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# Environmental Factors Influencing on Migratory Behavior of *Rutilus frisii kutum* in Shiroud River

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**Abstract:** It is unclear how much migration of fish is influenced by climate change in Caspian Sea. In present study, spawning migration of Caspian Kutum (*Rutilus frisii kutum*) into the Shiroud River, a tributary of the South Caspian Sea was investigated. Shiroud River is the most important river for migration and spawning for this fish. Upstream-moving adult Kutum are catched by gill net and trawling net fish in the range 33-63 cm total length. Significant correlations were observed between the number of migrants and the environmental factors; water temperature ($r= 0.6$; $P<0.001$).), weather ($r=0.30$; $p<0.041$), the delta of the river ($r= 0.4$; $p<0.001$), water level ($r=0.5$; $P<0.04$), turbidity ($r=-0.64$: $p<0.01$) and the wavy condition of the sea ($r= 0.454$; $p<0.001$). Thresholds of water temperature, water level and turbidity were revealed as general environmental cues. The spawning migration was studied as a basis for conservation and management of natural spawning proposes.

**Kay word:** *Rutilus frisii kutum* · Migration · Shiroud River · Environmental factor

## INTRODUCTION

The importance of the Caspian Sea to a diversity of fish species has been appreciated for many centuries, where such populations have been historically exploited by extensive fisheries. It has also long been known that many of these fish species exhibit migrations to the river for spawning.

Caspian Kutum, *Rutilus frisii kutum* are an important and high valued commercial and first Nations fisheries in north of Iran. The Shiroud River is of the largest producer of wild Caspian Kutum in Iran. The location and timing of Caspian Kutum migration is usually predictable. Each year at the end of winter, around the same time, maturing Caspian Kutum, stock travel to river to spawn in their natal freshwater streams. At present, the Caspian Kutum migrations are categorized into two main run timing groups as early Start run and late run for spawning purposes. The early stocks migrate quickly to the river when the water temperature increases in winter [1]. The late-run stocks usually spend some time (holding) in the sea areas, in the vicinity of the river mouth, for a period of weeks before they continue to migrate to the river. Understanding this will help us to manage special care for conservation of both stocks.

Population dynamics and stock assessment of Caspian kutum (*Rutilus frisii kutum* Kamensky, 1901) in Iranian waters of the Caspian Sea [2]. The change in ecology and global climate and the wish to manage fisheries sustainable have interest the need for understanding how environmental change affects the life history of important Caspian Kutum. It is an abundant semi-migratory fish in Caspian Sea, where it plays an important ecological role by feeding on zoo plankton and a number of benthic animals. Caspian Kutum further is more caught by a large costal fishery with annual landings more than 12000 ton. It is therefore important to understand the effects of environmental factors affect its migration for spawning. Migration of brood fishes is an adaptation aimed at finding an area for spawning. Kutum have to find an optimum places for spawning, attachment of the eggs, hydration of eggs, development of the eggs and incorporation of yolk sac, development of fins and completion of swim bladder to swim in water current for downstream migration. Migration is an important part of the fish life cycle and an inseparable part of their migration cycle and affects further life of the fish populations. The migration of the fish is not accidentally but create better circumstances for brood fish to lay their eggs and proper condition for very fry to be complete

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morphology, regulate and adapted them to new condition for further life. The cause and effect relationships that result in the migrations should be defined as the mechanism of the migrations, while the general tendency of the migrations should be interpreted as the historical reason that, in the process of the natural selection, has resulted in the migrations [3].

The available literature has data on the fish behavior with changes of the following environmental factors: Flow gradients [3]; Light [4]; Water temperature [5]. Other individual factors of fish also are important in fish migration. Some species segregate by size [6] or sex [7] when migrating, other species have large individuals leading the migration that act as scouts [6]. In Salmon study, the effects of discharge and temperature may differ between small and large rivers; fish of different sizes may respond differently to the environmental factors, there seems to be population specific differences in the migration patterns and the effects of the environmental variables [8].

Mining or taking out the sand for road construction from river side resulted in acidic streams with high chemical organic content that may adversely affect the spawning success of Kutum. Moreover, industrial and agricultural purposes combined with water extraction directly from streams for fish farming have affected Kutum populations negatively. One way to counteract the reduced natural production of Kutum is to release hatchery reared fish into the wild. After spending months to years foraging in the Caspian Sea, maturing Kutum return to their native river or stream to spawn, but several advantages specially keeping gene bank it is suggested the natural spawning. In natural spawning, the larvae of Kutum species are drifting downstream and are entering the floodplain with the floodwater, where they feed on the developed plankton. At the end of spawning season the fry migrate to the sea. However at present very few brood fish have the chance to have natural spawning.

The aim of the present study was to investigate the correlation between some environmental factors that have effect in stimulating the *Rutilus frisii kutum* to migrate to the Shiroud River at spawning time.

## MATERIALS AND METHODS

The investigation of the spawning migration of Kutum into the Shiroud River was conducted in the area at a site 500 m downstream of the river mouth. At average discharge the river cross-section at the sampling site is 10.0 m wide with a maximum depth of 1 m near the sea. The bottom consists of small particle sand.

The characteristic of fishes such as age, weight, length and migratory dynamics of spawning Caspian Kutum were examined in Shiroud River in North of Iran in 2003. The age of fish was determined by taking sample of scale. Spawning migration were monitored fourth each day from early March and lasted up to late May using a gill net and cast net. Water temperature during spawning migrations ranged from 7 to 19.5°C.

Based on the data cored at the time of spawning, in total approximately 30000 male and 10000 female were migrate to river in 2003. The proportion of females captured to males was 1 to 3 respectively. Among female 58.4 percent were artificially propagated.

To investigate the parameter affecting migration, a data form was prepared for scoring fish data and environmental factors including; water temperature, weather condition (Cloudy, shining, raining), wind (direction from the sea to land and vise wires), sea condition (Calm, wavy, stormy), water flow in the river (low, moderate, high), water clearance (clear, semi-turbid, turbid), river delta (direct, skewed to right or left).

Cloudy condition means covering the sky completely by cloud. Water flow in the river was measured by a sign in the wall of the river. Low water level was done, when no raining occurred in the river and high condition when heavy raining had happened in up-stream.

**Statistical Analysis:** Results are expressed as mean ± standard deviation. Significant means were subjected to multiple comparison test (Duncan) for post-hoc comparisons at $\alpha$=0.05 level. All statically analysis were carried out using SPSS.17 for Windows software package.

## RESULTS

In the year of 2003, the migration of fish started at March, when the water temperature increased up to 7°C. The weight and length of fish migrated to the river in 2003 scored are presented in Table 1. The age of fish were 3 to 8 years, higher frequency were 4 for male and females too.

The smaller males and female were interred to the river was 200 and 250 g respectively. The most temperature of migration period and the number of fish catched was in the range of 10-14°C (Table 2, Fig. 1 & 2). Figure 1 shows the pattern of fish catch in Shiroud River and Figure 2 illustrate temperature from early of migration when the water temperature was 7 to water temperature of 19.5°C. The mode and median temperature was 11°C. Water temperatures were differing significantly between the early spawning and the late ($P<0.001$).

Table 1: The weight and length of fish migrated to the Shiroud River

| | | Weight | | | | Standard Length | | | |
|---|---|---|---|---|---|---|---|---|---|
| Brood fish | Number | Mean | Sd | Min | Max | Mean | Sd | Min | Max |
| Male | 720 | 617.6 | 192.2 | 200 | 1850 | 33.9 | 3.4 | 23.6 | 49.2 |
| Female | 720 | 975.5 | 442.2 | 250 | 2550 | 39.6 | 6.1 | 28.0 | 56.0 |

Table 2: The frequent and average number of fish catch in Shiroud River

| Parameter | Criteria | Frequently | No. fish per catch in average |
|---|---|---|---|
| Temperature | 5-9°C | 83 | 147 |
| | 10-14°C | 126 | 191 |
| | 15-20°C | 39 | 138 |
| Water level in river at low turbidity | Low | 58 | 62 |
| | Medium | 146 | 212 |
| | High | 52 | 165 |
| Turbidity | Clear | 132 | 164 |
| | Low turbidity | 52 | 263 |
| | High- turbidity | 54 | 102 |
| Whether condition | shining | 89 | 151 |
| | Cloudy | 124 | 183 |
| | Raining | 33 | 163 |
| Wavy of sea water | Calm | 153 | 114 |
| | Wavy | 83 | 245 |
| | Stormy | 16 | 315 |
| Delta of River | Direct open | 150 | 193 |
| | Skewed | 99 | 132 |
| Time of catch | Morning | 60 | 162 |
| | Noon | 62 | 158 |
| | Afternoon | 62 | 195 |
| | Mid-night | 64 | 162 |

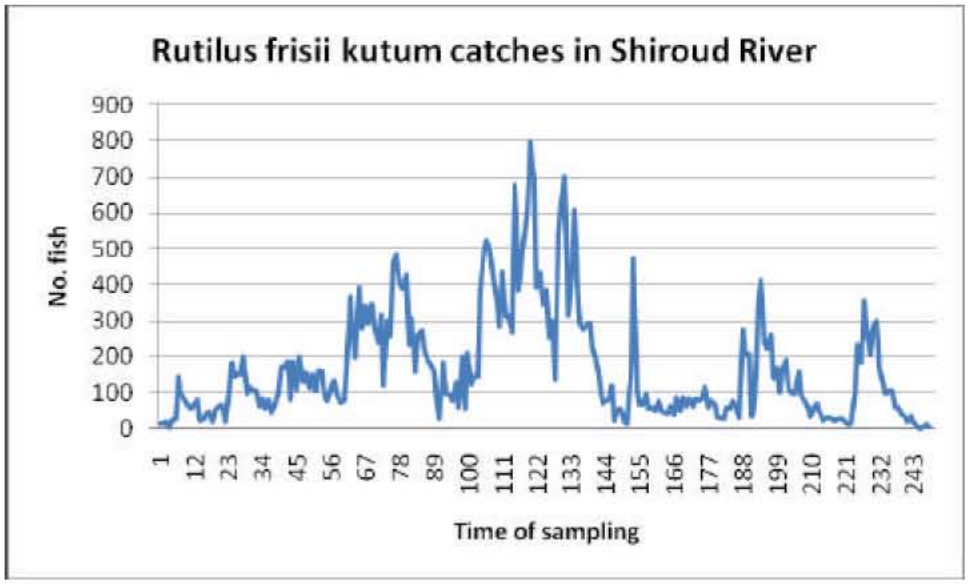


Fig. 1: Number of fish catches at every sampling step

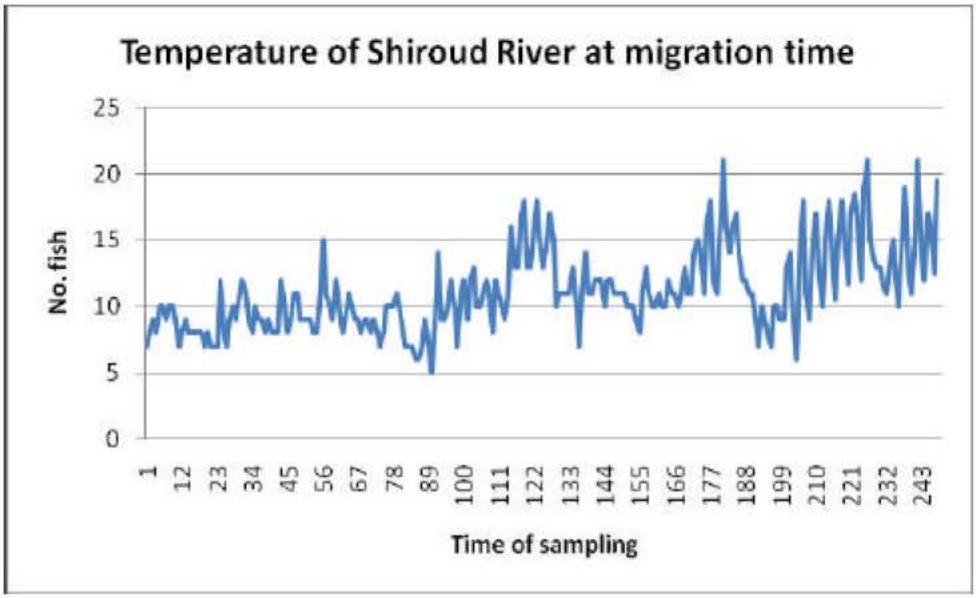


Fig. 2: Temperature of Shiroud River at migration period from early March to late of May

The corresponding average (±SD) temperatures were 12.6 ± 2.8. The linear regression ($R^2 = 0.3$, a = 0.03, b = 10.07, $P<0.05$) indicated significantly positive correlation with temperature and number of fish migrate to the river.

The recorded water levels revealed a correlation with total catch ($r=0.5$; $P<0.04$). It means after each raining period and when the turbidity decreased, while the water level in the river is high the total catch increase. Table 2 shows higher average number of fish catch in the Shiroud River when the water current was moderate and high.

Mean turbidity in the Shiroud River was comparing to clear or semi-clear condition in the river, which corresponds well with the observed water level differences between two times. The higher turbidity mainly reflected peak floods during that spawning season. Turbidity had highly significant correlation with number of fish migrate to the river ($r=-0.64$: $p<0.01$). The correlation was negative illustrate in turbid flood condition the rate of migration are decrease (Table 2).

There was highly significant in correlation between the weather condition and total catch ($r=0.30$; $p<0.041$). Based on the present study results, in cloudy weather the highest frequency of migration and highest number of fish migrated occurred (Table 2).

The effect of wind was obviously in increasing migration by statistical analysis comparing the number of fish catched one day after the direction of wind from sea to land and there was decrease in migration from land to sea. The data illustrate migration from sea to land was 10 fold grater comparing land to sea. In the other hand the effect of wind in inducing wavy and stormy condition of the sea is not negliable. In conformity with the effect of wind, the wavy condition of the sea showed highly significant increase in inducing brood fish migrate ($r= 0.454$; $p<0.001$). The average passage rate between the stormy and calm condition differed significantly ($P<0.05$), being 320 to 114 individuals per day. But it should be consider that most frequent migration (62 %) took place under calm condition of the sea.

One of the main factors in migration of fish is the condition of the mouth of river. By stormy condition of the river sometimes the straight direction of the river will be change. In the later cases the migration were reduced. The straight direction of delta showed highly significant increase in inducing brood fish to migrate ($r= 0.4$; $p<0.001$). The average passage rate between the straight direction and skewed to left and right was differed significantly ($P<0.05$). The most frequent migration (60 %) took place under straight direction to the (Table 2).

Other factors such as time of catching (Table 2), the status of females and sudden elevation or reduction of temperature, population, contamination and so on, have direct or indirect effect on migration but their effect was not significant ($p>0.05$).

## DISCUSSION

Migration is a common feature of many pelagic and non-pelagic fish species that move between nursery areas, spawning and feeding sites [9]. Migration routes, timing of migration and other features of migration are highly variable and often species specific. The changeability in the daily migration rate of fish could be controlled by a group of synergetic factors that characterizing the spawning season. Adult fish may be entering the river based on and in relation to the "biological clocks" that control maturation and migration events. It was proved in the present study that migration is in affecting by environmental cues such as temperature, rainfall, wind, light, salinity.

The Shiroud River is one of the Iran's largest producers of Kutum, with thousands of adults returning to spawn each year. In some populations, individuals vary considerably in physiological and energetic state at the start of their migration. Actually the transition into freshwater requires a series of changes in osmoregulatory and ionoregulatory systems [10], physiological and morphological changes associated with the development of secondary sexual characteristics [11, 12]. Specially in male of Kutum, the behaviour of fish will change and white small spots in head and body of the fish is recognized at spawning season [3]. Lucas and Baras [14] also stated that one of the most obvious changes in behaviour is that related to spawning activity, which has a marked impact on the migratory behaviour of many fish species.

Our results showed that a slight but quick increase of temperature of the climate at the end of winter in the southern of Caspian Sea corresponded with remarkably warmer temperatures over a longer period at the spawning site. Increasing temperature at this time may therefore not only induce spawning migrations but also provide and ensure that eggs development for spawning.

The control of migration is following egg maturation in Kutum and the cycles of hormone activity [13]. The cycle of internal endocrine secretion, may well give the fish an urge to migrate and this mechanism are synchronized with environmental cues. Increased water temperature and increased water level are among the main factors effecting upstream spawning migration, especially in salmonids [15].

Migration of Kutum is not a sudden decision of the fish. During spring and summer the fish make their eggs and wait over winter and remain relatively inactive in condition of low temperature and poor food in the southern part of Caspian Sea. The end of this period would appear as the fish became more active in response to rising temperature and postulate some factor which would direct them to the spawning ground. The direction of the spawning migration might be partly controlled by optimal water masses and by suitable depth and substrate for depositing eggs.

In the present study we investigated only the effect of environmental factors on migration, but it is evidence that several factor may affect the time or pattern of migration. There are highly variation in fishes of Caspian Sea [16, 17], therefore it can be expected that the genetic may influence the migration. The migration time are influenced by several factors including genetics, physiology, reproductive state, fish gender, distance to the spawning area and environmental factors such as stream discharge and water temperature [18], however in most cases the migration resulted from the influence of abiotic gradients (i.e., salinity, temperature, dissolved oxygen, tide, water current, etc.) on the spatial and temporal distribution of fish species. According to local fishermen, weather conditions affect species migrations at short time scales and some studies indicate that the seaward migration of species depends on environmental and atmospheric conditions [19].

Our analyses have demonstrated a strong relationship between sea temperature and the timing of spawning. Sea temperature was shown to be strongly positively related to the temperature at the spawning and egg development.

Climate change accentuates the need for knowing how temperature impacts the life history and productivity of economically and ecologically important species of fish. By increasing the water temperature from 3 to 7°C the migration of Kutom is encouragement but the most migration period was between 10-14°C. Later by increasing temperature the number of fish enters to the river are decreased. In this regard, Jansen and Gislason [20] have been documented significant relationships between temperature and North Sea mackerel spawning and migration. The results have implications for mackerel resource management and monitoring. An increase in temperature is likely to affect the timing and magnitude of the growth, recruitment and migration of North Sea mackerel with subsequent impacts on its sustainable exploitation.

The next important and higher correlation between environment and migration was the sea condition. Several other factors mainly the windy and rainy weather are related and associated with sea condition. Wind induced

waves and the associated turbulence and oscillatory currents are expected to affect the distribution of fish in shallow waters because the fish are directly exposed to these water movements. In the present study wind has relatively high correlation with Kutom migration depending the direction and speed of the wind. Our results are in contract with some other investigated about glass eel and Plaice. Wind speed and direction have been suggested to affect glass eel migration by moving water masses toward the direction of the river mouth [21]. The effect of wind on catch rates is well known to fishermen. Scholes [22] found that catches of plaice were low in the southern North Sea during northerly winds in autumn and winter, whereas catches of cod were higher with northerly winds in autumn and winter and with southerly winds in spring and summer.

Another factor in related to weather condition is rainfall. Rainfall has three side effect in inducing migration; changing atmosphere pressure, increasing water level and turbidity in the river. Our results of investigation showed, rainfall like as cloudy condition had effect on migration of Kutum. The same results were obtained in case of some other marine fishes e.g; numerous studies refer to the positive effect of rainfall on glass eel migration by increasing freshwater outflow (*A. australis*, *A. dieffenbachii*: [23], decreasing salinity (*A. anguilla*: [24], increasing water levels [25] and odor from drainage water as it has been shown experimentally [24].

Rain changes in atmospheric pressure may serve as a signal of approaching environmental changes and the response of the fish may be instinctive. Many teleost species are known to alter their swimming pattern in response to weather changes [26]. Climatic studies show that in the study area winter and late spring are characterized by increased rainfall [27], following marked changes in atmospheric pressure, temperature and prevailing winds [28].

One of the most and correlated important factors in inducing migration is the flow rate and turbidity of the river. Actually after a raining day the water flow will increase and consequently turbidity of the river will increase. After a period of time when the clarity of the river reach in moderate status the migration are start and increased. Turbidity is known to influence the distribution of fishes [29]

A combination of increasing water temperatures and decreasing water levels, corresponding to the period after a flood peak, offers high predictability of favourable spawning conditions at the spawning place and acts as a stimulus for the right timing for upstream migration of Kutum in Shiroud River.

The other important factor that will affect fish behavior in the water current is depth of water in the river. The fish transfer from one depth to another, with this transfer, the hydrostatic pressure changes. It is known that, depending on the pressure value and the length of adaptation to the pressure, many behavioral characteristics of fishes change [3]. Therefore, the vertical currents may induce certain hydrostatic reactions in the migratory fish.

In order to find all environmental factors affecting migration many parameter should be investigated that only some of them have been investigated in the present study. In addition to those we study in the present work, other factors such as salinity, water odor and moonlight, are suggested as important factors influencing from the sea toward inland ecosystems migration. However, the definition of their role is difficult due to the heterogeneity in local climatic and hydrological conditions, differences in sampling methods, studied species and ontogenic eel stages [30].

The condition or chemical status of the river are changed during different times [31]. Concentrations of total suspended solids (TSS), chemical pollution, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) if increase the migration will change. When the water current decrease, dissolved oxygen (DO) in effluent decline and ammonia-N concentrations increase. Chemicals cause adverse effects immigration and till now, this have not been analyzed reliably or often enough to allow a reliable assessment of their significance in effluent. The recent study on the status of the Shiroud River showed in the lower river increase of chemical factor, perhaps arising from agricultural or industrial activity. The role of chemical contaminants in affecting Kutum and other fish migration should be considered.

Body size also may have relationship with time of spawning, often been described for both pelagic and non-pelagic fish species that migrate for the purpose of spawning. In the present study it was found that at low flow rate or shadow condition of the river just small size of fish enter to the Shiroud River. Vandeperre and Methven [32], investigates this relationship for capelin (*Mallotus villosus*), a pelagic smelt-like species that spawns on the beaches of Newfoundland and found bigger fish arrived near the spawning grounds first and was most obvious for female capelin.

## CONCLUSION

The spawning migration was studied as a basis for conservation and management proposals. The timing and the effect of environmental factor on spawning was determined by regular inspection of the river for presence of brood stocks. The temperature factor in Sea is the main factor in initiating spawning. In addition to prevailing temperature, tide and flow conditions determined rate of migration of Kutum. Several local factors also should be considered for future conservation and management e.g. inhibited catching, pollution and the present physico-chemical character of the river.

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