

Investigation of rainbow trout (*Oncorhynchus mykiss*) culture in marine floating cages in the Southern Caspian Sea

Abstract

There is no long history of fish farming cages in the southern Caspian Sea. The rainbow trout is one of the most important fish raised in the last decade in this sea. The aim of this study was to determine the growth performance and survival of rainbow trout (*Oncorhynchus mykiss*) in floating cages in the south of the Caspian Sea. In this study, circular polyethylene floating cages with a diameter of 20 meters and a net height of 8 meters were used. The cages were located at a depth of 32 meters in the sea and at a distance of 5.6km from the shore. This research was conducted in 2017-2018 in a marine farm in the central region of the southern Caspian Sea. The fish culture period was 165days from December to May of the following year. For each cage, 37400±570 fish weighing 110±28grams and a fork length of 19.9±1.9cm were introduced. After 165 days, the average weight of fish reached 1200±168g in the marine fish farm. But, the fish yield was supplied with a weight of 700g to the local market, from March and continued to June of the following year (1200g). Fish average daily growth (ADG:g/day) was 6.61±1.02. The value feed conversion ratio of fish and the condition factor was determined 1.03±0.07 and 1.42±0.05 respectively. The fish special growth rate (SGR:%day⁻¹) was determined 1.44±0.09. The fish survival rate (SR%) at the end of during culture was determined 95.6±1.07 in cages. The results showed that the growth performance of rainbow trout was suitable in the Caspian Sea's brackish water in floating cages.

Keywords: cage culture, rainbow trout (*Oncorhynchus mykiss*), caspian sea, brackish water

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Introduction

The Caspian Sea has been isolated for over two million years and hosts a unique ecological system as a result. The Caspian Sea is unique ecological system with rich natural resources, which include mineral, biological, agro-climatic and recreational components. Like other inland seas, the Caspian Sea has been influenced by climate change and anthropogenic disturbance during recent decades, yet the scientific understanding of this water body remains poor.^{1,2} The Sea's marine environment suffers from an enormous burden of pollution from oil extraction and refining, offshore oil fields, and huge volumes of untreated sewage and industrial waste.³ The change in the trophic status coastal south of the Caspian Sea from oligotrophic to mesotrophic is attributed partly to the effects of *Mnemiopsis leidyi* on the Caspian Sea ecosystem.⁴ Therefore, any development in the Caspian Sea must be in accordance with environmental protection programs.

On the other hand, Iran is facing freshwater stress⁵ and the only way to develop aquaculture in this country is to use salt and sea water. Coastal waters of Iran have more potential for aquaculture development⁶ and the south of Caspian Sea has the potential to develop marine aquaculture.⁷ The marine cage fish farming is a good way to the culture of many fish species,⁸ and cages have shown that they are better than compared to ponds.^{9,10} There is no long history of fish farming cages in the south of Caspian Sea. The rainbow trout is one of the most important fish raised in the last decade in this sea.¹¹ The aim of this study was to determine the growth performance and survival of rainbow trout (*Oncorhynchus mykiss*) in floating cages in the south of the Caspian Sea.

Materials and methods

This study was carried out in an offshore fish farm in the southern region of the Caspian Sea (36°, 47', 12" N and 51°, 7', 50. 2" E) with a distance of 5.6km from the coast in a water depth of 32m (Figure 1). This research was conducted in 2017-2018 in a marine farm in the central region of the southern Caspian Sea.



Figure 1 The South of Caspian Sea included in this study (A: fish farm).

The floating cages were circular polyethylene with a diameter of 20m and net heights of 8m. Juvenile's fish were obtained from mountain farms around the marine sea cage culture. At first, the fish were adapted to Caspian seawater and then introduced in 5cages. Cages C₁ and C₃ received 38000 fish each; cages C₂, C₄ and C₅ received 37000 fish each. The fish weighed on average 110±28g and a fork length of 19.9±1.9cm. They were introduced in the cages on 16 December 2017. The initial fish stocking density was about 1.65 kg/m³ for cage. The fish culture period was 165 days from December 2017 to May 2018.

Commercial semi-submersible extruded feed (Faradaneh Company) was used to feed the fish. Feed content had 4% crude protein, 15% crude fat and 3% crude fiber. The fish were fed three times a day. Feeding Rate was 1- 3% of body weight in during the rearing period based on fish weight and water temperature. The health of fish was observed daily and dead fish were removed from cages. The fish growth performance was determined by sampling and biometrics during the rearing period (Figure 2).

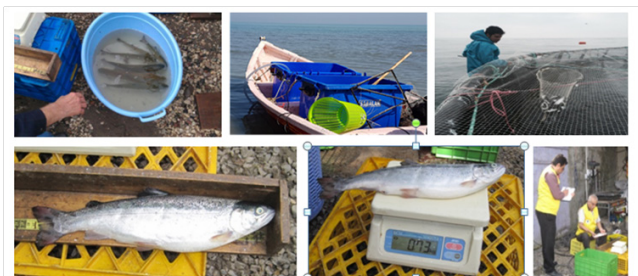


Figure 2 Rainbow trout (*Oncorhynchus mykiss*) culture in marine floating cages in the southern Caspian Sea.

The fish weight was measured with a scale of 1g and the length of fork was calculated with a scale of 1cm.

The relative standard deviation (RSD) was calculated by calculating the percentage of the coefficient of variations in the time of introduction and final of rearing periods.¹²

$$RSD = \frac{\text{standard deviation (SD)}}{\text{mean weight (g)}} \times 100$$

Low values of RSD (e.g. between 3 and 10 percent) usually indicate homogenous batches. High values of RSD (more than 20 percent) indicate a large size variation.

The condition factor (CF, %) of fish was calculated by Fulton equation.¹³

$$CF(\%) = \frac{W(g) \times 100}{L(cm)^3}$$

The weight gain (WG, g) were determined with the difference between the mean of initial (W_i ; g) and mean of final weights (W_f ; g) of fish at 165 days of rearing period in each cage, according to the following equation:⁴

$$WG = W_f - W_i$$

The fish specific growth rate (SGR, %day⁻¹) was calculated by the natural logarithm of final weight (W_f ; g) and the natural logarithm of initial weight (W_i ; g) of fish toward the number of rearing days (t, day).¹⁵

$$SGR = \frac{100 \times (\ln W_f - \ln W_i)}{t}$$

The fish average daily growth (ADG) was calculated by following equation:¹⁶

$$ADG (g/day) = \frac{WG (g)}{t (day)}$$

The feed conversion ratio (FCR) was calculated according to the following equation in each cage:

$$FCR = \text{Feed given} / \text{Average Weight Gain (AWG)}$$

After 165 days of feeding experiment the fish were counted to determine the survival rate (SR) according to the following equation in each cage.¹⁷

$$SR(\%) = \frac{\text{Number of Fish at the End of rearing}}{\text{Number of Fish introduced to the cage}} \times 100$$

Statistical analysis of the results for fish growth performance were conducted based on one-way analysis of variance using SPSS (version 20) software and Duncan's multiple range test at a 95% confidence.¹⁸

Results

The water temperature of the Caspian Sea was 19°C when the fish entered the cage and 21°C at end of fish culture period. During the rearing period (165 days), the average weight of fish reached 1200±168g (Figure 3).

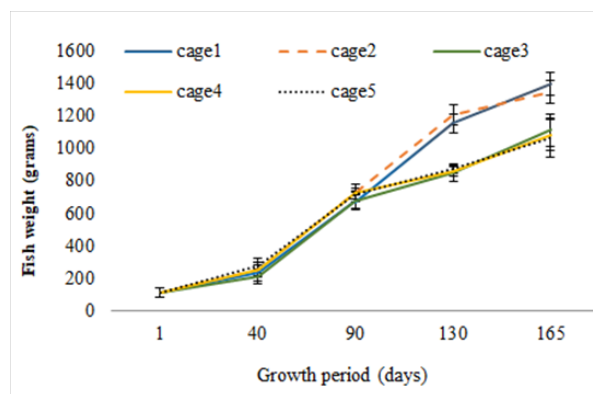


Figure 3 Time courses of rainbow trout (*Oncorhynchus mykiss*) average weight in marine cage culture in south of Caspian Sea.

The relative standard deviation (RSD) was 26% in the time of introduction fish to cages. The fish yield was supplied with a weight of 700grams to the local market from March and continued to June of the following year (1200grams). The fish survival rate (SR) at the end of during culture was determined 95.6±1.07% in cages. Fish average daily growth (ADG) was 6.61±1.02gr/day. The value feed conversion ratio of fish and the condition factor were 1.03±0.07 and 1.42±0.05 respectively. The fish specific growth rate (SGR) was determined 1.44±0.09 %day⁻¹ at the end of rearing period (Table 1,2).

Discussion

It is very clear that fish growth was not a constant factor and may have been affected by several environmental factors (physical, chemical/biochemical, or a combination there of).^{19,20} Water temperature was one of the most important physical factors affecting fish growth and production. For example, the survivable temperature range for *O. mykiss* is between 1 and 26°C. However, depending on the reference source, the "optimum" temperature for growth is between 13 and 21°C.¹⁹ In this study, the Caspian Sea water temperature at the beginning of the fish farming period was 19 °C in December and decreased to 10°C in February and then increased to 21°C until May. Therefore, there was the "optimum" temperature range for the growth of rainbow trout in south of the Caspian Sea.²¹ Also, in addition to the effect of environmental factors on fish growth, other factors such as species and breed, quantity and quality of feed, size, and density of fish affect the performance of fish growth.⁷

There is not documented information on the growth performance of *O. mykiss* in floating cages in the southern Caspian Sea region. However, there are *O. mykiss* growth results in marine farms of other

countries as well as inland water farms (mountainous and plain) using fresh and salt water.²²⁻²⁵

The rearing of *Salmonidae* in marine and saltwater was first successfully carried out in Norway around 1955 and since then has spread in other parts of the world.²⁶ The last studies have shown that trout in brackish water have better growth efficiency than fresh water.^{22,27-29} This coincides with the results of our study.

O. mykiss growth performance in the present study was better than in the Black Sea (Table 3). This advantage was probably due to the favorable water temperature conditions at lower latitudes and initial fish stocking density in cages. The initial fish stocking density in cage in the Caspian Sea and the Black Sea were 1.65kg/m³ and 2.1kg/m³,²² respectively.

Table 1 Initial and final biometrics of rainbow trout (*Oncorhynchus mykiss*) in the system of marine cage culture in the South of Caspian Sea

Cages	Weight (g)		Length (cm)		RSD(%)		CF		WG(g)
	W _i	W _f	L _i	L _f	R _i	R _f	CF _i	CF _f	
C1	110±28	1394±68	19.8±1.9	46.1±0.9	26	4.9	1.39±0.16	1.42±0.07	1284±68
C2	110±28	1346±74	19.8±1.9	45.6±0.8	26	5.5	1.39±0.16	1.41±0.03	1236±74
C3	110±28	1110±99	19.8±1.9	42.8±1.4	26	8.9	1.39±0.16	1.41±0.04	1001±99
C4	110±28	1082±94	19.8±1.9	42.5±1.2	26	8.7	1.39±0.16	1.40±0.04	972±94
C5	110±28	1067±121	19.8±1.9	42.2±1.6	26	11.4	1.39±0.16	1.41±0.05	957±121

W_i initial weight; W_f final weight; L_i initial length; L_f final length; RSD, relative standard deviation; CF, condition factor; WG, weight gain

Table 2 Growth performance of rainbow trout (*Oncorhynchus mykiss*) in the system of marine cage culture in the South of Caspian Sea

Cages	SGR (%day ⁻¹)	ADG (g/day)	FCR	SR %	Fish harvest (metric ton)
C1	1.54±0.03 ^a	7.78±0.41 ^a	1.10	96.00	35
C2	1.52±0.03 ^b	7.49±0.45 ^b	0.98	97.00	34
C3	1.40±0.05 ^c	6.06±0.60 ^c	1.12	95.00	29
C4	1.38±0.05 ^{cd}	5.89±0.57 ^{cd}	0.95	94.00	28
C5	1.37±0.07 ^d	5.80±0.74 ^d	0.99	96.00	26

SGR, specific growth rate; ADG, average daily growth; FCR, feed conversion ratio; SR, survival rate

Table 3 The Comparative growth performance of rainbow trout (*Oncorhynchus mykiss*) in the system of marine cage culture in the South of Caspian Sea and Black Sea

Area	period of rearing (day)	Weight (g)		SGR (%day ⁻¹)	FCR	SR %	Fish harvest (kg/m ³)
		W _i	W _f				
Caspian Sea	165	110	957-1384	1.44±0.09	1.03±0.07	95.6±1.1	12.1
Black Sea	202	118	740±174	1.02±0.99	1.65±0.32	89.2±0.1	12.1

W_i initial weight; W_f final weight; SGR, specific growth rate; CF, condition factor; FCR, feed conversion ratio; SR, survival rate

Another study Kljajić *et al.*,²⁹ in the Kotor Bay (Adriatic Sea) found that *O. mykiss* increased from 85g to 338g in 85 days during the rearing period. In this study, salmon increased from 110g to about 700g during a 90days rearing period. Anyway, the results showed that the growth performance of rainbow trout was suitable in the Caspian Sea's brackish water in floating cages.

Although cage culture has many roles in the world of aquaculture, it still does not hold a good position in Iran, especially in the south of the Caspian Sea.⁶ It is clear that in order to ease fishing pressures on marine stocks, the production of marine finfish through aquaculture must be accelerated.³⁰

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Conflicts of interest

The author declares that there is no conflicts of interest.

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