Benefit-cost analysis for fingerling production of kutum *Rutilus frisii kutum* (Kamensky, 1901) in 2005 in Iran

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Introduction

Knowledge of production costs and their evolution is essential to the successful management of a hatchery farm, and helps to identify the main items for which cost reduction is worthwhile. Benefit-costs analysis may also assist the manager in decision making and in adjusting to changes.

The primary interest in most fisheries is directed toward establishing viable industries for the purpose of, stock enhancement, domestic consumption, export, employment opportunities, income distribution, or a combination of these objectives (Shang, 1981 and Pillay, 1994). As Shang (1990) noted, elements such as biology, technology, feed and nutrition, engineering, fish pathology, and institutional factors all affect the economics of production. From a micro-economic view point the primary motivation of a fish farm may be profit making, but sometimes these can be other considerations such as stock enhancement (Salehi, 2003).

Research on the economics of kutum (*Rutilus frisii kutum*) culture will play an important role in its future development. It is clear now, to overcome the problem of declining kutum stocks the promotion of hatcheries to produce large quantities of fingerlings for stock enhancement is certainly going to be an important strategy. Stock enhancement is practiced in many countries with different methods and various objectives, not the least of which is the reconstruction of stocks of economically important species. For example, Japan has a long history in using stock enhancement to support and rehabilitate almost 80 species (Matsuda, 2000) with varying results. Iran contributes to these efforts through the reproduction and enhancement of more than thirteen main native species, releasing more than 250 million fingerlings into the Caspian Sea and the Persian Gulf annually (Bartley, 1995, Shehadeh, 1996, Bartley and Rana, 1998, Abdolhay, 1998, Tahori, 1998, Salehi, 2002, 2005 and PDD, 2007).

As Fushimi (Fushimi, 2001) noted, the main issue that should be considered in any stock enhancement plan is the economic aspects. The economic advantages of stock enhancement, and other aspects of population rehabilitation, have been considered in recent years by Bartley (1995) (1999); Sreenivasan (1998); Hansson, et al. (1997); Ahmad et al. (1998); Lorenzen et al. (1998); Gateway (1999), Kitada (1999) and Salehi (1999, 2002, 2005b & 2008). Some researchers emphasized the profitability of stock enhancement and stressed that in some species the rate of return of investment can be very high (Hansson, et al., 1997; Ahmad, et al., 1998; Lorenzen et al., 1998, Lorenzen et al., 2001, Gateway, 1999 and Salehi, 2006). The analysis of the economics of all aspects of stock enhancement for species such as kutum is a very complicated undertaking. It is also very expensive and takes a long time to generate satisfactory returns, although it may have a key role in improving the productivity of stock enhancement.

The natural maturation and reproduction of all bony fishes in the Caspian Sea, including kutum, has faced serious problems. As noted by Razavi Sayyad (1995) the contribution from hatchery production in the Caspian Sea landings has been estimated to be more than 95% for kutum. By considering the background data on stock enhancement of kutum and the results of fishing data, it seems that increase of the contribution of kutum in total fish catch was most probably affected by stock enhancement in Iran.

Study structure and methods

A study of kutum fingerling production was carried out to help clarify fingerling production costs. Specific objectives were:

1. To determine the real costs and production of kutum fingerlings.
2. To find the cost contribution of the input factors.
3. To determine the cost sensitivity of main operating cost factors for hatchery production of kutum fingerlings.

Attention was directed to addressing questions such as: which inputs are significant in explaining outputs from various hatcheries? What constraints inhibit increased productivity and production of existing kutum culture systems? The study, conducted in 2005, covered kutum hatcheries in northern Iran, including Guilan, Mazandaran, and Golestan provinces. For this purpose, a questionnaire was prepared and filled in by an expert team comprised of an economist, statistician and aquaculturist using data available in kutum hatcheries for fingerling production and other related departments in the Iranian Fisheries Organization, with data collection, classification, and analysis covering 2004. Two sources of data were used. Primarily data were obtained through personal interviews with managers and related experts in hatcheries, which were conducted to obtain information on the resources used and the quantity of output. Other relevant documents obtained from the Iranian Fisheries Organization (IFO) were consulted including information from the accounting, budgeting and stock enhancement offices. These data were supplemented with other data maintained by other affiliated departments of IFO, affiliated provincial fisheries offices and the Iranian Fisheries research Organization (IFRO). Data were entered into a Microsoft Excel spreadsheet 2003 and methods for classification, summarizing, averaging, and other functions based on Shang (1981, 1990); Jolly and Clonts (2003) and Salehi (1991, 2004 and 2006) were used for analysis.

Results

Total fingerling production of kutum increased from 2.8 million in 1982 to more than 225 million in 2002, but declined to 179 million by 2004. Fingerling production increased to more than 229 million in 2005 (Table 1) and again declined to 174 million in 2006 (PDD, 2007). From 1991-2006, on average, the contribution of kutum to total landings of bony fish was more than 51% in the Iranian reach of the Caspian Sea, ranging from a high of 67% in 1991 to a low of 40% in 2002. The annual landing of kutum averaged more than 9,209 tonnes over the 1991-2006, ranging from a high of 16,118 tonnes in 2006 to a low of 6,417 tonnes in 2002. Over the period 2000-2006, yearly production of kutum fingerlings averaged more than 186 million (Table 1). The trend line of fingerling releasing of the kutum shows steady growth over the period (Figure 1).

From 2000-2005, the contribution of kutum to total landings of bony fishes was almost 47% and annual landings averaged more than 8,040 tonnes. Kutum landings ranged from 7,036 to 9,631 tonnes over the same period. By considering fishing data in light of stock enhancement of kutum, as Table 1 shows, it seems that increases in the contribution of kutum to the total catch in Iran was positively influenced by stock enhancement.

In 2005, of 9,631 tonnes of kutum landings, 56% belongs to the province of Guilan, followed by 39% in the province of Mazandaran, with the balance produced by Golestan province (PDD, 2006). From 2000-2005, annual fishery production of bony fishes averaged more than 20,400 tonnes. Of that landings 47% belongs to the province of Guilan, followed by 35% in the province of Mazandaran, with the balance produced by Golestan province. Mazandaran Province had the highest variation but also showed steady growth in landings, averaging more than 7,000 tonnes over the 2000-2005 period.

As Figure 2 shows, in 2004, total costs per kutum fingerling production averaged IR Rials 130 ($US 0.016) in Iran. This represents a 7% increase in total cost per fingerling relative to 2003. Average cost for labor was IR Rials 54 representing an average of 42% of total costs. The other main costs were feed and fertilizer, maintenance and depreciation averaging 14%, 10% and 9% of total costs respectively. The cost of harvesting and post harvest averaged only 8% of total costs. The steady growth of kutum fingerling enhancement from 1995-2006 in the South Caspian Sea is shown in Figure 1. Fish landing data after the establishment of various kutum hatcheries along the Iranian parts of the Caspian Sea clearly indicate the success of stock enhancement programs over this period (Figure 3).

Cost sensitivity analysis of hatchery production of kutum shows that labor is the most sensitive component. A 50% increase of this item increases the total cost by almost 27%, followed by feed and fertilizer cost (Figure 4).

Table 1: Total landings and the number of kutum fingerlings releasing in the Caspian Sea between 1982 and 2006.

Year	Kutum landings (mt)	Number of kutum fingerlings releasing	Total landings of bony fishes (mt)	Contribution of kutum to total landings of bony fishes (%)
1982	563	2,809,000	7,924	7
1986	3,500	51,704,000	6,296	56
1991	10,920	109,843,000	16,335	67
1992	10,085	96,619,000	17,260	58
1993	10,061	100,047,000	17,629	57
1994	11,175	142,733,020	18,638	60
1995	9,525	117,918,845	17,981	53
1996	9,436	142,091,873	17,638	53
1997	8,316	154,367,000	16,698	50
1998	6,878	143,361,000	15,611	44
1999	6,583	147,879,000	12,804	51
2000	8,977	132,900,000	16,863	53
2001	7,199	196,600,000	16,378	44
2002	6,417	225,198,000	16,200	40
2003	8,984	155,000,000	16,573	54
2004	7,036	179,365,000	15,665	45
2005	9,631	229,110,000	21,845	44
2006	16,118	174,300,000	23,802	68
Average	9,209	152,958,296	17,370	46.6

Sources: Developed from Salehi (2005_b) and PDD (2005, 2006, 2007).

Discussion

Stock enhancement has many socio-economic and environmental advantages. Many researchers have discussed the positive effects of stock rehabilitation for sturgeon and bony fishes in Iran (see Razavi Sayyad 1995, Abdolhay 1998, 2006, Danesh Khoosh Asl 1998, Tahori 1998, Hosseini 1998, Pourkazemi 2000, 2006, Keyvan 2002, Salehi 2006, 2008 and Moghim et al., 2006). The importance as well as benefit return of hatchery enhancement and its opportunities for resource reconstruction have also been discussed internationally (eg. Bartley 1995, 1999, Hansson et al., 1997, Sreenivasan 1988, Salehi 1999, 2002, 2006, Ahmad et al. 1998, Lorenzen et al. 1998, Garaway 1999, Kitada 1999 and Lorenzen et al. 2001 and Rosenthal et al. 2006). Fsh landing data from 1991-2006 clearly indicate the success of stock enhancement programs initiated after the establishment of kutum hatcheries along the Iranian parts of the Caspian Sea over the period (Figure 1).

As shown in this study, the major cost in kutum hatcheries was labor, which averaged IR Rials 54 (almost $US 0.006) for each fingerling, followed by feed and fertilizer, were averaged IR Rials 18. Compared with other aquaculture activities, the share of labor cost in kutum hatcheries was very high compared to carp farming (12%), trout farming (13%), shrimp farming (17%) and shrimp hatcheries due to using foreign experts (26%) (see Salehi, 1999, 2003, 2005a and 2005b). It seems, the main reason for this higher labor cost may be the inactivity of hatcheries during a few months off season, which could be reduced

Table 2: Total landing of bony fishes in the north provinces of Iran over the 2000-2005.

Year / Province	2000	2001	2002	2003	2004	2005	Average yearly	% contribution of province to total landings	SD
Guilan	10,110	8,410	8,320	6,686	5,704	9,211	9,661	47	636
Mazandaran	5,840	4,837	5,280	7,983	6,046	8,316	7,078	35	1,751
Golestan	3,050	3,253	2,600	1,903	3,914	4,318	3,684	18	897
Total	19,000	16,500	16,200	16,572	15,664	21,845	20,423	100	2,012

SD: Standard deviation. Sources: Developed from Salehi, 2005$_b$ and PDD, 2006.

by adopting extra activities in such hatcheries. The importance of stock rehabilitation in general, and kutum enhancement in particular as a means of biodiversity preservation, and as a source of socio- economics activity has been addressed in this paper. Current production and enhancement of kutum fingerling and the huge investment expended by IFO suggest that this sector might be expected to become increasingly important in coming years. Future fingerling production of kutum is likely to vary widely and will be to a large extent dependent on ability to obtain brood fish from the Caspian Sea as well as continued investment by government. Overall, kutum rehabilitation may benefit from research aimed at developing technically viable production and enhancement systems, improved nutrition, genetic improvement, disease prevention, water quality and industry management. It seems that the co-operation of beach seine net co-operatives and other organizations involved in Iran might be expected to have an important effect on stock enhancement and biodiversity preservation of kutum in the coming years.

Considering an 8.3% fingerling return aged 3.7 years at 815 g average weight (Razavi Sayed, 1995 &1999) it might be expected that more than 19,016,130 kutum fingerlings will be returned by 2008-2009 with total meat production around 15,500 tonnes, assuming a 15% annual growth rate per year for kutum as recorded from 1993-2001 and 2001-2005 (PDD, 2002, 2005, 2006 & 2007). The wholesale price of this production would potentially be around IR Rials 1,100 billion (US$ 116 million). This suggests that a return of US$116 million could potentially be generated from an investment of less than US$ 320,000 used for stock enhancement in the year 2004. There are of course many questions and issues that need to be resolved in order to sustain kutum production such as the state of the environment, reduction of pollution to improve its suitability for kutum produc-

Figure 1: Number of kutum fingerlings releasing from 1991-2005 in the Iranian reach of the Caspian Sea. Sources: Developed from Salehi (2005b) and PDD (2006, 2007).

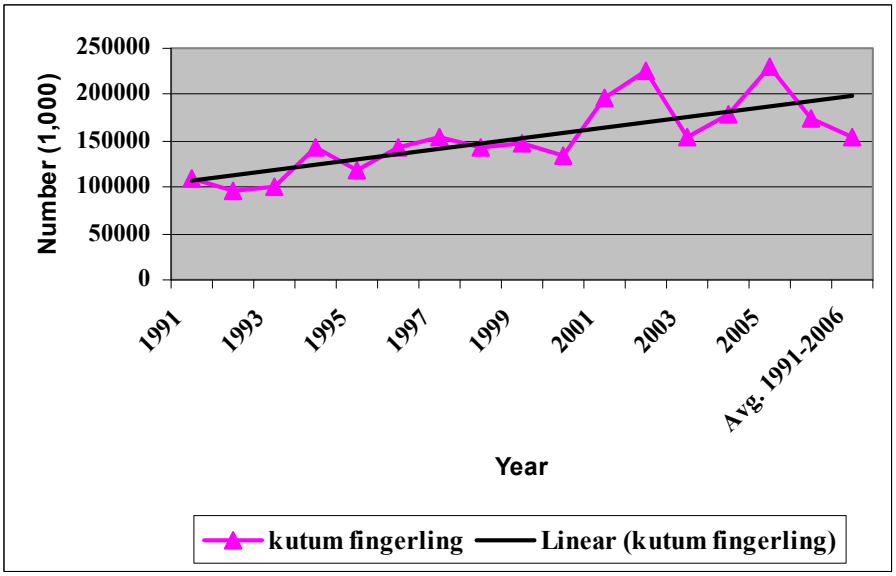


Figure 2: Average cost (Rials per fingerling) of kutum fingerling production in 2004 in Iran (L&S: Labor & Salary, F&F: Feed & Fertilizer, H&Ph: Harvesting & Post harvest, W&E: Water & Energy, Ch&D: Chemical & Drugs, Main: Maintenance, Misc: Miscellaneous and D: Depreciation).

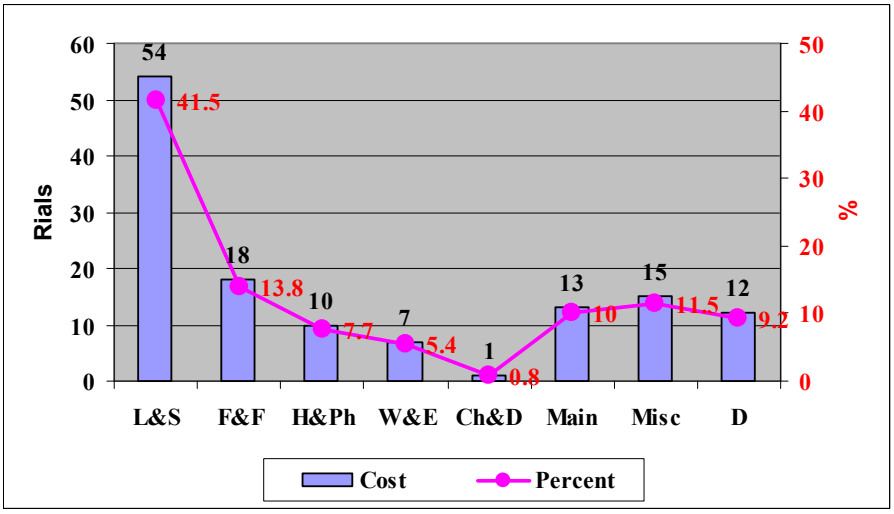


Figure 3: Total landing of kutum over the years 1991-2006 in Iran.

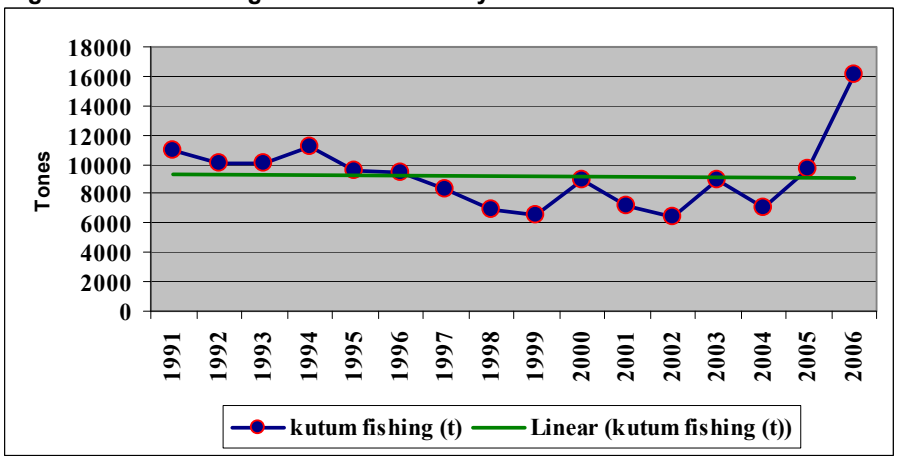
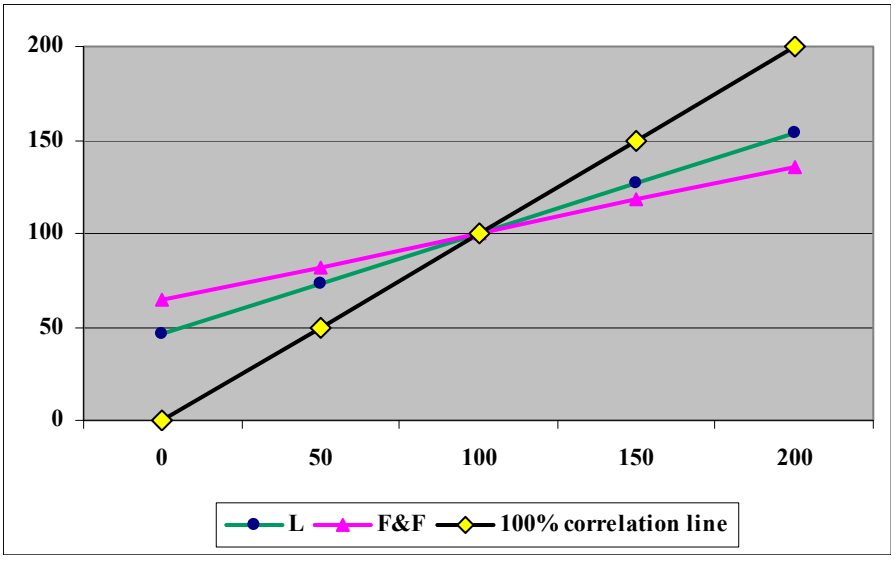


Figure 4. The cost sensitivity of fingerling production of kutum for the year 2004 in Iran.



tion, and the need to address illegal fishing activities. Who will be responsible and answer for these matters? Are 15,500 tonnes kutum attainable?

Overall, from the economic point of view, the results of this study indicate that the hatchery production of kutum is profitable and could present an option for increasing the productivity and breeding procedure of hatchery production in Iranian reach of the Caspian Sea. However, for enhancements to achieve their full potential and provide benefits on a sustainable basis, improvements are required in both policy and research support, particularly, on national and regional basis. Finally, key opportunities for regional cooperation arise from pro-active approaches to regional comparative studies, including identification of key opportunities for learning and designing programmes for collection and analysis regional data.

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The effects of feeding frequency on FCR and SGR factors of the fry of rainbow trout, *Oncorhynchus mykiss*

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Economically efficient production of carnivorous fish requires the use of suitable feeds in quantities and frequencies that produce efficient growth, considering both biological performance and return on feed costs invested by the farmer. Standard measures for determing ration performance are specific growth rate (SGR), food conversion ratio (FCR) and also condition factor (CF = weight x 100 / length^3).

Production cost efficiency can be improved by monitoring these performance indicators and assessing the impact of alterations in feed, feeding and other management practices. I conducted a study to investigate the effect of feeding frequency on growth and feed utilization efficiency in rainbow trout. The experiment involved several different treatments with feeding frequencies of 4, 6 and 8 feeds per day. The research was conduced at Ghezelrood Aquaculture center, in Broujerd, Iran.

The aims of my research into the effects of feeding frequency were to:

- Estimate and compare condition factor (CF) between experimental treatments.
- Determine optimum feeding frequencies for growth of fish with consideration of feed expense points.
- Estimate and compare SGR and FCR between experimental treatments.

Differences in feeding rate can result from different temperatures, environmental conditions and life stage of fish. In this experiment, fry of rainbow trout of around 6±1 g in body mass were placed into compartments, with 400 fry stocked in each net and with three replicates of each treatment. The fish were fed with regard to feeding tables based on body mass and temperature. They were grown for a period of 71 days with biometric assessment conducted every two weeks, while anaesthatised with carnation (clove flower) oil at a concen-