

Photo by G. Gabrielyan

# CONTEMPORARY AQUACULTURE TECHNOLOGIES FISH MARKETS AND EXPORT ARMENIA

IN PARTNERSHIP WITH



**WORLD BANK GROUP**

**IFC** | International Finance Corporation

This material is developed in cooperation with the  
Ministry of Economy of the Republic of Armenia  
and the Development Foundation of Armenia.



Ministry of Economy of the Republic of Armenia



Development Foundation  
of Armenia

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## FOREWORD

The strength of each country is its economic base. Fish farming can be a key element of a country's economic base and represent a segment of the population with a unique culture. Development of fish farming in Armenia is largely influenced by the rich experiences and effective management of economic entities engaged in the area, which in turn make the sector both profitable and promising.

Although the industry is quite developed, the value creation chains, regional integration, new technology development, strategic planning, and especially export mechanisms need improvement.

At the same time, studies show that the sector has significant unused resources: the rational use of such resources may produce beneficial outcomes.

With a view to fulfilling the aforementioned intentions, and in light of the peculiarities of the sector, the International Finance Corporation (IFC), a member of the World Bank Group, introduces this brochure in addition of the Fish Export Chain Mapping review of September, 2015, within the scope of the Armenia Investment Climate Reform Project jointly implemented with the Ministry of Economy of the Republic of Armenia (RA).

Undoubtedly, this new guide can become a useful source of information for fish industry development and export promotion in Armenia. Moreover, recommendations from international experts will contribute to an increase in the efficiency of activities of fish and associated servicing industries, hence creating conditions not only for further development of the industry and an increase in productivity, but also for an increase in investments, production and export volumes in this traditional now sector, which will, in turn, open up new development prospects.

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The Contemporary Aquaculture Technologies booklet is prepared by Mr. Marcel de Rooij, WBG International Expert. The Fish Markets and Export booklet is prepared by Mr. Andrew Kaelin, WBG International Expert. Works were assisted by Mr. Gagik Gabrielyan, WBG Consultant.

Prior to this booklet, the Project, at the request of the Ministry of Economy of the Republic of Armenia and the Development Foundation of Armenia, developed and published the "Armenia Aquaculture Sector Review" in September 2015, which lead to lively discussions among the participants of the workshop. In December 2015, the Project organized the workshop on "Food Safety Standards for fish production, new technologies and export market analysis" during which the international experts presented the possibility of implementing new technologies in fish farm operational management and analyzed the competence of the Armenian fish industry product and export market in order to sketch out the global picture for further opportunities for export-oriented development.

The Project would like to thank the representatives of business entities and public authorities (Ministry of Economy and Ministry of Agriculture) for their active participation in the discussions, as well as all those organizations and individuals that so readily gave of their time and expertise, thereby making a significant contribution to this booklet. In this regard, we would like to extend our special thanks to Mr. Arkadi Gevorgyan, fish farmer, for his valuable contribution.

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*Photo by M. de Rooij*

## CONTEMPORARY AQUACULTURE TECHNOLOGIES

# 1. INTRODUCTION

Fish farming has been carried out for centuries and is essentially fairly simple. It becomes a challenge when it is used for commerce. The ability to successfully manage the complications of an intensive and cost-efficient fish farm makes the difference between a healthy enterprise and a struggling one. This brochure highlights the major complications associated with intensive and cost-efficient fish farming.

In Armenia, there are a number of pro and cons to its relationship with fish farming. Armenia has abundant clean water sources. The water has limited suspended solids and little to no dissolved nitrogen. The effect of urbanization is also very limited, and water availability varies based on geographic location. Labor costs in Armenia are also low compared to European Union (EU) countries.

However, Armenia's geographical location presents a challenge. Feed, eggs, and equipment have to be imported, mainly from the U.S. and EU, which adds extra transportation costs that have significant impact especially on the cost of feed.

Trout and Siberian sturgeon are among the main species of fish farmed in Armenia.

There is a lot of information published on standard practices relating to trout farming ([www.thefishsite.com](http://www.thefishsite.com), [www.fao.org](http://www.fao.org)), while sturgeon farming has not been intensively researched and there is little published information about it.

Sturgeon is farmed mainly for its high-priced caviar and, as a secondary product, its meat. On the international market, sturgeon meat is a less common product.

To be a player on the international fish market, a fish farm must be competitive in three main areas:

- ▲ Consistent quality,
- ▲ Sufficient volume,
- ▲ The right sales price.

For the last area in particular, farm gate prices are very important. To obtain a competitive farm gate price, several topics have to be addressed and are discussed in this brochure, along with common perspectives of fish farming.

## 2. FARM GATE COSTS/PRICE

The farm gate price consists of three major components: Fixed costs + Variable costs + Margin.

### 2.1. Fixed costs

These are the costs that recur each year no matter how much the fish farm produces, for example indirect personnel costs, investment interest, etc.

### 2.2. Variable costs

These costs depend on the production volume, for example direct personnel and feed costs.

### 2.3 Profit and profit margin

Profit is the surplus revenue remaining after total costs (including production costs, depreciation, interest, taxes, and other expenses) are deducted from total revenue. Profit margin usually refers to the profit as percent of sales revenue.

### 2.4. Cost driver

The main cost driver of every fish farm is the price of feed, calculated per kilogram of fish growth. The price of a kilogram of fish growth depends on the feed price in combination with the feed conversion ratio.

Feed conversion ratio (FCR) is the ratio between the dry weight of feed fed and the weight of yield gain, measure of the efficiency of conversion of feed to fish (e.g. FCR = 2.8 means that 2.8 kg of feed is needed to produce one kilogram of fish live weight).

A common misconception is that cost savings can always be achieved by purchasing cheaper feed.

$$\text{Cost per kg. fish growth} = \text{Feed price} \times \text{feed conversion ratio}$$

The method of evaluating the cost per kilogram fish is described in section 3.1 and chapter 7.

### 2.5. Farm management

There are three main factors that are critical to sound farm management.

### 2.5.1. Growth

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There is only a daily contribution to fish farm revenue if fish grow every day. This is achieved by maintaining the right standing stock, providing the optimum feed volume over the course of the day, and careful management.

### 2.5.2. Mortality/loss

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When a fish dies or is deformed in any way, it cannot be sold, and the feed invested in the fish is considered a 100 percent loss.

### 2.5.3. Feed conversion

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As feed costs are the cost driver and the feed purchasing cost is fixed, the farmer can manage the feed conversion ratio through sound management. Good management means ensuring a proper feeding schedule, grading, oxygen availability, and reducing feed spill.

The farm gate price is reduced when there is higher production per cubic meter of water and lower mortality.

## 3. BASICS OF FISH FARMING

Fish can only grow when there are three elements present:

- ▲ Feed
- ▲ Oxygen
- ▲ Favorable water environment

The importance of these three elements is discussed in this chapter.

### 3.1. Feed

Fish can be fed in many ways depending on the aquaculture system and its densities. The majority of large commercial intensive fish farms use a pellet feed as shown in figure 1.

Feed varies depending on the type of production. For pond farming, feed is provided in addition to the natural feed present in the ponds. The formula for this additional feed is more basic compared to that used in a flow-through or recirculation farm where 100 percent of growth must come from the feed supplied.

*Figure 1: Fish feed pellets*



*Source: GCMEC company: [www.gcmeccom.com](http://www.gcmeccom.com)*

#### 3.1.1. Major indicators

Depending on the application method, several feed suppliers produce feed of different grades based on the size of the fish and the farming method.

The following indicators are used to compare the different feeds and suppliers:

- ▲ Protein (starter feed)
- ▲ Fat (feed for on-growing)
- ▲ Carbohydrates
- ▲ Minerals
- ▲ Vitamins

These parameters also vary by growth stage of the fish. Typically, the more mature the fish becomes, the less protein and more fat is required.

Depending on the species, feed may sink or float. For both trout and sturgeon, feed is typically formulated as “sinking” feed. To prevent fat build-up in the sturgeon caviar, feed is typically low in fat and high in protein, with between 45

percent to 50 percent protein. Trout feed, on the other hand, has 40 percent to 44 percent protein. Cheaper feeds are typically lower in protein, while the ingredients with high protein content are higher in price.

Making a feed pellet is not very complicated; **the challenge lies in ensuring that the feed pellet contains all the vitamins and 23 amino acids in the right ratio.** The quality of the pellet is determined by the characteristics of its ingredients, and the quality of the ingredients varies per supplier and from batch to batch. For this reason, for every batch, the fat and protein content should be determined and the recipe should be adjusted accordingly. Vitamins are added during the process. Additives to the recipe are the feed producers' secrets and, therefore, are not shared. A feed producer may develop his own recipe based on research and development.

Thus production of high quality fish feed requires a high level of sophistication of production and research and development. And in practice it would be hardly possible to have high quality feed production in a country; where local producers of fish feed do not have the equipment to determine the protein and fat content and R&D capacities.

### 3.1.2. Indicators of poor feed

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The amino acids in the pellet are required to produce the proteins in the fish. As there are 10 amino acids that cannot be made by the fish, they are introduced via the feed. An incorrectly balanced ratio of ingredients limits growth and causes deformities in the fish, and/or causes stress that can result in illnesses. Ultimately, such deformities and/or stress can be fatal or produce unsellable fish. Figure 2 provides some examples of deformities.

*Figure 2: Examples of fish deformities*



(a) Lower jaw deformity



(b) Spinal deformity



(c) Nose deformity

Sources: (a) [http://www.underwatertimes.com/news.php?article\\_id=79810532610](http://www.underwatertimes.com/news.php?article_id=79810532610); (b), (c) [www.forcechange.com](http://www.forcechange.com)

Fish that suffer from major deformities will not reach market size or will require more time to achieve market weight. When fish cannot survive, this is counted as a 100 percent loss, which means that all the feed invested to help the fish reach market weight is 100 percent lost as well.

Mortality has a major influence on the farm gate price. With good feed quality, the fish farmer can reduce deformities and mortality.

### 3.1.3. Supplier evaluation

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There are many fish feed suppliers. As fish feed is the main cost driver of the operation, it is essential to choose the feed supplier wisely.

$$\text{Cost per kg. fish growth} = \text{Feed price} \times \text{feed conversion ratio}$$

Typically, the supplier is selected based on the fish feed price per kilogram; however, this is only one relevant indicator. The feed conversion ratio (FCR) is also important.

The feed conversion ratio is provided by feed suppliers as an indicator, but can vary by fish farm. The best way to evaluate feed is by performing a test at the fish farm. This test procedure is described in chapter 7.

### 3.1.4. Example of calculations

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Below is an example of a calculation based on figures collected during the feeding test procedure as described in chapter 7.

#### Tank 1

Standing stock at the start of the test 100 kg

Feed given during test period 60 kg

Feed price = €1.80

Standing stock at the end of the test 150 kg

$$FCR = \frac{\text{Feed given}}{\text{Body weight growth}}$$

$$FCR = \frac{60 \text{ kg feed}}{50 \text{ kg fish}}$$

$$FCR = 1.2$$

$$\text{Cost per kg. fish growth} = \text{Feed price} \times \text{feed conversion ratio}$$

$$\text{Cost kg. fish growth} = €1.80 \times 1.2$$

$$\text{Cost kg. fish growth} = €2.16$$

#### Tank 2

Standing stock at the start of the test 100 kg

Feed given during test period 56 kg

Feed price = €1.60

Standing stock at the end of the test 140 kg

$$FCR = \frac{\text{Feed given}}{\text{Body weight growth}}$$

$$FCR = \frac{56 \text{ kg feed}}{40 \text{ kg fish}}$$

$$FCR = 1.4$$

**Cost per kg. fish growth = Feed price × feed conversion ratio**

$$\text{Cost kg. fish growth} = €1.60 \times 1.4$$

$$\text{Cost kg. fish growth} = €2.24$$

Evidently, even though the price of the feed used in tank 1 is higher, it results in a better farm gate cost/price due to a favorable feed conversion ratio.

However, it is important to keep in mind that the best way to ensure a reliable evaluation is to test the feed at the farmer's own fish farm.

### 3.1.5. Consideration about feed production domestically

Feed is the main cost driver of every fish farm. For this reason, it is important to consider cost reductions to lower the farm gate price or to increase margins. Producing a feed pellet is in itself not very complicated as basic recipes and production equipment are available, and it is feasible to produce locally made feed with the correct protein and fat percentages. However, the challenge is to produce feed that contains all necessary vitamins and building blocks and that also offers a favorable feed conversion ratio. Feed producers like Skretting, Coppens, and Biomar, for example, keep their detailed feed recipes private as developing the recipe requires considerable knowledge, equipment, and investment. The main question is what can a fish farmer do?

There are two options: buy relatively expensive feed (imported) with a favorable feed conversion ratio or use cheaper, locally produced feed and accept the lower feed conversion ratio. As it can be seen from the table 3.1, despite the higher price of higher quality feed (€1.80 vs €1.60), the feed cost for producing one kilogram of fish is lower (€2.16/kg fish vs €2.24/kg fish). Therefore, it is essential to conduct trials and determine the cost of the production of 1 kilogram fish in order to carry out a sound evaluation of feed. The procedure for doing so is described in chapter 7.

Table 3.1 Comparison of feed effectiveness

High quality feed	Lower quality feed
Feed price €1.80	Feed price €1.60
Feed conversion 1.2	Feed conversion 1.4
Feed cost price; €2.16/kg fish	Feed cost price; €2.24/kg fish

## 3.2. Oxygen

To digest feed, fish need oxygen. Trout, for instance, consume approximately 300 to 500 grams of O<sub>2</sub> per kilogram of feed. This means that for every kilogram of feed provided, fish need 300 to 500 grams of oxygen.

The quantity of oxygen available for consumption is important for the growth of the fish. Oxygen is dissolved in water and exists naturally in single-loop systems via the inflow of water.

There is a difference between the oxygen level and the oxygen available.

### 3.2.1. Dissolved oxygen available

The available oxygen is the oxygen level in the water minus the minimum required level of oxygen multiplied by the transport volume of oxygen.

$$\text{Oxygen}_{\text{available}} = (\text{Oxygen}_{\text{inlet}} - \text{Oxygen}_{\text{Min}}) \times \text{Water flow}$$

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

Feed gift is the amount of feed provided to the fish over one day period. Feed percentage is the quantity of feed given to one fish on a daily basis, expressed as percent body weight per day. See more details about feed gift and feed percentage in the section 5.

There are two methods of dissolving oxygen in water: aeration and oxygenation.

### 3.2.2. Aeration

Aeration forces air into the water where both oxygen and nitrogen dissolve in the water column. When air is inserted into the water column, the farmer has to be careful to monitor nitrogen levels to avoid over-saturation as nitrogen levels above 103 percent have a toxic effect on the fish.

Figure 3: Water aeration equipment



Source: Catvis company: [www.catvis.nl](http://www.catvis.nl)

### 3.2.3. Oxygenation

During the oxygenation process, pure oxygen is introduced into water, typically under pressure.

Depending on the water temperature and atmospheric conditions, a maximum of 6.7 to 14 milligrams of O<sub>2</sub> per liter can be dissolved.

Figure 4: Relationship between dissolved oxygen and water temperature

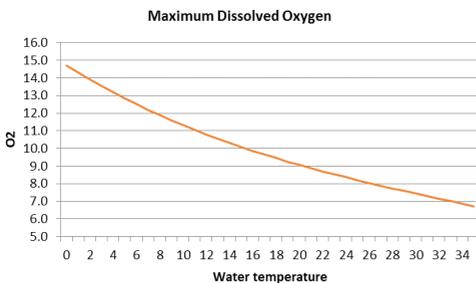
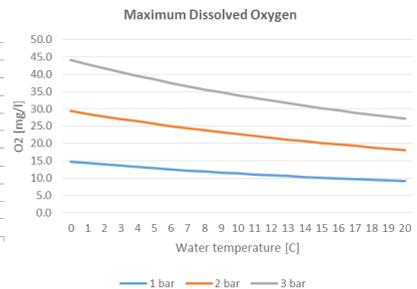


Figure 5: Relationship between dissolved oxygen and pressure



When the pressure on the water column is increased by one bar, the maximum saturation level doubles. Figure 5 shows the relation between temperature and the maximum dissolved oxygen and pressure.

In a recirculation system, fish consume the oxygen from the water. As the water is reused repeatedly when no oxygen is added, the oxygen level will drop to zero.

The oxygenation step adds pure oxygen to the water from a liquid oxygen storage facility or from an oxygen generator.

### 3.2.4. Oxygen storage

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Liquid oxygen is bought from a vendor and comes chilled at  $-183^{\circ}\text{C}$ , via trucks, to refill the fish farm's storage facility.

The oxygen storage facility consists of three major components:

- ▲ Storage tank(s)
- ▲ Evaporator
- ▲ Pressure regulation valve

It is important, when making arrangements for oxygen supply, choosing liquid oxygen to give due consideration to the logistics of liquid oxygen supply. If, for instance, the road is not accessible in the winter for a truck, carrying oxygen, then a solution will have to be found. This can be the installation of an oxygen generator at the fish farm or the enhancements of the road.

*Figure 6: Liquid oxygen storage facility*



*Source: Author's database*

### 3.2.5. Oxygen generator

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The oxygen generator extracts oxygen gas from the air. It consists of four main components: a compressor, an air dryer, the generator, and storage tanks. The oxygen generator typically produces oxygen with a purity of 90 percent to 94 percent at 5 bars. The disadvantage of the oxygenator is the use of electricity, which implies both additional operational costs and dependence on the availability of electricity. To avoid having issues during an electrical power failure, a backup generator should be installed.

*Figure 7: Oxygen generator*



*Source: <http://www.oxyamat.com/>*

One known oxygen generator manufacturer is Oxymat, which makes generators in different capacities. For example, a 1.7 m<sup>3</sup>/hour 93 percent oxygen generator costs approximately €15.000 excluding transportation costs from Denmark.

Figure 7 shows the compressor, dryer, and purification and storage tanks, making up the complete set.

Oxygen gas must be dissolved in the water column. This is achieved using pressurized oxygen via pressure regulation valves that feed into an oxygen reactor

(figure 8) or an MHO (Medium Head Oxygen Generator) (figure 9), which dissolves the oxygen in the water.

The reactor works with a pump to increase the water pressure, whereas the MHO uses the static pressure of the water column to dissolve the oxygen. Due to the enhanced pressure of the water, oxygen levels up to 24 mg/l are achievable.

Figure 8: Oxygen reactor



Source: Author's database

Figure 9: MHO generator



Source: Author's database

### 3.2.6. Concentration and transport

Oxygen concentration in the water column is typically measured with an oxygen meter. One such oxygen meter is the OxyGuard Handy Polaris, which has a digital screen that displays the water temperature, oxygen concentration, and percentage of saturation. The cost of purchasing a Polaris is estimated at €800. The meters can be ordered from a number of sources, but [www.catvis.nl](http://www.catvis.nl) is a well-known supplier.

Figure 10: Oxygen meter



Source: Catvis company: [www.catvis.nl](http://www.catvis.nl)

Fish consume oxygen from the water. It is important that in addition to monitoring oxygen concentration, sufficient fresh water must be transported.

The formula for available oxygen is as follows:

$$\text{Oxygen}_{\text{available}} = (\text{Oxygen}_{\text{inlet}} - \text{Oxygen}_{\text{Min}}) \times \text{Water flow}$$

If insufficient fresh water is transported, the oxygen concentration will drop and depending on density and flow, this may only take a matter of minutes.

### 3.2.7. Examples of calculations

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Below are two examples to illustrate the effect of concentration and transport on oxygen levels.

#### Example 1

- ▲ Oxygen level intake = 9.0 mg/l (water entering the tank/raceway)
  - ▲ Min. oxygen level outlet = 6.0 mg/l (minimum acceptable level determined based on the fish species)
  - ▲ Water flow 100 l/sec = 360 m<sup>3</sup>/hour
- This means that

- ▲ 3.0 mg/l is available for the fish to consume

$$\text{Oxygen}_{available} = (\text{Oxygen}_{inlet} - \text{Oxygen}_{Min}) \times \text{Water flow}$$

$$\text{Oxygen}_{available} = (9.0 - 6.0) \times 100$$

$$\text{Oxygen}_{available} = 300 \text{ mg/sec}$$

$$\text{Oxygen}_{available} = \frac{300 \text{ mg/sec} \times 3,600 \text{ sec} \times 12 \text{ hour}}{1,000 \text{ mg/gram}}$$

$$\text{Oxygen}_{available} = 12,960 \text{ gram}$$

- ▲ The fish require 300 grams of O<sub>2</sub> per kilogram of feed given

This means that with 12,960 grams of O<sub>2</sub> per day, ± 43 kilograms of feed per day can be provided

#### Example 2

- ▲ Oxygen level intake = 11.0 mg/l (water entering the tank/raceway)
- ▲ Min. oxygen level outlet = 6.0 mg/l (minimum acceptable level determined based on the fish species)
- ▲ Water flow 40 l/sec = 144 m<sup>3</sup>/hour

This means that

- ▲ 5.0 mg/l is available for the fish to consume

$$\text{Oxygen}_{available} = (\text{Oxygen}_{inlet} - \text{Oxygen}_{Min}) \times \text{Water flow}$$

$$\text{Oxygen}_{available} = (11.0 - 6.0) \times 40$$

$$\text{Oxygen}_{available} = 200 \text{ mg/sec}$$

$$\text{Oxygen}_{available} = \frac{200 \text{ mg/sec} \times 3,600 \text{ sec} \times 12 \text{ hour}}{1,000 \text{ mg/gram}}$$

$$\text{Oxygen}_{available} = 8,640 \text{ gram}$$

▲ The fish require 300 grams of O<sub>2</sub> per kilogram of feed given

This means that with 8,640 grams of O<sub>2</sub> per day, ± 28.8 kilograms of feed per day can be provided.

Even though in example 2 the concentration of the oxygen in the water is much higher, the feed that can be provided is much lower compared to example 1, which has a higher flow and lower concentration.

The effect on trout production of feeding with and without oxygen is shown below.

### Example 1

▲ Water volume = 100 m<sup>3</sup>

▲ Density = 80 kg/m<sup>3</sup>

▲ Feed percentage = 1.48%

▲ Minimum oxygen level = 6 mg/l

▲ Oxygen level water flow in = 9 mg/l

▲ Water flow 100 l/sec = 360 m<sup>3</sup>/hour

This means that:

Based on oxygen available, the maximum feed gift is as follows:

▲ 3.0 mg/l is available for the fish to consume

$$\text{Oxygen}_{\text{available}} = (\text{Oxygen}_{\text{inlet}} - \text{Oxygen}_{\text{Min}}) \times \text{Water flow}$$

$$\text{Oxygen}_{\text{available}} = (9.0 - 6.0) \times 100$$

$$\text{Oxygen}_{\text{available}} = 300 \text{ mg/sec}$$

$$\text{Oxygen}_{\text{available}} = \frac{300 \text{ mg/sec} \times 3600 \text{ sec} \times 12 \text{ hour}}{1,000 \text{ mg/gram}}$$

$$\text{Oxygen}_{\text{available}} = 12,960 \text{ gram}$$

▲ The fish require 300 grams of O<sub>2</sub> per kilogram of feed given.

This means that with 12,960 grams of O<sub>2</sub> per day, ± 43 kilograms of feed per day can be provided

Based on standing stock, the feed gift should be

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

$$\text{Feed gift} = 100\text{m}^3 \times 80 \text{ kg/m}^3 \times 1.48\% = 118.4 \text{ kg per day}$$

This means that the limiting factor is oxygen availability and without additional oxygen, only 36 percent of the optimum feed can be provided (43/118.4 × 100 = 36.3%).

## Example 2

- ▲ Water volume = 100 m<sup>3</sup>
- ▲ Density = 80 kg/m<sup>3</sup>
- ▲ Feed percentage = 1.48%
- ▲ Minimum oxygen level = 6 mg/l
- ▲ Oxygen level water flow in = 9 mg/l
- ▲ Water flow into farm 100 l/sec = 360 m<sup>3</sup>/hour
- ▲ Recirculation = 56 l/sec
- ▲ Oxygen level in recirculation = 16 mg/l

This means that for Oxygen that enters the farm

- ▲ 3.0 mg/l is available for the fish to consume

$$\text{Oxygen}_{\text{available}} = (\text{Oxygen}_{\text{inlet}} - \text{Oxygen}_{\text{Min}}) \times \text{Water flow}$$

$$\text{Oxygen}_{\text{available}} = (9.0 - 6.0) \times 100$$

$$\text{Oxygen}_{\text{available}} = 300 \text{ mg/sec}$$

$$\text{Oxygen}_{\text{available}} = \frac{300 \text{ mg/sec} \times 3600 \text{ sec} \times 12 \text{ hour}}{1,000 \text{ mg/gram}}$$

$$\text{Oxygen}_{\text{available}} = 12,960 \text{ gram}$$

Oxygen added for recirculation

- ▲ 10.0 mg/l is available for the fish to consume

$$\text{Oxygen}_{\text{available}} = (\text{Oxygen}_{\text{inlet}} - \text{Oxygen}_{\text{Min}}) \times \text{Water flow}$$

$$\text{Oxygen}_{\text{available}} = (16.0 - 6.0) \times 56$$

$$\text{Oxygen}_{\text{available}} = 560 \text{ mg/sec}$$

$$\text{Oxygen}_{\text{available}} = \frac{560 \text{ mg/sec} \times 3600 \text{ sec} \times 12 \text{ hour}}{1,000 \text{ mg/gram}}$$

$$\text{Oxygen}_{\text{available}} = 24,192 \text{ gram}$$

Total oxygen available = 12,960 + 24,192 grams = 37,152 grams

- ▲ The fish require 300 grams O<sub>2</sub> per kilogram of feed given

This means that with 37,152 grams of O<sub>2</sub> per day, 123.8 kilograms of feed per day can be provided.

Based on standing stock, the feed gift should be

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

$$\text{Feed gift} = 100\text{m}^3 \times 80 \text{ kg/m}^3 \times 1.48\% = 118.4 \text{ kg per day}$$

Based on oxygen availability, 123.8 kg can be fed.

Based on maximum growth, 118.4 kg can be fed.

This means that the limiting factor is the maximum growth capacity of the fish.

### 3.3. Water environment

As with air, water is not made up of just pure water. Many chemicals are dissolved in water and most are not harmful in certain concentrations or combinations. For fish farming, the most relevant elements of the water environment are discussed below.

#### 3.3.1. Ammonium

Fish consume feed and produce ammonium. The majority of the ammonium produced is flushed out with a flow-through system and ends up in the ecosystem where it will be absorbed by nature if concentrations are not too high.

For fish farming, it is important to double check ammonium concentrations in the raceway/tanks as the production of ammonium is directly connected to the feed gift. For every kilogram of feed, fish produce 35 grams of ammonium, and *the ammonium concentration in the tanks/raceways should not exceed 2 mg/l*. This is calculated based on the feed gift and the water flow.

- ▲ Total ammonium production of the fish farm per day

$$\text{Total ammonium} = \text{feed gift} \times 35 \frac{\text{gram}}{\text{kg}} \text{ feed}$$

- ▲ Retention time is the time needed for the water volume of the raceway to be refreshed.

$$\text{Retention time} = \frac{\text{raceway volume}}{\text{water flow}} \times 60$$

Raceway volume is measured in liters and water flow in liters/minute

The next step is to calculate the ammonium volume in the raceway

$$\text{Ammonium raceway} = \frac{\text{retention time}}{24 \text{ hour} \times 60 \text{ min}} \times \text{Total ammonium}$$

The ammonium concentration in the raceway is equal to

$$\text{Concentration} = \frac{\text{Ammonium}}{\text{raceway volume}}$$

In case the ammonium concentration increases, measurements have to be taken by reducing feed gift or by installing a biological filter.

### 3.3.2. Carbon dioxide

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Fish produce carbon dioxide (CO<sub>2</sub>), in addition to ammonium, which dissolves in the water. Carbon dioxide is easily removed from the water by aeration in a process called stripping. When working with aeration or a natural influx of oxygen, stripping can be done at the inlet by splashing the water into the tanks/raceway. When working with oxygenation, this splashing should be avoided at the entry of tanks as the oxygen can also be stripped from the water. To avoid this, stripping should be done before introducing oxygen to the water.

### 3.3.3. Solids

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Solids can accumulate in tanks/raceways, especially in flow-through systems. These solids can consist of sand, which is generally not harmful, but may also include organic material. This organic material can decompose and use oxygen while producing chemicals in the water. Organic settled solids should always be removed from tank/raceways and gutters.

### 3.3.4. Suspended solids

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Suspended solids float in the water. Typically, suspended solids are organic and can decompose and use oxygen from the water, adding chemicals, especially ammonium, to the water. However, the decomposing suspended solids impede the functioning of the gills of the fish. The effect on the fish of suspended solids can be best compared to humans breathing smoke in a fire. For these reasons, when circulating the water, suspended solids should be removed, which can be achieved through sedimentation on angled plates or by leading the water through a cloth.

### 3.3.5. Example of ammonium calculations

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The main purpose of these calculations is to determine that there is not too much ammonium build-up in the raceway. The main contributing factor for this is the retention time, which is the time required to refresh the tank/raceway.

Raceway; depth 1 meter, width 4 meter, length 20 meter

Fresh water in 20 m<sup>3</sup> per hour

Density 50 kg/m<sup>3</sup>

Feed percentage 1.48%

Water flow = 5.5 l/sec, 20 m<sup>3</sup>/hour

**Standing stock**

*Standing stock = water volume x density*

Standing stock = (4m x 1 m x 20m) x 50kg/m<sup>3</sup>

Standing stock = 400 kg

## Feed gift

Feed gift = standing stock in tank x feed percentage

$$\text{Feed gift} = 400\text{kg} \times 1.48\%$$

$$\text{Feed gift} = 5.92 \text{ kg}$$

## Total ammonium

$$\text{Total ammonium} = \text{feed gift} \times 35 \frac{\text{gram}}{\text{kg}} \text{ feed}$$

$$\text{Total ammonium} = 5.92 \times 35 \frac{\text{gram}}{\text{kg}} \text{ feed}$$

$$\text{Total ammonium} = 207 \text{ gram}$$

## Retention time

$$\text{Retention time} = \frac{\text{raceway volume}}{\text{water flow}} \times 60$$

$$\text{Retention time} = \frac{(4\text{m} \times 1\text{m} \times 20\text{m})}{20 \text{ m}^3/\text{hour}} \times 60$$

$$\text{Retention time} = 240 \text{ min}$$

## Ammonium

$$\text{Ammonium raceway} = \frac{\text{retention time}}{24\text{hour} \times 60 \text{ min}} \times \text{Total ammonium}$$

$$\text{Ammonium raceway} = \frac{240 \text{ min}}{24\text{hour} \times 60 \text{ min}} \times 207 \text{ gram}$$

$$\text{Ammonium raceway} = 34.5 \text{ grams}$$

## Ammonium concentration

$$\text{Concentration} = \frac{\text{Ammonium}}{\text{raceway volume}}$$

$$\text{Concentration} = \frac{34.5 \text{ gram}}{80 \text{ m}^3}$$

$$\text{Concentration} = 0.43 \text{ gr/m}^3$$

$$\text{Concentration} = 0.43 \text{ mg/l}$$

## 4. PRODUCTION EQUIPMENT

### 4.1. Hatchery

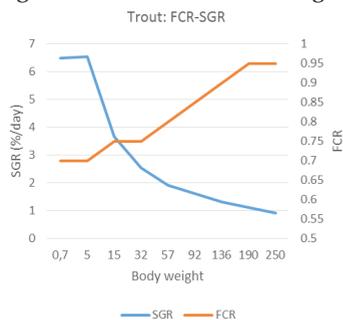
At the beginning of the growth cycle, fish are very efficient at the conversion of feed into standing stock (known as the feed conversion ratio, FCR) and growing very quickly (the specific growth rate, SGR), presented as a percentage body weight per day.

From the standpoint of cost efficiency, optimal use of this phase is a key. As the feed conversion ratio is so favorable, the cost per kilogram of fish production is relatively low, whereas the feed price is very high.

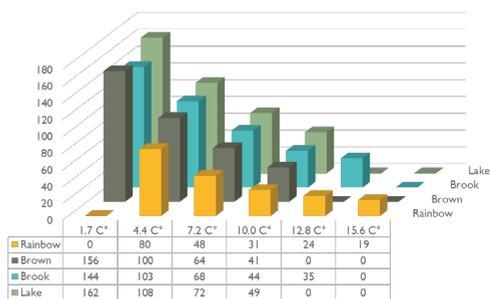
The system for hatching and growing fingerlings is relatively small, and smallness makes it easier to manage. The key for success is to create an optimum water environment (temperature) for hatching and growing the fingerlings, where the fish can be fed to the maximum level. For trout, within four months of hatching, fingerlings of 35 grams can be produced. In the hatchery system, several batches of 35 grams of trout can be produced during the year and inserted into the on-growing system.

Depending on the temperature of the water coming from the source, the water may need to be heated in order to hatch the eggs. Figure 12 below shows the number of days required to hatch eggs for various species of trout at different water temperatures.

Figure 11: Trout FCR and SGR graph    Figure 12: Trout: number of days required to hatch



Source: Author's database



Source: Author's database

Table 4.1 Growth parameters for trout farming

Month	Size Start (gram)	Size End (gram)	Avg. Density (kg/m <sup>3</sup> )	SGR (%/day)	FCR	SFR* (%/day)	Product. (kg feed/m <sup>3</sup> /day)	Tank vol. (m <sup>3</sup> )
1	0.1	0.7	2	6.49	0.70	4.54	0.09	6
2	0.7	5	8	6.55	0.70	4.59	0.37	10
3	5	15	16	3.66	0.75	2.75	0.44	22
4	15	35	25	2.53	0.75	1.89	0.47	32

\* SFR = Specific Feed Rate = SGR × FCR

### 4.1.1. Eggs

The hatchery starts with fertilized eggs, which can be purchased or harvested out of fish farmers' own brood stock.

Fertilized eggs can be purchased from specialized companies like "Troutex" or "Troutlodge" for trout or "Sturgeon churilov" for sturgeon.

### 4.1.2. Hatchery equipment

A hatchery typically consists of three major systems:

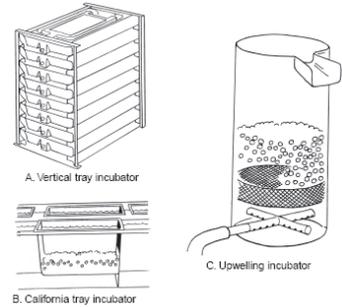
- ▲ Incubation system
- ▲ Fry system
- ▲ Fingerling system

#### Incubation system

Three types of incubators are typically used in the industry for hatching eggs:

- ▲ California tray incubator
- ▲ Vertical tray incubator
- ▲ Upwelling incubator

Figure 13



Source: [www.thefishsite.com](http://www.thefishsite.com)

Figure 14: California tray incubator



Source: [www.aquaculture-com.net](http://www.aquaculture-com.net)

Experience has shown that all three incubation systems work well and are used. The difference between the systems lies in the use of water, the required footprint, and the handling procedure. In general, the use of water is the key selection criterion.

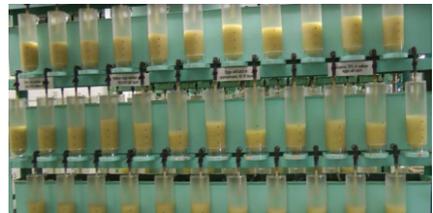
The California tray incubator and upwelling incubator use approximately 3-6 l/min per 10,000 eggs, resulting in a rate

Figure 15: Vertical tray incubator



Source: [www.marisource.com](http://www.marisource.com)

Figure 16: Upwelling incubator



Source: Author's database

of 60-120 l/min for 200,000 eggs (3.6-7.2 m<sup>3</sup>/hour). The vertical tray incubator uses approximately 0.9-1.2 l/min per 10,000 eggs, or 18-24 l/min for 200,000 eggs (1-1.4 m<sup>3</sup>/hour).

Use of water is therefore a valid selection criterion because egg hatching and fry growth are directly related to the water temperature, as shown in table 4.2. Depending on the water source temperature, the water may need to be heated. Therefore, the energy cost for heating is directly related to the volume of water to be heated.

*Table 4.2 Trout: Water temperature and days to hatch*

	Rainbow	Brown	Brook	Lake
Watertemp. [C°]	Days to hatch	Days to hatch	Days to hatch	Days to hatch
1.7 C°	-	156	144	162
4.4 C°	80	100	103	108
7.2 C°	48	64	68	72
10.0 C°	31	41	44	49
12.8 C°	24	-	35	-
15.6 C°	19	-	-	-

To avoid any risk of contamination from the water source, the water is pumped through a sand-filter and UV-unit before entering the incubators. The most frequently recommended incubation system is the vertical tray incubator. Of the three commonly used incubation systems, this incubator has the lowest water consumption and the lowest heating cost.

## Fry system

The fry system generally takes the form of swimming gutters, California tray incubators without inlays, or small raceways. In this system, the hatched eggs are weaned (to become accustomed to dry feed) and grown up to a weight of 0.5 grams. In a swimming gutter, 50,000 fry can be weaned with a water flow of 2.5 m<sup>3</sup>/hour and 50 percent recirculation.

The heated water from the incubators can be used as an input for the fry system unless chemical treatments are conducted or when eggs are taken from external sources. With the reuse of water, no energy is lost. Swim-up fry then learn to feed and can be transferred into the fry system when they reach approximately 0.5 grams.

## Fingerling system

The fingerling system has the largest footprint of the hatchery systems. Fry weighing 0.5 grams are grown until the fingerling stage, 15 centimeters and 35 grams, before being inserted into the on-growing system. Fingerling systems consist of small raceways of circular tanks, and the water from the fry system can be reused as make-up water in the other systems unless chemical treatments are conducted. For this reason, fingerling systems are very suitable for recirculation as they are small systems in which rapid growth can be achieved.

## Investment required for hatchery

The investment depends on three factors:

- ▲ Already available hardware at the fish farm, for example, reuse of swimming gutters or vertical tray incubators
- ▲ Water source temperature and availability
- ▲ Method of construction: are turnkey systems being purchased from vendors abroad or will they be built, using the right experts, in Armenia under its own regime?

In the absence of a detailed calculation, the following estimates can be provided for a 100 metric ton trout hatchery system:

- ▲ Buying a 100 percent turnkey system will cost approximately €300,000
- ▲ Reusing available hardware and building a system locally is estimated by experts to cost approximately €100,000.

## 4.2. Purchase eggs or harvest from own brood stock

Eggs can be harvested and fertilized from the farm's own brood stock. From the standpoint of cost, using brood stock would appear to be best since the purchase cost would be eliminated. However, this is not the case as the growth characteristics of purchased eggs are completely different due to genetic selection and the occurrence of all female, triploid eggs. The growth and resistance to illness of purchased eggs is much greater, which results in lower mortality and higher growth rates, leading to higher production levels per cubic meter of water. Another advantage of purchased eggs is that they are available over a longer period during the year as the hatchery can carry out several runs to produce fingerlings. It is important for fish farmers to be aware that purchased triploid eggs are sterile, which means that they cannot be used to create brood stock.

## 4.3. Grow out

Water quality is determined by the system used and water source. The water source is a known factor with existing fish farms and is not expected to present quality issues. However, water volume may or may not become an issue.

The farm system has a big influence on the FCR. In essence, two systems can be identified:

- ▲ Single-pass systems in which water is used only once (cage, pond, and flow-through systems)
- ▲ Multi-pass systems in which water is reused and repeatedly recirculated (Recirculation Aquaculture systems (RAS))

### 4.3.1. Single-pass systems

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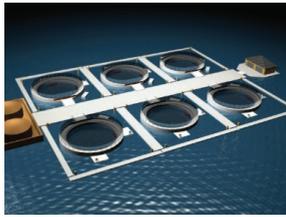
Single-pass systems are typically flow through, cage, and pond systems, as illustrated in figures 17, 18, and 19.

Figure 17: Pond



Source: Author's database

Figure 18: Cage



Source: Author's database

Figure 19: Flow through



Source: Author's database

Typically, water in a flow-through or pond system is extracted from a natural stream. As a result, the system depends on the water quality and quantity of the natural stream, resulting in sufficient oxygen levels and flow and a lack of pollution, whether natural or from civilization.

### 4.3.2. Multi-pass system

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A typical multi-pass system is the Recirculation Aquaculture System (RAS), as shown in figure 20, 21 in which the water at the end of the system is fully or partially pumped back to the start of the system.

During recirculation, a decision must be made regarding whether or not the water should be conditioned. Conditioning can take the form of removal of solids, re-oxygenation, and/or removal of dissolved pollution.

Figure 20: Recirculation aquaculture system



Source: HESY Aquaculture: [www.hesy.com](http://www.hesy.com)

### 4.3.3. Cage farming

Cages require the least investment and are widely used in the industry. There are many success stories in addition to major failures associated with cage farming.

The main advantage of cage farming is the low investment cost, whereas the biggest disadvantages are the following:

- ▲ Logistical handling of the farm is more difficult with respect to feeding and harvesting;
- ▲ Financial results depend significantly on management experience and monitoring of the fish;
- ▲ There is limited control of the water environment; and
- ▲ There is the challenge of pollution of the water environment.

The last two disadvantages have led to massive failures as complete lakes are polluted in ways that hinder fish farming, with highs of up to 100 percent mortality owing to the inflow of poor quality water. There are also challenges posed by low oxygen levels resulting from chemical pollution due to urbanization or chemical pollution by nature triggered by fish farming itself.

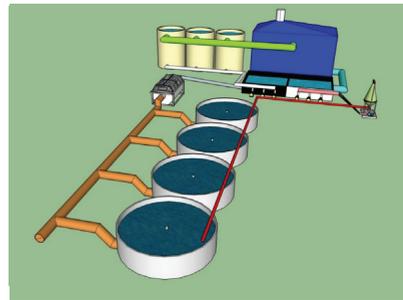
### 4.3.4. Full Recirculation Aquaculture System (RAS)

To ensure the most controlled and stable water environment, an RAS is used. A RAS is typically implemented indoors with limited added water—as low as 2 l/second for a fish farm producing 100 metric tons annually.

Owing to continual water recirculation, pollution is filtered out with biological and mechanical filters, and as a result of the constant and full control of water temperature, fish can grow at the optimum water temperature and can be fed up to maximum levels. In addition, because of the constant water temperature, fish grow as quickly in the winter as in the summer. From the standpoint of sales, this situation allows for consistent quality and delivery volume.

When opting for a recirculation system, it is important to realize that there are many companies that claim to be able to build a system. The components of a recirculation system are available in the industry from different suppliers. However, the design of a recirculation system is critical and, unfortunately, not all builders have sufficient knowledge in the field of design. Standard advice is to opt for system builders who have extensive knowledge and a proven record of accomplishment in this area. AKVA group ([www.akvagroup.com](http://www.akvagroup.com))

*Figure 21: Recirculation aquaculture system, schematic*

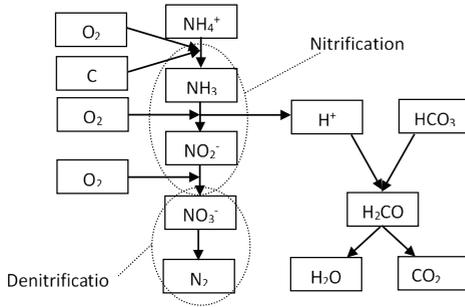


*Source: Author*

and Hesy (www.hesy.com) are the two major players in the field.

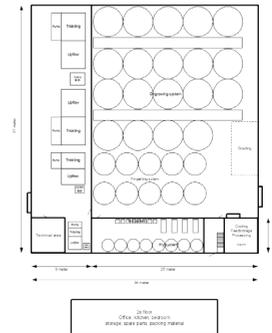
Figures 21-23 present a schematic of a RAS and a floorplan of an indoor RAS fish farm.

Figure 22: Recirculation aquaculture system



Source: Author

Figure 23: Recirculation aquaculture system, floorplan



Source: Author

### 4.3.4.1. Filter elements

In general, three types of filters can be identified:

- ▲ A sieve for removal of the solids, feces, and remaining feed;
- ▲ A trickling filter for transformation of ammonium to nitrates and removal of CO<sub>2</sub>;
- ▲ A submerged filter for transformation of nitrates to nitrites and nitrogen gas and for the collection of fine solid particles.

A moving bed is also becoming more and more common, but functions as a combination of a trickling filter and submerged filter.

#### Sieve

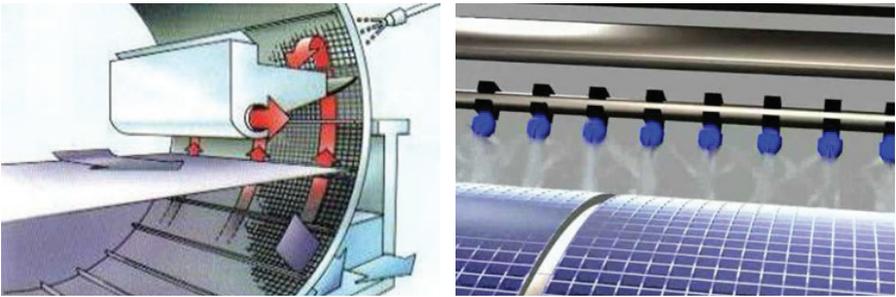
For the sieve step, a drum or disc filter is typically used. Water from the tanks flows into the drum/disc and flows outward to a cloth. Cloths are available in several meshes (40-60-100 μm). The mesh of the cloth determines the size of the particles passing through and, therefore, the color of the water. As trout are sensitive to suspended particles in water, a fine mesh is used whereas for other fish, a grove mesh is used.

The water level in the drum/disc is approximately 40 percent of the diameter. The drum/disc rotates so that the particles trapped in the cloth inside of the drum/disc rise above the water. With a high-pressure water nozzle, water is sprayed from the outside in so that the cloth is continually cleaned. The outside-in water flow,

with the particles, is collected in a gutter, which is drained.

A sieve is seen as a mechanical filter as no biological processes are involved.

Figure 24: Sieve filter

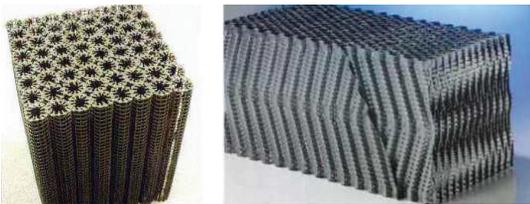


Source: Hydrotech company: [www.hydrotech.com](http://www.hydrotech.com)

## Trickling filter

A trickling filter is a combination of a biological and a mechanical filter. Water is sprayed over the top over a “bionet” (see figure 25). The trickling filter strips  $\text{CO}_2$  from the water through a mechanical process, and a ventilator pulls fresh air from the bottom through the filter to the top. In this way,  $\text{CO}_2$  is removed from the filter.

Figure 25: Trickling filter



Source: Author's database

Figure 26: Trickling filter



Source: Author's database

When installing a new trickling filter, it is necessary to start the filter through a biological process. Bacteria (nitrobacteria and nitrospiria) grow on the bionet, transforming ammonium to nitrates under aerobic conditions. Bacteria consume oxygen for this process and over time, the bacterial mass will grow. The hydraulic load on the trickling filter is also very important. If it is too low, the mass will grow and the filter will eventually be blocked; if it is too high, the filtration effect will decrease. Therefore, the design of the filter is very important.

## Submerged filter

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Bionet is also used as filtration media, but is typically submerged in a barrel approximately 4 meters deep. The main process is biological: slow water flow moves from the bottom to the top through the bionet. The bacteria (*Micrococcus*) transform the nitrates into nitrate gas under anaerobic conditions, which leaves the filter at the top of the barrel. One side effect is that because of the slow water movement, small particles in the water column will settle and collect in the bionet. For this reason, every two weeks, the filters must be cleaned and flushed. Maintenance is a relatively easy process. At the bottom of the barrel, pressurized air is blown in to clean the bionet and at the same time, the water is drained. Two or more barrels are typically used, and all barrels are never cleaned at the same time—only 50 percent are cleaned in one week and the other 50 percent in the following week. Cleaning temporarily decreases the effect of the bacteria; therefore, only cleaning 50 percent at a time limits this impact.

*Figure 27: Submerged filter*



*Source: Author's database*

### 4.3.4.2. Electricity usage

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The design of a full recirculation system is essential and depends on several factors. The main design factors are the fish production level required and the well water quality.

The figures provided below are based on the following:

- ▲ A production level of 100 metric tons of trout annually
- ▲ A 100 meter ground well that requires de-ironing
- ▲ Full recirculation
- ▲ Production of 600,000 fingerlings year round

Trout is used for this calculation as it is a sensitive fish, with stringent requirements for its water environment. Catfish, on the other hand, would require up to 30 percent of the estimates below.

## Hatchery

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For a 600,000 piece hatchery where eggs are hatched up to the fingerling stage of 35 grams, electrical power of 6 kW is required. This power is used for the circulation of the water over the tanks and filters.

## On-growing

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To achieve 100 metric tons of production annually, around 1,000 m<sup>3</sup>/hour is pumped, which results in a retention time of 30 minutes. Selection of the pumps is based on flow, height difference, and pipe and appendix resistance. In general, the low-cost pumps are less efficient and use more electricity; therefore, it is recommended that the purchase decision be based on the initial investment cost and the operational cost. When selecting the pump, an important characteristic to consider is the electricity use by the pump. With trout, for example, 16 kW pump power is required.

## Other considerations

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In a full recirculation system, there are other components not related to water circulation that are relevant. For example, additional energy costs are estimated at 4 kW for drum filter spray pumps, a blower for back-washing, a wastewater treatment unit, UV and/or ozone, a ground water pump, and a ground water treatment unit.

## Summary

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For the hatchery, 6 kW is required, which results in power consumption of 53,000 kWh per year (where 1kwh=€0.10).<sup>1</sup> With 600,000 pieces, the electrical operational cost per fingerling is less than €0.01.

With on-growing, 16 kW is required, resulting in power consumption of 140,000 kWh per year. To produce 100,000 kg per year, the electrical operational cost per kilogram of fish = €0.21/kg fish (113 dram/kg fish).

For all other electrical components, 4 kW is required, resulting in power consumption of 35,000 kWh per year, or €5,256 per year in total.

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1 1 kWh = €0.10 rate was used for simplicity of calculations. This rate is very close to the electricity tariffs applied in Armenia. As of June 2016, the following electricity tariffs were applied in Armenia for 1 kwh: daily tariff was 49 Armenian Dram (AMD), and night tariff was 39 AMD (source: Public Services Regulation Commission - <http://www.psrc.am/am/sectors/electric/tariffs>): Assuming the night is 1/23a of the day, the average tariff would be  $49 \times 2/3 + 39 \times 1/3 = 45.66$  AMD/kwh ~ €0.09/kwh, based on the annual average exchange rate for 2015 - €1 = 530.6 AMD (source: Central bank of Armenia: [www.cba.am](http://www.cba.am)):

## 4.4. Examples of financial calculations

The operational cost of a full recirculation system is not cheap compared to a flow-through system as there are costs for electricity, oxygen, maintenance, and chemicals that do not exist to the same degree in a flow-through system.

The main advantages of a flow-through system are the low labor cost and the very efficient feed conversion ratio. In Armenia, the cost of feed per kilogram is high and the feed cost is the primary cost driver in every fish farm.

Table 4.3 provides an example of the calculation of a full recirculation system for 100 metric tons of trout production annually. The cost price is €2.52 per kilogram of trout, and trout is available all year round with consistently high quality. **It is also worth noting that the fat percentage of the trout does not lower in winter.**

*Table 4.3 Estimated Production Cost for 100 Metric Tons of Trout*

<b>Juveniles</b>		€ 9,434
<b>Feed</b>		€ 181,199
<b>Other inputs</b>	electricity	€ 21,024
	gas	€ 0
	water	€ 0
	oxygen	€ 5,000
	chem., med., etc.	€ 5,000
	purification fee	€ 0
	subtotal	€ 222,253
<b>Other company costs</b>	maintenance	€ 1,500
	insurance	€ 0
	water testing	€ 1,500
	general costs	€ 3,000
	subtotal	€ 6,000
<b>Labor</b>	management	€ 15,000
	operation	€ 8,547
	subtotal	€ 23,547
<b>Total operational costs</b>		€ 251,800 Per year
<b>Cost price per kg fish</b>		€ 2.52 Per kg. fish

## 4.5. Considerations for recirculation aquaculture system

Every aquaculture system has advantages and disadvantages, but there are specific benefits of a full RAS for fish farmers, such as the following:

- ▲ The ability to meet potential future governmental regulations regarding pollution and water usage
- ▲ The flexibility of the location of the fish farm, even (sub) urbanized areas due to the limited need for water inflow

- ▲ The lower significance of the summer or winter season
  - ▲ Fish could also be delivered in the winter
  - ▲ The quality of the fish would remain constant year round
  - ▲ There would be more rapid and efficient growth of fish
- ▲ A more efficient operation

## Government regulations

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In time, government environmental regulations can force Armenian farmers to move toward more sustainable production methods. A transition of the existing facilities to partially recirculated farms, as happened in Denmark, could be an option. This would involve the use of liquid oxygen and the installation of bio filters and pumping and aeration equipment, resulting in an enormous reduction in water consumption and waste output, while dramatically increasing production.

The reason behind the increasing popularity of the recirculation system is that it is a simple and reliable way of controlling water quality parameters to the exact needs of the species cultured. This sophisticated, if simple, technology originated from the development of closed-circuit eel farming systems in Holland and Denmark. Today, the system is commonly used for the production of fry and fingerlings, and an increasing number of farms are using the principles for the production of portion-sized fish.

In recent years, recirculation technology has been used to rear practically all kinds of new species, especially in the first biological stages up to at least the fry or fingerling stage. The main advantages of recirculation are:

- ▲ Easy regulation and control of temperature, salinity, oxygen, and pH levels to meet the exact requirements of the species cultured and to meet the requirements of different growth stages, that is, to induce spawning, wean fish larvae, or simply grow fish to market size;
- ▲ The possibility of eliminating invasive fish diseases from the surroundings (biosecurity) and maintaining low levels of internal bacteriological pressure; and
- ▲ The ability to minimize the effluent of organic compounds, nitrogen, and phosphorus to the external environment.

Owing to these clear advantages of recirculation, the worldwide development of Recirculation Aquaculture Systems (RAS) for salmonids has gained considerably in experience and expertise over the past decade. The availability of this expertise and technology, combined with research on the performance of trout in RAS, provides substantial scientific and practical data to indicate the potential productivity.

## Location of the fish farm

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Where limited water inflow is required, a ground well with good quality water and limited flow of 50l/min per 100 metric tons is more than sufficient. For a full-cycle RAS, production per cubic meter is very good at 178 kg/m<sup>3</sup>/year, from

the egg stage up to 250 grams.

RAS are generally indoor systems. For full RAS production, an indoor facility of 1200 m<sup>2</sup> is required from the egg stage until market size. The facility is typically connected to the electrical and gas grid and is insulated. An environment with heavy surrounding vibration is not recommended.

### Absence of summer or winter season

When the RAS is implemented indoors and the water quality remains stable year round, there is year-round growth. Typically, in winter, when there are low external temperatures, fish are not fed. With an RAS, feeding is done every day so there are no limitations on the harvest.

### Other considerations

In Armenia, an RAS offers the most potential in the following areas:

1. Increased fingerling production
2. An increase in total annual production
3. The market need for fresh fish in winter

However, the biggest disadvantage of the RAS is the high investment cost of an on-growing system.

## 4.6. Water availability/usage in Armenia

In Armenia, water from natural sources has little to no pollution, and although the available water volume differs considerably depending on the farm, it does still exist. Yet, in a single-pass system, which is the standard at the moment, the water is used only once, **resulting in a high degree of waste of this most precious component of the fish farming system.**

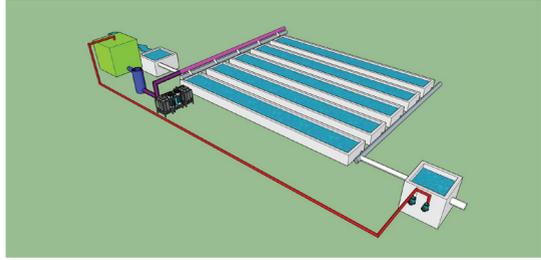
Water management is, therefore, a critical subject for future consideration by fish farms in Armenia and should be evaluated from the standpoints of both durability and marketing. The fish market is an international market and the bulk of suppliers are selected by price, an area in which Armenia still has a long way to go in order to be competitive. However, Armenia does possess water quality that is unmatched by other producer countries. For this reason, it is advisable to consider targeting the niche market of customers for whom sustainability is an important element of selection as these customers tend to be less price oriented.

## 4.7. Multi-pass systems outdoor

For further development of aquaculture in Armenia, it is important to enhance existing single pass, flow-through systems via the use of recirculation techniques. In the existing in Armenia concrete structures of flow through systems, water and oxygen availability is the limiting factor for increasing the fish production. With the use of recirculation technology the water is pumped back from the outlet of the

fish farm to inlet, making the transport of oxygen possible. In addition to the enhanced transport of oxygen, pure oxygen is supplied at the intakes of every raceway. When circulating water, extra attention has to be given to water quality. The circulated water has to go over a (trickling) filter where the dissolved nitrogen's and Carbon dioxides are removed.

Figure 28: Enhanced water management system



Source: Author

### Multi-pass system and outdoor temperature

Usually, a flow-through system is located in an outside environment where the external temperature affects the water temperature and, thus, the feed gift.

The work of the trickling filter (in terms of removing dissolved nitrogen) is also affected by the water temperature. The higher the water temperature the more active the bacteria are in the trickling filter in removing the dissolved nitrogen.

So the higher the water temperature, the higher the feed gift, the higher the nitrogen production, but the more effective the bacteria are in the trickling filter in removing the dissolved nitrogen.

In winter time, when the temperatures and, thus, the feed gift are low (feed gift may go down up to zero), it is recommended to stop the recirculation because there is no need for extra oxygen. This allows also saving electricity.

The trickling filter consists of blocks with bacteria on them. It is recommended to place a few blocks indoor at a temperature  $>10^{\circ}\text{C}$ , and every 2-3 days manually add Ammonia on the blocks. This would allow the bacteria stay alive during winter, which ensures a smooth startup in early spring.

A shelter is recommended for the oxygen equipment as for the recirculation pumps.

## 5. FARM MANAGEMENT

### 5.1. Feed conversion

In the on-growing unit, fish grow to market size. During this phase, feed is the main cost driver; therefore, the efficient conversion of feed to fish body weight is essential.

This conversion is called the feed conversion ratio (FCR) and is calculated as follows:

$$FCR = \frac{\textit{feed given}}{\textit{body weight growth}}$$

Both “feed given” and “body weight growth” are based on a specific time frame and are calculated between grading periods and at harvesting. For this reason, it is essential to record data on mortality, grading results, and feeding.

The FCR is influenced by the water quality and stability, the feed regime, grading, and, above all, by the quality of the feed.

Thus, from a management perspective, following a solid feed regime, grading, and recording the results of grading are key. Selection of the feed supplier and calculation of the financials and cost of producing 1 kilogram of fish are also important.

#### 5.1.1. Standing stock

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To determine the maximum feed gift of the fish per pond, it is necessary to know the exact weight of the standing stock. By calculating the precise feed gift on a daily basis, the farmer can prevent giving too much or too little feed.

The standing stock must be maintained at the correct level, both in terms of weight and weight distribution, in order to harvest the fish after the growth period. From this perspective, the standing stock can be viewed as inventory.

One common mistake made is to harvest too much of the standing stock in one year, leaving an inadequate amount of standing stock available for sale. Another mistake is made at the input side, whereby there are no eggs available from the farm’s own harvest or there is a high mortality rate of the younger fish and the distribution of weight classes is distorted.

#### Mortality

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Spawning of eggs is a delicate, but well-known process. The egg quality and treatment of the eggs during and after hatching, as well as management of the weaning and production processes, are the main factors influencing the final survival rate of the animals.

The average experience with Rainbow trout hatchery demonstrates 24 percent

total losses, mainly during hatching and early rearing. For sturgeon, this varies between 50 percent and 80 percent. During the hatchery phase, mortality is mortality rate comes at a low cost because little feed is given to the fish.

Mortality during on-growing is relatively expensive as fish feed, which is the main cost driver, is supplied to fish. For example, for every kilogram of mortality, €1.80 of the feed cost is lost. Therefore, mortality in the on-growing phase should not exceed 10 percent.

In summary, the farm gate price is reduced by limiting direct feed loss.

### 5.1.2. Grading

With respect to fish growth, there is a natural spread between slow and fast growers. This is caused by genetics, sex, illness period, and (non-) aggressive behavior. To provide the fish with the right type of fish feed matching the growth cycle and to match the pellet size with the size of the mouth it is important to grade the fish. By doing this the Feed conversion ratio will be positively influenced, what reduces the farm gate price.

#### Frequency of grading

Younger fish should be graded more frequently than larger fish. The best indication is to look at the weight class distribution in the tanks, and a practical way of checking this is visually or by removing some small fish from the tank and grading them.

One approach to grading is to sort the original fish stock into two groups based on whether they fall below or above the average. If the original fish stock is very uneven in size, three new groups should be formed instead of two.

Restocking the tanks after grading is typically done based on the density schedule shown in table 5.1, bearing in mind that oxygen is applied.

Densities commonly found in intensive Rainbow trout systems are provided in cubic meters where the fish are distributed over the water column.

*Table 5.1 Fish density schedule*

Fish size (gram)	Start density (kg/m <sup>3</sup> )	Final density (kg/m <sup>3</sup> )
1 – 5	4 – 5	20 – 25
5 – 15	10 – 15	30 – 40
15 – 50	15 – 20	45 – 60
50 – 100	25 – 40	50 – 70
100 – 200	35 – 50	70 – 90
200 – 300	50 – 70	80 – 100

Sturgeon is one type of fish that stays at the bottom of the tank and for this reason; densities are provided in square meters. There is limited research available on stocking densities.

*Table 5.2. Sturgeon density schedule*

Fish size (gram)	Density (kg/m <sup>2</sup> )
0-200	1.5
200 – 3000	60-70
3000-8000	80

These are optimum densities for production purposes, with the application of oxygen.

### Grading equipment

Depending on the size of fish, different grading tools are available. Up to the fingerling stage, the grading box used is a manual grader. Fish are placed gently in the box, and the box is lightly shaken so that the smaller fish pass through grading box and the larger ones stay on top and can be dropped into another tank.

*Figure 29: Fish sorting table*



*Source: Author*

*Figure 30: Fish grading box*



*Source: Catvis company: [www.catvis.nl](http://www.catvis.nl)*

For the larger sizes of fish, the sorting table is very useful for farms up to a volume of 100 metric tons annually. In this case, grading is best done by a minimum of three persons.

For bigger volumes, semi-automated grading machines can be used, but require a considerable investment that will have to be earned back on labor costs, which will not be easy for Armenia.

When using buckets or tubs during the grading process, it is crucial to monitor oxygen levels. Mortality during grading is not uncommon, and low oxygen contributes significantly to this.

Figure 31: Fish grading equipment



Source: Author's database

Application of oxygen directly into buckets and tubs is advised, and fish handling and scoping should be done quickly, efficiently, and with care. When done properly, mortality is close to zero, stress levels are lower, and fish return more quickly to their original feed schedule. These measures must be followed to keep farm gate prices low.

When grading fish it is important to keep a record of the grading tank, the number and size of the fish, and the tank into which the fish are placed. For the receiving tank, it is important to know the number of fish and the average weight. This average weight has to be measured precisely, not estimated, as the number and average weight determine the standing stock, which is the basis from which to determine the feed gift. This, in turn, determines growth and efficiency.

The grading records from the grading tank are used to calculate the specific growth rate (SGR), which is a key parameter of growth performance.

$$SGR = \frac{\ln(\text{final total weight}) - \ln(\text{initial weight})}{\text{Growth period}} \times 100$$

Weight is given in kilograms

Period is given in days

Table 5.3 Sample grading form

Tank number		
Grading or receiving tank		
Weight class	X gram	Y gram
	#	#
	#	#
	#	#
	#	#

The procedure to determine average weight during grading is as follows:

1. Fill a bucket with 30 percent water
2. Place it on a scale and set the scale to zero
3. Depending on the size of the bucket and the size of the fish, fill the bucket up to 60 percent
4. Determine the weight of the (added) fish
5. Count the number of fish in the bucket
6. Divide the weight by this number to determine the average number
7. Repeat this procedure 8 to 15 times for every weight class during grading
8. Calculate the final average weight of every grading class of fish

## 5.2. Production volume

### 5.2.1. Feed gift

Depending on the standing stock in a tank, calculations of feed gift can be done on a daily basis.

Grading indicates how many fish are in a tank and the average weight and body weight of the fish.

Table 5.4 below shows the feed percentage of standing stock per day.

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

Table 5.4 Feed percentage of standing stock per day

Fish weight	Feed size (mm)	Water temperature						
		6 °C	8 °C	10 °C	12 °C	14 °C	16 °C	18 °C
35-100	3.0	0.79	0.95	1.15	1.4	1.69	2.04	1.65
100-200	3.0/4.5	0.63	0.77	0.93	1.12	1.35	1.64	1.33
200-300	4.5	0.57	0.69	0.84	1.01	1.22	1.48	1.2
300-400	4.5	0.53	0.65	0.78	0.95	1.14	1.38	1.12
400-500	6.0	0.51	0.61	0.74	0.90	1.09	1.32	1.07
500-750	6.0	0.48	0.58	0.70	0.85	1.03	1.24	1.01
750-1000	6.0	0.45	0.54	0.65	0.79	0.96	1.16	0.94

Source: Coppens International

For instance, 250 kilograms of fish in the tank, with 450 grams weight of each fish, at a water temperature of 16 °C result in a feed percentage of 1.32 percent.

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

$$\text{Feed gift} = 250 \text{ kg} \times 1.32\% = 3.3 \text{ kg per day}$$

After feeding the fish for a day, multiplying the feed provided by the FCR gives the increase in standing stock. This has to be added to the previous day's standing stock and with the new figure; the feed gift for the new day can be calculated:

$$\text{standing stock 2} = \text{standing stock 1} + (\text{FCR} \times \text{feed gift}) - \text{mortality}$$

### 5.3. Monitoring

Monitoring is essential to evaluate the performance of the fish farm. The data recorded can be used to determine the performance of the fish farm by calculating the feed conversion ratio (FCR).

The recorded data is also used to troubleshoot issues. With the parameters recorded, the baseline state of the operation can be established so that issues such as reduced growth and increased mortality, among others, can be determined.

Some parameters are recorded by tank and others are more applicable for the total farm.

Total farm parameters include the following:

- ▲ Water temperature
- ▲ Water flow
- ▲ Oxygen level at intake

Table 5.5 Fish farm performance table

Tank/ raceway	O2*,before feeding (mg/l)	O2*, 30 min after feeding (mg/l)	Feed supply (kg)	Mortality (number/weight)
1	08:00			
	12:00			
	17:00			
2	08:00			
	12:00			
	17:00			
3	08:00			
	12:00			
	17:00			

\*O2 levels are measured in the outlet of the tank/raceway

## 6. SUSTAINABILITY

In some markets, especially northern European markets, sustainability is increasingly becoming a question of selection and price. Animal welfare, use of medication, water usage, and environmental pollution are subjects that are topical in the northern European context, and consumers are willing to pay a higher price for sustainably produced products. From this standpoint, a multi-pass or recirculation system would be well suited to water management and efforts to prevent environmental pollution.

### 6.1. Marketing value

**Armenia has a very good water supply, and it is important, as a marketing value, to emphasize the use of this water during farming and the care the farmers take of the water.** Single-loop systems lacking filtration after use are not optimal; multi-pass systems that include filtration and reuse are important.

### 6.2. Certification

Aquaculture fish farms are certified by specialized organization called such as the Aquaculture Stewardship Council (ASC)<sup>2</sup>. Certification is done based on the production process at the environmental level, for example, managing pollution and water usage, and at the social level, for example, working conditions, safety, and payments.

For trout there is a standard for certification, set by the ASC<sup>3</sup>, and there are certified farms only in Denmark, Germany, Greece, and Italy. For sturgeon, there is no standard certification available and there will not before 2019. The cost of certification depends very much on the state of development of the farm, but is on the order of €5,000 to €15,000. Armenian fish farmers fall on the higher end of this range as there is limited certification implemented at this stage.

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2 The Aquaculture Stewardship Council (ASC) was founded in 2010 by WWF (World Wide Fund for Nature) and IDH (Dutch Sustainable Trade Initiative). It is an independent non-profit organization with global influence. ASC aims to be the world's leading certification and labelling program for responsibly farmed seafood. The ASC's primary role is to manage the global standards for aquaculture, which were developed by WWF. <http://www.asc-aqua.org/>

3 [http://www.asc-aqua.org/upload/ASC%20Freshwater%20Trout%20Standard\\_v1.0.pdf](http://www.asc-aqua.org/upload/ASC%20Freshwater%20Trout%20Standard_v1.0.pdf)

## 7. FISH FARM PRACTICAL CALCULATIONS AND DETAILS

### 7.1. Fish farm – scenario 1

No oxygen applied, no recirculation, maximum feeding

Assumptions

- ▲ Water volume 500 m<sup>3</sup>
- ▲ Density = 60 kg/m<sup>3</sup> (for calculation purposes only)\*
- ▲ Feed percentage = 1.48%
- ▲ Minimum oxygen level = 6 mg/l
- ▲ Oxygen level water flow in = 9 mg/l
- ▲ Water flow into farm 100 l/sec = 360 m<sup>3</sup>/hour
- ▲ Feeding period = 8 months
- ▲ FCR = 1.2

This means:

Based on oxygen available the maximum feed gift is:

- ▲ 3.0 mg/l is available for the fish to consume.

$$Oxygen_{available} = (Oxygen_{inlet} - Oxygen_{Minimum}) \times Water\ flow$$

$$Oxygen_{available} = (9.0 - 6.0) \times 100$$

$$Oxygen_{available} = 300\ mg/sec$$

$$Oxygen_{available} = \frac{300\ mg/sec \times 3,600\ sec \times 12\ hour}{1,000\ mg/gram}$$

$$Oxygen_{available} = 12,960\ gram$$

- ▲ Fish require 300 grams of O<sub>2</sub> per kilogram of feed given
- ▲ This means that with 12,960 grams of O<sub>2</sub> per day, ± 43 kilograms of feed per day can be fed.

Based on standing stock, the feed gift should be:

$$Feed\ gift = standing\ stock\ in\ tank \times feed\ percentage$$

$$Feed\ gift = 500m^3 \times 60\ kg/m^3 \times 1.48\% = 444\ kg\ per\ day$$

The available oxygen per day is the limiting factor.

The maximum annual production based on the maximum feed capacity and period of feeding is:

$$Maximum\ production = \frac{annual\ feed\ gift}{FCR}$$

$$Maximum\ production = \frac{\frac{8\ months}{12\ months} \times 365\ days \times 43\ kg.\ day}{1.2}$$

Maximum production = 8.7 metric tons/year

\* Due to limitations, the density of 60kg/m<sup>3</sup> cannot be maintained. The 60 kg/m<sup>3</sup> is the potential density, and in this scenario is not reached due to not adding oxygen.

## 7.2. Fish farm - scenario 2

Oxygen applied, recirculation, maximum feeding

Assumptions

Water volume 500 m<sup>3</sup>

- ▲ Density = 60 kg/m<sup>3</sup>
- ▲ Feed percentage = 1.48%
- ▲ Minimum oxygen level = 6 mg/l
- ▲ Oxygen level water flow in = 9 mg/l
- ▲ Water flow into farm 100 l/sec = 360 m<sup>3</sup>/hour
- ▲ Recirculation = 300 l/sec = 1080 m<sup>3</sup>/hour
- ▲ Oxygen level in recirculation = 16mg/l
- ▲ Feeding period = 8 months
- ▲ FCR = 1.2

This means:

Oxygen that enters the farm

- ▲ 3.0 mg/l is available for the fish to consume.

$$Oxygen_{available} = (Oxygen_{inlet} - Oxygen_{Minimum}) \times Water\ flow$$

$$Oxygen_{available} = (9.0 - 6.0) \times 100$$

$$Oxygen_{available} = 300\ mg/sec$$

$$Oxygen_{available} = \frac{300\ mg/sec \times 3,600\ sec \times 12\ hour}{1,000\ mg/gram}$$

$$Oxygen_{available} = 12,960\ gram$$

Oxygen added in recirculation:

- ▲ 10.0 mg/l is available for the fish to consume.

$$Oxygen_{available} = (Oxygen_{inlet} - Oxygen_{Minimum}) \times Water\ flow$$

$$Oxygen_{available} = (16.0 - 6.0) \times 300$$

$$Oxygen_{available} = 3,000\ mg/sec$$

$$Oxygen_{available} = \frac{3,000\ mg/sec \times 3,600\ sec \times 12\ hour}{1,000\ mg/gram}$$

$$Oxygen_{available} = 129,600\ grams$$

Total oxygen available = 12,960 grams + 129,600 grams = 142,560 grams

- ▲ Fish require 300 grams of O<sub>2</sub> per kilogram of feed given.
- ▲ This means that with 142,560 grams of O<sub>2</sub> per day, 475 kilograms of feed per day can be fed.

Based on standing stock, the feed gift should be:

$$\text{Feed gift} = \text{standing stock in tank} \times \text{feed percentage}$$

$$\text{Feed gift} = 500\text{m}^3 \times 60 \text{ kg/m}^3 \times 1,48\% = 444 \text{ kg per day}$$

Based on oxygen availability, 475 kg can be fed.

Based on maximum growth, 444 kg can be fed.

The limiting factor is now the speed of growth of the fish.

The maximum annual production based on the maximum feed capacity and period of feeding is:

$$\text{Maximum production} = \frac{\text{annual feed gift}}{\text{FCR}}$$

$$\text{Maximum production} = \frac{\frac{8 \text{ months}}{12 \text{ months}} \times 365 \text{ days} \times 444 \text{ kg.day}}{1.2}$$

$$\text{Maximum production} = 90 \text{ ton/year}$$

## Total ammonium

$$\text{Total ammonium} = \text{feed gift} \times 35 \frac{\text{gram}}{\text{kg}} \text{ feed}$$

$$\text{Total ammonium} = 444 \times 35 \frac{\text{gram}}{\text{kg}} \text{ feed}$$

$$\text{Total ammonium} = 15,540 \text{ gram}$$

## Retention time

$$\text{Retention time} = \frac{\text{raceway volume}}{\text{water flow}} \times 60$$

$$\text{Retention time} = \frac{500 \text{ m}^3}{100 \text{ m}^3/\text{hour}} \times 60$$

$$\text{Retention time} = 300 \text{ min}$$

## Ammonium

$$\text{Ammonium raceway} = \frac{\text{retention time}}{24 \text{ hour} \times 60 \text{ min}} \times \text{Total ammonium}$$

$$\text{Ammonium raceway} = \frac{300 \text{ min}}{24 \text{ hour} \times 60 \text{ min}} \times 15,540 \text{ gram}$$

$$\text{Ammonium raceway} = 3,237 \text{ gram}$$

## Ammonium concentration

$$\text{Concentration} = \frac{\text{Ammonium}}{\text{raceway volume}}$$

$$\text{Concentration} = \frac{3,237 \text{ gram}}{500 \text{ m}^3}$$

$$\text{Concentration} = 6.5 \text{ gram/m}^3$$

$$\text{Concentration} = 6.5 \text{ mg/l}$$

The ammonium concentration is above the maximum of 2 mg/l that is the limit for trout farming.

Adding oxygen and recirculating the water solves the issue of oxygen availability. In this way, the fish can be fed to ensure maximum growth. Through recirculation, the ammonium is kept in the system, which creates a new limiting factor—ammonium concentration.

This issue can be resolved rather easily by adding a bio filter just before the oxygenation step. The design of the bio filter depends on the water temperature, ambient temperature, pump selection and field elevations in the fish farm, and layout of the farm, and it is critical to hire a company with experience for the design and construction of the bio filter.

### 7.3. Financial figures for fish farms (scenario 1 and 2)

#### Scenario 1

Production cost	Oxygen limit	trout	
Juveniles		€ 820.75	
Feed		€ 15,795	
Other inputs	electricity	€ 1,500	
	gas	€ 0	
	water	€ 5,950	
	oxygen	€ 0	
	chem., med., etc.	€ 0	
	purification fee	€ 0	
	subtotal	€ 24,065	
Other company costs	maintenance	€ 0	
	insurance	€ 0	
	water testing	€ 1,500	
	general costs	€ 3,000	
	subtotal	€ 4,500	
Labor	management	€ 10,000	
	operational	€ 6,755	
	subtotal	€ 16,755	
Total operational costs		€ 45,320	Per year
Cost price per kg fish		€ 5.21	kg fish
Production	8,700	Kg/year	

#### Scenario 2

Production cost	max growth	trout	
Juveniles		€ 8,490	
Feed		€ 163,079	
Other inputs	electricity	€ 21,024	
	gas	€ 0	
	water	€ 595	
	oxygen	€ 4,698	
	chem., med., etc.	€ 5,000	
	purification fee	€ 0	
	subtotal	€ 202,886	

Other company costs	maintenance	€ 1,500	
	insurance	€ 0	
	water testing	€ 1,500	
	general costs	€ 3,000	
	subtotal	€ 6,000	
Labor	management	€ 15,000	
	operational	€ 8,547	
	subtotal	€ 23,547	
Total operational costs		€ 232,434	Per year
Cost price per kg fish		€ 2.58	kg fish
Production	90,000	Kg/year	

## Conclusion

The overall conclusion for scenarios 1 and 2 is that with the same fish farm, tanks/raceways, and flow of water, production goes from 8.7 metric tons to 90 metric tons, simply with the addition of a pump, an oxygenator, and a bio filter. The operational cost increases the requirements in terms of working capital, but the cost price of a kilogram of trout decreases from €5.21 to €2.58 per kilogram of fish.

### 7.4. Evaluation of fish feed

Too often, the fish feed producer is selected based on feed price per kilogram. This is only one part of the equation as fish growth is as important as the feed price. In the end, the feed investment required to produce 1 kg of fish is very important.

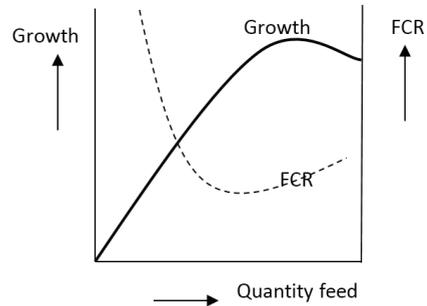
The best way to make a decision is to do parallel testing. This means that in two or more separate tanks fish from the same batch are fed and evaluated at the same time.

An example of steps to be taken for such parallel testing is given below:

- ▲ Grade one batch of fish.
- ▲ From the same weight category, split the fish in two equal parts and divide them over two or more tanks of the same size—same batch, same standing stock, and same density.
- ▲ Feed the fish up to the level of saturation of the fish, which is when the fish are still eager to eat, but let less then when feeding began. Feeding up to the saturation point can make a difference in the feed supply between the two batches.
- ▲ Record the amount of feed supplied and mortality (numbers and weight) per tank.

- ▲ Maintain feeding up to next grading moment.
- ▲ Grade the fish per tank and determine per grade/category the numbers of fish per weight category.
- ▲ For each tank calculate the following:
  - ▲ Growth in kilograms
  - ▲ Feed given
  - ▲ Feed conversion ratio (FCR)
  - ▲ Feed cost per kilogram of fish

Figure 32: Fish growth and FCR



Source: Author

After calculating the cost price per kilogram of fish, a feed supplier can be selected. The evaluation is done based on the maximum growth tables of the pellet feed producers. Depending on a fish farmer's ambition, the feed can be based on maximum growth or on an optimal feed conversion ratio (FCR).

The graph above depicts this relationship. In practice, the difference in feeding between maximum growth and optimal FCR is not significant.

## 7.5. Determine water flow

There are many kinds of specialist measurement equipment that can measure water flow precisely, but which are sometimes not available at a fish farm throughout the year. The method described below has proven to be effective.

Requirements:

- ▲ Floating object (piece of wood)
- ▲ Stopwatch
- ▲ Measuring tape

This method works with a constructed inlet channel with fixed dimensions as shown in the image below.

### Determine flow velocity

When placing a floating object into the water, the time required to travel a certain distance is measured. Determine the measuring distance: the longer the time measurement, the more reliable it is. Place the object upstream before the start of the measuring point so it can build speed. Start the stopwatch at the moment the object passes the starting point and stop it when it passes the end.

The less the floating object touches the wall, the more accurate the measurement will be.

Then calculate the surface velocity as follows (in meters per second):

$$v_{surface} = \frac{\text{distance [m]}}{\text{time [s]}}$$

This indicates the surface velocity, which is a different velocity than the average speed of the total stream. It is necessary to compensate for the average velocity:

$$v_{average} = v_{surface} \times 0.87$$

Figure 33: Determining water flow velocity



Source: Author

### Wet flow-through surface

To calculate the flow-through surface, the dimensions below (in meters) are required:

- ▲ Width at the bottom of channel (a)
- ▲ Width at water level (b)
- ▲ Water depth (h)

The surface area is calculated as follows (in m<sup>2</sup>)

$$A_{wet} = \frac{1}{2} \times (a + b) \times h$$

### Calculate water inflow

When the wet flow-through surface and flow velocity are known, the next step is to calculate the flow as follows:

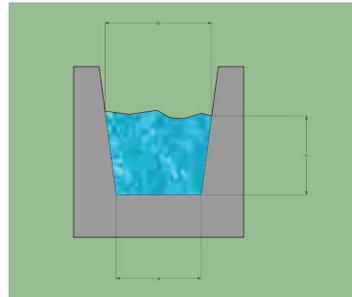
$$Q = v_{average} \times A_{wet} \times 3,600$$

\*(in m<sup>3</sup> per hour)

To convert from m<sup>3</sup>/hour to l/min, multiply by 16.66 (1,000/60)

To convert from m<sup>3</sup>/hour to l/sec, multiply by 0.277 (1,000/3,600)

Figure 34: Determining water flow trough surface



Source: Author



*Photo by G. Gabrielyan*

## **FISH EXPORT AND MARKETING (Marketing of rainbow trout and sturgeon)**

# 1. INTRODUCTION

Armenia’s principal competitive advantages in aquaculture are its unique location in the high mountains, climate, and clean water resources, which are critical for creating a reputation for clean antibiotic free products of high quality. To be competitive in new markets, Armenia will need to address other critical factors, including reducing the costs of production, producing specific product forms demanded by the market at a competitive price, meeting international standards for safety and quality, developing a buyers network, and creating a trusted brand.

This guide provides essential information to guide Armenian aquaculture producers to enter and compete in new export markets for Armenian fish production. The information is focused on markets where demand exists for specific forms of trout and sturgeon:

- ▲ Fresh and frozen Rainbow trout fillets to China, European Union (EU), United States (U.S.)
- ▲ Fresh golden trout to China
- ▲ Processed sturgeon steaks and loins to Asia
- ▲ Potential new markets for sturgeon caviar in Asia.

The guide provides the steps Armenian aquaculture producers can take to develop a product that can compete and be profitable in these markets:

*Figure 1: Product development and marketing stages*



## 2. PRODUCTION COST

Table 2.1 below presents the breakeven point by cost per kilogram for fresh and frozen Rainbow trout for China, the United States, and Armenia. Production cost includes all inputs—seed, feed, processing, packaging, and transport—necessary to get a product to a foreign market. It is apparent from the chart below that Armenia has a cost of production disadvantage against fresh product in China and USA, and frozen product in China. This does not take into account, however, that China currently produces only limited amounts of trout for the live fish market in the large population areas and that their production of large Rainbow trout for sushi grade fillets is limited to the high mountain plateaus of Qinghai and are costly to transport.

In the United States, the water resources for Rainbow trout are no longer available. The majority of U.S. production goes fresh into the market, and market shortfall is met with large volumes of frozen fillets imported from South America. Therefore, it is possible that Armenia will be able to compete in the large sushi grade markets of China and in the frozen market of the United States.

*Table 2.1 Rainbow Trout costs (fresh fillet to Chinese, and frozen fish to USA markets)*

Costs (US\$/kg)	Frozen Fillet			Fresh Fillet		
	China	USA	Armenia	China	USA	Armenia
Production Inputs						
Seed	\$0.60	\$0.35	\$0.10	\$0.60	\$0.35	\$0.10
Feed	\$1.50	\$1.45	\$2.00	\$1.50	\$1.45	\$2.00
Other	\$0.40	\$0.50	\$0.40	\$0.40	\$0.50	\$0.40
Labor	\$0.50	\$0.85	\$0.50	\$0.50	\$0.85	\$0.50
Farm Gate	\$2.90	\$3.15	\$3.00	\$2.90	\$3.15	\$3.00
Processing Yield	39%	40%	40%	39%	40%	40%
<b>Production Cost</b>	<b>\$7.43</b>	<b>\$7.87</b>	<b>\$7.50</b>	<b>\$7.43</b>	<b>\$7.87</b>	<b>\$7.50</b>
<b>Processing Cost</b>	<b>\$0.40</b>	<b>\$0.66</b>	<b>\$0.50</b>	<b>\$0.40</b>	<b>\$0.66</b>	<b>\$0.50</b>
Transportation						
Truck	\$0.07	\$0.35	\$0.17	\$0.07	\$0.55	\$0.00
Air	\$0.00	\$0.00	\$0.00	\$1.55	\$0.00	\$2.20*
Refrigerated Container	\$0.35	\$0.00	\$0.40	\$0.00	\$0.00	\$0.00
<b>Transportation Cost</b>	<b>\$0.42</b>	<b>\$0.35</b>	<b>\$0.30</b>	<b>\$1.62</b>	<b>\$0.55</b>	<b>\$2.50</b>
<b>Total Break Even</b>	<b>\$8.25</b>	<b>\$8.89</b>	<b>\$8.57</b>	<b>\$9.45</b>	<b>\$9.08</b>	<b>\$10.20</b>

*Source: Individual producers in Armenia, US, and China*

\* Note: The air transportation cost from Armenia indicated in the table is the price of transporting fresh fish in passenger airplanes. The transportation cost for hiring a cargo airplane would be significantly higher.

Given its geographic location, transportation costs represent a strategic cost disadvantage for Armenian product, due to the need to use refrigerated trucks to transport frozen product via Georgia for export in refrigerated containers, and for air transport

from Yerevan for fresh product. Since alternative, cheaper transport options are not available at this time, Armenian producers must focus on other strategies to increase cost competitiveness, namely:

Increase production efficiencies with increased yield and fillet size.

Production yield increases when fish gain more weight per unit of feed provided. This ratio is called the feed conversion ratio, or FCR. The higher the quality of feed, the more growth will be achieved per unit. The cost disadvantage for Armenia is the *added costs of importing feed*—customs duties, taxes, and, custom clearance procedures. According to IFC’s review of the aquaculture supply chain, **customs valuation procedures increase the price of feed by at least 10 percent to 15 percent.** The best way to reduce costs is to produce extruded feed locally with as many locally produced ingredients as possible, while improving production efficiencies at the farm level and reforming the customs regime at the government level.

Extruded feed has a higher FCR and remains suspended in the water column long enough to be eaten by the fish before sinking. The following steps are necessary for the development of a high quality local fish feed product:

- ▲ **Conduct an inventory of viable local feed ingredients**, such as wheat, barley, and by-products from beer production.
- ▲ **Test a variety of “feed formulas” using local ingredients** to assess their feed conversion ratios, compared to the high-quality imported pellet feeds now being used.
- ▲ **Determine the cost–benefit of extrusion equipment to produce floating and slow sinking feed** (including costs of import). Extruded feed is essential to the efficiency of net cage production because slow sinking and floating feed reduce feed residue. It can also be useful in limiting raceway residue and requires less filtration in recirculating systems designed for water conservation in raceway systems. Currently, a high rate of water flows through the raceways and is not recirculated, raising concerns about excess water usage and lack of proper water conservation.
- ▲ **Determine whether a newly constructed feed mill with extrusion equipment can produce high-quality feed at a lower cost than the cost of imported feed.**
- ▲ **Assess cost competitiveness of feed produced with extrusion equipment.** Conduct pond trials comparing Armenian produced feed with imported feed to determine whether local feed improves the FCR and maintains or improves survival rates.
- ▲ **Determine whether larger fish yielding larger fillets can be produced with improved feed and production efficiencies.**

The technical aspects of new production methodologies and improving production efficiencies are covered in a separate guide; however, they are mentioned here because high production cost limits access to and competitiveness in export markets.

### 3. PRODUCT FORM AND TARGETING NEW MARKETS

Target markets determine product form. Product form is the central factor to consider when targeting markets for Armenian product. To be competitive, Armenian producers must be able to grow fish to market sizes and fillet and process them to client specifications for different product forms. Consequently, the ability to market different product forms is determined by the size and quality of fish that can be produced, which in turn are determined by growth rates, FCR, and harvest sizes.

Most international markets are characterized by established preferences for product forms, each defined by standards and client specifications that producers must meet. Working back from the market, therefore, Armenian producers can determine their capability to meet the standards for specific product forms and remain competitive with other sellers in the market. The primary factors are size, quality, and color:

- ▲ **Size:** length, weight, fillet thickness, belly flap thickness, and cook yield
- ▲ **Quality:** fillet moisture, fillet fat, and cooked fillet firmness

All of these variables directly affect the price that can be captured for the final product. Consequently, the growth curve of the fish is of high importance because it determines harvesting end points where size and quality are optimized.

*Table 3.1 Product Market Requirements and Characteristics*

Live Market	Fresh Market	Frozen Market
Only high-value species	Fillets or large head on & gutted	HACCP processing
Air shipment possible	HACCP processing	Individually quick frozen (IQF)
Aeration	Cold rooms for super chilling	Filleted & processed to specification
	Air shipments & efficient logistics	

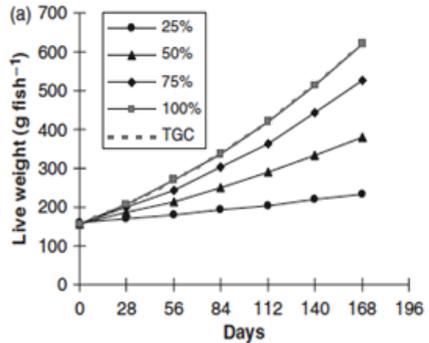
**Plan production for optimum size and quality.** A recent study<sup>4</sup> on the growth performance and fillet quality of larger farm-raised trout provides a reference point for production planning and harvest end point to achieve larger sizes while maintaining quality and cost effectiveness. The most common size for farm-raised

4 Davidson, J.W., P.B. Kenne, M. Manor, C.M. Good, G.M. Weber, A. Aussanasuwanakul, P.J. Turk, C. Welsh and S.T. Summerfelt. (2014) “Growth Performance, Fillet Quality, and Reproductive Maturity of Rainbow Trout (*Oncorhynchus mykiss*) Cultured to 5 Kilograms within Freshwater Recirculating Systems.” *Aquaculture Research & Development* 5(4).

Rainbow trout is one pound or less for a pan-sized fillet. Larger fillets for Rainbow trout are less common, but carry a premium in the market. In the study cited, researchers evaluated the “growth performance and fillet quality attributes of all-female Rainbow trout reared using freshwater recirculating systems operated at a mean water temperature of 13°C, under constant lighting, and with around-the-clock feeding.” The study found that:

- ▲ The trout grew to 4.8 kg in 22 months post-hatch.
- ▲ Growth rates declined with the onset of reproductive maturity. Rainbow trout weighed 5.2 kg at 26 months.
- ▲ The FCR was 1.36:1, from first feeding to 22 months, but increased substantially from 23-25 months.
- ▲ As Rainbow trout approached reproductive maturity, the quality attributes of the fillet were assessed.
- ▲ Fillet yield peaked at 20-22 months when trout were at 3.8-4.8 kg.
- ▲ Cook yield, cooked fillet firmness, and crude fat decreased, while fillet moisture and raw fillet firmness increased from 24-26 months.
- ▲ Changes in fillet quality coincided with reduced growth rates, decreased feed efficiency, and increasing size of reproductive glands (gonad somatic index).

Figure 2: Trout performance graph



Source: Davidson, et al “Growth Performance, Fillet Quality, and Reproductive Maturity of Rainbow Trout Cultured to 5 Kilograms within Freshwater Recirculating Systems”

**Rainbow Trout.** The largest U.S. producer and distributor of trout products is Clear Spring Foods. Examples of Rainbow trout products being marketed by Clear Spring Foods are shown below, including white fillets and value-added crusted products that require more sophisticated processing.

Clear Springs Foods ([www.clearsprings.com](http://www.clearsprings.com)) is seeking new production sources and currently have a joint venture in Argentina. The contact at Clear Springs Foods, is Don E. Riffle, Executive VP of Global Supply Chain Development, [don.riffle@clearsprings.com](mailto:don.riffle@clearsprings.com). There is also sales potential with companies in the United States that specialize in smoked fish; Rainbow trout is a popular smoked fish and most of the smoked seafood companies are looking for new supplies of quality fish. An example of a medium-sized company is Ducktrap River of Maine, [www.ducktrap.com](http://www.ducktrap.com), contact [Jason.thibodeau@marineharvest.com](mailto:Jason.thibodeau@marineharvest.com).

**Sturgeon:** Sturgeon is only marketed as whole fish to the Russian market or produced and sold live in the Chinese market. All sizes of whole fish are sold to Russia, and the common market size for live fish in China is a 500 to 750 gram

Figure 3: Trout product examples

The screenshot shows the Clear Springs Foods website. At the top, there are logos for Clear Springs Foods (Built, Made & Since 1988) and Fresh Fish Attache. A navigation bar includes links for HOME, OUR STORY, PRODUCTS, POS/IMAGES, VIDEOS, RECIPES, and CONTACT. Below this, the 'CONSUMER Clear-Cuts®' section features two images of boneless trout fillets. Text describes Clear-Cuts as 100% guaranteed boneless rainbow trout, available in Butterfly and Natural styles. It also mentions a 'V' cut to remove pin bones. A product filter bar shows 'Trout' selected. Below are five product categories, each with an image and description:

- CLEAR-CUTS® BUTTERFLY STYLE:** Clear-Cuts® rainbow trout fillets are 100% boneless for ultimate customer satisfaction. As the only guaranteed boneless rainbow trout available, Clear Springs Clear-Cuts® are truly exceptional. Fillets pair well with a variety of seasonings and sauces, making rainbow trout a perfect option for dinner.
- CLEAR-CUTS® NATURAL FILLETS:** Clear-Cuts® rainbow trout fillets are 100% boneless for ultimate customer satisfaction. As the only guaranteed boneless rainbow trout available, Clear Springs Clear-Cuts® are truly exceptional. Fillets pair well with a variety of seasonings and sauces, making rainbow trout a perfect option for dinner.
- CRUNCHY POTATO CRUSTED RAINBOW TROUT FILLETS:** Crunchy Potato Crusted Rainbow Trout Fillets are specially crusted in a crunchy potato stick coating, these fillets bring classic fish fry flavors straight to every fresh seafood case. Plus, they're ready to bake or sauté for easy dinner preparation.
- HARISSA CRUSTED RAINBOW TROUT:** Harissa Crusted Rainbow Trout Fillets are coated in the bold flavor of Harissa, a North African hot and spicy seasoning, to give this fillet the perfect amount of intensity for spicy palates. It's a great accompaniment in your fresh seafood case or as tray packs in your freezer case.
- MUSTARD PRETZEL CRUSTED RAINBOW TROUT:** Mustard Pretzel Crusted Rainbow Trout Fillets blend the popular flavor of Dijon mustard with the delicate, mild-flavored rainbow trout for a hot and tangy seafood option. It's a great accompaniment in your fresh seafood case or as tray packs in your freezer case.

Source: [www.clearsprings.com](http://www.clearsprings.com)

fish. Sturgeon is rarely seen in the European or U.S. market, but may have a sales opportunity in processed form as loins or steaks. This market would have to be explored at a Seafood Exposition with potential importers in the United States and Europe.

**Production Volume:** It is important for the producer to plan production to consistently produce required quantities depending on the product form, volume, and shipping method. Fresh product is shipped by air container. The standard minimum size shipment for fresh product is the LD3 air cargo container fitting approximately 1,000 kg in Styrofoam boxes, with water absorption pads placed in the insulated cooler and exterior cardboard box, which are in turn placed in the air container. Frozen product is packed in bulk plastic bags or in inner branded boxes, which are then placed in master cases (15 to 20 kg), generally packed according to buyers' specifications. These master cases are then placed in refrigerated 20 metric ton containers (reefers) for maritime transport.

## 4. MARKET PRICE

**Plan production for market competition.** Market price can be determined by pricing services such as Urner Barry in the US, (see link below), or checking competitive online offers, such as through Alibaba (alibaba@service.alibaba.com). It is helpful to see what products Asian processors and re-processors are offering on the international market.

**Direct Sales:** To illustrate how production factors play out in the market, below is an example of a typical offer from a Peruvian producer of Rainbow trout to a U.S. importer:

**Product:** Premium Quality Fillets, Frozen, C Trim, IQF, PBO (Produced by Owner), master carton 10 kg

**Fillet Size:** 3-5, 5-7, 7-9, 9-11 oz.(1 oz = 28.3 gr)

**Price:** US\$8.47/Kg CFR Main USA port

**Indirect Sales:** The following illustrates pricing by a U.S. importer selling to the U.S. wholesale market:

Country of Origin Colombia, Quote March, 2016:

RAINBOW TROUT WHITE BUTTERFLY HOF PBO Skin-On

Packed IQF 10 or 50 lb case (1 lb ≈ 450 gr)

7/9 US\$4.45/lb (US\$9.79/kg)

9/11 US\$4.45/lb (US\$9.79/kg)

RAINBOW TROUT WHITE D-TRIM FILLETS PBO IQF 10 or 50 lb case

3/5 US\$5.60/lb (US\$12.32/kg)

We vacuum pack for an additional US\$0.15/lb (US\$0.675/kg)

To compete with the Peruvian producer with the *same* product sizes, Armenian producers would need to lower their production costs and increase efficiencies in feed and production to influence the growth curve, size, and quality of their product. To produce *larger* sizes that can be processed into larger fresh and frozen fillets, existing systems in Armenia must be adapted to enhance the growth curve of the fish, for example, by producing in raceways and finishing in large lake net cages.

*Figure 4: Trout fillets*



Source: Author

The photograph below shows the price differential for sushi grade Rainbow trout in the Chinese market. (Sushi grade is the highest quality grade indicating it is safe to eat raw.)

## 5. TARGET MARKET

Alternative markets for Armenian aquatic products are likely to be those where additional supply is needed because of water resource constraints in markets where Armenia can cover the higher cost of air and maritime transportation. This will be primarily the U.S. market for frozen product, followed by the China market for fresh sushi grade large trout fillets, and other Asian markets, such as Malaysia, Singapore, and Hong Kong. Malaysia, Singapore, and Hong Kong markets have the level of disposable income that that could afford higher valued Armenia products, especially sturgeon caviar.

The following contacts are considered reliable and well-positioned companies in Asia for Armenian producers:

**Singapore:** Rong Yao Group, (PTE Ltd), Singapore <http://www.rongyao.com.sg/>, contact Mr. Edmund Choo, Director of New Business Development, [edmundchookl@gmail.com](mailto:edmundchookl@gmail.com), [edmundchoo@rongyao.com.sg](mailto:edmundchoo@rongyao.com.sg). This group has multiple food divisions, “Fresh & Natural”, “Rong Yao Fisheries”, “Meidi-Ya”, and distributed to Food Service in Singapore and Hong Kong, and would be an excellent client for sturgeon caviar, and possibly new product development of sturgeon loins and steaks.

**Malaysia:** TexChem Group, <http://texchemgroup.com/index.aspx>, contact Mr. Poh Keat Wong, [wong.pk@texchemfood.com](mailto:wong.pk@texchemfood.com). TexChem Group has both restaurant and food divisions throughout Malaysia and branches in Hong Kong.

**General Market and Pricing Information:** Market data is available from a variety of public and private sources:

**Customs import data from target countries** is the best source for understanding new export markets. U.S. markets <http://www.ers.usda.gov/data-products/aquaculture-data.aspx>, European markets: <http://ec.europa.eu/fisheries/market-observatory/>

**UN Food and Agriculture Organization (FAO)** provides data on fisheries production by country: [www.fao.org](http://www.fao.org)

**Annual Global Marketing Seafood Conference (GMSC)** for market intelligence <http://www.aboutseafood.com/about/global-seafood-market-conference>

**Global Aquaculture Alliance (GAA) GOAL** <http://gaalliance.org/goal/>

**Urner Barry:** Private U.S. subscription service for reference prices <http://www.urnerbarry.com/>

## 6. TRADE SHOWS

Entering new markets can be facilitated by trade show participation, especially participation by a broad spectrum of producers in a country, sponsored by a country export promotion entity. The most important seafood industry tradeshow are listed in table below.

*Table 6.1 Top-Ranking Seafood Industry Tradeshow*

Market	Date	Location
China Fisheries and Seafood Expo <a href="http://chinaseafoodexpo.com">http://chinaseafoodexpo.com</a>	November	Qingdao, China
Seafood Expo North America <a href="http://seafoodexpo.com/north-america">http://seafoodexpo.com/north-america</a>	March	Boston, MA USA
Seafood Expo Global <a href="http://www.seafoodexpo.com/global/">http://www.seafoodexpo.com/global/</a>	April	Brussels, Belgium
Global Marketing Seafood Conference (GMSC) <a href="http://www.aboutseafood.com/about/global-seafood-market-conference">http://www.aboutseafood.com/about/global-seafood-market-conference</a>	January	Changing Cities, United States

## 7. INTERNATIONAL PROCESSING CONTROL REQUIREMENT

Almost all global export markets have regulatory standards and requirements for processing control that include the following:

- ▲ **Hazard Analysis and Critical Control Point (HACCP)**  
<http://www.fda.gov/Food/GuidanceRegulation/HACCP/>
- ▲ **Standard Sanitary Operations Procedures (SSOP)**  
[http://www.fsis.usda.gov/wps/wcm/connect/4cafe6fe-e1a3-4fcf-95ab-bd-4846d0a968/13a\\_IM\\_SSOP.pdf?MOD=AJPERES](http://www.fsis.usda.gov/wps/wcm/connect/4cafe6fe-e1a3-4fcf-95ab-bd-4846d0a968/13a_IM_SSOP.pdf?MOD=AJPERES)

**European Union (EU).** Armenia currently is in the process of getting EU certification for its aquaculture production, which is necessary in order to ship to Europe. This is currently being undertaken by the Department of Agriculture of the Armenian government, and is expected in 2016/2017. As in the Chinese market, the original opening has to have input from the Armenian government. In addition, the HACCP certifications and SSOP guidelines have to be in place for the processing facilities placing the fish for export.

In Europe, the principal salmonid species consumed is salmon produced in Norway. Therefore, the smaller trout fillets are considered a lesser value species to

the large salmon fillets. As illustrated by the chart below, consumption of sea-captured ground fish, small pelagic (sardine, Mackerel), tuna and the aquaculture bivalves surpass consumption of the salmon species.

*Figure 5: Trout product examples*

*Supply balance and apparent consumption in 2011 at EU level and by commodity group (live weight equivalent)*

Commodity group	Production (tonnes)		Import (tonnes)		Export (tonnes)		Apparent consumption (tonnes)			Per capita (kg)		
	Fishery	Aquaculture	Fishery	Aquaculture	Fishery	Aquaculture	Fishery	Aquaculture	Total	Fishery	Aquaculture	Total
Bivalves and other molluscs and aquatic invertebrates	244.268	627.392	307.054	147.656	6.291	6.962	545.031	768.085	1.313.116	1,08	1,53	2,61
Cephalopods	114.972	3	539.468	0	27.610	0	626.830	3	626.833	1,25	less than 0,01	1,25
Crustaceans	214.364	242	407.295	292.323	99.890	1.774	521.769	290.791	812.560	1,04	0,58	1,62
Flat fish	203.941	11.039	54.635	1.307	50.475	4	208.102	12.342	220.444	0,41	0,02	0,44
Freshwater fish	37.700	89.927	130.727	497.149	4.925	2.948	163.502	584.128	747.630	0,33	1,16	1,49
Groundfish	516.110	0	2.468.617	21.184	136.557	87	2.848.170	21.097	2.869.267	5,67	0,04	5,71
Miscellaneous aquatic products	34.137	55	317.719	0	9.006	0	342.850	55	342.905	0,68	less than 0,01	0,68
Other marine fish	512.132	148.432	576.016	30.775	165.074	6.024	923.074	173.183	1.096.257	1,84	0,34	2,18
Salmonids	8.437	357.497	72.709	764.749	38.083	66.815	43.064	1.055.431	1.098.494	0,09	2,10	2,19
Small pelagics	2.084.872	1	454.628	0	690.152	0	1.849.347	1	1.849.348	3,68	less than 0,01	3,68
Tuna and tuna-like species	340.160	5.060	1.298.329	1	294.130	421	1.344.360	4.640	1.349.000	2,68	0,01	2,68
<b>Total</b>	<b>4.311.093</b>	<b>1.239.648</b>	<b>6.627.198</b>	<b>1.755.143</b>	<b>1.522.192</b>	<b>85.035</b>	<b>9.416.099</b>	<b>2.909.756</b>	<b>12.325.855</b>	<b>18,74</b>	<b>5,79</b>	<b>24,53</b>

Source: EUMOFA – European Market Observatory for Fisheries and Aquaculture Products. [www.eumofa.eu](http://www.eumofa.eu)

**China:** The following are some Chinese government agencies, for which facilitation by the government of Armenia is required to allow access to the Chinese fish market:

- a. **General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ).** The government of Armenia, through the Armenian Embassy in Beijing, must negotiate a *Fisheries Protocol* to establish the terms of trade between the two countries. <http://english.aqsic.gov.cn/>
- b. **Certification and Accreditation Administration (CNCA).** Once the Fisheries Protocol is in place, Armenian companies can register with CNCA, an independent agency that confirms compliance with the negotiated Fisheries Protocol and with sanitary and processing regulations (HACCP), to obtain a *Certificate of Conformity*. <http://www.ccc-certificate.org/en/renzheng-jigou/guojiarenjianwei-cn>
- c. **Entry-Exit Inspection and Quarantine Administration (QIC).** Armenian companies must obtain an Inspection and Quarantine Certificate for all imported food products. <http://en.ciqcid.com/>

**Japan:** The Japanese market is dominated by large trading companies such as Mitsubishi Marine Products (<http://www.mitsubishicorp.com/us/en/bg/ps/mp.html>) and Marubeni, ([https://www.marubeni.com/business/life\\_industry/foods/](https://www.marubeni.com/business/life_industry/foods/)). They have specific product preferences and are best approached through established contacts or off shore subsidiaries that may be interested in new sources of product. Once a Japanese company has established a reliable source of high-value product, with reliable delivery, they very seldom change suppliers. Price is not the most important factor as it is in other markets. High quality and reliability of supply are more highly valued. Contacts have to be made in person and time spent at the Tsukiji Market in Tokyo, Japan, the world’s largest fish market. The Japanese International Seafood and Technology Exposition ([https://www.jetro.go.jp/j-messe/tradefair\\_en/The18th\\_49214](https://www.jetro.go.jp/j-messe/tradefair_en/The18th_49214)) also provides insight into the market, however the marketing process is long and time consuming and entry into the market is slow.

### Third-Party Quality and Sustainability Certifications

Commercial buyers in the target markets often require specific quality and sustainability certifications:

*Table 7.1 Certification agencies*

Market	Requirement
Europe	British Retail Consortium (BRC) <a href="http://www.brcglobalstandards.com/">http://www.brcglobalstandards.com/</a> Global Good Agriculture Practices (GAP) <a href="http://www.globalgap.org/uk_en/index.html">http://www.globalgap.org/uk_en/index.html</a> Soci�t� G�n�rale de Surveillance (SGS) <a href="http://www.sgs.com/">http://www.sgs.com/</a>
North America	Best Aquaculture Practices (BAP) <a href="http://bap.gaalliance.org/">http://bap.gaalliance.org/</a>
China	Developing a new “ Green China ” (Organic) National Scheme

## 8. BRANDING AND MARKETING

Armenian producers must create a unique identity based on product origin and a reputation for quality and safety in markets where major buyers do not presently recognize Armenia as a producer of caviar and high-quality fish. Some of the characteristics on which the Armenian aquaculture sector can build a brand include its unique location, climate, and clean water resources.

Most people in the United States and Asia do not know where Armenia is located, or its geography or history. Armenia needs its own “country brand,” such as “Boston Lobster,” a generic name for *Homrus Americanus* recognized in China even when it comes from both the United States and Canada. It is characterized by its two large claws, bright red color when boiled, and rich taste. The highest value lobster with the best quality is Clearwater’s product from Canada. This company was able to change the generic name “Boston Lobster” when it applied for and received a patent to shrink wrap the claw with the Clearwater brand indicating Canadian origin. This branding allows the company to receive a premium for its lobsters.

Armenia’s brand can be built on its high mountain location, fresh water sources, and unique culture and history, with a distinctive name and visual trademark that is both recognized and that evokes Armenia, such as Mt. Ararat. Just creating an attractive trademark, however, will create no value unless it represents quality production. This is generally done by a market leader that distinguishes its production from all other producers in the market by name and visual trademark.



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