the 1950's studies on the whiting continued extensively. Subjects and areas covered are given in Table 1.

Table 1. Earlier studies carried out on the whiting in the Black Sea (* : from IVANOV & BEVERTON, 1985)

Author		Subject	Region
KOSYAKIN	1954*	Maturity, spawning, fecundity	?
PROBATOV	1957*	"	Off Soviet coast
SVETOVIDOV	1964*	"	?
DEHNIK	1973	"	?
OWEN	1979	"	?
MELYATEKII	1938*	Food and feeding	?
KANEVA & MARINOV	1960	"	?
BURDAK	1964	"	Off Soviet coast
PRODANOV	1980	Population parameters	Bulgarian coast
	1982	"	Bulgarian coast
AKŞIRAY	1954	Distribution and taxonomy	Turkish coast
SLASTENENKO	1956	Distribution and taxonomy	Black Sea Basin
KUTAYGIL & BILECIK	(1969-73)	Catch composition	Kefken-Ereğli/Sinop-Çaltı
KARA	1980	Catch composition	Sinop-Ordu
DBT-DEU	1986	Effects of trawl catches	Sinop-Ünye
BİNGEL et. al.	1993	Stock assessment	Turkish B.S. coast
UYSAL	1994	Growth, age and biomass	Eastern B.S.coast

1.2.1. RECENT STUDIES CARRIED OUT AT THE TURKISH COAST

In the Turkish Black Sea coasts, the first information obtainable was about the distribution and taxonomy of fish fauna given by AKSIRAY (1954) and SLASTENENKO (1956). KUTAYGIL & BİLECİK (1969-73) studied the catch composition of demersal species, and their distribution in space and time between Kefken and Ereğli and between Sinop and Çaltı. Whiting was the dominant species in the catches. Later, KARA (1977) established the catch composition data for the region between Sinop and Ordu. He also found that whiting was the dominant species. A study carried out by the DBT-DEU (1986) in the continental shelf region between Sinop and Ünye dealt with the effects of trawl catches on demersal fish stocks. In this region, whiting was the dominant species amongst the demersal fish and constituted 78% of the catch. UYSAL (1994) studied the biology and population dynamics of whiting using the samples collected from the Sinop-Hopa region in June-1988 and March-1989. He found that whiting was dominant in the catches and that the total trawlable biomass of whiting in the region between Sinop and Ünye decreased from 22,311 tonnes in 1986 to 3,506 tonnes in 1989 which implied over-fishing of the whiting stock. Recently another study was carried out by BINGEL et. al. (1993) on the stock assessment of demersal and pelagic fish species inhabiting the Turkish Black Sea coast. They divided the Turkish continental shelf area into eight sub provinces (the western region was divided into 3 and the eastern region into 5 subregions) for the assessment of the biomass of demersal fish species. Total biomass was estimated using the swept area method. The biomass estimated and the percentage occurrence of whiting in the bottom trawl catches during the study period are given in Table 2.

Table 2. The biomass and percentage occurrence of whiting estimated from trawl study in the Black Sea (from BINGEL et.al.1993)

	Years			
	1990		1991	1992
	West	East	East	East
% of occurrence	67.9	49.3	71.6	81.4
Biomass (tonnes)	879	3,266	18,300	32,075

1.3. GENERAL CHARACTERISTICS OF THE STUDY AREA

The Black Sea, with a maximum depth of 2200 m, a surface area of 4.2×10^5 km^2 and a volume of 5.3×10^5 km^3 represents one of the largest land-locked isolated basins in the world. It is connected with adjacent seas, the Sea of Azov and the Mediterranean Sea, through the Kerch Strait in the north and through the Turkish Straits System in the south, (SOROKIN, 1983, OGUZ et. al., 1990).

The Black Sea has a complicated bottom topography around the periphery of the basin. The abyssal plain (depths of about 2000 m) is flat in structure and constitutes about 60% of the basin. The continental shelf with a depth of 200 m, comprising about 25% of the total area is narrow (maximum 20 km in width) except in the northwestern Black Sea. The northwestern shelf area, having a flat and wide topography, decreases in width towards the south and terminates at Sakarya Canyon, where the depth suddenly increases from 100 m to 1500 m (OGUZ et. al. 1990).

The shelf of the Anatolian coast is narrow and comprises about 4% (~15.447 km^2) of the total shelf area of the Black Sea. It is often dissected by steep slopes adjoining the land or canyons located off the Bosphorus entrance and off the Sakarya and Kızılırmak Rivers. The continental shelf, except in localized regions off Sinop and the Yeşilırmak and Kızılırmak rivers, narrows towards the east from the Sakarya canyon. The depth increases rapidly 10-20 km offshore and reaches more than 1000 m (OGUZ et. al. 1992) .

The Black Sea is located in a semi-arid climatic zone and is affected by seasonal changes in the atmospheric pressure pattern over Europe and Asia thus displaying a positive water balance. The inputs from fresh water sources exceed losses by evaporation and lead to dilution of the surface waters. The conservation of mass and salinity of the Black Sea are maintained by the balance of two-layer flows though the Turkish Strait systems. The less saline and lighter waters of the Black Sea flow into the Mediterranean Sea through the Bosphorus and Dardanelles Straits while the saltier and denser Mediterranean water flows into the Black Sea. The exchange of water through the Bosphorus maintains the salt balances of the Black Sea at a constant level and forms a permanent halocline between depths of 50 and 150 m. The permanent halocline separates the saltier and poorly oxygenated deep water of Mediterranean origin from the low salinity surface waters (OGUZ, et.al., 1990, 1992).

The vertical pattern of salinity is generally the same everywhere in the basin, except in the coastal and shelf regions of the basin. The mean salinity of the deep waters in the Black Sea is 22.2-22.4‰ depending on the regional deep water convection and mixing characteristics of the basin. Between the surface and halocline at depths of 100-200 m, there are the sharp salinity gradients. The salinity of surface waters is exposed to considerable seasonal and geographical variations depending on the amount of evaporation, precipitation and river run-off (OĞUZ et. al.,1990). In the central part of the Black Sea, the average salinity of surface waters is 18-18.5‰. In the northwestern shelf area and in the coastal waters influenced by river outflow, the salinity is lower (13-17‰) (IVANOV & BEVERTON, 1985).

The Black Sea water column responds to considerable mixing and convection events throughout the year by seasonal heating and cooling. The strongest mixing occurs at the base of the thin surface layer (~30 m) during the winter months. In late winter, the upper layer is almost homothermal. A significant temperature stratification does not occur in the spring while the thermocline forms at the base of the thin surface layer at the beginning of summer. During the summer, transportation of the warmer surface waters to the lower layer by turbulence result in the formation of the thermocline which is characterized by a steep temperature gradient and develops at 25 to 30 m depth. This temperature stratification continues until the end of the autumn stagnation condition (SOROKIN, 1983; OĞUZ et. al., 1992).

Below the seasonal thermocline - halocline, there exists another layer of strong temperature stratification, the Cold Intermediate Water (CIW). The Cold Intermediate Water, characterized by temperatures of <8^{0}C forms in the northwestern shelf region and the centre of cyclonic eddies. This layer is formed when mixing of the seasonally cooled surface waters of about 7-8^{0}C penetrates the deeper levels (~ 50 m) where the remnant of CIW has similar temperature values. A homogeneous layer is formed with temperatures of 7-

7.5°C down to depths of 70-80 m. A similar homothermal layer of CIW is observed during winter with cooler temperatures of ~6°C along the Turkish coast of the western Black Sea (OĞUZ et. al. 1992). The water masses below the halocline possess almost no seasonal variation. The temperature remains constant throughout the year.

The general circulation of the Black Sea is described by the basin scale cyclonic boundary current following the continental slope region and semipermanent anticyclonic eddies on the periphery between the boundary current and the coast. This boundary current (referred to as the Main Black Sea Current or as "Rim Current") is strongly influenced by the winds and by the configuration of the coast. The speed of main Black Sea current, which have a width of about 50 km increases up to 40 cm/s along the topographic slope near the Turkish continental shelf. The intensity of the boundary current system decreases within 30-40 km off the coast (Figure 1). In summer, the two large cyclonic gyres concentrate in the western and eastern basins separated by an anticyclonic eddy formed in the central basin (Figure 2). In winter, on the other hand, the current system appears to be stronger as compared to the summer situation (OĞUZ et. al. 1990, 1993b).

OĞUZ et. al. (1990) studied the geostrophic flow picture along the Anatolian coast of the Black Sea and found that there are series of mesoscale anticyclonic circulations situated between the Rim Current and the undulations of the coast. Entering the Bosphorus exit region from the north as a strong jet flow, the Rim current follows the general topography associated with the Bosphorus Canyon and bifurcates into two branches.

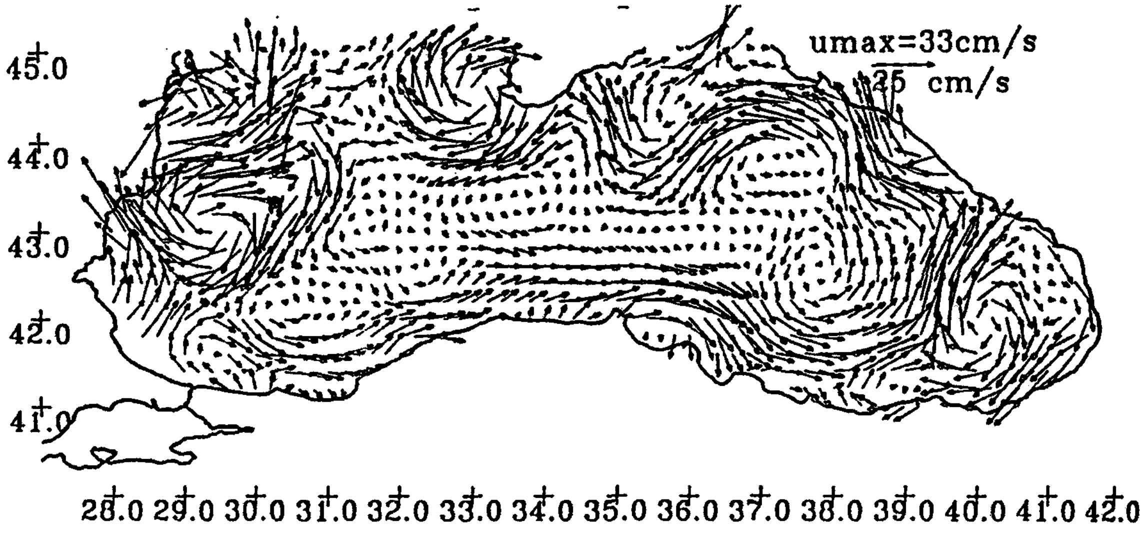


Figure 1. Geostrophic currents (cm/s) of Black Sea obtained from dynamic topography (OĞUZ et. al. 1993).

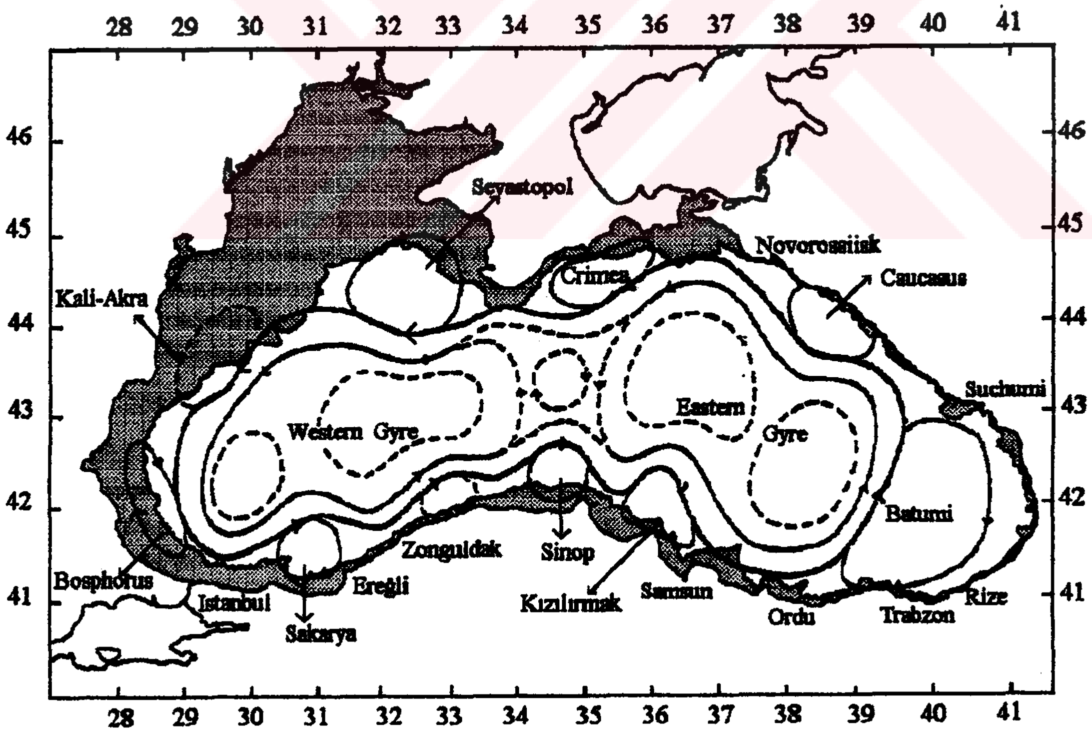


Figure 2. General circulation of surface currents in the Black Sea (OGUZ et. al., 1994). The bold line symbolizes the Rim current. Grayed area; Shelf area with depth<200m.

While one branch turns towards the east, the other partially flows into the Bosphorus Strait and partially turns the northwest of the Bosphorus entrance to form an anticyclonic eddy. The eastern branch of the Rim Current turns offshore and forms anticyclonic eddy in the Sakarya canyon region. Then, the Rim current continues further eastwards along the coast without much changes in its structure till 35° E. In this region, a part of it flows to north to become part of the general circulation of the western basin. The other part of the current continues eastward and forms anticyclonic eddies off the cape of Sinop and off the Yeşilırmak river. The remaining water flows along the eastern Black Sea coast, north of the anticyclonic eddy (Figure 2).

1.4. BLACK SEA FISH AND FISHERIES

The Black Sea Basin inhabits 165 fish species and subspecies. 119 of them are marine, 24 are anadromous or semi-anadromous and 22 are fresh water species (IVANOV & BEVERTON 1985). Its faunistic character is described as Aral, Pontic and Caspian. Because of its connection to the Mediterranean (through the Dardanelles and Bosphorus straits), the Black Sea fauna (especially at pre-Bosphorus region) is influenced by the Mediterranean (SLASTENENKO, 1956). From these 165 species only anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*), shad (*Alosa pontica*), whiting (*Merlangius merlangus euxinus*), striped mullet (*Mullus barbatus*), bluefish (*Pomatomus saltator*), horse mackerel (*Trachurus mediterraneus*), Atlantic bonito (*Sarda sarda*), turbot (*Psetta maxima maeotica*), thornback ray (*Raja clavata*) and sturgeons (*Acipenser* sp.) are economically important. The dominant species producing largest fish flesh and economic input are the small pelagics such as anchovy, sprat and horse mackerel, and the demersal fish such as whiting and striped mullet (BINGEL et.al., 1993). While Bulgaria, Romania, Ukraine and Turkey are dependent more or less totally on the Black sea fish resources, for the Russia, only a small percentage of total fish production is obtained from the Black Sea (IVANOV & BEVERTON, 1985). Since 1981, the highest annual fish catches from the Black Sea have been achieved by Turkey (GFCM, 1993).

1.4.1. FISHERY: PAST AND PRESENT

During the last few decades, profound changes have occurred in the Black Sea ecosystem as reported in the literatures. The most remarkable changes was observed in the northwestern shelf area which receives the largest discharge via substantial rivers (e.g. Danube, Dniester and Dnieper) containing high levels of nutrients besides other pollutants (KIDEYS, 1994; ZAITSEV, 1993). As a result, this oligotrophic sea of the 1940s, has changed displaying first mesotrophic and later eutrophic features. The shallow northwestern region of the Black Sea has even occasionally shown dystrophic properties (ZAITSEV, 1993).

Until recently a steady rise of the biomass of small pelagics in the Black Sea was the result of the increasing eutrofication, together with the escalation of fishing and the reduction in the number of predators (BINGEL et. al., 1993). The total catch of small pelagic fish increased from $350 x 10^3$ ton in the late 1970s to $700 x 10^3$ ton in the 1980s despite a remarkable increase in the population of the jelly fish *Aurelia aurita,* which competed for zooplanktonic food (KIDEYS, 1994).

Recently, the introduction of a member of phylum ctenophora, *Mnemiopsis sp.* affected all compartments of pelagic life. Because of the *Mnemiopsis* outburst, the quantity of copepods and other zooplankton in the late 1980s was reduced almost tenfold. Since the time of *Mnemiopsis'* mass appearance in summer 1988, the fisheries of the riparian countries of the Black Sea has been reduced dramatically (KIDEYS, 1994; ZAITSEV, 1993). Anchovy catches for the Commonwealth of Independent States (CIS) consistently dropped between 1988 and 1991; 237×10^3 tonnes in 1988, 65×10^3 tonnes in 1989, 29×10^3 tonnes in 1990 and only 6×10^3 tonnes in 1991 (GFCM, 1993). For Bulgaria, there are no records for anchovy catches since 1989. Anchovy along the Romania coast disappeared almost completely by 1989 from its former 1.5×10^3 tonnes in 1987 and 3.2×10^3 in 1988 (GFCM, 1993). Dramatic reduction have also been reported in the Turkish Black Sea fisheries since 1988. Similarly, sprat catches (from some $6\text{-}9 \times 10^3$ tonnes in the late 1980s to 0.7×10^3 tonnes in 1991) dropped in Romania and stocks of *Clupeonella cultiventris* in the Azov Sea had virtually disappeared by 1990 (KIDEYS, 1994).

ZAITSEV (1993) explained the evolution of Black Sea fisheries from the 1930s until the present and mentioned that the evolution of Black Sea fisheries has been characterized by the following parameters: In the 1930-1950s the small pelagic fish, anchovy and sprat, made up 35% of the total catch; the rest being composed of large pelagic fish, estuarine and demersal species (bonito, mackerel, bluefish, grey mullets, turbot etc.). In the 1980s, large fish disappeared in commercial numbers and the catch was composed mainly by small forage-fish, such as anchovy and sprat (75-80%), and also by whiting, and horse mackerel.

1.4.2. STATE OF WHITING STOCK

The catch of Black Sea countries increased until 1985-1986 after which a sharp decline occurred. The mean annual landings of all fish from the Black Sea bordering countries were 183.000 tons in 1966-1970 (IVANOV & BEVERTON, 1985) and increased to 737.200 tons in 1980-1987 (GFCM, 1989). The catches were composed mainly by fourteen pelagic and demersal species. Among demersal species, the whiting was the dominant fish caught and followed by striped mullet and turbot (Table 3). Furthermore, the whiting has a rank of 3 to 6 among the main fourteen species landed by the countries bordering the Black Sea between 1966 and 1989 (Table 3).

Table 3. Average annual nominal catch (in thousand tonnes) of the main fish species or species groups landed by the countries bordering the Black Sea during the period 1961-87 (from IVANOV & BEVERTON 1985;* from GFCM, 1989).

	Period (years)					
Species	61-65	66-70	71-75	76-80	81-85*	85-89*
Anchovy	69.0	98.0	191.3	262.3	496.4	402.3
Sprat	6.2	3.0	6.1	44.1	61.4	75.4
Horse mackerel	18.4	22.8	29.9	42.1	72.0	100.8
Atlantic bonito	20.1	29.4	4.5	7.4	20.0	13.0
Mackerel	9.8	2.1	-	-	7.9	19.1
Bluefish	0.8	5.9	2.3	9.8	19.6	10.2
Shad	1.9	1.4	3.0	2.5	0.8	0.1
Turbot	3.6	3.7	3.7	2.9	3.5	1.0
Picked dogfish	-	2.7	0.8	1.7	0.1	0.1
Thornback ray	-	1.6	1.2	2.4	2.7	1.8
Mugils	3.6	4.8	2.7	7.8	3.1	3.4
Striped mullet	1.1	3.2	1.7	2.0	4.5	5.4
Sturgeons	0.6	0.4	0.3	0.3	1.3	1.0
Whiting	-	3.8	15.5	16.1	14.4	27.5
Total	135.1	182.8	253.0	401.3	707.7	661.1
Whiting (%)	-	2.1	6.1	4.0	2.0	4.2

The whiting fishery, with annual catches changing between 20.000 and 31.000 tonnes, has been one of the most important fisheries of the Black Sea for the last few years. After 1980, the annual nominal catch of whiting began to increase until 1988 to a maximum of 31.000 tonnes and then started to decrease again towards 1991 (Table 4).

Table 4. Annual landings (in tonnes) of whiting caught by the bordering countries of Black Sea during 1979-1991 (from GFCM,1993).

Year	Bulgaria	Romania	Former USSR	Turkey	Total
1979	71	1,205	11,377	20,778	33,431
1980	30	618	2,690	6,838	10,176
1981	1	894	2,238	4,669	7,802
1982	4	800	1,513	4,264	6,581
1983	-	1,080	2,381	11,696	15,157
1984	-	1,192	4,738	11,595	17,525
1985	-	3,138	2,655	16,036	21,829
1986	-	1,949	2,652	17,738	22,339
1987	-	615	2,764	27,103	30,482
1988	-	1,009	2,223	28,263	31,495
1989	-	2,738	591	19,283	22,612
1990	-	2,653	322	16,259	19,234
1991	-	59	24	18,956	19,039

The Black Sea fisheries have a special importance in Turkish fisheries. The largest proportion of national fish yield, which is over 70% since 1970 was obtained from the Black Sea. Anchovy was the dominant fish within the total catch (60-72% of total catch between 1980 and 1988) and among demersal species, the whiting is the dominant fish (BINGEL et. al. 1993). Annual nominal catches of the whiting have shown fluctuations, but an increasing trend appears between 1982 and 1989 (Table 4). Whiting catches of Turkey reached their maximum 28.000 tonnes in 1988, and decreased from 19.000

tonnes in 1989 to 16.000 tonnes in 1990. In the following year, a slight increase in landings was recorded with 19.000 tonnes (DIE, 1992). The fluctuations in the fisheries accentuate the need for a better understanding of the status of the Black Sea fish stocks in order to achieve a rational utilization.

2. GENERAL FEATURES OF WHITING

2.1. TAXONOMY

The taxonomic classification of whiting postulated in relation to the systematic categories by AKSIRAY (1954), SLASTENENKO (1956), WHEELER (1969), FISHER (1973) and WHITEHEAD et. al., (1986) is incomplete. The large systematic categories, therefore, made by NIELSON (1984) were considered. This taxonomic classification is as follow:

Regnum	: ANIMALE
Phylum	: CHORDATA
Subphylum	: VERTEBRATE
Superclass	: GNATHOSTOMATA
Grade	: PISCES
Class	: OSTEICHTHYES
Subclass	: ACTINOPTERGII
Infraclass	: NEOPTERYGII
Division	: HALECOSTOMI
Subdivision	: TELEOSTEI
Infradivision	: EUTELEOSTEI
Superorder	: PARACANTHOPTERYGII
Order	: GADIOFORMES
Family	: GADIDAE
Genus	: *MERLANGIUS*
Species	: *MERLANGIUS MERLANGUS*
Subspecies	: *MERLANGIUS MERLANGUS EUXINUS*

2.1.1. SUBSPECIES

There are two subspecies of whiting in the North-eastern Atlantic and Mediterranean. These subspecies are identified by barbel on chin and pectoral fin length (FISHER, 1973; WHITEHEAD et. al., 1986).

I) ***Merlangius merlangus merlangus*** is an Atlantic form inhabiting in the North European coasts. There is no barbel on chin. Pectoral fin is 13.8-15.6% of body length.

II) ***Merlangius merlangus euxinus*** is common along the European coasts of the Mediterranean and in the Black Sea. This subspecies has a conspicuous barbel on chin. Pectoral fin is 15.4-18.2% of body length.

2.2. MORPHOLOGICAL IDENTIFICATION

The body is elongate, but rather deep (depth about five to six times in total length). 3 dorsal fins are separated by small interspaces. There is not any interspace between two anal fins. The origin of the first anal fin is under the midpoint of the first dorsal fin. The snout is long and rather pointed. The upper jaw is distinctly longer than the lower. A small barbel is present, but is inconspicuous or even absent in large specimens. Lateral line does not continue behind the end of the base of the third dorsal fin. They have not spiny rays in the fins. The color is variable, often dark blue or green on the back, sometimes sandy, but always having strikingly white or silvery sides and belly. There is a dark spot at the pectoral base (FISHER, 1973; WHEELER, 1969; WHITEHEAD et. al., 1986).

2.3. MERISTICAL IDENTIFICATION

In *Merlangius merlangus*, the dorsal fin rays are 12-15, 18-25 and 19-22, respectively. The first anal fin rays are 30-35 and the second anal fin rays are 21-23. The vertebrae on the backbone are 53-57. There are 19-26 gill rakers on the gill arch (WHEELER, 1969; WHITEHEAD et. al, 1986).

In *Merlangius merlangus euxinus*, the dorsal fin rays are 14-17, 16-19 and 18-22, respectively. The first anal fin rays are 28-32 and second anal fin rays are 19-22. The number of vertebrae is 51-54. The gillrakers are 20-23 (WHITEHEAD et. al., 1986). According to SLASTENENKO (1956), in the Black Sea, these species has 13-17, 16-20 and 17-22 dorsal fin rays, respectively. The first anal fin rays are 27-32 and the second anal fin rays are 19-22.

2.4 DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE MEDITERRANEAN AND BLACK SEA

In the Mediterranean and the Black Sea, the most similar species to *Merlangius merlangus* are *Trisopterius* species, *Micromesistius poutassou* and *Pollachius pollachius*. The distinctive characteristics of these species from those of *Merlangius merlangus* are shown in Figure 3.

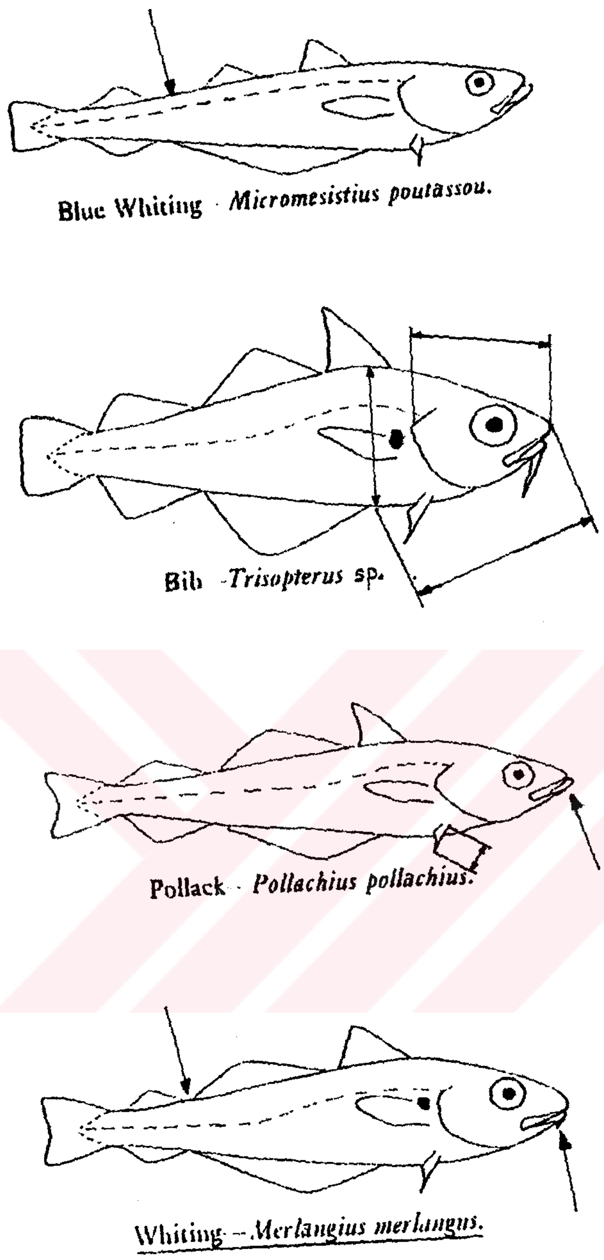


Figure 3. Distinctive characteristics of *Merlangius merlangus* with the most similar species in the Mediterranean and Black Sea (WHEELER, 1969).

Trisopterius species differ from *Merlangius merlangus* by their deeper body (depth about four times in total length), their short snout (eye diameter is longer than snout) and the presence of a long barbel below the chin (barbel is about half or usually equal to eye diameter) (FISHER, 1973; WHITEHEAD et. al.,1986).

Micromesistius poutassou differs from *Merlangius merlangus* by the well spaced dorsal fin bases, the interspace between the second and the third being larger than the first dorsal fin base. Also, the origin of the first anal fin is in front of or just behind the origin of the first dorsal fin and there is no barbel on chin (FISHER, 1973; WHITEHEAD et. al., 1986).

Pollachius pollachius differs from *Merlangius merlangus* by the lower jaw protruding distinctly beyond the upper, the short pelvic fin which does not reach the origin of the first anal fin and its color pattern, particularly the conspicuous dark-green lateral line. Also there is no dark spot at pectoral fin. base (FISHER, 1973; WHITEHEAD et. al., 1986).

2.5. GEOGRAPHICAL DISTRIBUTION

Whiting is a common gadoid fish in the North-eastern Atlantic and the Mediterranean. *Merlangius merlangus merlangus* is common in the European coasts from Iceland and south-western Barents Sea to northern coasts of Portugal, and from western Baltic to Gotland Island. *Merlangius merlangus euxinus* is common in the Black Sea and adjacent parts of the Azov Sea. In the Mediterranean, it is apparently restricted to the Aegean Sea and the Adriatic (SLASTENENKO, 1956; FISHER, 1973; WHITEHEAD et.

al.,1986). Its distribution in the Black Sea has not been sufficiently studied to enable the stock to be evaluated, but on the basis of the data available on the Turkish catches, the whiting is distributed over the continental shelf of the Black Sea and considerable populations exist on the shelf off the Turkish Black Sea coast (IVANOV & BEVERTON, 1985).

2.6. HABITAT AND BEHAVIOR

Black Sea whiting (*Merlangius merlangus euxinus*) is a cold water species. The adults prefer water between 5 and 16°C, but the young fish, in the first year of their life, are found during the warm season in the upper layers (IVANOV & BEVERTON, 1985). The whiting inhabits inshore waters over muddy grounds, forming shoals at depths between 30-100m, but generally not deeper than 85m (FISHER, 1973; WHITEHEAD et. al., 1986). In the Black Sea, it does not perform long migrations. In Spring, they move to lesser depths (the upper boundary of distribution is at 15-30 m) for feeding and migrate to greater depths (80-120 m) for spawning in autumn (SHULMAN, 1974; IVANOV & BEVERTON, 1985).

The whiting makes regular vertical migrations; descending during the day above the bottom, and rising during the night to the thermocline or to the upper layers of distribution (WHITEHEAD et. al., 1986).

The postlarvae or zero age group are found in the coastal waters and in the open sea, in the surface layers down to 65 m over depths of 1000-2000 m in the Black Sea (IVANOV & BEVERTON, 1985). In a study on the vertical distribution of postlarvae of whiting (*Merlangius merlangus*) off Plymouth, postlarvae below 12 mm in length showed little or no vertical migration at night, while specimens over 12 mm in length migrated (RUSSELL, 1976). Regional distribution and migratory routes of whiting in the Black Sea are shown in Figure 4.

2.7. REPRODUCTION

Reproduction of the Black Sea whiting takes place the whole year round with a maximum in September-March. In winter, spawning takes place in the upper 80 m of the water layer in temperatures between 7 and 8°C, and in summer below the thermocline in temperatures between 6 and 8°C. The eggs are spawned in batches (IVANOV & BEVERTON, 1985).

The eggs of the whiting are pelagic, spherical 0.97-1.32 mm in diameter, yolk is unsegmented, and contains no oil globule (Figure 5). The incubation period as depend on the temperature, is 12-15 days (RUSSELL, 1976).

The spawning of whiting in captivity was studied by HISLOP (1975). Eggs were shed in batches over about 10 weeks by a single female, and the size of the eggs decreased as the season advanced from 1.15-1.22 mm in diameter to 1.05-1.12 mm.

2.7.1. LARVAL DEVELOPMENT

The newly hatched larvae are usually about 3.2-3.5 mm long (RUSSELL, 1976) in the northeast Atlantic coasts and 2.7-2.8 mm long (SLASTENENKO, 1956) in the Black Sea. The larvae have unsegmented yolk without an oil

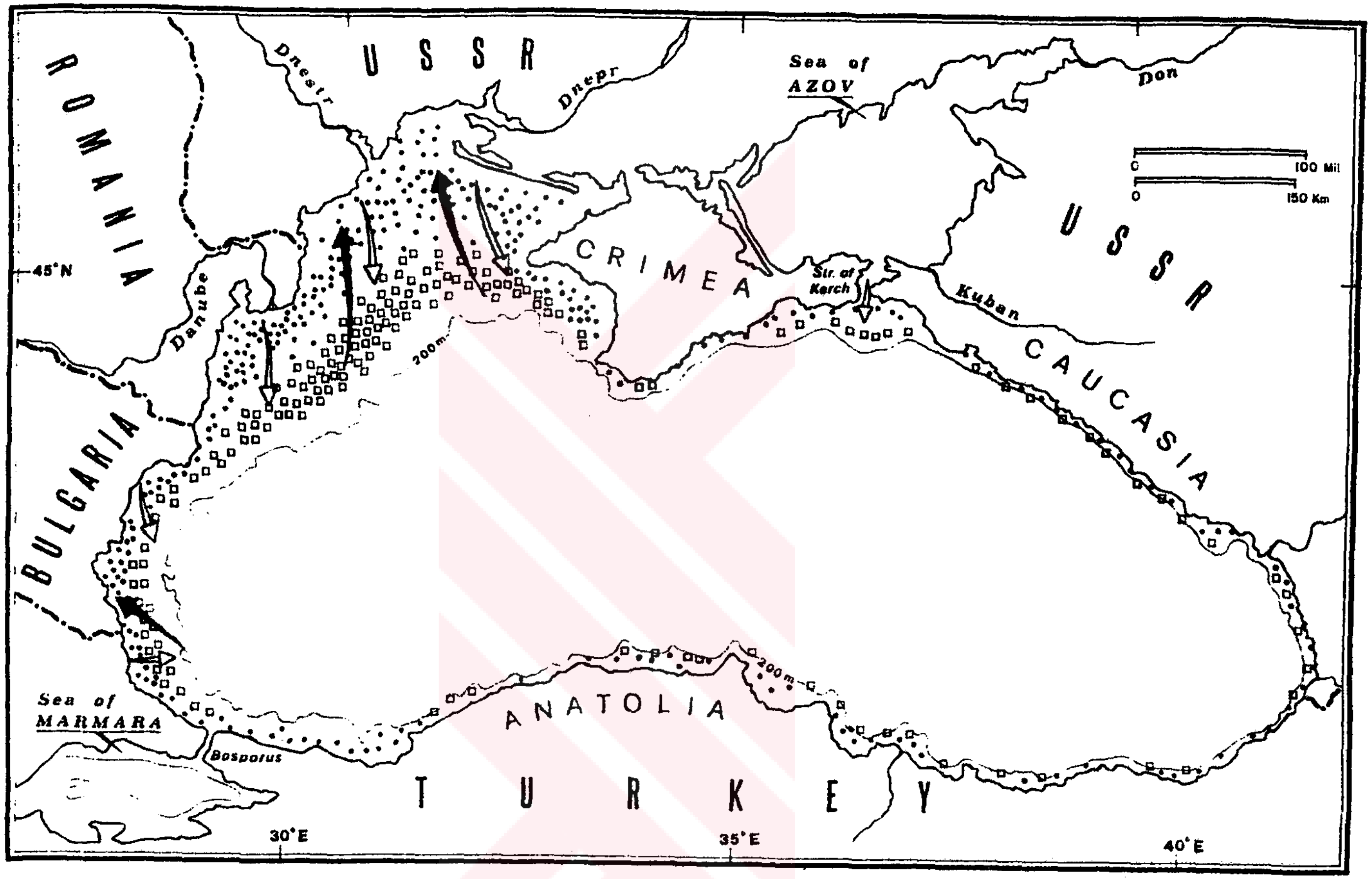


Figure 4. Distribution and migration of whiting (IVANOV & BEVERTON, 1985)

□□□ Spawning areas, and migration to them

:::::::: Feeding areas, and migration to them

➡ feeding areas ⇨ spawning areas

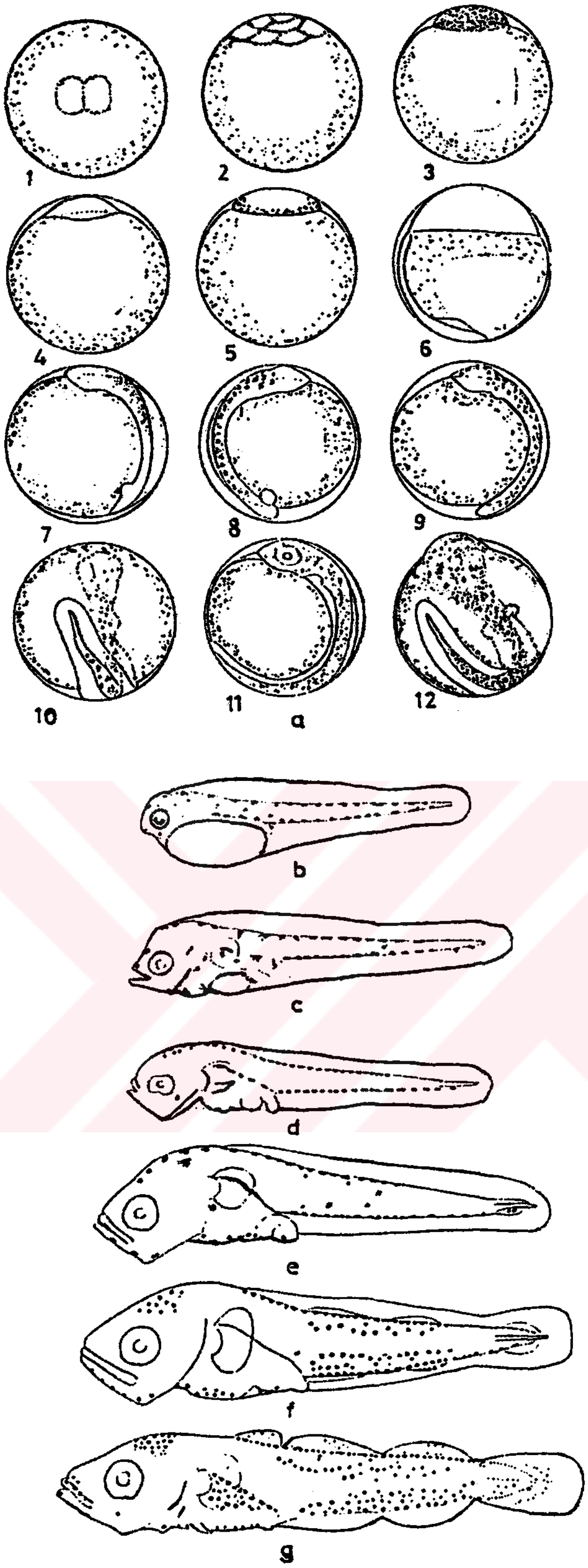


Figure 5. The eggs of whiting with embriyo, prelarval and postlarval stages of the embryonic development: (a) egg stages of the embryonic development, (b) larvae, newly hatched, 3.0 mm; (c) larva, 5.5 mm long, 5 days old; (d), (e), (f) and (g) postlarvae, 4.3 mm, 6-8 mm, 9.0 mm and 16 mm. (from RUSSELL, 1976)

globule (Figure 5). Yellow pigments are variably present on the yolk sac and primordial fin. When the larvae have reached 4 mm in length, the yolk sac is absorbed, the eyes become dark and the body is pigmented as free. The larvae grow to 5.5 mm long within 5 days after hatching (RUSSELL, 1976).

2.7.2. POSTLARVAL DEVELOPMENT

Up to about 6 mm in length there is a little change in the pigmentation, which is characterized by the fact that the dorsal row of melanophores does not extend so far back as the ventral row (Figure 5).

At a length of 6.5 mm a few melanophores may already be present on the sides of the body preanally. Interspinous ray appear dorsally and ventrally in the caudal fin and notochord is still straight.

The notochord has started to turn upwards at length of 9 mm. Fin rays are apparent in all unpaired fins, but only just detectable in first dorsal fin. The pelvics are just appearent as small knobs. The anus is a little anterior to the front end of the developing second dorsal fin .

At a length of 11 mm a few melanophores are appearent between the rays on the proximal portions of both anal fins.

3. UNIT STOCK

The fishing grounds along the Turkish Black Sea coast are being managed currently as one unit; that is, controls on mesh size, fishing effort, fishing season, and minumum saleable sizes, are applied in a blanket policy along the approximately 1400 km of shoreline, without regional distinction. This type of management would be appropriate if fish species, exploited at numerous fishing grounds existed as only one homogeneous stock. However, evidently there are no records or results of research which may indicate geographical homogeneities within the limits of geographical distribution of this fish population in the Black Sea. The genetic isolation inherent in intrastock breeding, along with differential interstock growth coefficients, would necessitate setting the controls on mesh size and fishing effort according to each stock's own regenerative capacity and particular growth characteristics (WEATHERLY, 1972).

By definition, a unit stock is a collection of individuals of a single fish species which functions as a breeding unit while sharing a common gene pool and being genetically isolated from other stocks of the same species. Furthermore, a group of fish of the same species or race, which has a self-maintaining system having the same indicators of mortality and physiological features (body growth), and inhabiting a particular geographical area, is also considered as a unit stock. Stocks are discrete groups of animals which show little mixing with the adjacent groups and one essential feature is that the population parameters remain constant over the distribution area of the stock. Additionally, a group of fish having a single spawning ground to which the adults return year after year is treated and/or defined as unit stock

(CUSHING, 1968; SPARRE et. al., 1989). However, BEVERTON & HOLT (1957) define a stock as a self-regenerating open system, exchanging materials with environment and usually tending to a steady state. Utilizing the ideas of various authors, BINGEL et. al., (1971) provided a general definition; a unit stock is a group of organisms consisting of the same species or race, having a self-regenerated system, spawning in a particular geographical area and time (of the year), and fished independently from other stocks.

The stock concept is closely related to the concept of growth parameters and mortality coefficients. An assential characteritics of a stock is that, its growth parameters and mortality coefficients should remain constant in a particular geographical area and time period. Therefore, fish stock assessments should be made for each stock separately. The results may or may not subsequently be pooled into an assessment of a multispecies fishery (RICKER,1975).

3.1. SOURCE OF VARIATION IN A SPECIES

The differences in morphometric and meristic characters of a species between regions may result from the differences in genotype, in environmental factors operating on one genotype, or both of these acting together (PARRISH & SHARMAN, 1958). While both morphometric and meristic characters respond to changes in environmental factors, their responses are different in some situations. The meristic characters, e.g numbers of vertabrae and keeled scales, are fixed in early embryonic stage of the individual which is a short period of time of their life span and then remain unchanged. On the other hand, the morphometric characters are not sensitive to short term local fluctuations, and reflect the average differences over long periods between environmental factors in different areas (PARRISH & SHARMAN, 1958; BRANDER, 1978; FAHY, 1978). The influence of short fixation period on meristic characters may give rise to wide variations in their values (within genetically controlled limits) amongst the members of the same and different year classes of a single unit stock (PARRISH & SHARMAN, 1958). In early studies, an inverse relationship between meristic characters and water temperature during early development was demonstrated and stated that the number of meristic character decreases by increasing water temperature in this restricted period. There are also other factors known to affect meristic characters in fishes. These are dissolved oxygen concentration, salinity, carbon dioxide concentration, light intensity, exposure to X-rays, etc. (JOHNSON & BARNETT, 1975).

The borders between different stock areas may or may not be very distinct and this borders sometimes coincide with ecological borders such as salinity frontiers or topographical boundaries (ridges, troughs). If the borders between different stocks is not clear, interstock mixing occurs (THUROW, 1982). An obvious separation between different regions may lead to genetic variations, or differences in frequencies of occurrence of some inheritable characters between stocks. These variations between subpopulations may result from the initial migration of a fraction of the original population into unoccupied environment and this effect of the migration may be direct and indirect. Directly, if the size of migrating fraction is very small, the carrying probability of representative gene pool to the new habitat is small and also frequencies of some characters may be small or large due to sampling error, or may be missing in the new population. Indirectly, if the migrating fraction is large, different environmental pressures in the new niche may be selective for certain phenotypes (such as, survivability, sexual maturity and fertility) over the generations since a new stock with different allele frequences is produced for the characters under differential selection. However, in the case of the migration of a genetically identified species to a new habitat which has very similar environmental conditions, genetic differences could not be detected although in reality the stocks may form different units (PAYZA, 1983).

The number and relative abundance of races, which are alternate forms of the previous population are measures of the genetic variation. ODUM (1971) underlined the genetic variations are the result of the adaptation to environmental change (or stress) for survival, and therefore, the races arise as the response to the natural selection .

3.2. STOCK IDENTIFICATION

Statistical techniques have often been used for purposes of discrimination and classification. SHARP et. al., (1978) used multivariate discriminant function analyses to assess the degree of statistical separation between groups, to evaluate the relative importance of the various meristic and morphometric characters as diagnostic tools, and to develop classification functions for six groups considered and determined discrete stocks by using the Generalized Distance of Mahalonobis. They stated that, although analyses of meristic chacters provided no evidence of discrete stocks, analyses of morphometric characters provided strong statistical separation between areas. VILLALUZ & MACCRIMMON (1988) applied the discriminant analysis of Generalized distance (Mahanalobis D^2) to population of milkfish in Philippine waters and this analysis indicated several morphometric subgroups of milkfish in the area.

POPE & HALL (1972) used multivariate statistical analysis to ascertain whether significant differences in body shape existed between North Sea herring stocks and showed quite clearly differences in morphometric characters among different stocks. JAHNSON & BARNETT (1975) used standard statistical tests to show the relationship between meristic counts and food supply on four species of mid-water fishes and hypothesized that this relationship reflects differences in egg size, fecundity, size at hatching, and size at comparable stages of larval development between populations in different areas. EHRICH & REMPE (1980) attempted to show morphometric discrimination between hake populations (*Merluccius sp.*) from the Northeast Pacific by the use of Generalized Distance analysis of Mahalanobis and showed the morphometric (11 characters) similarities and differences among four populations. They also stated that the morphometric differences between two populations inhabiting different temperature suggests that the morphometric differences could become greater because of the differences in water temperature in spawning areas. BURD (1969) used for the discrimination of North Sea herring populations, not only meristically but also relative values of metric variables related to the total length. The result was unsatisfactory. The separation of the populations was based essentially on the condition factor which was highly significantly correlated with the total length. GAMBLE (1959) made analysis using the vertebral counts of whiting in the North Sea area and stated that there is a definite correlation between the vertebral characters of whiting and latitude, and this suggests that there is little interchange between the fish in the adjacent regions . GAMBLE (1960) compared the Clyde whiting stock with other whiting stocks in a number of ways (e.g. the age and length composition of the stocks, the vertebral count, the otolith types and growth rates of the two groups of whiting) and showed that there is little connection between the Clyde and Minch stocks. BOONSTRA (1977) separated the stocks of Kingklip (*Genypterus capensis*) using the regression of fish lengtht on otolith length and of fish length on otolith-height ratio, and comparing the distribution of vertebral number for the geographically different areas of the South Africa. AGNEW (1988) used the frequency distribution analysis to separate the two populations of Irish Sea cod (*Gadus morhua*) and stated that the two populations separated by frequency distribution analysis have different growth characteristics. GARROD & GAMBELL (1965) used tagging experiments, analyses of meristic characters and blood groups to separate the stocks within the Irish Sea and showed that the various populations fished within the Irish Sea are not independent unit stocks.

AVSAR (1987, 1994) and AVSAR et.al. (1988a, b, 1990) carried out the stock differentiation studies of scaldfish (*Arnoglossus laterna* W.), silverbelly (*Leignathus klunzingeri* S.), lizardfish (*Saurida undosquamis* R.) in the Gulf of Mersin, and sprat (*Sprattus sprattus phalericus* R.) in the Turkish Black Sea coast. For the separation of stocks in the Gulf of Mersin, morphometric characteristics were used in the analysis of the generalized distance of Mahalanobis. For the separation of stocks of sprat in the Black Sea coast, fifteen morphometric measurements, together with nine meristic counts were used in the analysis of the generalized distance of Mahalanobis.

In this study, Generalized Distance of Mahalanobis was used to ascertain whether significant differences in morphometric and meristic characters existed between the whiting (*Merlangius merlangus euxinus*) stocks fished within the Turkish Black Sea coast.

4. MATERIAL AND METHODS

The samples were obtained using R/V Bilim and R/V Surat 1. The bottom trawling surveys were carried out on several occasions from 1990 to 1993. The period of the trawling surveys and regions sampled are given below (Table 5).

Table 5. Sampling periods and regions (WBS: Western Black Sea, EBS: Eastern Black Sea)

VESSEL	PERIOD	REGION SAMPLED
R/V BILIM	April 1990	WBS (Igneada-Civa Cape)
	September 1990	WBS (Igneada-Civa Cape)
R/V SURAT 1	September 1991	EBS (Sinop Cape-Hopa)
	October 1992	EBS (Sinop Cape-Hopa)
R/V SURAT 1	June 92-May 93*	Beşikdüzü, Trabzon, Sürmene

* : every month from June 1992 to May 1993, except September 1992

Samples were collected by applying the stratified sampling technique. The area stratification was based on geographical areas which are divided into regions according to the bottom depth. The depth intervals choosen were 0-50 m and 50-100 m. Figure 6 shows the survey areas with strata used during the bottom surveys. The total number of trawl stations in the survey was 66, of which 21 were taken from the western regions between the Bulgarian border and Sinop-İnce Cape and 45 (of which 3 were montly sampling stations) from the eastern part (Sinop Cape-Hopa).

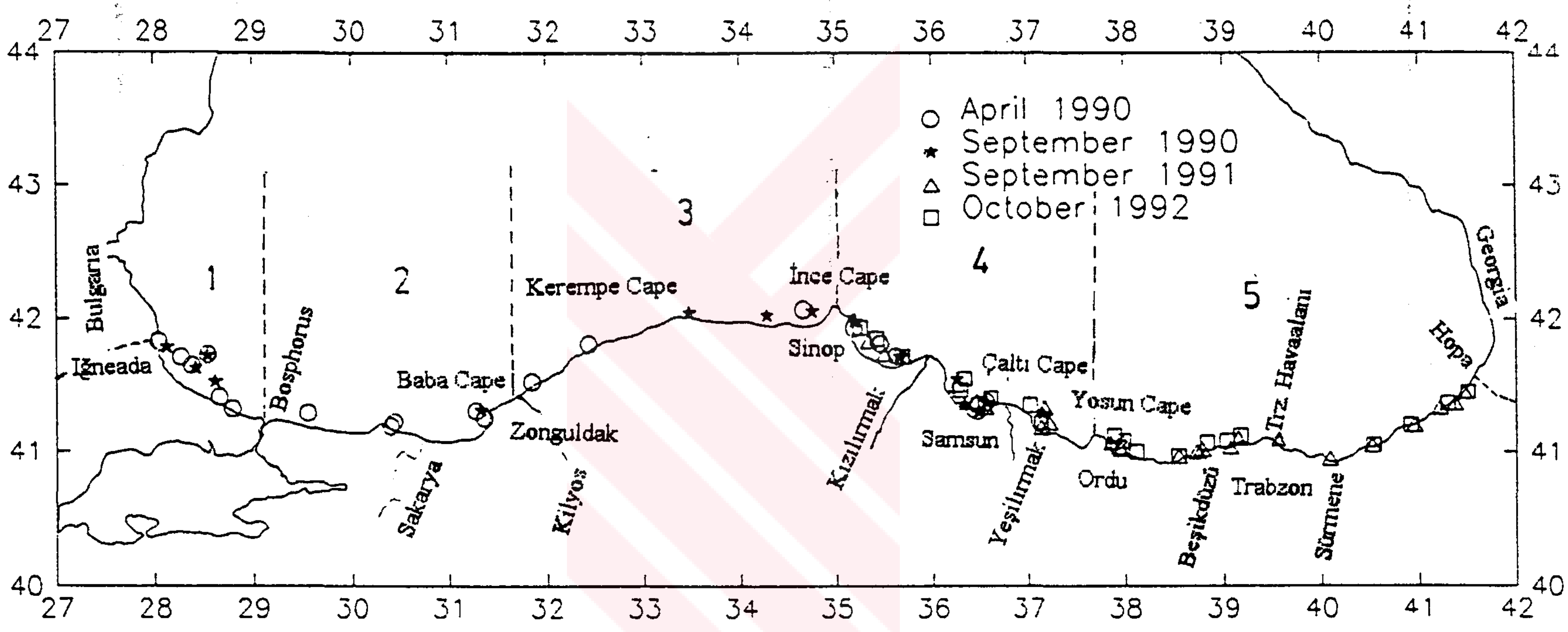


Figure 6. Locations of sampling along the Turkish Black Sea Coast.

Sampling by R/V Bilim was performed with a bottom trawl equipped with head rope of 40 m in length. The cod end mesh size was 7 mm from knot to knot. The tows generally performed 30 min in duration at a vessel speed of 2.5 knots. However, in some cases, the towing duration was changed due to the sea bed topograpy. During the bottom trawl investigations which were performed on board R/V Surat 1, a net with head rope length of 20 m was used. The cod end mesh size was 14 mm from knot to knot.. The tows were restricted to 30 min at a vessel speed of 1.5 knot .

After the catch was taken on the board, mud and other organic and inorganic matter were washed out carefully by sea water and sorted according to species. In poor hauls, total catch was used for analysis. When the catches were in excess, then a subsampling procedure was applied as described by HOLDEN & RAITT (1974).

The number of individuals analysed to discriminate the stocks, to estimate growth parameters and to determine the stomach content for each sex group are shown in Table 6 for the whole sampling period.

The samples taken were preserved with buffered 4% formaldehyde solution in 15 litre plastic jars with a label containing the information on the cruise number, date, station number and position (latitude-longitude), depth, hauling time and speed of vessel.

In laboratory, samples preserved in 4 % formaldehyde solution were removed from plastic jars and washed with tap water to remove excessive formaldehyde solution. After washing, the fishes were examined immediately to prevent the deformations of body lengths which would be resulted from drying of fish.

Table 6. The number of individuals analysed in each sex and in whole sampling period.

DISCRIMINANT ANALYSIS

PERIOD		MALE	FEMALE	TOTAL
April	1990	672	783	1455
September	1990	657	722	1379
September	1991	771	901	1672
October	1992	632	938	1570
TOTAL		2732	3344	6076

GROWTH STUDIES

PERIOD		MALE	FEMALE	TOTAL
April	1990	672	783	1455
September	1990	657	722	1379
September	1991	771	909	1680
October	1992	632	936	1568
June	1992	41	109	150
July	1992	44	87	131
August	1992	38	78	116
October	1992	20	34	54
November	1992	19	20	39
December	1992	62	67	129
January	1993	36	64	100
February	1993	45	74	119
March	1993	51	98	149
April	1993	40	79	119
May	1993	53	116	169
June92-May93		449	826	1275
TOTAL		3181	4176	7357

Table 6 continued

STOMACH CONTENTS AND PARASITES				
PERIOD		MALE	FEMALE	TOTAL
April	1990	672	780	1452
September	1990	139	139	278
September	1991	120	147	267
January	1992	33	42	75
June	1992	41	109	150
July	1992	44	87	131
August	1992	38	78	116
October	1992	9	27	36
November	1992	19	20	39
December	1992	51	54	105
January	1993	34	58	92
February	1993	36	64	100
March	1993	51	98	149
April	1993	40	79	119
May	1993	53	116	169
June92-May93		416	790	1206
TOTAL		1380	1898	3278

4.1. MORPHOMETRIC MEASUREMENTS

Morphometric measurements were made using a measuring board and calipers. Overall length measurements were made with the fish lying on its right side, snout to the left, on a measuring board consisting essentially of a wooden carrying a center scale and having a headpiece (nose block) against which the snout is gently pressed. The mouth was closed, the fish body and tail were straightened along the mid-line and the reading was taken from the scale. Longitudinal, vertical and lateral measurements other than overall length were made using a caliper as a straight line between perpendiculars along the median vertical and lateral body axes. Fifteen length measurements were taken from each fish (Figure 7). All morphometric measurements were determined to the nearest millimeters.

Each morphometric measurement was symbolized by a letter. The positions of these measurements are shown in Figure 7 and the definition of these positions were listed below as defined by HOLDEN & RAITT (1974).

L	Mandibular symphysis
O	Anterior edge of orbit
O'	Posterior edge of orbit
Y	Gill-cover notch
P	Anterior point of insertion of first pectoral fin ray
D1	Insertion of anterior dorsal
D3	Insertion of first ray of last dorsal
A	Insertion of first anal fin ray
V	Anterior point of insertion of first pelvic fin ray
S	Posterior tip of urostyle (forward protuberance of hypural blade)
N	Distal tip of the longest dorsal caudal fin ray, lobe normally extended
B	Insertion of dorsal lobe of caudal fin

Overall length measurements

LN	Total length
LS	Standard length
LB	Body length

Longitudinal measurements

LO	Preorbital length
LY	Head length
OO'	Orbital diameter

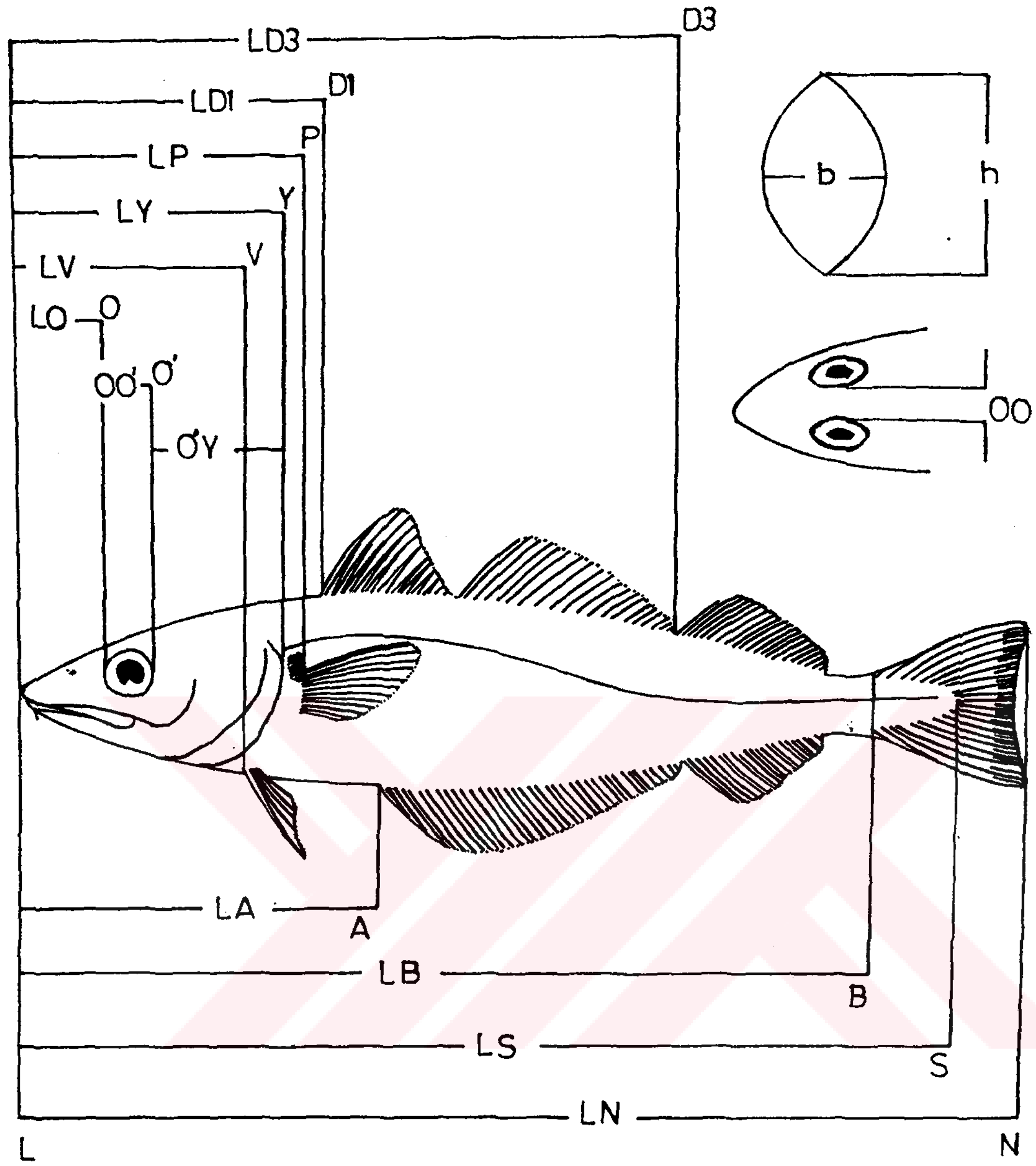


Figure 7. Measured morphometric characteristics of *Merlangius merlangus euxinus* (N.) (Figure from FISCHER, 1973 and definition of morphometrics from HOLDEN & RAITT, 1974)

LN=Total length, LS=Standart length, LB=Body length, LO=Preorbital length, LY=Head length, OO'=Orbital diameter, O'Y=Postorbital distance, LP=Prepectoral distance, LV=Preventral distance, LD1=Preanterior dorsal distance, LD3=Last dorsal distance, LA=Preanal distance, h=Greatest depth, b=Greatest breadth, OO=Interorbital distance

O'Y Postorbital distance
LP Prepectoral distance
LV Preventral distance
LD1 Preanterior dorsal distance
LD3 Last dorsal distance
LA Preanal distance

Vertical measurement

h Greatest depth

Lateral measurements

b Greatest breadth
OO Interorbital distance

4.2. MERISTIC COUNTS

Eleven meristic characters consisting of gill rakers, gill filaments, vertebrae and all fin rays were counted after all morphometric measurements were taken. The counts were made by means of a binocular microscope (magnification X 10). In order to count gill rakers and gill filaments, the first gill arch under the left operculum was removed using a scarpel and forceps and put in petri dish containing water.

The vertebrae were removed by cutting with a scarpel from posterior side to anterior margin. The vertebral column was then cleaned of the remains of flesh and was counted immediately.

Dorsal, pectoral, anal, caudal, pectoral and pelvic fin rays were counted freshly since the skin of dried fin is more difficult to nick. The number of rays on the paired fins was counted on one side only.

4.3. WEIGHING

In order to establish length-weight relationship and to calculate gonadosomatic indices, the whole fish and its gonad was weighed by means of an electrical balance (down to 0.01g) after drying on a blotting paper.

4.4. SEX DETERMINATION AND MATURITY STAGES

The body cavity was opened from anus to anterior of gill. After exposure of the gonads, differentiation between sexes was made by naked eye. In the immature virgin stage the distinction between sexes was made by binocular microscope examination; ovaries are granular in appearence while the testes are flat.

A seven-stage maturity scale and the relation between gonad size and size of the body cavity, and the shape of gonad at each stage (Figure 8) defined by BOWERS (1954) was used for the determination of maturity stages. The appearence of the gonad at each of the maturity stages employed in this investigation is described in Table 7.

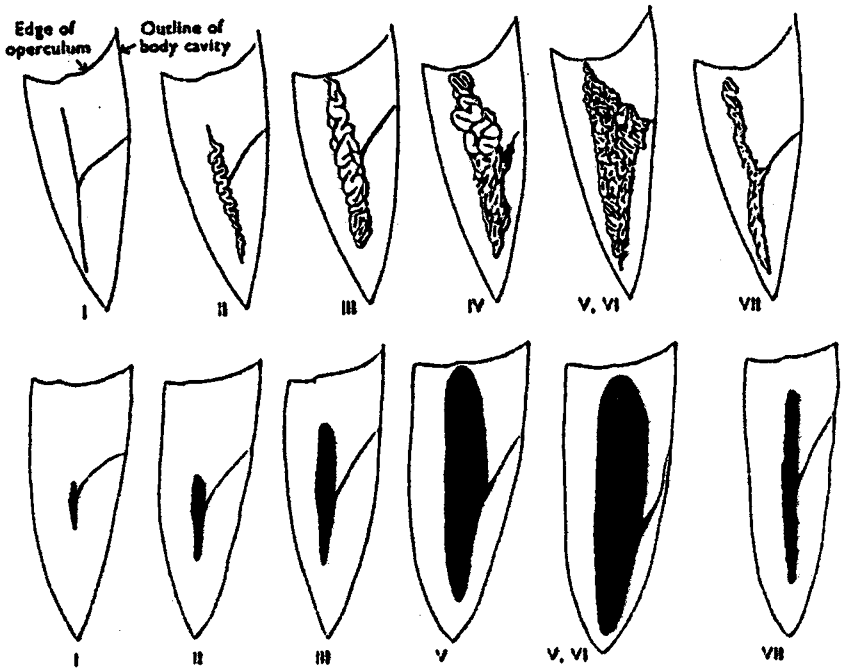


Figure 8. Changes in size of gonad in relation to the body cavity at different stages of maturity. Upper row: testis; lower row: ovary (from Bowers, 1954).

Gonadosomatic index (GSI) used as an indicator of gonad development was calculated for each month (GIBSON & EZZI, 1980; 1981; HTUN-HAN, 1978) using the equation,

$$GSI = \frac{\text{Gonad weight}}{\text{Body weight without gonad}} \times 100$$

Condition factor (K) was determined to express the changes in the food reserves stored in the muscle (HOLDEN & RAITT 1974; HTUN HAN, 1978; GIBSON & EZZI 1980; 1981). So, there is an inverse correlation between the GSI and K which was defined as the ratio of the weight of the whole fish (without the gonads) to the cube of its length.

Table 7. The appearence of the gonad at each of the maturity stages (Bowers, 1954).

STAGE	STATE	External appearence and description
		MALE
I	Immature virgin	Testis a very thin narrow translucent ribbon lying along an unbranched blood vessel.
II	Maturing virgins	Testis slightly lobed and lightly coiled. Opaque white at anterior end, transparent at posterior at first, later uniformly white.
III	Maturing and ripening	Length of testis about three-quarters length of body cavity. Testis more strongly coiled with fat lobes, whitish grey in colour with blood vessels clearly seen in the lobes.
IV	Maturing and ripening	Testis coiled and convoluated, completly opaque, white.
V	Ripe not yet running	Testis a mass of tightly coiled and convoluated lobus. Completely opaque, creamy white in colour.
VI	Running	Milt extruded easily by slight pressure on the flanks of the fish. Appearance as at stage V.
VII	Spent	Testis crinkled and shrunken,rather broodshot Yellowish white colour.
		FEMALE
I	Immature, virgin	Ovaries very small, not more than one-fifth of the length of the body cavity, usually less than 2 cm. long. Elongated sausage shape whitish, translucent. Eggs microscopic.
II	Maturing virgin	Ovary not more than one-third length of body cavity, torpedo-shaped. Colour varying from wine-coloured, translucent, to dull orange.
III	Maturing and ripening	Ovary not more than one-half length of body cavity. Colour pink, pinkish buff, or flesh colour. Eggs opaque, visible to the naked eye in good light.
IV	Maturing and ripening	Ovary enlarged and distended occupies about two-thirds of body cavity. Orange pink in colour. Eggs clearly visible, opaque.
V	Ripe not yet running	Ovary very swollen, tunica bursts easily. Some eggs transparent.
VI	Running	Eggs extruded easily by slight pressure on the flanks of the fish. Nearly all eggs transparent.
VII	Spent	Ovary pinkish white, flaccid, shrunken, with some residual eggs.

$$K = \frac{\text{Body weight - Gonad weight}}{\text{Length}^3} \times 100$$

For the analysis of length at sexual maturity, a whiting was defined as being mature if the gonads were in the ripening, ripe, spawning, spent or recovering condition (BEACHAM & NEPSZY, 1980).

4.5. FECUNDITY

The ovaries used for fecundity estimation were collected from whiting reached the ripe stage. In 1990, 115 specimens were collected from the western Turkish Black Sea coast. 25, 47 and 48 specimens were obtained from the eastern Turkish Black Sea coast in 1991, 1992 and 1993, respectively.

The ovaries were cut longitudinally and stored in Gilson's fluid (HISLOP & HALL, 1974; HOLDEN & RAITT, 1974). The ovaries were then treated as described by HISLOP & HALL (1974) and BAGENAL (1978) for counting. To separate the eggs from the connective tissue remnants, the eggs were placed in a graduated glass cylinder and water was added to make up a suspension of known volume. The suspension was agitated using a non-rotary action, until the eggs appeared to be distributed uniformly and, a sample of known volume was extracted with a pipette. All samples were counted at least three times under binocular microscope and the mean value was calculated. The fecundity was estimated by multiplying the mean value by the factor V/v, where V is the volume of the suspension and v is the sample volume.

The data were grouped by geographical area, i.e. eastern (east of 35° E) and western (west of 35° E) Black Sea, and for analysis fitted by least squares regressions using log-log (base 10) transformations as described by HISLOP & HALL (1974), and BOWERING (1980). Analysis of covariance (ROHLF, 1986) was used to test the significance of the differences between regression coefficients and between the logarithms of the adjusted means.

4.6. STOMACH CONTENTS

Whiting stomachs were sampled either seasonally (in spring and autumn) between 1990 and 1992, or monthly except in September from the three fixed stations (Beşikdüzü, Trabzon-Havaalanı and Sürmene; Figure 6) in the eastern Black Sea between 1992 and 1993. A total of 3272 stomachs were examined (Table 6).

As soon as possible following the catch, 4 % buffered formaldehyde was injected into the stomachs. Stomachs were removed by insicion with a scalpel at the pharynx and pylorus. Total stomach weights were taken after drying on blotting paper. Later, the stomachs were opened and the contents were sorted to taxonomic groups or to species where possible. Total weight and number of each prey category were recorded. Where possible the total length of prey (fish) found in the stomach was measured to the nearest cm. In some cases it was impossible to count some food organisms like copepods due to the partial digestion, these food items were then weighed only.

Stomachs which were evidently empty (may be due to regurgitation) were counted and rejected. The criterion used to estimate whether a stomach was empty due to regurgitation was the same as used by DAAN (1973). Prey fish which appeared extremely fresh when the stomach was opened were omitted, as these were suspected to have been swallowed (due to confusion) during the trawl. If the stomach contained only water it was considered empty.

The stomach content data were analysed using both the relative importance and the relative frequency of occurrence methods. The relative frequency of occurrence gives an estimate of how often one prey category appears in the average stomach relative to total number of items (HYSLOP, 1980). The relative importance (or gram prey per-predator) of the different prey categories in terms of wet weight was calculated as the relative contribution of each prey species to the total diet.

The digestive tract was searched internally in all fish used the stomach content analysis and the number and locations of endoparasite present in individual fish was recorded.

4.6.1 DAILY FOOD CONSUMPTION

In order to estimate the daily food consumption, a simple model formely used on cod, haddock and whiting (JONES, 1974, 1978), was applied to the present data on stomach contents of whiting. JONES (1974) found that the rate of elimination of food from the stomachs of cod, haddock and whiting was a function of the mean stomach content weight, the size of the predator, water temperature, and type of prey. He derived the following equation expressing the relationship between these parameters. In this metod, it was assumed that, the feeding rate is equal to the rate of elimination of food from the stomach.

$$R = Q\,(L / 40)^{1.4}\,W^{0.46}$$

where,

R: rate of elimination of food from the stomach (g/h)

L: length of fish (cm)

W: weight of food in the stomach (g)

Q: digestion coefficient (rate of elimination of 1 g of food from the stomach of fish of 40 cm)

Q was recalculated for the mean temperature (10.1°C) from the values that JONES (1974) found in continuous-feeding and single-meal experiments at different temperatures (6 and 12°C) and for different species of prey. In other words, the Q values were standardized by a correction factor ($10^{0.035(t_c-t_0)}$) as reported by JONES & HISLOP (1978), ARMSTRONG (1982) and DU BUIT (1984). The daily consumtion rate was calculated by multiplying the rate of elimination by 24 (hrs) and then the yearly rate was estimated by multiplying the daily rate by 365.

Estimation of the whiting's consumption of other commercially exploited fish species (sprat, whiting, anchovy and goby) was made by calculating its percentage (weight) in total.

4.7. AGEING

The age of fish can be estimated, ideally, from the annual growth rings on the scales, in the otoliths or in other skeletal structure. Demographic methods (e.g. Petersen method) can also be used for age determination. For the whiting however, only the otolith provides a reliable basis for age determination in older fish. The scales from young whiting are readable, but they become increasingly difficult in fish older than about four years of age. Petersen method is difficult after the first year of life in most regions , probably because of the long spawning season of whiting. This causes each year-class to have an extended length range, and consequently results in consecutive year-classes overlapping very considerably on a length scale. Vertebrae, spines and some bones of the head of whiting all show seasonal growth zones which can be interpreted to give the age of the fish, but as with the scales, they become increasingly difficult with age, and also suffer from the disadvantage of being difficult to collect in some cases (GAMBELL & MESSTORFF, 1964). This leaves the otolith, which gives an estimate of the age of the whiting over the whole life span of the fish.

The otolith of the whiting is an elongate structure, rounded or obliquely truncated anteriorly and tapering to a point posteriorly. The shape changes considerably with age. The margin is crenellated. The surface, which lies towards the brain is slightly convex in transverse section; the outer surface is flattened. Whiting otoliths are thinner and flatter than those of most other gadoids (BOWERS, 1954).

Estimation of age for whiting was presently based almost exclusively on interpretation of otolith structures for the presence of hyaline and opaque zones which are assumed to represent winter and summer growth periods respectively. Removing, storage, preparation and examination of otolith formats are given as follows: The fish was laid on its abdomen, cut transversely across the head by means of scarpel, slightly behind the eyes, far enough into the skull to allow the head to be broken open. Both otoliths were removed, undamaged, by means of forceps and placed in a labeled envelope. The envelopes containing otoliths from each sample were stored together in a wooden-box.

Otoliths stored dry become opaque and are unreadable as whole otoliths without further treatment. Sagittal otoliths were presently sectioned across the center of the nucleus, using a scarpel, and the section or surface of otoliths were corrected in order to make it much easier to read by using the grinding. Otoliths mounted on adhesive plastic surface in the Plexiglas tray and they were fixed by means of the white cement, and then burned at 200^{o} C for about half and hour (BINGEL, 1980) .

The otoliths were examined in glycerin under a binocular microscope by direct light from above. The burning enhanced the visibility of hyaline zones. These zones appeared brown while the opaque zones remained white.

4.8. DISTANCE FUNCTION

For the discrimination of morphometric and meristic characteristics, which were obtained from the individuals of different localities, the Generalized Distance Function analysis developed by MAHALANOBIS et.al. (1949, c.f.

WEBER, 1972) was used. This form of multivariate analysis gives a measure of distance between pairs of groups in units of standard deviation (LERMAN, 1965; EHRICH & REMPE, 1980) and a mean for determining whether two groups represents a discrete stock or the same stock. The quantitative separation of the whiting stocks was made by using the equation given by WEBER (1972):

$$D^2 = (b_1 d_1 + b_2 d_2 + b_3 d_3 + b_4 d_4 \ldots\ldots\ldots\ldots + b_m d_m)/m$$

where;

m : Number of measured and counted characters

D^2 : Generalized Mahalanobis Distance

b_i : Discrimant functions of the i 'th measurement

d_i : Mean difference of the i ' th measurement

A significance test described by SNEATH & SOKAL (1973); OVERAL & KLETT (1972) and DAVIS (1973) was used to qualify the statistical difference between two groups.

4.8.1. ARRANGEMENT OF THE DATA FOR DISCRIMINANT ANALYSIS

The goal of Discriminant Analysis is to separate two groups from each other, and to include the elements which can not be grouped into such pre-separated groups. When individuals of two or more groups are to be compared, the sample size (# of individuals examined) should be increased as much as possible to increase the discrimination of two groups.

Before running the discriminant analysis, morphometric measurements should be standardized either by directly multiplying or dividing by size or by any measurable character related to length (BLACKITH & RAYMENT, 1971). In present study, there were considerable differences between the minumum and maximum total lengths of both sexes in each sampling period. Therefore, morphometric measurements were standardized by dividing with the cleaned (eviscerated) weight as defined by AVSAR et. al.,(1994).

Similarly, there were obvious differences between the sex and age compositions of the samples, and especially, between the sex compositions of age group III and higher age groups in all regions. The difference between sex ratios of age group I and II is smaller than those of the age group III and higher (Table 8). Therefore, the comparison of the samples for the discrimination was meaningless prior to standardisation of the data set. In general, male and female of a fish species shows different growth characteristics (HOLDEN & RAITT, 1974) and individuals of a species exhibit different annual growth characteristics from one age to other and also succesive cohorts may grow differently depending on environmental conditions (SPARRE et. al. 1989), and Generalized Distance increases with increasing differences in total lengths (EHRICH & REMPE 1980). Therefore, it is assumed that such differences either between age groups or sexes will much affect the results of Discriminant Analysis. In order to eliminate age-influenced size differences of each morphometric measurement and prevent the error which will result from the differences in percentage ratios of males and females, the numbers of individuals of the same age group in each sex were equalized.

The total number of the fish analyzed in each sampling period for their morphometric and meristic discrimination belonging to different age groups and to different sexes are given in APPENDIX A.

Table 8. The numbers (n) and differences in percentage ratios (%) of males and females in different sampling periods and age groups in five sampling areas.

	REGIONS														
Sampling periods	1			2			3			4			5		
	%	M	F	%	M	F	%	M	F	%	M	F	%	M	F
APR 1990	6	165	138	10	277	339	12	85	109	8	158	185	-	-	-
SEP 1990	6	180	202	4	48	45	2	129	125	8	299	351	-	-	-
SEP 1991	-	-	-	-	-	-	-	-	-	12	282	358	6	485	547
OCT 1992	-	-	-	-	-	-	-	-	-	16	302	418	22	332	518
	REGIONS														
Age group	1			2			3			4			5		
I	6	242	215	6	135	178	4	128	119	2	771	741	4	482	445
II	6	86	113	2	173	167	8	82	96	26	262	445	10	305	372
III	62	6	22	34	16	32	50	4	12	96	3	120	70	33	186
IV	100	0	1	100	0	8	100	0	7	100	0	9	88	2	34
V	-	-	-	-	-	-	-	-	-	100	0	2	88	1	15
VI	-	-	-	-	-	-	-	-	-	-	-	-	100	0	7
VII	-	-	-	-	-	-	-	-	-	-	-	-	100	0	6
IX	-	-	-	-	-	-	-	-	-	-	-	-	100	0	2

4.8. 2. SELECTION OF THE GROUPS COMPARED

Whiting, which is a cold-water demersal species and distributed over the whole continental shelf in the Black Sea, has pelagic eggs. Reproduction takes place the whole year round with a maximum in September-March. They do not need to migrate to wintering grounds. In winter, mature fish move into the deeper part of their range (i.e. 10 to 130 m) for spawning. The youngest and smallest fishes (post larvae, age 0+) are found in summer in the coastal waters and in the surface layers down to 65 m over depths of 1000-2000 m of the open sea (IVANOV & BEVERTON 1985). The distribution and orientation of the eggs and larvae are much affected by the existing current system in the area. The fish eggs and larvae may be transported and dispersed long distances and over large areas by currents (LAEVASTU, 1993).

When all the features mentioned above are considered, sampling stations were grouped into 5 regions in order to obtain reasonable results from discriminant analysis. The April 1990, September 1990 samples were collected between first and fourth regions while the September 1991 and October 1992 samples were collected from fourth and fifth regions (Figure 6).

The first region was chosen as the area between the Bulgaria-Turkey border to the Bosphorus entrance of the Black Sea (Figure 6) since the more saline deep waters, originated from Mediterranean, flow along the Bosphorus and the rim current bifurcates to form an anticyclonic eddy along the western side of the Bosphorus entrance (OĞUZ et. al. 1989). This more saline water and anticyclonic eddy might be considered as the oceonagraphic barrier along the eastern border of this group.

The second region is located between the Black Sea entrance of the Bosphorus and Zonguldak (Figure 6). This area is under the effects of anticyclonic eddies along the shelf in the Sakarya region (OĞUZ et. al., 1989) and the effects of Sakarya and Kilyos Rivers.

The region from Cape Baba to the Cape İnce (Figure 6) can be classified as the third group which contains the widest continental shelf towards the west side of Sinop. The analysis of 1992 hydrographic data and satellite images showed persistent upwelling with surface temperatures as low as 12 ^{0}C between Cape Baba and Cape İnce (SUR et al., 1993). In this region, the flow continues further eastwards along the coast without significant changes in its structure until offshore of the Cape İnce.

The region located between the Cape İnce and the Cape Yasun (Ordu) can be taken as fourth group (Figure 6). The main oceonagraphic conditions of the area is influenced by high freshwater flow of the Kızılırmak and Yeşilırmak rivers. The flow going eastward forms an anticyclonic eddy to the east of the Sinop Cape and another eddy located off the Yeşilırmak-Kızılırmak rivers region (OĞUZ et. al 1989). In the region, Sinop and Samsun Bays constitute the two wide continental shelves of the eastern Black Sea coast of Anatolia.

Fifth group covers the region between the Cape Yosun and the Georgia border (Figure 6). The rest of the flow continuing eastward gives the large scale anticyclonic eddy located between 37^{0} E and 41^{0} E longitutes along the shelf (OĞUZ et. al. 1989). The continental shelf in the region becomes narrower and deepens suddenly.

4.9. GROWTH IN LENGTH AND WEIGHT

The length-weight relationship for fish is generally described by the equation

$$w = a\, l^{b} \qquad \text{or} \qquad \ln w = \ln a + b \ln l$$

where:

w = the body weight (g)

l = the total length (cm)

a = the intercept (is the nutritional condition of the fish)

b = the slope (is the type of growth of the fish)

Functional regressions (RICKER, 1975; SPARRE et. al., 1989) fitted to length and weight data for the Black Sea whiting obtained during research surveys in 1990-93 in order to produce the length-weight relationship.

The growth in fish can be either isometric or allometric. The growth type of fish was decided in relation to the regression constant b. When the weight is equal to the 3' rd power of the length, the growth is isometric, otherwise it is called allometric (RICKER, 1975; SPARRE et. al., 1989). The condition of fish in a given time was estimated from regression constant a. To compare the conditions for different sampling times, Fulton's condition factor given by RICKER (1975) was used.

$$a = \frac{\overline{w}}{\overline{l}^{b}}$$

where:

a : Fulton's condition factor

$\overline{w}$: Mean weight

$\overline{l}$: Mean length

4.10. ESTIMATION OF GROWTH PARAMETERS

Seasonally oscillating version of von Bertalannfy Growth Function, which is modified by PAULY & GASCHUTZ (1979) and PAULY & DAVID (1980) was used for the estimation of growth parameters. This equation is derived from the assumption that fish generally grow faster during the period of higher water temperature than the period of lower temperature. By adding an oscillation term that follows a sine wave with one year period, fluctuation in the annual growth rate is simulated. This modified form of seasonally oscillating Growth curve has the following form :

$$L_t = L_\infty [1 - e^{-(K(t - t_0) - (CK/2\pi)^* \sin(2\pi (t - t_W))}]$$

where,

L_∞ = asymptotic length

K = growth coefficient

t_0 = the age the fish would have had at length zero

π = 3.14159

t_W = the winter point; at the time of the year when the fraction t_W of the year has elapsed the growth rate is lowest and $t_W = t_S + 0.5$, where t_S is the summer point and takes the value between 0 and 1.

C = the amplitude and usually takes values between 0 and 1. C=0 implies no seasonality of the growth rate, i.e. the above equation reduces the ordinary von Bertalanffy equation. The higher the value of C the more pronounced are the seasonal oscillations. If C=1, the growth rate becomes zero at the winter point.

This equation is rearranged as follows;

$$y = a + b_1x_1 + b_2 x_2 + b_3x_3$$

where,

$$y = \ln (1 - L_t / L_\infty)$$

$$x_1 = t \text{ (age in years)}$$

$$x_2 = \sin 2\pi t$$

$$x_3 = \cos 2\pi t$$

and where the parameters K, t_o, C and t_s are estimated from the relationships

$$a = Kt_o$$

$$b_1 = - K$$

$$b_2 = - K\, C/2\pi \cos 2\pi t_s$$

$$b_3 = - K\, C/2\pi \sin 2\pi t_s$$

$$t_s = \{ \arctan (-b_3 / b_2\}/ 2\pi$$

In this study age readings were carried out on the annual base, which is not sufficent to take the seasonality into consideration. Therefore, age readings were rearranged assuming that the spawning always takes place on 1st of January, which is partly true since *Merlanglus merlangus euxinus* spawned in batches and for which spawning takes place in mid winter with a maximum in January as it will later be discussed in section 5.4. In rearrangement, year based age readings were converted into daily readings, such that 1 year old individual collected on April is treated as 1.25 years old (Table 9a , b).

With this form, parameters of the equation can be estimated by multiple regression, which is already implemented in a software called ETAL (PAULY & GASCHUTZ (1979).

In this method, the initial guess of L_∞ is inputted into the analysis , which is then improved by means of the routine, until maximum r^2 (multiple regression coefficient) achieved. At this stage of calculation, a, b_1, b_2, and b_3 are the final values.

Table 9a. The mean lengths in each age and sex group during the period of one year (M; male, F; female, T; total)

	Age (year)														
	I			II			III			IV			V		
Month	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
Jun-92	9.7	9.8	9.8	13.2	13.8	13.6	15.7	17.0	16.9	19.5	20.7	20.7	-	23.5	23.5
Jul-92	10.4	10.1	10.3	13.5	14.6	14.2	16.4	17.9	17.7	-	22.0	22.0	-	-	-
Aug-92	10.3	11.1	10.7	14.1	14.4	14.2	16.8	17.9	17.7	-	-	-	-	-	-
Oct-92	11.3	11.1	11.2	15.0	15.9	15.7	17.9	19.6	19.1	-	-	-	-	-	-
Nov-92	12.3	11.4	11.9	15.6	16.0	15.8	18.5	19.1	18.9	-	-	-	-	-	-
Dec-92	11.8	12.4	12.1	14.7	15.6	15.1	-	21.5	21.5	-	-	-	-	-	-
Jan-93	-	-	-	12.3	13.2	12.9	15.2	16.1	16.7	-	-	-	-	-	-
Feb-93	-	-	-	12.9	13.3	13.1	15.5	16.4	16.1	-	-	-	-	-	-
Mar-93	8.5	9.0	8.8	13.1	13.4	13.2	16.6	17.1	16.9	-	22.3	22.3	-	24.8	24.8
Apr-93	-	-	-	13.0	13.3	13.2	16.0	17.2	16.9	-	22.3	22.3	-	-	-
May-93	9.1	9.1	9.1	13.1	14.2	13.7	16.6	17.6	17.3	-	21.2	21.2	-	-	-

Table 9b. Ages converted into daily readings from yearly reading and mean lengths at this ages (M; male, F; female, T; total).

Relative age	M	F	T	Relative age	M	F	T
1.33	9.1	9.1	9.1	3.17	16.6	17.1	16.9
1.17	8.5	9.0	8.8	3.09	15.5	16.4	16.1
1.42	9.7	9.8	9.8	3.25	16.0	17.2	16.9
1.50	10.4	10.1	10.3	3.33	16.6	17.6	17.3
1.59	10.3	11.1	10.7	3.42	15.7	17.0	16.9
1.75	11.3	11.1	11.2	3.50	13.5	14.6	14.2
1.89	12.3	11.4	11.9	3.50	16.4	17.9	17.7
1.92	11.8	12.4	12.1	3.59	16.8	17.9	17.7
2	12.3	13.2	12.9	3.75	17.9	19.6	19.1
2.09	12.9	13.3	13.1	3.89	18.5	19.1	18.9
2.17	13.1	13.4	13.2	3.92	-	21.5	21.5
2.25	13.0	13.3	13.2	4.17	-	22.3	22.3
2.33	13.1	14.2	13.7	4.25	-	22.3	22.3
2.42	13.2	13.8	13.6	4.33	-	21.2	21.2
2.59	14.1	14.4	14.2	4.42	-	23.5	23.5
2.75	15.0	15.9	15.7	4.42	19.5	20.7	20.7
2.89	15.6	16.0	15.8	4.50	-	22.0	22.0
2.92	14.7	15.6	15.1	5.17	-	24.8	24.8
3	15.2	16.1	15.7				

4.10.1. GROWTH PERFORMANCE AS AN INDEX OF GROWTH PARAMETERS

Since growth is not linear, growth comparisons in two fish populations using L_∞ and K separately may be misleading (GUCU, 1991). However, PAULY & MUNRO (1984) proposed that growth performance which takes K and L_∞ into account together can be expressed by an index Ø' defined by

$$Ø' = \log K + 2 \log L_\infty$$

where K is expressed on an annual basis and L_∞ in cm.

4.11. ESTIMATION OF MORTALITY RATES

The total mortality rate (Z) was estimated from the survival rate calculated using a portion of the age series formulated by RICKER (1975).

$$S = \frac{N_{t+1} + N_{t+2}}{N_t + N_{t+1} + N_{t+2}}$$

where,

S : Survival rate

N_t : Number of fish at age t

N_{t+1} : Number of fish at age t+1

N_{t+2} : Number of fish at age t+2

In this study, age frequency data used for the estimation of the survival rates between 1990 and 1992 are given in Table 10.

Table 10. Age-fequency data calculated for 1990, 1991 and 1992

Age		I	II	III	IV	V	VI	VII	IX
Frequency	1990	1724	984	104	22	-	-	-	-
	1991	914	576	170	7	5	5	2	1
	1992	810	545	163	32	12	3	3	-

The relationship between the survival rate and the total mortality rate is given by RICKER (1975) as $S = e^{-Z}$

The total mortality rate Z consist of two components ($Z = F + M$). Here, F denotes for fishing mortality coefficient, M, the natural mortality coefficient.

Having two of these additive terms the third one can be calculated. The estimation of fishing mortality is not easy nor straightforward. However, the natural mortality coefficient can be estimated using either URSIN (1967) method or PAULY's emprical formula. According to URSIN (1967),

$$M = \bar{w}^{-1/b}$$

Where,

M : The natural mortality coefficient

$\bar{w}$: Mean weight of samples

b : Regression constant

Pauly's emprical formula is based on multiple regression analysis of growth parameters of 175 different fish stocks and estimates the linear relationship;

$$\log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log K + 0.4634 \log T$$

where,

M : natural mortality coefficient

L_{∞} : asymptotic length

K : growth coefficient

T : mean annual water temperature ("T" was taken as 14.8 C for the Black Sea (OGUZ et. al., 1992)).

4.12. ESTIMATION OF EXPLOITATION RATE

The exploitation ratio allows one to (roughly) assess if a stock is overfished or not. When the ratio of F/Z is equal to 0.5, the stock is exploited optimally. If the ratio is above 0.5, the stock is overfished and the reverse (below 0.5), is underfished. The exploitation rate was estimated from the equation

$$E = F / Z$$

where,

E : Exploitation rate

F : the fishing mortality coefficient

Z : the total mortality coefficient

4.13. YIELD PER RECRUIT (Y/R)

Yield per recruit analyses give the yield that can be expected from a unit recruitment to the stock, that is, from a single fish entering the fishery at some specified young age. The analysis predicts the long-term yields that can be expected from a particular level of fishing mortality and selection pattern, and hence levels of fishing mortality can be identified appropriate for the rational utilization of the stock. The maximum yield per recruit and the fishing mortality rate required to take that catch (F_{max}) can be estimated particularly (HORWOOD, 1993).

In this study, the simplified version of BEVERTON and HOLT (1957) yield per recruit model given in RICKER (1975) was utilized to explore the effect of fishing on the whiting stock for a range of growth and natural mortality parameters.

$$Y = F \cdot R\, e^{-Mr} \cdot W_{\infty} \left[\frac{1}{Z} + \frac{3e^{-Kr}}{Z+K} + \frac{3e^{-Kr}}{Z+2K} + \frac{e^{-Kr}}{Z+3K} \right]$$

where;

Y = yield

R = abundance (size in number) of a cohort at the age of recruitment to the stock ($=N_{tr}$)

r = tc - tr (tc: age at first capture, tr: age at recruitment)

K = von Bertalanffy growth constant

W_{∞} = asymptotic body weight

F = fishing mortality coefficient

M = natural mortality coefficient

Z = F+M, total mortality coefficient

In this model, recruitment is constant with time. However, the fishing and natural mortalities are constant from the entry to the exploited phase. The yield per recruit can be calculated for combinations of F and l_c (or t_c), which can be modulated by management action. The precise mathematical form of growth in length and weight allows the equations to be integrated analytically. Presentation of results is given as yield isopleths plotted against variable mortality and length at first capture.

4.14. BIOMASS ESTIMATION

The biomass estimation was based on the swept area method. This method is generally applied to the virgin (unexploited) stocks (SAVILLE, 1977), but it can be used for the exploited stocks and for monitoring of the changes in stock (CLARK, 1981, c.f. BINGEL, 1985). The version used in the present study is also compiled by SPARRE et.al. (1989). This method assumes that the mean catch in weight per unit effort or per unit area is proportional to the biomass per unit area.

Area swept (a) by the net was calculated by

$$a = v \times t \times h \times X_2$$

where

v : the velocity of the trawl over the ground when trawling

t : the time spent for trawling

h : the length of the head rope

X_2 :The wing spread relative to length of head rope.(PAULY (1984) suggested X_2=0.5 of the head rope length of bottom trawl net as the best compromise)

The biomass B_i in stratum i, is given by

$$B_i = \frac{A_i}{a_i \ q_i} . \bar{c}$$

where

$\bar{c}$: the mean catch in weight per haul in stratum i

A_i : the surface area of stratum i

a_i : the sub i 'th trawling area

q_i : the catchability coefficient of the trawl net.

In total, the entire inshore area was stratified into two depth zones since a higher precision of estimation of the biomass can be obtained by increasing the number of hauls or by stratified sampling in which variance was reduced (SPARRE, 1989). The sea areas between 0-50 m and 50-100 m depths were calculated using a planimeter.

4.15. ESTIMATION OF POTENTIAL YIELD

Potential yield (Py) shows the maximum upper limit of the usable stock and is calculated roughly by several methods (e.g. GULLAND, 1975; CADIMA 1977; and GARCIA et. al., 1989 model, c.f. SPARRE et. al., 1989), where time series of the catch and effort data are not avaible. The simplest method among these is the model suggested by GULLAND (1975). It requires an estimate of the total biomass and natural mortality (SPARRE et. al. 1989). In this study, potential yield was estimated by using Gulland's formula given below for virgin (unexploited) or little exploited stocks.

$$Py = 0.5 * M * Bv$$

where,

M : coefficient of natural mortality

Bv : virgin stock biomass

5. RESULTS

The results obtained on stock differentiation, population parameters (like growth, age, mortality, exploitation rate, biomass etc.) and biology (stomach content, sexual maturity, fecundity, parasite) of Black Sea whiting are given below separately.

5.1. STOCK DIFFERENTIATON

Significancy test (P>0.01) and Generalized Distance of Mahalanobis analysis, compared for the same and different sampling periods indicate a single unit stock in the Turkish Black Sea coast (Table 11).

The calculated Generalized Mahalanobis Distances between the regions for different periods are higher than those found for the same period. Fish from the same period showed the discriminant value ranging 0.0265-0.1506, while fish from different period showed the value ranging 0.0632-0.7701 (Table 11). This may be due to the differences in the growth rates which are influenced by seasonal and annual differences in the environmental conditions between two regions.

Percentage frequency distributions of the discriminant values of whiting collected from the Black Sea coast of Anatolia in different sampling periods are given in APPENDIX B. As can be seen from the figures of APPENDIX B the minumum and maximum values of the Discriminant scores from the first region to the fifth region are -1,255,554 and 1,452,179; -1,772,616 and 1,451,894; -2,510,668 and 1,288,423; -1,572,661 and 897,103; and

Table 11. Generalized Distance of Mahalanobis values compared for the same and different sampling periodsand their significance test results.the Generalized Mahalanobis Distance are given above the diogonal and the results of the significancy test below the diagonal.
(-) No significant difference at P>0.01 level.

GROUP		APR90 I	APR90 II	APR90 III	APR90 IV	SEP90 I	SEP90 II	SEP90 III	SEP90 IV	SEP91 IV	SEP91 V	OCT92 IV	OCT92 V
APR 1990	I	******	0.0623	0.1506	0.0913	0.1463	0.2622	0.1783	0.0883	0.2454	0.1429	0.1501	0.1403
	II	(-)	*******	0.0670	0.0641	0.2409	0.3442	0.2742	0.1637	0.1396	0.1777	0.2239	0.1667
	III	(-)	(-)	*******	0.0745	0.4379	0.7701	0.4374	0.2399	0.2523	0.2822	0.4273	0.3385
	IV	(-)	(-)	(-)	*******	0.2155	0.4196	0.3111	0.2039	0.1566	0.2054	0.2612	0.1944
SEP 1990	I	(-)	(-)	(-)	(-)	*******	0.0699	0.0488	0.0391	0.1061	0.0796	0.0972	0.0918
	II	(-)	(-)	(-)	(-)	(-)	*******	0.0602	0.0703	0.1927	0.1782	0.1868	0.1914
	III	(-)	(-)	(-)	(-)	(-)	(-)	*******	0.0510	0.1333	0.0911	0.1295	0.1112
	IV	(-)	(-)	(-)	(-)	(-)	(-)	(-)	*******	0.0822	0.0632	0.1064	0.0844
SEP 1991	IV	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	*******	0.0876	0.1129	0.0842
	V	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	*******	0.1438	0.0968
OCT1992	IV	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	*******	0.0265
	V	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	*******

-2,512,397 and 1,287,016 respectively. As shown in the figures all groups do not show discrepancy among each other in their double combination for each sampling period and different sampling periods.

5.2. POPULATION PARAMETERS OF WHITING

Population parameters of the Black Sea whiting concerning sex, age, growth, mortality, exploitation rate, yield per recruit, potential yield, biomass and catch composition and their results are given below.

5.2.1. SEX COMPOSITION

The percentages of the sex composition obtained from 7,357 fish are given in Table 12 for each sampling period. Females always predominated the samples, (60%) particularly in October 1992. The male to female ratio in the population reached the highest value (1 : 2.7) in June 1992 between monthly samples. The overall male to female ratio was 1 (43%) : 1.2 (57%).

The sex ratios of each age group estimated from all pooled data are given in Table 13. The male to female ratios were always high in all age groups except age group I. The sex ratio in age group-I is almost same although male ratio is slightly higher than female ratio (male 51%, female 49%; 1:1). After age group-I, the ratio of female increases with increasing age. However, the sex ratios between age group-IV and age group-IX should be taken cautiously since the samples after age group IV consist of small numbers. So, the total number of males between age group-IV and age group-IX is only 4 whose 3 in age group-IV and I in age group VI while the number of females between this groups is 136 (Table 13).

Table 12. Percentage distribution of sexes for each sampling period.

PERIOD	MALE	(%)	FEMALE	(%)	SEX RATIO
APRIL 1990	672	(46)	783	(54)	1 : 1.2
SEPTEMBER 1990	657	(48)	722	(52)	1 : 1.1
SEPTEMBER 1991	771	(46)	909	(54)	1 : 1.2
OCTOBER 1992	632	(40)	936	(60)	1 : 1.5
JUNE 1992	41	(27)	109	(73)	1 : 2.7
JULY 1992	44	(32)	87	(68)	1 : 2.1
AUGUST 1992	38	(33)	78	(67)	1 : 2.0
OCTOBER 1992	20	(37)	34	(63)	1 : 1.7
NOVEMBER 1992	19	(49)	20	(51)	1 : 1.1
DECEMBER 1992	62	(48)	67	(52)	1 : 1.1
JANUARY 1993	36	(36)	64	(64)	1 : 1.8
FEBRUARY 1993	45	(38)	74	(62)	1 : 1.6
MARCH 1993	51	(34)	98	(66)	1 : 1.9
APRIL 1993	40	(34)	79	(66)	1 : 1.9
MAY 1993	53	(31)	116	(69)	1 : 2.2
POOLED DATA	3181	(43)	4176	(57)	1 : 1.2

Table 13. Percent sex distributions in each age group.

Age group	male	(%)	female	(%)	sex ratio
I	1857	(51)	1779	(49)	1 : 1
II	1131	(43)	1505	(57)	1 : 1.3
III	189	(20)	756	(80)	1 : 4
IV	3	(3)	100	(97)	1 : 33.3
V	0	-	21	(100)	-
VI	1	(13)	7	(87)	1 : 7
VII	0	-	5	(100)	-
IX	0	-	3	(100)	-
n	3181		4176		

5.2.2. AGE COMPOSITON

Percentage distribution of year-classes for each sex and for all pooled data from different sampling periods are given in Table 14. As can be seen in

Table 14, nine age groups were observed in the samples taken from the Turkish Black Sea coast with a predominance of 1-3 year old fish. The percentage of age composition of the population in the seasonal samples decreases with increasing age except that of April 1990. In April 1990, considerable proportion of the sample composed of the age group II. The age group II and age group III also predominate in the monthly data collected between June 1992 and May 1993.

Table 14. Percentage (%) of age composition of the population for each sampling period and pooled data (M: male; F: female; T:total; JUN-MAY93 implies the samples between Jun 1992 and May 1993).

	APR 1990			SEP 1990			SEP 1991			OCT 1992			JUN-MAY93			OVERALL		
AGE	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
	%			%			%			%			%			%		
I	19	20	39	43	41	84	30	24	54	25	27	52	8	7	15	25	24	49
II	25	28	53	4	11	15	15	20	35	15	20	35	17	24	41	15	21	36
III	2	5	7	-	1	1	1	9	10	1	9	10	10	30	40	3	10	13
IV	-	1	1	-	-	-	-	-	-	-	2	2	-	3	3	-	1	1
V-IX	-	-	-	-	-	-	-	1	1	-	1	1	-	1	1	-	-	1
			100			100			100			100			100			100

5.2.3. LENGTH-WEIGHT RELATIONSHIP

The length-weight relationships for each sex and for different sampling periods (April 1990, September 1990, September 1991 and October 1992) are shown in Figure 9. The functional regression b-values were found to be greater than 3 for each sex and their pooled data in all sampling periods.

This implies that the Black Sea whiting shows a positive allometric growth. There are also differences between the functional regression value "b" of four different sampling periods.

The length-weight relationships computed separately for each sex group and pooled data collected within the study period (April 1990, September 1990, September 1991, October 1992) are shown in Table 15:

Table 15. Length-weight relationship during the sampling periods

Period	April 1990			September 1990			September 1991			October 1992		
	male	female	pooled	male	female	pooled	male	female	pooled	male	female	pooled
a	0.0059	0.0059	0.0059	0.0048	0.0047	0.0047	0.0044	0.0041	0.0043	0.0044	0.0037	0.0039
b	3.093	3.089	3.085	3.181	3.185	3.183	3.207	3.232	3.214	3.235	3.299	3.278
n	672	782	1455	657	722	1379	771	909	1680	632	936	1568
r	0.99	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.99

The length-weight relationships for each sex group and their pooled data collected from the eastern Black Sea (Havaalanı, Beşikdüzü, Sürmene) between June 1992 and May 1993 were calculated separately (Table 16a) and the significance of the differences between regression coefficients were tested by analysis of covariance (Table 16b). All figures of the length-weight relationships are given in APPENDIX C.

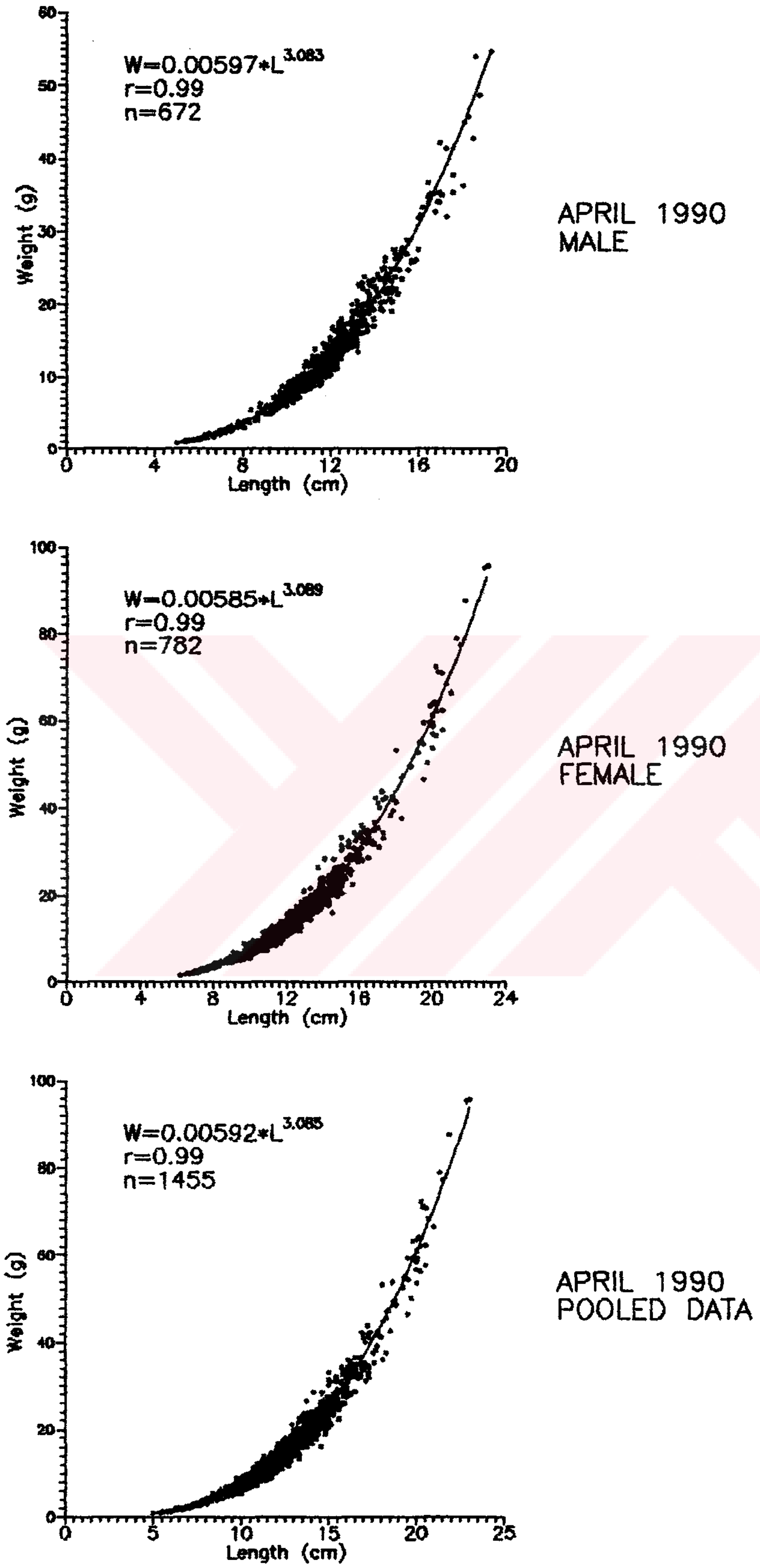


Figure 9. The length-weight relationship of each sex and their pooled data in different sampling periods

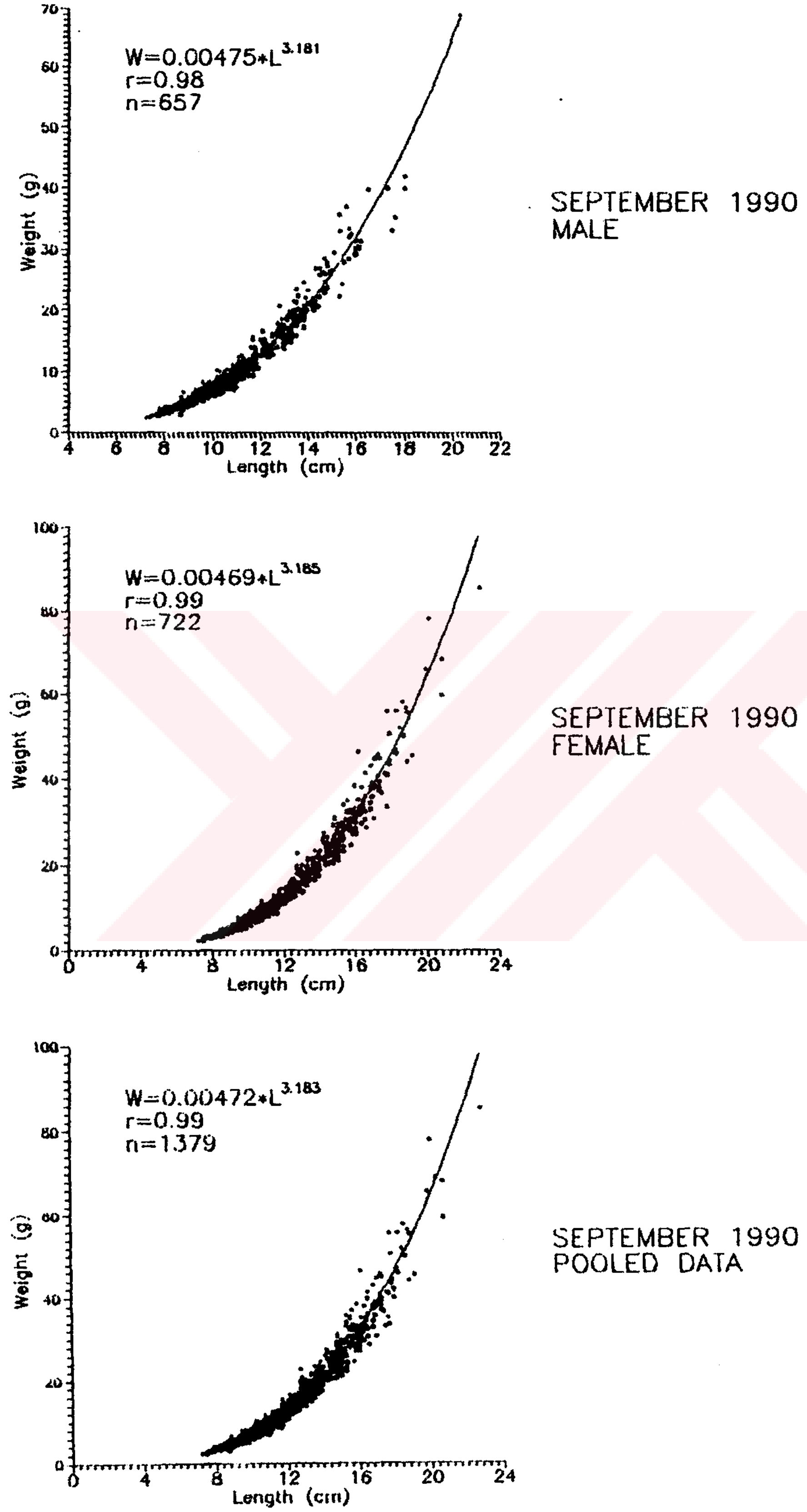


Figure 9. continued

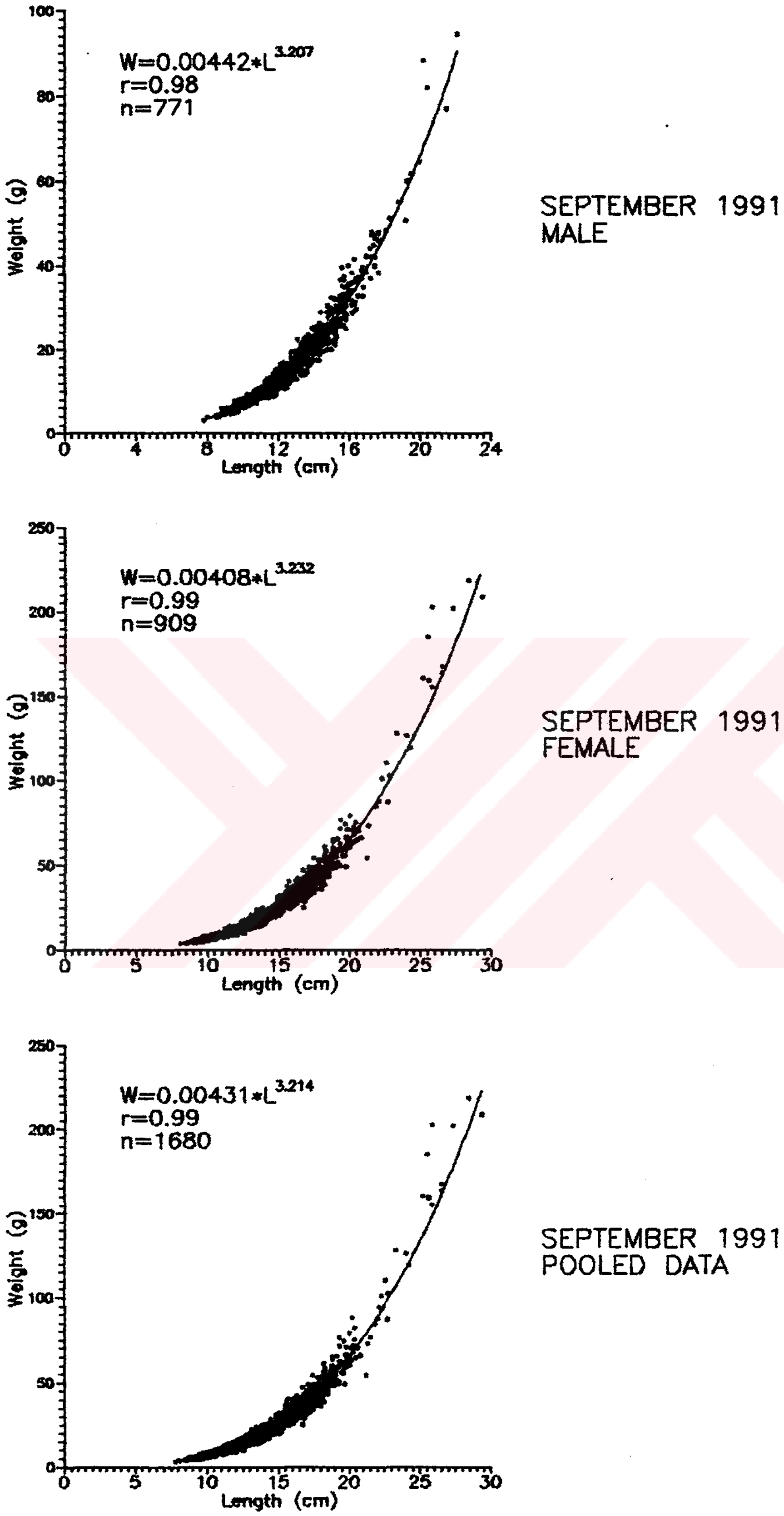
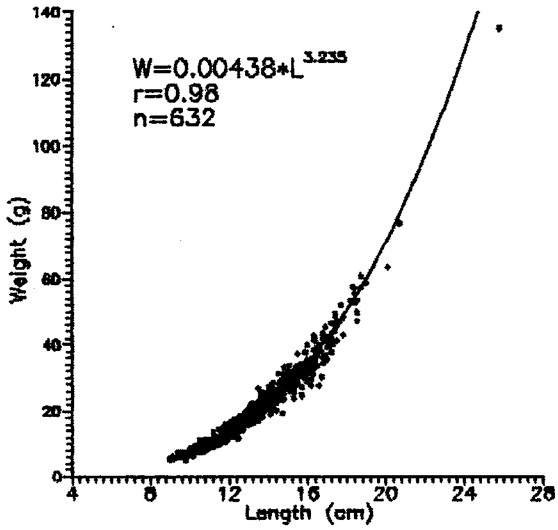
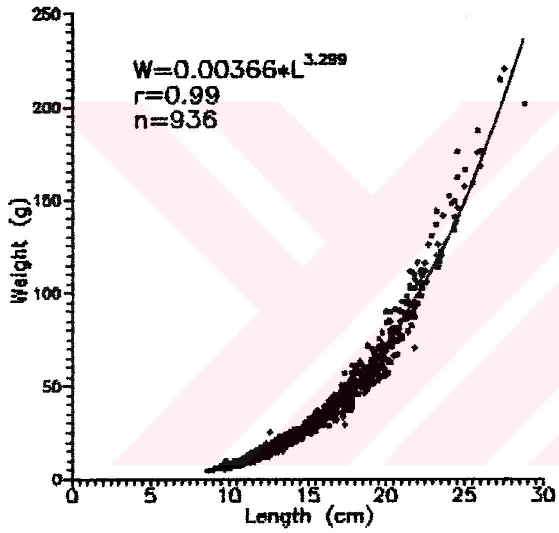


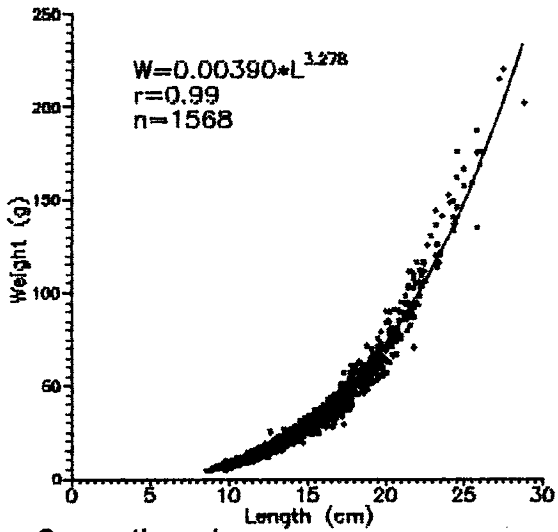
Figure 9. continued



OCTOBER 1992
MALE



OCTOBER 1992
FEMALE



OCTOBER 1992
POOLED DATA

Figure 9. continued

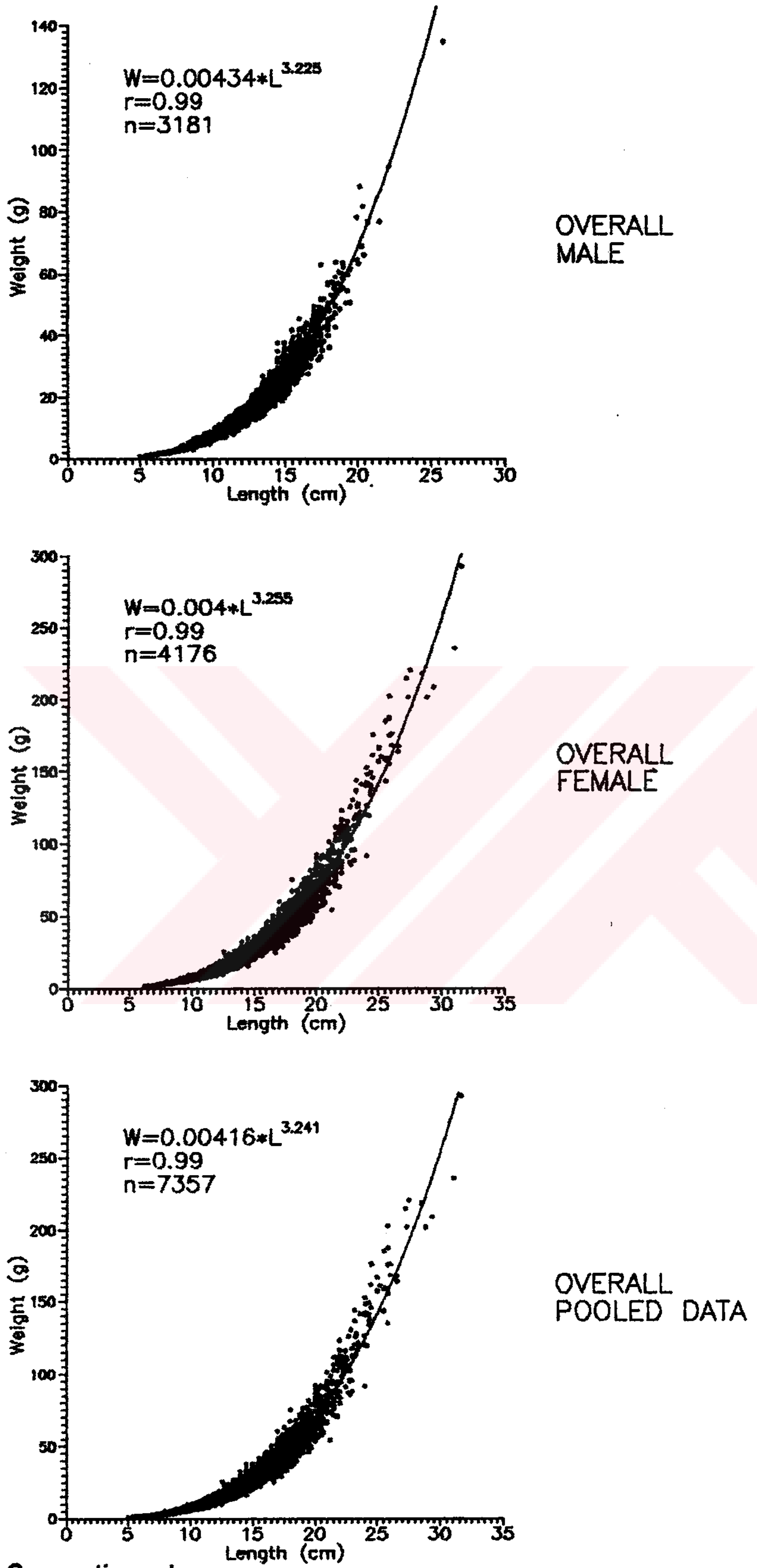


Figure 9. continued

Table 16a. The monthly regression coefficients of length-weight relationships of whiting between June 1992 and May 1993.

	Male				Female				Total			
Month	a	b	r	n	a	b	r	n	a	b	r	n
Jun 1992	0.006	3.12	0.99	41	0.007	3.11	0.99	109	0.006	3.12	0.99	150
Jul 1992	0.004	3.26	0.99	44	0.006	3.15	0.99	87	0.005	3.21	0.99	131
Aug 1992	0.007	3.09	0.99	38	0.005	3.17	0.99	78	0.006	3.14	0.99	116
Oct 1992	0.004	3.27	0.99	20	0.005	3.15	0.99	34	0.004	3.20	0.99	54
Nov 1992	0.005	3.26	0.99	19	0.004	3.29	0.99	20	0.004	3.30	0.99	39
Dec 1992	0.003	3.45	0.98	62	0.005	3.25	0.98	67	0.004	3.32	0.98	129
Jan 1993	0.005	3.21	0.98	36	0.005	3.18	0.99	64	0.005	3.16	0.98	100
Feb 1993	0.003	3.40	0.99	45	0.003	3.34	0.99	74	0.003	3.35	0.99	119
Mar 1993	0.008	3.02	0.98	51	0.008	3.05	0.99	98	0.008	3.05	0.99	149
Apr 1993	0.006	3.13	0.98	40	0.007	3.09	0.98	79	0.006	3.11	0.98	119
May 1993	0.007	3.05	0.99	53	0.005	3.18	0.99	116	0.006	3.15	0.99	169

Table 16b. Results of covariance analysis of differences between regression coefficients for each month (+ indicates significant differences at P<0.01 level)

	Jun	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Jun	****	-	-	-	-	+	-	+	-	-	-
Jul	2.84	****	-	-	-	-	-	-	+	-	-
Aug	0.06	1.81	****	-	-	-	-	+	-	-	-
Oct	1.45	0.01	1.05	****	-	-	-	-	-	-	-
Nov	3.97	1.20	3.79	1.22	****	-	-	-	+	-	-
Dec	7.13	2.30	5.97	1.89	0.05	****	-	-	+	-	-
Jan	0.19	0.53	0.08	0.37	2.56	3.23	****	-	-	-	-
Feb	10.7	4.25	9.55	3.71	0.29	0.09	5.55	****	+	+	+
Mar	1.69	8.08	2.06	4.89	8.08	12.5	1.83	17.9	****	-	-
Apr	0.05	2.19	0.16	1.36	3.57	5.69	0.31	8.49	0.57	****	-
May	0.35	1.62	0.07	0.76	3.23	5.98	0.01	9.31	3.71	0.40	****

Analysis of covariance of the length-weight data for the samples collected every month during an annual period (June 1992-May 1993) indicated significant differences ($P<0.01$) between the regression coefficients of June 1992 and December 1992; June 1992 and February 1993; July 1992 and March 1993; August 1992 and February 1993; November 1992 and March 1993; December 1992 and March 1993; February 1993 and March 1993; February 1993 and April 1993, and February 1993 and May 1993. This may be due to variation in the feeding and/or variation in the food supply, and the spawning activity. In the winter months (especially February), the empty stomach rate, which shows the feeding intensity of the fish, was at its highest level and the condition of fish reached the lowest level in this intensive spawning period. Besides, in November and December, when the significant differences were found compared to March, the stomachs were mostly full in November and December and the gonad development increased sharply to a maximum in January.

The length-weight relationships of three stations (Havaalanı, Beşikdüzü, Sürmene) were also calculated separately (Table 17a) and the significance of differences were tested between their regression coefficients (Table 17b).

Table 17a. The monthly regression cooefficients of length-weight relationships of whiting sampled at three stations in the eastern Black Sea.

	Havaalanı				Beşikdüzü				Sürmene			
Month	a	b	r	n	a	b	r	n	a	b	r	n
Jun 1992	0.005	3.24	0.99	48	0.008	3.04	0.99	57	0.006	3.12	0.99	45
Jul 1992	0.004	3.29	0.99	45	0.006	3.15	0.99	46	0.006	3.14	0.99	40
Aug 1992	0.008	3.00	0.99	39	0.005	3.17	0.99	54	0.003	3.40	0.95	23
Oct 1992	-	-	-	-	-	-	-	-	0.004	3.20	0.99	54
Nov 1992	-	-	-	-	-	-	-	-	0.004	3.30	0.99	39
Dec 1992	0.004	3.33	0.98	59	-	-	-	-	0.004	3.35	0.98	70
Jan 1993	0.005	3.17	0.98	54	0.006	3.14	0.98	46	-	-	-	-
Feb 1993	0.003	3.44	0.99	45	0.004	3.24	0.99	38	0.005	3.17	0.99	36
Mar 1993	0.006	3.13	0.98	58	0.006	3.19	0.99	45	0.012	2.89	0.99	46
Apr 1993	0.005	3.24	0.99	42	0.008	3.00	0.98	35	0.009	3.00	0.98	42
May 1993	0.008	3.03	0.99	44	0.006	3.16	0.99	63	0.005	3.18	0.99	62

The monthly analysis of covariance of the length-weight data of three stations indicated no significant differences in the regression coefficients except for Havaalanı-Beşikdüzü in June 1992, and Havaalanı-Sürmene and Beşikdüzü-Sürmene in March 1993. In October and November 1992, there is only one sample taken from Sürmene or Beşikdüzü station. The differences between stations in March 1993 may be due to that samples collected from Sürmene stations include smaller length groups (87-170 mm) than that of Beşikdüzü and Havaalanı (108-250 mm and 113-312 mm, respectively).

Table 17b. Results of covariance analysis of length-weight data in different months (+ indicates significant differences at P<0.01 level)

JUNE 1992	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	+	-
Beşikdüzü	8.663	*************	-
Sürmene	1.415	0.888	************
JULY 1992	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	-
Beşikdüzü	2.456	*************	-
Sürmene	2.111	0.010	************
AUGUST 1992	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	-
Beşikdüzü	4.320	*************	-
Sürmene	2.200	0.726	************
OCTOBER 1992*			Sürmene
NOVEMBER 1992*		Beşikdüzü	
DECEMBER 1992	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	no data	-
Beşikdüzü	-	************	no data
Sürmene	0.043	-	************
JANUARY 1993	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	no data
Beşikdüzü	0.051	*************	no data
Sürmene	-	-	************
FEBRUARY 1993	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	-
Beşikdüzü	2.681	*************	-
Sürmene	5.055	0.342	************
MARCH 1993	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	+
Beşikdüzü	0.391	*************	+
Sürmene	7.517	8.590	************
APRIL 1993	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	-
Beşikdüzü	4.067	*************	-
Sürmene	5.670	0.002	************
MAY 1993	Havaalanı	Beşikdüzü	Sürmene
Havaalanı	************	-	-
Beşikdüzü	2.208	*************	-
Sürmene	3.178	0.209	***********

* : in October and November only one fishing ground exist.

Fulton' s condition factors were estimated to compare the condition of whiting in different sampling periods due to their allometric growth characteristics (Table 18).

Table 18. Fulton' s condition factor for each sex and for pooled data in the different sampling periods.

PERIOD	MALE	FEMALE	TOTAL
APR - 1990	0.0083	0.0086	0.0085
SEP - 1990	0.0083	0.0090	0.0087
SEP - 1991	0.0084	0.0092	0.0090
OCT - 1992	0.0089	0.0104	0.0100
JUN - 1992	0.0098	0.0099	0.0102
JUL - 1992	0.0097	0.0099	0.0102
AUG - 1992	0.0094	0.0094	0.0095
OCT - 1992	0.0087	0.0087	0.0089
NOV - 1992	0.0098	0.0112	0.0106
DEC - 1992	0.0096	0.0096	0.0096
JAN - 1993	0.0091	0.0087	0.0088
FEB - 1993	0.0089	0.0088	0.0089
MAR - 1993	0.0093	0.0104	0.0102
APR - 1993	0.0089	0.0094	0.0093
MAY - 1993	0.0098	0.0105	0.0105

Females have higher condition than the males in each sampling period (April 1990, September 1990 and 1991, October 1992). However, certain seasonal changes in the condition of whiting occurred in the monthly seasonal samples between June1992 and May 1993. Both sexes have the smallest condition during the intensive spawning period (January and February) and also males have higher condition than females in this period. After spawning period, the condition of both sexes begin to increase and reach the highest level in summer. A decreasing trend in the condition occurred again until December.

5.2.4. GROWTH IN LENGTH

The estimated constants of the seasonalized von Bertalanffy growth equation for each sex of the Black Sea whiting are given Table 19.

Table 19. The seasonalized von Bertalanffy growth constants of the Black Sea whiting

	L_{∞} (cm)	K	t_0 (year)	C	ts
Male	33.5	0.17	-1.08	0.56	0.25
Female	40.4	0.15	-0.92	0.24	0.35
Pooled	39.1	0.15	-1.53	0.23	0.48

The calculated and observed mean lengths for each sexes and age group are given Table 20. During the first year of life, individuals attain 40% (12.4 cm) of their maximum adult size and growth rate over subsequent years becomes less rapid. At the second, thirth, and fourth years (at about 70% of their maximum adult size) and they reach mean length of 16.1, 19.3 and 22.1 cm, respectively. Although the annual growth rate decreases gradually with increasing the age of fish, such as; 3.7, 3.2, 2.7 and 2.4 cm/year between age groups I-II, II-III, III-IV and IV-V, respectively, the mean annual growth of whiting, from age group I to IX, has been estimated to be 3.4 cm/year.

Table 20. Observed and calculated mean lengths of whiting at age for each sex and pooled data (total length cm).

	age groups (yrs)								
	I	II	III	IV	V	VI	VII	VIII	IX
				MALE					
Observed	10.84	13.91	16.81	21.03	-	25.80	-	-	-
Calculated	10.38	13.95	17.05	19.59	21.79	23.60	25.16	26.45	27.57
Annual increment	10.38	3.57	3.1	2.54	2.2	1.81	1.56	1.29	1.12
Increment (%)	37.6	12.9	11.2	9.2	7.9	6.6	5.7	4.7	4.1
				FEMALE					
Observed	10.88	14.57	18.05	21.63	24.55	26.16	27.60	-	30.60
Calculated	10.32	14.45	18.12	21.18	23.89	26.16	28.17	29.85	31.34
Annual increment	10.32	4.13	3.67	3.06	2.71	2.27	2.01	1.68	1.49
Increment (%)	32.9	13.2	11.7	9.8	8.6	7.2	6.4	5.4	4.7
				POOLED DATA					
Observed	10.84	14.29	17.80	21.61	24.55	26.11	27.60	-	30.60
Calculated	12.43	16.09	19.34	22.05	24.47	26.47	28.26	29.74	31.07
Annual increment	12.43	3.66	3.25	2.71	2.42	2.0	1.79	1.48	1.33
Increment (%)	40.0	11.8	10.5	8.7	7.8	6.4	5.8	4.8	4.2

As can be seen in Table 20, growth is rapid in both sexes for the first year, and the mean length at the end of the year is between 10 and 11 cm. Both male and female fish grow about 4 cm in the second year. As compared to the high numbers (7217 individuals) of the age groups I - III, only a few fish (140 individuals) could be found in age groups IV-IX (Table 10) to make an accurate assessment of growth beyond age group III. However, the available data suggest that the females continue to grow steadily at a rate of 2 or 3 cm per year until the eighth year (age group 7) when the growth slows down. The male fish grow less than the females after the second year, and the disparity in the mean length of the male and female fish at each age group increases with age (Figure 10). Nearly all fish older than 3 years old (19 cm) were females (Table 14).

5.2.5. GROWTH IN WEIGHT

The observed mean weights at age for each sex and pooled data are given Table 21.

Table 21. Observed mean weights of whiting by age group for each sex and pooled data (total weight g).

	age groups (yrs)								
	I	II	III	IV	V	VI	VII	VIII	IX
MALE									
Observed	10.12	22.30	41.20	74.05	-	134.95	-	-	-
Annual increment	10.12	12.18	18.9	32.85	-	-	-	-	-
Increment (%)	7.5	9.0	14.0	24.3	-	-	-	-	-
FEMALE									
Observed	10.16	25.81	51.62	92.94	145.90	180.24	203.77	-	245.90
Annual increment	10.16	15.65	25.81	41.32	52.96	34.34	23.53	-	-
Increment (%)	4.1	6.3	10.5	16.8	21.5	14.0	9.7	-	-
POOLED DATA									
Observed	10.14	24.30	49.54	92.39	145.90	175.58	203.77	-	245.90
Annual increment	10.14	14.16	25.24	42.85	53.51	29.68	28.19	-	-
Increment (%)	4.1	5.8	10.3	17.4	21.8	12.1	11.5	-	-

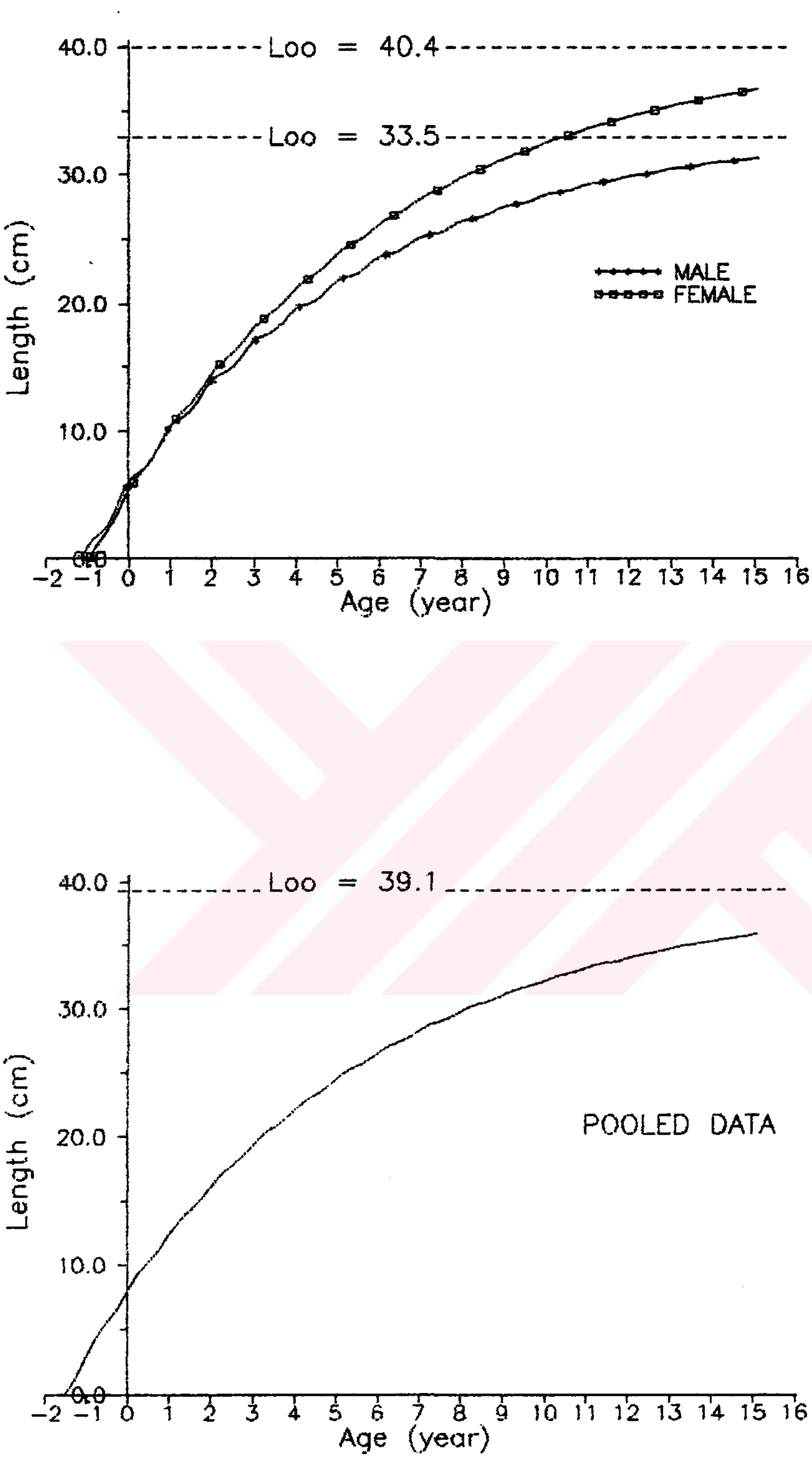


Figure 10. Theoretically calculated growth curve in length of the Black Sea whiting for each sex and their pooled data

Growth in weight is slow in both sexes for the first years (age group I and II) and then the growth rates become more rapid until age group V. After age group V, growth gets slower (Figure 11). As can be seen in Table 21 and Figure 11, during the first and second year of life, individuals attain 10.14 g and 24.3 g in weight, respectively. After completion age group II, growth rates become more rapid until age group V and attain about 60% (145.9 g) of their maximum weight. Between fifth and eighth age group, annual growth rate decreases from 53.5% to 28.2%. The mean annual growth rate in weight of whiting was found to be 27 g/year between age group I and IX. The deflection point of the growth curve for whiting is equal to 120g between age group IV and V.

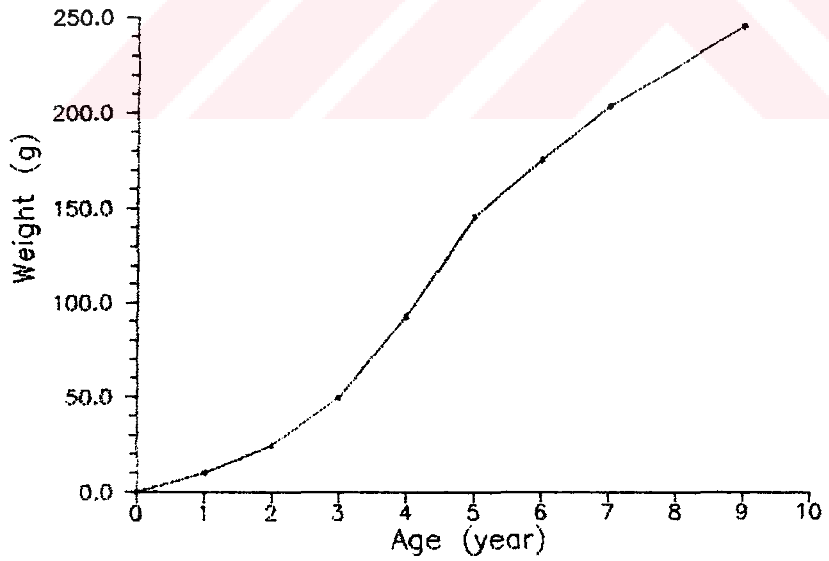


Figure 11. Growth curve(in weight)of Black Sea whiting (from observed data)

5.2.6. MORTALITY ESTIMATES

Since commercial catch data are not reliable, accurate fisheries mortality rates could not be estimated separately. However, total mortality and natural mortality rates were calculated separately. Hence, by subtracting the natural mortality rate from total mortality coefficient, fishing mortality coefficient can be determined (Z=F+M).

The total, natural and fishing mortality rates obtained on an annual basis for the whiting in the Turkish Black Sea coast are presented in Table 22.

Table 22. The total, natural and fishing mortality rates of the whiting (S: the survival rate)

YEAR	S	M	F	Z
1990	0.114	0.43	1.74	2.18
1991	0.240	0.38	1.05	1.43
1992	0.275	0.36*	0.93	1.29
Mean	0.210	0.39	1.24	1.63

* the natural mortality coefficient (M) in1992 was computed using the two different methods (URSIN and PAULY) which gave the same value.

The mean total mortality rate (Z) and its components, natural mortality (M) and fishing mortality rate (F), are Z=1.63, M=0.39 and F=1.24. The total mortality coefficient (Z) values computed for different years show fluctuations from 2.18 to 1.29 with respect to time and also to space. The (Z) value calculated from the samples taken between İğneada and Civa Cape by R/V Bilim in April-September 1990 is higher than the (Z) values calculated from the 1991 and 1992 data collected between Sinop and Sarp by R/V SURAT-1.

This is may be due to the difference of regions and/or the difference of mesh size of trawl nets equipped in both ships. The cod end mesh size (7 mm from knot to knot) of trawl net on R/V Bilim smaller than those of R/V Surat 1 (14 mm). Fishing mortality rate (F) in the western Black Sea is also higher than that of the eastern Black Sea. This is may be the results of closing of Çaltı Cape-Sarp region in the eastern Black Sea to bottom trawl fishing.

5.2.7. EXPLOITATION RATE

The exploitation rates estimated by the use of M and Z values were E= 0.79 for 1990, E=0.73 for 1991 and E=0.72 for 1992. These high rates are indication of over-exploitation of the whiting stock between 1990 and 1992.

5.2.8. YIELD PER RECRUIT

The yield isopleth diagram (Y/R) obtained by applying the yield per recruit model of BEVERTON and HOLD (1957) implies overfishing (Figure 12) and indicates that with the existing fishing intensity (F=1.24) the minumum allowable length of whiting should be over 18.5 cm. However, the total length of whiting in catches ranged between 5.5 and 29.3 cm during the study period, the median length in spring and autumn of 1990, 1991 and 1992 fluctuated around 14 -17 cm, and it was found that the whiting generally attains sexual maturity at the age of 2 although there is a difference between sexes (male, at 12.5 cm length or at the end of their first year; female, at 14.5 cm length or at the end of their second year). At present, it is necessary to decrease fishing intensity (F= 0.45) or to enforce a minumum allowable total length (17.5) for an optimum exploitation of this species.

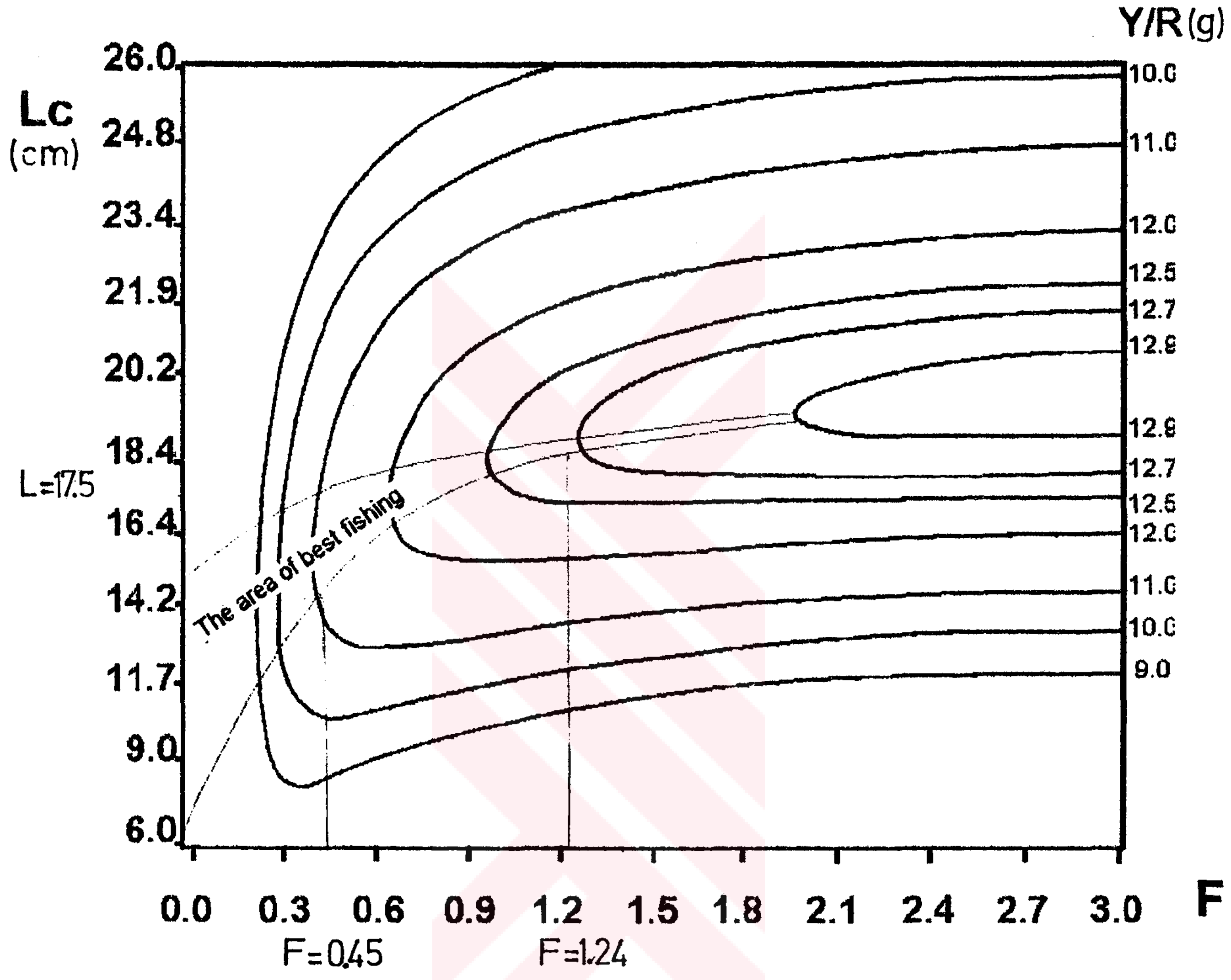


Figure 12. The yield isopleth diagram (Y/R) of Black Sea whiting.

5.2.9. BIOMASS ESTIMATION

Total trawlable biomass during four successive periods were computed using stratified swept area method (SAVILLE, 1977) and results are given in Table 23.

Table 23. Total trawlable biomass of whiting in the Turkish Black Sea Coast (q=1; depth range 0-100m; İgneada-Ereğli(I), Ereğli - Sinop (II), Sinop- Çaltı Cape(III), Çaltı Cape-Sarp(IV)).

		BIOMASS (tonnes)					
	Depth	Western BS			Eastern BS		
Period	range(m)	I	II	Total	III	IV	Total
APR1990	0-50	19	-	19	1	-	-
	50-100	677	421	1098	32	-	-
	Total	696	421	1117	33	-	-
SEP 1990	0-50	-	-	-	52	-	-
	50-100	1637	127	1764	125	-	-
	Total	1637	127	1764	177	-	-
SEP 1991	0-50	-	-	-	1177	2580	3757
	50-100	-	-	-	928	14548	15476
	Total	-	-	-	2105	17128	19233
OCT 1992	0-50	-	-	-	1037	7402	8439
	50-100	-	-	-	7256	14493	21749
	Total	-	-	-	8293	21895	30188

The trawlable biomass of whiting in April 1990 was found to be 696 tonnes between İğneada and Ereğli, 421 tonnes in Ereğli-Sinop region and 33 tonnes in Sinop-Çaltı Cape region. However, in September 1990 survey, the biomass increased to 1,637 tonnes between İğneada-Ereğli and 177 tonnes Sinop-Çaltı Cape, but decreased to 127 tonnes between Ereğli-Sinop.

In September 1991, the trawlable biomass rose sharply and attained 17,128 tonnes in Çaltı-Sarp region while the biomass was calculated 2,104 tons in Sinop-Çaltı Cape region. In October 1992, the same situation occurred; the biomass was found 8,293 tonnes in Sinop-Çaltı region and rose about three times (21,894 tonnes) between Çaltı Cape-Sarp. The difference in trawlable biomass between these two regions of the eastern Black Sea coast of Turkey results from closing of Çaltı Cape - Sarp region to bottom trawl fishing. When comparing the biomass with the catch data of the State Institute of Statistics of Prime Ministry Republic Turkey , it was found that 43 to 59 percent of the whiting biomass of the eastern Black Sea was removed by fishery activities between 1991 and 1992.

5.2.10. POTENTIAL YIELD

Potential yield approximation is used to estimate the optimum amount of biomass to be caught by the commercial fleet. The maximum catchable potential yields estimated by applying the Gulland's formula for the eastern and western Black Sea are given in Table 24 . In the study period between 1990 and 1992, this was only estimated for the western Black Sea in 1990 and for the eastern Black Sea in 1991 and 1992.

In 1990, potential yield (Py) estimated according to the total biomass (2,881 tonnes) and the natural mortality rate (0.43) for the western Black Sea was 619 tonnes. In this period, the annual catch (2634 tonnes) was well above the calculated Py. In 1991 and 1992, potential yield for the eastern Black Sea was 654 tonnes (natural mortality: 0.38) and 5,434 tonnes (natural mortality:0.36), respectively, and the annual catches (11,314 in 1991, 12,994 tonnes in 1992) of the whiting exceeded two or three times the optimum level.

Table 24. Potential yield (Py), total biomass and annual landing of whiting (*Merlangius merlangus euxinus* N.) along the Turkish Black Sea Coast (weight are given as tonnes; catch data from DIE,1990-92)

	Western BS			Eastern BS		
Periods	Biomass	Py	Catch	Biomass	Py	Catch
1990	2,881	619	2,634	-	-	-
1991	-	-	-	19,232	3,654	11,314
1992	-	-	-	30,188	5,434	12,994

5.2.11. CATCH COMPOSITION

The percentage occurence of the fish and other organisms in different regions from trawl catches are presented in Table 25 for the sampling periods April/September 1990, September 1991 and October 1992.

An interannual comparison of the percentage distributions revealed that the whiting (*Merlangius merlangus euxinus*) was the most important demersal fish in the catches followed by striped mullet (*Mullus barbatus*), turbot (*Psetta maxima maeotica*), and picarel (*Spicara smaris*). Some non-demersal (pelagic or semipelagic) fish species such as *Alosa pontica* (twaite shad), *Spicara smaris* (picarel), *Sprattus sprattus* (sprat) and *Trachurus mediterraneus* (horse mackerel) were also commonly present in the trawl catches. Among the total fish species occurred, only three were cartilaginous, rest being from the teleost group. Regarding biomass, the trawl catches mainly consisted of fish, Molluscs (mainly the Mediterranean mussel *Mytilus galloprovincialis* and Thomas` rapa whelk *Rapana venosa*) and jellyfish (*Aurelia aurita*) comprised a considerable proportion of catches.

Table 25. The percentage frequency of fish species in the catch during the study periods.

Species name	Common name	Apr90	Sep90	Sep91	Oct92
BONY FISHES					
Alosa pontica	Twaite shad	2.85	-	0.01	0.01
Blennius sp	Blennies	-	-	0.01	0.01
Gobius sp.	Goby	0.08	0.17	2.30	1.30
Engraulis encrasicolus	Anchovy	0.01	-	-	0.01
Merlangius m. euxinus	Whiting	14.2	19.4	57.0	62.7
Mullus barbatus	Striped mullet	0.33	-	8.50	8.50
Neogobius melanostomus	Black-spotted goby	0.01	0.21	-	-
Physic physic	Fork beard	-	-	0.01	0.01
Pleuronectes flesus luscus	Flounder	0.01	0.03	0.95	1.28
Pomatomus saltator	Blue fish	-	-	0.01	0.01
Psetta maxima maeotica	Turbot	3.90	1.70	0.83	1.26
Sciaena umbra		-	-	-	0.08
Scorpaena porcus	Black scorpionfish	-	-	0.01	0.26
Solea vulgaris	Common sole	0.01	-	0.01	0.04
Spicara smaris	Picarel	0.02	-	1.80	0.35
Sprattus sprattus	Sprat	5.90	3.70	0.01	0.04
Sygnathus sp	Pipefish	-	0.01	0.01	0.01
Trachinus draco	Greater weever	0.02	-	0.36	0.83
Trachurus mediterraneus	Horse mackerel	0.02	-	0.23	0.08
Trigla lucerna	Tub gurnard	0.07	-	0.01	0.01
Uranoscopus scaber	Stargazer	0.01	-	0.25	0.40
CARTILEGOUS FISHES					
Dasyatis pastinaca	Common stingray	-	-	0.71	0.49
Raja clavata	Thornback ray	5.10	2.70	1.90	4.78
Squalus acanthias	Piked dogfish	1.90	12.4	0.24	5.30
Acipenceridae	-	0.20	-	-	0.01
OTHER ORGANISMS					
Carcinus aestuarii	Med. shore crab	-	0.10	0.48	0.70
Crangon crangon	Common shrimp	0.76	0.06	0.01	0.08
Mytilus galloprovincialis	Med. mussel	27.8	55.9	16.9	8.03
Rapana venosa	Thomas` rapa whelk	0.03	0.44	0.01	0.08
Molluscs		6.10	-		
Aurelia aurita	Jellyfish	29.4	2.60	6.90	3.41

5.3. FOOD COMPOSITION

A total of 3,272 whiting stomachs were examined for the stomach content analysis. The percentage of empty stomachs was 28.9% (944). Mean total length of fish sampled was 13.2 cm and mean stomach content weight including the empty ones was 0.4 g.

In terms of weight in percentage, the diet of whiting consisted almost entirely of fish (78.0%), crustaceans (15.7%), and poychaetes (3.8%; Table 26). The importance of crustaceans in the diet is overshadowed by the fish proportion because large whiting eat heavier meals consisting primarily of fish. However, Table 26 is useful because it serves as a composite list of the prey types commonly found in the stomachs of whiting. Fish such as sprat, *Sprattus sprattus phalericus* ; whiting, *Merlangius merlangus euxinus;* goby, *Gobius* spp.; and anchovy, *Engraulis encrasicolus,* each makes up >4% of the stomach contents. Sprat (38.9%) dominate among the fish prey in the diets of whiting. The undefined pisces category, which could not be identified, also constituted a relatively large proportion of the diet (5.2%).

Crustacea in the diet is represented principally by decapods (mostly *Upogebia pusilla*, 5.9%, *Crangon crangon,* 4.9%, and *Pagurus* spp., 0.1%) and copepods (almost all identified as *Calanus helgolandicus,* 3.6%). Amphipods found in the stomachs consist primarily of the families Ampeliscidae (*Ampelisca diadema,* 0.04%), and Caprellidea (*Phtisica marina*, 0.14%).The remaining crustacean groups are the Isopoda (mostly comprised of *Synisoma capito,* 0.5%), Cumacea (mostly *Iphinoe* spp., 0.11%), and Mysidacea (mostly *Paramysis* spp., %0.08).

Table 26. Dietary composition of 3272 whiting collected in all sampling periods (+ indicates <0.01%.) .

Prey	Percentage weight Male	Female	Total
Polychaeta	5.06	3.38	3.81
Crustacea	19.79	14.16	15.72
Amphipoda	0.87	0.28	0.42
Phtisica marina	0.24	0.10	0.14
Ampelisca diadema	0.07	0.03	0.04
Corophium volutator	0.02	0.08	0.01
Microdeutopus damnonienois	+	-	+
Microdeutopus gryllatalpha	+	0.01	0.01
Stenogammarus deminutus	+	-	+
Erichthonius difformis	+	-	+
Caprella acanthifera	0.01	+	+
Orchomene humilis	0.01	+	+
Gammarellus carinatus	+	-	+
Synchelidium maculatum	0.03	0.01	0.01
Corophium mucranatum	+	+	+
Jasa falcata	0.01	+	+
Gammarus spp.	-	+	+
Pontogammarus spp.	+	+	+
Other Amphipoda	0.48	0.12	0.21
Decapoda	10.87	11.04	10.99
Upogebia pusilla	5.02	6.26	5.94
Crangon crangon	5.75	4.63	4.92
Pagurus spp.	0.10	0.10	0.10
Calibanarius erythropus	-	0.05	0.03
Mysidacea	0.14	0.07	0.08
Paramysis spp.	0.13	0.07	0.08
Paramysis kroyeri	0.01	+	+
Cumacea	0.23	0.07	0.11
Iphinoe spp	0.21	0.07	0.11.
Iphinoe serrata	0.01	-	+
Pseudocuma spp.	0.01	-	+
Copepoda	6.70	2.43	3.61
Anisopoda	+	-	+
Apseudei ostroumovi	+	-	+
Isopoda	0.98	0.27	0.51
Synisoma capito	0.95	0.26	0.50
Sphaeroma serratum	0.03	0.01	0.01
Eurydice pontica	-	+	+
Holothuroidea	0.81	0.41	0.51
Labidoplax digitata	0.81	0.41	0.51
Ascidiacea	0.04	0.04	0.04
Pisces	71.29	80.39	78.04
S. sprattus phalericus	43.38	37.31	38.88
M. merlangius euxinus	11.47	28.62	24.19
Engraulis encrasicolus	7.28	3.33	4.35
Gobius spp.	3.67	6.09	5.47
Unidendified pisces	5.49	5.04	5.15
Molluscs	0.10	0.05	0.06
Mytilus spp.	0.05	0.03	0.03
Other mollusc	0.05	0.02	0.03
Anthozoa	0.32	0.32	0.32
Actinaria	0.32	0.32	0.32
Ophiuroidea	0.01	+	0.01
Unidentified food material	2.06	1.26	1.46
No. of stomachs examined	3272		
No. of empty stomachs	944		
Mean stomach content weight (g)	0.366		
Mean length of predator (cm)	13.2		

The polychaetes, which were difficult to identify, were mostly non-burrowing forms.

Some other stomach contents identified belonged to the Ascidiacea (0.04%), Actinaria (0.32%), Holothuroidea (*Labidoplax digitata*, 0.51%), and Molluscs (0.06%).

The diet of male and female whiting do not differ much in quality and quantity of food (Table 26). The percentage of crustaceans in the diet of males is only slightly higher than those of females, whilst the opposite is seen for the percentage of fish in the diet.

5.3.1. CHANGES IN DIET WITH SIZE

The percentage weight of the predominant prey groups; fish, crustaceans, polychaetes, echinoderms, ascidiacea and undefined digested materials for each size of whiting is given in Table 27.

Species composition in the diet varies with size of predator. Evidently the most important prey for whiting below 12 cm is crustaceans and polychaetes. Fish becomes of increasing importance in the diet with increasing size of the whiting; thus more than 75% of the stomach contents in whiting above 15 cm consist of fish. Holothuroidea (especially *Labidoplax digitata*) are of minor importance in all size classes; the same is true for the various groups which includes ascidiacea and unidentified food remains.

Table 27. Weight percentage of the predominant prey groups for each size class of whiting (cm). FISH:Fish, CRUS:Crustacea, POLY:Polychaete, HOLO:Holothuroidea, ASCI:Ascidiacea, UND:Undefined material

APRIL-1990

N	Size Class	FISH	CRUS	POLY	HOLO	ASCI	UND
37	4 - 6	-	73.4	13.3	-	-	13.3
214	7 - 9	2.1	20.1	55.8	2.4	-	19.6
752	10 - 12	22.5	21.2	43.8	2.1	-	10.4
346	13 - 15	71.0	21.6	4.2	0.3	-	2.8
74	16 - 18	54.1	44.5	0.6	-	-	0.9
30	19 - 21	92.3	6.8	0.2	-	-	0.7
2	>22	100	-	-	-	-	-

SEPTEMBER-1990

N	Size Class	FISH	CRUS	POLY	HOLO	ASCI	UND
123	7 - 9	39.1	24.9	22.1	0.4	-	13.5
126	10 - 12	48.7	15.1	28.5	1.2	-	6.5
20	13 - 15	65.1	26.1	7.1	1.1	-	0.6
9	16 - 18	75.4	24.6	-	-	-	-

SEPTEMBER-1991

N	Size Class	FISH	CRUS	POLY	HOLO	ASCI	UND
84	10 - 12	21.6	55.6	2.1	15.8	-	5.0
86	13 - 15	76.3	18.2	1.4	3.1	-	1.0
72	16 - 18	89.7	9.8	0.1	0.4	-	-
13	19 - 21	97.9	2.1	-	-	-	-
9	>22	93.5	6.5	-	-	-	-

JANUARY-1992

N	Size Class	FISH	CRUS	POLY	HOLO	ASCI	UND
19	7 - 9	-	85.0	4.7	-	-	10.3
56	10 - 12	63.6	32.2	1.5	-	-	2.7

FROM JUNE 1992 TO MAY 1993

N	Size Class	FISH	CRUS	POLY	HOLO	ASCI	UND
59	7 - 9	67.6	21.7	10.7	-	-	-
223	10 - 12	33.2	48.1	12.3	1.3	-	5.1
424	13 - 15	78.7	15.3	3.5	0.4	0.2	1.9
363	16 - 18	78.6	17.8	2.8	0.1	0.1	0.6
110	19 - 21	95.2	3.8	0.6	-	-	0.4
20	>22	100	-	-	-	-	-

5.3.2. CHANGES IN DIET WITH AGE

The percentage frequency of occurrence of the main prey categories of whiting within age groups are listed in Table 28. There appears a distinct change in the composition of the diet with increasing age of the whiting. With increasing age of the whiting, crustaceans and polychaetes decrease in importance whereas fish as a food becomes more and more dominant. Holothuroidea and Ascidiacea also make up a large percentage of the diet of fish in the I-II age group, but their occurrence within the diet declines in higher age groups.

5.3.3. MEAN WEIGHT OF PREYS

The mean weight of food in the stomachs increased greatly with fish length (Table 29). Empty stomachs were not included when the mean weight of food in the stomachs was calculated from montly samples.

5.3.4. SIZE DISTRIBUTION OF PREYED FISH

From the lengths measurements made on fish prey found in the stomachs there appears to be an increase in the length of the prey with an increase in the length of predator (Figure 13). However, this increase is more pronounced for the whiting within the size range 12-18 cm; for whiting above 18 cm there is no increase in the mean length of prey fish. Even large fish take some small individiuals since the tendency for large whiting to eat large fish-prey items does not stop them from eating smaller prey when they are available. So, the size group larger than 19-21 cm shows smaller mean prey length. However, in this size group a small number of fish, retrieved from the stomachs, were suitable for measuring accurately.

Table 28. Percentage of occurrence of the predominant prey groups for each age group of whiting in all sampling periods. FISH:Fish, CRUS:Crustacea, POLY:Polychaete, HOLO:Holothuroidea, ASCI:Ascidiacea, UND:Undefined material

APRIL-1990

N	Age Group	FISH	CRUS	POLY	HOLO	ASCI	UND
921	I	3.1	34.1	33.3	3.4	-	26.2
432	II	21.9	36.3	18.9	3.3	-	19.6
83	III	38.0	45.1	7.1	1.4	-	8.5
19	IV	66.7	25.0	8.3	-	-	-

SEPTEMBER-1990

N	Age Group	FISH	CRUS	POLY	HOLO	ASCI	UND
255	I	13.7	33.0	33.5	1.4	-	18.4
15	II	11.1	44.4	11.1	11.1	-	22.3
8	III	62.5	37.5	-	-	-	-

SEPTEMBER-1991

N	Age Group	FISH	CRUS	POLY	HOLO	ASCI	UND
92	I	6.8	52.7	9.5	21.6	-	9.5
117	II	32.7	35.6	7.7	16.4	-	7.7
45	III	80.8	19.2	-	-	-	-
5	IV	100	-	-	-	-	-

JANUARY-1992

N	Age Group	FISH	CRUS	POLY	HOLO	ASCI	UND
67	I	8.6	67.1	10.0	-	-	14.3
8	II	42.9	42.9	-	-	-	14.2

FROM JUNE 1992 TO MAY 1993

N	Age Group	FISH	CRUS	POLY	HOLO	ASCI	UND
370	I	31.8	52.3	7.3	3.5	0.4	4.8
456	II	45.7	38.7	8.0	3.0	1.0	3.7
337	III	65.2	25.6	4.3	0.5	1.0	3.4
34	IV	78.6	14.3	7.1	-	-	-

Table 29. Mean weight of stomach contents and mean length of whiting of each size class sampled between Jun-92 and May-93.

Size Class (cm)	Mean length of predator (cm)	Mean weight of the stomach contents (g)
7-9	9.1	0.104
10-12	11.6	0.232
13-15	14.6	0.802
16-18	17.3	1.668
19-21	20.0	2.532
>22	24.4	4.068

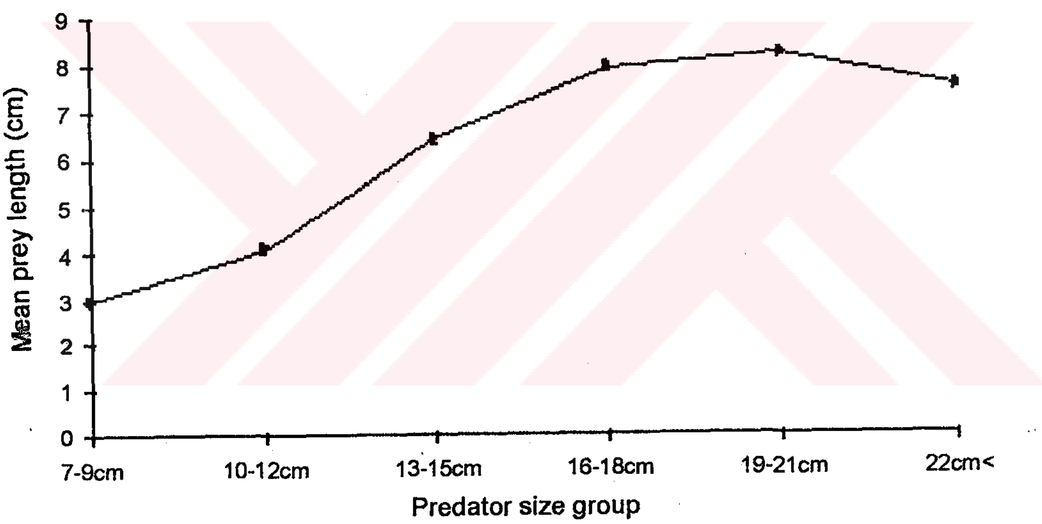


Figure 13. Change in the length of prey fish as a function of mean predator length. Data base; June 1992 and May 1993.

5.3.5. SEASONAL VARIATIONS IN FEEDING

Seasonal changes of the percentage frequency of occurrence of the main prey groups is shown in Figure 14. The data plotted was the means taken from fish of all lengths in the sampling period between June 1992 and May 1993. Fish prey occurred in a higher proportion in the stomach of whiting between October and December and in early summer. From December to April, fish clearly decrease in the food of whiting while cruataceans increase. Crustaceans represent a much smaller percentage in late summer and early autumn. Polychaetes, holothuroidae and ascidia do not reveal a clear seasonal pattern in the diet of whiting. However, polychaetes occurred more frequently in the diet during spring and August.

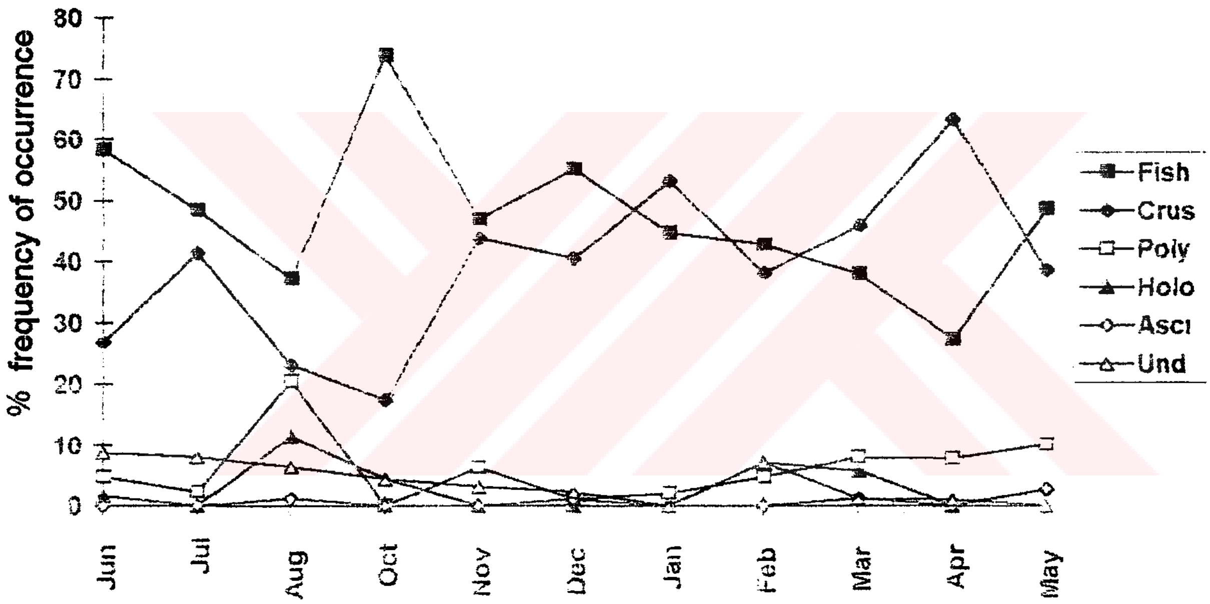


Figure 14. Seasonal cycle of the percentage frequency of occurence of the main faunal groups (—■— Fish, —◆— Crustacea, —□— Polychaete, —▲— Holothuroidae, —◇— Ascidiacea, —△— Undefined material).

Some prey were eaten at all times of the year whilst others were very seasonal in their occurrence in the diet. Sprat and goby were eaten at all times of the year whilst anchovy were eaten seasonally. Anchovy migrations are well documented locally, and they are known to be abundant in the Turkish Black Sea Coast from late autumn to early spring. Crayfish, one of the two main components of the crustacean prey, were also eaten throughout the year, but they were generally of major importance in the diet only during the May-July period. It seems that, the diet of whiting does reflect seasonal changes with respect to the abundance of avaible food. Whiting may therefore be considered as an opportunistic carnivorous predator.

The percentage frequency of occurrence of the main prey items in the diet by season and by length are presented in Table 30. There is a general trend in all months for a change in the diet from crustacea to fish with increasing size.

In the 7-9 cm length group, analysis of the stomach contents showed that crustacea were generally the dominant food item in all months. Fish accounted for only a small part of the diet in all months.

In the 10-12 cm length group, crustaceans were again the dominant food item for all months. Fish occurred also more frequently in the diet. Polychaetes and Holothuridae attained major importance after crustacean and fish in the diet.

In the 13-15 cm length group, fish were predominant in the diet for all months. Crustacea, polychaetes, holothuridae and ascidiacea respectively were of decreasing importance in the diet. The 16-18 cm and larger length groups showed a continuation of this trend towards a fish diet. The percentage of crustacea in the diet decreased with increasing length groups.

Table 30. The percentage frequency of occurrence of the main prey categories by season and by length (cm).

		Months										
		Jun	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Length	**Prey categories**											
7-9	Fish	57.1	-	25.0	-	-	-	-	-	-	-	50.0
	Crustacea	28.6	100	75.0	-	-	-	-	-	100	-	50.0
	Polychaete	14.3	-	-	-	-	-	-	-	-	-	-
	Holothuroidae	-	-	-	-	-	-	-	-	-	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	-
	Undefined mat.	-	-	-	-	-	-	-	-	-	-	-
10-12	Fish	54.2	21.4	9.5	-	15.4	-	15.4	15.4	-	4.5	85.7
	Crustacea	25.0	50.0	23.8	-	84.6	87.5	76.9	61.5	75.0	95.5	14.3
	Polychaete	12.5	7.1	38.1	-	-	6.25	7.7	7.7	6.3	-	-
	Holothuroidae	-	-	19.1	-	-	-	-	7.7	12.5	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	-
	Undefined mat.	8.3	21.5	9.5	-	-	6.25	-	7.7	6.3	-	-
13-15	Fish	60.4	41.4	25.0	75.0	62.5	67.9	51.9	50.0	13.3	18.9	27.3
	Crustacea	25.6	48.3	17.9	-	25.0	28.6	48.1	29.2	63.3	70.3	45.5
	Polychaete	2.3	3.5	28.6	-	12.5	-	-	4.2	13.3	8.1	22.7
	Holothuroidae	4.7	-	14.3	-	-	-	-	8.3	6.7	-	-
	Ascidiacea	-	-	3.6	-	-	1.79	-	-	3.3	-	4.5
	Undefined mat.	7.0	6.8	10.7	25.0	-	1.79	-	8.3	-	2.7	-
16-18	Fish	51.4	66.7	69.2	66.7	57.1	62.5	71.4	80.0	68.8	50.0	35.7
	Crustacea	35.1	29.6	23.1	25.0	14.3	37.5	28.6	20.0	21.9	35.7	47.6
	Polychaete	-	-	-	-	14.3	-	-	-	6.3	14.3	11.9
	Holothuroidae	-	-	7.7	8.3	-	-	-	-	3.1	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	4.8
	Undefined mat.	13.5	3.7	-	-	14.3	-	-	-	-	-	-
19-21	Fish	87.5	63.6	83.3	85.7	100	100	-	-	100	100	83.3
	Crustacea	-	27.3	16.7	14.3	-	-	-	-	-	-	11.1
	Polychaete	-	-	-	-	-	-	-	-	-	-	5.6
	Holothuroidae	-	-	-	-	-	-	-	-	-	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	-
	Undefined mat.	12.5	9.1	-	-	-	-	-	-	-	-	-
>22	Fish	100	100	-	-	-	-	-	-	100	-	100
	Crustacea	-	-	-	-	-	-	-	-	-	-	-
	Polychaete	-	-	-	-	-	-	-	-	-	-	-
	Holothuroidae	-	-	-	-	-	-	-	-	-	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	-
	Undefined mat.	-	-	-	-	-	-	-	-	-	-	-

Fish generally dominated the food of the larger length groups (13-18 cm) of whiting from autumn to early spring, whilst mostly occurring in the food of the small length groups (7-12 cm) in late spring and early summer. The percentage of crustacaean is generally at its maximum in the diet of 13-18 cm length group of whiting from spring until the beginning of summer. Crustaceans commonly occurred in the diet of the small length groups in late spring and summer, and during winter in a small proportion. The percentage of Polychaetes and Holothuroidae in the under 15 cm length group were higher in summer than at other times.

The percentage frequency of occurrence of the main prey items in the diet by season and by age are given in Table 31. A common trend for change from crustacea, polychaete and other main prey items to fish feeding with increasing age occurred in all months. In age group-I, crustaceans were predominant in winter (January-April) and summer (July-August). In age group-II, crustaceans were the dominant prey in the diet only between March and May whilst fish was the dominant prey item in the diet from June to February. Age group-III did not show any seasonal a change in the percentage of crustacea.

Table 31. The percentage frequency of occurrence of the main prey categories by season and by age

Age	Prey categories	Jun	Jul	Aug	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
		Months										
I	Fish	55.0	19.1	14.3	50.0	33.3	50.8	17.6	29.4	-	6.7	54.5
	Crustacea	27.5	57.1	34.3	-	61.9	42.6	76.5	52.9	73.9	93.3	45.5
	Polychaete	12.5	4.8	25.7	-	4.8	1.6	5.9	5.9	8.7	-	-
	Holothuroidae	-	-	17.1	-	-	-	-	5.9	13.0	-	-
	Ascidiacea	-	-	-	-	-	1.6	-	-	-	-	-
	Undefined mat.	5.0	19.0	8.6	50.0	-	3.3	-	5.9-	4.3	-	-
2	Fish	58.3	47.1	42.9	72.7	66.7	63.0	60.0	45.0	23.7	24.3	34.8
	Crustacea	27.1	47.1	10.7	27.3	11.1	37.0	40.0	30.0	55.3	64.9	39.1
	Polychaete	2.1	2.9	25.0	-	11.1	-	-	5.0	13.2	8.1	21.7
	Holothuroidae	4.2	-	10.7	-	-	-	-	10.0	5.3	-	-
	Ascidiacea	-	-	3.6	-	-	-	-	-	2.6	-	4.3
	Undefined mat.	8.3	2.9	7.1	-	11.1	-	-	10.0	-	2.7	-
3	Fish	60.5	67.7	80.0	80.0	100	100	60.0	80.0	92.0	60.9	46.2
	Crustacea	26.3	25.8	20.0	10.0	-	-	40.0	20.0	8.0	21.7	40.4
	Polychaete	-	-	-	-	-	-	-	-	-	17.4	9.6
	Holothuroidae	-	-	-	10.0	-	-	-	-	-	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	3.8
	Undefined mat.	13.2	6.5	-	-	-	-	-	-	-	-	-
4	Fish	100	100	-	-	-	-	-	-	-	-	75.0
	Crustacea	-	-	-	-	-	-	-	-	-	-	16.7
	Polychaete	-	-	-	-	-	-	-	-	-	-	8.3
	Holothuroidae	-	-	-	-	-	-	-	-	-	-	-
	Ascidiacea	-	-	-	-	-	-	-	-	-	-	-
	Undefined mat.	-	-	-	-	-	-	-	-	-	-	-

Whiting reveal a clear seasonal cycle in the percentage of empty stomachs (Figure 15). The empty stomach ratio ranged from 18% to 44% throughout the year. Empty stomachs were mostly found during winter and late summer. They were mostly full in November, December and April.

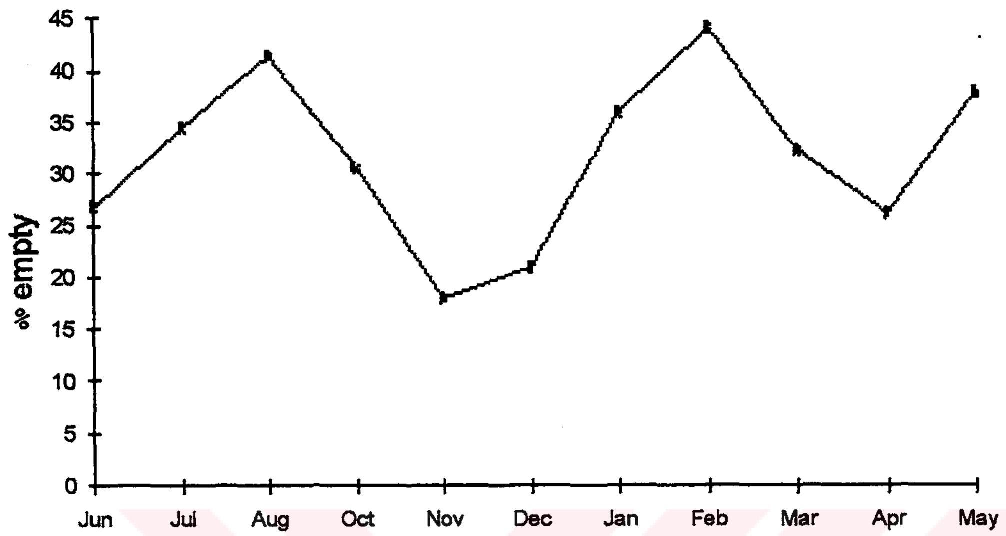


Figure 15. Seasonal change of the percentage of empty stomachs of whiting

5.3.6. DAILY AND YEARLY FOOD CONSUMPTION

Daily and yearly food consumption rates for whiting in each size class calculated by using the values of Q (digestion coefficient) and the mean weight of stomach contents are given in Table 32. The mean lengths shown in this table are the means of each size class and they were converted to mean weights by means of the lenght-weight relationship of whiting $W=0.0042*L^{3.24}$. The data in Table 32 confirm that there is an increase in food intake with increase in length. Table 32 also shows that the average rate of food intake (mean across all whiting sizes studied) of whiting is 3.3% of body weight per day when excluding empty stomachs from the data but this figure drops to 2.4% per day when empty stomachs are included.

Table 32. Daily and yearly food consumption rate of whiting (a, excluding empty stomachs; b, including empty stomachs).

Mean length(cm)	Mean weight(g)	Daily consumption rate (g)		Yearly consumption rate (g)		Daily coefficient (%)	
		a	b	a	b	a	b
6.2	1.6	0.05	0.03	17.3	9.2	3.1	1.9
9.1	5.4	0.19	0.16	70.1	57.2	3.5	2.9
11.6	11.8	0.39	0.31	142.3	113.2	3.3	2.6
14.6	24.9	0.85	0.69	308.9	250.1	3.4	2.8
17.3	43.1	1.50	1.12	548.5	408.3	3.5	2.6
20.0	69.0	2.23	1.79	814.3	652.6	3.2	2.6
24.4	131.3	3.67	2.11	1337.8	769.1	2.8	1.6

The whiting's consumption of fish species (sprat, whiting, goby and anchovy - either total or separately) was calculated from the weight percentage of fish prey found in the stomachs (Table 33) and the results are given by both including and excluding empty stomachs in Table 34.

Table 33. The weight percentage of sprat, whiting, anchovy, goby and undefined fish species consumed by whiting of different size classes.

Size class	Sprat	Whiting	Goby	Anchovy	Und.fish
7 - 9	91.4	6.7	1.0	-	1.0
10-12	82.1	6.0	11.1	0.2	0.6
13-15	68.6	19.4	6.5	4.1	2.9
16-18	51.1	20.5	21.9	2.1	4.5
19-21	36.7	24.9	33.1	1.9	3.5
>22	6.2	50.9	6.8	-	36.1

Table 34. Yearly consumption of sprat, whiting, goby and anchovy by whiting of the given lengths (a, excluding empty stomachs; b, including empty stomachs)

	Yearly Consumption (g)									
	Total fish		Sprat		Whiting		Goby		Anchovy	
Mean length whiting (cm)	a	b	a	b	a	b	a	b	a	b
6.2	0	0	-	-	-	-	-	-	-	-
9.1	19.1	15.6	17.5	14.4	1.3	1.1	0.2	0.1	-	-
11.6	53.8	42.8	44.2	35.1	3.2	2.6	6.0	4.8	0.1	0.1
14.6	224.9	182.1	154.3	124.9	43.6	35.3	14.6	11.8	9.2	7.5
17.3	408.6	304.2	208.8	155.4	83.8	62.4	89.5	66.6	8.6	6.4
20.0	774.4	620.6	284.2	227.8	192.8	154.5	256.3	205.4	14.7	11.8
24.4	1308.4	752.2	81.1	46.6	665.9	382.9	89.0	51.1	-	-

Daily consumption rates for I, II, III, and IV-year-old whiting were 0.25, 0.71, 1.36, and 2.18 grams body weight per day respectively. The results of daily and yearly consumption rates, and yearly consumption of total fish, sprat, whiting, goby and anchovy for each age group of whiting are given in Table 35.

Table 35. Yearly consumption of sprat, whiting, goby anchovy and total fish species in grams for each age group of whiting.

					Yearly Consumption (g)				
Age	length (cm)	weight (g)	Daily rate (g)	Yearly rate (g)	Total Fish	Sprat	Whit.	Gobius	Anch.
1	10.6	8.9	0.25	91.3	42.5	31.8	4.9	1.6	0.9
2	14.7	25.3	0.71	259.2	190.3	131.1	28.5	22.3	4.4
3	18.1	49.9	1.36	496.4	418.0	193.5	88.6	112.0	7.5
4	21.0	81.1	2.18	795.7	779.8	312.7	368.8	19.5	-

5.4. MATURITY AND CHANGES IN GONAD

Gonads classified by their macroscopic appearence are given in Table 36. Immature virgin fish (stage I), which were found throughout the year, are not included in the Table 36.

Table 36. Number of fish in each gonad stage between June 1992 and May 1993.

Month		Gonad Stage						
		II	III	IV	V	VI	VII	Total
Jun92	N	58	1	15	21	-	-	95
	%	61.1	1.0	15.8	22.1	-	-	-
Jul	N	62	9	3	4	-	2	80
	%	77.5	11.3	3.8	5.0	-	2.5	-
Aug	N	68	7	-	-	-	-	75
	%	90.7	9.3	-	-	-	-	-
Oct	N	25	13	7	4	-	-	49
	%	51.0	26.5	14.3	8.2	-	-	-
Nov	N	8	12	8	1	-	-	29
	%	27.6	41.4	27.6	3.5	-	-	-
Dec	N	31	22	15	7	-	-	75
	%	41.3	29.3	20.0	9.3	-	-	-
Jan93	N	23	15	16	4	-	-	58
	%	39.7	25.9	27.6	6.9	-	-	-
Feb	N	22	17	14	6	1	-	60
	%	36.7	28.3	23.3	10.0	1.7	-	-
Mar	N	42	5	39	21	2	7	116
	%	36.2	4.3	33.6	18.1	1.7	6.0	-
Apr	N	29	7	15	4	1	11	67
	%	43.3	10.5	22.4	6.0	1.5	16.4	-
May	N	41	12	20	20	9	3	105
	%	39.1	11.4	19.1	19.1	8.6	2.9	-

The records showed that some fish began to develop towards maturity as early as September and October, but the gonads of most fish were then in the recovered or resting state (stage II) and showed little change in size and appearence until January. From January to March there was a steady advance towards maturity, and in March ripe fish (stage V) were dominant. In April, spent and recovering fish (stages VII and II) were the most common. The greater part of fish examined in August were recovering or recovered from spawning, and none had stage IV and over. The large range in gonad condition from October to July is an indication of a wide variation in the time of the year at which different fish mature.

Ripe and running fish (stage V and VI) in samples taken between October and July show that the spawning season extends over at least 10 months of the year. The intensity of spawning in each month throughout the spawning period is shown in Table 37 for a comparison of the number of ripe and running fish with the total number of fish . Most of fish spawn between February and May and spawning continues until July.

Table 37. Montly percentage of ripe and running fish throughout the spawning period

MONTHS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
No. of fish examined	49	29	75	58	60	116	67	105	95	80
No.of ripe and running fish	4	1	7	4	7	30	16	32	21	6
% of total	8.2	3.5	9.3	6.9	11.7	25.9	23.9	30.5	22.1	7.5

Spent gonads appear to recover rapidly in the whiting, since most of the fish had gonads in the resting stage (II) by June. This was reflected in the sharp fall in the number of spent fish caught from April to June (Table 36). Recovery implies the complete resorption of residual eggs and sperm and the change in general appearence from the shrunken, rather bloodshot spent gonad to the firm, clear gonad.

The larger fish matured earlier in the season than the smaller fish of spawning size, and presumably spawned earlier (Table 38). In February and March for example, mature females sized between 17-25 cm long which had attained 100 per cent sexual maturity were in a more advanced stage of gonadal development than those under 17 cm length of which most were ripening for the first time. Similar differences in time of ripening can be demonstrated among male fish of different length groups.

Table 38. Percentage of female fish at each stage of gonad maturity for different length groups and their number.

		Gonad stage						Total
	Size	II	III	IV	V	VI	VII	(N)
FEBRUARY	<17 cm	52	12	8.0	20	4	4	25
	17-25 cm	0	30	20	40	10	0	10
MARCH	<17 cm	66.7	3	21.2	6.1	3	0	33
	17-25 cm	23	6.7	43	23	0	3.4	30

The monthly gonadosomatic index showed that the gonad development was remarkably high between December and mid-March and the maximum was reached in January (Figure 17). After March, the gonadosomatic index showed a sharp decline.

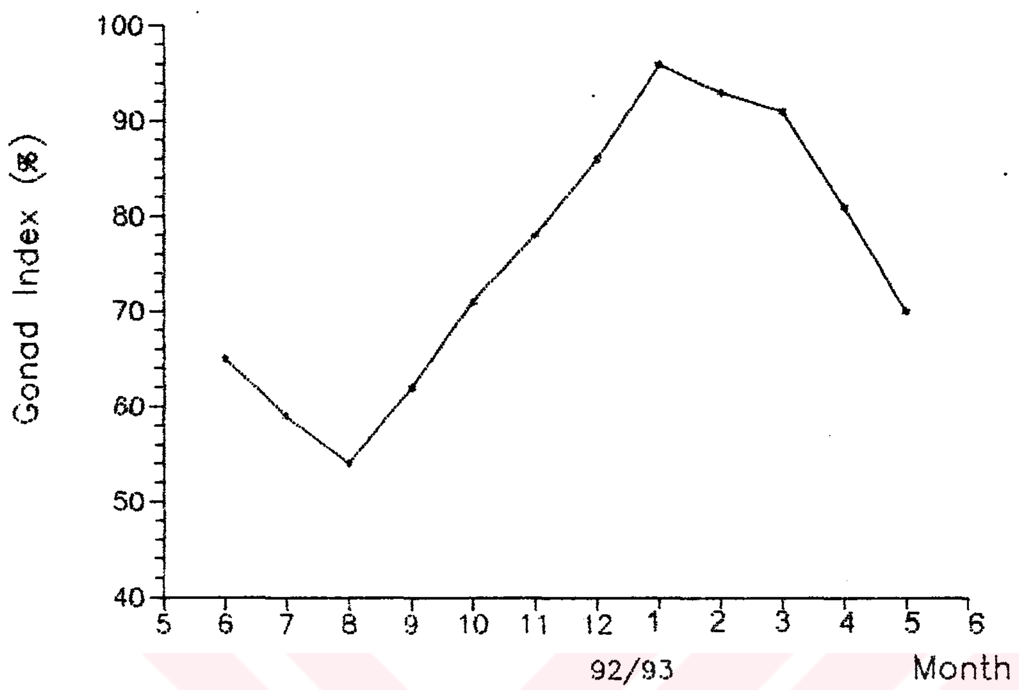


Figure 16. Seasonal variation of gonadosomatic index of Black Sea whiting

5.4.1. LENGTH AND AGE AT SEXUAL MATURITY

The transition from immature to the mature condition in fish usually occurs over a range of length in the form of a sigmoid curve. From the percentages of mature whiting (ripening, spawning, spent or recovering condition), the mean lengths (cm) at 50% maturity were calculated with 1 cm length intervals and shown in Figure 17.

Males attained sexual maturity at smaller sizes (12.5 cm) than females (14.7 cm). Mature fish below 8 cm for male and 11 cm for female was not present. Individuals of both sexes attained 100 per cent sexual maturity at the same length, e.g. 18 cm.

In age group I, female fish with gonads more mature than stage II was not found. Maturing and ripe fish were commonly found in age group II. On the other hand, immature virgin fish were found in approximately 1% of female in age group III. Therefore, it appears that the female whiting in the Black Sea generally spawn for the first time at the end of their second year of life, and by the end of the third year (just entering age group III) all females are mature. Male whiting may spawn at the end of their first year of life, as ripening fish were found in approximately 20% of age group I males.

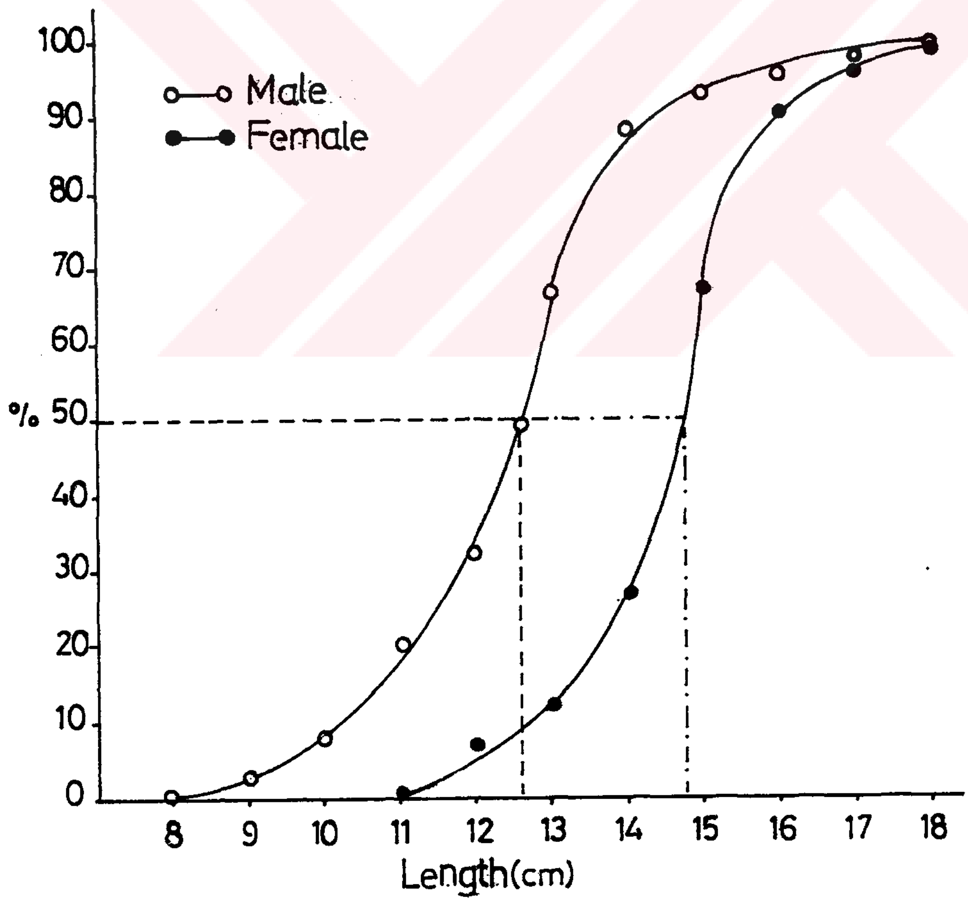


Figure 17. The mean lengths at 50% maturity of Black Sea whiting

5.5. FECUNDITY AND ITS RELATION TO FISH LENGTH AND AGE *

The average fecundity of a representative female in the population is a biological parameter needed for the estimation of the absolute size of a spawning population of fish from total egg production data (HISLOP & HALL, 1974). BAGENAL (1978) defines the fecundity as " the number of ripening eggs in the female just prior to the next spawning period ".

There are few references related to the fecundity of whiting in the literature. KANDLER (1958; c.f. HISLOP & HALL, 1974) estimated the fecundity of 37 pre-spawning whiting from the Baltic, ranging in length from 25 to 39 cm. Their fecundity ranged between 108,000 and 221,000 eggs, and the relation between fecundity and length (L) in cm was expressed in the form $Fecundity=72000+2.404*L^3$. MESSTORFF (1959) counted 120,400 and 1,151,000 eggs in 37 whiting, ranging in length from 23.5 to 38.5 cm, from the southern North Sea. He reported a relationship between fecundity and length as $Fecundity=0.0065*L^{5.28}$. He also noted a tendency for older whiting to be more fecund than younger ones at the same length. HISLOP & HALL (1974) made fecundity estimations for whiting from the North Sea, the Minch and Iceland. For the Icelandic fish, they found a relationship between fecundity and length expressed as $Fecundity=aL^{3.72}$, For all other samples the relationship was shown as $Fecundity=aL^{3.25}$. HISLOP (1975) also gave the fecundity of whiting from the North Sea, ranging in length from 25 to 51

*) This section of thesis is published (ISMEN, A., 1995, Fecundity of whiting, *Merlangius merlangus euxinus* (N.) on the Turkish Black Sea Coast. Fisheries Research 22:309-318.

cm. It ranged from 170.000 to 2.089.000 eggs. IVANOV & BEVERTON (1985) mentioned that the average annual fertility of the Black Sea whiting is 120.000 eggs.

Analysis of the data from the western Turkish Black Sea coast in 1990, and from the eastern Turkish Black Sea coast in 1991, 1992 and 1993 indicated that fecundity (the number of eggs, F), is related to length (L, in cm) and age (A, years) of the fish. The fecundity-length and the fecundity-age relationships are given in Table 39.

Table 39. The fecundity-length and fecundity-age relationships of whiting for 1990, 1991, 1992 and 1993.

Period	Length	Age
1990	log F=2.197 log L + 2.182	log F=0.702 log A + 4.713
1991	log F=2.203 log L + 2.421	log F=1.017 log A + 4.905
1992	log F=3.362 log L + 0.801	log F=1.271 log A + 4.691
1993	log F=2.744 log L + 1.585	log F=1.106 log A + 4.729

Plots of fecundity-length and fecundity-age data and the arithmetic forms of these relationships are shown in Figure 18. In all cases the correlation coefficients (r) are significantly different from zero ($P<0.01$); in other words, there exist a strong correlation between the data pairs. But, the correlation coefficients (r) for all fecundity-age ralationships are lower than those for the respective fecundity-length relationships (Table 40).

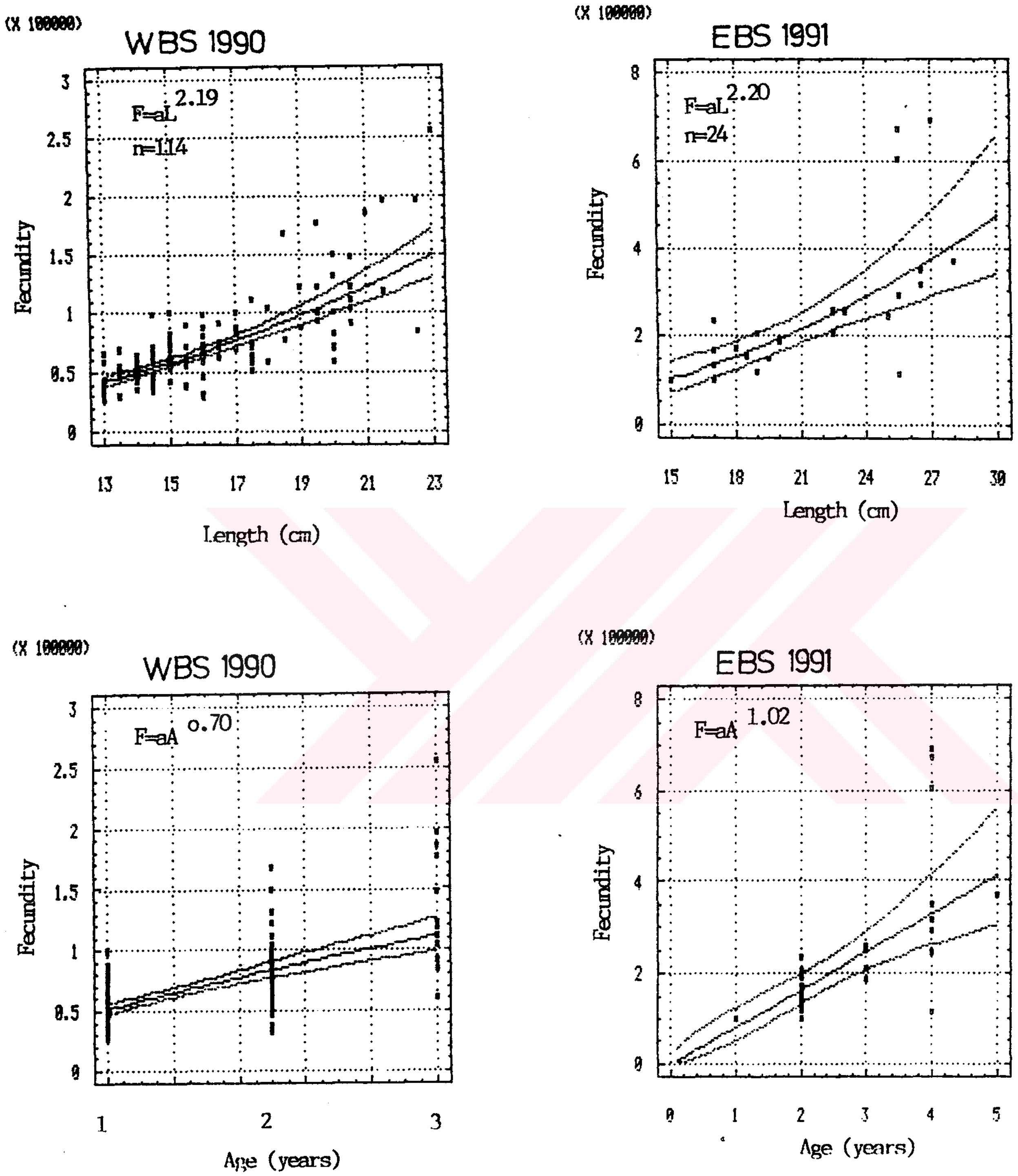


Figure 18. Relationships of fecundity to length and age for Black Sea whiting between 1990 and 1993. WBS: western Black Sea, EBS: eastern Black Sea.

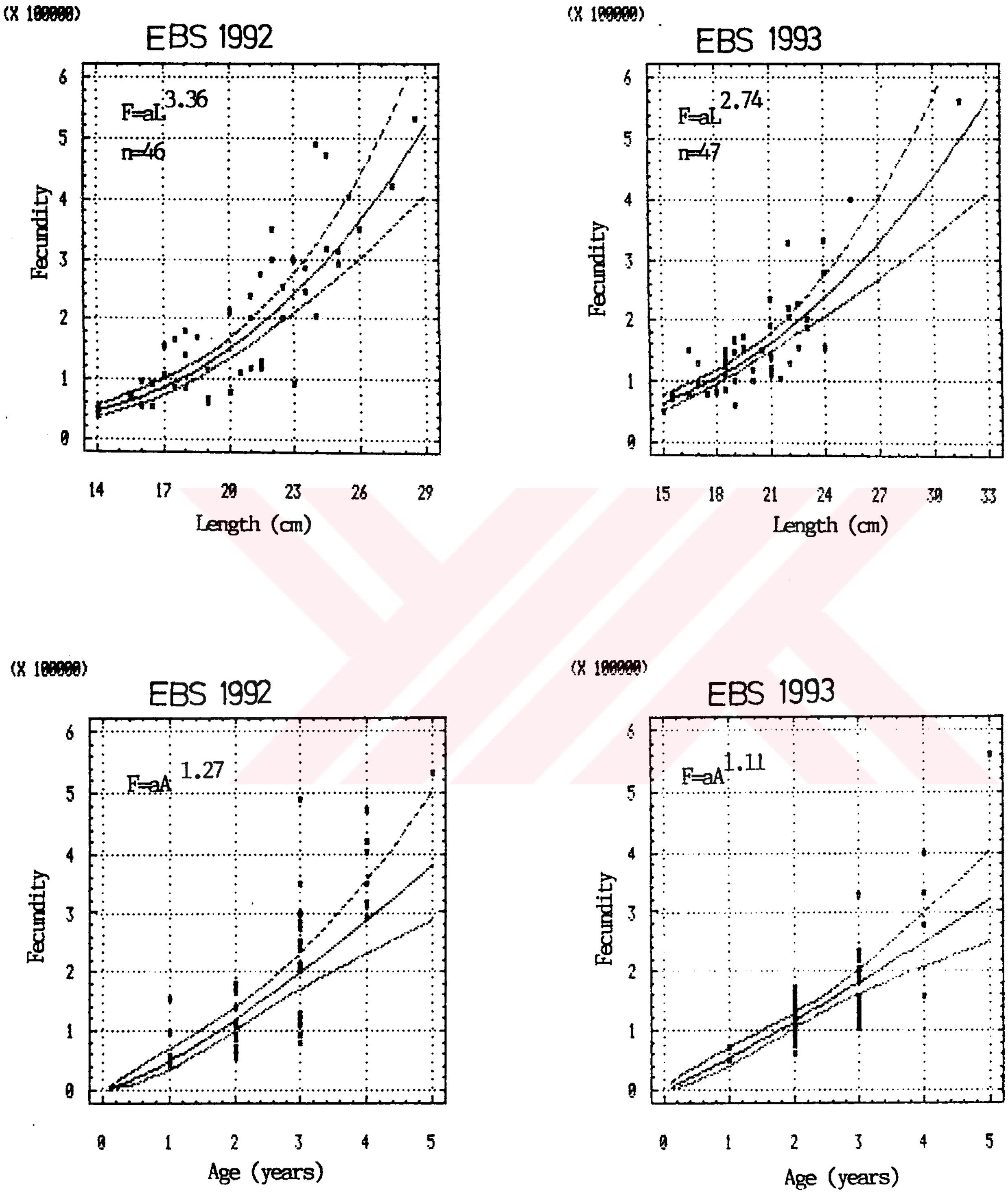


Figure 18. continued

Table 40. Regression constants and tests of significance of correlations of fecundity with length and age for whiting from the western and eastern Turkish Black Sea coasts, 1990-93.

Area	No of fish	Slope (b)	Intercept (log a)	r
		Fecundity-length		
Western Black Sea,1990	115	2.197	2.182	0.75**
Eastern Black Sea 1991	25	2.203	2.421	0.75**
Eastern Black Sea 1992	47	3.362	0.801	0.85**
Eastern Black Sea1993	48	2.744	1.585	0.80**
		Fecundity-age		
Western Black Sea,1990	115	0.702	4.713	0.65**
Eastern Black Sea,1991	25	1.017	4.905	0.72**
Eastern Black Sea,1992	47	1.271	4.691	0.74**
Eastern Black Sea,1993	48	1.106	4.729	0.73**

** : significance at P<0.01

Analysis of covariance of the fecundity-length and fecundity-age data for the eastern Turkish Black Sea coast indicated no significance in the regression coefficients (rate of egg production) between 1991 and 1993. However, the adjusted means (quantity of eggs produced) for both data sets are significantly different only for 1991-1993. Similar comparison (analysis of covariance) of the data from the western Turkish Black Sea in 1990 and the eastern Black Sea in 1991-93 indicated that the difference in regression coefficients is significant with P<0.01 and the difference in the adjusted means is highly significant with P<0.01 (Table 41).

Table 41. Summary of covariance analyses for regressions of fecundity against length and age for whiting from western and eastern Turkish Black Sea Coast.

Area	Mean squares: Regression coefficients	F	Adjusted means	F
Fecundity-length				
Western Black Sea, 1990 / Eastern Black Sea, 1991-93	0.159	7.752**	0.476	22.424**
Eastern Black Sea, 1991 / Eastern Black Sea, 1992	0.129	5.058	0.141	5.214
Eastern Black Sea, 1991 / Eastern Black Sea, 1993	0.240	1.235	0.247	12.618**
Eastern Black Sea, 1992 / Eastern Black Sea 1993	0.040	1.909	0.011	0.527
Fecundity-age				
Western Black Sea, 1990 / Eastern Black Sea, 1991-93	0.633	23.562**	1.174	39.804**
Eastern Black Sea, 1991 / Eastern Black Sea, 1992	0.042	1.262	0.181	5.407
Eastern Black Sea, 1991 / Eastern Black Sea, 1993	0.004	0.159	0.253	1.011**
Eastern Black Sea, 1992 / Eastern Black Sea, 1993	0.107	3.796	0.001	0.029

**: significance at P<0.01.

5.5.1. FECUNDITY RELATED TO LENGTH AND AGE

On the basis of the analyses presented above, fecundity in whiting appears to be related to both fish length and age. However, the lesser variation and higher correlation of fecundity-length data (Table 40) indicate that fecundity is more related to length than to age. A multiple correlation analysis was performed in order to determine the relative contributions of length and age to variation in fecundity (Table 42).

Table 42. Summary of statistics for multiple correlation of fecundity length and age for whiting (X_1=log fecundity, X_2=log length and X_3=log age in estimating equation $X_1=a_{1\ 23}+b_{12\ 3}X_2+b_{13\ 2}X_3$).

Parameters		Western Parts	Eastern Parts		
		1990	1991	1992	1993
Number of specimens	N	115	25	47	48
Coef.of determination for X_1 and X_2	r^2_{12}	0.559	0.557	0.722	0.637
Coef.of determination for X_1 and X_3	r^2_{13}	0.417	0.521	0.547	0.538
Coef.of multiple determination	$r^2_{1\ 23}$	0.559	0.558	0.727	0.637
Coef.of partial determination	$r^2_{13\ 2}$	0.005	0.105	0.009	0.100
F for $r^2_{13\ 2}$		0.018	0.083	0.000	0.101

For the fecundity data from both geographical areas, the coefficients of determination for log-fecundity and log-length (r^2_{12}) are slightly greater than those for log-fecundity and log-age (r^2_{13}) (Table 41). However, when log-length and log-age are considered together in relation to log-fecundity, the coefficients of multiple determination ($r^2_{1.23}$) for both areas are equal to the simple coefficients for log-fecundity and log-length (r^2_{12}). Analysis of correlation indicated that the relative contributions of age to variation in fecundity are not significantly different from zero (Table 42). In conclusion, the variation in fecundity is adequately explained in terms of length alone.

5.6. PARASITES

The seasonal prevalence and intensity of the whiting parasites were studied and ectoparasites are not detected within the time span 1990-1993.

In the endoparasitic examination, only nematodes were recorded in some fish examined the stomachs. A random sample of these nematodes was identified as *Hysterothylacium aduncum* *) (Anisakidae). Adults of this nematode species were present in the stomach and intestine of whiting and their larvae and young species occurred in its body cavity. There was little difference in the percentage occurrence of the nematode between three stations in the eastern Black Sea and therefore the results have been pooled. Table 43 gives the percentage occurrence (percentage of fish infected) and intensity (mean number of parasites per fish) of nematods for the different length groups and months.

As can be seen in Table 43, there is a sesonal change in the percentage occurrence of nematodes. The highest prevalence (54.8%) was found in July/August. After these warm months, a decrease in the number of whiting infected was observed and in January/February the lowest value (21.8%) was recorded. Together with the increasing temperature, the prevalence of nematodes and their increase was detected again.

---

*) : Kindly identified by Dr. T. LANG from Bufo fur Fischereiokologie-Lab., Cuxhaven (GERMANY)

Table 43. The percentage occurence of nematodes in the stomachs of whiting *Merlangius merlangus euxinus* from three stations (Havaalanı, Beşikdüzü, Sürmene) in the eastern Black Sea coast (values in parenthesis are the number of fish examined).

	Length groups (cm)										
	7/8	9/10	11/12	13/14	15/16	17/18	19/20	21/22	23/24	>25	Total
MAY/JUN	25.0	20.9	20.8	32.1	47.6	42.9	56.7	57.9	60.0	-	44.8
	(16)	(43)	(24)	(56)	(63)	(63)	(30)	(19)	(5)	-	(319)
JUL/AUG	100	39.3	65.6	41.0	65.5	50.8	64.3	50.0	-	-	54.8
	(2)	(28)	(32)	(39)	(55)	(61)	(28)	(2)	-	-	(247)
NOV/DEC	-	36.4	58.3	35.5	46.2	45.8	71.4	100	-	-	52.1
	-	(11)	(24)	(62)	(39)	(24)	(7)	(1)	-	-	(144)
JAN/FEB	-	25.0	12.2	30.9	15.4	23.5	33.3	-	-	-	21.8
	-	(12)	(41)	(68)	(78)	(17)	(3)	-	-	-	(219)
MAR/APR	0.0	66.7	47.8	38.6	32.5	46.4	41.7	40.0	0.0	100	41.4
	(1)	(6)	(46)	(57)	(80)	(56)	(12)	(5)	(2)	(4)	(268)

As it is also seen in Table 43, a clear positive relationship between length of fish and prevelance of nematode was only found in May/June. In the other months there was no a clear relationship between length of fish and prevelance of nematode.

The prevalance and intensity of infection with nematodes in whiting of different age groups are shown in Table 44. The level of infection with nematods mostly increased with age of the host in the data taken monthly .

Table 44. The percentage occurence of nematodes in the stomachs of each age group of whiting from three stations (Havaalanı, Beşikdüzü, Sürmene)in the eatern Black Sea coast (values in parenthesis are the number examined).

	Age group (year)					
	I	II	III	IV	>V	Total
MAY/JUN	21.5	35.0	43.7	66.7	0	
	(65)	(80)	(135)	(37)	(2)	(319)
JUL/AUG	50.0	57.3	54.5	0	-	
	(52)	(82)	(112)	(1)	-	(247)
NOV/DEC	47.9	47.6	76.9	100	-	
	(71)	(59)	(13)	(1)	-	(144)
JAN/FEB	11.1	22.0	23.9	-	-	
	(18)	(109)	(92)	-	-	(219)
MAR/APR	26.7	42.6	40.6	33.3	75.0	
	(15)	(115)	(128)	(6)	(4)	(268)

Prevalences and mean intensities of nematode in monthly and seasonal samples are shown in Table 45.

As can be seen in Table 45, the analysis of intensity levels has demonstrated the seasonal changes in parasite levels in the Turkish Black Sea Coasts. While the lowest mean intensity was occurred in January/February (0.35 parasites per fish), the highest values were found in July/August and November/December.

The highest nematod number in one fish (at length 9.5 cm, nematod number 32; at length 14.5 cm, nematod number 38) also occurred in April 1990 samples.

Table 45 . Prevalences and mean intensities of infestation of whiting from all areas in monthly and seasonal samples.

	N	Occurence(%)	Intensity	Mean Intensity
MAY/JUN-92	319	44.8	328	1.03
JUL/AUG-92	248	54.8	346	1.40
NOV/DEC-92	144	52.1	209	1.45
JAN/FEB-93	211	21.8	73	0.35
MAR/APR-93	268	41.4	252	0.94
APR 1990	1455	33.6	1185	0.81
SEP 1990	299	25.8	140	0.47
SEP 1991	258	28.3	166	0.64
JAN 1992	75	38.7	60	0.80

6. DISCUSSION

Various characteristics of the Black Sea whiting were presented in the previous chapter. These included the stock differentiation, population parameters e.g. growth, age, mortality, exploitation rate as well as stomach content, sex and sexual maturity etc. Each of them is discussed below separately .

6.1. STOCK DIFFERENTIATION

Results of this study indicate the occurrence of a single unit stock of whiting along the Turkish Black Sea coast. The degree of discrimination (D^2) obtained between two groups or more is directly related to the intermingling of specimens of the considered groups. In the present study, a small degree of multiple character discrimination (D^2) ranging from 0.0265 to 0.7701 between 5 sub regions shows no indication of discrimination for the morphometric and meristic characteristics of Black Sea whiting along the Turkish coast. MAIS (1972) made a subpopulation study on Pacific sardines (*Sardinops caeruleus*) inhabiting the west coast of North America and Mexico and found that California and central Baja California stocks are quite closely related and undoubtedly intermingle to a considerable degree. Fish from these areas overlapped so greatly that no inference of separate stocks can be made. The D^2 values of these stocks were calculated as 0.309 -1.353. EHRICH & REMPE (1980) studied morphometric discrimination between hake populations (*Merluccius productus*) from the Northeast Pacific by using a size-independent discriminant analysis and stated that the groups which include the Generalized Distance values (D^2) ranged from 0.3 to 2.9, belong to one stock. AVSAR (1994) studied the stock differentiation of the sprat (*Sprattus sprattus phalericus*) off the southern Black Sea coast and obtained D^2 values varying from 0.04 to 0.64. These valuese implied that all the Turkish Black Sea sprat collected in the 1990-92 period can be considered as a single unit stock.

Relatively larger (D^2) values occurred between regions for different sampling periods. This may be explained by the fluctuations in temperature and other environmental factors during the spawning and post-spawning periods and be related to differences in the growth characteristics influenced by seasonal as well as annual changes in environmental conditions. PARRISH & SHARMAN (1958) stated that the meristic characters are fixed in early embryonic life of the individual and remain unchanged thereafter. Thus they respond to environmental factors during only a short period of time, after which their values are unaffected by environmental fluctuations and the short-term local fluctuations in environmental factors may give rise to wide variations in their values amongst members of the same and different year-classes of a single unit stock. They also stated that the physiological characteristics of which the rate and pattern of growth are the most important are not so susceptible to short-term local fluctuations, and reflect more the average differences over longer periods between environmental factors in different areas. VILLALUZ & MACCRIMMON (1988) stated that meristic characters are often subject to early phenotypic modifications by environmental variations (e.g. temperature, salinity, food).

Transportation and mixing processes (e.g. rim current) can provide an exchange of genes between the fishes inhabiting the basin of the Black Sea despite the border of the eastern and western cyclonic gyres which could be considered an oceanographic barrier for eggs and larvae of the eastern and western Black Sea whiting. IVANOV & BEVERTON (1985) stated that whiting is distributed over the entire continental shelf in the Black Sea and reproduction takes place the whole year round reaching a maximum during September-March. The eggs are pelagic and spawned in batches, and the post larvae are found in summer in the coastal waters, the open sea and in the surface layers down to 65 m over depths of 1000-2000 m. LAEVASTU (1993) mentioned that the egg and larvae may be transported long distances and dispersed over large areas by currents. OGUZ et. al. (1993 a) described upper ocean circulation of the Black Sea by a well defined cyclonic boundary current approximately following the narrow continental slope region and a series of semipermanent anticyclonic eddies between the boundary current and the undulations of the coast. They stated that geostrophic surface currents exceeded 30 cm/s in the southeastern corner of the Black Sea Basin. OGUZ et.al. (1993 b) found that the rim current had a width of about 50 km with a maximum current speed of about 30 cm/s in the multi-national coordinated surveys of September 1991 and the rim current along the southern coast indicated small amplitude meanders with a length scales of about 125 km. BINGEL et. al. (1993) reported that the ADCP measurements (Acoustic Doppler Current Profiler) in April 1993 indicated a current speed of about 50 cm/s at the core of the Rim current and meandering currents were found along the southwestern coast, with speeds reaching up to 100 cm/s and larger values. The rim current, flowing along the continental slope region can transport eggs and larvae over a short time from spawning grounds to new inshore or offshore areas all along the Turkish Black Sea coast. That is, eggs and larvae of whiting may be transported in as little as about 54 days along approximately 1400 km of Anatolia shoreline by the mean current speed of 30cm/s. HISLOP (1975) stated that an individual female spawns in batches and its spawning season lasts at least ten weeks (75 days). RUSSELL (1976) stated that the incubation period of the eggs based on their temperature is generally 12-15 days and that 5.5 mm length is reached within 5 days after hatching when the postlarval stage begins. During the time periods mentioned by HISLOP (1975) and RUSSELL (1976) eggs and larvae may be transported and mixed either completely or partly. These processes may allow the exchange of genetic characteristics between fish inhabiting the western and eastern basins of the Black Sea and as a result, may sufficiently dilute any differences in general phenotypic and genotypic characteristics as to imply the existence of a single unit stock.

GARROD & GAMBELL (1965) made a study on the distinction of whiting stocks by tagging experiments in the Irish Sea and showed that whiting may move considerable distances within the Irish Sea and that various populations fished in the Irish Sea intermingled, and therefore were not completely distinguishable from adjacent stocks. However, the migrations and distribution of whiting have not as yet been sufficiently understood to enable the stock to be evaluated (IVANOV & BEVERTON 1985). Besides the egg and larvae transport; migration of adult whiting over long distances contributes to the mixing of entire population in the Black Sea.

6.2. SEX COMPOSITION

Females were predominant in all seasonal samples taken from the Turkish Black Sea coast and the ratio of female was relatively higher (60 %) in the

October 1992 samples than for those of April 1990 and September 1990-1991. DBT-DEU (1986), studied the trawl area between Sinop and Ünye at the end of September 1985 and the beginning of October 1985 and found that the ratio of females in the population was significantly higher (male 33%, female 67%). UYSAL (1994), studied the biology and population dynamics of whiting in the eastern Black Sea in June-1988 and March-1989 and also found that females were dominant in the population. The male to female ratio was 1 : 2.2 (31% ; 69%) in June, 1 : 1.6 (39% ; 61%) in March. In the present study, during the same periods (in June 1992, October 1992 and March 1993) the male to female ratios were 1 : 2.7 (27% ; 73%), 1 : 1.7 (37% ; 63%) and 1 : 1.9 (34% ; 66%) respectively. These results are similar to those of DBT-DEU (1986) and UYSAL (1994).

The seasonal changes in the male to female ratios occurred in the samples taken between June 1992 and May 1993. So, in the summer months the male to female ratio increased to 1:2.7 whilst the male to female ratio decreased to 1:1.1 during the spawning period. The changes in the male to female ratios over one year are probably due to the fact that the shoaling habits and distribution of whiting during the year. The young and small fish are found closest to the coast, whilst the larger and older whiting tend to be found in deeper waters (IVANOV & BEVERTON, 1985; GARROD & GAMBELL, 1965) The mature whitings migrate to deeper water for spawning, and it is highly probable that they may shoal at this time. GARROD & GAMBELL (1965) reported that at certain times (especially during the last three months of the year) whiting aggregate to form dense local concentrations in the Irish Sea. However, for reliable positive conclusion, repeated sampling in consecutive years is necessary.

The sex ratios were higher for females than males in all age groups except age group I, where it was almost the same 1:1.04 (male 51%, female 49%). After age group-I, the female ratio increased with increasing age. However, the increases in the sex ratios between age group-4 to age group-9 were non-regular (Table 13). The results obtained from this study agree with the results given by UYSAL (1994). He concluded that the ratio of females in the eastern Black Sea was always high for all age groups but that this ratio was smaller in age groups 0 and I. AVSAR (1993) based the increase of the female ratio with increasing age in the inshore sprat population on the fraction of females and males retained in the cod-end before maturation. He stated that the body height of females increases more than in males due to ovarian development after maturation and therefore the retained fraction of females and males in the cod-end was different for adult fish. In this study, the sex ratio in age group I was almost equal and this may be due to the reason mentioned above by AVSAR (1993). The non-regular increases in the sex ratio between age group 4-9 may be related with insufficient sample sizes since the highest fishing pressure is directed on these age groups. Therefore, these age groups may not be representative.

6.3. AGE COMPOSITION

Age determinations made by means of otolith readings showed that fish in all age groups up to 9 were present in the area investigated. Age groups I to III were well represented, but older fish were scarce. In addition, the percentage distribution of ages in the samples showed great similarity for all sampling periods except in April 1990 where a considerable proportion of the sample was composed of age group II individuals. Age group II and age group III were also predominant in the seasonal data collected between June 1992 and May 1993. The results agree with those given by IVANOV & BEVERTON (1985), DBT-DEU (1986) and UYSAL (1994), although the sampling times are different. IVANOV & BEVERTON (1985) reported that six or seven age groups were observed in the catches made in the west and northwest Black Sea where 1-4 year old fish were predominant. DBT- DEU (1986) stated that the catches made between Sinop-Ünye consisted of four age groups (0 (11.5 cm), I (14.2 cm), II (19.2 cm), III (23 cm) and IV (28.7 cm)) and that age group II was predominant. UYSAL (1994) mentioned that the samples taken from the region between Sinop and Sarp comprised eight age groups with a predominance of age groups I-IV.

The young individuals of age group 0 could not be sampled in all periods. BOWERS (1954) reported that samples examined were not entirely representative of the whiting population in the area because of mesh selection by the nets used, and habitat selection by fish of different ages. IVANOV & BEVERTON (1985) stated that the smallest fish (age 0+) are found in regions the closest to the coast and in the surface layers down to 65 m over depths of 1000-2000m in the open sea, whereas the larger and older fish live at greater depths. GAMBELL & MESSTORFF (1964) mentioned that whiting revert to bottom-dwelling, in about July or August of their first summer when they change their habits from pelagic to demersal.

The age composition of the population was characterized by decreasing percentage from age group I to age group IX . The decrease in the percentage occurrence of older ages may be due to fishing pressure and senescent stress as mentioned by AVSAR (1993) for sprat of the same region.

6.4. LENGTH-WEIGHT RELATIONSHIP

The length-weight relationships were calculated from pooled data (Figure 9) for each sampling period. The functional regression b-values were found to be greater than 3 for each sex and their pooled data for all sampling periods. This implied positive allometric growth. A considerable difference between the functional regression value "b" for four sampling periods was also observed. RICKER (1975) reported that the "b" value represents the body form and is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and the characteristics of habitat etc. within a year. He also mentioned that isometric growth denotes a fish with unchanging body form and specific gravity. In April 1990, both sexes displayed a more or less ideal form with the value of b=3.09, while they showed the most positive allometric form with a b-value of b=3.30 in October 1992. In September 1990 and 1991, b-values were 3.19 and 3.23, respectively and positioned after those of April 1990.

The seasonal changes in the functional regression b-values of Black Sea whiting are in good agreement with the intensive spawning and nutrition period (SHULMAN 1974). In October, the body shape of whiting differed from its ideal form (isometric growth condition) due to fatness and development of ovaries and testis before spawning. The minimum fatness was observed after the shedding of gonads in winter.

The length-weight relationship constant (a) was calculated to compare the condition of whiting caught in different periods. Seasonal fluctuations in the condition of whiting were observed in the seasonal samples taken between June 1992 and May 1993. Both sexes were poorest condition during the intensive spawning period (January and February) and thereafter, the condition of both sexes was observed to improve until the spawning time. The decrease in condition of both sexes is probably related to the intensive egg and sperm production and the apparent utilization of their entire fat reserves to supply energy for spawning and morphogenetic processes (SHULMAN 1974).

The length-weight relationships computed from the data collected between 1990 and 1993 showed allometric growth. Previous studies concerned with length-weight relationships in whiting were carried out by MALKOV & EFREMOV (1976), PRODANOV (1980), GIOVANARDI & RIZZOLI (1983), SUAE (1992), UYSAL(1994). The computed values of "a" and "b" from these studies are given in Table 46 to compare with results of the present study..

As can be seen from Table 46, the length-weight relationship constants calculated vary in space and time. These differences observed in the parameters may be as a result of spatial and temporal variations in nutritional conditions in different sampling periods. However, extended special sampling is necessary for a classification of this discrepancy.

Table 46. Comparison of the length-weight relationship constants of whiting (m : male; f : female). EBS: eastern Black Sea, WBS: western Black Sea, EBS-TBS: eastern Black Sea-Trabzon, Beşikdüzü, Sürmene.

Author		a	b	Region
MALKOV & EFREMOV	(1976)	0.0073	3	Atlantic
PRODANOV	(1980)	0.0054	3.07	Bulgarian Coast
GIOVANARDI & RIZZOLI	(1983)	0.0061	3.11	Adriatic
SUAE	(1992)	0.0077	3.06	EBS (1988)
		0.0064	3.07	EBS (1989)
		0.0078	2.99	EBS (1990)
		0.0076	2.99	EBS (1991)
UYSAL	(1994)	0.0070(m)	3.01	Giresun-Hopa (1988)
		0.0080(f)	2.99	Giresun-Hopa (1988)
		0.0230(m)	2.58	Sinop-Giresun (1989)
		0.0130(f)	2.81	Sinop-Giresun (1989)
PRESENT STUDY		0.0042	3.24	Black Sea (Pooled)
		0.0059	3.09	WBS (April 1990)
		0.0047	3.18	WBS (Sep 1990)
		0.0043	3.21	EBS (Sep 1991)
		0.0039	3.28	EBS (Oct 1992)
		0.0055	3.16	EBS-TBS (92-93)

6.5. GROWTH IN LENGTH

Recent extensive studies on Black Sea whiting allow comparison of von Bertalanffy growth constants. In the present study, the length growth constants of *Merlangius merlangus euxinus* were found to be L_∞=39.1 cm; K=0.15 and t_0 = -1.53. PRODANOV (1980) estimated the growth parameters from the length- age data of samples taken in Bulgarian waters and found L_∞=31.8 cm K=0.13 and t_0 = -2.824. UYSAL(1994) computed the growth parameters from length-age data in the eastern Turkish Black Sea coast. The data so far found in the literature are summarized in Table 47.

Table 47. Von Bertalanffy length-growth constants of the Black Sea whiting (m male; f female; Ø' Munro's phi prime)

AUTHOR	REGION	L_∞	K	t_0 (year)	Ø'	year
PRODANOV (1980)	Bulgarian coast	31.8	0.13	-2.8	2.12	1976-78
UYSAL (1994)	Giresun-Hopa (m)	35.3	0.15	-1.4	2.27	1988-89
	Giresun-Hopa (f)	51.1	0.09	-0.3	2.37	
	Sinop-Giresun (m)	41.8	0.14	-2.2	2.39	
	Sinop-Giresun (f)	49.1	0.11	-1.2	2.42	
BINGEL et. al.(1993)	Turkish coast	33.6	0.30	-0.5	2.53	1991-92
PRESENT STUDY	Turkish coast	39.1	0.15	-1.5	2.36	1992-93
	Turkish coast (m)	33.5	0.17	-1.1	2.28	
	Turkish coast (f)	40.4	0.15	-0.9	2.39	

The accuracy of the values obtained and the statistical significance of the results were evaluated using "Munro's phi prime test (PAULY & MUNRO, 1984) and "students t-test" and it was found that the Ø' values obtained were not significantly different from that of available growth parameters estimated for Black Sea whiting (t-test, $P<0.05$).

The mean lengths of Black Sea whiting by age group obtained in the present study and by other authors are given in Table 48. As can be seen from Table 48, the conclusions drawn in this study about the growth characteristics for length are close to and agree well with the results given by BURDAK (1964), PRODANOV (1980) and UYSAL (1994) excepting those of DBT-DEU (1986). UYSAL (1994) also stated that the differences in mean lengths of each age group when comparing both studies could have resulted from misreading of otoliths by DBT-DEU (1986)

Table 48. Mean lengths (cm) of Black Sea whiting for each age group from different studies

Length (cm)	Age I	II	III	IV	V	VI	VII	VIII	IX
BURDAK (1964) - Soviet coast									
	11.2	14.9	17.2	19.3	21.0	22.0	-	-	-
Male	10.6	13.2	15.4	17.0	-	-	-	-	-
PRODANOV (1980) - Bulgarian coast									
	12.8	15.2	17.2	19.0	20.8	22.0	-	-	-
DBT-DEU (1986) - Eastern Turkish Black Sea coast									
	14.[illegible]	19.2	23.0	28.7	-	-	-	-	-
UYSAL (1994) - Eastern Turkish Black Sea coast									
Female	12.0	15.2	18.1	21.1	24.3	26.5	28.5	31.6	
Male	12.2	15.5	17.9	20.5	25.0	-	-	-	-
PRESENT STUDY - Turkish coast									
Female	10.3	14.5	18.1	21.2	23.9	26.2	28.2	29.9	31.3
Male	10.4	14.0	17.1	19.6	21.8	23.6	25.2	26.5	27.6
Pooled*	12.4	16.1	19.3	22.1	24.5	26.5	28.3	29.7	31.1

*) The difference obtained in the pooled data (compared to males or females) is caused by leaving out the mean value of age group 5 of females in March (with which was difficult to find a good fit).

In the present study and that of UYSAL (1994), the growth characteristics are higher than those of BURDAK (1964) and PRODANOV (1980). In other words, the mean lengths estimated for each age group in the 1990's were found to be higher than in previous studies. This may be due to spatial and temporal changes in nutritional conditions.

Growth in length was determined according to sex and it was found that male fish grow less than the females after the second year, and that disparity in the mean lengths of male and female fish in each age group increases with age (Figure 10). This is in agreement with the observations of BURDAK (1964) and BOWERS (1954) who studied the breeding and growth of whiting in the Isle of Man Waters. BOWERS (1954) stated that male individuals grow less than the females after the second year and the difference in the mean length of males and females in each age group increases with age.

6.6. GROWTH IN WEIGHT

The growth in weight of Black Sea whiting for each age group as reported by various authors is presented in Table 49.

Table 49. The growth in weight of Black Sea whiting for each age group estimated in different studies (M:male; F:Female).

Authors		Age Groups I	II	III	IV	V Weight (gr)	VI	VII	VIII	IX
PRODANOV (1980)		13.4	22.7	34.3	46.7	59.1	70.3	-	-	-
UYSAL (1994)	(F)	13.6	30.0	45.1	70.5	112.3	144.0	156.0	254.0	-
	(M)	13.8	27.9	40.9	62.3	113.4	-	-	-	-
PRESENT STUDY	(F)	10.2	25.8	51.6	92.9	145.9	180.2	203.8	-	245.9
	(M)	10.1	22.3	41.2	74.1	-	135.0	-	-	-
		10.1	24.3	49.5	92.4	145.9	175.6	203.8	-	245.9

When the above values are compared with the results of the present study, the mean weight of each age group of Black Sea whiting is closer to the results given by UYSAL (1994) than those of PRODANOV (1980) who analysed samples collected from the Bulgarian coast The differences between growth in weight from one local area to another in the Black Sea may result from differences in food quantity and quality, and the temperature.

The annual growth rate of whiting by weight between age group I and II was found to be 27.3 g/year. Growth of this species by weight increased continuously until age IV and then began to decrease between age groups V and IX. This deflection point in the growth curve of whiting (by weight) corresponds to about 90-100 g of fish, equivalent to 19-20 cm (Figure 11). Fishing orientated towards individuals of this weight is more economically viable since a catch which includes the same number of fish, but with individuals of in a higher weight produces a much greater yield and is important for stock maintenance.

6.7. MORTALITY ESTIMATES

The mean total mortality rate (Z) and its components, natural mortality (M) and fishing mortality rate (F), were found as Z=1.63, M=0.39 and F=1.24. PRODANOV (1980) found that the mean natural mortality rate (M) lies between 0.4 and 0.5. UYSAL (1994) reported that the total mortality rate (Z), natural mortality rate (M) and fishing mortality rate (F) in the Giresun-Hopa region which is closed continuously to bottom trawling since 1973 (1380-Fisheries law) , are 1.17, 0.31 and 0.86, respectively and in the Sinop-Giresun region they were 1.28, 0.32 and 0.96, respectively. The natural mortality rates given above and found in the present study are somewhat different. 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 et. al. 1989).

6.8. EXPLOITATION RATE

According to DIE (1968-1992), whiting (*Merlangius merlangus euxinus*) is the most important demersal fish in the catch followed by striped mullet (*Mullus barbatus*), turbot (*Psetta maxima*) and tub gurnard (*Trigla lucerna*). The whiting stock in the Black Sea after the collapse of the ancovy in 1988-1989 exposed to a high fishing pressure, leading to a considerable decrease, on the annual catch of this fish. While the number of the trawl fleets in the Black Sea increased considerably (from 94 to 273) between 1990 and 1992, the whiting catches decreased to 20197 tons in this period (more evident in catch per unit of effort) (APPENDIX D).

The exploitation rate (E) was calculated as 0.79, 0.73 and 0.72 for 1990, 1991 and 1992 respectively, confirming the heavy fishing pressure on the whiting stock. BINGEL et. al. (1993) and UYSAL (1994) stated that there was over exploitation on the whiting stock of the Black Sea in recent years. BINGEL et. al. (1993) estimated the exploitation rate as 0.86 for 1991 and 0.84 for 1992 based on increased fishing pressure on demersal fishes which originated after the decrease in pelagic stocks. UYSAL (1994) calculated the exploitation rate as 0.73-0.75 for the 1988 and 1989 sampling periods (Table 50).

Table 50. The exploitation rate (E) as calculated by several authors between 1988 and 1992.

Author	Year	E
UYSAL (1994)	1988	0.73
	1989	0.75
BINGEL et.al. (1993)	1991	0.86
	1992	0.84
PRESENT STUDY	1990	0.79
	1991	0.73
	1992	0.72

In the same period (1991 and 1992), the differences in exploitation rates determined for the present study and that of BINGEL et. al. (1993) may be due to the different methods used. BINGEL et. al. (1993) calculated the total mortality coefficients of whiting by means of the length converted catch curve data (PAULY, 1983) while in this study, the total mortality coefficient was estimated from the survival rate calculated using the age frequency data.

6.9. YIELD PER RECRUIT

A variety of management strategies are available for the regulation of fisheries. These include total allowable catches, control of effort expended by the fleets, closed areas, and the regulation of mesh and minimum landing sizes. Most fisheries are managed by a combination of such mechanisms. All methods have some degree of effect on the overall level of fishing mortality directed on the stock. The effect may vary with the age or size of fish depending on the selectivity of the methods used. Consequently, evaluation of the effects of different levels of fishing mortality, and of selectivity, is the basis for many management decisions and the concept of the yield per recruit approach. The equation of BEVERTON & HOLT (1957) is used as the traditional approach for evaluation and management decisions (HORWOOD, 1993). In this study, a simplified version (RICKER, 1975) of the yield per recruit model of BEVERTON & HOLT (1957) was applied to evaluate the effects of present fishery pressure on the Black Sea whiting stock.

The yield isopleth diagram (Y/R) given in Figure 12, implies overfishing. This figure indicates that the majority of fish caught should be over 18.5 cm at the existing fishing intensity (F=1.24). However, the total length of whiting ranged between 5.5 and 29.3 cm in catches during the study period. The median length in spring and autumn of 1990, 1991 and 1992 fluctuated around 14 -17 cm with average lengths of 11.2-14.2 cm, and it was found that the whiting generally attains sexual maturity at age 2 although there is a difference between sexes for maturity length (males at 12.5 cm length or at the end of their first year; females at 14.5 cm length or at the end of their second year). At present, it is necessary to decrease fishing intensity, i.e. F= 0.45 or to enforce a minimum allowable total length (17.5) for optimum exploitation of this species. The optimum exploitation strategy is also determined by the age (or length) at first capture. Therefore, it is important to estimate the L_{50}% (the length of fish retained (50%) by the meshes once it has entered the trawl) when assessing a fishery. As a result, by redefining the mesh size of the trawl to be used in the Black Sea at present, the level of fishing mortality can be decreased.

6.10. BIOMASS

In this study period between 1990 and 1992, the total trawlable biomass in the four subregions and within 0-50 m and 50-100 m depth range along the Turkish Black Sea coast was computed using the stratified swept area. The total trawlable biomass for the eastern Black Sea was found to be higher than that for the western Black Sea. Besides, among the border regions (Çaltı-Sarp and Sinop-Çaltı) of the eastern Black Sea, it was found that the trawlable biomass differed by more than three to eight times. DBT-DEU (1986) determined that the trawlable biomass of whiting was 22,131 tonnes in the region (trawl area-1303 km^2; 17,0 tonnes/km^2) between Sinop and Ünye in 1985. UYSAL (1994) reported that the trawlable biomass of whiting in the same region was 3.506 tonnes (trawl area-2511 km^2; 1,4 tonnes/km^2) between 1988 and 1989. He also found that a trawlable biomass of 4.367 tonnes in the region (trawl area-2113 km^2; 2,1 tonnes/km^2) between Ünye-Sarp. This would indicate that somehow the whiting stock over this short time (3 years) had collapsed, in other words were severley overfished. In this study, the total trawlable biomass of whiting in four subregions along the Turkish Black Sea coast between 1990 and 1992 were calculated. The trawlable biomass of the eastern Black Sea between 1991 and 1992 increased from 19,232 tonnes to 30,188 tonnes. This may be due to the variation of the number of trawls in the eastern Black Sea (165 trawls in 1990; 58 trawls in 1991; 207 trawls in 1992). The trawlable biomass of the Sinop-Çaltı region (trawl area-2726 km^2) covering the study regions of DBT-DEU (1986) and UYSAL (1994) was found to be 2,105 tonnes (0,8 tonnes/km^2) in 1991 and 8,293 tonnes (3,0 tonnes/km^2) in 1992. The trawlable biomass of the Çaltı Cape-Sarp region (trawl area-1866 km^2) was calculated as 17,128 tonnes (9,2 tonnes/km^2) in 1991 and 21,895 tonnes (11,7 tonnes/km^2) in 1992. When comparing with the results of UYSAL(1994), the trawlable biomass of the Sinop-Çaltı region showed only a small increase whilst the trawlable biomass of the Çaltı Cape-Sarp region increased about four times. These differences may also result from variation in handling of fishing equipment, i.e., skill of the crew and captain, but it still shows that the whiting stocks are overfished.

In the present study, total trawlable biomass within 0-50 m and 50 -100 m depth range in the eastern and western Black Sea was also different. Total trawlable biomass within 50-100 m depth range of both regions in each sampling period was found to be higher than that in 0-50 m depth range. This agrees with the result of DBT-DEU (1986). DBT-DEU (1986) found that total trawlable biomass increased with increasing the depth of swept area (~ 20,000 tonnes within 0-50 m; ~ 2,100 tonnes within 50-100 m). Unfortunately the sampling depth in UYSAL (1994) consisted mostly of 50-100 m. There existed only one sampling (in 45 m) within 0-50 m depth range and its biomass was 60 tonnes. This difference between the stratas may result from variation in size distribution of fish, i.e., large individuals are found in deeper water.

6.11. FOOD AND FEEDING

The observation that crustacea and fish are the main components of the diet of whiting in coastal waters of the Black Sea of Turkey agrees with the findings of previous workers in other areas. As observed in earlier investigations, the percentage of fish in the diet also increased with increasing size of whiting. GORDON (1977) investigated the feeding habits of whiting in the inshore waters of Scotland and concluded that fish and crustacea were the main food items and that their occurrence in the stomachs was clearly related to the size of the whiting and also to their seasonal abundance. ARNTZ & FINGER (1981) reported that whiting predate mainly on fish and crustaceans (to a lesser degree) in the western Baltic Sea, whereas polychaetes, mollusks and other benthic animals are comparatively insignificant and with increasing size of the predator, crustaceans and polychaetes decrease in importance whereas fish as a food becomes more and more dominant. FLINTEGAARD (1981) estimated the food consumption of whiting in the southern Kattegat and the Sound and reported that the most important prey for whiting of less than 20 cm is crustaceans and polychaetes, and that fish becomes ever more important in the diet with increasing size of the whiting. HISLOP et. al. (1983) stated that the greatest part of the food of whiting consists of fish and crustaceans in the North Sea, the proportion of fish in the diet increased with predator size. DAHL & KIRKEGAARD (1986) showed that the main components of the food of whiting consists of fish and bottom invertebrates in the North Sea, and that the proportion of fish increases with predator size.

The preferred fish in the diet of whiting appeared to be shoaling species such as sprat (*Sprattus sprattus phalericus*) and anchovy (*Engraulis encrasicolus*) provided that they are of a suitable size for the whiting to ingest them whole. The other fish, namely whiting and goby, were also important prey in the diet. If a comparison is made with previous studies despite the differences in habitats, it can be seen that the diets are similar. GORDON (1977) stated that the fish which occurred most commonly in the diet were herring (*Clupea* *harengus*), sprat (*Sprattus sprattus*), Norway pout (*Trisopterus esmarkii*), poor cod (*Trisopterus minutus*) and gobies. ARNTZ & FINGER (1981) stated that whiting concentrate on clupeids (herring and sprat). PATTERSON (1985) reported that the most important foods for whiting were Norway pout (*Trisopterus esmarkii*), sandeel (*Ammodytes marinus*), sprat (*Sprattus sprattus*), herring (*Clupea harengus*), shrimps (*Pasiphaea sivado*) and cuttlefish (*Sepiola atlantica*) in the Irish Sea. Whereas sprat and Norway pout were eaten throughout the year, herring, cuttlefish and sandeel were eaten seasonally. He also said that whiting is an opportunistic predator and their diet reflects seasonal changes in the abundance of available food. CASEY et. al. (1986) found that fish belonging to the Gadidae, namely haddock (*Melanogrammus aeglefinus*), whiting and Norway pout, along with sandeel, herring and mackerel (*Scomber scombrus*) form an extremely important part of the whiting diet for all size groups of this predator in the North Sea. FLINTEGAARD (1981) noted that a few different fish species; herring, sprat, whiting and gobies were found in the stomachs and that the smaller size classes generally preferred Gobius spp. whilst herring and sprat are the predominant prey for the larger whiting. DU BUIT and MERLINAT (1985) said that the greatest portion of the diet of whiting consists of fish (chiefly poor cod, Norway pout, clupeids and blue whiting) in the Celtic Sea. HISLOP et. al. (1983) also stated that the greater part of the fish prey consisted principally of sandeel, sprat, herring, haddock, whiting, cod and Norway pout.

The crustacean component found in the diet of whiting generally corresponds with that identified in earlier work although the areas studied differ. GORDON (1977) stated that the dominant crustacea in the diet were euphasids and crangonids although copepods, mysids and amphipods were also recorded.

FLINTEGAARD (1981) mentioned that the most important species among the crustaceans are crangonids and euphausiids, and that small whiting (below 15 cm) mainly prey upon Cumacea (*Diastylis* sp.) and various small amphipods. ARNTZ & FINGER (1981) give Cumacea (*Diastylis* sp) as the dominant crustacea in the diet of whiting. In this study, the most important crustacean prey in the diet of Black Sea whiting were crangonids (*Crangon crangon*) and crayfish (*Upogebia pusilla*). Amphipods, isopods, cumacea, mysidacea and copepods were also recorded in the stomachs. HISLOP et. al. (1983) reported that the two main components of the crustacean prey were euphausiids and crangonids. CASEY et. al. (1986) found that amongst the crustaceans, euphausids and crangonids are the dominant groups.

An increase in the length of prey fish found in the stomachs whilst predator size also increased was observed in the seasonal sampling. In addition, it was found that there is no significant increase in the mean length of prey fish for individuals above 18 cm and that the mean length of prey fish was lower in the food of the largest length group. Similar results were obtained from the earlier studies. FLINTEGAARD (1981) showed that the mean length of prey fish increases with an increase in predator size and this increase is more pronounced for whiting within the size range 11-25 cm; for whiting above 20 cm there is no longer a significant increase in the mean length of prey fish. He also concluded from the size distribution of prey in the stomachs that the heaviest predation by whiting occurs on 0-II age group sprat, the older age-groups of this species being of little importance in the food of even the largest whiting. CASEY et. al. (1986) noted that the average size of fish prey increases with predator size but that large fish also take small individuals. DU BUIT and MERLINAT (1985) studied the feeding of the Celtic Sea whiting, and found that the mean length of sprat ingested by whiting decreased while the predator size increased after a certain length. FELDMAN (1988) studied the diurnal ration and prey size preferences of predatious gadoids, and stated that the mean lengths of ingested fish increased constantly with increasing predator size in nature. However, he also showed that the length range of the consumed fish is initially narrow and then expands as the size of the predator increases. In the other words, the maximum prey size increased whilst minumum prey size remained constant. After the predator attained a certain size, the length range of its prey narrowed again as small fish were eliminated from its diet. He explained this situation based on two circumstances. Firstly, the energetical expenses for the detection and capture of small fish by large predators are not compensated for by the energy accumulated from their consumption and secondly, the accessibility of prey to predator depends on the extent of overlap of their habitats. The degree of habitat coexistence between large predators and small fish (prey) is less than for medium size predators and small fish.

There are only a few publications available about seasonal changes in food composition. GORDON (1977) found a seasonal shift in the diet of whiting mainly linked with the occurence of 0-group clupeids. Kiel Bay cod (ARNTZ , 1974) exhibit a very distinct seasonal cycle in their food composition throughout the year, with fish dominating in winter and successive peaks of crustaceans and polychaetes in summer and autumn. Mollusks play the greatest part when other food items are rare. ARNTZ & FINGER (1981) stated that fish clearly predominate in the food of whiting from October to April; only in summer crustaceans take over whereas polychaetes are important in early summer and autumn. The reason is based on the seasonal cycle of food composition and migration of whiting between shallow and deep water. In this study, it was found that the percentage occurrence of the main prey groups changed seasonally (Figure 14). Fish occurred in a higher proportion in whiting diet between October/December and May/June. Crustaceans in the diet began to increase after December, especially in early spring. Polychaetes appeared more frequently during spring and in August. Whiting have an extended spawning season (BOWERS 1954) and spawn virtually throughout the year resulting in populations with a considerable range in length, which exploit the most readily available supply of food (GORDON 1977). In winter however, the fish population which are preyed upon by whiting, are composed of anchovy which have migrated from northern parts of the Black Sea and intensively winter-spawned sprat (spawning can be seen all round year and especially from winter to early spring AVSAR, 1993). The extended spawning season of the sprat also provides an adequate supply of food in spring to the whiting population. This is probably the reason for the increase in the percentage occurrence of sprat in the diet of whiting in spring. The importance of crustacea in spring and the increase in the occurence of polychaetes and other benthic prey in August may be related to the migration of whiting from deep water to shallow water for feeding in spring (IVANOV & BEVERTON 1985).

JONES (1954) studied the seasonal changes in the intensity of feeding of whiting in the North Sea and concluded that for whiting of less than 21 cm feeding was most intense between March and May. The number of individuals with empty stomachs was found to peak in winter. JONES also noted another peak in July and August. GORDON (1977) reported that there was a common trend for a higher percentage of empty stomachs in July/August, November/December and January/February and the lower intensity of feeding from November to February was based on environmental factors and a decrease in the abundance of many of the food organisms. The July/August results were based on examination of small fish from 0-age group which were feeding on crustacea during the night. ARNTZ & FINGER (1981) mentioned that the seasonal changes in feeding intensity are linked with feeding conditions (i.e. water temperature, abundance of prey). HAWKINS et. al. (1985) studied growth and feeding in juvenile cod and concluded that the lowest feeding intensity in January/February resulted from a reduction in the numbers of vulnerable prey present in winter. IVANOV & BEVERTON (1985) and AVSAR (1993) showed that, the feeding intensity of sprat being a cold water species starts to increase after the intensive spawning period in winter and continues during the post spawning period. BOWMAN (1983) provided a detailed description of the feeding habits of silver hake in the Northwestern Atlantic. He found silver hake feed most intensively in the spring-summer and autumn periods. During the summer (when silver hake spawn) and winter, he noted that the feeding rate diminishes. In this present study, the percentage of empty stomachs observed in the seasonal sampling showed two peaks, in February and August and the feeding was most intense in autumn and spring. These results show similar trends to those found for whiting and other cod species by JONES (1954), GORDON (1977), ARNTZ & FINGER (1981), HAWKINS et. al. (1985) and BOWMAN (1983). The lower intensity of feeding or the higher percentage of empty stomachs during winter was probably initially due to environmental factors alongwith a decrease in abundance of many food organisms as mentioned by GORDON (1977), ARNTZ & FINGER (1981) and HAWKINS et. al. (1985) and secondly due to a decrease in the intensity of feeding during the spawning period as reported by BOWMAN (1983), IVANOV & BEVERTON (1985) and AVSAR (1993).

6.11.1. DAILY FOOD CONSUMPTION

In this study, the total annual consumption rate of whiting was estimated as a first approximation and results were compared to similar estimates on the daily food consumption rate of whiting as a mean of all whiting sizes studied in different regions. FLINTEGAARD (1981) who used the same method, found the total daily consumption rate of whiting to be 1.42% of body weight per day. DU BUIT (1982) also used the same method for whiting sampled in the Celtic Sea, but she excluded empty stomachs from the data in calculating mean stomach content weight. She found the rate of daily food intake to be 3.96 % of body weight (mean value for fish between 15 and 55 cm long). DU BUIT & MERLINAT (1985) again used the same method to estimate daily consumption rate in the Celtic Sea. They concluded that the daily food indices varied between 2 and 4% according to length.

ARMSTRONG (1979; c.f. PATTERSON 1985) used a different method to estimate the rate of food consumption of whiting in the Irish Sea and found it to be 2.5 % of body weight daily (mean value for fish between 15 and 49 cm long). PATTERSON (1985) estimated the daily consumption rates of whiting in the Irish Sea by using three different methods: (i) Malyshev method (indirect); (ii) direct method, diel feeding periodicity effects included; (iii) direct method, no estimate of feeding periodicity effects, as was used in this study. Besides, Flintegaard's growth data were used to produce an estimate of the consumption rate of Irish Sea whiting by Malyshev's method. He concluded that with Malyshev's method estimates (3.82% of body weight per day) were nearly twice those obtained by direct estimates (1.84% and 1.65%, respectively), the daily feeding periodicity increased the estimation of consumption rates by about 10% and the consumption coefficient was at a higher rate than those of Flintegaard.

In this study, the daily coefficient was calculated separately for data which included empty stomachs and for that which excluded empty stomachs in order to compare the present results with those of other workers. The results showed that the daily consumption rate varies between 1.6 and 2.9 % (mean 2.4%) for Black Sea whiting when the mean stomach content weight included empty stomachs, whilst it lies between 2.8 and 3.5 % (mean 3.3%) when empty stomachs were not included. Differences in the estimates of daily ration calculated in the studies given above reflect differences in the mean stomach content weight of the fish, as well as differences in the methods used to estimate daily ration. However in general, estimates of the daily ration in Black Sea whiting were found to be greater than in the Atlantic whiting.

The present data showed that Black Sea whiting eat sprat. In the area studied, the consumption rates of one, two, three and four-year-old whiting was 32, 131, 194, and 313 grams of sprat per year respectively. From the lengths of ingested sprat and available data on length-weight relationships (AVSAR, 1993), mean live weight was calculated to be 1.7 g; they were mainly one-year-old sprat. It could then be calculated (from the total weight of sprat eaten yearly and the mean weight of individual sprat) that one, two, three and four-year-old whiting eat 19; 77; 114 and 184 sprat per year.

This predation may have been having a significant effect on the Black Sea sprat stock. The stock size of whiting in the eastern Black Sea coast was given as 18,300 tonnes in 1991 and 32,075 tonnes in 1992 (BINGEL et. al., 1993). The highest whiting yield is produced from this region (about 90% in 1988, 70% in 1991-92; DIE, 1988,1991,1992) and also the production obtained from the eastern Turkish Black Sea coast accounts for 90% of annual landings of whiting caught by all the bordering countries of the Black Sea (GFCM, 1993). The annual consumption of sprat by whiting was calculated as 86 grams (=51 individuals). From this data, the reduction in the size of the stock of sprat due to predation by whiting was estimated to be 78,690 tonnes in 1991 and 137,923 tonnes in 1992 for the eastern Turkish Black Sea coast . Since there is no literature on the stock size of Black Sea sprat for the present study period, it is not known if there is any correlation between the abundance of sprat and that of whiting in the same year, but the data given for the period 1967-1981 by IVANOV & BEVERTON (1985) may be helpful in comparing the effects of whiting predation on the stock size of sprat. IVANOV & BEVERTON (1985) reported that the parent stock of sprat in the Black Sea accounted for 880,000 tonnes in 1980 and about 400,000-500,000 tonnes between 1975 and 1980. It may be inferred that, the effect of predation on the sprat stock is important and therefore, it may be helpful to consider the impact of whiting predation when trying ,to predict sprat recruitment.

6.12. MATURITY

The results of this investigation show that Black Sea whiting have ripe gonads virtually all year round and that maximum spawning occurs in January-

February, but continues until July (Table 37, Figure 17). This is in agreement with other studies made on the Black Sea whiting. In a study performed on the breeding of whiting (*Merlangius merlangus euxinus*) in the eastern Black Sea, gonad development began after September and a maximum gonadosomatic index was attained in January and March 1991 (SUAE, 1992). IVANOV & BEVERTON (1985) stated that the reproduction of whiting takes place the whole year round with a maximum in September-March and spawning occurs in temperatures between 7 and 8 ^{o}C in winter, and 6 and 8^{o}C below the thermocline in summer.

When comparing the spawning periods of whiting from different regions with those in the southern Black Sea, it could be concluded that southern Black Sea whiting spawn earlier than those in northern latitudes. BOWERS (1954) studied the breeding and growth of whiting in the Isle of Man Waters and found that most of the fish spawn in March and April and that spawning had virtually ceased by June. He stated that spawning of the Manx whiting occurs later due to the increase in latitute and that a variation of 4 months in the onset of spawning can be seen for different regions of Western Europe. He assigned these variations in spawning time to the water temperature and stated that in many areas maximum spawning occurs as the temperature rises after the winter minumum. WHEELER (1969) pointed out that spawning begins in the middle of January in the south and continues through to July in the north, and the peak of spawning intensity varies from January off the Biscay coast, to late May off Iceland. In a study on the fecundity of whiting (*Merlangius merlangus)* in the North Sea, the Minch and at Iceland, HISLOP & HALL (1974) noted that spawning period of an individual fish may be very long because of a large range of sizes of maturing eggs in a ripe ovary. This was confirmed by observations on whiting spawning in an aquarium where it was found that individual females spawn at regular intervals for ten to fourteen weeks. It is underlined that a prolonged spawning season might be expected to reduce the extent of annual fluctuations in the year class strength of a species since changes in a large proportion of the spawning products of a population being liberated during a particularly favourable or unfavourable period of environmental conditions should be less than when spawning is restricted to a short period (HISLOP, 1975).

The larger fish mature and presumably spawn earlier than smaller fish. This agrees with the results given by BOWERS (1954). He compared the maturing females between 20 and 30 cm lengths to the females over 30 cm in length during February and March and found that the larger fish matured and spawned earlier than the small fish.

This study indicated that male whiting attain sexual maturity at smaller lengths (12.5 cm) than females (14.7 cm) and that mature fish of less than 8 cm for male and 11 cm for female were not found. Similar results have been reported for other gadoids. In a study on the sexual maturity of white hake (*Urophycis tenuis)* in the Southern Gulf of St. Lawrence, BEACHAM & NEPSZY (1980) reported that males attained sexual maturity at smaller sizes than females, and it was attributed that the yearly increase and decline in the mean length at 50% maturity bore an inverse relationship between the mean length at sexual maturity and population biomass. BOWERS (1954) showed that males attained sexual maturity earlier than females. He found that the female Manx whiting generally spawns for the first time after its second year of life whilst male whiting attaines sexual maturity at the end of their first year.

SHULMAN (1974) and IVANOV & BEVERTON (1985) stated that northern Black Sea whiting reach sexual maturity in the second year. The present study showed that, the female whiting in the Black Sea generally spawns for the first time at age II and male whiting may sheds its testis at the end of their first year of life.

The age and length at maturity of Black Sea whiting was found to differ from those in other regions. This study indicated that male whiting in the Black Sea reach sexual maturity at age 1 and at a length of 12.5 cm whilst the females reach sexual maturity at age 2 and at a length of 14.7 cm. GIOVANARDI & RIZZOLI (1983), in a study on the biological data of whiting (*Merlangius merlangus*) in the Adriatic Sea, reported that sexual maturity is reached at a length of about 20 cm and at the end of the first year of life. BOWERS (1954) found the smallest Manx whiting in an advanced state of maturity (i.e. stages V, VI, VII) to be a male of 19 cm and a female of 21 cm total length and stated that age and length at maturity increases from the south to the northern range of their distribution. Such geograhical variation in age and length at maturity may result from different growth rates. TEMPLEMAN et. al. (1978); BEACHAM & NEPSZY (1980) based the variation in mean length at 50% maturity seen from 1951 to 1960 on the changing growth ratio associated with their abundance.

6.13. FECUNDITY

Fecundity in whiting from the western and eastern Turkish Black Sea coasts was found to be related more to body length than age. This agrees with results from earlier studies in the North Sea, the Minch, Iceland and

Northwest Atlantic on such species as whiting (*Merlangius merlangus;* HISLOP & HALL, 1974), Atlantic cod (*Gadus morhua),* American plaice (*Hippoglossoides platessoides),* witch flounder (*Glyptocephalus cynoglossus)* and Greenland halibut (*Reinhardtius hippoglossoides;* BOWERING, 1980).

Fecundity in the same species has been reported to vary from one geographical area to another. HISLOP & HALL (1974) reported that the fecundity level of fish from Iceland differed from those in the North Sea and the Minch. This was attributed to a difference in growth rates between different areas. KJESBU (1988) found significant variation in the fecundity of Northeast Arctic cod and coastal cod from the region of northern Norway. BOWERING (1980) found for Greenland halibut that the fecundity-length relationship for southern Labrador was significantly different to that for the southeastern Gulf of St. Lawrence. The Greenland halibut differed in the rate of egg production and the number of eggs produced which BOWERING (1980) attributed to their maturing at considerably smaller sizes in the southeastern Gulf of St. Lawrence area. The present study shows that the fecundity level of whiting from the Turkish Black Sea coast differs from those in the North Sea, the Minch and Iceland. At the same length (e.g. 25 cm), the Black Sea whiting have a relatively higher level of fecundity but the rate of increase in fecundity with length is relatively slow (Table 51).This may be due to a variation in size at maturity as stated by BOWERING (1980). The fecundity-length relationship for whiting from the western Turkish Black Sea coast is significantly different from those in the eastern Turkish Black Sea coast. This may be due to a dominance of small species in samples taken from the western areas in 1990 (Table 52).

Table 51. A comparison of the predicted number of eggs, at standard length (25 cm), with 95 % confidence limits

Sea Area	Year of sampling	Number of eggs (thousands) L = 25 cm Mean	95%limits
Northern North Sea	1964*	219	203-235
	1965*	227	212-243
	1966*	216	193-242
	1967*	207	191-223
	1969*	170	159-182
Southern North Sea	1966*	254	233-278
	1967*	240	219-263
Minch	1970*	175	159-191
Iceland	1968&1969*	105	88-126
Western Black Sea	1990**	179	169-189
Eastern Black Sea	1991**	313	269-366
	1992**	314	281-351
	1993**	263	243-286

* : Data taken from Hislop and Hall 1974.
**: Present study

Table 52. Comparison of mean length and age distributions for estimated whiting egg numbers from the western and eastern Turkish Black Sea coasts .

		N	Mean length (cm)	Mean age (year)
Western parts				
	1990	115	16.4 (13-24)	2
Eastern Parts				
	1991	25	21.5 (15-29)	3
	1992	47	20.6 (14-29)	3
	1993	48	20.2 (15-32)	3

Annual fluctuations in the fecundity of whiting was not apparent in this study of fecundity-length and fecundity-age relationships for the eastern Turkish Black Sea coast between 1991 and 1993. OOSTHUIZEN & DAAN (1974; c.f. KJESBU, 1988) found that the fecundity of cod in the North Sea was very similar for different years. BUZETA & WAIWOOD (1982) compared the fecundity of cod from the Gulf of St. Lawrence with data published about 25 years earlier and they too were unable to detect any significant change. BOWERING (1980) also stated that an annual fluctuation in fecundity was not apparent for the southern Labrador area in 1976 and 1977. However, such variation has been reported in many studies . BAGENAL (1963), from a study in the Firth of Clyde, attributed annual fluctuation in the fecundity of the witch flounder to changes in fishing intensity, which in turn affected fecundity through variation in the food supply. He also concluded that the changes in fecundity were not related to altering hydrographic conditions. PINHORN (1984) found annual variation in the fecundity of Newfoundland cod. He attributed the observed variation to poorer feeding, a slower digestion rate and increased atresia at low temperatures because of the extremely cold water temperature.

6.14. PARASITES

During external examination, no identifiable ectoparasites were detected on the Black Sea whiting. However, some authors reported that, certain ectoparasites belonging to different families occur in the British waters and infest North Sea whiting. POTTER et. al. (1988), PILCHER et. al. (1989) and LANG (1990) recorded the infestation of whiting with crustaceans

Lernaeocera branchialis (Copepoda: Pennellidae) and *Clavella adunca* (Copepoda: Lernaeopodidae), trematodes *Diclidophora merlangi* (Monogenea: Polypisthocotylea) and *Cryptocotyle lingua* (Digenea: Heterophyidae).

The only endoparasite occurred on whiting during the present study was the nematod *Hysterothylacium aduncum*. Anisakids, and particularly larval anisakids (*Hysterothylacium* sp), are among the most common nematodes of marine fishes. They affect fish by causing pathological symptoms and possibly mortalities, reduce the commercial value of fish, and they may infect man producing harmful effects (KINNE, 1984).

The percentage frequency of nematodes in the stomach found here is high when comparing with results given by GORDON (1977). He found that the frequency of occurrence of nematods in the stomachs of similarly sized whiting in the west coast of Scotland was under 38%. However, the percentage of occurrence nematodes in the Black Sea whiting falls into the lower limits of the range (about 60%) obtained by NAGABHUSHANAM (1964) from whiting of similar size in the Isle of Man waters. By examining the whole gut of fish from the same area, SHOTTER (1973b) found that over 90% of whiting contained nematodes.

In the present study, a seasonal change in the percentage occurrence of nematodes was found. Neither NAGABHUSHANAM (1964) nor SHOTTER (1973 b) working in the same area did not record seasonal differences in nematode occurrence. GORDON (1977) observed a seasonal change in the percentage occurrence of nematodes and detected a decline in the prevalence of nematodes during cold months. The highest prevalance on the examined whiting was recorded in July/August. AVSAR (1993) working on Black Sea sprat found that the percentage occurrence of nematodes in January was relatively smaller than that for warm periods (May/September). Although different fish species were examined for the frequency of occurrence of nematodes, there is good agreement between the results obtained in the present study and those found by GORDON (1977) and AVSAR (1993).

When comparing the total lengths of whiting in 1 cm length class intervals with the percent age prevalence of infestation by the nematodes, the results did not reveal clearly the prevalence-length relationship. The number of whiting infested only seemed to increase with increase in the total length of fish in May/June. However, there was a stronger correlation between the age of fish and the prevalence of infection by nematodes. For almost all months, the prevalence of infection increased with fish age. GORDON (1977) reported the percentage occurrence of nematodes for different length groups and months, and stated that a possible prevalence-length relationship for whiting was not indicated. WOOTTEN & WADDELL (1977) studied the prevalence and intensity of larval nematodes from the musculature of cod and whiting in Scottish waters and found that infection with larval nematodes increased with age and length of the fish. He stated that accumulation of larval nematodes with increasing age and length of whiting probably occurs because each nematode is long-lived and they are continually acquired by most fish throughout their lives. In addition, larger and older fish consume greater quantities of food which will probably result in larger numbers of larval nematodes being ingested. AVSAR (1993) stated that the percentage occurrence of nematodes generally increased with increasing age of the

Black Sea sprat. ELKIN (1955, c.f. GORDON 1977) found a low frequency of occurrence of nematodes in older whiting off the Irish Coast. The variations observed between the studies on parasite infestation with respect to age and length of the fish are possibly due to differences in the geographical distribution of the invertebrate and vertebrate hosts of the parasites as stated by WOOTTEN & WADDELL (1978).

A seasonal difference in the intensity of infection (the number of nematodes per fish) was found in this study. However, no comparison could be made as no other literature exists about the infection of Black Sea whiting with endoparasites. The only comparable study is that of SHOTTER (1973b) who examined whiting parasites in the Isle of Man. In general terms, SHOTTER's findings on seasonality parallel with those of the present study, namely, that the intensity of infection with *H. aduncum* is higher in summer than in winter. AVSAR (1993) did not mention any seasonality of endoparasites. However, considering that whiting prey mainly upon sprat this would lead to the conclusion that whiting probably become infected by eating infected sprat; since as KINNE (1984) underlines, such infections mostly occur as a result of ingesting infected food.

SUMMARY AND CONCLUSION

In this work the biology and population parameters of whiting in the Turkish Black Sea coast were studied in some detail (stock identification; maturity; fecundity; parasites; stomach content; daily food consumption; age and growth) all of which are important in fishery management and control.

The stock differentiation of whiting from the Black Sea coast of Turkey was carried out morphometrically and meristically by applying the generalized distance of Mahalanobis. Firstly, the effects of several factors such as temperature, salinity, current, nutritional contiditions on the variation in the possible stocks of Black Sea whiting have been discussed. The results of analysis indicated that differences in the phenotypic and genotypic pecularities did not provide sufficient discriminination between individuals of the southern Black Sea whiting and it is concluded that there exists a single unit stock in the Turkish Black Sea coast.

Females were dominant during all sampling periods; the overall male to female ratio was 1 (43%) : 1.2 (57%).

Age determinations were made by means of otolith readings. The maximum age of the fish examined during the sampling period was 9 years. The stock in the area investigated consisted mainly of fish from age groups I, II, and III, with mean lengths lying between 10.8 and 17.8 cm.

The length-weight relationship implied allometric growth with an intercept "a"= 0.0042, and slope "b"= 3.24 for all data. The comparison of Fulton's condition factor for the different periods showed that fish were in poorest condition (0.0088) in winter, and in the best condition (0.0105) in summer. This is clearly related to the feeding and spawning periods.

No statistical difference was found between the growth parameters estimated by the seasonalized von Bertalanffy growth equation and the growth parameters (or performance) calculated in earlier studies. The annual growth rate in length between age groups I and IX was found to be 3.4 cm/year. During the first year of life, individuals attained 40% (12.4 cm) of their maximum adult size after which growth rates slowed down. They reached a mean length of 16.1 cm, 19.3 cm and 22.1 cm in their second, third, and fourth years (about 70% of their maximum adult size), respectively. As compared to the number of fish found in age groups I - III only a few older fish were found belonging to age groups IV-IX (Table 10) so it was not possible to make an accurate assessment of growth beyond age group III, but the available data suggests that, there is a difference in growth rate between male and female fish; the females grow faster and reach a greater maximum length.

Growth in weight is slow for both sexes during the first years (age group I and II), later becoming more rapid until age group V after which it slowed again. The mean annual increase in the weight of whiting was found to be 27 g/year between age groups I and IX. The deflection point in the growth curve of whiting is situated between age group IV and V, equivalent to 120 g.

The total, natural and fishing mortality rates were obtained on an annual basis. The exploitation rates indicated that the stock is highly over-exploited (in 1990, E=0.79; in 1991, E=0.73; in 1992, E=0.72). The over-exploitation of the whiting stock can be explained by an increase in fishing effort concentrated on demersal fishes after the decrease in pelagic stocks. Finally, application of yield per recruit analysis implied that the minumum allowable length of whiting with in the existing fishing intensity (F=1.24) should be over 17.5 cm. However, the median length of whiting fluctuated around 14-17 cm between 1990 and 1992 and it generally attained sexual maturity at age II (females, at 14.5 cm; males, at 12.5 cm). It was concluded that a decrease in fishing intensity (F= 0.45) or the enforcement of a minumum allowable total length (17.5 cm) is necessary to allow optimum exploitation of the whiting stock at present. Fishing intensity may be reduced either by increasing the mesh size or by decreasing fishing operations in the region. Fishing operations can be reduced by decreasing the length of the fishing season, limiting the license, closing the fishing grounds either totally or periodically or by limiting the total catch.

Estimation of the total trawlable biomass for the four subregions studied during four successive periods was made by using the stratified swept area method and the highest trawlable biomass was found in the region between Çaltı and Sarp which is a closed area to trawl fishing. The potential yield, which denotes the optimum number of landings by commercial fleets was estimated from the total biomass under an optimum level of effort or exploitation and was found to be lower than the annual landings of whiting from the Turkish Black Sea coast. It was therefore concluded that the whiting stock in the Black Sea was overexploited between 1990 and 1993.

A comparison of the percentage distributions of fish and other organisms in the trawl catches revealed that whiting was the dominant fish and its percentage occurence in trawl catches from the eastern Black Sea was higher than that for the western Black Sea (14.2% in April 1990, 19.4% in September 1990 in the western Black Sea and 57.0% in September 1991, and 62.7% in October 1992 in the eastern Black Sea).

Stomach contents of 3272 whiting collected in the Turkish Black Sea coast during the period 1990-1993 were analyzed. The results of analysis were illustrated in terms of weight and frequency of prey items in the diet. The mean stomach content weight was calculated for every 2 cm length interval. An estimate of the total daily and annual consumption was made by applying the data on stomach contents to a simple model (JONES, 1978) relating the rate of elimination of food from the stomach to the weight of stomach contents.

Whiting, below 12 cm in total length (TL) fed mostly on crustaceans and polychaetes. Fish of 12 cm TL or more took increasing proportions of fish prey, namely *Sprattus sprattus phalericus, Engraulis encrasicolus, Gobius* spp and *Merlangius merlangus euxinus.* With increasing age of the whiting, fish prey became dominant in the diet whilst the importance of crustaceans and polychaetes decreased. There was considerable seasonal variation both in the quantity and type of food eaten. Whiting fed most intensively during spring and autumn. The mean weight of food and the length of prey fish in the stomachs increased with the length of the predator.

The daily food consumption rate was estimated as 2.4% (1.6%-2.9%) of body weight, taking into account the empty stomachs. Predation on sprat was estimated to be 78,690 tonnes in 1991 and 137,923 tonnes in 1992.

Seasonal changes in gonad condition were assessed by applying a seven stage classification of maturation which was described by BOWERS (1954). Whiting have a long spawning period extending almost throughout the whole year, with a peak in January-February. Seasonal changes in the gonadosomatic ratio and condition factor support this intensive spawning season. Recovery from spawning is rapid.

The male whiting may shed its gonad for the first time at the end of their first year, but most fish spawn for the first time at the end of the second or beginning of the third year of their life, i.e. in age group 2. Spawning was observed in nearly all fish of age group 3. The mean length at 50% maturity was found to be 12.5 cm for males and 14.7 cm for females. Both sexes attained 100 per cent sexual maturity at the same length (i.e., 18 cm). Mature fish below 8.0 cm for male and 11.0 cm for female were not present in the samples.

Fecundity in Black Sea whiting was found to be highly correlated with length and to a lesser extent with age, the relationships being best described in terms of log-log regressions. Southern Black Sea whiting was found to be highly fecund. The higher fecundity of the southern Black Sea whiting may be due to their early maturity at considerably smaller size than their counterparts living at the higher latitudes within their range of distribution. Annual fluctuation in fecundity was not apparent in the Turkish Black Sea coast between 1991 and 1993.

While externally visible ectoparasites were not detected, only one endoparasite, *Hysterothylacium aduncum* (Nematode) was recorded in all visceral organs and liver examined. Their occurrence and intensity was higher in the warm season (July-August) than in the colder period (January-February). A clearly positive relationship between the length of fish and the prevalence of nematodes was only found in May/June. During the other months there was no clear relationship found between the length of fish and the prevalence of nematodes.

REFERENCES

AGNEW, D. J., 1988: Evidence for the exsistance of two populations of Irish Sea cod (*Gadus morhua* L.) from consideration of growth rates. ICES CM /G: 65. Demersal Fish Committee. 19 p.

AKŞIRAY, F., 1954; Türkiye deniz balıkları tayin anahtarı. İ.Ü. Fen Fak. Hidrobiyoloji Araş. Enst. yay. sayı 1: Pulhan matbaası İst. 283 p.

ARMSTRONG, M. J., 1982: The predator-prey relationships of Irish Sea poor-cod (*Trisopterus minutus* L.), pouting (*Trisopterus luscus* L.) and cod (*Gadus morhua* L.). J. Cons. int. Explor. Mer, 40:135-152.

ARNTZ, W. E., 1974; A contribution to the feeding ecology of juvenile cod (*Gadus morhua* L.) in the western Baltic. Rapp. P. v. R'eun. Cons. int. Explor. Mer. 166: 13-19.

ARNTZ, W. E. & FINGER, I., 1981: Demersal fish in the western Baltic: their feeding relations, food coincidence and food selection. ICES C.M/J:6. 15p. 7 tab, 9 figs.

AVSAR, D., 1987; Application of Mahalanobis Distance Function for the morfometric separation of some demersal fish stocks in the Gulf of Mersin, M.Sc. Thesis. IMS-METU., 162 p.

AVSAR, D., BINGEL, F. & UNSAL, M., 1988a; Application of Mahalanobis distance function for the morfometric separation of scaldfish (*Arnoglossus laterna* WALBAUM) stocks in the Gulf of Mersin. DOGA TU J. Biol. (Genetics, Microbiologie, Molecular Biology, Cytology) (12): No. 2. pp.87-92.

AVSAR, D., BINGEL, F. & UNSAL, M., 1988b; Application of Mahalanobis distance function for the morfometric separation of siverbelly *Leignathus klunzingeri* STEINDACHNER) stocks in the Gulf of Mersin. ACTA ADRIAT., (29): No. 1-2. pp.153-160.

AVSAR, D., BINGEL, F. & UNSAL, M., 1990; Application of Mahalanobis distance function for the morfometric separation of Lizardfish (*Saurida undosquamis* RICHARDSON) stocks in the Gulf of Mersin. METU Journal of Pure and Applied Science. (20): No. 3. pp.311-320.

AVSAR, D., 1993; The Biology and Population Dynamical Parameters of the sprat (*Sprattus sprattus phalericus* RISSO) on the Southern Coast of the Black Sea. Ph. D. Thesis, IMS-METU, 240 p.

AVSAR, D., 1994: Stock differentiation of the sprat (*Sprattus sprattus phalericus*) off the southern coast of the Black Sea. Fisheries Research, 29p., 3 Tabs and 2 Figs.

BAGENAL, T. H., 1963. The fecundity of witches in the Firth of Clyde. J.Mar. Biol. Assoc. UK,43:401-407.

BAGENAL, T. B., 1978. Fecundity. In Methods for assessment of fish production in fresh waters. IBP Handbook No.3.Third edition, pp.166-178.London Blackwell Scientific publications.

BEACHAM, T. D., NEPSZY, S. J., 1980; Some aspects of the biology of white hake, *Urophycis tenuis*, in the southern Gulf of St.Lawrence. J. Northw. Atl. Fish. Sci. 1:49-54.

BEVERTON, R. J.H. & HOLT, S.J., 1957; On the dynamics of exploited fish populations . U.K. Min. Agric. Fish., Fish Invest. (Serz), 19:533 p.

BINGEL, F., BRUNSWIG, D., GRIMM, H., GEHHAAR, C., JOHN, C., 1971; Fischbestandskunde. Eine Bearbeitung der Vorlesung "Fischbestandskunde" gelesen von F. THUROW in IfMk an der Uni. Kiel. Verofft des Inst. f. KuBiffi-Hamburg, 49: 92 p.

BINGEL, F., 1980; Identification von Structuren in Otolithen des Dorsches (Gadus morhua) der Kieler Bucht. Meeresforschung 28(H-1): 69-74.

BINGEL, F., 1985; Balık Populasyonlarının İncelenmesi. İ. Ü. Su Ürünleri Yüksek Okulu. Sapanca. Balık Ür. ve Islah Merkezi. no:10. 133 p.

BINGEL, F., DOĞAN, M., STEPNOWSKI, A., GÜCÜ, A.C., KAYIKCI, Y., MUTLU, E., 1991; Karadeniz Stok Tespiti. 1990 yılı raporu. Proje no: DEBÇAĞ 40/G, ODTÜ-Erdemli D.B.E. ve Tarım Orman Köyişleri Bakanlığı Trabzon Su Ürünleri Araştırma Enstitüsü, 182 p.

BINGEL, F., KIDEYŞ, A. E., ÖZSOY. E., TUĞRUL, S., BAŞTÜRK, Ö., OĞUZ, T., 1993; Stock Assessment Studies for the Turkish Black Sea Coast. NATO-TU FISHERIES FINAL REPORT. METU-D.B.E., Erdemli. 108 p.

BLACKITH, R. E., & RAYMENT, R. A., 1971; Multivariate morphometric. Academic Press, Inc; New York, USA 412 p.

BOONSTRA, H. G. v. D. (Edit.), 1977: Stock differentiation and growth of the southern African kinglip (*Genypterus capensis*). Galvin & Sales (Pty) Ltd., Cape Town, South Africa. 32 p.

BOWERING, W. R., 1980. Fecundity of Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum), from Southern Labrador and Southeastern Gulf of St. Lawrence. J.Northw tl. Fish. Sci., Vol.1: 39-43.

BOWERS, A. B. 1954; Breeding and Growth of Whiting (*Gadus merlangus* L.) in Isle of Man Waters. J. Mar. Biol. Ass. U.K. 33:97-122.

BOWMAN, R. E., 1983: Food of silver hake, Merluccius bilinearis. Fishery Bulletin. Vol. 82: no.1. 21-35 p.

BRANDER, K., 1978; The relationship between vertebral number and water temperature in cod. J. Cons. int. Explor. Mer, 38(3): 286-292.

BURDAK,V. D., 1964. Biology of the whiting (*Odontogadus merlangus euxinus*) of the Black Sea. Tr. Sevastop. Biol. Stn., 15:196-278.

BUZETA, M.-I and WAIWOOD, K. G., 1982. Fecundity of Atlantic cod (*Gadus morhua*) in the southwestern Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci. 1110, 6 pp.

BURD, A. C., 1969: Trials with principal component analysis for herring racial studies. ICES CM/H: 30. Pelagic Fish (Northern) Cttee. 11 p.

CASEY, J., DANN, J. & HARDING, D., 1986: Stomach contents of cod and whiting caught during the English Groundfish Survey of the North Sea in 1982 and 1984. ICES CM/G:14. Demersal Fish Committee. 8p, 7 tabs and 6 figs.

CLARK, S., 1981; Use of trawl survey data in assessments. Can. Spec. Publ. Fish. Aquat. Sci. 58: 82-92.

CUSHING, D., 1968: Fishery Biology. A study in population dynamics. The Uni. of Wisconsin Press Ltd. USA, 200 p.

DAAN, N., 1973; A quantitative analysis of the food intake of North Sea cod. Netherlands Journal of Sea Research, 6:479-517.

DAHL, K. & KIRKEGAARD. E., 1986: Stomach contents of mackerel, horse mackerel and whiting in the eastern part of the North Sea in July 1985. ICES, C.M./H:68. 7p., 8 tabs and 1fig.

DAVIS, J. C., 1973: Statistics and Data Analysis in Geology. John Wiley and Sons, Inc. USA, 550 p.

DBT-DEU., (1986) Orta Karadeniz (Sinop-Ünye) Trol Sahalarının Hidrografisi ve Verimliliği. Birinci Dönem Araştırmaları, Dokuz Eylül Üni., Deniz Bil. Tekno. Enst., İzmir, 50 p.

DEHNIK, T.V., 1973; The Ichthyoplankton of the Black Sea. Kiev, Naukova dumka, 234 p. (in Russian).

DEMIR, M., 1963; Analysis of vertebral counts of *Sardina pilchardus* WALB. from the Sea of Marmara and the Aegean Sea. Repp. Proc.-Ver. Reun. C.I.E.S.M.M., (17): no, 2.

DIE., 1968; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:597 , 24 sayfa.

DIE., 1971; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:626 , 29 sayfa.

DIE., 1974; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:718 , 356 sayfa.

DIE., 1979; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:874 , 21 sayfa.

DIE., 1981; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:947, 966. 21, 25 sayfa.

DIE., 1982; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1007 , 20 sayfa.

DIE., 1984; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1066 , 18 sayfa.

DIE., 1985; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1129 , 18 sayfa.

DIE., 1986; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1166, 20 sayfa.

DIE., 1987; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1189, 22 sayfa.

DIE., 1988; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1265, 22 sayfa.

DIE., 1989; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1389 , 22 sayfa.

DIE., 1990; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1401 , 18 sayfa.

DIE., 1991; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1467 , 24 sayfa.

DIE., 1992; Su Ürünleri İstatistikleri. T.C. Başbakanlık Devlet İstatistik Enstitüsü, Yayın No:1583 , 26 sayfa.

DPT., 1989; Su Ürünleri ve Su Ürünleri Sanayii özel ihtisas komisyonu raporu, T.C. Başbakanlık Devlet Planlama Teşkilatı Yay. No: DPT:2184-OIK: 344, 210 p.

DU BUIT, M. H., 1982. Essai d'evaluation de la predation de quelques teleosteens en Mer Celtique. J. Cons. int. Explor. Mer., 40(1): 37-46.

DU BUIT, M. H., 1984: Predation de la cardine (Lepidorhombus whiffiagonis W.) au nord et a l'Ecosse. J. Cons. int. Explor. Mer, 41:194-198.

DU BUIT, M. H. & MERLINAT, F., 1985. Alimentation du merlan *Merlangius merlangus* L. en mer Celtique. Rev. Trav. Inst. Peches marit., 49 (1 et 2): 5-12.

EHRICH, S. & REMPE, U., 1980: Morphometric discrimination between hake populations (Osteichthyes, Gadiformes, Gn. *Merluccius*) from the Northeast Pasific by use of a size-independent discriminant analysis. Mitteilungen aus dem Inst. fuer Seefisch., der Bundesforschungsanstalt fuer Fischerei, Hamburg No 31: 50 p.

FAHY, W. E., 1978; The influence of temperature change on number of anal fin rays developing in *Fundulus majalis* (W.). J. Cons. int. Explor. Mer, 38(3): 280-285.

FELDMAN, V. N., 1988: Two approaches to estimating the diurnal ration and prey size preferences of predatious gadoids. ICES, C. M/H:32. 24p.

FISHER, W., 1973; FAO species identification sheets for fishery purposes Mediterranean and Black Sea (fishing area 37). FAO, Rome, (I)

FLINTEGAARD, H., 1981: An estimate of the food consumption of whiting (*Merlangius merlangus*). ICES, C.M./G:81. 11p.

GAMBLE, R., 1959: Investigations of the sub-division of North Sea whiting populations. Part I. Further observations on the the vertebral counts of whiting in the North Sea area. ICES CM /36. Near Northern Seas Committee. 3 p.

GAMBLE, R. 1960: The Clyde whiting- a comparison with other whiting stocks. ICES CM/8. Near Northern Seas Committee. 12 p.

GAMBLE, R. & MESSTORFF, J., 1964; Age determination in the whiting (*Merlangius merlangus* L.) by means of the otoliths. Journal du Conseil, 28: 393-404.

GARROD, D. J. & GAMBELL, R., 1965: Whiting of the Irish Sea and the Clyde. Ministry of the Agriculture, Fisheries and Food, Fishery Investigations. Series II, vol. XXIV, no. 3. 64 p.

GFCM., 1989; Statistical Bulletin, No: 5. Nominal catches 1975-87. FAO Bull. of Fishery Statistics, Rome.

GFCM., 1993; Statistical Bulletin, No: 9. Nominal Catches 1979-1991. FAO Bull. of Fishery Statistics, Rome

GIBSON, R. N., EZZI, I. A., 1980; The biology of the scaldfish, *Arnoglossus laterna* (Walbaum) on the west coast of Scotland. J. Fish. Biol. (17):5 pp. 565-575.

GIBSON, R. N., EZZI, I. A., 1981; The biology of the Norway goby, *Pomatoschistus norvegicus* (Collectt) on the west coast of Scotland. J. Fish. Biol. (19): 697-714.

GIOVANARDI, O. & RIZZOLI, M., 1983; Biological data , collected during the Pipeta expeditions, on the whiting, *Merlangius merlangus*, in the Adriatic Sea. FAO, Rapp. sur les peches, m. 290. 2 p.

GORDON, J. D. M., 1977. The fish populations in inshore waters of the west coast of Scotland. The food and feeding of the whiting, *Merlangius merlangus*. J. Fish. Biol. 11:513-529.

GULLAND, J. A., 1975; Manual of methods for fisheries resource survey and appraisal, FAO Fish. Tech. Pap. 145: 1-29.

GÜCÜ, A. C., 1991: A fisheries model for the Mersin Bay Fisheries Ecosystem, Ph. D. Thesis. METU- D.B.E. Erdemli. 192 p.

HAWKINS, A. D., SOOFIANI, N. M. & SMITH, G.W., 1985: Growth and feeding of juvenile cod (*Gadus morhua* L.). J. Cons. int Explor. Mer, 42: 11-32

HISLOP, J. R. G. and HALL, W. B., 1974. The fecundity of whiting, *Merlangius merlangus* (L.)in the North Sea, the Minch and at Iceland. J. Cons. Int. Explor. Mer, 36(1): 42-49.

HISLOP, J. R. G., 1975. The breeding and growth of whiting, *Merlangius merlangus* in captivity. J.Cons. Int. Explor. Mer, 36(2): 119-127.

HISLOP, J. R. G., ROBB, A. P., BROWN, M. A., and ARMSTRONG, D., 1983: A preliminary report on the analysis of the whiting stomachs collected during the 1981 North Sea stomach sampling project. ICES, C.M./g:59. 4 p., 6 tabs, 6 figs.

HOLDEN, M. J. & RAITT, D. F. S. (Eds); 1974: Manual of fisheries science. Part 2-Methods of resource investigation and their application. FAO Fish. Tech. Rap; (115): Rev. 1, 214 p.

HORWOOD, J., 1993; Advances in Marine Biology. Vol.29. Blaxter, J.H.S., A.J. Southward (Eds). Acedemic Press, Great Britain. 393 p.

HTUN-HAN, M., 1978; The reproductive biology of the dab, *Limanda limanda* (L.) in the North Sea: gonosomatic index, hepatosomatic index and condition factor. J. Fish. Biol. (13):369-378.

HYSLOP, E. J., 1980; Stomach content analysis- a review of methods and their application. J. Fish. Biol. 17: 411-429.

IVANOV, L. & BEVERTON, R. J. H., 1985: The fisheries resources of the Mediterranean. Part two: Black Sea. Etud. Rev. CGPM/Stud. Rev. GFCM. (60): 135 p.

JAHNSON, R. K. & BARNETT, M. A., 1975: An inverse correlation between meristic characters and food supply in mid-water fishes: Evidence and possible explanations. Fishery Bulletin. (73), No.2: pp.284-298.

JONES, R., 1954: The food of the whiting and comparison with that of the haddock. Mar. Res. Scot., 2:pp.34.

JONES, R., 1974. The rate of elimination of food from the stomachs of haddock *Melanogrammus aeglefinus*, cod *Gadus morhua* and whiting *Merlangius merlangus*. J. Cons. int. Exp. Mer, 35:225-243.

JONES, R., 1978. Estimates of food consumption of haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua)*. J. Cons. int. Exp.Mer, 38:18-27.

JONES, R. & HISLOP, J. R. G., 1978; Further observations on the relation between food intake and growth of gadoids in captivity. J. Cons. int. Explor. Mer, 38(2): 244-251.

KANEVA, A. & MARINOV, T.M., 1960. On the food of some species of benthos-eating fish (striped mullet, whiting, flounder). Tr. Nauchnoizsled. Inst. Ribar. Ribn. Prom., Varna, 2:41-71 (in Bulgarian)

KARA, Ö. F., 1980. Karadeniz'in Balıkçılık potansiyeli ve bölgedeki balık avlama olanakları. Türkiye Sınai Kalkınma Bankası A.Ş. No. 32: 56p.

KIDEYS, A.E., 1994. Recent dramatic changes in the Black Sea ecosystem: The reason fro the sharp decline in Turkish anchovy fisheries. Journal of Marine systems. 5:171-181p.

KINNE, O. 1984. Diseases of Marine Animals. Introduction, Pisces. vol. IV. part 1. Germany, p.541.

KJESBU, O.S., 1988. Fecundity and Maturity of Cod (*Gadus morhua* L.) from Northern Norway. ICES, C.M. 1988/G:28. Norway.

KUTAYGIL, N., BILECİK, N., 1969-1973; Batı ve Orta Karadeniz Bölgesi Dip Balıklarının Dağılımı ve Mevsimsel Tezahürleri. Et ve Balık Kurumu Araştırma Projesi, Istanbul, 74 p.

LAEVASTU, T., 1993: Marine climate, weather and fisheries: The effects of weather and climatic changes on fisheries and ocean resources. Blackwell scientific publication Ltd. Great Britain. 204 p.

LANG. T., 1990. Infestation of North Sea Whiting, *Merlangius merlangus* L., with externally visible parasites. ICES, C. M. / E:31, Ref. G. p. 1-23

LERMAN, A., 1965: On rates of evolution of unit characters and character complexes. Evolution, (19): pp. 16-25.

MAIS, K. F., 1972: A subpopulation study of the Pacific sardine. Calif. Fish Game (58): pp. 296-314.

MALKOV, A. C. & EFREMOV, A. A., 1976; The whiting, *Merlangius merlangus*. Biol. Fishery investiations in the Atlantic Ocean. ATLANTNIRO, Kaliningrad, 597.533.1 (261.26).

MENGI, T., 1971; Die Plattfische und ihre Populationen in den Turkischen Kustengewassern. Revue de la Faculte des Sciences de L'universite D' İstanbul. S'erie B. Tome XXXVI. Fasc. 1-2. pp. 53-70.

MESSTORFF, J ., 1959. Untersuchungen über die Biologie des Wittlings *Merlangius merlangus* in der Nordsee. Ber. Dt. Wiss. Kommn f. Meeresforsch NF. 15, H.4: 277-334.

NAGABHUSHANAM, A. K. 1964. On the biology of the whiting, *Gadus merlangus*, in Manx waters. J. Mar. Biol. Ass. U.K. 44:177-202.

NIELSON, J. S., 1984; Fishes of the world. 2nd Edition, John Wiley & Sons, Inc. New York USA. 523 p.

ODUM, E. P., 1971: Fundamentals of ecology. Third Edition. W.B. Saunders Company, Philedelphia. USA 574 p.

OĞUZ, T., LATIF, M. A., SUR, H. I., UNLUATA, U., 1989: Batı ve Orta Karadenizin Oşinografisi, Cilt I. Fiziksel Oşinografi, Ulusal Deniz Ölçme ve İzleme Programı, Batı Karadeniz alt projesi ve Orta Karadeniz alt projesi, ODTÜ-DBE, 97 p.

OĞUZ, T., TUĞRUL, S., BINGEL, F., UNSAL, M., 1990; Stock Assessment studies for the Turkish Black Sea coast. NATO-TU Fisheries, first technical report. METU- Inst. Mar. Sci., Erdemli, 122 p.

OĞUZ, T., LA VIOLETTE, P.E., ÜNLÜATA, Ü., 1992; The Upper layer circulation of the Black sea: Its variability as inferred from hydrographic and satellite observations. J. Geophys. Res., 97:12569-12584.

OĞUZ, T., LATUN, V.S., LATIF, M. A., VLADIMIROV, V.V., SUR, H. İ., MARKOV, A.A., ÖZSOY, E., KOTOVSHCHIKOV, B.B., EREMEEV, V.V., ÜNLÜATA, Ü., 1993a; Circulation in the surface and intermediate layers of the Black Sea. Deep-Sea Res., 40: 1597-1612.

OĞUZ, T., AUBREY, D.G., LATUN, V.S., DEMIROV, E., KOVESHNIKOV, L., DIACONU, V., SUR, H.İ., BEŞİKTEPE, Ş., DUMAN, M., LİMEBURNER, R., EREMEEV, V., 1993b: Mesoscale circulation and thermohaline structure of the Black Sea observed during HydroBlack'91. Deep-Sea Res (I) 41(4) 603-628..

OOSTHUIZEN, E. and DAAN, N., (1974). Egg fecundity and maturity of North Sea cod, *Gadus morhua*. Neth. J. Sea. Res. 8,378-397.

OVERALL, D. & KLETT, C. J., 1972: Applied multivariate analysis. Mc Graw-Hill Book Company. N Y., 500 p.

PARRISH, B. B. & SHARMAN, D. P., 1958: Some remarks on methods used in herring racial investigations, with special referance to otolith studies. Rapp. et Proc.-Verb. (143): II. 66-80 pp.

PATTERSON, K. R., 1985: The trophic ecology of whiting (*Merlangius merlangus*) in the Irish Sea and its significance to the Manx herring stock. J. Cons. Int. Explor. Mer, 42: 152-161.

PAULY, D., 1978; A preliminary compliilation of fish length growth parameters. Ber. Inst. Meereskd. Christian - Albrechts Univ., Kiel 55, 1-200.

PAULY, D., 1979; Theory ana management of tropical multispecies stocks; A review, with emphasis on the southeast Asian demersal fisheries. ICLARM Stud. Rev. 1, 1-35.

PAULY, D., 1983; Some simple methods for the assessment of the tropical fish stocks. FAO Fish, Tech. Paper., No. 234, 52 p.

PAULY, D., 1984; Fish populations dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Stud. Rev. 8, 1-325.

PAULY, D. & DAVID, N. 1980; An objective method for determining fish growth from length-frequency data. ICLARM Newsletter 3(3):13- 15.

PAULY, D. & GASCHUTZ, G., 1979; A simple method for fitting oscillating length growth data with a programme for pocket calculators. Cons. Int. Explor. Mer, C.M. 1979/G:24.

PAULY, D., & MUNRO, J. L. 1984; Once more on growth comparison in fish and invertebrates. Fishbyte 2(1):21.

PAYZA, K., 1983: Biochemical genetic study of three fish species of the eastern Mediterranean, M. Sc. Thesis. IMS-METU., 51p.

PILCHER, M. W., WHITFIELD, P. J. and RILEY J. D., 1989; Seasonal and regional infestitation characteristics of three ectoparasites of whiting, *Merlangius merlangus* L., in the North Sea. J. Fish. Biol. 35: 97-110.

PINHORN, A.T. 1984; Temporal and spatial variation in fecundity of Atlantic cod (*Gadus morhua*) in Newfoundland waters. J. Northw. Atl. Fish.Sci. 5, 161-170. Rohlf, F. J., 1986. Biom. A package of statistical programs to company the text Biometry. 108 pp. USA.

POPE, J. A. & HALL, W. B., 1972: Further results on discrimination on the basis of multiple morphometric measurements. ICES/C. M. Pelagic Fish (Northern) Committee H:32, 5 p + 5 Tabs. and 2 Figs.

POTTER, I. C., GARDNER, D. C., AND CLARIDGE, P. N., 1988; Age composition, movements, meristics and parasites of the whiting, *Merlangius merlangus*, in the Severn estuary and Bristol Channel. J. Mar. Biol. Ass. U.K. 68: 295-313.

PRODANOV, K., 1980; Preliminary data on the growth and age of the whiting (*Odontogadus merlangus euxinus*) along the Bulgarian coast of the Black Sea. Izv. Inst. Rybn. Resur., Varna, 18:35-44.

PRODANOV, K., 1982; An Approximate Estimation (Evaluation) of the Optimum Level of Exploitation of Whiting's Stock. Izv. Ins. Rybn. Resur., Varna, 19:59-65.

RICKER, W. E., 1975; Computation and interpretation of Biological statistics of fish populations. Bull. Fish. Res. Board Can. (191): 382 p.

ROHLF, F. J., 1986; Biom. A package of statistical programs to accompany the next Biometry. State Uni. of New York, USA, 108 p.

RUSSELL, F.S., 1976; The eggs and planktonic stages of the British Marine Fishes. Academic Press. New York, USA. 524 p.

SAVILLE, A., 1977; Survey methods of appraising fishery resources. FAO Fisheries Tech. Paper. No:171, pp. 1-76.

SCHAEFER, M., 1954. Some aspects of dynamics of populations important to the management of the commercial marine fisheries. Inter. Amer. Trop. Tune Comm. Bull. 1(2); 27-56.

SHARP, J. C., ABLE, K. W. & LEGGET, W. C., 1978: Utility of meristic and morphometric characters for identification of capelin (*Mallotus villosus*) stocks in Canadian Atlantic waters. J. Fish. Res. Board Can: (35). pp. 124-130.

SHOTTER, R. A., 1973b. Changes in the parasitic fauna of whiting, *Odontogadus merlangus* L., with age and sex of host, season, and from different areas in the vicinity of the Isle of Man. J. Fish Biology, 5, 559 - 573.

SLASTENENKO, E., 1956; Karadeniz Havzası Balıkları. Translated from the Russian by Altan, H. E.B.K. Umum Müd. Yay., İstanbul 711p.

SHULMAN, G. E. 1974. Life cycles of fish ; physiology and biochemistry. 258 pp. Wiley, Newyork

SNEATH, P. H. A. & SOKAL, R. R., 1973: Numerical taxonomy. The prenciples and practice of numerical classification. Freeman Co. San Francisco. 573p.

SOROKIN, YU. I., 1983; The Black Sea, In: Ketchum, B.H. (Ed.) Ecosystems of the World estuaries and enclosed seas. Elsevier, Amsterdam,26: pp. 253-291.

SPARRE, P., URSIN, E. & VENEMA, S. C., 1989: Introduction to tropical fish stock assessment. Part I. Manual. FAO Fish. Tech. Pap. No. 306. 1. Rome, FAO, 337p.

SUR, H. I., ÖZSOY, E., ÜNLÜATA, Ü., 1993; Boundry current instabilities, upwelling, shelf mixing and eutriphication processes in the Black Sea. Prog. Oceanog. (in press).

SUAE, 1992; Doğu Karadeniz Bölgesindeki Mezgit Balıkları (*Gadus merlangus euxinus*) Üzerine Araştırmalar. Ekonomik Deniz Ürünleri Araştırma Projesi. T. K. B. Trabzon Su Ürünleri Araştırma Enstitüsü, No:82A040030

TEMPLEMAN, W., HODDER, V. M, and WELLS, R., 1978; Sexual maturity and spawning in haddock, *Melanogrammus aeglefinus*, on the southern Grand Bank. ICNAF Res. Bull., No. 13:53-65.

THUROW, F., 1982: Sustained fish supply-An introduction to fishery management. Arch. FischWiss. (33): 1/2, pp.1-42.

URSIN, E., 1967; A mathematical model of some aspects of fish growth, respiration and mortality. J. Fish res. Board Can., 24:2355-2453.

UYSAL, A., 1994; Doğu Karadeniz (Sinop-Hopa) Bölgesi Mezgit Balığının, *Merlangius merlangus euxinus* Biyolojisi ve Populasyon Dinamiği. Bülten. Sayı:9, No:9, pp.145-173.

VILLALUZ, A. C. & MACCRIMMON, H. R., 1988: Meristic variations in milkfish *Chanos chanos* from Philippine waters. Marine Biology. 97, pp: 145-150.

WEATHERLY, A. H., 1972: *Growth and Ecology of Fish Populations*. Pub. Academic Press New York and London 293p.

WHEELER, A. C., 1969; The fishes of the British Isles and North West Europe. Michig. Stat. Univ. Press: 530 p.

WEBER, E., 1972: Grundriss der biologischen Statistik. 7. Aufl. VEB Gustav Fisher Verlag Jena. 706p.

WHITEHEAD, P. J. P., BAUCHOT, M. L., HUREAU, J. C. , NILSEN, J., TORTONESE, E.,1986; Fishes of the North-Eastern Atlantic and the Mediterranean. UNESCO ed. Printed by Richard Clay Ltd. U.K. 510 p.

WOOTTEN, R. & WADDELL, I. F., 1977. Studies on the biology of larval nematodes from the musculature of cod and whiting in Scottish waters. J. Cons. int. Explor. Mer, 37(3): 266-273.

ZAITSEV, YU. P., 1993; Fisheries and Environment Studies in the Black Sea System. Part 2: Impact of eutrophication on the Black Sea Fauna. FAO Studies and Reviews General Fisheries Council for the Mediterranean, Rome. No. 64, pp. 59-86.

APPENDIX A

The equalized numbers of each age group of males and females of Black Sea whiting collected from the five regions during the 1990-1992 sampling periods.

PERIOD	REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
APR 1990	I	M	78	71	5	-	-	-	154
		F	64	64	18	1	-	-	147
APR 1990	II	M	78	71	5	-	-	-	154
		F	64	64	18	1	-	-	147
APR 1990	I	M	17	65	3	-	-	-	85
		F	14	64	11	1	-	-	90
APR 1990	III	M	17	65	3	-	-	-	85
		F	14	64	11	1	-	-	90
APR 1990	I	M	78	72	2	-	-	-	152
			64	64	6	1	-	-	135
APR 1990	IV	M	78	72	2	-	-	-	152
		F	64	64	6	1	-	-	135
APR 1990	II	M	17	65	3	-	-	-	85
		F	14	78	11	6	-	-	109
APR 1990	III	M	78	65	3	-	-	-	85
		F	14	78	11	6	-	-	109
APR 1990	II	M	81	74	2	-	-	-	157
		F	78	96	6	6	-	-	186
APR 1990	IV	M	81	74	2	-	-	-	157
		F	78	96	6	6	-	-	186
APR 1990	III	M	17	65	2	-	-	-	84
		F	14	78	6	6	-	-	104
APR 1990	IV	M	17	65	2	-	-	-	84
		F	14	78	6	6	-	-	104
APR 1990	I	M	78	14	-	-	-	-	92
		F	64	49	4	-	-	-	117
SEP 1990	I	M	78	14	-	-	-	-	92
		F	64	49	4	-	-	-	117

PERIOD	REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
APR 1990	I	M	42	6	-	-	-	-	48
		F	38	6	1	6	-	-	45
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	6	-	-	45
APR 1990	I	M	78	16	-	-	-	-	95
		F	64	19	1	1	-	-	85
SEP 1990	III	M	78	16	-	-	-	-	95
		F	64	19	1	1	-	-	85
APR 1990	I	M	78	22	-	-	-	-	100
		F	64	64	5	-	-	-	133
SEP 1990	IV	M	78	22	-	-	-	-	100
		F	64	64	5	-	-	-	133
APR 1990	II	M	94	14	-	-	-	-	108
		F	139	48	4	-	-	-	191
SEP 1990	I	M	94	14	-	-	-	-	108
		F	139	48	4	-	-	-	191
APR 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
APR 1990	II	M	94	16	1	-	-	-	111
		F	105	19	1	-	-	-	125
SEP 1990	III	M	94	16	1	-	-	-	111
		F	105	19	1	-	-	-	125
APR 1990	II	M	94	22	-	-	-	-	116
		F	139	75	5	-	-	-	219
SEP 1990	IV	M	94	22	-	-	-	-	116
		F	139	75	5	-	-	-	219
APR 1990	III	M	17	14	-	-	-	-	31
		F	14	49	4	-	-	-	67
SEP 1990	I	M	17	14	-	-	-	-	31
		F	14	49	4	-	-	-	67

PERIOD		REGION	SEX	AGE GROUPS						TOTAL
				I	II	III	IV	V	VI	
APR	1990	III	M	17	6	-	-	-	-	23
			F	14	6	1	-	-	-	21
SEP	1990	II	M	17	6	-	-	-	-	23
			F	14	6	1	-	-	-	21
APR	1990	III	M	17	16	1	-	-	-	34
			F	14	19	1	-	-	-	34
SEP	1990	III	M	17	16	1	-	-	-	34
			F	14	19	1	-	-	-	34
APR	1990	III	M	17	22	-	-	-	-	39
			F	14	75	5	-	-	-	94
SEP	1990	IV	M	17	22	-	-	-	-	39
			F	14	75	5	-	-	-	94
APR	1990	IV	M	81	14	-	-	-	-	95
			F	78	49	4	-	-	-	131
SEP	1990	I	M	81	14	-	-	-	-	95
			F	78	49	4	-	-	-	131
APR	1990	IV	M	41	6	-	-	-	-	47
			F	38	6	1	-	-	-	45
SEP	1990	II	M	41	6	-	-	-	-	47
			F	38	6	1	-	-	-	45
APR	1990	IV	M	81	14	1	-	-	-	95
			F	78	19	1	-	-	-	98
SEP	1990	III	M	81	14	1	-	-	-	95
			F	78	19	1	-	-	-	98
APR	1990	IV	M	81	22	-	-	-	-	103
			F	77	75	5	-	-	-	157
SEP	1990	IV	M	81	22	-	-	-	-	103
			F	77	75	5	-	-	-	157
APR	1990	I	M	78	72	1	-	-	-	151
			F	64	64	18	1		-	147
SEP	1991	IV	M	78	72	1	-	-	-	151
			F	64	64	18	1		-	147

PERIOD	REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
APR 1990	I	M	78	72	5		-	-	155
		F	64	64	18	1	-	-	147
SEP 1991	V	M	78	72	5		-	-	155
		F	64	64	18	1	-	-	147
APR 1990	II	M	94	95	1	-	-	-	190
		F	128	161	31	1	-	-	321
SEP 1991	IV	M	94	95	1	-	-	-	190
		F	128	161	31	1	-	-	321
APR 1990	II	M	93	97	16	-	-	-	206
		F	85	118	27	4	-	-	234
SEP 1991	V	M	93	97	16	-	-	-	206
		F	85	118	27	4	-	-	234
APR 1990	III	M	17	65	-	-	-	-	82
		F	14	78	11	1	-	-	104
SEP 1991	IV	M	17	65	-	-	-	-	82
		F	14	78	11	1	-	-	104
APR 1990	III	M	17	65	3	-	-	-	85
		F	14	78	11	4	-	-	107
SEP 1991	V	M	17	65	3	-	-	-	85
		F	14	78	11	4	-	-	107
APR 1990	IV	M	81	74	1	-	-	-	156
		F	78	96	6	1	-	-	181
SEP 1991	IV	M	81	74	1	-	-	-	156
		F	78	96	6	1	-	-	181
APR 1990	IV	M	81	74	2	-	-	-	157
		F	78	95	6	4	-	-	183
SEP 1991	V	M	81	74	2	-	-	-	157
		F	78	95	6	4	-	-	183
APR 1990	I	M	78	72	-	-	-	-	150
		F	64	64	18	1		-	147
OCT 1992	IV	M	78	72	-	-	-	-	150
		F	64	64	18	1		-	147

PERIOD		REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
APR	1990	I	M	78	72	5		-	-	155
			F	64	64	18	1	-	-	147
OCT	1992	V	M	78	72	5		-	-	155
			F	64	64	18	1	-	-	147
APR	1990	II	M	93	72	-	-	-	-	165
			F	85	110	31	2	-	-	228
OCT	1992	IV	M	93	72	1	-	-	-	165
			F	85	110	31	2	-	-	228
APR	1990	II	M	93	97	16	-	-	-	206
			F	85	118	31	8	-	-	242
OCT	1992	V	M	93	97	16	-	-	-	206
			F	85	118	31	8	-	-	242
APR	1990	III	M	17	65	-	-	-	-	82
			F	14	78	11	2	-	-	105
OCT	1992	IV	M	17	65	-	-	-	-	82
			F	14	78	11	2	-	-	105
APR	1990	III	M	17	65	-	-	-	-	85
			F	14	78	11	2	-	-	105
OCT	1992	V	M	17	65	-	-	-	-	85
			F	14	78	11	2	-	-	105
APR	1990	IV	M	81	74	-	-	-	-	153
			F	78	96	6	2	-	-	182
OCT	1992	IV	M	81	74	-	-	-	-	153
			F	78	96	6	2	-	-	182
APR	1990	IV	M	81	73	2	-	-	-	156
			F	78	96	6	4	-	-	184
OCT	1992	V	M	81	73	2	-	-	-	156
			F	78	96	6	4	-	-	184
SEP	1990	I	M	42	6	-	-	-	-	48
			F	38	6	1	-	-	-	45
SEP	1990	II	M	42	6	-	-	-	-	48
			F	38	6	1	-	-	-	45

PERIOD	REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
SEP 1990	I	M	111	14	-	-	-	-	125
		F	105	19	1	-	-	-	125
SEP 1990	III	M	111	14	-	-	-	-	125
		F	105	19	1	-	-	-	125
SEP 1990	I	M	165	14	-	-	-	-	179
		F	150	49	4	-	-	-	203
SEP 1990	IV	M	165	14	-	-	-	-	179
		F	150	49	4	-	-	-	203
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	III	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	IV	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	III	M	111	16	-	-	-	-	127
		F	105	19	1	-	-	-	125
SEP 1990	IV	M	111	16	-	-	-	-	127
		F	105	19	1	-	-	-	125
SEP 1990	I	M	165	14	-	-	-	-	179
		F	118	48	4	-	-	-	170
SEP 1991	IV	M	165	14	-	-	-	-	179
		F	118	48	4	-	-	-	170
SEP 1990	I	M	164	14	-	-	-	-	178
		F	128	49	4	-	-	-	181
SEP 1991	V	M	164	14	-	-	-	-	178
		F	128	49	4	-	-	-	181
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-		-	45
SEP 1991	IV	M	42	6	-	-	-	-	48
		F	38	6	1	-		-	45

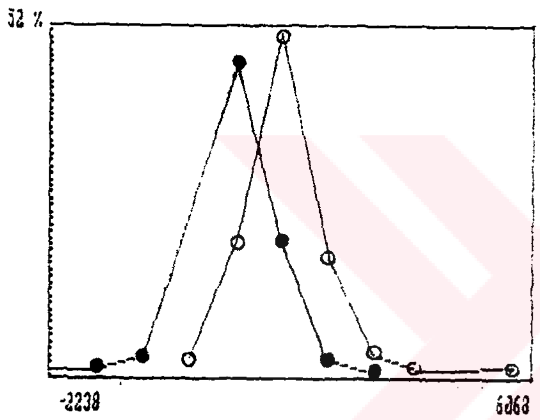
PERIOD	REGION	SEX	AGE GROUPS I	II	III	IV	V	VI	TOTAL
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1991	V	M	42	6	-	-	-	-	48
		F	38	6	1	-	-	-	45
SEP 1990	III	M	110	16	-	-	-	-	126
		F	92	19	1	-	-	-	112
SEP 1991	IV	M	110	16	-	-	-	-	126
		F	92	19	1	-	-	-	112
SEP 1990	III	M	111	16	-	-	-	-	127
		F	103	19	1	-	-	-	123
SEP 1991	V	M	111	16	-	-	-	-	127
		F	103	19	1	-	-	-	123
SEP 1990	IV	M	182	22	-	-	-	-	204
		F	128	75	5	-	-	-	208
SEP 1991	IV	M	182	22	-	-	-	-	204
		F	128	22	5	-	-	-	208
SEP 1990	IV	M	132	22	-	-	-	-	154
		F	128	74	5	-	-	-	207
SEP 1991	V	M	132	22	-	-	-	-	154
		F	128	74	5	-	-	-	207
SEP 1990	I	M	157	14	-	-	-	-	171
		F	150	49	4	-	-	-	203
OCT 1992	IV	M	157	14	-	-	-	-	171
		F	150	49	4	-	-	-	203
SEP 1990	I	M	147	14	-	-	-	-	161
		F	150	49	4	-	-	-	203
OCT 1992	V	M	147	14	-	-	-	-	161
		F	150	49	4	-	-	-	203
SEP 1990	II	M	42	6	-	-	-	-	48
		F	38	6	1	-		-	45
OCT 1992	IV	M	42	6	-	-	-	-	48
		F	38	6	1	-		-	45

PERIOD		REGION	SEX	AGE GROUPS						TOTAL
				I	II	III	IV	V	VI	
SEP	1990	II	M	42	6	-	-	-	-	48
			F	38	6	1	-	-	-	45
OCT	1992	V	M	42	6	-	-	-	-	48
			F	38	6	1	-	-	-	45
SEP	1990	III	M	111	16	-	-	-	-	127
			F	105	19	1	-	-	-	125
OCT	1992	IV	M	111	16	-	-	-	-	127
			F	105	19	1	-	-	-	125
SEP	1990	III	M	111	16	-	-	-	-	127
			F	105	19	1	-	-	-	125
OCT	1992	V	M	111	16	-	-	-	-	127
			F	105	19	1	-	-	-	125
SEP	1990	IV	M	198	22	-	-	-	-	220
			F	237	75	5	-	-	-	317
OCT	1992	IV	M	198	22	-	-	-	-	220
			F	237	75	5	-	-	-	317
SEP	1990	IV	M	121	22	-	-	-	-	143
			F	128	75	5	-	-	-	208
OCT	1992	V	M	121	22	-	-	-	-	143
			F	128	75	5	-	-	-	208
SEP	1991	IV	M	182	72	1	-	-	-	255
			F	118	110	41	1	-	-	270
OCT	1992	IV	M	182	72	1	-	-	-	255
			F	118	110	41	1	-	-	270
SEP	1991	IV	M	147	72	-	-	-	-	219
			F	118	110	41	-	-	-	269
OCT	1992	V	M	147	72	-	-	-	-	219
			F	118	110	41	-	-	-	269
SEP	1991	V	M	111	72	-	-	-	-	183
			F	110	107	41	2	-	-	260
OCT	1992	IV	M	111	72	-	-	-	-	183
			F	110	107	41	2	-	-	260

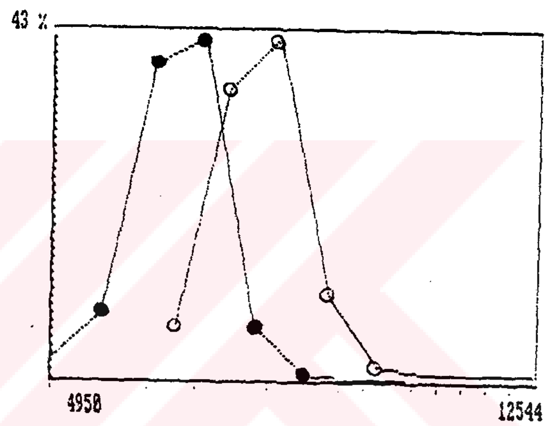
PERIOD		REGION	SEX	AGE GROUPS						TOTAL
				I	II	III	IV	V	VI	
SEP	1991	V	M	111	107	16	-	-	-	234
			F	110	107	77	4	3	2	303
OCT	1992	V	M	111	107	16	-	-	-	234
			F	110	107	77	4	3	2	303
SEP	1991	IV	M	132	97	1	-	-	-	230
			F	128	111	68	1	2	-	310
SEP	1991	V	M	132	97	1	-	-	-	230
			F	128	111	68	-	-	-	310
OCT	1992	IV	M	157	72	-	-	-	-	229
			F	158	110	41	2	-	-	311
OCT	1992	V	M	157	72	-	-	-	-	229
			F	158	110	41	2	-	-	311

APPENDIX B

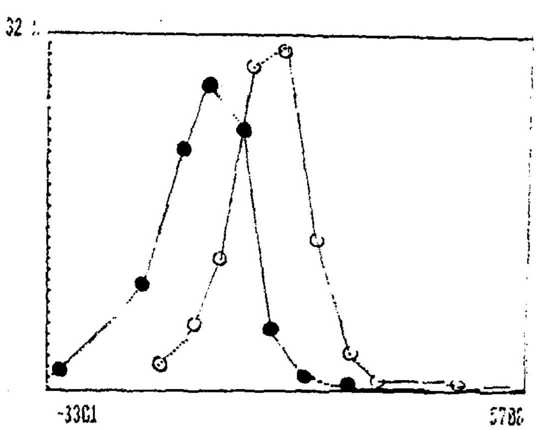
Percentage frequency distributions of the discriminant values of *Merlangius merlangus euxinus* N. collected from five regions along the Turkish Black Sea coast in the different sampling period.



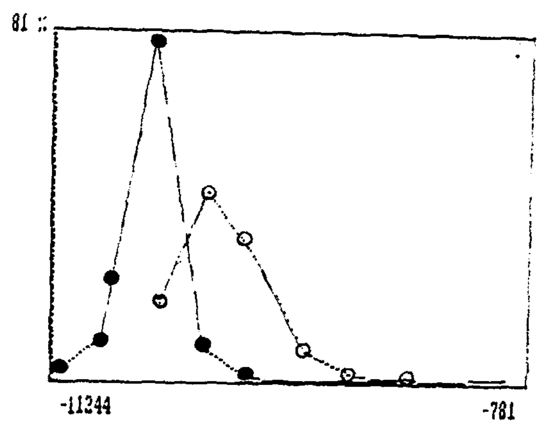
APRIL 1990 (1) - APRIL 1990 (2)
(o—o) (●—●)



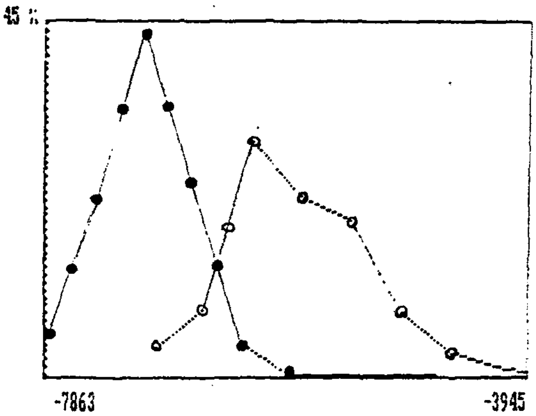
APRIL 1990 (1) - APRIL 1990 (3)
(o—o) (●—●)



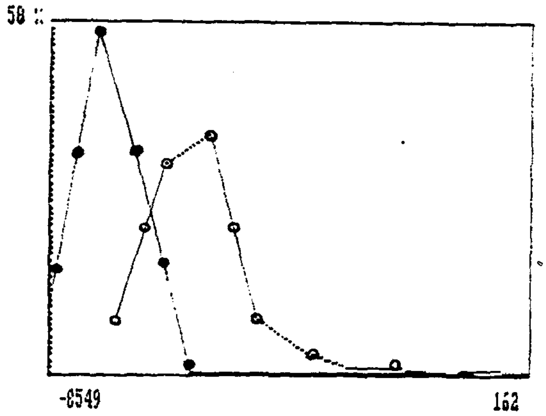
APRIL 1990 (1) - APRIL 1990 (4)
(o—o) (●—●)



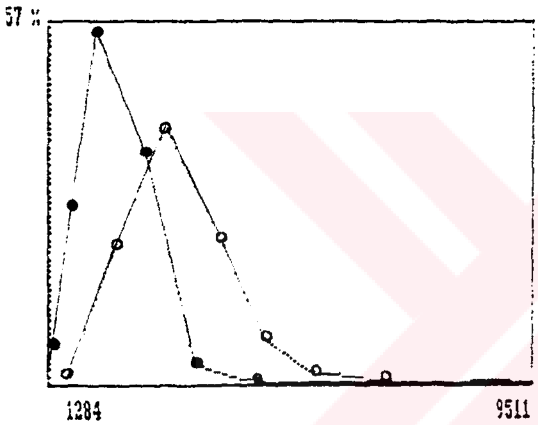
APRIL 1990 (1) - SEP 1990 (1)
(o—o) (●—●)



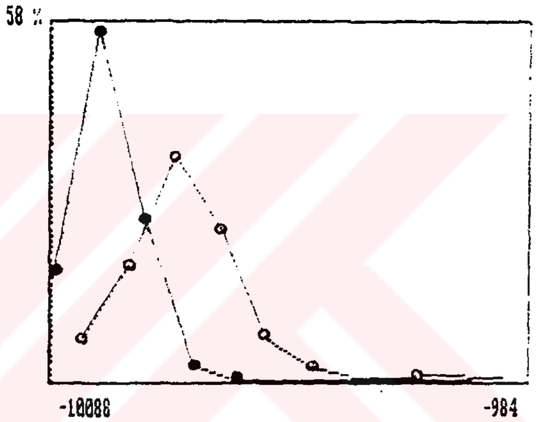
APRIL 1990 (1) - SEP 1990 (2)
(o——o) (●——●)



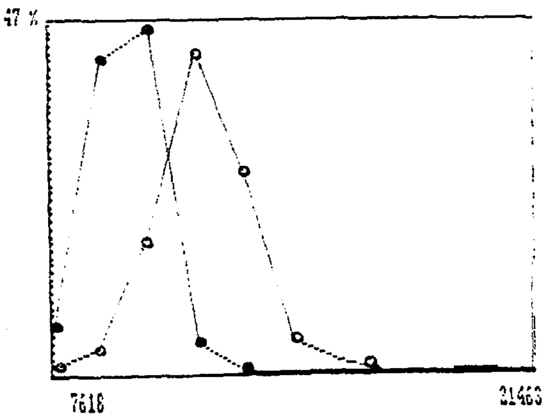
APRIL 1990 (1) - SEP 1990 (3)
(o——o) (●——●)



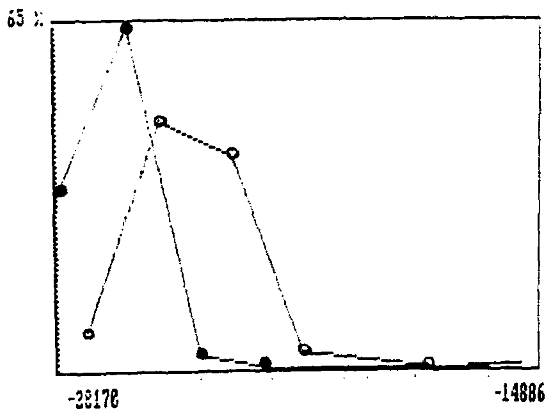
APRIL 1990 (1) - SEP 1990 (4)
(o——o) (●——●)



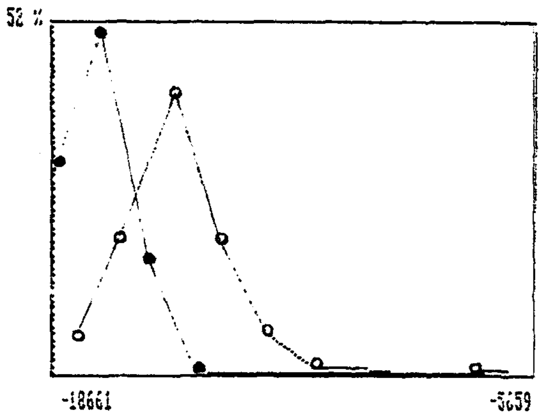
APRIL 1990 (1) - SEP 1991 (4)
(o——o) (●——●)



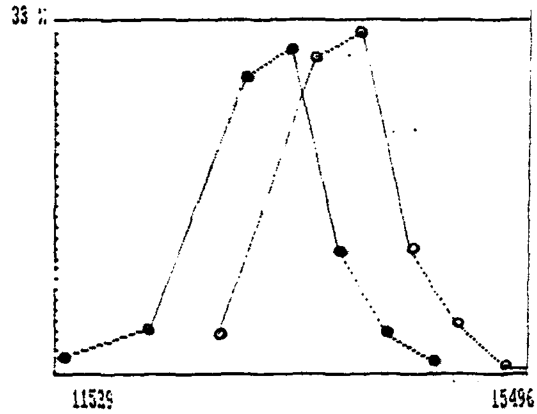
APRIL 1990 (1) - SEP 1991 (5)
(o——o) (●——●)



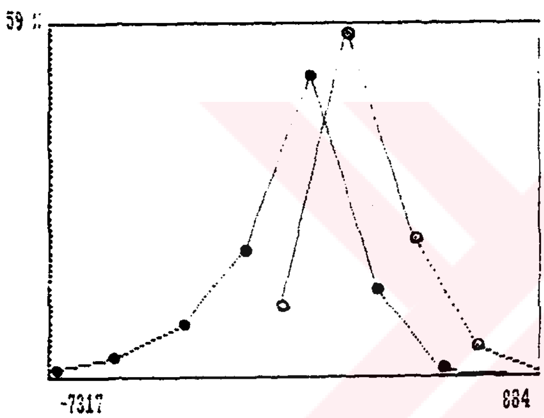
APRIL 1990 (1) - OCT 1992 (4)
(o——o) (●——●)



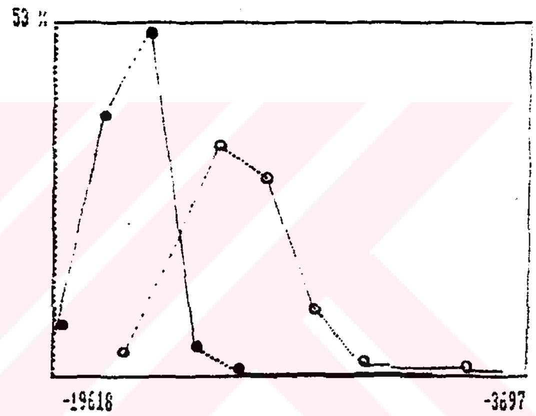
APRIL 1990 (1) - OCT 1992 (5)
(o—o) (●—●)



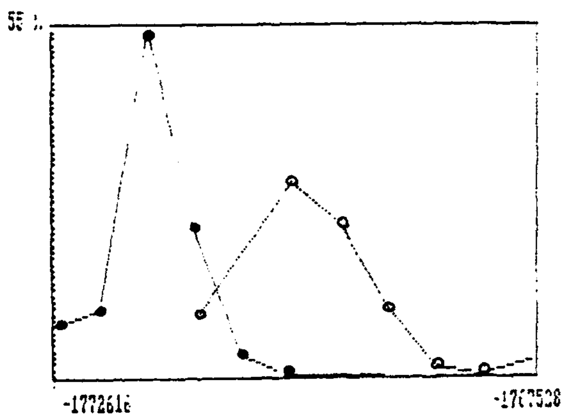
APRIL 1990 (2) - APRIL 1990 (3)
(●—●) (●—●)



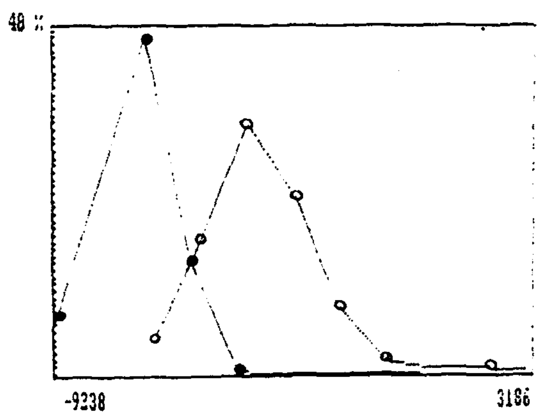
APRIL 1990 (2) - APRIL 1990 (4)
(o—o) (●—●)



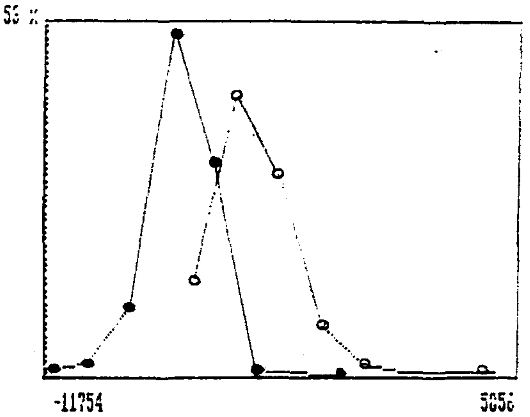
APRIL 1990 (2) - SEP 1990 (1)
(o—o) (●—●)



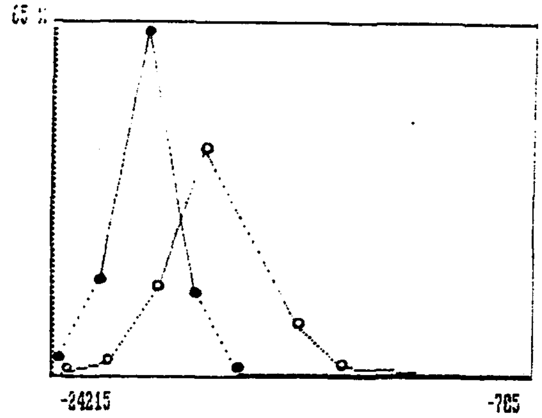
APRIL 1990 (2) - SEP 1990 (2)
(o—o) (●—●)



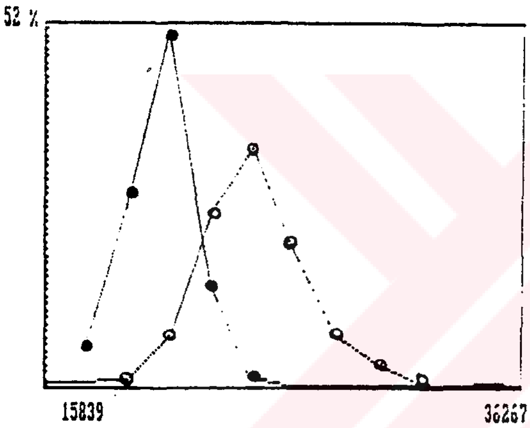
APRIL 1990 (2) - SEP 1990 (3)
(o—o) (●—●)



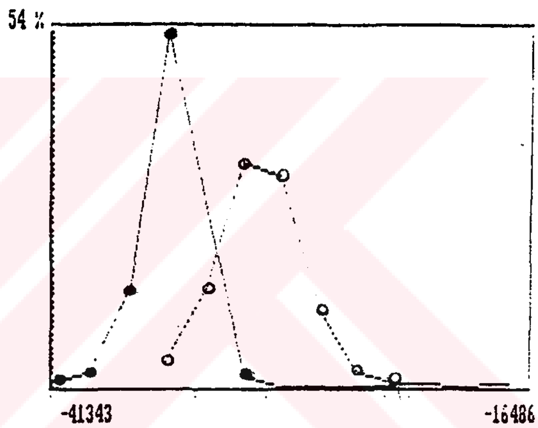
APRIL 1990 (2) - SEP 1990 (4)
(o------o) (●------●)



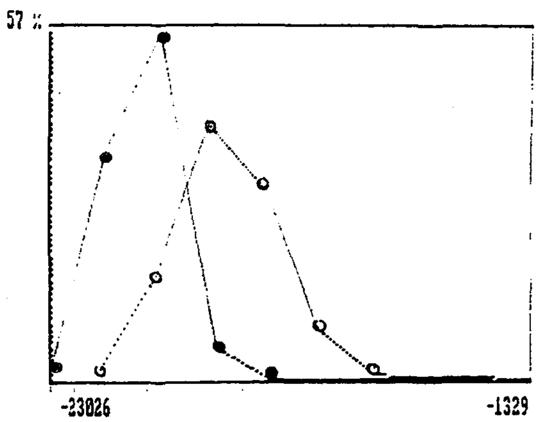
APRIL 1990 (2) - SEP 1991 (4)
(o------o) (●------●)



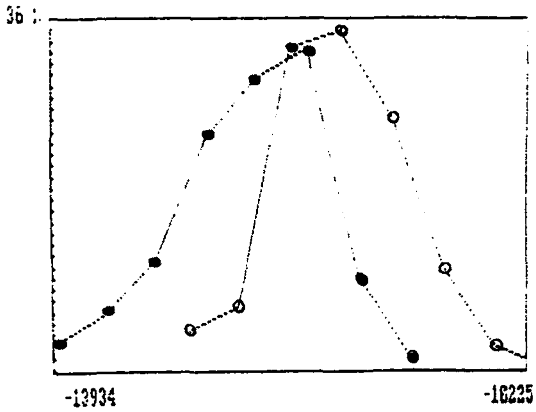
APRIL 1990 (2) - SEP 1991 (5)
(o------o) (●------●)



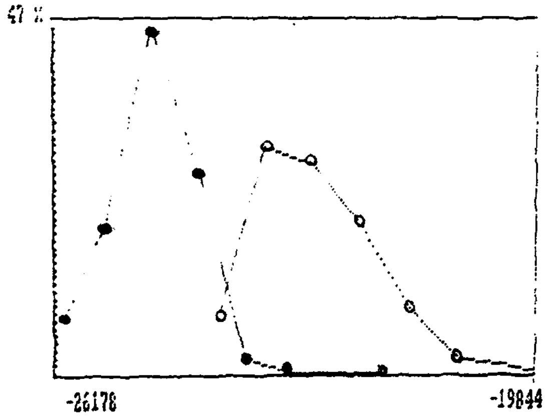
APRIL 1990 (2) - OCT 1992 (4)
(o------o) (●------●)



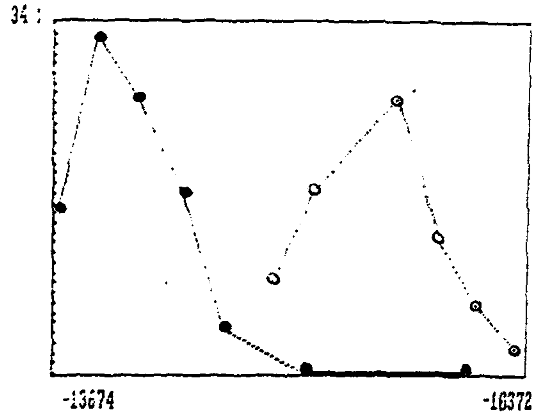
APRIL 1990 (2) - OCT 1992 (5)
(o------o) (●------●)



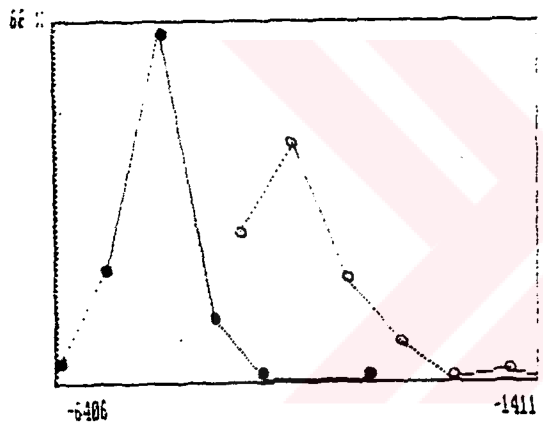
APRIL 1990 (3) - APRIL 1990 (4)
(o------o) (●------●)



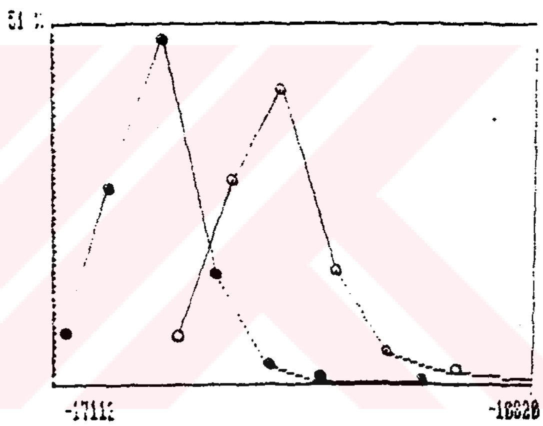
APRIL 1990 (3) - SEP 1990 (1)
(o——o) (●——●)



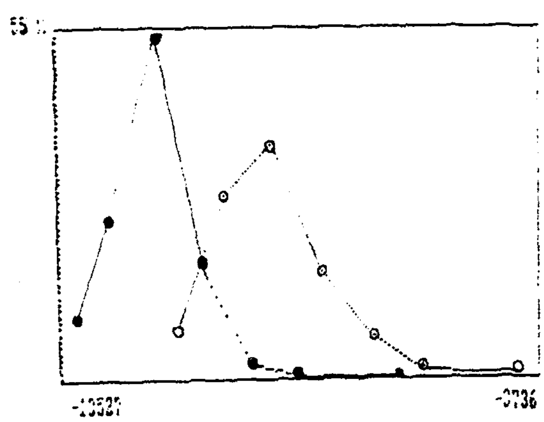
APRIL 1990 (3) - SEP 1990 (2)
(o——o) (●——●)



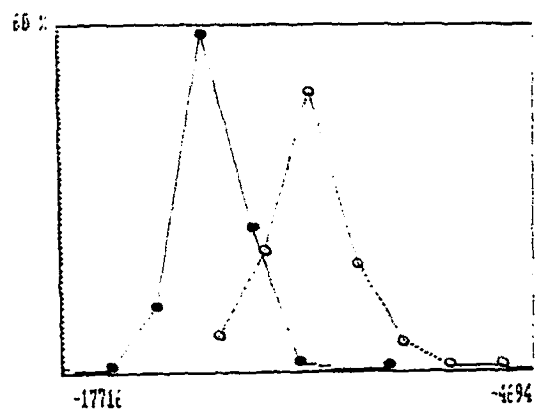
APRIL 1990 (3) - SEP 1990 (3)
(o——o) (●——●)



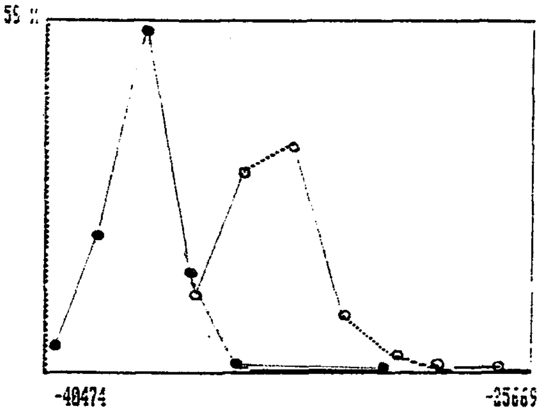
APRIL 1990 (3) - SEP 1990 (4)
(o——o) (●——●)



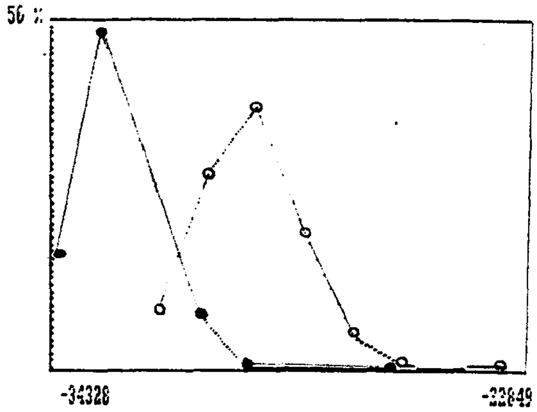
APRIL 1990 (3) - SEP 1991 (4)
(o——o) (●——●)



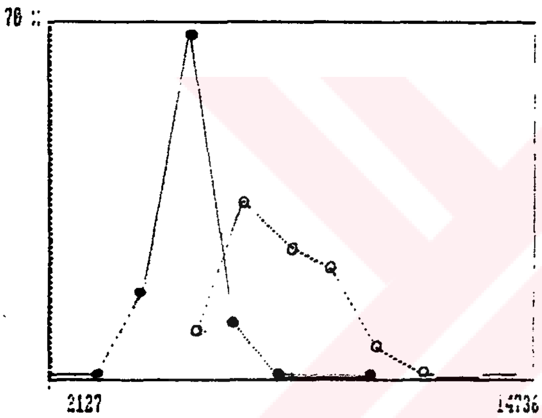
APRIL 1990 (3) - SEP 1991 (5)
(o——o) (●——●)



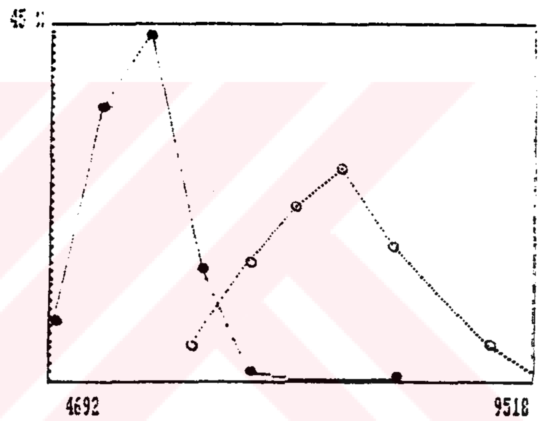
APRIL 1990 (3) - OCT 1992 (4)
(o——o) (●——●)



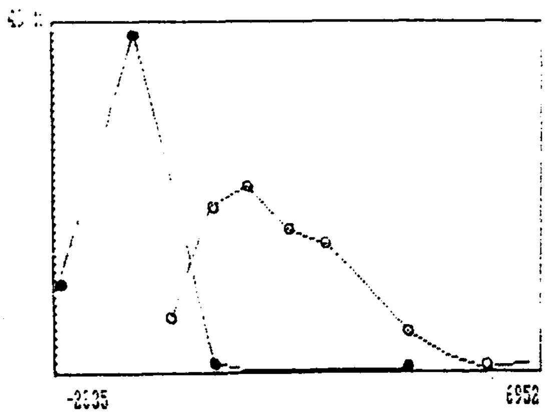
APRIL 1990 (3) - OCT 1992 (5)
(o——o) (●——●)



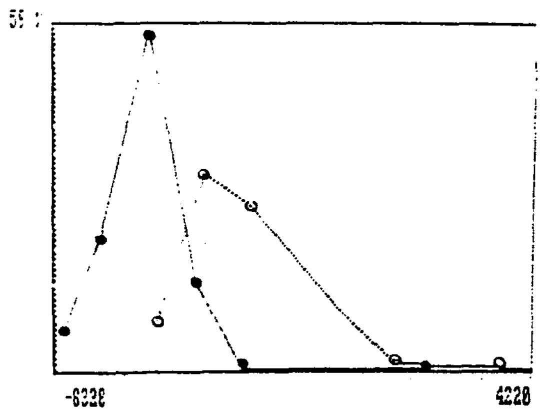
APRIL 1990 (4) - SEP 1990 (1)
(o——o) (●——●)



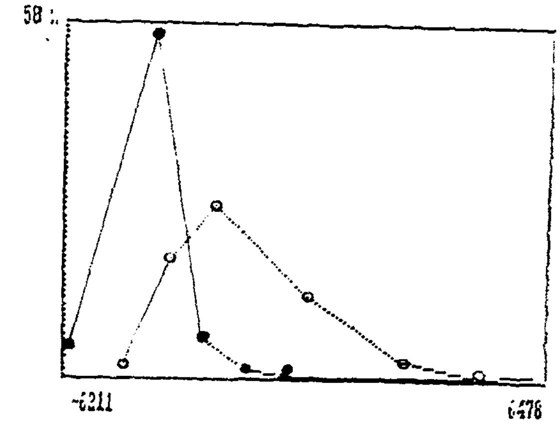
APRIL 1990 (4) - SEP 1990 (2)
(o——o) (●——●)



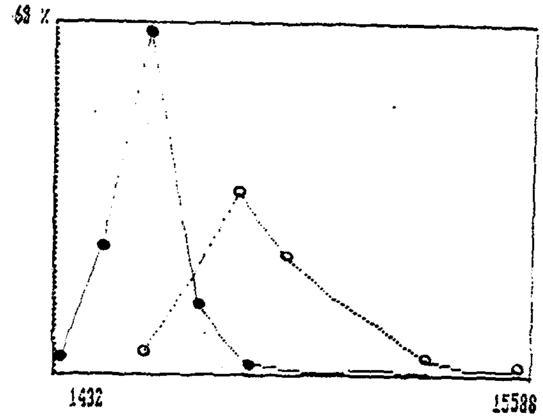
APRIL 1990 (4) - SEP 1990 (3)
(o——o) (●——●)



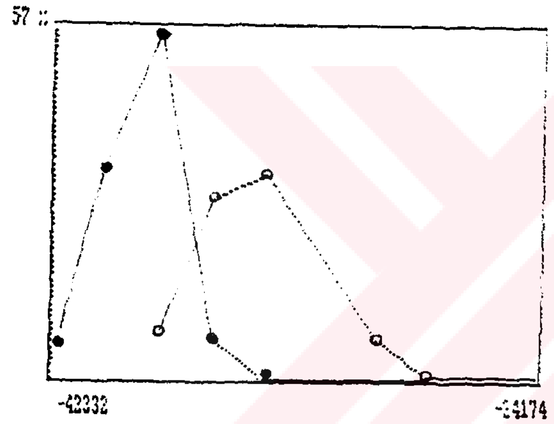
APRIL 1990 (4) - SEP 1990 (4)
(o——o) (●——●)



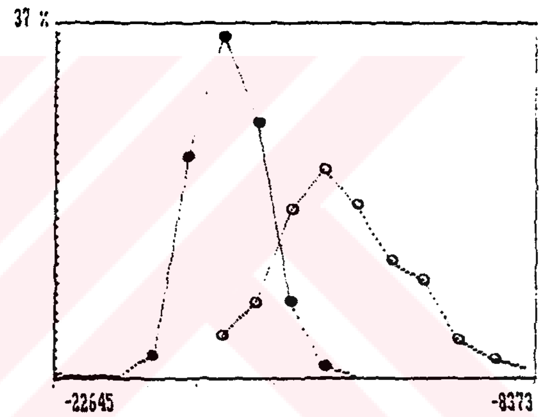
APRIL 1990 (4) - SEP 1991 (4)
(○—○) (●—●)



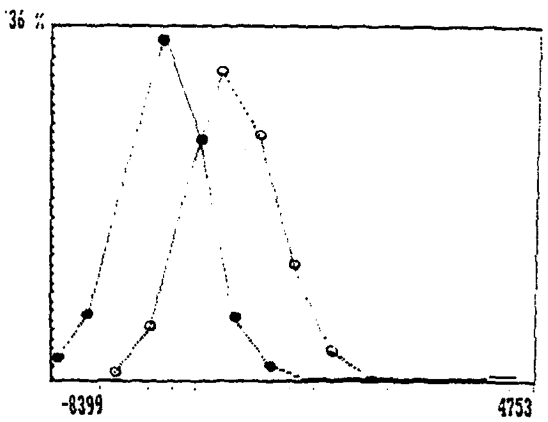
APRIL 1990 (4) - SEP 1991 (5)
(○—○) (●—●)



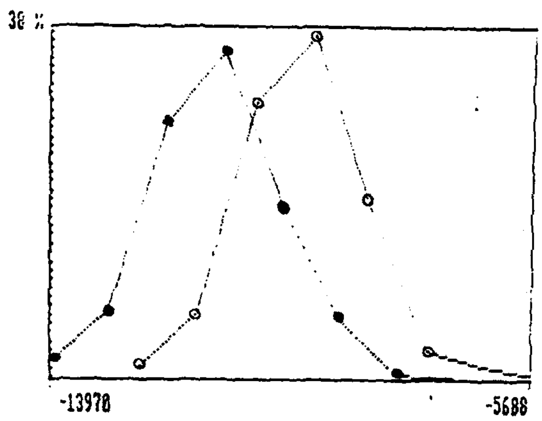
APRIL 1990 (4) - OCT 1992 (4)
(○—○) (○—○)



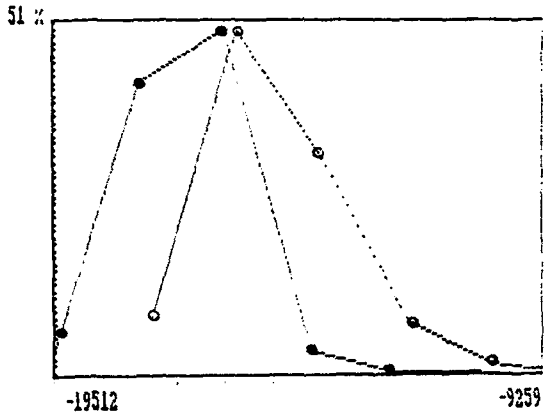
APRIL 1990 (4) - OCT 1992 (5)
(○—○) (●—●)



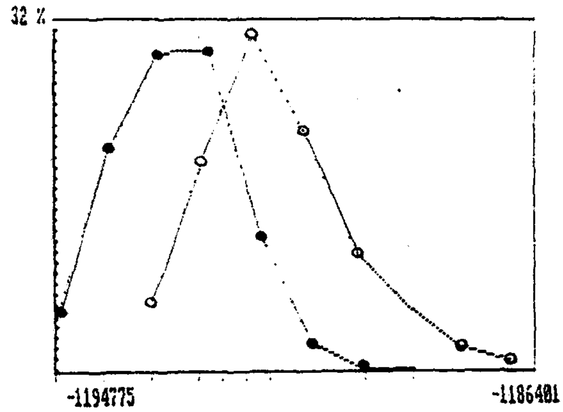
SEP 1990 (1) - SEP 1991 (4)
(○—○) (●—●)



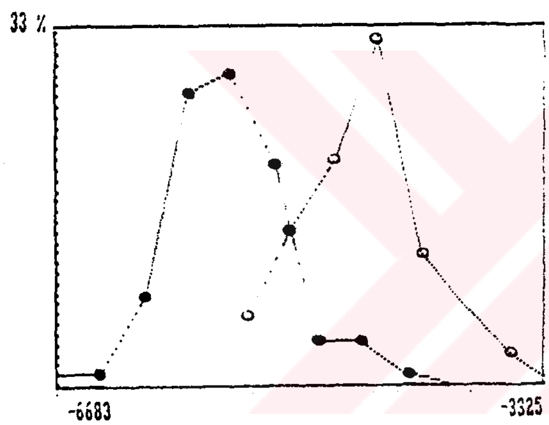
SEP 1990 (1) - SEP 1991 (5)
(○—○) (●—●)



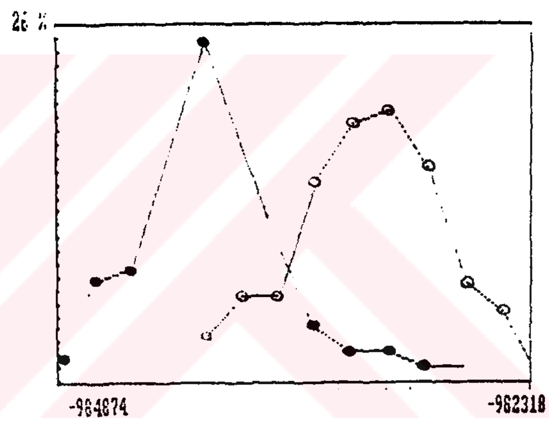
SEP 1990 (1) - OCT 1992 (4)
(o—o) (●—●)



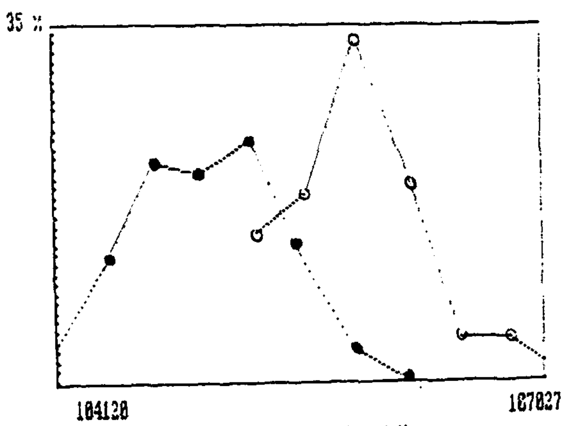
SEP 1990 (1) - OCT 1992 (5)
(o—o) (●—●)



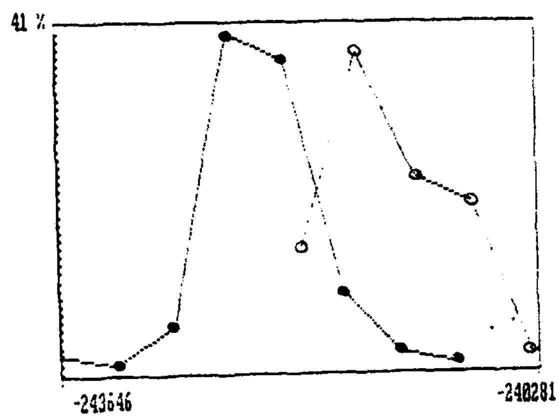
SEP 1990 (2) - SEP 1991 (4)
(o—o) (●—●)



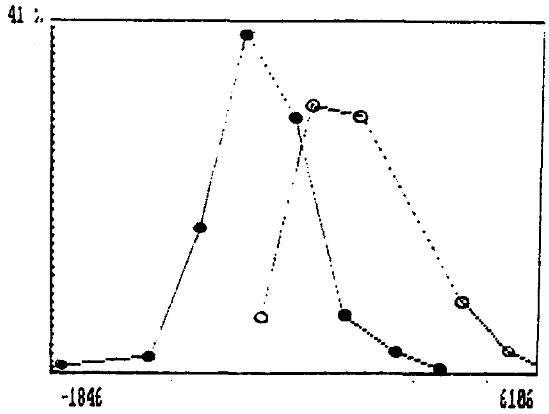
SEP 1990 (2) - SEP 1991 (5)
(o—o) (●—●)



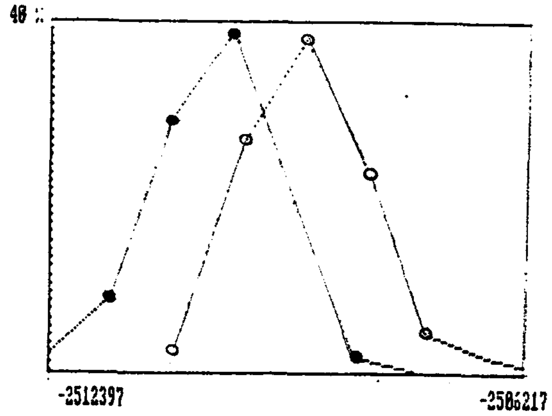
SEP 1990 (2) - OCT 1992 (4)
(o—o) (●—●)



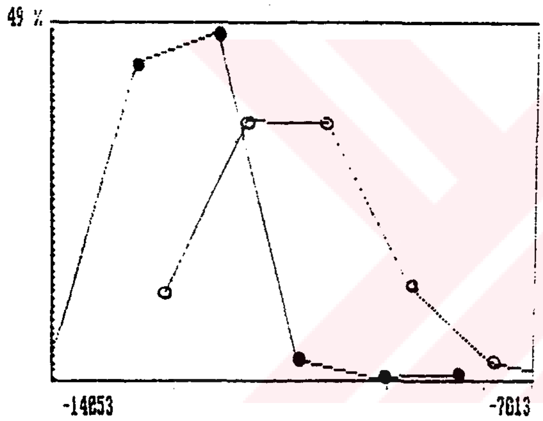
SEP 1990 (2) - OCT 1992 (5)
(o—o) (●—●)



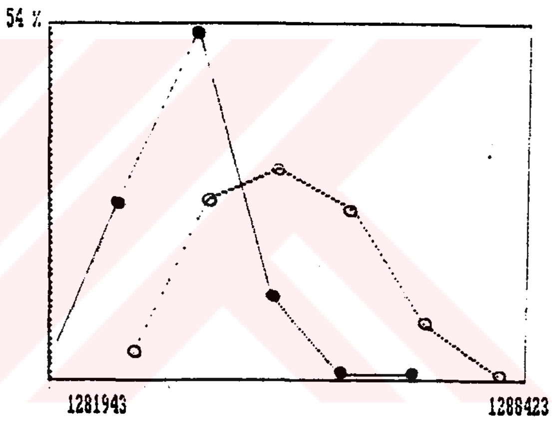
SEP 1990 (3) - SEP 1991 (4)
(o——o)   (●——●)



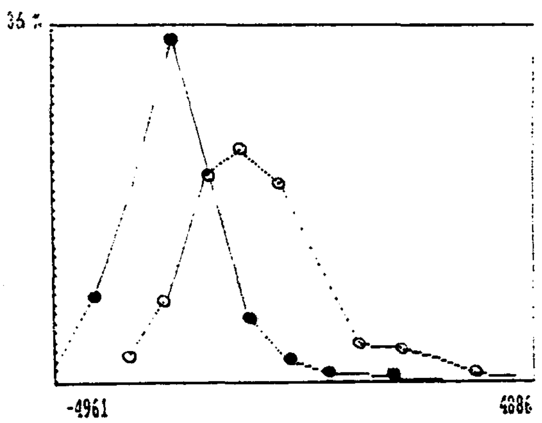
SEP 1990 (3) - SEP 1991 (5)
(o——o)   (●——●)



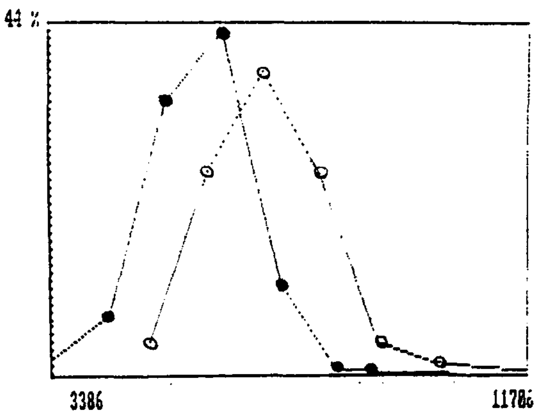
SEP 1990 (3) - OCT 1992 (4)
(o——o)   (●——●)



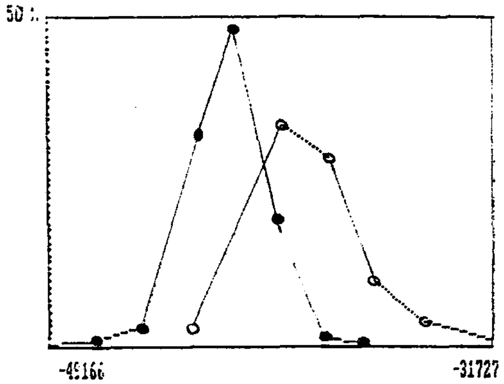
SEP 1990 (3) - OCT 1992 (5)
(o——o)   (●——●)



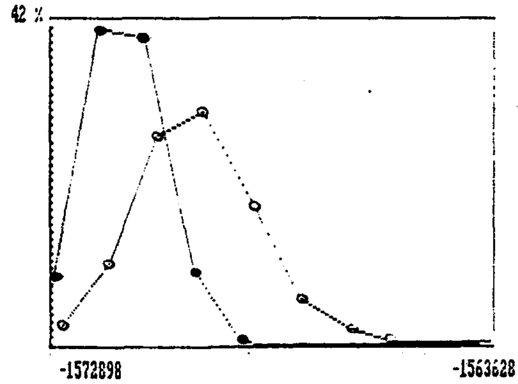
SEP 1990 (4) - SEP 1991 (4)
(o——o)   (●——●)



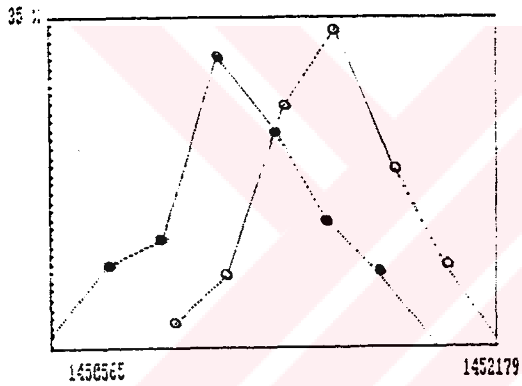
SEP 1990 (4) - SEP 1991 (5)
(o——o)   (●——●)



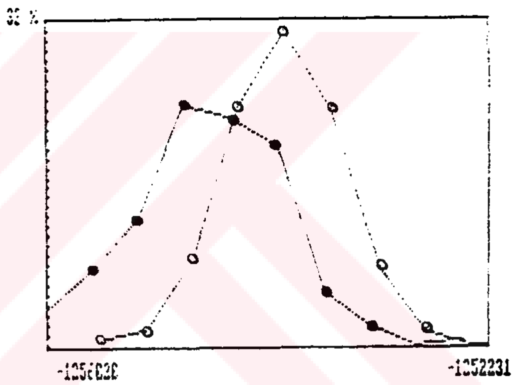
SEP 1990 (4) - OCT 1992 (4)
(o——o) (●——●)



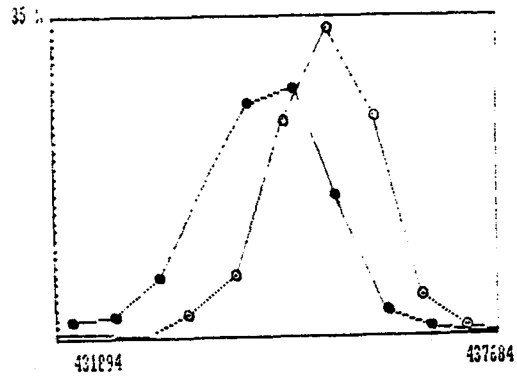
SEP 1990 (4) - OCT 1992 (5)
(o——o) (●——●)



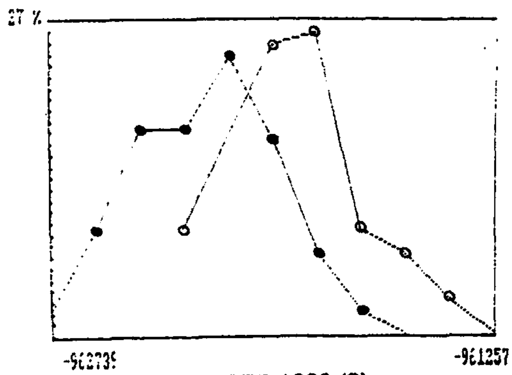
SEP 1990 (1) - SEP 1990 (2)
(o——o) (●——●)



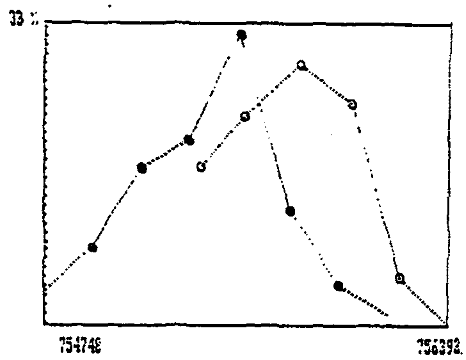
SEP 1990 (1) - SEP 1990 (3)
(o——o) (●——●)



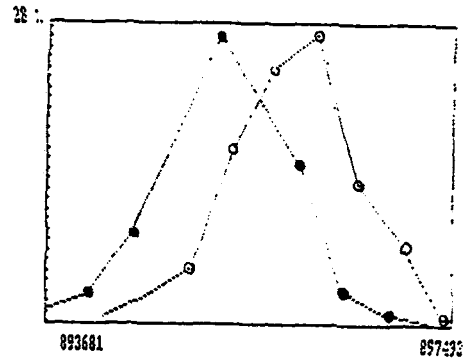
SEP 1990 (1) - SEP 1990 (4)
(o——o) (●——●)



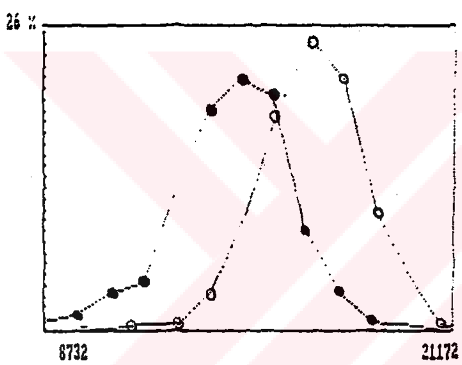
SEP 1990 (2) - SEP 1990 (3)
(o——o) (●——●)



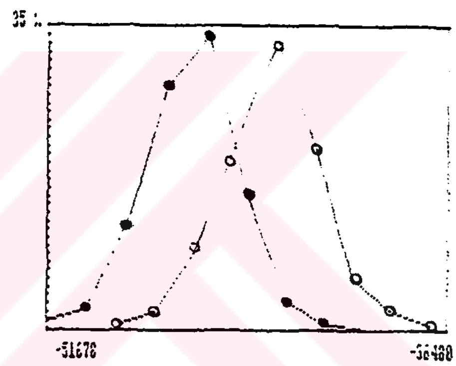
SEP 1990 (2) - SEP 1990 (4)
(o—o) (●—●)



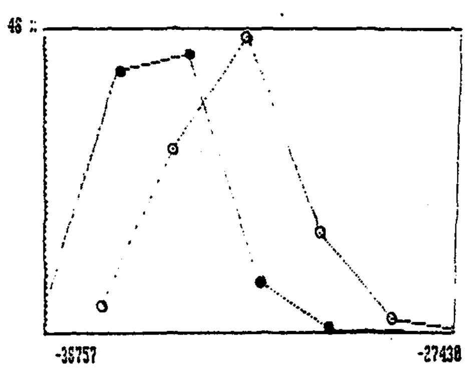
SEP 1990 (3) - SEP 1990 (4)
(o—o) (●—●)



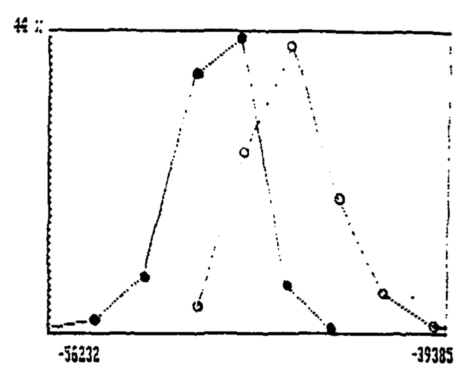
SEP 1991 (4) - SEP 1991 (5)
(o—o) (●—●)



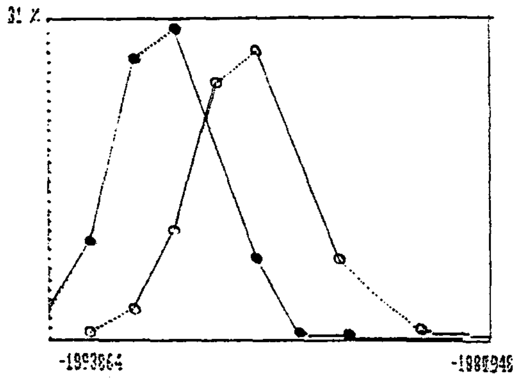
SEP 1991 (4) - OCT 1992 (4)
(o—o) (●—●)



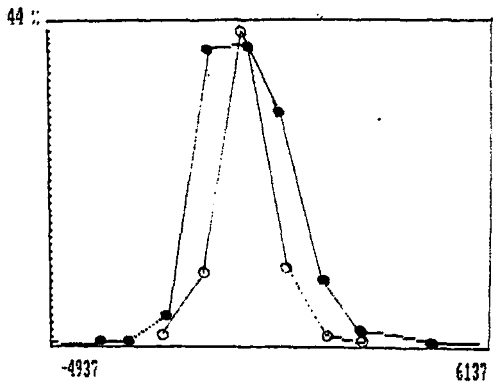
SEP 1991 (4) - OCT 1992 (5)
(o—o) (●—●)



SEP 1991 (5) - OCT 1992 (4)
(o—o) (●—●)



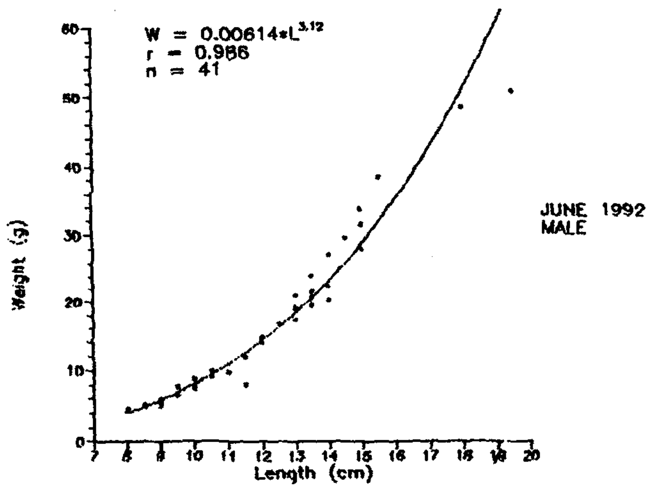
SEP 1991 (5) - OCT 1992 (5)
(○——○) (●——●)

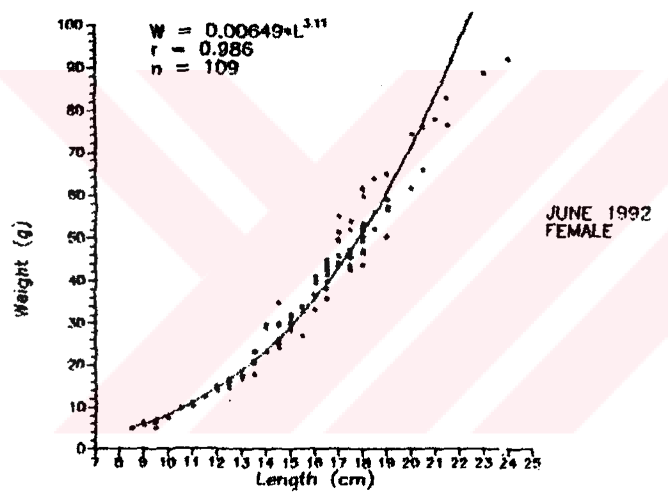


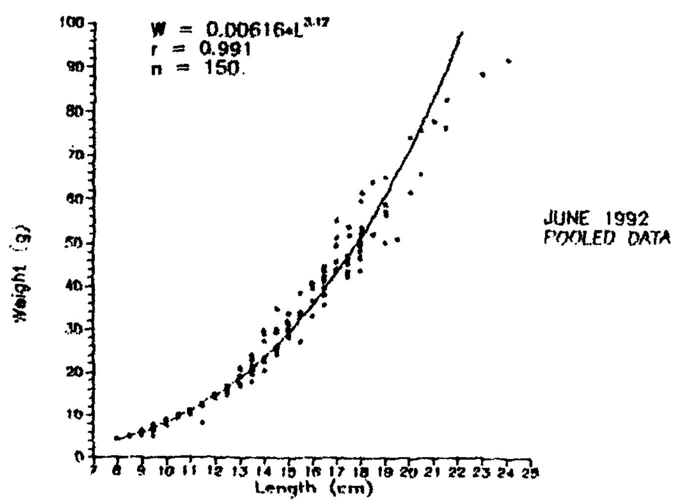
OCT 1992 (4) - OCT 1992 (5)
(○——○) (●——●)

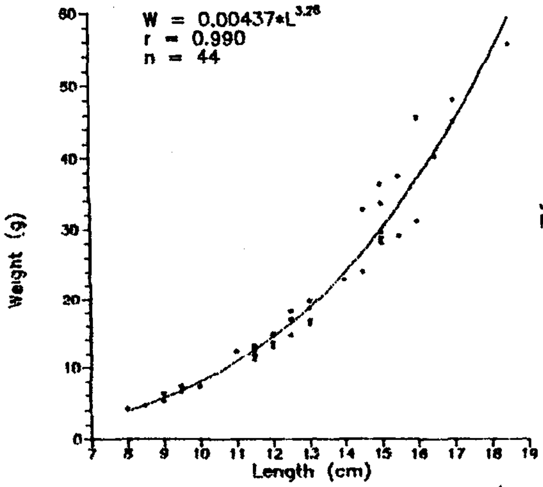
APPENDIX C

The length-weight relationships for each sex group and their pooled data collected from the eastern Black Sea (Havaalanı, Beşikdüzü, Sürmene) between June 1992 and May 1993.

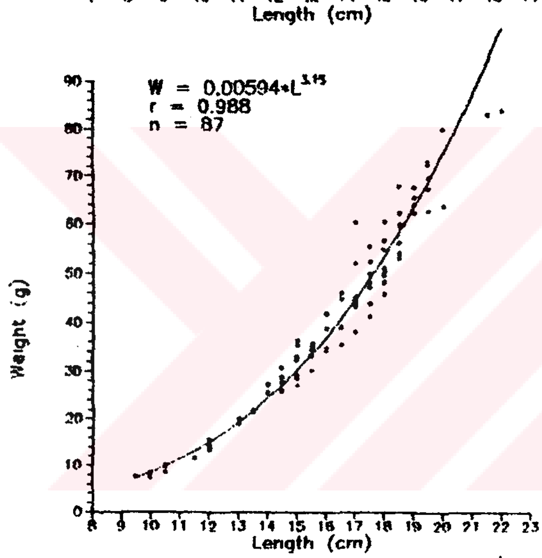




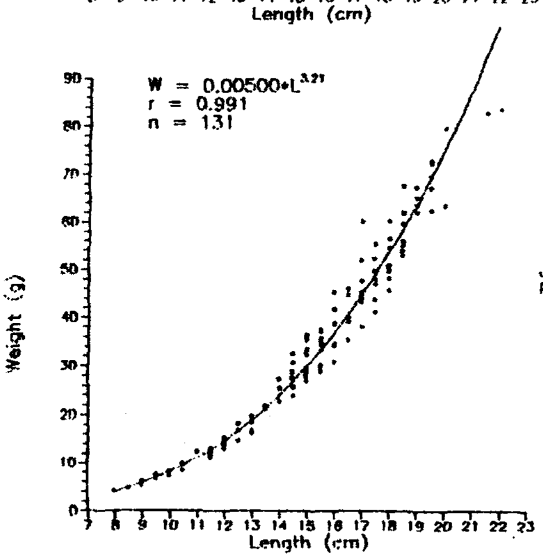




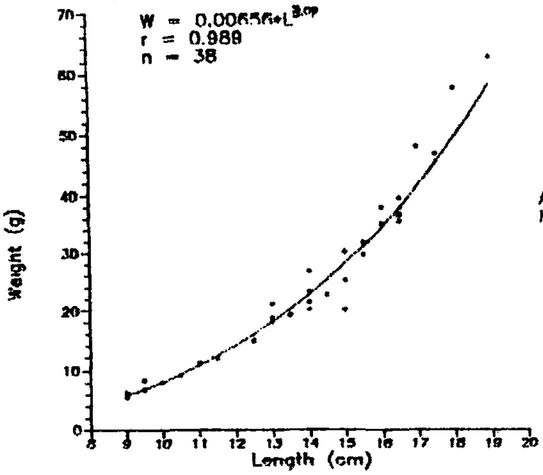
JULY 1992
MALE



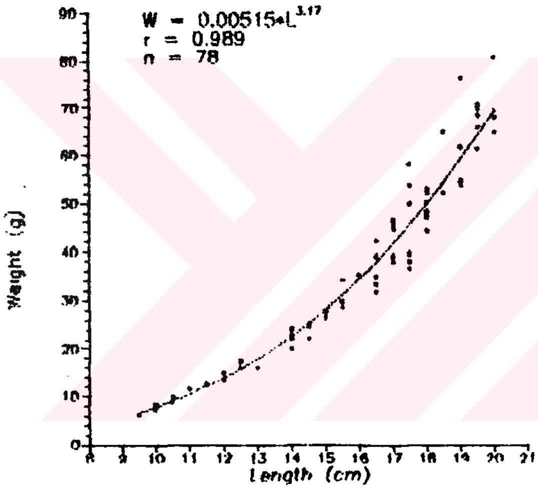
JULY 1992
FEMALE



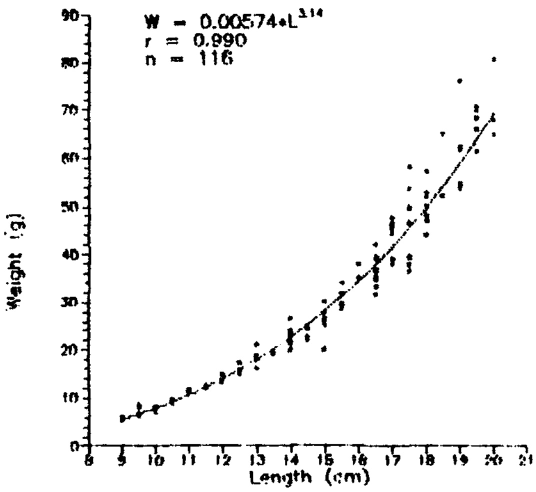
JULY 1992
POOLED DATA



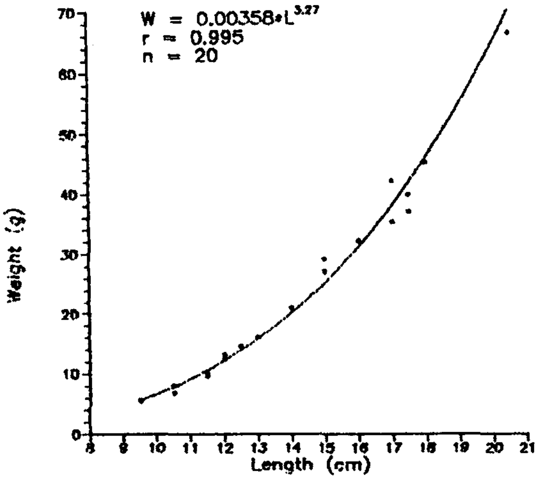
AUGUST 1992
MALE



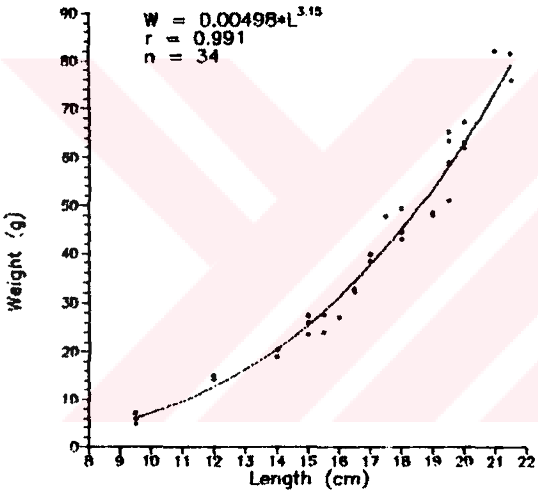
AUGUST 1992
FEMALE



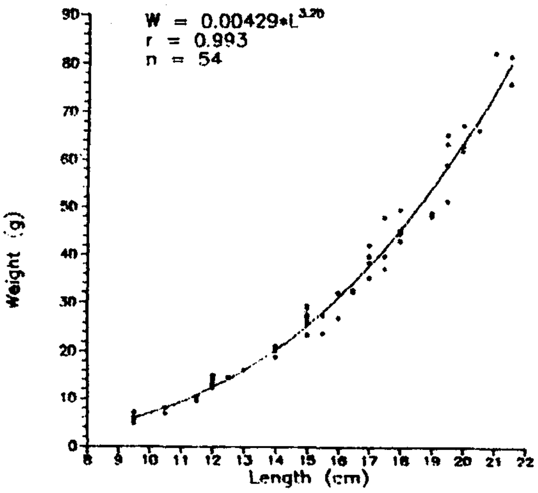
AUGUST 1992
POOLED DATA



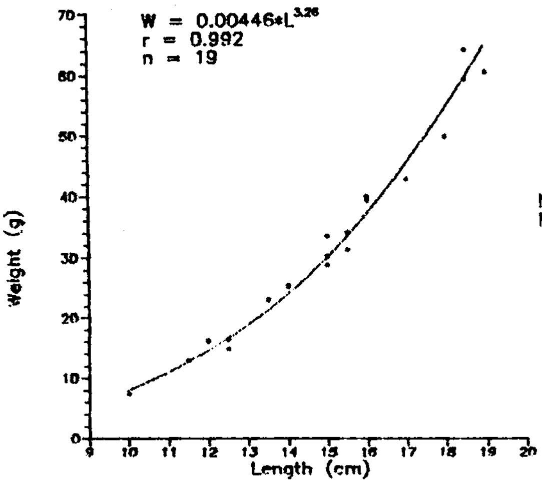
OCTOBER 1992
MALE



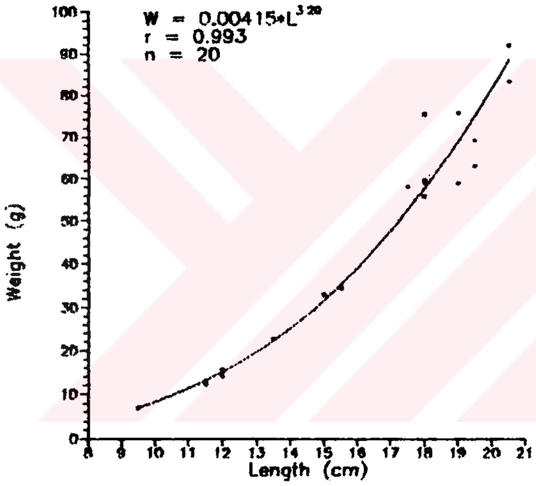
OCTOBER 1992
FEMALE



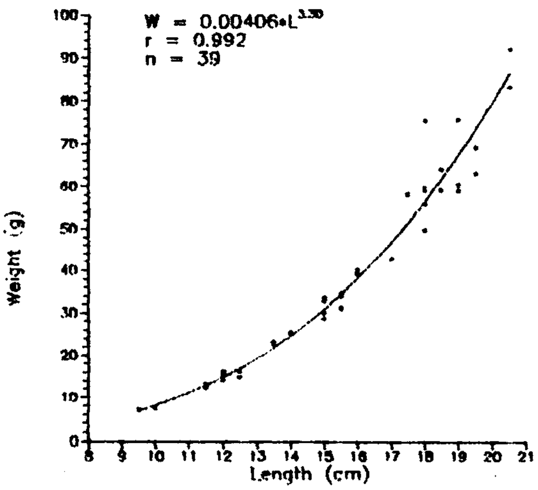
OCTOBER 1992
POOLED DATA



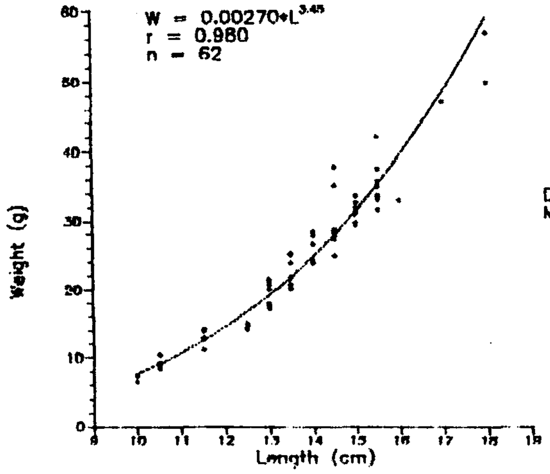
NOVEMBER 1992
MALE



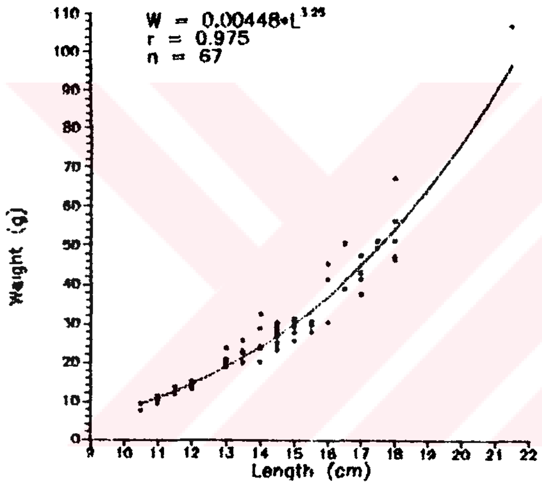
NOVEMBER 1992
FEMALE



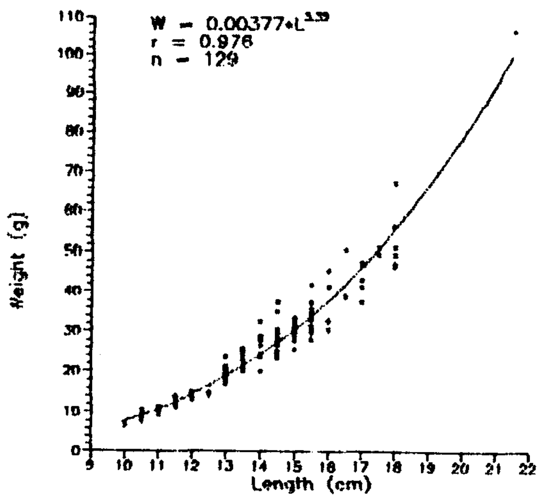
NOVEMBER 1992
POOLED DATA



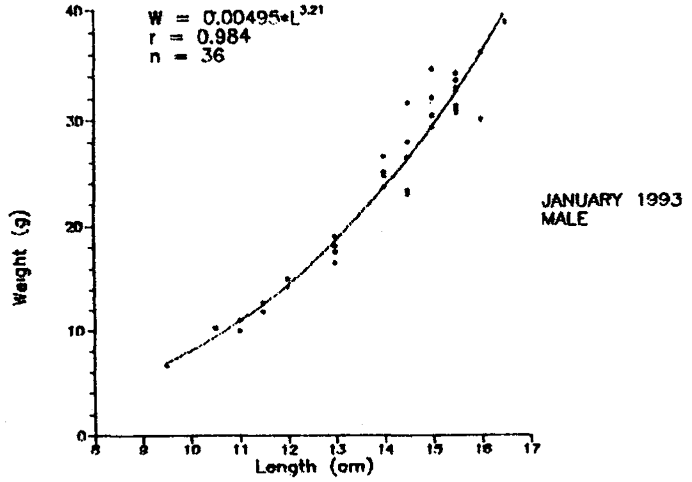
DECEMBER 1992
MALE

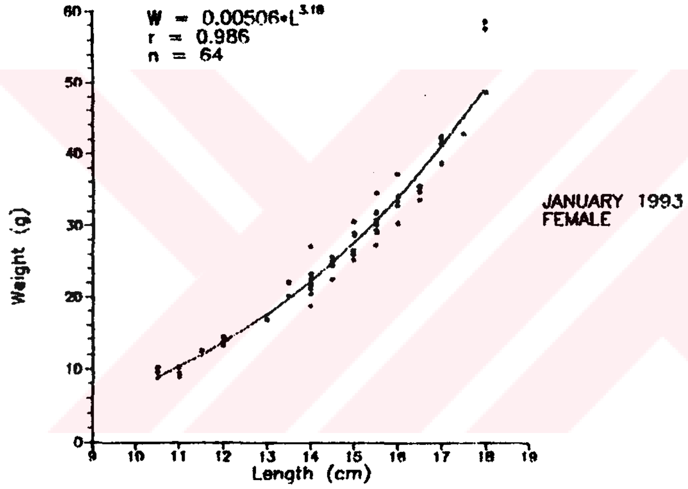


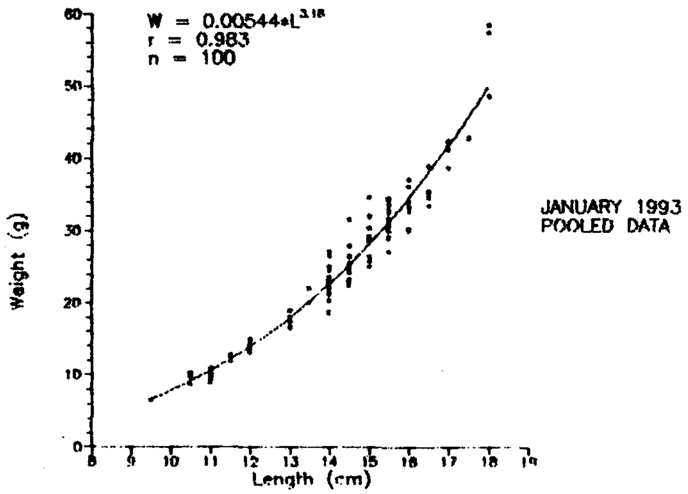
DECEMBER 1992
FEMALE

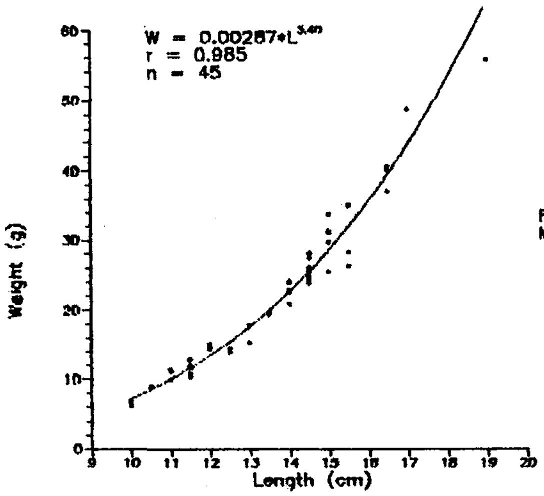


DECEMBER 1992
POOLED DATA

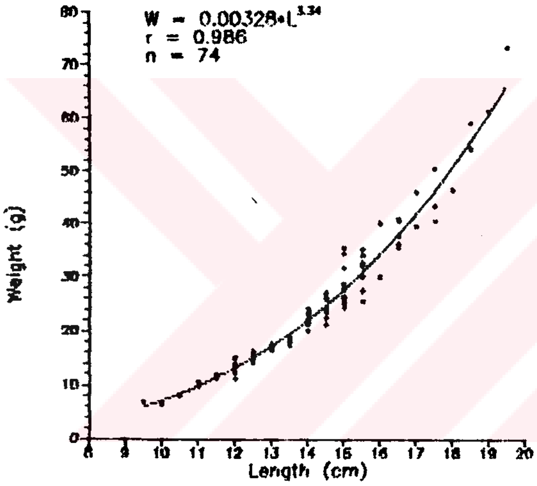

W = 0.00495*L^3.21
r = 0.984
n = 36
Weight (g)
Length (cm)
JANUARY 1993
MALE


W = 0.00506*L^3.19
r = 0.986
n = 64
Weight (g)
Length (cm)
JANUARY 1993
FEMALE

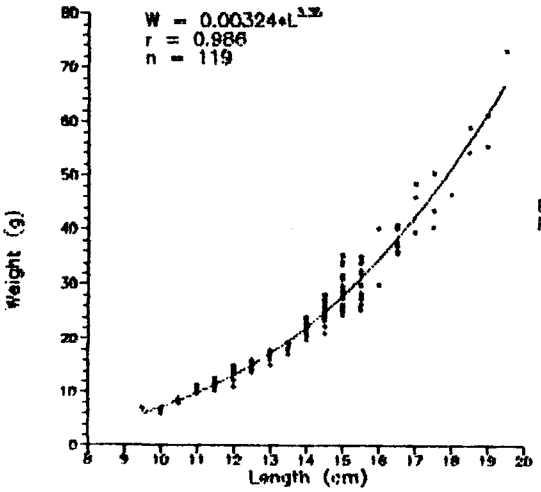

W = 0.00544*L^3.16
r = 0.983
n = 100
Weight (g)
Length (cm)
JANUARY 1993
POOLED DATA



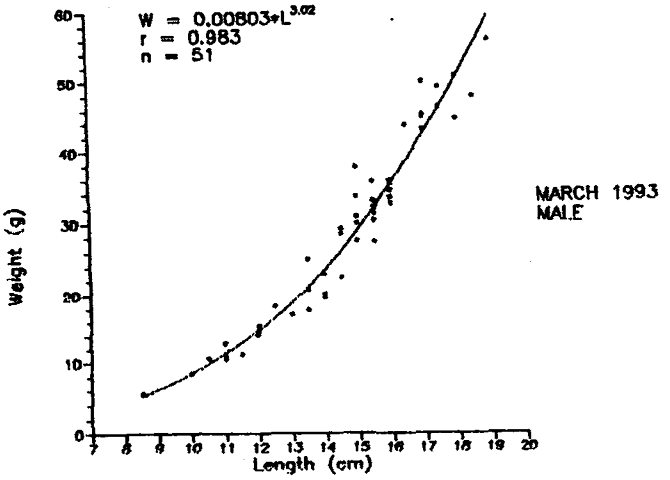
FEBRUARY 1993
MALE

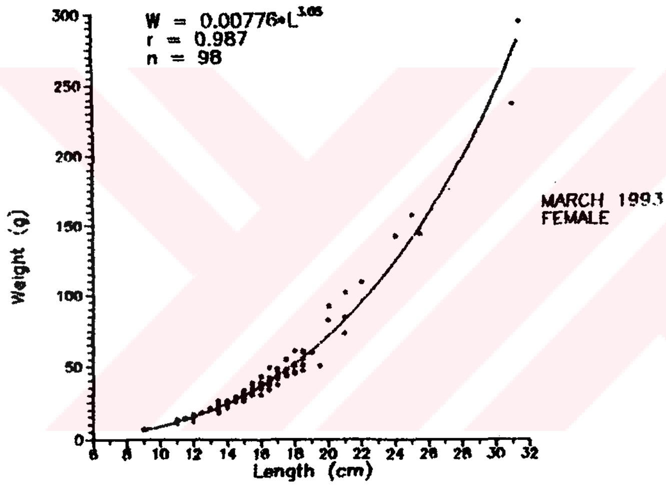


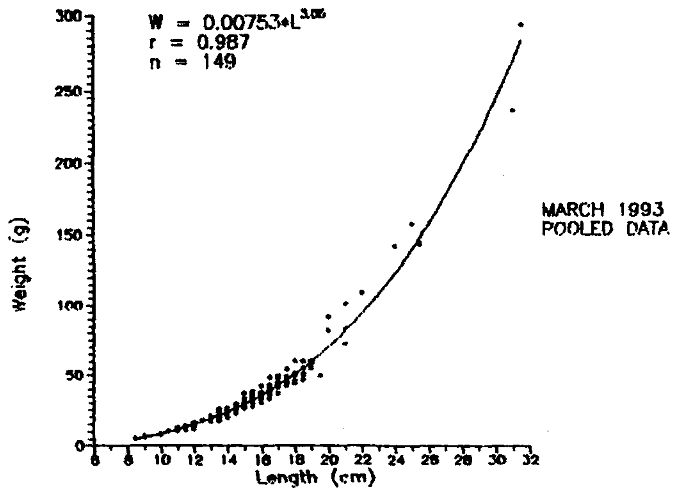
FEBRUARY 1993
FEMALE

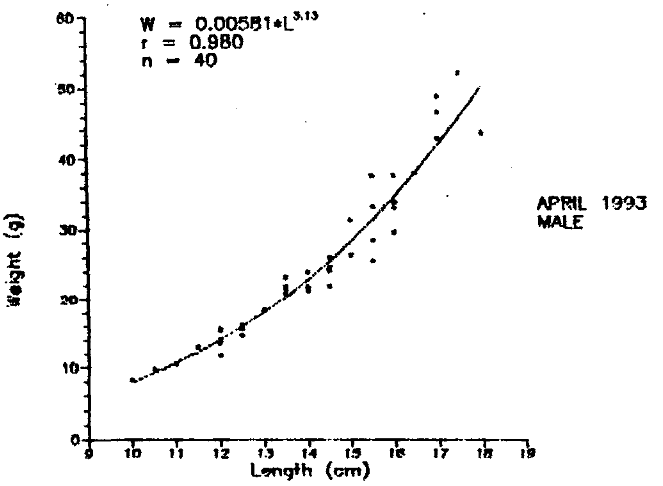


FEBRUARY 1993
POOLED DATA

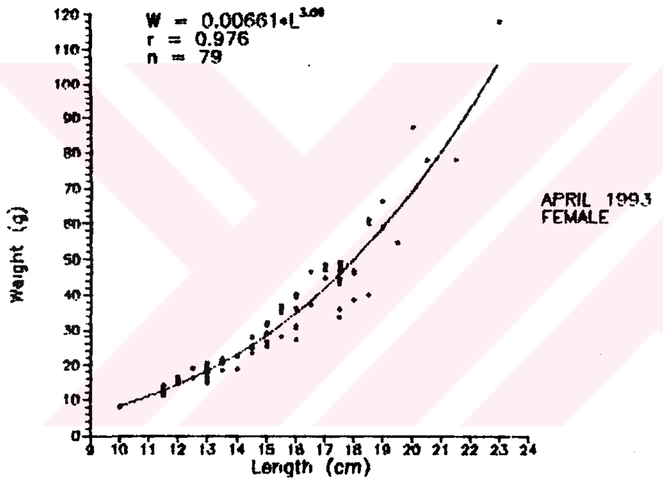

W = 0.00803*L^3.02
r = 0.983
n = 51
MARCH 1993
MALE
Weight (g)
Length (cm)


W = 0.00776*L^3.05
r = 0.987
n = 98
MARCH 1993
FEMALE
Weight (g)
Length (cm)

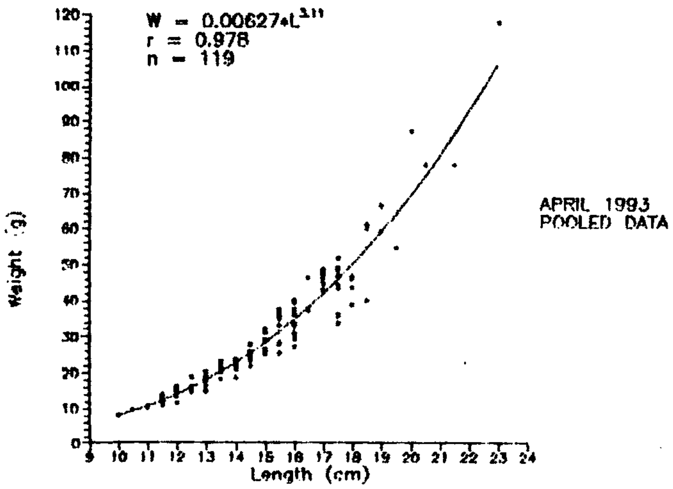

W = 0.00753*L^3.05
r = 0.987
n = 149
MARCH 1993
POOLED DATA
Weight (g)
Length (cm)



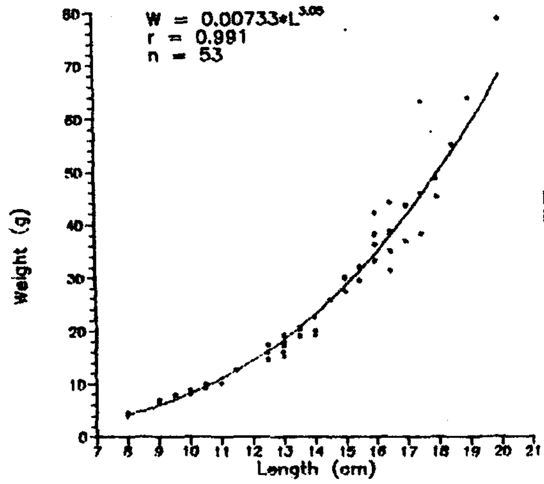
W = 0.00581*L^3.13
r = 0.980
n = 40
Weight (g)
Length (cm)
APRIL 1993
MALE



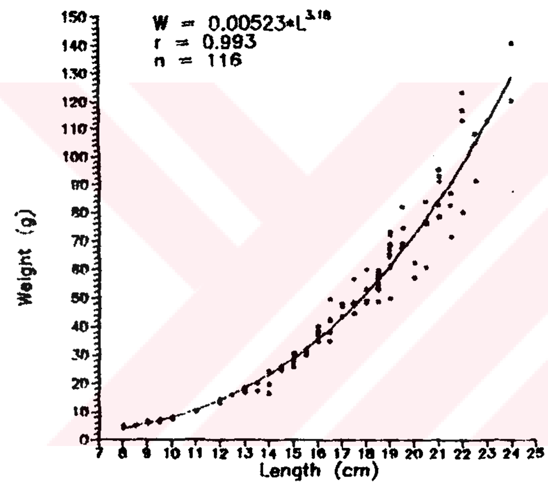
W = 0.00661*L^3.09
r = 0.976
n = 79
Weight (g)
Length (cm)
APRIL 1993
FEMALE



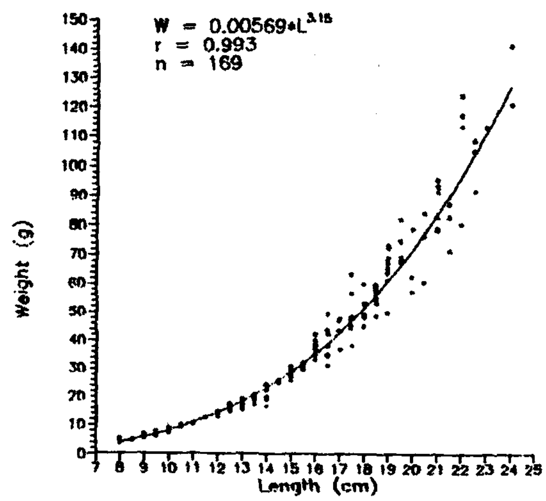
W = 0.00627*L^3.11
r = 0.978
n = 119
Weight (g)
Length (cm)
APRIL 1993
POOLED DATA



MAY 1993
MALE



MAY 1993
FEMALE



MAY 1993
POOLED DATA

APPENDIX D

[illegible]andings (in tonnes) of whiting in the Turkish Black Sea region in the years 1968-1992.

Years	western	eastern	total
1968	101	4,426	4,527
1969	155	4,574	4,729
1970	125	8,987	9,112
1971	45	5,501	5,546
1972	41	5,023	5,065
1973	523	1,735	2,257
1974	138	2,510	2,648
1975	381	3,437	3,818
1976	159	4,054	4,213
1977	875	4,851	5,726
1978	1,265	20,000	21,265
1979	778	20,000	20,778
1980	1,043	5,795	6,838
1981	1,918	2,751	4,669
1982	1,751	2,513	4,264
1983	4,045	7,651	11,696
1984	5,856	5,739	11,595
1985	4,948	11,088	16,036
1986	3,140	14,598	17,738
1987	4,798	22,305	27,103
1988	3,008	25,255	28,263
1989	4,075	15,208	19,283
1990	2,634	13,625	18,950
1991	7,642	11,314	22,694
1992	4,929	12,994	20,197