Cost factor analysis of Caspian salmon 
(Salmo trutta caspius Kessleri, 1877) fingerling production and release in Iran

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Abstract: Iran contributes to the stock enhancement of several economically valuable fish species, including the Caspian salmon, S. trutta caspius, by producing and releasing millions of fingerlings into the sea. This work was conducted to determine the production costs of the Caspian salmon fingerlings in the years 2002 and 2003. For this purpose, a questionnaire was prepared and filled in by an expert team using data available in the Kelardasht Caspian Salmon Hatchery and other related departments. Among various expenditures, on average, cost of labor (52%) and cost of feed (16%) had the greatest share. Results showed the average cost of production and release of a single fingerling in Iran was IRRls 6,685, (US$ 0.84) over the 2002-2003. The cost sensitivity of hatcheries production of the Caspian salmon shows that labor cost is the most sensitive, and a 50% increase in the cost of this item increases the total cost by more than 25% followed by feed cost.

Keywords: Economic Analysis, Caspian salmon, Costs, Stock enhancement, Iran

Introduction

Wild-population fisheries are seriously declining worldwide (Botsford et al., 1997; Vitousek et al., 1997; Pauly et al., 1998). Several factors such as irregular fishing, dam construction, sand extraction from river beds, and various forms of pollution cause deterioration in aquatic habitats that affect fish stocks, including the Caspian salmon. Three methods are commonly used to attempt the replenishment of depleted stocks: (i) regulating fishing effort, (ii) restoring habitats critical to one or more life stages of the stock, and (iii) artificially supplementing the reproductive population through restoration or enhancement programs (Leber & Lee, 1997).
Although stock restoration or enhancement is gaining increased popularity and many countries are involved in stock enhancement or reconstruction of economically valuable fish stocks, it is generally not closely monitored or evaluated. Japan has a long history to support and rehabilitate resources of almost 80 species (Fushimi, 2001) with varying results. A major problem in justifying the expense and effort associated with stock enhancement is determining if it is successful. Leber (1999) points out that success has typically been measured by production levels and numbers of fish stocked. However, the success of a stock enhancement endeavor should be evaluated according to the goals of the project (Vea Salvanes et al., 1995; Bell & Gervis, 1999; Kuwada et al., 2000; Ashford & Danzmann, 2001; Rasmussen & Geertz-Hansen, 2001). The goals are often defined as the measurable contribution to the fishery or to the reproductive population.

Among the main issues that should be considered in any stock enhancement plan are the economic aspects in terms of costs and returns, which have been the object of several studies in recent years (Bartley, 1995 & 1999; Hansson et al., 1997; Hilborn, 1998; Sreenivasan, 1988; Ahmad et al., 1998; Lorenzen et al., 1998; Pruder et al., 1999; Garaway, 1999; Kitada, 1999; Salehi, 1999, 2003a, 2004 & 2005b) and some researchers emphasized the profitability of stock enhancement and stressed that in some species the rate of return of investment was very high (Hansson et al., 1997; Ahmad et al., 1998; Lorenzen et al., 1998; Garaway, 1999; Fushimi, 2001; Lorenzen et al., 2001; Stickney & McVey, 2002). However, the economic analysis of all aspects of stock enhancement is very complicated, expensive, and takes long time to gain satisfactory returns.

Iran contributes to the stock enhancement efforts through artificial breeding of more than thirteen native species and releasing more than 500 million seedlings into the Caspian Sea and the Persian Gulf annually (Bartley, 1995; Shehadeh, 1996; Bartly & Rana, 1997; Abdolhay, 1998; Tahori, 1998; Salehi, 2003a, 2004 & 2005b). The natural maturation of the Caspian salmon in the south Caspian Sea seems to be facing serious problems, and there has been no evidence for natural maturation of the Caspian salmon so far (Razavi Sayyad, 1999). The total production of Caspian salmon was between 2-14 tons over the years 1995-2005,
however, it declined from 13 tons in 1995 to less than 3 tons by 2005 (Ghaninejad et al., 2001; Sayyade Burani et al., 2006; FAO, 2004; PDD, 2006). By considering the background of stock enhancement of the Caspian salmon and the result of fishing data, it seems the average catch of almost 6 tons per year over the 1995-2005 has probably been due to the stock enhancement program. Although the quality of the released Caspian salmon fingerlings has increased in the past few years, the quantity of fingerling production has remained constant in Iran, which averaged 350,000 fingerlings by 2003 (PDD, 2005).

Overall, for increasing the productivity and breeding procedure of hatchery production of the Caspian salmon in the Iranian reach of the Caspian Sea, including Guilan, Mazandaran and Golestan provinces, where the government has heavily invested over the last two decades as well as to help clarify the Caspian salmon fingerling production cost, input cost factor and their contributions, this study was carried out.

Materials and methods

The emphasis of the study was focused on selected preliminary investigations together with secondary data analyses. To determine the costs of production of the Caspian salmon fingerlings for the years 2002 and 2003, a questionnaire was prepared in 2004. An expert team comprising of economist, statistician and aquaculturist filled in the questionnaire using data provided by Kelardasht Caspian Salmon Hatchery. Other relevant documents available in different sections of the Iranian Fisheries Organization (IFO), especially accounting, budgeting and stock enhancement offices were also consulted. Secondary data were collected from IFO and its affiliated departments, Iranian Fisheries Research Organization (IFRO) and other organizations, such as FAO. Data were loaded into a Microsoft Excel spreadsheet and all the required functions, particularly the method for cost sensitivity analysis were used for analysis.
Results

Over the years 2002 and 2003, about 344,000 and 325,000 fingerlings of the Caspian salmon were respectively produced in Kelardasht Caspian Salmon Hatchery (Fig. 1). The total expenditure increased by 8% from IRRls\(^1\) 2,125 million in 2002 to 2,288 million in 2003. The total operation costs increased by 6% and averaged IRRls 1,920 million over the same period. The two main operation costs were labor and feed that averaged IRRls 1,152 million and 350 million, respectively (Table 1).

![Graph showing number of Caspian salmon fingerling production and releasing over the years 1996-2004 in the South Caspian Sea.](image)

Figure 1: Number of Caspian salmon fingerling production and releasing over the years 1996-2004 in the South Caspian Sea.

Source: PDD, 2005.

\(^1\) On average, 1US$ = IRRls 8,000 over the 2002 and 2003.
Table 1: Total expenditures (IRRs 1,000) of the Caspian salmon fingerling production over the 2002-2003 in Iran.

<table>
<thead>
<tr>
<th>Cost factors</th>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td></td>
<td>1100910</td>
<td>1203304</td>
<td>1151783</td>
<td>72403</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>367678</td>
<td>331709</td>
<td>350830</td>
<td>25434</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>165774</td>
<td>155560</td>
<td>161073</td>
<td>7222</td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td>70135</td>
<td>121246</td>
<td>94879</td>
<td>36141</td>
</tr>
<tr>
<td>Handling &amp; Releasing</td>
<td></td>
<td>76511</td>
<td>77780</td>
<td>77227</td>
<td>897</td>
</tr>
<tr>
<td>Chemicals &amp; Drugs</td>
<td></td>
<td>27629</td>
<td>32027</td>
<td>28684</td>
<td>3110</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>51007</td>
<td>54904</td>
<td>52956</td>
<td>2756</td>
</tr>
<tr>
<td>Operation costs</td>
<td></td>
<td>1859644</td>
<td>1978818</td>
<td>1919638</td>
<td>84269</td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td>265664</td>
<td>308833</td>
<td>286842</td>
<td>30525</td>
</tr>
<tr>
<td>Total costs</td>
<td></td>
<td>2125308</td>
<td>2287651</td>
<td>2206480</td>
<td>114794</td>
</tr>
</tbody>
</table>

1- SD= Standard deviation.
2- Depreciation was calculated based on Planning and Management Organization and Aquaculture Department of Fisheries Organization of Iran methods for ponds, buildings and machineries and completed by Salehi, 1999 & 2005.

Over the years 2002 and 2003, the average cost per fingerling production increased by 14% from IRRs 6,269 in 2002 to 7,123 in 2003. The total operation cost per fingerling production increased by 12% and averaged IRRs 5,816 over the same period. Labor and feed costs per fingerling production averaged IRRs 3,489 and 1,063, respectively. Depreciation and maintenance costs per fingerling production averaged IRRs 869 and 488, respectively (Table 2).

Table 2: Average costs (IRRs per fingerling) of Caspian salmon fingerling production over the 2002-03 in Iran.

<table>
<thead>
<tr>
<th>Cost factors</th>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>Contribution costs (%)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td></td>
<td>3247</td>
<td>3747</td>
<td>52</td>
<td>354</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>1085</td>
<td>1033</td>
<td>16</td>
<td>37</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>489</td>
<td>484</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td>207</td>
<td>378</td>
<td>4</td>
<td>121</td>
</tr>
<tr>
<td>Handling &amp; Releasing</td>
<td></td>
<td>226</td>
<td>242</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Chemical &amp; Drugs</td>
<td></td>
<td>81</td>
<td>100</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>150</td>
<td>171</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Operation costs</td>
<td></td>
<td>5485</td>
<td>6161</td>
<td>87</td>
<td>478</td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td>784</td>
<td>962</td>
<td>13</td>
<td>126</td>
</tr>
<tr>
<td>Total costs</td>
<td></td>
<td>6269</td>
<td>7123</td>
<td>100</td>
<td>604</td>
</tr>
</tbody>
</table>

SD= Standard deviation.
Contribution of the main costs of fingerling production over the years 2002 and 2003 is shown in Table 2. Among various expenditures, on average, the labor cost with 52% and feed costs with 16% of total costs have the greatest share; depreciation (13%), maintenance (7%), handling and releasing (4%), and energy cost (4%) are the other important cost factors (Fig. 3).

The differences between years in contributing cost factor for fingerling production in Iran were negligible (Fig. 2). Operation costs per fingerling production between the succeeding years of 2002-2003 increased by 15% (Table 2). As Table 2 shows, the contribution of feed cost per fingerling production declined from 17.3% of total costs to 14.5%, however the contribution of harvesting and releasing cost increased from 3.3% to 5.3% of total costs over the years 2002-2003.

Figure 2: Contribution of the main costs of Caspian salmon fingerling production over the years 2002-2003 in Iran.
The cost sensitivity of hatchery production of the Caspian salmon shows labor is the most sensitive, which is shown by the shape of labor line and a 50% increase in the cost of this item increases the total cost by more than 25% followed by feed cost (Table 2).

**Discussion**

Stock enhancement has many socio-economic and environmental advantages and many researchers have discussed the positive effects of stock rehabilitation of sturgeon and bony fishes in Iran (Razavi Sayyad, 1995; Abdolhay, 1998; Danesh, 1998; Tahori, 1998; Hosseini, 1998; Pourkazemi, 2000; Salehi, 1999 & 2003a; Keyvan, 2002) and other countries (Sreenivasan, 1988; Bartley, 1995 & 1999; Hansson et al., 1997; Leber & Lee, 1997; Ahmad et al., 1998; Lorenzen et al., 1998; Welcomme & Bartley, 1998; Garaway, 1999; Kitada, 1999; Stoner & Davis, 1994; Leber et al., 1996; Leber et al., 1998; Leber, 1996; Lorenzen et al., 2001). To measure the success of Pacific threadfin (*Polydactylus sexfilis*) stock enhancement programme, American researchers in Hawaii considered the increases in its percentage share in fishermen's creels (Ziemann, 2003). Japanese researchers used increases in the catch statistics versus number of seeds released to measure the bay scallop (*Argopecten irradians*) stocking success (Kitada & Fujishima, 1997). In 1999, 30% of the harvested commercial salmon in Alaska was hatchery reared (Stickney & McVey, 2002).

Fish landing data after the establishment of various hatcheries along the Iranian part of the Caspian Sea clearly indicate the success of stock enhancement programs over the last two decades in Iran. This success was also noted for sturgeon by the beach seiners co-operatives (Abdolhay 1998; Tahori, 1998; Fadaee, 2002). In any way, all these important matters were noted to require the sensitivity and foresight of the researchers and fishery managers.

The estimated production cost for the Caspian salmon fingerling (IRRs 6,269 and 7,123 for the years 2002 and 2003, respectively) (Table 2) was higher than the corresponding costs for the sturgeon (IRRs 1,753 and 2,028) and kutum (IRRs 54 and 121) (Salehi, 2005b & 2006a). The main reason for higher production cost of
the Caspian salmon fingerling might be the lack of brood stock, the lower quantity of production and the scale of hatchery. As shown in this study (Fig. 2), the major cost in hatchery was labor cost, which averaged IRRls 3,489 ($US 0.44) for each fingerling, followed by feed, averaging IRRls 1,063. Compared with cultivation of other aquatic organisms, contribution of labor cost in Caspian salmon fingerling production was also very high; for instance, it was higher than in carp farming by 12% (Salehi, 1999), trout farming by 13% (Salehi, 2005a), shrimp farming by 17% (Salehi, 2003b), shrimp hatcheries by 26% (despite employing foreign experts), and sturgeon fingerling production in Iran (Salehi, 2005b, 2006b) and sturgeon farming in USA (Katherine et al., 1985) by 32% and 12%, respectively. If the depreciation cost is omitted, the costs of labor and feed may increase to almost 60% and 18%, respectively. It seems the main reason for this higher labor cost can be attributed to the inactivity of the hatcheries during a few months off season, which could be reduced by adopting extra activities in such hatcheries. The cost sensitivity of hatchery production of the Caspian salmon shows labor is the most sensitive, and a 20% decrease in labor cost will lead to a total cost reduction by almost 12% though, reduction in these two major costs may increase productivity of the Caspian salmon hatchery and farm management. Current production and enhancement of the Caspian salmon fingerling and the huge investment suggest that this sector might be expected to become increasingly important in coming years. Future fingerling productions vary widely and will be, to a large extent, dependent on the ability to obtain brood fish from the Caspian Sea as well as government potential investment. Overall, the Caspian salmon rehabilitation industry may benefit from research aimed at developing technically viable production and enhancement systems as did before, improved nutrition, genetic improvement, disease prevention, water quality and industry management.

As for the fish return, it has been estimated that only 0.5% of the Caspian salmon fingerlings released annually return (Sayyade Burani et al., 2006) at age 3-4 years (Karimpour & Hossienpour, 1988), which is 50% lower than the return rate for the Atlantic salmon (Krayushkina, 1999). Considering even the 0.5% return for the Caspian salmon, almost 1,720 fish of 334,000 released fingerlings over the
years 2002-2003 might be expected to return over the years 2006-2007. With an average weight of 2.5kg for each Caspian salmon (Sayyade Burani et al., 2006), the total catch might be valued around IRRIs 375 million (US$ 41,625). However, from the economic point of view, the positive effect of stock enhancement of the Caspian salmon in Iran is clear, and it might be necessary to promote low-cost methods for hatchery production as well as providing institutional and policy support to gain satisfactory returns.

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