Scoping study Turkish Rainbow trout aquaculture

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Summary

An inventory was made of the options for recirculating aquaculture system (RAS) applications in the Turkish rainbow trout aquaculture industry. The aim of this scoping study was to gain insight in the potential business opportunities for Dutch companies and research institutes supplying RAS related knowledge, technology, services and hardware. A desk study was done to characterize the Turkish rainbow trout industry, to identify general drivers for RAS application and to establish which drivers were responsible for the transition of the Danish trout industry from production in flow through systems to production in RAS. An inventory of opportunities for RAS application in the Turkish trout industry, the underlying drivers and the associated needs was made by semi-structured interviews of Turkish stakeholders including Turkish government representatives, researchers and private companies active in trout production. The need for RAS by the Turkish rainbow trout industry was assessed by confronting the information on the Turkish rainbow trout industry and the information collected during the interviews with Turkish stakeholders to the main drivers for RAS application in general. The extent to which these drivers are relevant to the Turkish rainbow trout industry provided insight in the needs and potential for RAS.

It seems unlikely that environmental legislations will force the Turkish trout industry to adopt RAS in the near future, as was the case in Denmark. Turkish trout aquaculture currently does not seem to be limited by the availability of sufficient, good quality fresh water. Opinions among the interviewees on whether this will change in the future and affect their need for RAS vary. Opportunities for RAS application in the Turkish rainbow trout industry mainly relate to advantages of temperature control, use in hatcheries and nurseries and to possible restricted access to water the future. The economic feasibility was the main concern of the interviewed trout farmers that were already familiar with the concept of RAS. Whether RAS application in the Turkish trout industry is economically feasible remains to be established. The Turkish trout industry has not yet started to implement RAS. The potential for RAS has been recognized while the market for RAS knowledge, technology and hardware transition has not yet been claimed by other parties. The challenge now is to frame Dutch RAS expertise among Turkish stakeholders to ensure that once a transition to RAS begins, Dutch companies and institutions are the natural and preferred suppliers of RAS knowledge, technology, services and hardware to the Turkish market. It is therefore recommended to develop a strategy of “framing and monitoring”.

1. Introduction

Annual Rainbow trout aquaculture in Turkey exceeds 100.000 ton, making it the largest trout producer in the world. Production predominantly takes place in flow through systems and cages systems in fresh water (artificial) lakes by a few thousand companies. Transition from open flow through and cage systems to more closed re-use or recirculating aquaculture systems (RAS) may be required in the near future. Such a transition would provide significant business opportunities for Dutch companies and institutions supplying RAS technology, hardware and knowledge. An inventory of the possibilities for RAS application in the Turkish trout production industry and the resulting business opportunities for Dutch companies and institutions has therefore been made.

2. Assignment

The overall objective of this scoping study is to make an inventory of the options for RAS application in the Turkish trout aquaculture industry and the resulting business opportunities for Dutch companies and institutions.

Specific objectives are:
- General characterization of the Turkish trout aquaculture industry
- General characterization of the transition in Denmark of the trout production in flow through systems to production in re-use and RAS systems, and a comparison with the situation of the Turkish trout industry.
- Establish the need for RAS application by the Turkish trout industry, including the underlying drivers.
- To make an inventory of the needs of Turkish companies, governmental institutions and research institutions with respect to RAS.
- To make an inventory of the potential role of Dutch companies and institutions in the introduction or expansion of RAS application by the Turkish trout industry.
- To advise the client on the next steps to take in the promotion Dutch RAS expertise in Turkey.

The results of this scoping study aim to give insight in the business opportunities of Dutch companies and research institutes resulting from RAS application in the Turkish trout aquaculture industry. Based on that insight the client can decide on what next steps to take to utilize the business opportunities.

3. Aquaculture production systems

Flow through systems
Flow through systems consist of tanks or ponds for fish production. These fish holding units come in a wide variety of shapes, sizes and construction materials. The tanks or ponds are continuously flown through with water, hence the name flow through system. The water flow over the fish tanks or ponds serves to maintain proper water quality by transporting oxygen to the fish and by removing fish metabolites. Water is typically sourced from rivers and wells and is passed through the farm by gravity or pumping. After a single passage through the farm, the water is discharged to the environment, either with or without treatment. The carrying capacity of the fish production system, expressed e.g. as the maximum feed load per unit of time, is a function of the quality and quantity of the intake water. Access to water of sufficient quality and in sufficient quantity is a prerequisite for operating a fish farm as a flow through system. A second prerequisite is that it has to be (legally) possible to discharge large volumes of treated or untreated fish farm effluent containing dissolved and suspended nutrients.

Cage systems
A cage for fish farming consists of an open mesh net attached to a most often circular framework that floats on the water surface. Most often several cages are arranged together to form fish farming site, in some cases along a floating wharf. The cages are held in place by moorings to the bottom of the water body. Cages diameter and depth are typically 10 to 30 meters. Replacement of the water in the cages to maintain proper water quality inside the cage, and thereby the carrying capacity of the system, relies on natural water currents and local water quality. Solid wastes settle on the bottom under or near to the cages, depending on water currents. Cage systems thus require sites that provide sufficient natural water current and local water quality and sufficient water depth. In addition suitable sites are also sufficiently sheltered to protect the system from wave and wind action. Cage systems are applied in rivers, (artificial) lakes as well as marine coastal and off shore locations.

Recirculating aquaculture systems (RAS)
Similar to flow through systems and cage systems, fish tanks in RAS require continuous water exchange to maintain sufficient water quality for fish production; the water flow over the fish tank serves to transport oxygen to the fish and to remove fish metabolites. Unlike flow through systems in which water is discharged after single passage through the farm, RAS involve reuse of culture water after internal purification. To this end all designs of RAS remove solid wastes, oxidize ammonia and nitrite, remove carbon dioxide, and aerate or oxygenate the water before returning it to the fish tank. More intensively-stocked systems or systems culturing sensitive species may require additional treatment processes such as fine solids removal, dissolved organics removal, and water disinfection. Irrespective of their exact design, all RAS are mechanically sophisticated and biologically complex compared to flow through tank or cage production systems. Recirculating aquaculture technology can be applied for all stages of aquatic animal production, including brood stocks, hatchery and nursery rearing, grow-out and quarantine holding.

RAS technology has evolved significantly in Europe over the last several decades, thanks to both publicly funded research and development programmes and private investments. As a result, the technology is currently successfully used for the commercial production of several freshwater fish species, such as European eel, pike-perch, rainbow trout and African catfish in The Netherlands and Denmark. The application of RAS technology for marine fish production is increasingly prevalent during the hatchery and nursery phases of seabass and seabream in the Mediterranean region, while commercial production of turbot in RAS is now being applied in France, Germany, the UK, Denmark and The Netherlands.

The most important advantages of RAS compared to open systems such as flow through tanks and cage systems are a minimum water demand, limited space demand, reduced water and nutrient discharges, stable and controlled water temperature to optimize productivity, stable and controlled water quality, tight control of feeding to maximize feed conversion efficiency, rather site independent, exclusion of predators and climatic events, low use of chemicals, constant quality of the end product and year-round production. Balanced against these advantages, RAS typically require high capital costs to set up, are technically complex, and technical failures can result in rapid, serious crop losses. RAS place greater demands on management control, feed design, health management, and demand professionalism in their use and therefore should run as optimal as possible to ensure economic viability.

RAS cannot always provide an economically viable alternative to flow-through and cage systems. In areas that offer access to water of sufficient quality and in sufficient quantity, while discharge of water and nutrients from the farm is not restricted, there may be no incentive for RAS application. Under these conditions cost of production in RAS will most likely be higher compared to production of the same fish species in flow through and cage systems. Consequently RAS only provide an economically viable alternative to flow-through and cage systems in case of restricted access to water, (legal) limitations regarding nutrient discharges, geographical conditions or climatological conditions limiting the use of flow through or cages systems, or in specific cases in which RAS offer significant technical and therefore competitive advantages such as temperature control and increased bio-security (see also section 4). Clearly the decision to apply RAS to farm fish requires a detailed and site specific analysis of the advantages and disadvantages of RAS compared to alternative and competing production systems.

4. Drivers for RAS application

Limited water availability
RAS require far less water than open aquaculture production systems such as flow through, cage and pond systems. This low water requirement of RAS allows for aquaculture production on sites where the quantity of the available water is insufficient for aquaculture production in open systems. In cases where water quality is insufficient, the low water demand of RAS may also allow for water treatment prior to its use for aquaculture. Limited water availability may be due to natural conditions or legal restrictions related to water use for aquaculture.

Reduced nutrient and water discharge – reduced environmental impact
RAS limit and provide control over nutrient and water discharge resulting from aquaculture. This may allow for aquaculture production on sites where water and nutrient discharge is (legally) restricted. In addition the control over nutrient flows allows for controlled and responsible discharge and reuse of nutrients from aquaculture, reducing its environmental impact.

Temperature control
All fish species have clear, species specific temperature optima for growth. Water temperatures below and above these optima result in lower growth rates and underutilization of production potential. Due to the low system water renewal of RAS a large part of the energy invested in either heating or cooling of the water in the system is retained in the system instead of being discharged with the farm’s effluent. This retention of energy allows for cost effective temperature control. Temperature control allows for the installation of optimal growth temperatures year-round and independent from conditions outdoors.

Year-round production
As for the above mentioned temperature control, RAS can provide optimal conditions for aquaculture production year-round and independent from conditions outdoors. This allows for season independent production planning and market supply, which in many cases offers significant competitive advantages.

Biosecurity
Open aquaculture productions systems are exposed to pathogens and toxic compounds that can be transmitted via the water source used to supply the system with water. In RAS this exposure is reduced as for the much lower intake of water. In addition, the low water demand of RAS may allow for the use of safe but limited water sources such as wells or even tap water. The low water demand of RAS also allows for effective water disinfection treatments prior to its use in the farm, e.g. by sand filtration, UV or ozone. As for the relative compactness of RAS, it is often feasible (if not necessary) to place RAS indoors. This effectively isolates the system from outdoor influences and allows for more elaborate hygiene measures. In addition, it allows for effective measures to isolate pathogens and fish within the farm and prevent spreading of diseases via the farm effluent. Altogether, RAS offers the opportunity to significantly enhance biosecurity. This is especially important for brood stock, hatchery and nursery facilities.

Compact production system
To be economically feasible, production in RAS needs to be intensive. As a result RAS are often more compact, i.e. require less area to realize the same production as flow through systems. On sites where land is scarce or expensive this may provide an important competitive advantage.

5. Materials and Methods

General
This scoping study consists of a desk study and a scoping mission to Turkey during which Turkish government representatives, researchers and private companies active in trout production were visited. The scoping mission took place from the 29th of September until the 1st of October 2015. The mission and visits were organized, facilitated and attended by the client. The visited companies and institutions are presented in Table 1.

Table 1 Institutions and companies visited during the scoping mission.

Date	**Company or institution**	**Contact person**	**Address**	**Business activities**
29-09-2015	Ministry of Food, Agriculture and Livestock, Izmir Provincial Directorate	Ahmet Güldal, Provincial Director	Űniversite Caddesi No 47 Bornova, Izmir	Government
29-09-2015	Ministry of Food, Agriculture and Livestock, Izmir Provincial Directorate	Levent Özkan, Division Director of Fisheries and Aquaculture	Űniversite Caddesi No 47 Bornova, Izmir	Government
29-09-2015	Çamli Feed - Animal Husbandry, Yaşar Holding	Hasan Girenes, President – Agriculture, Livestock and Fisheries group	Kemalpaşa Cad. No 250/A 35070 Işikkent, Izmir	Feed and Fish production, Dairy production & processing
29-09-2015	Çamli Feed - Animal Husbandry, Yaşar Holding	Yasemin Özbakkaloğlu, Business development assistant director	Kemalpaşa Cad. No 250/A 35070 Işikkent, Izmir	Feed and Fish production, Dairy production & processing
29-09-2015	Ege University, Faculty of Fisheries	Prof. dr. Ertan Taşkavak, Dean	35100 Bornova, Izmir	Research and education
30-09-2015	Önder Alabalık	Abdullah Özdemir, owner & director	48300 Fethiye / Muğla	Trout production in flow through
30-09-2015	Ayhan Alp	Mustafa Doğan, production manager	Fethiye Kemer	Trout production in flow through
30-09-2015	Kuzey Balık	Ahmet Bedirhanoğlu, general manager	Fethiye Kemer	Trout production in flow through

Date	Company or institution	Contact person	Address	Business activities
01-10-2015	Baysallar	Ali Baysal, Board Chairman	Isparta	Trout production in flow through and cages
01-10-2015	Şahlanlar	Osman Şahlan, owner & director	Atatűrk Bulvari, Askeri Hastane Karşısı, Isparta	Trout production in cages

General characterization of the Turkish trout aquaculture industry.
The Turkish trout aquaculture industry was characterized by (grey) literature research in a desk study and information collected during the scoping mission to Turkey.

General characterization of the transition from the use of flow through systems to re-use and RAS by the Danish trout aquaculture industry.
The transition from flow through systems to the use of re-use and RAS by the Danish trout producers was characterized by literature research in a desk study.

Inventory of the need for RAS application by the Turkish trout industry, including the underlying drivers, the needs of Turkish companies, governmental institutions and research institutions with respect to RAS.
An inventory of options for RAS application in the Turkish trout industry, the underlying drivers and the associated needs was made by semi-structured interviews of Turkish stakeholders (Table 1). During each interview the interviewer made sure that at least the following topics were addressed:

1. Discharge of water and nutrients from the farm: legal framework, limiting factors;
2. Attitude towards RAS: interest in RAS, know-how about RAS, experiences with RAS, needs related to RAS.

In the interviews with the fish farmers, the following three points were also addressed:

3. General information on the farming systems;
4. The sourcing of water: quantity and quality of inlet water, legal framework, limiting factors;
5. Water quality within the farm.

RAS related business opportunities for Dutch companies and institutions in the Turkish trout industry.
Based on the characterization of the Turkish trout industry and its need for RAS technology an expert judgement on RAS related business opportunities for Dutch companies and institutions was made.

6. Results

6.1 General characterization of the Turkish trout aquaculture industry.

Modern aquaculture in Turkey started with the production of rainbow trout in the 1960s. Trout is mainly produced in traditional flow through systems fed by rivers and wells and in cage systems located in (artificial) lakes. Production of portion sized trout gradually increased from less than 30,000 tons in 1997 to more than 120,000 tons in 2013, making Turkey the world’s largest trout producer. In 2014 production had declined to 107,000 tons (FEAP, 2015).

Early 2015 the EC implemented a countervailing duty (anti-dumping duty) of 6.9-9.5% on rainbow trout imports from Turkey (Commission implementing regulation (EU) 2015/309) after complaints by the Danish Aquaculture Association. The objective of the anti-dumping duty is to protect the EU's trout industry from material damage caused by subsidized trout imports from Turkey. Considering that the EU is a major market for Turkish trout and the narrow profit margin of ~ 8% of Turkish trout production, the economic viability of the Turkish trout industry may be significantly affected by the EU's anti-dumping duty.

6.2 General characterization of the transition from flow through systems to re-use and RAS by the Danish trout aquaculture industry.

Trout production in Denmark has seen a transition from production in traditional flow through systems to production in systems that apply varying degrees of water re-use (re-use systems) and recirculation (RAS). The current Turkish trout production in flow through systems is comparable to the situation in Denmark prior to its transition to re-use systems and RAS. The Danish trout industry is therefore a useful reference for the current scoping study. It gives insight in the drivers that can initiate a transition from flow-through to RAS as well as the associated farming technologies.
The transition of the Danish trout production in traditional flow through systems to re-use systems and RAS was driven by strict environmental legislation by the Danish national government following the implementation of the EU Water Framework Directive. The objective was environmental neutral expansion of the trout production. Legislation led to restrictions in the amount of water that could be taken in from natural water courses by fish farms as well as restrictions in the discharge of dissolved and suspended wastes and oxygen depleted water via fish farm effluents. Effectively this forced Danish trout farmers to significantly reduce their water requirement and nutrient discharge. Together with market forces, the legislation around water use and nutrient discharge from fish farms led to reconstruction of traditional flow-through farms into the so-called Model trout farms. Model trout farms are traditional flow through systems reconstructed into semi-recirculation systems by application of RAS technology. Model trout farms typically require 3-4 m^3 water per kg of feed, a significant reduction of the water demand of 30-60 m^3 per kg feed of traditional flow-through systems. Full RAS typically require even less water, 0.2-0.5 L/ m^3kg feed.
Permits for trout farming in Denmark are based on waste production in relation to feed load. This so-called feed allowance determines the amount of feed a fish farmer is allowed to use in his farm and thus how much fish can be produced. For traditional flow-through systems reconstructed into Model trout farms the feed allowance is corrected for the reduction in waste discharge resulting from the newly introduced water treatments within the fish farm. The increased feed allowance and resulting increase of the production serves as an incentive to invest in farm reconstruction. Farm effluent treatment in constructed wetlands before discharge to the environment results in additional increase of the feed allowance (Jokumsen and Svendsen, 2010).

6.3 The need for RAS in the Turkish rainbow trout industry

General
The need for RAS by the Turkish rainbow trout industry was assessed by confronting the information on the Turkish rainbow trout industry as collected in the desk study and the information collected during the interviews with Turkish stakeholders during the scoping mission to the main drivers for RAS application in general (see section 4). The extent to which these drivers are relevant to the Turkish rainbow trout industry provides insight in the needs for RAS.

Limited water availability

None of the interviewed trout farmers indicated to be currently limited in the water supply to their farms. However, the interviewed stakeholders, including farmers, have different views on the availability of sufficient good quality water for trout farming in the future, as illustrated by the following quotes:

"Fresh water is available in unlimited amounts"

"There are a lot of suitable fresh water sites for cage culture in lakes that have not been taken into production"

"Lakes are polluted by industries which makes them less suitable for trout farming in cages"

"Current use of fresh water for trout aquaculture is not sustainable"

"In the future RAS may be needed because access to water is restricted"

"Competition with drinking water production will increase, resulting in restricted water use for aquaculture"

"Unlimited use of water for trout production will not be allowed in the future"

"Water use will be regulated by a legal framework in the future"

"Fresh water will be a key issue in the future"

"Water shortages will occur in 10 years from now".

Water from rivers and wells is not for free, farmers pay a *water rent tax.* This however is an insignificant cost according to one of the farmers.

Water discharge by rivers fluctuates seasonally, with the lowest discharge in summer. However, even in summer water quantity apparently does not limit trout production, although several farmers do indicate that too high water temperature is an issue in summer (see below). Apart from temperature in summer, the quality of intake water seems more than adequate and none of the interviewed farmers operating flow through systems applies any water treatment before intake in the farm. Often several trout farms rely on the same river for their intake water. One of the interviewed farmers indicated that the upstream location of his farm guarantees year-round access to sufficient, good quality water. This farmer also indicated that farms situated downstream may be faced with water shortage and poor water quality, especially in summer.

In all farms the available water results in water flow rates over fish tanks that are seemingly more than sufficient to secure proper water quality in the tanks. Apparently it is not necessary to use water efficiently and limit water flow rates to the minimum requirements for oxygen supply and ammonia removal. This observation indicates that water availability does not limit trout production. According to one of the farmers production is limited by the maximum stocking density, while water flow is what it is. This also indicates that if a reduction in water consumption by trout farms is desired, the first step is limiting water intake to the actual requirements for given fish biomasses and feed loads.

Turkish (regional) governments analyse the production capacity of a production site based on the availability of water and water temperature. Based on these analyses licences for a certain aquaculture production are granted per site.
According to regional government representatives there is no fresh water shortage at this moment; trout production is not limited by the availability of water, although this could change in the future. Trout production is concentrated in regions with a high and reliable water availability. There seems to be no clear indication that the Turkish (regional) government intends to strictly regulate either the intake of river or well water or the discharge of nutrients in the near future. On the other hand, some of the interviewed farmers indicated to expect to some extent future limitations in the availability of water for trout production. At present however, there seem to be other, higher priority and short term issues than water availability, such as feed costs and the anti-dumping tax imposed by the EU: *"Anything that reduces cost price in trout production is welcome".*

Restricted nutrient and water discharge
All farmers discharging their fish farm effluents to rivers indicated that legislation imposes removal of solids from fish farm effluents. To this end farmers treat the farm effluents with drum filters and this is checked by government officials monthly. Two farmers indicated that the sludge produced by the drum filter is used as fertilizer in horticulture with good results. Water and dissolved nutrients are discharged via the fish farm effluent seemingly without legal restrictions on volumes and nutrient levels.
Discharge of water and nutrients is currently restricted for solids. Farmers can comply to this regulation by installing drum filters. Discharge of water and dissolved nutrients seems unrestricted and not regulated. Interviews did not result in indications that this situation is expected to change in the near future.

Temperature control and year-round production
Several trout farmers are confronted with too high water temperature for trout production in summer. For the visited cage farms in the Isparta region the trout production season runs from November until May. The cages are stocked early November and harvested in May. From June to October the cages are not used because the water temperature in the artificial lake is too high for trout production.
In the Fethiye region some of the trout farmers operating flow through systems are also confronted with too high water temperatures in the summer period. Water temperature is controlled to some extend by mixing the river water with colder well water. This however cannot prevent that in the farm water temperature may reach 19 to 20°C, leading to lower feed intake, increased mortality and subsequently lower trout production in this period.
Farmers expressed their interest in RAS as a tool to control water temperature and to overcome the current issues with too high water temperature in summer. Technically RAS can indeed provide the desired temperature control and year-round optimal temperatures for growth. However, the question is whether an investment in RAS and the higher operational costs of trout production in RAS financially counteract production losses during a few months per year due to high water temperature in otherwise relatively low-cost production systems. Answering this question requires a detailed and situation specific feasibility study, which should consider, next to the benefits of temperature control, all advantages and disadvantages associated to both flow through systems and RAS. It should be mentioned that in these cases there may be other, less complex solutions to overcome temperature related production losses that are worth exploring before considering RAS application. Reduced growth of trout at 19 to 20°C is first of all attributable to the lower oxygen availability at these temperatures rather than temperature itself. Increasing the oxygen supply to the fish may therefore provide an adequate solution for temperature related production losses. In case water is already being pumped to the fish tanks, it is relatively easy to increase the oxygen supply to the fish by enriching this flow of water with oxygen.

Absence of temperature control in trout production may not only lead to too high temperatures in summers as described above, it may also result in sub-optimal temperatures for growth in other seasons. All fish, including trout, have clear temperature optima for growth. Sub-optimal temperatures, both higher and lower than the optimum, can result in significant reductions of production due to lower feed intake and growth in otherwise healthy fish. Especially in the juvenile stages, which generally have a higher optimal temperature for growth than adult fish, much faster growth can be obtained by increasing the water temperature. Year-round optimal temperatures for growth requires cost effective heating of a minimal amount of water, which can be realized in RAS. The economic feasibility will depend on the competitive advantages of being able to produce fish at its optimal growth temperature. A thorough costs price analysis of production is RAS is needed to establish economic feasibility. As water temperatures in trout production in open systems are below optimal growth temperatures competitive advantages of fish production at its optimal temperature for growth seems worth exploring.

Attitudes towards RAS
Knowledge about RAS varies widely among the interviewed stakeholders. Some are very familiar with the concept of RAS while others were not familiar with it. Also the attitude towards RAS varied as illustrated by the following quotes (ranked from more positive to more negative):

"RAS will definitely be the main system for fish production in the future because of the sustainability debate driven by consumers"

"RAS is the final destination of aquaculture"

"It is not too early to start to develop RAS"

"I want to realize a RAS demonstration project"

"Trout hatcheries should think about RAS. For grow-out of trout RAS is not feasible"

"RAS may be interesting to overcome the problem of too high water temperature in summer"

"We will see RAS development in 5 to 10 years because of environmental and sustainability issues"

"For trout the cost price in RAS is too high. Maybe it is possible for species like pikeperch"

"RAS is especially interesting for seabass and maybe for trout hatcheries"

"RAS demands a high investment. Why should I? I don't need it"

"I don't need RAS to produce trout at this moment"

"I don't need RAS at this moment but to prepare for the future I bought land to realize a RAS pilot"

"The cost price of trout produced in RAS is too high for the European market"

"It is not possible to realize profitable trout production in RAS. Production in cages is much cheaper and there are many suitable sites for cages that have not been taken into production yet"

In general the trout farmers are well aware of the concept of RAS. In their opinion the cost of trout production in RAS will be higher than the costs of production in their current flow through and cage

production system. This is considered a major bottleneck because they expect that RAS produced trout will have to compete with trout produced in flow through and cage systems on the same market segment. RAS produced trout is expected to fetch the same market prices while the costs of production are higher and margins already narrow. Final conclusions on the economic feasibility of trout production in RAS require a detailed technical and economic feasibility study that considers all factors that affect costs of production in RAS. These factors are specific for production sites, e.g. related to summer temperatures. In addition, the outcome of such feasibility studies are typically very sensitive to fluctuations in market prices.
Although he claims not to need RAS at this moment, one of the interviewed trout farmers has far developed plans to realize a RAS pilot to prepare for his expected future needs for RAS, including the acquisition of required land. Financial support from the government for his RAS pilot project is expected by this farmer, in his opinion the government should support such an initiative, and required to realize the project.

In general the interviewed farmers mention a lack of support of their governments for the Turkish trout industry. The Turkish government is said not to have paid attention to the trout industry over the last two years, to lack a long-term vision for the industry and to insufficiently serve the interests of the industry in relation to e.g. the EU’s anti-dumping duty. Some farmer’s mention that it is or will be very difficult to obtain licences for land-based aquaculture, an obvious pre-requisite for RAS implementation. In some cases the current production licences for cages are renewed annually. Renewal is not guaranteed as the government may change the use of water bodies into e.g. drinking water production. Farmers mention that this unpredictability of their government hampers long-term investments by the industry in aquaculture production.

There is no specific government program to stimulate uptake of RAS by the Turkish aquaculture industry. However, the interviewed government representative confirmed that RAS projects are certainly not excluded from rural development programs. That way there seem to be options to obtain government support for RAS development in Turkey.

In one of the interviews it is mentioned that within the Turkish aquaculture industry RAS is of most interest to the marine aquaculture of seabass. In contrast to seabream, the other important species in marine aquaculture, market price of seabass increases with size. At the same time, seabass growth more or less ceases in winter due the low water temperature. As a result the production of seabass of 1kg/piece takes 3 years in sea cages in open water while, according to the interviewee, in RAS this production period can be reduced to 1.5 years, offering an important competitive advantage over production in sea cages.

In several instances it was mentioned that Turkish agri-businesses are quick to adopt new technologies once their advantages are clear. In this respect the Turkish dairy industry is often mentioned as an example. Apparently the Turkish dairy industry has seen a rapid replacement of traditional family based farms by large-scale and high tech farms. Also horticulture is mentioned as an industry that rapidly absorbed new, foreign technologies, be it after adaption to specific needs of the Turkish industry. These examples given by several interviewees served to illustrate that the Turkish aquaculture industry may quickly implement RAS technologies once there is confidence about the benefits and when circumstances are supportive.

6.4 The potential role of Dutch companies and institutions in the introduction of RAS application by the Turkish trout industry

Expert judgement on the potential of RAS for the Turkish trout industry

The transition of the Danish trout production in traditional flow through systems to re-use systems and RAS was driven by strict environmental legislation imposed by the Danish national government and the policy of environmental neutral expansion of the trout production. This strong driver for RAS application seems absent in Turkey. As far as this scoping study could establish, it seems unlikely that in the near future environmental legislations will force the Turkish trout industry to adopt reuse systems or RAS. Turkish trout aquaculture currently does not seem to be limited by the availability of sufficient, good quality fresh water. Opinions among the interviewees on whether this will change in the future vary from considering fresh water being a more or less infinite and currently under-utilized resource, to the need for much more efficient use of fresh water to anticipate on lower availability and stricter regulations in the near future. This study cannot establish which of these two is the more likely scenario.

Turkish trout production can be increased by better temperature control. Too high temperatures in summer clearly limit trout production at certain sites, while underutilization of production potential may also occur due to water temperatures below optimal temperatures for growth. RAS can provide the required temperature control. However, economic feasibility of RAS implementation for temperature control remains to be established.

The concept of RAS is relatively well established among the interviewed trout farmers. Those that are familiar with RAS have formed opinions on RAS. Most are concerned about the economic viability of trout production in RAS, suspecting a higher cost price while supplying the same market segment as trout produced in traditional systems. Indeed costs of production are in general higher in RAS and therefore this is a likely assumption. However final conclusions on the economic feasibility of trout production in RAS require a detailed technical and economic feasibility study that considers all factors that affect costs of production in RAS.

RAS technology is often first adopted in the hatchery, nursery and pre-ongrowing phases of aquaculture production. This is for example seen in the Atlantic salmon industry where smolts (juvenile salmon) are increasingly produced in land-based RAS. The grow out of smolts to market sized salmon still mostly takes places in sea cages. The same trend is observed in seabass and seabream production. Increased biosecurity, water quality control and temperature control are important advantages of RAS application in the hatchery, nursery and pre-ongrowing phases. Temperature control allows for the production of larger juveniles for stocking in the sea cages. Sea cages provide the required large production volume for grow-out at relatively low costs.
Therefore the best option for initial RAS application in the Turkish trout industry probably lies in RAS for trout hatcheries, nurseries and pre-ongrowing. The systems needed for these production phases are relatively small compared to grow-out; the required investments in RAS as well as the operational costs of RAS for hatcheries, nurseries and pre-ongrowing are therefore relatively low compared to RAS for grow-out. Financial risks are therefore smaller and economic feasibility easier achieved.

Opportunities for Dutch companies and institutions

Given the size of the Turkish trout production industry, the number of companies and the production volume, any shift from the use of flow through systems and cage systems towards reuse and RAS systems by the Turkish trout aquaculture industry would clearly provide many business opportunities for companies supplying RAS knowledge, technology and hardware. Although not explicitly addressed in this study, the interviews leave the impression that Turkey would need to import RAS knowledge, technology

and hardware, indicating that, at least initially, mainly foreign parties could benefit from the RAS related business opportunities.
The question however is if and when the Turkish trout industry will make a shift toward reuse system and RAS.

The scoping study revealed the following leads for business opportunities that are of interest to follow up.

Lead 1. Mitigation of negative effects of high water temperatures in summer.
High summer temperatures are a clear problem for some the Turkish trout producers leading to suboptimal production during summer months. These production losses can be prevented by technical solutions that Dutch companies can provide. A transition from production in flow through to production in RAS would solve the problem, but the economic feasibility of this solution is doubtful. Oxygenation of the water in summer probably provides an equally technically effective and a more cost effective solution. Dutch aquaculture experts could be connected to Turkish trout producers to supply this solution.

Lead 2. Establish a RAS (pilot) with a Turkish trout producer.
One of the visited trout producers clearly indicated his desire to establish a RAS for trout production; many arrangements had already been made. This trout producer could be connected to Dutch aquaculture experts to elaborate the RAS plans in more detail and then move on to actual realisation. Dutch aquaculture experts can provide the required RAS knowledge, technology and hardware. The project could serve as a flagship project for RAS demonstration and research. Research topics could include economic feasibility and the reduction in water use and environmental impact. An associated research program requires involvement of research institutions, preferably both Turkish and Dutch. A flagship and research function of such a project would possibly extent the interests beyond those of the individual trout farmer to the interests of the Turkish aquaculture industry as a whole. This in turn would justify financial support of the project by Turkish government, assuming an interest to support sustainable development of the Turkish trout industry. Such financial support was mentioned by the trout farmer as a prerequisite for realising the project.

Lead 3. Utilization of trout cages in summer.
The interviewed trout producers using cages in an (artificial) lake can use their cages only from November until June due to too high water temperatures for trout production in summer. As a result the cages remain unused for ca. 4 months per year. The farmers themselves explored opportunities to use their cages outside the trout season to farm warm water fish species such as tilapia. As far as this study could establish there are currently no successful examples for such shift-cultivation. Difficulties to obtain the required extension of the farmers' licences to produce fish in cages in the lake was mentioned to be the main bottleneck.
Despite the apparent legislative bottleneck, the use of RAS to utilize the cages in summer could provide an interesting pilot RAS project for Dutch-Turkish cooperation. The period of 4 months in which the cages are currently unused will in many cases be too short to grow fish of a marketable size. This could be overcome by pre growing these fish in RAS during the winter months and then stock them in the cages in June (after the trout is harvested) for a final grow out period of four months until a marketable size till October (before the cages are stocked with trout). Fish species for summer production could e.g. be tilapia or pikeperch. Dutch companies could provide the RAS technology and hardware as well as the tilapia or pikeperch seedlings.

These leads will be presented at the upcoming gathering of the Dutch Aquaculture Experts (DAE). DAE unites Dutch companies active in aquaculture related businesses on the international market. The objective of the presentation of these leads is to raise interest and define follow up actions.

7. Recommendations

The Turkish trout industry has not yet started to implement RAS, while RAS application in the Turkish marine aquaculture industry (seabass and seabream) is still very limited. In that respect the timing of the current scoping study is ideal: the potential for RAS has been recognized while the market for RAS knowledge, technology and hardware transition has not yet been claimed by other parties. The challenge now is to frame Dutch RAS expertise among Turkish stakeholders to ensure that once a transition to RAS begins, Dutch companies and institutions are the natural and preferred suppliers of RAS knowledge, technology, services and hardware to the Turkish market. In addition steps could be undertaken with the aim to increase interest in RAS technology. It is therefore recommended to develop a strategy of "framing and monitoring". To this end the following activities are recommended:

- Closely monitor developments and trends in the Turkish aquaculture industry and relevant legislation in relation to the drivers for RAS application;
- Establish working relations between Turkish and Dutch research institutions and universities in the field of aquaculture;
- Study the technical and economic feasibility of Turkish trout production in RAS in comparison to current practises;
- Establish flagship pilot projects aimed at demonstrating and studying RAS technology in the Turkish context (not necessarily with the trout industry);
- Connect Dutch companies to early adopters and precursors within the Turkish aquaculture industry;
- Facilitate the follow-up on the leads mentioned in section 6.4 in order to establish business relations between Turkish and Dutch companies;
- Make an inventory of the need for RAS applications in the Turkish marine aquaculture industry (seabass and seabream producers);
- Focus on RAS applications for hatcheries and nurseries;
- Create and utilize opportunities for Dutch companies and institutions to display their RAS expertise to the Turkish aquaculture industry.

Although these recommendations are all aimed at the strategy of "framing and monitoring", the recommended activities not necessarily comply with the role and responsibility of the client. It is up to the client to decide which of the recommended activities to follow up on.

8. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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