Grow-Out Of Sea Bream *Sparus aurata* in Turkey, Particularly in a Land-Based Farm With Recirculation System in Çanakkale: Better Use of Water, Nutrients and Space

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Abstract

Gilthead sea bream (*Sparus aurata*) is being farmed in Turkey mostly in cages in the Aegean coast from Çeşme to Fethiye. There is also a new facility that utilizes land-based re-circulation technology in Çanakkale. Stocking densities, growth, maturation and FCR, water quality, diseases and management are examined in the different types of production techniques.

Key Words: gilthead sea bream, *Sparus aurata*, Çanakkale, growth, management.

Introduction

Sea bream grow out is mainly uses cage systems and located in the Southwest coast of Turkey. The typical stocking densities in cages are examined. Also The relation between feed intake, growth, maturation and FCR is examined. FCR represents the performance of commercial activity in cage farming so things other than feed that effect the FCR are also examined which are water quality, diseases and management of the cage farm. A land-based farm in Çanakkale is observed which can submit all of the above parameters at optimum conditions.

Grow- out of Sea Bream

Farming systems

There are mainly two ways for sea bream grow out in Turkey: sea cages and land-based farms.

Sea cages: These can be shore cages or offshore cages. Although they need more investment and are more difficult to manage than shore cages, offshore cages are becoming more popular as they are a more industrialized way to grow sea bream and sea bass. Sea bream grow-out cage sites in Turkey are in Çeşme south to Fethiye on the Aegean Sea coast. Trials at the northern Gökçeada cage site were not successful from the growth point of view due to the low water temperature (12°C) during the long winter. For sea bream grow-out, cages are 12-16m. Double netting is generally used to prevent the escape of the stock through holes made by fish in the cage.

Land-based farms: Sea bass and sea bream are also grown out in earth ponds around Milas and in a recirculation tank facility in Çanakkale, Turkey. Fish produced in earth ponds around Milas have a higher market value especially in the Aegean region, where people are familiar with wild sea bream. Possibly, pond-raised sea bream have the taste and color that are better preferred. The production system in the recirculation tank facility in Çanakkale is described in a separate section below.

Stocking density

Juvenile sea bream 2-5 g are stocked in net cages (mesh size 4-6 mm) and grown until they reach about 20 g. During this period, the stocking density should be 100-150/m^3. As the fish grow, the stocking density is decreased either by transferring the fish to larger cages or grading them. To grow fish from 20 g to 50 g, the net used has a mesh size of 6-12 mm and the stocking density is 70-100/m^3. For fish larger than 50 g, the stocking density must be calculated according to the harvest size of the fish (300-350 g or larger), so that it is between 12 and 15 kg/m^3. These figures can change, according to many variables like temperature and the dissolved oxygen concentration at the cage site.

Feeding and feed conversion

Basically there are three kinds of feed for sea bream during grow-out. At the very beginning of fish farming in Turkey, farmers used ‘trash’ wild fish as feed for farmed sea bream and sea bass. Although use of ‘trash’ fish is no longer common, there are still farmers doing it. It takes a lot of ‘trash’ fish to produce farmed fish, and ‘trash’ fish often spoils the water quality in the farm.

Thus, more and more farmers now use pellets and extruded feeds, which can be supplied regularly. The daily ration of sea bream is calculated as a percentage of the body weight. The amount of feeds required is calculated from this percentage and supplied to the farmer by the feed producer. With extruded feeds, the fat and protein contents of the feed can be adjusted more flexibly. The protein content of the feed used is reduced from 55% to 40% as the fish grow. The amino acid requirements have been determined (Kissil *et al*., 1981; Santinha *et al*., 1996). Lipid content in sea bream feeds is increased as the fish grows. Sea bream weighing about 45 g can use lipids effectively for energy and thereby spare protein for growth. Feed producers make a special feed for sea bream that has 10-15% less fat content that is %16-18 by weight in feed, and an energy content of 20-23 MJ/kg. The use of high-energy feeds for sea bream still has to be evaluated in terms of the carcass composition and quality of the resulting product.

The vitamin requirements of sea bream have been determined by many scientists (Kissil *et al*., 1981; Morris *et al*., 1995). In common with other species, ascorbic acid deficiency in sea bream results in anorexia, scale loss, internal and external haemorrhage, depigmentation, and poor wound healing (Alexis *et al*., 1997).

The food conversion ratio or FCR is the fish's ability to metabolize the feed eaten and gain weight from it. Sea bream has an advantage in FCR over sea bass *Dicentrarchus labrax*, a fact shown in laboratory experiments (Kissil *et al*., 1981). FCR is the most critical indicator of the commercial viability of the farming operation for the fish farmer. FCR depends on many variables, each very important: type and quality of feed, water temperature, dissolved oxygen, diseases, farm management, and fish age. The FCR of sea bream fed 'trash' fish is usually 4-7, whereas those fed pellets and extruded feeds have FCR of 1.8-3. Diet compositions can be adjusted to achieve the best FCR (Takeuchi, 1990).

Research has shown that sea bream usually have better appetite than sea bass and feeding according to appetite increases the FCR. Feeding tables supplied by feed producers must be strictly obeyed for sea bream to achieve a lower FCR than in sea bass.

The feeds of the future will certainly have to be made with more plant proteins. Sunflower seed, cotton seed, tomato pulp, and corn gluten have been evaluated as feedstuff for sea bream (Robaina *et al*., 1995; Nengas *et al*., 1995).

Water quality

Water temperature affects the physiology of the fish and the chemical and microbiological activity in the water. Sea bream can tolerate temperatures up to 30°C, but they are not tolerant of cooler waters unlike sea bass. The daily feed ration of sea bream can double with a temperature increase from 12°C to 22°C.

Dissolved oxygen concentration is surely the most important environmental variable for all fish species. Oxygen concentration of 5 mg/l is the minimum required by fish during grow-out. Sea bream is more sensitive to low oxygen than sea bass. Oxygen is also very important in feed conversion: low oxygen results in high FCR.

Diseases and deformities

Sea bream is more sensitive to parasites than to bacterial attacks. No viral attack has been seen in sea bream that caused a catastrophe like VNN (viral nervous necrosis) did among farmed sea bass in 1995. Although sea bream can be carrier, they do not seem to be affected by the VNN virus. Thus, many farmers especially in Greece reduced their sea bass stocks and boosted their sea bream production instead.

Deformities in juvenile sea bream cause trouble for the farmer because of the slower growth and the lower market price. These deformities must be eliminated or reduced through improvements in hatchery techniques.

Management

Management of the grow-out production system is very important for optimum growth, feed conversion, survival, harvest, and profits. Management includes selecting the best feeds, the best methods, the best equipment for a given farm environment and level of operation. The composition of the feed may be perfect, but the environment may not enable the fish to get what the feed gives, unless managers monitor and record the most important physical, chemical, and microbiological variables in the farm. Some improvements in fish handling, grading, vaccination, and night illumination helped reduce the FCR and increase the survival, growth, and profit in sea bream farms in the last few years. But care must be taken to guard against the habit of sea bream to eat or destroy the nets of cages! Also, counting and disposal of dead fish (especially during a disease) must be done properly. On the whole, management of sea bream grow-out is easier than sea bass grow-out, contrary to the situation in the hatchery.

Growth versus maturation

Sea bream are protandrous hermaphrodites and begin to mature at 150 g body weight. They are initially all male and in their second or third year, some will change sex to become females. During gonad development, energy coming from food intake, has to be shared between gonad development and growth. But some individuals grow better than others and have better FCR. This growth variation may be used to advantage in the development of broodstocks in hatcheries. Some selective breeding projects are now being conducted on sea bream, as on sea bass.

For the farmer, the average growth of fish is important so the seedstock must be homogeneous. The only way obtain a homogeneous stock is to get them from a hatchery, rather than from the wild. Seedstock of hatchery origin can be accurately aged and the time of stocking can be manipulated so that sexual maturation can be delayed. Fast-growing younger fish have FCR of 1-1.2; older fish nearing sexual maturation have FCR of 2-2.5.

The ECOFISH™ System

ECOFISH is a concept for land-based fish farming developed at SINTEF (The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology), one of the largest research institutions in Europe. The system is commercialized and marketed worldwide by AquaOptima and AquaOptima´s sole agents for specific markets. ECOFISH is an environment-friendly system, where both the internal environment for the fish and the relation of the farm to the external environment are appropriately controlled (Figure 1).

The ECOFISH system is based on several products that control the quality of the water in the tanks, and optimize the use of essential factors such as water, oxygen, energy, and feed. The developed products have the names ECO-TRAP (the particle trap system), ECO-TANK (the design and the configuration of the tanks), and ECO-FLOW (inlet system with flow-meter).

The ECO-TRAP system includes a particle trap installed at the bottom of the tank, a sludge collector outside the tank, and a water level control outside the tank. To obtain full efficiency of the ECO-TRAP, there must be a proper water inlet system, consisting of a vertical pipe with holes or slots designed to ensure hydrodynamic control and optimal conditions in the tank, and a flow-meter and a valve to control the inlet system.

ECO-TANK is a modular system of octagonal tanks with shared walls, each tank with a water inlet through a vertical pipe and a central outlet into the particle trap. Number of tanks can vary according to project size and the target specie. Each tank can be individually regulated in terms of water flow and oxygenation, depending on the actual biomass in the tank. Commercial operations show that each tank can hold sea bass as much as 90-100 kg/m^3 without adverse effect on growth, and experiments have gone as high as 150 kg/m^3. Sea bream are held at 70-80 kg/m^3 before harvest in İdagıda’s grow-out facility.

ECO-RECIRC is the water treatment system for recirculation. Solids are removed from the tank by means of the particle trap system. The water treatment system depends on local conditions, such as water quality and the available amount of water. Systems can support recirculation rates corresponding to water replacement every 15 days (or 7% of the volume per day).

The ECOFISH system is documented to give the following unique benefits:

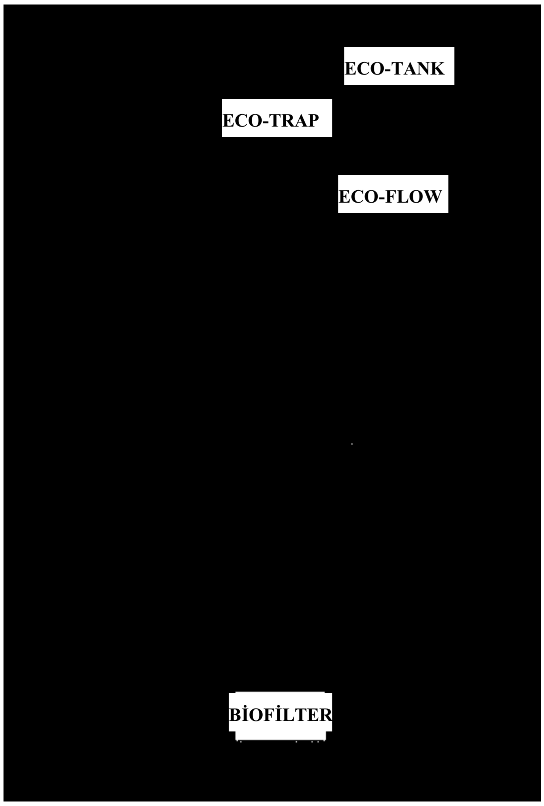

Figure 1. Ecofish system.

- The shape of the tanks and the design of the water inflow give full hydrodynamic control of the water flow in the tank. This provides excellent water replacement, mixing of oxygen in the whole water volume, and self-cleaning of the bottom of the tank.
- Particles such as feces and wasted feeds are very efficiently and rapidly removed from the tank (within 2-3 min in small tanks). SINTEF documented 98% removal of wasted feeds and 91% removal of feces. This provides good water quality in the tanks and the effluent is good enough to meet environmental standards for suspended particles, organic matter, nutrients, and medicated feed waste.
- The particle separation system is designed to enable continuous observation of the feed waste in a collector outside the tank. Thus it becomes possible to minimize the feed waste and to feed exactly according to the appetite of the fish. Experiments at commercial farms in Norway and Turkey have shown that appetite-based feeding (according to the feed waste in a feed waste collector) gives up to 60% growth increase. Such system improves the production economy through reduced feed waste and increased growth!
- By measuring the amount of sludge (mostly feces) in the collector and the daily feed consumption, the daily growth and the biomass can be estimated

without even handling and weighing the fish. Such growth estimation is documented by SINTEF to be accurate.

- The very efficient removal of particles before they dissolve in the water makes the effluent water suited for recirculation by simpler means of water treatment than ordinary rearing systems.
- The sludge from the particle trap system has a dry solid content more than 25% higher than sludge from end-of-pipe treatment units (sieves etc.).

A farm with a recirculation system in Idagida, Çanakkale

A farm with a capacity of produce 200 tons of fish a year is operated by Idagida, in Çanakkale based on the ECOFISH design and on the growth data is from this farm. The farm has been in operation for only two years, and company is new in the aquaculture business but believes that the potential for increased growth is significant.

Technical description: The farm consists of 22 tanks of two sizes: 10 units of 20 m^3 tanks for nursery or quarantine, 4 units of 145 m^3 transition tanks, and 8 units of grow-out tanks each 145 m^3.

A bore hole supplies sea water at temperature about 18°C. The water goes through sand filters and UV-disinfection before being pumped into the farm. The sea water in the tanks are temperature regulated at 22-24°C all year around. The water is heated by means of a heat exchanger at the water influent/effluent junction, and an oil or gas boiler and another heat exchanger for the make up water (exchanged water) to come to the correct temperature. The volume of recirculated water supplied to the farm is about 70 m^3/hour, equal to 80% exchange of water volume in the farm per day.

The water recirculation system for each tank consists of:

- The ECO-TRAP to remove settleable solids (uneaten food and feces) in the tanks.
- Screen filter (mesh size 60 µm) to remove fine dissolved solids.
- Biological filter with aeration to remove ammonia.
- Aeration in sump beneath biofilter to remove CO_2.
- Oxygenators that add oxygen to compensate for the oxygen consumption of fish.

The water flows by gravity from the tanks through the mechanical filters, is pumped to the biofilters, and pumped from the biofilter back to the tanks through the oxygen saturators. To monitor the nitrification process in the biofilters, pH is measured continuously in each sump, and ammonia and CO_2 are measured frequently.

The oxygen level in the tanks is most important to control. Each tank has an oxygen sensor that takes continuous measurements and sounds an alarm for high and low levels. The amount of oxygen going to each tank is automatically regulated based on signals from the oxygen sensor. The oxygen is provided from a storage tank with liquid oxygen.

All signals-- from feeders, oxygen sensors, water level switches, pumps, etc. are hooked on to a cable leading to the central control room. A PLC (programmable logic control) handles all this monitoring in the farm and has software to present statistics showing water quality and events in the grow-out cycle. Alarms are both seen and heard and after normal working hours, are transferred to a phone alarm center that calls pre-programmed mobile or home phone numbers. For emergency situations, there is a diesel generator and oxygen back-up with air-stones in each tank.

The sludge from the mechanical filters and sludge collectors is automatically transported in pipes to a central storage tank, where it is stabilized with lime and collected for use as nutrients on green lands or other agriculture purposes (after being dried and washed).

Production plan: The plan is to produce 200 tons of fish (50% sea bass and 50% sea bream) in one year, based on the growth of sea bream from 3 g to 350 g in 12 months at a temperature of 22°C. About 160,000 fingerlings (2 g body weight) are stocked in each four 20 m^3 nursery tanks. After 10 weeks, when fish are 18-20 g, they are transferred to one group of transition tanks where they stay for 12 more weeks. About 12 weeks after an input of fingerlings into the nursery tanks, another input of 160,000 fingerlings comes in to start another cycle.

From the transition tanks, the fish weighing about 75 g are transferred into four grow-out tanks, where they stay until harvest. Harvest starts after about 44 weeks when fish weigh 300 g. At the time harvest starting, the fish biomass is about 70–75 kg/m^3 and is kept at this level by weekly or daily harvest, depending on the market situation. During grow-out, the sea bream are graded when they reach sizes of 25 g, 100 g, 200 g, and 300 g. Fish larger than 300 g are transferred to the harvest tank whereas the smaller ones are returned to the grow-out tanks. The fish are graded and harvested by means of agrading machine operated from the floor or from a walkway between the rows of tanks.

With this farm lay-out and production plan, every generation is kept separate from each other. The separate water treatment systems and separate water circulation loops prevent the spread of any disease. Each group of grow-out tanks and the nursery tanks have separate sets equipment for fish handling fish that are not carried around in the farm. With the ECOFISH method, each input of fish will give a harvest of about 50 tons. With four cycles (2 times sea bass, 2 times sea bream) per year, the total production is 200 tons.

Conclusion

Sea bream's faster growth rate, lower FCR, tolerance of husbandary procedures, resistance to diseases make grow-out operations much easier than in sea bass and may shift the farm production towards more sea bream, as what happened in Greece. The only constraint is that until now most hatcheries do not produce sea bream because they can not compete with the low price of wild seed. The seed for sea bream grow-out is only available during the natural spawning season and the harvest and supply of market-size sea bream throughout the year is not possible. The market glut during the harvest period makes for very low price for sea bream. Production of hatchery-reared seedstock and development of temperature-controlled land-based farms will allow expansion and greater profitability of sea bream grow-out operations.

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