FISHERY AND POPULATION DYNAMICS OF CASPIAN KUTUM,

Rutilus frisii kutum **(CYPRINIDAE), IN THE CASPIAN SEA**

by

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Thesis submitted in fulfillment of the requirements

for the degree of

Doctor of Philosophy

October 2010

ACKNOWLEDGEMENT

All praises to Allah Almighty whose countless blessings enabled me to complete this thesis. The Iranian Fisheries Research Organization (IFRO) and Agriculture Training Research Organization (ATRO) supported this study. The materials were obtained from a my province project entitle “Age, growth, feeding items, and reproductive of *Rutilus frisii kutum* in the Caspian Sea’’ performed with cooperation at the Caspian Sea Ecological Research Center in Sari, Inlandwaters Aquaculture Research Center in Guilan, and Inlandwaters Aquatic Stock Research Center in Golestan provinces. Thanks are due to the previous and now managers of the Agriculture Training Research Organization (ATRO) Dr. Khalghani and Dr. Pourhemat and to the head of the Iranian Fisheries Research Oraganization (IFRO) Dr. Motalebi, for financial support.

I am very grateful to my supervisor, Prof. Mashhor Mansor who always gives me constructive advices, guidance, encouragement, critical reading, and moral support during the research of my thesis, thank you so much. My former co-supervisor, Dr. Khoo Kay Huat, thank you for your help especially on fish physiology and ecology. I would like to thanks my co-supervisors, associate Prof. Dr. Shahrul Anuar Mohd Sah and Dr. Mansor Mat Isa for their constrictive comments and suggestions during this the completion of thesis.

I would like to express thanks to my field co-supervisor, Dr. Shahram Abdolmaleki from Inlandwater Aquaculture Research Center in Anzali for his continual supporting, guidance and reading the thesis while completed my graduate studies.

I am grateful to the president of the Caspian Sea Ecology Research Center, Dr. Pourgholam, for assistance and support in execute my project and my study. I would like to thanks my entire department colleague, Dr. Hassan Fazli, Ens. Mehdi Moghim, Hassan Molaei, Aliasghar Janbaz, Abdollah Hashemian, Hossein Taleshian, Davod Kor, Khodadad Shabani, Reza Daryanabard, Mr. Faramarz Bagheri, Mr. Pourmand for cooperation; Ens Mohammad Taghi Rostamian and Ali Ganjian for identify plankton groups, Ens. Kambiz Khedmati and Behroz Nahrevar from Inlandwater Aquaculture Research Center of Guilan, and Ens. Gholamali Bandani and Mohammad Larijani from Inlandwater Aquatic Stock Research Center of Golestan for data collectionhe. I would like to thank Dr. Farhad Keymaram, Dr. Shahram Ghasemi, Dr. Farokh Parafkandeh Haghighi from Iranian Fisheries Research Oraganization (IFRO) for assistance, cooperation in executing this project and support on time money for purchase fish. I thank Dr. Hassan Nasrolahzade for guidance and moral support. I would like to thank Dr. Bani and Dr. Heidari from Fisheries department, faculty of natural resources, University of Guilan, Swomeh-Sara for preparing gonads histology.

Last but not least, I must thank my devoted wife (*FIROZEH*), my lovely daughter (*FAEZEH*) and my darling son (*AMIR REZA*) for their moral supports, patiences and tolerate my problems during study. I also thank my beloved mother for her prayers.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Description
°C	Degree centigrade
♀	Female
♂	Male
‰	Parts per thousand
AFC	Average fixed cost
ANIS	Average number of fish in the sea
AVC	Average variable cost
B′/R	Biomass per recruitment
CDFA	Canonical discriminate function analysis
CEP	Caspian Sea environment program
CF	Fulton condition factor
Cm	Centimeter
CPUE	Catch per unit effort
E	Exploitation rate
$E_{0.1}$	The value of E at which marginal increase in Y′ */R* is 10% o its value at *E=0*
$E_{0.5}$	The value of E at 50% of the unexploited relative *B'/R*
E_{max}	The value of *E* given maximum relative *Y'/R*
F	Instantaneous fishing mortality coefficient
FAO	Food and agriculture organization
F_i	Frequency of occurrence
FiSAT	FAO-ICLARM stock assessment tools
FL	Fork length
Fp	Frequency of percentage
GaSI	Gastrosomatic Index
GSI	Gonadosomatic index
H´	Shannon-Wiener diversity index
ICES	International council for the exploration of the Sea
IFRO	Iranian fisheries research organization
IRI	Index of relative importance

ISI	Important species index
K	Growth rate per unit of time
$\bar{L}$	Mean length of all fish
L'	Smallest length of fully recruited fish (cut off length)
L_∞	Asymptotical length
L_m	Size at 50% maturity
L_{max}	Maximum length
L_t	The length of the fish at age t
M	Instantaneous natural mortality coefficient
M	Number of stomachs containing food
MCS	Monitoring, control and surveillance
MEY	Maximum economic yield
M_i	Number of stomachs containing prey component i
MSY	Maximum sustainable yield
N_Σ	Total number of prey detected
N_i	Number of prey specimen of prey group i
$\acute{\phi}$	Growth performance index
oC	Degree centigrad
P	Mature proportion in each size classes
PFC	Pare fishing cooperative
Q	Break-even point
S	Survival rate
SHILAT	Iranian fisheries organization
t_0	Theoretical age
T_c	Age-at-first capture
TC	Total fixed and variable cost
TFC	Total fixed cost
t_{max}	Maximum age
TVC	Total variable cost
USSR	Union of Soviet Socialist Republics
VBG	von Bertalanffy growth
VBGF	von Bertalanffy growth function
W	Weight
W_Σ	Total weight of prey detected

Wi	Weight of prey group *i*
Y	Yield
Y′/R	Yield per recruitment
Z	Instantaneous total mortality coefficient

PERIKANAN DAN DINAMIK POPULASI KUTUM CASPIAN,

***Rutilus frisii kutum* DI LAUT CASPIAN**

ABSTRAK

Laut Caspian merupakan tasik terbesar di dunia. Airnya tidak begitu masin atau payau. Tujuam projek ini dijalankan untuk menentukan panjang-matang (length maturity) Lm_{50}%, menilai item makan, menyelidik beberapa aspek biologi termasuklah nisbah jantina, pertumbuhan dan struktur umur, pekali mortaliti seketika, hasil kelestarian maksimum (MSY) dan titik pulang modal bagi *Rutilus frisii kutum* yang terdapat di Selatan Laut Caspian. Spesimen Kutum dikumpul daripada tangkapan di 131 buah tapak sampel, sepanjang perairan Iran di Laut Caspian.

Panjang cabang dan berat yang minimum dan maksimum adalah 21 dan 58cm dengan min 38.4±6.3 cm; 104 dan 2450g dengan min 775.2±382.5 g, masing-masing. Nisbah jantan dan betina adalah 0.65: 1 (jantan: betina). Faktor keadaan di Guilan adalah melebih jika dibandingkan dengan di Mazandaran dan wilayah Golestan. Panjang-matang ($L_{m50\%}$) Kutum mencapai 39.1 cm. Kefekunan mutlak minimum dan maksimum didapati berubah-ubah iaitu daripada 15,713 kepada 130,737 biji telor dengan min 69,961.7±3,836.4. Fasa pembaikan bertambah panjang iaitu daripada Februari-April. Pembiakan puncak adalah pada Mac, dengan nilai purata tertinggi 5.52 bagi jantan dan April dengan purata tertinggi 17 bagi betina. Disebabkan itulah, migrasi jantan daripada laut ke sungai lebih cepat daripada betina.

Diet terdiri daripada mangsa yang berbeza, dwicengkerang mewakili kumpulan mangsa paling penting (59%), dan diikuti oleh *Cerastoderma lamarki*

(57%). Kadar mortaliti seketika semula jadi dianggarkan M= 0.46 y^{-1}. Berdasarkan pekali mortaliti seketika total (Z) daripada keluk tangkapan ikan yang berbeza panjang berdasarkan musim, diperoleh F (pekali mortaliti perikanan seketika) sebagai 0.82 y^{-1} melalui perkaitan: F=Z-M, dan memberikan kadar eksploitasi semasa E (=F/Z) sebagai 0.64 y^{-1}. Length-at-first capture dan age-at-first capture adalah L_c = 36.8 cm dan 3.92 tahun, masing-masingnya.

Hasil kelestarian maksimum (*MSY*) berdasarkan analisis kohort bagi Kutum diperoleh sebagai *MSY*= 20,004 tan dengan biojisim *B* adalah 51,937 tan. Prosedur ogif pilihan memberikan ringkasan berikut: E_{max}=0.76, $E_{0.1}$= 0.65, $E_{0.5}$= 0.39. Hasil per analisis mencadangkan bahawa stok spesies ini mempunyai kadar eksploitasi yang sederhana E=0.64. Kutum menyumbang lebih kurang 76% daripada jumlah ikan bertulang yang dijual di utara Laut Caspian, dan jumlah pendapatan daripada jualan Kutum dianggarkan sebanyak US$ 30,415,998. Pendapat nelayan melalui jualan *R. f. kutum* daripada jumlah pendapatan ikan bertulang adalah 74% di Guilan, 85.8% di Mazandaran, dan 26% di wilayah Golestan. Oleh itu, *R. f. kutum* memainkan peranan yang signifikan dalam pendapatan nelayan di perairan selatan Laut Caspian. Titik pulangan modal daripada Kutum diperoleh dengan min 19,220±5,364.5 di Guilan, 18,843±4,989.2 di Mazandaran, dan 10,677±1,358.2 di wilayah Golestan, yang disertai dengan usaha menangkap ikan, nisbah tangkapan, jumlah koperasi perikanan, dan jumlah buruh.

FISHERY AND POPULATION DYNAMICS OF CASPIAN KUTUM, *Rutilus frisii kutum*, IN THE CASPIAN SEA

ABSTRACT

The Caspian Sea is the largest enclosed body of water in the world. The water is slightly brackish. The aim of project was to determine length at maturity (Lm_{50}%), evaluate of feeding items, investigation some of biological aspects included in sex ratio, growth and age structure, instantaneous mortality coefficient, maximum sustainable yield (MSY) and break-even point of *Rutilus frisii kutum* in southern part of the Caspian Sea. Specimens of Kutum were collected from the catches obtained from 131 sample sites along the Iranian coast of the Caspian Sea.

The minimum and maximum fork length and weight was 21cm and 58cm with mean 38.4±6.4 cm; 104 and 2450 g with mean 775.2±382.5 g, respectively. The sex ratio of males to females was 0.65: 1 (males: females). The condition factor in Guilan was more than Mazandaran and Golestan provinces. The length at maturity ($L_{m50\%}$) of Kutum obtained was 39.1cm. The minimum and maximum absolute fecundity varied from 15,713 to 130,737 eggs with mean 69,961.7±3,836.4. The reproduction phase was extended from February to April, peak in March, with the highest average values 5.52 for males and the highest value was 17.00 for the females in April. Due to males' migration from sea to river occurred sooner than that of the females.

The diet consisted of different prey items, bivalves representing the most important prey group (59%), and followed by *Cerastoderma lamarki* (57%). The

instantaneous natural mortality rate was estimated M= 0.46 y^{-1}. Based on total instantaneous mortality coefficient (Z) from the seasonalized length-converted catch curve, F (the instantaneous fishing mortality coefficient) as 0.82 y^{-1} through the relationship: $F=Z-M$, and giving a current exploitation rate E (=F/Z) as 0.64 y^{-1}. The length-at-first capture and age-at-first capture was obtained L_c =36.8 cm and 3.92 years, respectively.

The Maximum sustainable yield (MSY) based on cohort analysis for Kutum resulted MSY=20,004 tonnes with biomass B of 51,937 tonnes. The selection ogive procedure gave the following summary: E_{max}=0.76, $E_{0.1}$=0.65 and $E_{0.5}$=0.39. Yield per recruit analysis suggests that the stock of this species has a moderately exploitated at E=0.64. Kutum contributed about 76% of total sell bony fish in south of the Caspian Sea and total income of Kutum sell were estimated US$30,415,998. The income of the fishermen through selling of *Rutilus frisii kutum* from total bony fish income was 74% for Guilan, 85.8% for Mazandaran, and 26% for Golestan provinces. Therefore, *R. f. kutum* plays a significant role in fishermen's income in southern coasts of the Caspian Sea. The break-even point of Kutum obtained with mean 19,220±5,364.5 for Guilan, 18,843±4,989.2 for Mazandaran, and 10,677±1,358.2 for Golestan provinces, which coincided with the fishing effort, catch ratio, number of fishing cooperatives, and number of labour.

CHAPTER 1

GENERAL INTRODUCTION

1.1 History and Background of the Caspian Sea

The Caspian Sea is one of the biggest lakes in the world and uniquely has no outlet. There are five countries bordering the shores of the lake namely Iran, Azerbaijan, Russia, Kazakhstan, and Turkmenistan (Figure 1.1). According to Kosarev and Yablonskaya (1994) the recent Caspian Sea originated as part of an ancient, brackish Pontic lake-sea 5-6 million years ago. In the late Mezozoic and Early Paleocene, the ancient Tethys Sea covered the areas now occupied by the present Mediterranean, Black, Caspian, and Aral seas. During Paleocene and Neocene times, the Black and Caspian seas were joined and separated several times. In the early Pliocene, the Caspian Sea was separated for the first time from the Black Sea and, the primary marine fauna was party eliminated and party modified. During the Mid-Pliocene, the Caspian Sea was completely isolated from the Black Sea and since that time the two basins, and their fauna, has developed independently. The typical brackish water Caspian fauna formed at this time has persisted to the present day.

Based on CEP (2002) the Caspian Sea is the largest inland water body with no connection to world oceans, occupying a deep depression on the boundary of Europe and Asia with a water level at present of approximately 27 m below the level of the world Oceans. Having been isolated from the world oceans at the end of the Pliocene epoch 1.8 million years ago, its ecosystem incorporates remnants of the fauna of the larger regional seas, mainly Mediterranean and the Arctic biogeography complexes. A major difference between that Caspian and other large inland water bodies is its meridian orientation and great length (1200 km) so there are large climate differences among different areas of the sea. For example, the north shores are exposed to the extremes of the continental climate, while the southern and south-western coast is subtropical

Figure 1.1: Map showing the Caspian Sea and adjacent countries

The Caspian Sea lies between 47˚ 13′ and 36˚ 34′ 35″ north latitude and between 46˚ 38′ 39″ and 54˚ 44′ 19″ east longitude. The north-southern length is almost 1200 km and the greatest east–west breadth is 466 km. The average breadth of the Caspian from the west to the east is 330 km but in the region of the Absheron peninsula, it is only 204 km. The surface area of the Caspian Sea is about 436,000 km^3, and the volume is about 77,000 km^3. The maximum depth is 1,025 m, with an average of 184 m (CEP, 2004). The area of the Caspian Sea can be divided into three, approximately equal parts: north, middle, and south. The volume of each part is different, making up 1%, 35%, and 64% of the total area, respectively. The northern part of sea is relatively shallow, averaging about 5-6 m in depth. The average depth of the middle Caspian is 190 m, and its greatest depth is 788 m. The deepest part of the Caspian Sea is in the south Caspian with the maximum depth reaching 1,025 m with average depth is about 300 m (Aubrey, 1994). As reported by CEP (2004), the largest river is the Volga River that drains an area of 1,400,000 km^2 and runs into the northern part of the Caspian. Over 90% of the inflowing freshwater is supplied by the five largest rivers namely Volga, 241 km^3; Kura, 13 km^3; Terek, 8.5 km^3; Ural, 8.1 km^3, and Sulak 4 km^3, respectively. The Iranian rivers included Sefidroud, Tajan, and Gorganrod and the smaller streams on the western shores supply the rest, some parts have not permanent inflows especially on the eastern side.

The biodiversity of the Caspian Sea derived from the long history of the existence of the sea and its isolation, allowing ample time for speciation. The number of endemic aquatic taxa, which is over 400 species, are evolutionary impressive. There are 126 species of fish, of which a number are anadromous and migrate from the Caspian up to the rivers to spawn. The best known of these are the seven species and subspecies of sturgeon, which have been a valuable economic resource for over a century. It should be noted that, the Caspian seal is one of only two freshwater seal species that occur worldwide, the other one is found in Lake Baikal. The mammal acts as the ecology pyramid top predator of the Caspian Sea (CEP, 2004). The pronounced abiotic characteristic of the Caspian Sea is its salinity values that range from 0.1‰ in the northern part and 13.7‰ in the southern part. The average salinity reading is 12.8‰. The lowest salinities occur in the northern areas about 5-10‰. Salinities in the middle and southern area are higher about 12.7‰ and 13‰, respectively (Aladin and Plotnikocv, 2004). According to Dumont (1998a) water temperatures show a similar north-south gradient, caused by a climate-depth interaction. In summer, when strong thermocline develops down to 60-80 m, north-south gradients are important because the shallow northern basin heats up rapidly such that the middle basin is then slightly cooler than both other zones. Dumont (1998a) stated that during winter, the north cools strongly, whereas the middle and south basins, because of their volume and warmer climate, remain warmer. The south basins never drop below 10°C, while the north and the lateral shelves froze for several months during winter. The Caspian Sea is not only characterized by a rich biodiversity but also high endemism. The longest found species are among the group of indigenous, brackish water organisms that include a high percentage of endemic species and even genera. The rest of the organisms found today are basically derived mainly from the Mediterranean marine biogeography region as well as the Arctic marine region or the freshwater complex.

According to CEP (1998) the north Caspian has the greatest diversity both of habitats and species. This is due to the inputs from big rivers, such as the Volga and Ural, which create zones where the marine and freshwater fauna are mixed. Historically, the Volga river system was also the ancient route for the migration of Arctic and Mediterranean species, which are still found in the Caspian Sea. The

Caspian Sea has a highly variable topography, consisting of vast shallows, some deep depression and wide deltas, from the Volga and other rivers, among these areas, salinities vary between 0.12‰ and 10‰. This geographic and physical variability creates several different ecological niches that, in turn, support high species diversity.

Three main forms are clearly distinguished in the relief of the bottom of the Caspian which comprised shelf, continental slope, and bed of deep-water depressions. The shelf stretches from the coastline up to depths of about 100 m. The continental slope begins from the depth of 100 m and stretches to the Middle Caspian up to the depth of 500-600 m, and in the southern the depth reach 700-750 m. Two deep-water depressions are distinguished in the Caspian Sea. In the Middle Caspian, the Derbent depression with the maximum depth of 790 m however in the southern depression reach the maximum depth of 1025 m (CEP, 2004).

In the sea and deltas of the Caspian basin approximately 126 fish species belong to 17 families (Kazancheev, 1981) have been recorded. Most are from the families of Carp (33%), gobies (28%), and shads (14%), which together make up about 75% of the species inhabiting the Caspian Sea. The commercially important fish including the five unique sturgeon species such as the Beluga sturgeon (*Huso huso*), the Persian sturgeon (*Acipenser persicus*), the Russian sturgeon (*Acipenser gueldenstaedtii*), the Ship sturgeon (*Acipenser nudiventris*) and the Stellate sturgeon (*Acipenser stellatus*). The other commercial fishes are the bony fishes such as the Kutum (*Rutilus frissi kutum*), mullets, breams, carps, barbus, salmons, and kilka fish.

Rutilus frissi kutum is the most important bony fish inhabiting the Caspian Sea and is a very popular species among fishermen, coastal dwellers and the people in Iran as well as in other Caspian littoral states. Its high nutritive value and good tasting meat have resulted in a popular demand for this fish. This species has a life span of 9-10 years in the Caspian Sea. It is caught between early October and the middle of April every year. There are two spawning migrations, winter and spring. The two forms or stocks of this species in the Iranian waters of the Caspian Sea are interesting natural phenomena.

1.2 Various species groups of the Caspian Sea

An important feature of the Caspian is the extreme diversity of biotypes, biotic and abiotic conditions (Zenkevitch, 1963). Water salinity in different parts of this lake is quite different (Kosarev and Yablonskaya, 1994). The recent fauna and flora of the present Caspian Sea consists of the four main components included Caspian origins, arctic origins, Atlantic and Mediterranean origins, and freshwater origins, respectively (Derzahvin, 1947).

The fauna and flora of the Caspian Sea generally could not compete with invaders and often such invaded fauna and flora destroyed native species. The biodiversity of the Caspian Sea is 2.5 times poorer, than that of the Black Sea or 5 times poorer, than that of the Barents Sea (Zenkevitch, 1963). The main reason is probably due to its variable salinity readings. However, the Caspian Sea is a safety area for brackish water species originating both from marine, and from continental water bodies (Mordukhai-Boltovskoi, 1978). In general, the Caspian Sea is inhabited by 4 endemic genera, 31 endemic species and 45 endemic subspecies (Kazancheev, 1981).

The total number of phytoplankton species found during 1962-1974 was 449 (Kosarev and Yablonskaya, 1994). Dumont (1998b) reported that the total number of phytoplankton (450 species), zooplankton (315 species), phytobenthos (64 species), zoobenthos (379 species), mammals (1 species), birds (466 species) and fish (126 species) species in the Caspian Sea while the majority of fish in the Caspian Sea are endemic around 123 species. The species number of phytoplankton decreases from the north (414 species) to the middle (225 species) and south (71 species) mainly due to the disappearance of freshwater forms toward the south (Kideys *et al.*, 2005).

A characteristic feature of the Caspian Sea ichthyofauna is the wide range of species which migrate between fresh and brackish waters, with many varied forms of adaptation to different salinity from fresh water to the relatively high salinity of eastern inlets of the Caspian Sea. Among the fish, there is a distinct group of migratory fish, which inhabit the sea but migrate up the rivers for spawning.

The exceptional richness of migratory fish is an interesting feature of the Caspian Sea. All the Acipenseridae (sturgeon), Salmonidae, and Cyprinidae of the Caspian Sea enter a river for spawning and then return to the sea (Coad, 1995). Among the teleost species, Herrings (Kilka), Kutum (*Rutilus frisii kutum*), Carp (*Cyprinus carpio*), and Mullet (*Liza auratus*) are nowadays the most commercially important fish in the Caspian Sea.

1.3 General aspects of population dynamics

According to Ghadirnejad (1996) the population dynamics is the study of marginal and long-term changes in the numbers, individual weights and age composition of individuals in one or several populations, and biological and environmental processes influencing those changes. Population dynamics also attempts to study topics such as aging populations or population decline. Population dynamic is a branch of life science, which deals with the study of changes in numbers, weights and age of individuals in one or several populations, and biological and environmental processes influencing them. In fisheries and wildlife management, population is affected by three dynamic rate functions:

1.3.1 Natality or birth rate, often recruitment, which means reaching a certain size or reproductive stage. Usually refers to the age of a fish that can be caught and counted in nets.

1.3.2 Growth rate, which measures the growth of individuals in size and length. More important in fisheries, in which population is often measured in biomass.

1.3.3 Mortality, which includes harvest mortality and natural mortality. Natural mortality includes non-human predation, disease, and old age.

In the last century fishery biologists started studying the biology of several species of fish and shellfish which were of commercial interest. The objective was primarily to gain knowledge of source of dynamism these animals. The scientists studied the areas of distribution, the migration patterns, spawning seasons, fecundity, development of eggs and larvae, food, feeding habits and behaviour. Fisheries science gradually became quantitative during the middle years of the 20th century, starting with the concepts developed by Branov (1918), Russell (1931), and Graham (1935) culminating in the fish stock assessment models of Beverton and Holt (1956b), (1967) and Schaefer (1954) and (1957).

The beginnings of fishery research as a distinct scientific and activities and the establishment of many of the major research institutes in Europe and North America around the turn of the century, as well as the setting up of the International Council for the Exploration of the Sea (ICES) in 1902, were largely due to the concern about falling catch rates of some of the prime fish stocks which were the first target of industrial scale fishing, such as the plaice in the North Sea (Gulland, 1988). Fisheries are based on wild stocks, living in their natural environment. These stocks cannot be controlled in the direct and positive way like the farmer controls his domestic animals. Nevertheless, the fish stocks are affected by man's activities to an increasing extent and the success of the fisheries depends critically on the state of the fish stock which all those concerned with making policy decisions about fisheries must take into account. The decision makers therefore need scientific advice about the state of the fish stock (Gulland, 1983). The basic purpose of fish stock assessment to provide advice on the optimum exploitation of aquatic living resources. Living resources are renewable but limited, and fish stock assessment may be described as the search for the exploitation level which in the long run gives the maximum yield in weight from the fishery (Sparre *et al.,* 1989).

1.4 A brief history of Iranian fisheries

The Islamic Republic of Iran lies in western Asia between 44˚ 14′ and 64˚ 20′ north latitude and 25˚ and 36˚ 47′ east longitude, bordered by Azerbaijan and Turkmenistan to the north, Turkey and Iraq to the west. The Persian gulf and the gulf of Oman to the south, and Pakistan to the east. The fisheries sector has been divided in to seven independent district but the main divisions are Northern, Southern, and Inland Fisheries. Prior to the Islamic revolution in 1979, the Iranian fisheries were divided between two companies, the Northern and Southern, relating to the Caspian Sea in the north and the Persian and Oman Gulfs in the south (Valipour and Khanipour, 2006).

In 1980, through the legislation passed by the council of the revolution, the southern and the northern companies were merged into a single organization which officially began its activities in 1982. It should be noted that, up to the year 1835, fishing activity in the Iranian sturgeon fishing areas of the Caspian Sea was controlled by the local governors. From that year up to 1927, in a mutual agreement between the Iranian and Russian governments, permission for fishing in the Iranian part of the sea was given to different contractors, mainly Russian. In 1927, by a new agreement between both countries, a common company named the Mixed Fishing Company of Iran and Russia was established for a 25 years period. At the beginning of February 1952, the Iranian fisheries were nationalized and named Shilat-e- Iran, translated as Iranian Fisheries (Razavi *et al.*, 1972). Iranian fisheries company (Shilat) has put great emphasis on development of sustainable fisheries. Large sums of money are allocated for preservation of sturgeons. Because of their importance, fishing sturgeons, caviar-producing species, is only the responsibility of Iranian fisheries company. On the other hand, Iranian Fisheries monitors fishing methods to prevent overfishing and damage to fish stocks. For example, beach seining is the only allowed fishing system for licensed cooperatives to catch bony fishes other than kilka. In order to prevent illegal fishing, marine guards control the fishing activities in the Caspian Sea. Iranian fisheries agency has established Iranian fisheries research and training organization (IFRTO) to give technical and scientific supports for fisheries related activities. Funds are allocated to research on identification and conservation of fish stocks.

Caspian Kutum (*R. f. kutum*) is short-lived, fast-growing species and comprised or average more than 50% of commercial bony fish catch in Iranian coastal water of the Caspian Sea. According to historical catch statistic data, Iranian landing of this species showed fluctuating and falling trends in various degrees from 1927 to 2008 (Figure 1.2). The Iranian fisheries research organization (IFRO) established a policy of controlling effort through strict monitoring, control and surveillance (MCS) in the 1960s, combined with a restocking policy for Caspian Kutum and some other fish species.

Kutum landings fell from 6,000 tonnes in 1939 to around 100-2,000 tonnes/year from the mid 1950s onwards and were < 100 tonnes/year in 1979-80. Restocking programmed started in 1978 and succeeded not only in reversing the effects of over fishing in the 1930s and 1940s but brought the fishery to much higher landing of 11,000 tonnes/year (nearly twice the 1939 peak of 6,000 tonnes in naturally recruited landings) from 1990-1994. The mean catch of this species was

2,414±2,157.5; 9,194±1,555.5, and 9,043±3,396.4 tonnes in 1980s, 1990s, and 2000-2008, respectively (Shilat, 2008).

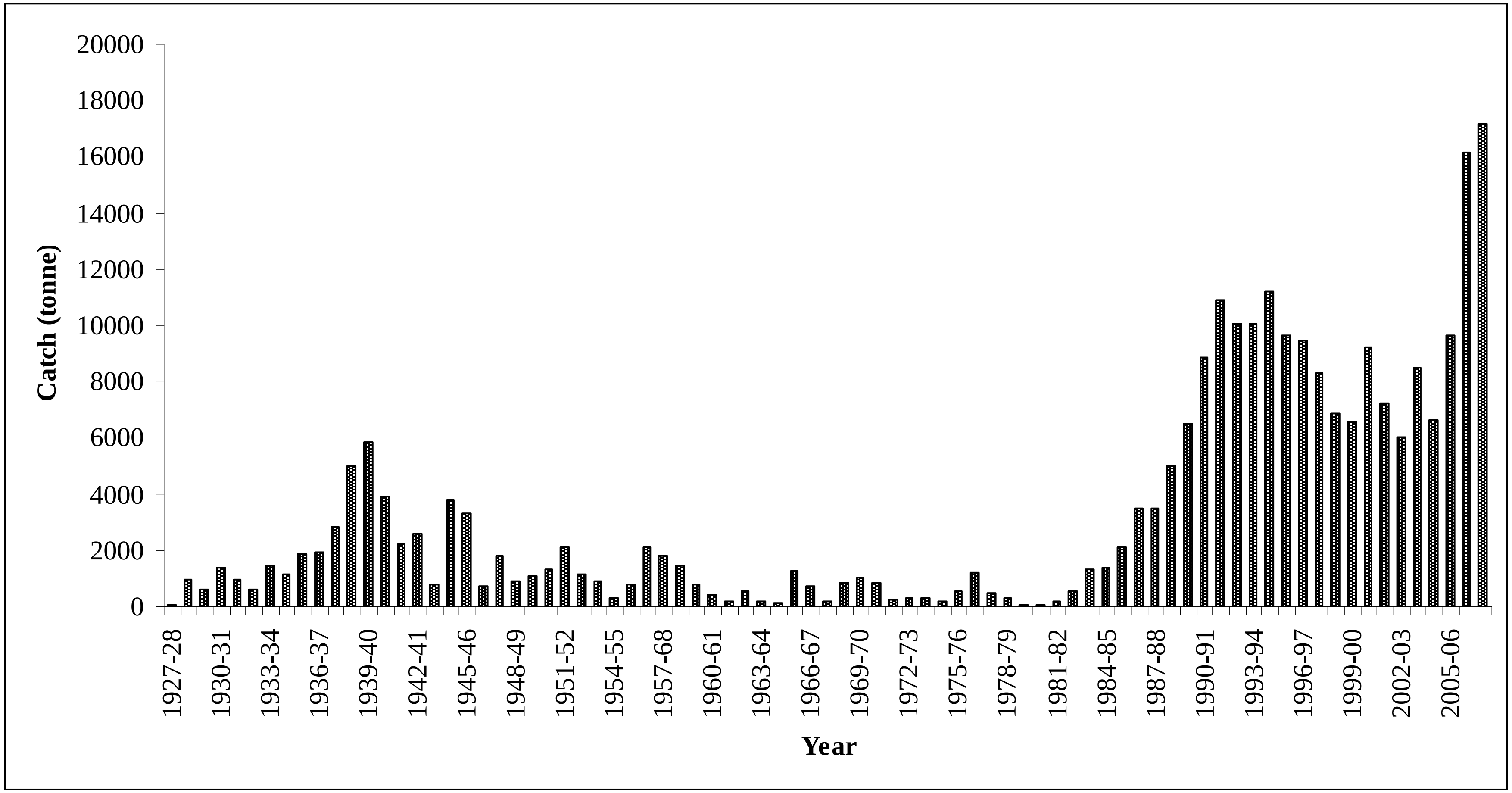


Figure 1.2: Annually catch changes of *Rutilus frisii kutum* in the southern Caspian Sea from 1927-1928 to 2007-2008

1.5 Family Cyprinidae

According to Nelson (1994) the species of Cyprinidae are distributed in north of America (northern Canada to southern Mexico), Africa, and Eurasia. Pharyngeal with 1-3 rows of teeth, each row with a maximum of 8 teeth. Usually thin lips, papillae absent, mouth sometimes suckerlike (*Garra* and *Labeo*) with or without barbells. Premaxilla usually borders the upper jaw making the maxilla entirely or almost entirely excluded from the gape and protractile upper jaw. Dorsal fin is with spinelike rays in some.

Shunping *et al.* (2008) noted that primitive number of chromosomes 2n=50, some with 48; polyploidy exists. The minimum and maximum lengths are from 5 cm and up to 2.5 m. The Cyprinidae belongs to the Class Actinopterygii (ray-finned fishes) and the Order Cypriniformes. It is the largest family of freshwater fish, with over 2100 species in about 200 genera. The family belongs to the order Cypriniformes, of whose genera and species the cyprinids make up two-thirds. It may be found in salinity, brackish and Freshwaters environments. Many members of this family are used in the aquarium trade. Compared with other fish, the activity level of this family tends to be normal. Members of this family have been dated back to the Eocene epoch of the Tertiary period. This family can be found from 70° north to 34° south and 150° west to 170° east.

1.5.1 Morphology of ***Rutilus frisii kutum***

According to Abassi *et al.* (1999) the dorsal fin with 3 unbranched and 8-10 usually 9 branched rays, anal fin with 3 unbranched and 9-12 usually 10 branched rays, pectoral fin branched rays 16-19 and pelvic branched rays 8-9. Lateral line scales 53-62 mostly 55-58. Scales are regularly arranged over the body. A pelvic axillary scale is present. Scales have numerous circles. Total gill rakers 7-12 and very short. Pharyngeal teeth 6-5 crowns rounded above a slender stalk, posterior teeth with a weakly hooked tip, and posterior most tooth margin may be serrated.

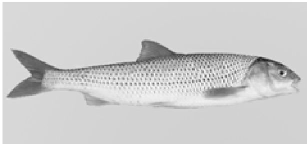
It has a pair of lateral lines that run on the two sides of the body from the operculum up to the tip of the caudal fin. Epithelial tubercles are found on the top of the head and on the sides of the body in males during the spawning season. Tubercles are white in contrast to the dark head and look like a wedding dress (Abbasi *et al.*, 1999). Depth of the body is less than or equal to head length. Anal fin is longer than high. Lower lobe of the caudal fin is usually shorter than head. Dorsal fin in large specimens is as long as high (Berg, 1946).

1.5.2 Classification of ***Rutilus frisii kutum***

The classification of Caspian Kutum indicated that is a subspecies from *Rutilus frisii* in the Caspian Sea (Nelson, 2006) (Table 1.1).

Table 1.1: Classification and various names of *Rutilus frisii kutum* in different countries

Caspian Kutum



Scientific classification:

Kingdom:	Animalia
Phylum:	Chordata
Class:	Actinopterygii
Order:	Cypriniformes
Family:	Cyprinidae
Genus:	*Rutilus*
Species:	*Rutilus frisii* (Nordman, 1840)
Subspecies:	*Rutilus frisii kutum*

Trinomial name:

Rutilus frisii kutum(Kamensky, 1901)

Common name:

Russia: Kutum	**Kazakhstan**: Kutim
Turkmenistan: Akbalyk	**Azerbaijani**: Zujag
Iranian: Mahi-sefid	**English name**: Kutum

1.5.3 Ecology of *Rutilus frisii kutum* (Life cycle)

Rutilus frisii kutum spends the remaining period of spring and summer feeding and growing in the shallow coasts of the Caspian Sea where there is an abundance of benthic fauna. In late summer when the water temperature is very high and the epilimniom extends to the depth of 30 m, these fish leave the shallow coastal regions and move to deeper layers close to the thermocline only to return to the shallow coastal regions (<20 m) during the autumn circulation for feeding. In autumn, this species migrates in shoals along the coastline from the west to the east or vice versa. Such migrations are very dependent on atmospheric conditions and sea currents caused by wind. During late autumn and early winter when surface layers become cold and during thermal stratification, Kutum populations gradually abandon the shallow coastal regions and move to deeper regions and rarely found in the shallow regions particularly between mid December and late January. Kutum spends the winter in deeper regions of the sea bottom which sometimes even exceed 100 m (Valipour and Khanipour, 2006). Feeding activity in this species is low in winter. Between late January and early February when climatic conditions are favorable, the spring forms of this species start moving towards the coastal regions of the sea and resume feeding to store energy in the form of lipids and prepare for their spawning migration to rivers and lagoons. The main spawning migration in the rivers and Anzali Lagoon occurs in mid March and lasts until mid May depending on water temperature, sea processes and ecological conditions.

The peak of spawning month is observed at the end of April, at the water temperature of 13-15 ºC **(**Berg, 1946**)**. The Kutum is in the end of IV stage of sexual maturity when it enters the river and attains complete sexual maturity and is ready for spawning when it reaches the spawning ground. Spawning begins when the temperature is 8 ºC and reaches a peak at 13-15 ºC (Berg, 1946). Fertilized eggs swell up on absorbing water and are adhesive sticking to the stony bottom until the larvae hatch in 16 days at 14-16 ^{o}C. The larvae begin to swim freely when the yolk sac is almost absorbed. Fry in the spring form of Kutum normally remain in the river for 30-45 days before they enter the sea (Khanipour, 1989).

1.6 Objectives of the study

The present study is based on a research project, which was planned and submitted to the Iranian Fishery Research Organization (IFRO) and Agriculture Training and Research Organization (ATRO). The basic reason that accommodates the IFRO to initiate such a project was the big gap in knowledge and lack of research on fish population dynamics and economic society in Iranian waters. Very few studies have been done to date on the population dynamics, feeding habits and length maturity the Caspian Kutum (*R. f. kutum*). The objectives of study are:

(1) To assessment of biological aspects (length-weight relationship, age, dynamics of spawning, maturation stage, gonadosomatic index (GSI), fecundity, $Lm_{50\%}$.

(2) To study feeding habits (feeding intensity, gastrosomatic index (GaSI), Fullness Index (FI), Frequency of occurrence, Index of Relative Importance (IRI), diversity index of Shannon-Wiener).

(4) To measure maximum sustainable yield (MSY), mortality (fishing and natural mortality), exploitation rate, length at first capture, age at first capture and biomass.

(5) To study net profit of *R. f. kutum* captured by Pare fishing cooperative.

CHAPTER 2

LITURATURE REVIEW

2.1 A brief about fishing cooperatives

Commencing in 1961 the Iranian fishing company has established local fishing cooperatives along the Iranian shores. The first fishing cooperatives was established in 1964 in Astara in south–west of the Caspian Sea following that, in a short period of time, the number of cooperatives increased to 30 and by 1966 there were 40 cooperatives altogether (Valipour and Khanipour, 2006). Nowadays, there are 131 fishing cooperatives in Iranian shores of the Caspian Sea comprise 58 in the Guilan, 53 in Mazandaran and 20 in Golestan provinces. There are about 12,000 fishermen in the north of Iran. On average, each cooperative comprises about 80 members. Fishing cooperative has permission to fish during the fishing season (from early October to first of April of the following year) from sunrise until sunset in a defined location. The fishing season is about 180 days in total. However, due to storm and very cold weather, approximately 40 days are lost. Thus, they have fishing activities for 127 to 151 days. Fish samplings carried out using beach seine. The beach seine is hauled by tractors (Abdolmaleki *et al.,* 2008).

The first recording on the catch of Kutum was in 1927 when fishing company governed with Mixed Russian and Iranian fishing company. Ichthyologic characteristics of the Caspian Kutum were earliest described by Berg (1946) and Nikolskii (1961). The first study on Caspian Kutum in Iranian coastal water of the Caspian Sea was done by Ferid-Pak (1968). Ralonde and Walczak (1971) and Razavi *et al*. (1972) surveyed stock status of the bony fishes in this area. Stock assessment and biology of *R. f. kutum* species were surveyed by Noei *et al.* (1992); Razavi Sayad (1995); Ghaninezhad *et al.* (1993); (1996); (2001); (2003) and Abdolmalaki *et al.* (2005), (2004), Daryanabard *et al.* (2005), and Afraei Bandpei *et al.* (2007).

2.2 Catch of *Rutilus frisii kutum*

Caspian Kutum is the most important bony fish species in terms of catch numbers and selling price. This species now comprises more than 50% of the total bony fish catch in the Iranian shores of the Caspian Sea (Abdolmaleki and Ghaninezhad, 2007a). According to historical catch statistic data, Iranian landing of this species showed fluctuating and falling trends from 1927 to 2008. The Iranian fisheries research organization (IFRO) established a policy of controlling effort through strict monitoring, control and surveillance (MCS) in the 1960s, combined with a restocking policy for Caspian kutum and some other fish species. Iranian Fishery Organization (IFO) released artificial breeding of Kutum in 1982 with 4 million fries into the sea (Figure 2.1).

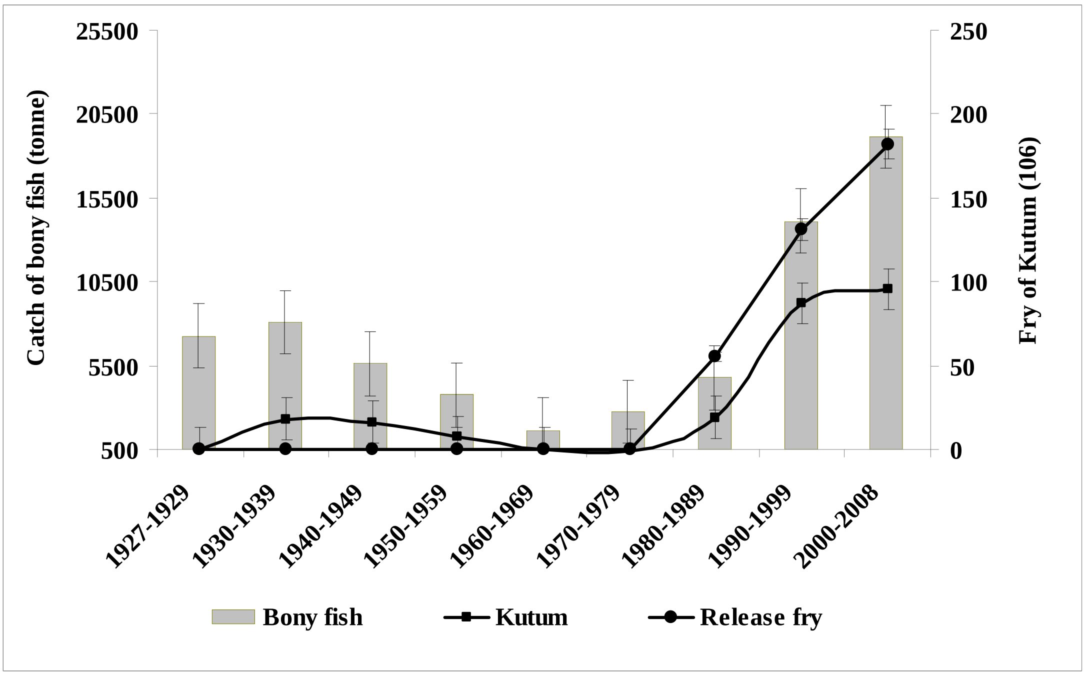


Figure 2.1: Annually catch changes and released fry of *Rutilus frisii kutum* in the southern Caspian Sea from 1927 to 2008. Note: Vertical bars indicate standard deviations.

This is a very valuable commercial fish in the southern part of the Caspian Sea and has a great demand, due to its good taste and culinary customs of the local people, and is consumed all year round. The average annual catch of Kutum in Iran was about 9,600 tonnes in 1991–2001 (FAO, 2003). Abdolmaleki and Ghaninezhad (2007) reported total catch of the commercial bony fishes was estimated at 15,500 tonnes (included illegal catch, statistical error, and breeding) from which the Kutum amounted to 8,477 tonnes, 45.5% of the total in 2003-2004. Pure catch of the bony fishes of beach seine cooperatives was estimated at 10,667 tonnes while the Kutum comprised 5,180 tonnes (48.65%). The catch per unit effort (CPUE) of the Kutum amounted to 93.3 kg/set.

Abdolmaleki and Ghaninezhad (2007a) reported overfishing, destruction of spawning grounds together with intensive artificial reproductions and release of

Kutum fingerlings have caused remarkable fluctuations in the stocks of the fish in the Caspian Sea over the past decades. The mean catch size of the fish during periods 1937-1947, 1967-1977 and 1987-1997 were 3,110, 990 and 8,505 tonnes respectively. The minimum catch was recorded as 121 tons in 1964 and the maximum catch was recorded as 11,175 tonnes in 1994. The catch per unit effort (CPUE) of the species shows high variations such that it has been 17 kg/set in 1971, 216 kg/set in 1989 and 112 kg/set in 1999.

The decline in CPUE in 1999 was due to increase in fishing efforts of 3.8 orders of magnitude (in comparison to the year 1989) as a result of the increasing fishing cooperatives during that period. Afraei Bandpei *et al.* (2008b) reported that total fish catch of bony fish was 9,008 tonnes in the Mzandaran province coastal of southern Caspian Sea which Kutum (*R. frisii kutum*) contributed 5,876 tonnes (65.2%). The catch per unit effort (CPUE) of Kutum was 282.4 kg/ set with the highest value recorded in Amirabad and the lowest amount was in Tonekabon regions. A minimum catch was in October with 32.5 tonnes and maximum catch was in March and April with 2,430.5 and 2,560.9 tonnes, respectively, which were coincided with spawning periods. The highest abundance Kutum was recorded in the Amirabad (99.4%) in April and the lowest value was in the Babolsar (0.7%) in October. Figure 2.2 shows biomass, MSY, and catch of Kutum in the southern Caspian Sea from 1990-91 to 2006-07 (Daryanabard *et al.*, 2007b).

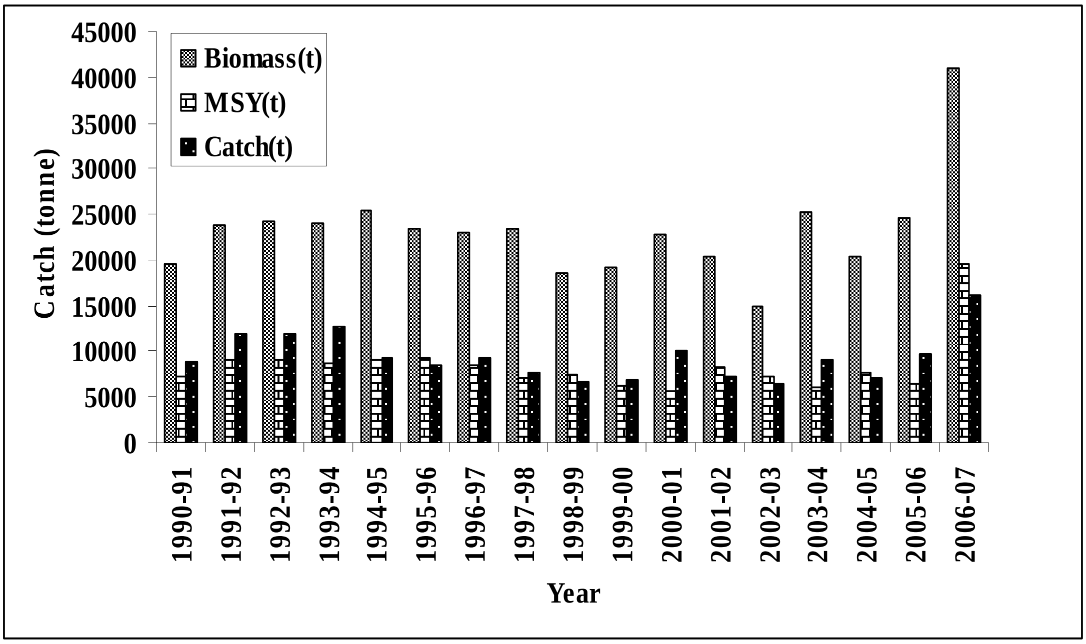


Figure 2.2: Annually catch changes, aximum sustainable yield (MSY), and biomass of *Rutilus frisii kutum* in the southern Caspian Sea from 1990-91 to 2006-07.

Abdolmalaki and Psuty (2007) reported that frequency catch of Kutum from 12.2% in 1927 to 20% in 1980 in the southern Caspian Sea. Afraei Bandpei *et al.* (2008b) indicated that the total catch of bony fish amounted to 23802 tons in fishing season 2006-2007 in the southern Caspian Sea. Maximum catch frequency of *R. f. kutum* occurred at Guilan (75.5%), Mazandaran (69.34%) and Golestan (27.4%) (Table 2.1). The average annual catches of Kutum (*R. f. kutum*) in Azerbaijan amounted to 2.5 thousand tonnes in 1931-1935 and reached 1.9- 5.0 thousand tonnes in harvests along the southern coast of the Caspian Sea in Iran. The catches of Kutum in the Caspian Sea peaked at 7.0 thousand tons in 1939. The present catches in Azerbaijan decreased to 55.9 tonnes in 1985, to 3.8 tonnes in 1993. The harvest in the waters of Dagestan is insignificant, 0.2 thousand tonnes were caught in 1968. Ninety percent of all Kutum is now harvested illegally (Caspianenviroment, 2008). In the waters of Azerbaijan and Dagestan, fishing is carried out with gill nets and beach seine in spring during the spawning period. The Kutum species has been included into the Red Books of both in Kazakhstan and Russia under the third category status (Caspianenviroment, 2008). There are kinds of species *R. frisii* (Nordmann, 1840) in Black Sea subspecies inhabits the Black and Azov Sea basins. However, due to the fishing industry, high rate illegal fishing, unsustainable fisheries management, and reduction spawning areas, as a result of economic activities this specie is becoming relatively rare.

Table 2.1: Catch ratio of bony fish with emphasis on *Rutilus frisii kutum* in 2006-2007 from the southern Caspian Sea.

Species	Catch area			
	Guilan (tonnes)	Mazandaran (tonnes)	Golestan (tonnes)	Total (tonnes)
Abramis brama	12.4	1	0	13.4
Alosa spp.	85.9	76.5	24.8	187.2
Aspius aspius	0.3	2	0	2.3
Barbus brachycephalus	3.3	3	0	6.3
Carassius auratus	150	0	0	150
Chalcalburnus chalcoides	13.2	7.1	0	20.3
Cyprinus carpio	61.4	529.3	1,169.9	1,760.6
Esox lucios	105.5	1	0	106.5
Liza auratus	1,422.7	2,710.6	559.6	4,693
Others	512.5	0	0	512.5
Rutilus frisii kutum	7,804.6	7,645.4	667	16,117
Rutilus rutilus caspicus	14.1	23.1	12.3	49.5
Salmo trutta caspius	0.6	2	0	2.6
Sander lucioperca	106	9.2	0.3	115.5
Silurus glanis	21.1	0	0	21.1
Vimba vimba	28.9	14.7	0	43.6
Total	10,342.5	11,025.5	2,434	23,802

2.3 Age and Growth parameters of Kutum

Age is defined as 'duration of life'. Lagler (1956) stated that a knowledge of the correct age and rate of growth of fish is essential in solving many management problems. The methods for age determination are diverse. Work on this topic is going on for the last 250 years and has resulted in the accumulation of a large amount of information in this field. The various techniques of age determination have been reviewed and described by Rounsefell and Everhart (1953); Lagler (1956); Chugunova (1959); Ricker (1968) and many others.

Several factors influence growth in Kutum such as hereditary characteristics, food reserves, environmental factors, and pollution. Overfishing and illegal catch of this species using inappropriate fishing gear has also contributed to this situation. Considering that there is no selection involved in choosing male and female spawners for artificial breeding programs, the gene bank of this species is gradually shifting.

Age composition of Caspian Kutum has been estimated by scales. Ghadirnezhad (1996) examined age readings using scales and otoliths for grey mullet (*Liza aurata*) in the southern Caspian Sea. He found that the best method for determining the age of grey mullet seems to be by scales, and he concluded that determination of age by otoliths is unsuitable. Furthermore, Fazli (2008) reported that scales alone have been used in his studies for age estimation of grey mullet. Berg (1946) for river Lenkoran and FishBase (2008) for USSR farmer recorded age 7 and 12, respectively. Life span is at least 9 years in Dagestan and 8 years in Iran (Holčik and Oláh, 1992). The age of Kutum from the catches data is estimated to be 3-8 years