MARINE AQUACULTURE IN TURKEY

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Oceanus and Thetis
Roman mosaic (400 A.C.)
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PREFACE

This book, containing up-to-date information about marine aquaculture in Turkey was prepared to provide a projection about Turkish marine aquaculture, to the world literature and the aquaculture sector and prepared with a collective effort from scientists from different institutions, experts from related government agencies and representatives of the aquaculture sector.

Marine aquaculture is developing rapidly not only in Turkey but also in the entire world. While each individual chapter of this book presents the current status and the future projections of marine aquaculture from the beginning of the scientific and sectoral milestones of aquaculture, the general assessment of the overall subject is left to the reader.

I would like to thank Prof. Dr. Bayram Öztürk and all others involved in preparing this book for bringing us together with the hope that this book will help everybody to understand the importance and the impact of marine aquaculture as a whole, not just as a matter of increasing aquaculture production output in Turkey.

I am very grateful for support and contributions of Kılıç Groups, Akuadan, Turbotsan, Agromarin.

Prof.Dr. Akın CANDAN
Board Member Turkish Marine
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PAST, PRESENT AND FUTURE OF THE MARINE AQUACULTURE

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1. INTRODUCTION

Turkey is a large country with a size of about 779,452 square kilometres and has a relatively young population approaching 70 million, which is increasing at around 1.5 percent a year. The country has rich and diverse aquatic resources ranging from fresh to brackish and marine: 8,333 km of coast line, 151,080 square kilometres of economic coastal zone, 177,714 km total river length, around 900,000 ha natural lakes, and 500,000 ha of dam reservoirs (ÇELIKKALE et al., 1999, Table 1). Despite of these large resources, Turkish fisheries has stagnated at an annual production of around 600,000 tons and depends mainly on small-scale and largely small pelagic species. Therefore, marine aquaculture has been seen as an alternative source for marine capture fisheries, potentially relieving the pressure on the capture fishery sector.

Table 1. Data on Turkish coastline

Marine Resource Areas	Coastline (km)	Aquaculture/fishing Area (ha)
Black Sea, Aegean Sea and Mediterranean	6,892	23,475,000
Sea of Marmara, Bosporus and Dardanelles	1,441	1,132,200
Total	**8,333**	**24,607,200**

Aquaculture is an important economic activity in the coastal and rural areas of many countries. It offers opportunities to alleviate poverty, creates employment, helps community development, reduces overexploitation of natural aquatic resources, and contributes enhancing food security. Due to the increasing worldwide demand for aquatic products, aquaculture is one of the most important and fastest growing sectors - not only within fisheries and but also within the food production sector.

Turkey’s coastal resources for aquaculture are exceptional. A wide diversity of aquatic species can be farmed in brackish or salt water using a variety of production systems. Today marine aquaculture plays an increasingly important role in the production of fishery products. In 2005, its share of total aquaculture and fishery production were around 59% and 13% by volume respectively and it was much higher in value terms. The sector can be characterized by limited species (primarily three species: rainbow trout, sea bass and sea bream) and system diversity (cages), small farms, a production oriented approach and export dependent (EU) market.

Current per capita fish consumption in Turkey is very low (around 7 kg) comparing to many European countries, but it is expected that the recent developments will lead to increases in domestic fish consumption. In fact there are some indicators that this is happening already. On the other hand, wild fish stocks are already under pressure from over-fishing, environmental degradation and pollution. About 41% of total marine fish production is from one species – anchovy. The country therefore needs aquaculture development for a number of reasons:

- to support increased per capita fish consumption and service export market demand;
- rational natural resource utilization and to develop recreational and ornamental fisheries;
- restocking and ranching;
- stabilize the domestic market.

2. HISTORY OF MARINE AQUACULTURE IN TURKEY

Various forms of aquaculture have a long history around Mediterranean; however, although some form of extensive aquaculture has been practised in Mediterranean lagoons in Turkey, called “dalyan fisheries”, it was not a wide-spread traditional activity. Therefore, aquaculture in Turkey is a relatively young industry; it started with rainbow trout (*Oncorhynchus mykiss*) culture in 1970 and little happened in terms of marine aquaculture until 1985 when first sea bream (*Sparus auratus*) and sea bass (*Dicentrarchus labrax*) hatchery was established by Pinar Sea Products and on-growing started in the Aegean Sea in 1985. First official aquaculture statistics were published in 1986 and marine fish culture was about 35 tons.

It was not until "anchovy crisis" in late 1980s that aquaculture gained big attention as a potential. A sharp drop in production of Black Sea small pelagics has led to seeking new alternatives to traditional fisheries. During early 1990s Atlantic salmon (*Salmo salar*) and rainbow trout mariculture in the Black Sea has attracted considerable attention and efforts, but trials for salmon farming have to be terminated due to high water temperatures during summer. There were some attempts for kuruma shrimp (*Penaeus japonicus*) on the Mediterranean coast (OKUMUŞ *et al*., 2000) during mid-1990s. Another major development was a joint project supported by Government of Japan on developing hatchery technology for Black Sea turbot (*Psetta maxima*) in Central Fisheries Research Institute in Trabzon. Hatchery technology has been developed for the turbot after 7 years project, but in spite of some trials, there is no commercial production yet. Initiation of bluefin tuna (*Thunnus thynnus*) farming or "fattening" in the Mediterranean and Aegean Sea was the main development at the beginning of the new millennium. Lack of shellfish production has been a limiting issue for diversity of Turkish aquaculture. Only recently mussel farming has started in the Aegean Sea.

The EU import ban in 1998 due to difficulties implying Council Directive 91/491/EEC laying down the health conditions for the production and placing on the market of fishery products caused great economic difficulty for sea bass and bream farmers. In addition, the sector had a major crisis during country's general economic crisis during 2001-02. Recovery of the sector has started with economic recovery after 2003 and production increased rapidly with developments in EU associated membership and subsides provide by the government (Figure 1).

Recently R&D activities in private hatcheries concentrated on new or alternative Mediterranean species, namely common dentex (*Dentex dentex*), common seabream (*Pagrus pagrus*), common pandora (*Pagellus erythrinus*), sharpsnout seabream (*Puntazzo puntazzo*), white grouper (*Epinephelus aeneus*), shi drum (*Umbrina cirrosa*), striped seabream (*Lithognathus mormmyrus*), meagre (*Argyyrosomus regius*), greater amberjack (*Seriola dumerili*), brown meagre (*Sciena umbra*), white seabream (*Diplodus sargus*), two-banded seabream (*Diplodus vulgaris*). Some hatcheries are marketing common dentex, common Pandora, sharpsnout seabream and meagre fries at size range of 1-8 g, and have been successfully produced around few hundred tons of in cages.

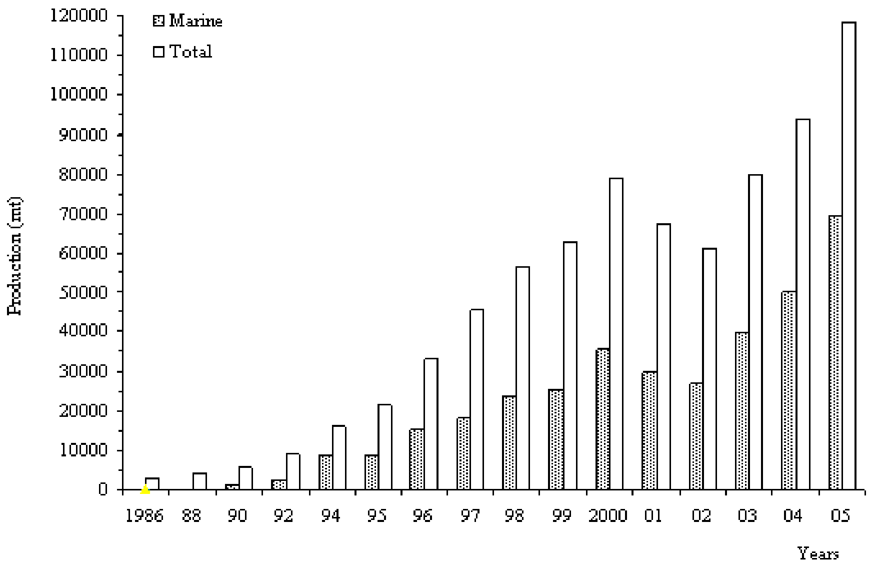

Figure 1. Developments in total and marine aquaculture (excluding bluefin tuna) production (mt).

The industry has developed to such an extent that Turkey is currently the third largest farmed finfish producer (i.e., excluding shellfish) in Europe and the second largest producer of both sea bass and sea bream (after Greece) and of rainbow trout (after Norway). Production figures in last 5 years show that Turkey is among first 12 countries with fastest developing aquaculture sector. As in other Mediterranean countries, during its development stage, marine aquaculture in Turkey has been driven by following factors:

- low volume of major farmed species (seabass and seabream) from capture fisheries and originally high prices),

- availability of sheltered sites and good water quality for rapid growth,
- government supports,
- loose or flexible regulations,
- high private sector interest for aquaculture investment and developments,
- rapid development of specific marine hatchery technologies,
- rapid bio-technical developments in live feed, pathology, feed, cages,
- self- rationalization of sector and transformation from the production driven strategy to a market oriented strategy.
- low labour cost

3. CURRENT STATUS

3.1. Importance of Marine Aquaculture

In 2005, total production from the fisheries sector reached nearly 544,773 tonnes. Regarding environments and sources, marine capture accounted for 380,381 tonnes and inland capture 46,115 tonnes, marine aquaculture 69,673 tonnes and freshwater aquaculture 48,604 tonnes (Table 2).

Marine aquaculture production is growing rapidly (Figure 1). Over the last decade, marine aquaculture increased from 1.3 to 12.8% of the total fisheries and 39 to 59% of total aquaculture production.

Table 2. Aquaculture Production in Turkey: 1994-2005 (mt)

Year	Inland	Marine	Total Aquaculture	Total Fisheries Production	Aquaculture % of Total Fisheries Production
1986	3,041	35	3,075	582,920	0.5
1988	3,965	105	4,070	676,004	0.6
1990	4,649	1,133	5,782	385,114	1.5
1992	6,677	2,425	9,102	454,346	2.0
1994	7,265	8,733	15,998	601,104	2.66
1995	13,113	8,494	21,607	649,200	3.33
1996	17,960	15,241	33,201	549,646	6.04
1997	27,300	18,150	45,450	500,260	9.09
1998	33,290	23,410	56,700	543,900	10.42
1999	37,770	25,230	63,000	636,824	9.89
2000	43,385	35,646	79,031	582,376	13.57
2001	37,514	29,730	67,244	594,977	11.30
2002	34,297	26,868	61,165	627,847	9.74
2003	40,217	39,726	79,943	587,715	13.60
2004	44,115	49,895	94,010	644,492	14.59
2005	48,604	69,673	118,277	544,773	21.71

Source: TURKSTAT

3.2. Systems and Species

Production from marine (including brackish water) aquaculture in 2005 totalled 69,673 mt (59% of total aquaculture production) whilst inland (freshwater) aquaculture production was 48,604 t (41%) (Table 2).

Marine aquaculture production mostly depends on cage farming. There are only 60 land based pond farms, but 229 cage farms. Marine aquaculture in Turkey is primarily (92% of sea farms) located on the Aegean Region where geographical and hydrographic conditions suit the species cultured. There are only 12 farms on each of the Mediterranean and the Black Sea coasts. Along the Aegean coast, 63% of the total marine fish farms are situated in province of Mugla, 23% in Izmir and 5% in Aydın. Site availability for cages is a major constraint for further development in the Aegean Sea, whilst in the Black Sea high summer temperatures for trout and low winter temperatures for sea bass and a general lack of sheltered areas are the main limitations.

Two main production systems are employed: floating cages, ponds and raceways. Raceways are used mainly for juvenile production, floating cages are used for on-growing stages for all species (sea bass, sea bream, trout and tuna), whilst ponds are used mainly for sea bream and sea bass. Fibreglass tanks are mostly preferred in hatcheries and juvenile production. There is only one farm using a closed re-circulated aquaculture system. Mussels are cultured on ropes suspended from floating rafts.

The cages used are mostly circular, made from High Density Polyethylene (HDPE), with diameters (ø) ranging from 12 to 70 m. Sea bass/sea bream farms are using ø 16-30 m, while trout producers use cages smaller than ø 20 m; tuna farmers prefer over ø 50 m. Recently, large companies have started to establish standard offshore sea bass/sea bream production systems having an annual capacity of 2,000 mt consisting of 18 cages of ø30 m and automated feeding systems.

Turkish aquaculture has limited species diversity. Currently only the following species are cultured commercially: Rainbow trout (*Oncorhynchus mykiss*); Sea bass (*Dicentrarchus labrax*); Sea bream (*Sparus aurata*); Blue-fin tuna (*Thunnus thynnus*) and Mediterranean mussel (*Mytilus galloprovinciialis*).

Major new or alternative Mediterranean species cultured in experimental or pilot scales are common dentex (*Dentex dentex*), common sea-bream (*Pagrus pagrus*), common pandora (*Pagellus erythrinus*), sharpsnout sea-bream (*Puntazzo puntazzo*), white grouper (*Epinephelus aeneus*), shi drum (*Umbrina cirrosa*), striped seabream (*Lithognathus mormmyrus*), meagre (*Argyyrosomus regius*), greater amberjack (*Seriola dumerili*), brown meagre (*Sciena umbra*), white sea-bream (*Diplodus sargus*), two-banded sea-bream (*Diplodus vulgaris*). Among these species, only the common dentex and sharpsnout sea bream have been cultured and marketed; other species are still at the experimental stage. Considerable efforts have been made to farm common sea bream but abnormal pigmentation is the major limitation and production has ceased. Currently there several hatcheries trying to develop larvae and fry production, and four farms are registered to culture these new species in addition to sea bass and sea bream.

Efforts are also being made to develop the commercial production of species new to the Black Sea as well. The target species are turbot (*Psetta maxima*), sturgeons (*Acipenser* spp) and native sea going trout (*Salmo trutta*). Considerable progress has been achieved in the hatchery phase for turbot, but there is a need for considerable investment for on-growing. A Technical Cooperation Project has been submitted to the FAO in 2006, aimed at the conservation, restocking and developing commercial aquaculture of sturgeon.

3.3. Current Production and Trends

During the 1990s, production from three major species, rainbow trout, sea bass and sea bream increased rapidly until 2000 and then declined during the following two years due to general economic crisis faced by the country (Figure 1). Aquaculture production started to rise again in 2003 with a general recovery of the economy, progress towards EU membership and financial support from the government. It has grown around 25% during the last 3 years. Current production has approached 120,000 mt with a first hand sale value of Euro 360.7 million. Annual increments in marine aquaculture (mainly sea bass and sea bream) were around 36% during the post-crisis period. The contribution of aquaculture production to total fishery production has increased steadily from 0.5% in 1986 to 6% in 1996 and 22% by volume (Table 2) and 44% by value in 2005.

The limited species diversity (and as a result product diversity) is illustrated in Table 3 and Figure 2 – three species clearly dominate, all of which are intensively cultured carnivorous species and essentially luxury food items. The extensive and/or polyculture practices and also molluscs, crustacean and aquatic plant aquaculture is almost absent or very limited.

Sea bream grow from 1-5g to portion size (300-400 g) in 11-12 months, while sea bass needs 18-26 months. The Feed Conversion Ratio (FCR) is around 1.6-2.0 for sea bream and 1.8-2.2 for sea bass. Production cost given by some producers is around Euro 3.3-3.8/kg with a sorting (handling) and packing cost of Euro 0.28/kg. Portion size (300-400g) prices for whole fresh fish in fish market range between Euro 3.5-4.1/kg for sea bream and Euro 3.7-3.9/kg for sea bass. Sea bass and sea bream are mostly marketed as fresh and whole at sizes of 200-300, 300-400 or 500-1000 g, with some companies filleting fish over 500 g.

Trout mariculture has been practiced in the Black Sea since the beginning of 1990s. The juveniles of 20-30 g or portion size fish 200-300 g are transferred from freshwater farms to sea cages during October- December and harvested before July due to rising summer temperatures. These fish reach size range from 500 up to 3000 g at harvest depending stocking size. The large trout produced in marine cages are marketed as Black Sea "*somon*" (salmon). Some of the producers use pigmented feeds to produces red salmon-trout. Trout farming in cages therefore presents an opportunity for development of aquaculture in the Black Sea region.

Table 3. Marine aquaculture production by species: 2000-2005 (mt)

	2000	2001	2002	2003	2004	2005
Trout (marine)	1 961	1 240	846	1 194	1 650	1 249
Sea bream	15 460	12 939	11 681	16 735	20 435	27 634
Sea bass	17 877	15 546	14 339	20 982	26 297	37 290
Mussel	321	5	2	815	1 513	1 500
Others (new species)	27	-	-	-	-	2 000
Total	**35 646**	**29 730**	**26 868**	**39 726**	**49 985**	**69 673**

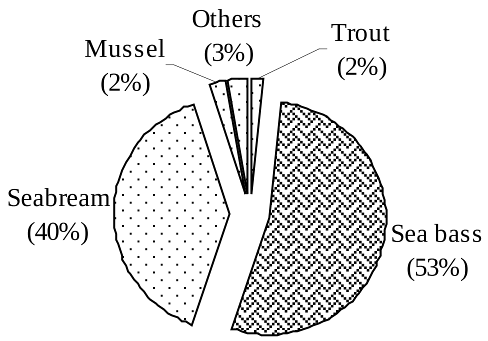

Figure 2. Aquaculture production by species (2005).

The aquaculture sector currently supports a total of 1,556 farms: 1,260 inland and 296 marine (Table 4 and 5). More than two-thirds of these are small rainbow trout farms, while sea bass and sea bream farms comprise 17% (by number). Indeed the aquaculture business model in Turkey varies from small family farms with multiple income sources (e.g. inland farms) to limited partnerships or corporations (which may include foreign ownership). The annual production capacity of the sea farms varies between 50-3500 mt/year. The development of marine aquaculture has been much more rapid as the number of farms and total capacity has increased by 19% and 53% respectively in 2005, respectively.

Table 4. Number of marine fish farms and hatcheries by species.

Species	No. of farms	Total capacity (mt/year)
Sea bass and sea bream	276	75,138
Trout	5	1,750
Trout + sea bass	7	1,190
Tuna	6	6,300
Mussel	2	1,590
Hatchery (sea bass, sea bream and other Mediterranean species)	14	200-250 million

Source: MARA DGAPD Fisheries Department, 2006

Table 5. Number of marine farms by production capacity.

Size of farm (mt)	Number of farms	%	Total Capacity (mt/y)	%
<50	124	40.92	3 230	4.05
51-100	61	20.13	5 173	6.48
101-250	53	17.49	9 307	11.67
251-500	19	6.27	8 050	10.09
501-1000	33	10.89	29 321	36.75
>1000	13	4.29	24 700	30.96

Source: Source: MARA DGAPD Fisheries Department, 2006

3.4. Hatcheries and Juvenile Production

There are 14 active marine hatcheries producing around 220 million sea bass and sea bream fry annually. These hatcheries are modern, employing automated water quality control and feeding systems and producing out of season (photoperiod application) fry. There have been shortages in sea bream fry supply in recent years and sea bream fry imports (15,000 fry) have been permitted during the 2006 production. Some hatcheries also export sea bass and sea bream fry.

The leading company in Turkey has three hatcheries and total annual capacity of 120 million sea bass and sea bream fry. Three other operators each have two hatcheries and between them produce 60 million fry; total production target of these hatcheries for 2007 is planned to be around 300 million fry. Half of these marine hatcheries have also been attempting to produce other new Mediterranean species.

Live fish import and export permits are issued by MARA (DG for Protection and Control in consultation with DG General for Production and Development). Health certificates are required to protect against major pathogens and products must arrive at designated airports or ports.

3.5. Public and Private Sector Support Services

The government has started to support aquaculture production by providing financial support for products marketed or produced since 2005. The main objectives of the scheme are to prevent unregistered or unlicensed production, create a competitive sector in Europe, develop environmentally friendly production systems, increase production, value added fishery products, quality and domestic consumption and support R&D activities. The rate of support for 2006 is:

- Sea bass/sea bream: TRY 0.85 (€0.45)/kg
- Trout: TRY 0.65 (€0.35)/kg
- New species: TRY 1.00 (€0.55)/kg
- Mussels: TRY 0.10 (€0.06)/kg
- Fry: TRY 0.05 (€0.03)/kg

The government also provides support to encourage producers joining aquaculture associations. Any producer who is a member of an association can get an additional 10% on the above subsidies for first 10 mt and 3% for 10-40 mt production.

There are sufficient numbers of national and international service providers, particularly in terms of equipment (cages, nets, tanks, mooring systems, and various devices), feed (including larval feeds) and health product (vaccines and antibiotics) supply. Although some national and international companies offer insurance schemes, this is a limited practice in the aquaculture sector.

3.6. Research, Development and Training

There is no doubt that Turkey has significant know-how and research capacity in aquaculture related areas; unfortunately it is not well organised. Aquaculture R&D activities are mainly performed by various Fisheries Faculties and MARA Research Institutes. There are 14 Fisheries Faculties and five departments at agriculture faculties providing undergraduate and graduate education in fisheries (including aquaculture) and aquatic sciences. Currently each year more than 300 students graduate from these faculties (down from 600 in 2001-2002). The numbers employed by the sector, however, are very limited. Graduates mainly work in marine aquaculture. Faculties conduct aquaculture studies under MSc and PhD programs directly financed by either research funds from the institution, funds from TUBITAK and EU FP6 or 7. Curiosity driven academic research priorities are chosen according to universal scientific developments, national priorities set by TUBITAK and the SPO, regional issues and laboratory/research infrastructure of the particular academic units.

Current aquaculture research priorities include fisheries genetic resources and conservation, fish health management and welfare, fish breeding and biotechnology, increased species and system diversity in aquaculture and the development of environmentally friendly aquaculture systems. Research results are either left as thesis/dissertations or presented/published in scientific conferences and journals. There are constraints to the application of some research performed by universities (except privately funded research), mainly due to the lack of effective extension work by MARA; hence the popularity of customer driven applied research projects for research institutions and MARA.

MARA organises its own R&D activities through Directorate General for Agricultural Research (DGAR - TAGEM) and fisheries research institutes. Only two institutes (Trabzon and Antalya) have the capacity to perform aquaculture research or corporate with other institutions in collaborative research programmes. In general DGAR has ranked fisheries related research as of “medium” priority (and by specific discipline: fish health - medium to high; fish breeding and farming – medium; socio-economic studies - medium to low; and organic (ecological) fish farming - low).

DGAR mainly supports applied projects submitted by its own institutes. Universities cannot submit projects on their own but have to go through at least one of the MARA's fisheries research institutes. Projects are submitted once a year, generally before March, either following a national call by DGAR or as an open request for research proposals. DGAPD and DGPC present their customer driven project requirements before the end of each year other to DGAR or to a research institute. DGAR then organises a project evaluation meeting once a year. Newly submitted proposals and progress reports for ongoing projects are submitted by the proposed project leaders and subject to peer review by a panel of academics and DGAR staff. Final decisions and approvals are then given by DGAR Project Evaluation Committee taking into account the priority, originality and impact of the project and comments from the review panel. If the project is accepted, the project budget is transferred to the central budget of the implementing institute for the following year.

Dissemination and extension services are the weakest link of the research and development activities. There is also a lack of partnership between stakeholders, producer associations and public institutions – these are considered major constraints for development of an environmentally sound and economically viable aquaculture sector.

4. FUTURE OF MARINE AQUACULTURE IN TURKEY

Current population of Turkey is over 70 million; average annual growth rate of near 2 percent and population is relatively young with < 14 age group comprising 30% of the population. Per capita consumption of 7 kg is just half of the world and one third of EU average values. Wild fish stocks have been badly managed and overfished. All these facts leave Turkey only one alternative, that is sustainable development of aquaculture to not only for increasing per capita fish consumption but also for creating new jobs and rational utilization of rich natural resources Yet demand from Europe, and emerging markets in the Middle East and Asian countries also should be considered in this context. As in other Mediterranean countries, the marine aquaculture sector in Turkey has grown substantially over recent years in terms of production volume and reached at a crucial point. It holds the potential to satisfy the growing demand for fish from both domestic and foreign markets. Opportunities of Turkish marine aquaculture in the near future can be summarised as (see also Table 6):

- Relatively rich and diverse coastal resources
- Increasing seafood demand
- Wild capture fisheries mostly depending on small pelagics and and unlikely to expand significantly
- Government support
- EU membership negotiations
- Human sources
- Globalization
- Creation of regular supply
- Consistency of quality
- Lower cost in value chain
- Promotion activities based on available supplies
- Increasing demand for fresh fish
- Technical innovations

However, Turkish marine aquaculture might be facing some crucial problems in the short terms. Potential challenges (see also Table 1.6):

- Conflicts with tourism sector, second or summer house owners and small-scale fishermen
- Allocation of natural sources, mainly sites
- Private use of the commons
- Environmental concerns
- Engineering cage systems for offshore or exposed environments
- Trade disputes (dumping, labelling)
- Overproduction and lower prices
- Limiting factors such as fish meal trap and increasing price of feed.

Cage farms have already started moving off-shore or more exposed sites. There is no doubt that moving off-shore will reduce conflicts between coastal zone users, increase production capacity while reducing environmental concerns, and improve productivity and profitability. However, the sector will face with off-shore technical challenges, and will need new investment costs, legislative and administrative regulations, environmental impact assessment (EIA) procedures, development of Integrated Coastal Zone Management (CZM) plans and applications, skill and management.

Stocking pre-growing juveniles into offshore cages provides important strategic advantages, including low mortalities, better quality control, reduced net cost, no need to handle fish at sea, increasing farm turn-over and stocking, production and commercial strategic options. It is also obligatory for off-shore conditions. However, this requires either pre-growing cage sites in sheltered bays or land-based systems.

In the long term, however, there is no doubt that the marine aquaculture is going to be effected by many different regional, national and global complex trends from over the coming years, all operating together, sometimes in very unexpected ways and producing changes in the industry that may be very rapid indeed. The ability of the industry to foresee and react to these trends and changes is of vital importance to the future development and success of the sector (DIXON, 2002). Thus the further expansion of aquaculture needs to take into account environmental impacts, sustainability aspects which do not have to be limited to the environmental aspects but to the economical aspects as well. The success of aquaculture with species like salmon, seabass and seabream has been thanks to the development of monocultures but the further expansions needs better integration. The waste for example that is produced by the intensive production units can be the source as a nutrient for further growing of seaweeds and bivalves. So in the future marine aquaculture along the coasts of Turkey needs more diversifications in species, system, product and market. Sustainable development of the sector also requires urgent actions to improve management and planning, improved planning through the inclusion of the aquaculture sector within integrated coastal zone management programmes. Improvements in the dissemination of research and to the extension services, as well as a strengthening of the partnership between stakeholders, producer associations and public institutions are vital importance.

Conclusions and Recommendations:

1. Modern marine aquaculture in Turkey is just around 20 years old and in spite of relatively short history manages to exhibit rapid development. The industry has developed to such an extent that the country is currently the third largest farmed finfish producer in Europe and the second largest producer of both sea bass / sea bream and of rainbow trout.
2. Marine aquaculture plays an increasingly important role in the supply and trade of fish products. It therefore requires increased recognition in the future agriculture, fisheries and maritime policy of the Turkish government and in the implementation of rural and coastal management policies.
3. The driving forces for development of aquaculture are rational resource allocation, private initiatives, public support, innovations and technological solutions, globalisation, and the retail sector.
4. There are a number of management and planning issues related to site leasing as well as to licenses and site leasing fees, which should be addressed in order to provide more manageable and equitable conditions for all producers.
5. There is an urgent need for national plan for sustainable development of aquaculture which will address coastal conflicts and support common actions to promote the benefits of farmed fish products.
6. Animal welfare issues regarding to aquacultured species and soft issues (environmental sensitivities, responsible resource utilization) will remain as critical social issues.
7. There is also need and potential for allocating new production zones in the framework of coastal management and planning.
8. Hatcheries will remain as highly strategic sector and pre-growing facilities will gain importance for off-shore cage farming.
9. Increasing the level of fish consumption is an important challenge for the development of aquaculture. In this respect, the price is the main indicator and increasing production will decrease the prices.
10. Limited species, product and system diversity are the major characteristics of the sector. This can be exploited as potential for development.
11. The market potential for aquaculture products can be developed through different strategies, including: improved knowledge of markets and consumer trends by producers, developing domestic market potential as alternative to saturated export markets for seabass and seabream, promoting new species to increase export and domestic consumption, diversification of species, innovation and value addition, and involving stakeholders and informing of the benefits of eating farmed fish and shellfish grown under sustainable conditions.
12. Role of producers associations, education and training as well as cooperation between farmers and industry with research institutions needs to be recognised and developed.

Table 6. Strength, Weakness, Opportunities and Threats (SWOT) Analysis of marine aquaculture in Turkey

STRENGTH	WEAKNESSES	OPPORTUNITIES	THREATS
• Rich aquatic coastal resources • Dynamism and investment capacity of the sector • High capacity modern hatcheries support the aquaculture industry • Developments in feed manufacture and feeding techniques • Government policy of support • Education, research and training activities • Established aquaculture Associations and Federation • Innovative sector • Ongoing R&D efforts for new/alternative species. • Strong ancillary support services (cage, net, tanks etc) • Completed farmers registration	• Strong competition between main producing countries • Market limited to Mediterranean countries • Limited presentation forms and product range • Overcrowding of conflicting activities in some bays • Except for major facilities, inadequate fish health control and disease management disease labs • Lack of reliable environmental data on existing sites and sub-optimal use of environmental planning system • Characterisation of industry as high risk making insurance costs high. • Limited number of species and system diversity • Relatively short rental period for sea area and high rental fees • Lack of public awareness	• The opportunity for Turkey to be a leading player in the development of global aquaculture. • Development of allocate zones for aquaculture development • Development of production technologies for new species • Market development and funding opportunities upon membership of the EU • Identifying new markets • Increasing added value • Reducing cost of production • Enlarging product offer • Development of shellfish farming (particularly bivalves)	• Competing claims/conflicts particularly with tourism sector/summer houses • Over-production and price crashes • Water pollution • Finding new sites/space for development • High international price of fish meal and fish oil. • Increasing public concern about environment • Increased international competition in the market (price reduction in sea bass/bream due to over-supply) • New law on environmental controls (removal of fish farms from closed bays)

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CULTURE OF EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*), GILTHEAD SEA BREAM (*SPARUS AURATA*) AND OTHER MEDITERRANEAN SPECIES

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1. INTRODUCTION

Over the last 25 years, finfish mariculture has been gradually progressing in Europe. Most of the main problems about European sea bass (*Dicentrarchus labrax*) and gilthead sea bream culture (*Sparus aurata*) are now solved. The increasing of this improvement in this sector is ensured by introduction of high technology and information to the mariculture system. Also, knowledge on biological requirements of these species and recent progress in aquacultural engineering contributed considerably to this achievement. In this way, application of knowledge on broodstock management, egg incubation and larval rearing protocols in different culture systems are also ensured this success. Moreover, developments in feed and sea cage technology is played major role on increasing production. In this section, culture systems of European sea bass and gilthead sea bream, both of which are produced in large quantities and also new candidate marine species which are produced in pilot scales and appear to be promising, are described in Turkey.

2. EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*) AND GILTHEAD SEA BREAM (*SPARUS AURATA*) CULTURE

2.1. Larval Culture

The first marine fish hatchery was founded in Çeşme–Izmir by private investment, Pınar Marine Products Inc. in 1985. Also, at the same time, larviculture experiments on European sea bass and gilthead sea bream was taking place in Ege University, Faculty of Fisheries. After first establishment in 1985, the number of marine fish hatchery sharply increased and reached to 21 units in 2001. The number of hatchery decreased to 9 due to economical crisis, lacks of technology and technical personnel, in 2004, but this number increased back to 12 in 2006. However this fluctuation of the number of hatchery did not cause any decrease in juvenile production. During this time, small scale hatcheries which were not maintained properly were closed while modern hatcheries were well maintained, updated their technology, production facility and marketing. Larval production was sharply increased after 2000's, 45 and 80 million sea bass and sea bream fry were produced in 2002 and 2003, respectively. This rate is estimated for both species as 180 million for 2006.

2.1.1. European Sea Bass (*Dicentrarchus labrax*) Culture

2.1.1.1. Broodstock and Egg

Sea bass breeders usually captured from the nature and/or selected from cultured fish which have highest growth performance. Broodstock are generally stocked in cylindrical tanks that have 5–15 m^3 volume. Both circulated sea water and closed sea water systems are used in these tanks. These tanks usually have dark colour and are cylindrical, and their bottoms are inclined. Flow rate in these tanks is changed between 10% and 20% per hour. Breeders are usually selected among 2 to 6 years-old-fish and stocking rate of these fish ranges between 5 to 18 kg/m^3 (FIRAT et al., 2004). Female/male rate is adjusted as 1:1, 1:2, 2:1, 3:2 kg in tanks and breeder population is renewed at a 30% rate every year.

Before spawning season, breeders are usually fed with pellet food. During spawning preparation, breeders fed with both pellet food and dry food which have high nutritional value. Cuttlefish (*Loligo vulgaris*), squid (*Sepia officinalis*), octopus (*Octopus vulgaris*), shrimp (*Paropaneaus longirostris*) and, lower economic valued fish (*Diplodus vulgaris*, *Triglia lucerna*, *Diplodus annularis*, *Trachurus trachurus*) are used as dry foods. Breeders are usually fed ad libitum 2–3 times during the day.

Spawning generally takes place in natural season; however, some hatcheries obtain egg by both natural spawning and decalage which is based on photoperiod manipulation. Both circulated sea water and closed sea water systems are used in decalage to obtain egg from breeders. Some hatcheries obtain their eggs from the broodstock hatcheries. While most of these hatcheries apply photoperiod-temperature manipulation, some of them only uses photoperiod manipulation. Decalage manipulation starts 6–12 months before spawning. LHRHa hormone is commonly used for spawning usually when oocyte diameter reaches about 650 μm. In this stage, it has been reported that 5–10 μgr/kg LHRHa hormone treatment with 12 h intervals, ovulation was observed in first 48 h (FIRAT et al., 2004). In spawning season, sea water filtered and temperature is changed from 14 to 15 ºC. Breeders usually spawn 150.000–300.000 egg/kg under natural conditions but sometimes this rate may be more than 300.000 egg/kg. Similar egg numbers are also reported after hormonal treatment during natural spawning season.

During incubation period, 425–530 μm mesh sized incubator with a capacity of 10–50 liter volume is used. Flow rate is changed between 5% and 10% per hour and eggs were incubated from 14 to 17 ºC. Hatching time mainly depends on water temperature and usually is between 60 and 80 hours. Although, some hatcheries use different stocking densities during incubation, most of them usually use 4000–7000 egg/l as a density.

2.1.1.2. Larval rearing

In Turkey, intensive and hyperintensive culture methods are mainly used in sea bass larval rearing. Newly hatched larvae are stocked at density of 100-150 ind/l in conico-cylindrical tanks; in some cases this rate could be reached 200 ind/l. Larval rearing is made in both closed sea water and circulated sea water systems but most hatcheries use closed sea water system. In this system, culture environment is activated by bacteria inoculation before 1–2 months of production. When system is prepared, used water in larval tanks is collected in collection tank. In this tank, 8–15% sea water is renovated per hour and salinity and temperature is adjusted. Water renewal rate is adjusted to maintain total ammonia nitrogen levels below circa 0.5 ppm and pH in the range of 6.5–8.5. Then, sea water is passed through a sand and a UV filter sequentially, but in some hatcheries sand filter followed by cartridge filter is used. In several hatcheries, protein skimmer is used after UV filtration and this system rarely established with larval tanks. After protein skimmer, sea water passes through high pressure biological filters and cleans ammonium. Before entrance in larval tanks, in order to reduce nitrogen and saturate oxygen levels, sea water it goes to a saturation colon. Neither ozonation equipment nor protein skimmers are commonly used in closed systems. Larval tanks are generally conico-cylindrical shaped and their volumes are range between 2 m^3 and 15 m^3 but commonly used tanks are gel-coated, dark coloured and 4–6 m^3 in size. In sea bass larval rearing, salinity reducing technique is commonly used but in case of lack of fresh water, larviculture is maintained with natural sea water. At the beginning of the larval rearing, water temperature is adjusted to 15–16 ºC and gradually increased to 19–20 ºC. During the larval rearing, photoperiod and light intensity could be changed according to the hatcheries' protocols but illumination is usually started low light intensities (10–100 lx) and continued relatively higher intensities (max 1000 lx) until end of larviculture (ALPBAZ et al., 2001).

Rotifer (*Brachionus plicatilis*) and *Artemia* (*Artemia* sp.) which has different origins and sizes are commonly used as live foods during larval development. Generally, rotifer is given during the first ten days of larval rearing. After mouth opening, it is introduced at a density of 6–8 ind/ml and reduced with *Artemia* substitution to a density of 0–2 ind/ml. In larval rearing facilities, there is a unit in which only *Artemia* is hatched. In this hatchery, dark period is lasted to 8–10 days and larval feeding is started with *Artemia* (without rotifers). *Artemia* used is usually AF and EG type from Salt Lake. According to larval feeding protocol, *Artemia* is enriched with enrichment media such as Selco (EG_1) is given from 16–18 days after hatching (DAH). Generally, larval survival ranges between 20% and 60% depending on the culture techniques.

Weaning is started from 40–45 DAH in sea bass larvae. During this stage, larvae usually reach 19–21 mm at total length and 35–40 mg in weight (SAKA et al., 2002). But, these parameters could be affected by water temperatures. Average larval stock density is 10–12 ind/l in larval tanks; however, in some hatcheries this rate can be increased to 18–20 ind/l by additional liquid oxygen supply. In a few hatcheries, larval rearing and weaning is conducted in relatively larger tanks (10–15 m^3 volume). Illumination is adjusted as 1500–2000 lx with duration of 16 h. Micparticulate food is distributed by automatic feeders. Pellet sizes are started from 80–500 μ and changed according to larval age and size. This stage lasts 15–20 days and enriched *Artemia* metanauplii is used with micparticulate food. Water temperature and flow rate for weaning is 20 ºC and 50–100%, respectively. Survival rate varies between 80% and 90% under optimal conditions. Due to decline of water quality parameters by microparticulate food in weaning tanks, open water systems are preferred in larval culture. Larvae are stocked in these tanks until reached at 350–400 mg weight. Mainly depend on larval development, juveniles are graded between 70 and 80 DAH. Also, weaning is conducted in concrete tanks at relatively lower temperature (16–18 ºC). This situation is similar in salinity parameters and 5‰ salinity water is commonly used during weaning and following stage. Juveniles are also separated as deformed and the ones without swim bladder.

After weaning, juveniles are transferred to on-growing units. The characteristics of on-growing tanks are similar to weaning tanks which are changed from 10 to 15 m^3 and cylindrical. In on-growing units natural sea water salinity is applied and stocking rate is varied at a density of 3000–5000 ind/m^3. When liquid oxygen is used, this rate reaches at a density of 6000–8000 ind/m^3. Flow rate is adjusted to a rate of 80–150% per hour according to fish size and stock rate. Also, on-growing is maintained in larger concrete tanks which are covered by a geomembrane. In this period, illumination is applied for 16 h and water temperature is varied between 19 and 21 ºC, however temperature could be reached to 24–26 ºC in ground water used hatcheries (FIRAT et al., 1999). Also, this period is maintained in concrete tanks and as similar in weaning stage, salinity parameters and 5‰ salinity water is commonly used during this stage. Before juveniles are transferred to sea cages, deformed ones are separated on a sorting table illuminated from the bottom.. Survival rate varies between 90 and 95% unless diseases are not observed.

2.1.2. Gilthead Sea Bream (*Sparus aurata*)

2.1.2.1. Broodstock and egg

As stated in sea bass culture, broodstock management and breeders' equipments in gilthead sea bream are similar in broodstock tank volumes are changed between 5 and 15 m^3. Breeders in 2–6 years are usually preferred by the hatcheries. Stock rate of breeders is varied from 3 to 6 kg/m^3 and female/male rate is adjusted as 1:1, 1:2, 2:1, and 3:2 kg in this species (ÇOBAN et al., 2004).

Before spawning season, breeders are usually fed with pellet food. During preparation of spawning, they fed with pellet food as well as dry food with high nutritional value. Recently, in order to obtain high quality eggs, some hatcheries prepare their own feed ratio which contains HUFA (highly unsaturated fatty acids). Breeders are fed to satiation two or three times a day and fresh natural food such as cuttlefish, squid, octopus, and fish are used during the spawning season. Renovation rate of breeders is changed between 1 and 6 years in hatcheries.
As mentioned in sea bass broodstock management, in order to obtain eggs, natural and decalage methods are also applied in gilthead sea bream. This period usually takes about two months. While breeders spawn 300.000–500.000 egg/kg in natural season, some hatcheries obtain more than 500.000 egg/kg. Hatcheries commonly use LHRHa hormone between 5 and 20 μgr/kg as a dose. After hormonal treatment, spawning rate is determined as 250.000–300.000 egg/kg.

Generally, eggs are obtained by photoperiod-temperature manipulation in the decalage method. In addition to this, hormonal treatment is used to obtain eggs. In decalage method, preparation of the breeders is changed between 3 and 12 months before spawning. In some cases, eggs contain more than one oil globule. It is reported that hormonal treatment causes reduction in egg diameter, decline of fertilization and hatching rate, relatively shorter larval length, and more malformed larvae. Additionally, mortality at gastrulation stage, differences on blastomer sizes, increase on number of oil globules are observed after hormonal treatment. However, it is determined that relatively smaller egg diameter, increase on oil globule number, and mortality at gastrulation stage are also observed in eggs harvested by decalage method (ÇOBAN et al., 2004).

Incubation is conducted in 20–200 liter volume incubators and mesh size in these incubators vary between 300 and 425 μm. In some hatcheries, different types of tanks are used for incubation. Gilthead sea bream eggs are usually incubated between 14 and 18 ºC. Hatching lasts from 50 to 80 h depending on water temperatures. Hatcheries usually use 2000–7000 egg/l as a stocking density.

2.1.2.2. Larval rearing

In Turkey, sea bream larval rearing is mainly conducted in intensive and hyperintensive culture systems. Stocking density varies between 50-100 ind/l in larval tanks and in some hatcheries this rate reaches to density of 120 ind/l. Larval rearing tanks are similar to sea bass larval tanks. In general, closed sea water and air-lift systems are used for sea bream larval rearing. In these systems, larvae are cultured with addition of algae to the water. This technique is called green water technique. Gilthead sea bream larval rearing is carried out between 18 and 22 ºC. While natural sea water is used in larval rearing until recently, currently, salinity is decreased to 30‰ in larval tanks (SAKA et al., 2004a).
Larval feeding in sea bream mainly depends on rotifer (*Brachionus plicatilis*) and *Artemia* (*Artemia* sp.). Green water technique usually carried out with *Chorella* sp., *Nannochloropsis* sp., *Nannochloris* sp, *Isochrysis* sp., and *Tetraselmis*

sp. with a density of 5-7x10^5 cell/ml. Mouth width of sea bream larva are relatively smaller (about 100µ) so small type (S–type) rotifer is commonly used at early stage of larval development. As mentioned above, rotifer is commonly used in larval feeding of sea bream. The rotifer feeding regime is as following: 3 and 5 DAH, 15 ind/ml; from 5 to 12 DAH ,10–12 ind/ml, from 12 to 15 DAH at 8–10 ind/ml, between 15 and 20 DAH at 6–8 ind/ml, and from 20 to 25 DAH at 4–6 ind/ml. Also, in some hatcheries rotifer could be used until 30 DAH. Generally, sea bream larvae are fed with *Artemia* nauplii from 15 DAH and commonly used type is AF type. The size of this live prey is 480µ in length and165-175µ in width and contains more than 10 mg/gr HUFA. EG types *Artemia* is commonly used from 30 DAH. This type contain relatively lower protein (45–47%) and HUFA content ranges between 5–7 mg/g. Enriched EG_1 type *Artemia* used in sea bass culture is not commonly used in sea bream larval rearing because of size (length 740–780µ and width 225–240µ). This type *Artemia* generally used in weaning stage. *Artemia* nauplii are introduced at a density of 0.5 ind/ml from 15 to 20 DAH, at 1 ind/ml between 20 and 25 DAH, and at 2 ind/ml until 40 DAH. Survival rate ranges between 10 and 30% according to culture techniques.

Larvae are transferred into weaning tanks about 40–42 DAH for microparticulate food adaptation. Weaning is commonly carried out in larval tanks. Adaptation to compound diet is started when larvae are reached to 25–30 mg weight. Sea bream can relatively adapt easily to this type of diet than sea bass. Weaning stage lasts between 10 and 12 days, and, amount of *Artemia* is gradually decreased while amount of compound diet is slowly increased. Feeding rate is adjusted to 8-10% of biomass because of extreme cannibalistic behavior of this species. At the end of this stage, larval weights reach to 300 mg. Water temperature and flow rate is maintained as 20-22 ºC and 50-100%, respectively. Sea bream adapts to weaning relatively easily and faster than sea bass. Larval survival rate is usually ranges between 85 and 95%. After completion of weaning, juveniles are transferred to on-growing unit and adapted to natural sea water. In sea bream, on-growing conditions and requirements are similar to ones described for sea bass.

2.2. Cage culture of European sea bass and gilthead sea bream

Sea bass and sea bream aquaculture make up 45% of the total cultured fish. Fish production supplied aquaculture is maintained from 45% of sea bass and sea bream culture. Cage culture of both species has shown sharp increase since 1985. First built fish farms started their operations in protected bays and basic cage culture systems. Recently, sea cage farms continued to production such as off shore systems. Sea bass and sea bream cage culture now spreaded out to Black Sea (Ordu, Sinop, Trabzon), Aegean (Aydın, Muğla, İzmir) and Eastern Mediterranean (Antalya). But, only sea bass not sea bream is cultured in Black Sea Region due to low salinity. Approximately 300 marine fish farms with different capacities existed In Turkey. About 45 % of these farms have 100 tones, and 21 of them have 1000 tones/year production capacity.

2.2.1. Field Properties of Cage Culture Systems

Generally, farms are 0–2000 m far from the coast. Twenty percent of more than 100 tones capacity farms are built usually 2 km far from coast, and others are spread out between 0–250 m. Although, these distances may seem close from the coast, it is permitted to build farms this close because depth rapidly increases in these coastal areas. However, in some bays, the close distance between some farms, caused disease problems, and disrupted production capacity. Earlier cage systems are built about 6–10 m in depth; they are employed 16–40 m in depth (YILDIRIM and ALPBAZ, 2005a). According to recently accepted laws, the cages must be employed 40 m in depth.

Sea ground is the most important factor for cage aquaculture. Over 100 tones capacity farms are generally spread out to areas where the sea bottom is sandy, sandy-slimy, and sandy-gravel. In these areas, wavelengths vary between 2–3.5 m in Black Sea, 0.5–3 m Middle and North Aegean, 0.5–6 m in South Aegean and West Mediterranean Region. Annual salinity and temperature values vary between 15–18 ‰ and 10–24 °C in Black Sea, and 35–41 ‰ and 12–28 °C, other regions, respectively.

2.2.2. Technical Properties of Cage Culture Systems

Cage culture systems in Turkey demonstrate differences according to regions. In Black Sea region, farms are generally use square-wooden and circular-polyethylene shaped cages. Square-wooden cages have 5x5x5 m and 6x6x5 m dimensions, and circular-polyethylene cages have 10–22 m diameters. Circular-polyethylene cages are built 6–12 m in depth.

Production cages currently used between Aegean and Mediterranean Region coasts, have more variety in respect to shape (square, circular and polygonal) and materials with which they are made (wooden, polyethylene and galvanized metal). Square shaped wooden cages have 5x5x5 m dimensions. Galvanized cages vary between 9x9x8–9 m and

11x11x8–9 m dimensions., Square-polyethylene cage dimensions are also varies between 5x5x5–8 m and 7.5x7.5x5–8 m. Circular and polygonal cage diameters and depths are varies between 10–13 m and 8–13 m, and 9–16 m and 6–11 m, respectively. In all type cages, knotted and unknotted square or crosswise mesh types are used **(**YILDIRIM and ALPBAZ, 2005b).

2.3. Production Properties of Cage Culture Systems

In sea bream and sea bass culture, fish are placed into cages with different stock densities. In farms located coastal region, fish are transported to cages when they reach 1.5–2 gr weight, but moved to off shore cages when they reach 5–10 gr weight. During on–growing stage, sea bass are stocked between 12.2–17.7 kg/m^3 in Black Sea region. In Middle and North Aegean region, on the other hand, sea bass and sea bream stocking rates vary between 11.9–21 kg/m^3 and 13.1–17.1 kg/m^3, respectively. Stocking rates in South Aegean and West Mediterranean region varies between 9.7–16.3 kg/m^3 and 9.7–18.2 kg/m^3 for sea bream and sea bass, respectively.

During the summer season, in farms located at Black Sea, sea bass fingerlings are fed 5 times a day until they reach 50 gr, and fed twice when they are over 50 gr. In winter, they are only fed once a day (mainly morning). In Aegean and Mediterranean region farms, both sea bass and sea bream are fed 5–8 times until they reach 2 gr in weight, and fed 3 times a day until 50–60 gr during the summer season. When they are over 50–60 gr, sea bass and sea bream are generally fed 2–4 times a day. In winter season, daily feeding is accomplished 1–3 times. Feeding is provided with press and extruder pellets, and either feeding rate is accommodated generally based on water temperature–fish weight relation or provided as ad libitum feeding (KORKUT, 2005).

Feed conversion ratios (FCR) show variation according to region, food and fish quality. In Black Sea farms, sea bass FCR range between 1.8 and 2.2. For sea bream, FCR is approximately 2.15±0.07 (ranges between 1.8 and 2.4) in farms located at Aegean and Mediterranean regions. FCR of approximately 350 gr sea bass is between 1.7 and 2.2, and about 1.97±0.06 kg of food is used per 1 kg sea bass. In farms located at South Aegean and West Mediterranean region, FCR ranges between 1.6 and 2.5 for a 350 gram sea bream, and is about 2.06±0.06 for 1 kg sea bream. FCR varies between 1.5 and 2.2 until they are 350 gr, and FCR is about 1.90±0.04 for 1 kg sea bass.

The time required for sea bass and sea bream to reach to the portion size depends on transportation time from larval rearing facilities to cages and regional conditions. The reach to portion size of sea bass and sea bream is demonstrated differences according to transfer time to cages and culture conditions. In Black Sea region, 2-3 gr size sea bass in June reaches to 350 gr in 19-20 months and to 500 gr in 28-30 months in cages. In Middle and North Aegean region, 2-3 gr size sea bass in April-May and/or June-August reaches 350 gr in 19-20 months and 15-17 months, respectively. Also 2-3 gr weighted sea bream sea is reached 350 gr in 13-15 months. In South Aegean and West Mediterranean region, 2-3 gr size sea bream in April-May and/or June-August are reached 350 gr in 12-14 months and 15-16 months, respectively. Also 2-3 gr sea bass in April-May are reach 350 and 500 gr in 13-15 and 18-20 months, respectively (YILDIRIM and ALPBAZ, 2005c).

3. NEW MEDITERRANEAN SPECIES

The culture of promising new candidate species in Mediterranean countries has been rapidly increasing since 1990 by European Union financed projects. For this purpose, about 20 species have been investigated in detailed studies by these countries (ABELLAN and BASURCO, 1999). New candidate species are classified into two groups. The first group is consists of relatively faster growing but lower priced species such as yellowtail (*Seriola* sp.) and mahi mahi (*Coryphaena hippurus*). The second group is relatively slower growing but high priced species such as red porgy (*Pagrus pagrus*), common dentex (*Dentex dentex*) and dover sole (*Solea solea)* (KENTOURI et al., 1995). In recent years, economical crisis related to exports and decline in gain from the sales caused to search for new promising candidate species for production enhancement.. In Turkey, over the period of last five years, experimental and scientific culture studies have been carried out in common dentex (*Dentex dentex*), red porgy (*Pagrus pagrus*), meagre (*Argyrosomus regius*), sharpsnout sea bream (*Diplodus puntazzo*), common pandora (*Pagellus erythrinus*), Black Sea turbot (*Psetta maxima*), red drum (*Umbrina cirrosa*), shi drum (*Sciaena umbra*), blue fin tuna (*Thunnus thynnus*), white grouper (*Epinephelus aeneus*), leerfish (*Lichia amia*), and red banded sea bream (*Pagrus auriga*).
As a result of these studies, commercial scale culture of these species has been succeeding in Sparid species. Knowledge of reproduction, larval culture, on-growing techniques of sea bream are important tools for the determination of Sparid species culture techniques. In this section, some information about several Sparid species which are cultured on a commercial scale in Turkey is presented.

3.1. Common dentex (*Dentex dentex*)

This is the fist Sparid species experimentally cultured since 2002 and first larviculture production was carried out in Akuvatur Marine Product Inc. Breeders are collected from the nature and spawning takes place between April and June. Frozen cuttlefish (*Sepia officinalis*), leander squilla (*Palaemon elegans*) were provided daily as the primary food source. Spawning usually lasts about 3 months and daily egg production ranges between 21000-23000 egg/kg (SAKA et al., 2004b; FIRAT et al., 2005)

Larviculture is carried out in closed sea water systems and green water technique in 4-6 m^3 tanks at 30-60 ind/l density. Larval feeding is conducted with rotifer and *Artemia*. From 40 DAH, larvae are stocked at density of 2-4 ind/l because of cannibalism; weaning and on-growing are carried out in relatively larger tanks. When juveniles reach to 4-5 gr, they transferred to sea cages and similar techniques and cage types are used as in sea bass and sea bream culture. Diameters of sea cages vary 12, 16 and 23 m and depths of net changed between 8 and 12 m. Unknotted meshes from 8 to 18 mm are used in these cages. Stocking density in sea cages is relatively lower than the other teleosts and fish are fed with semi-wet food. In the last three years, 150 tones of common dentex has been coming out to markets from Akuvatur Marine Product Inc.

Over the last decade, common dentex culture has been intensively carried out in Mediterranean countries. One of the main advantages of common dentex culture is relatively faster growth rate of this fish than the other Sparids. However, some problems still exist from the larval to end of on-growing stage. Selection of broodstock from the nature is not possible during spawning period and breeders are too sensitive to manipulations. Additionally, more information on feeding, biological requirements, broodstock maturation and reproduction system of this species is required.

During larval stage, although larvae are from the same batch and age, large differences on growth could be observed. Feeding and nutritional requirements of larval stage of *D. dentex* are still not described. Cannibalism is a very common problem in larval culture. In addition to this, pathogenic factors, deformed and malformed individuals threaten the success in larviculture. In sea cage culture, sensitivity to diseases and optimal nutritional composition of pellet food are important problems. Solutions on feeding problems are more or less solved by special semi-wet food but further studies on diseases for *D. dentex* are needed.

3.2. Red Porgy *(Pagrus pagrus)*

Culture studies of red porgy have begun after problems started in sea bass and sea bream culture in our country. Sixty thousand red porgy fry have produced since 2000 by Bodrum Fisheries Research Institute. In 2005, about one million larvae were cultured in hatcheries of Kılıç Marine Products Inc.

In Bodrum region, cage culture of red porgy started in 2002. Sea bream/sea bass cages (wooden-hexagonal) and sea bream pellets are used for producing studies. However, it was observed that the growth rates and product quality are not suitable for marketing because of indefinable feeding demand and insufficient culture techniques. During these attempts, 4 gr size fry in May reached to 206.92±53.94 gr weight size and to 22.17±1.77 cm total length at 15 months in Bodrum region. In order to achieve proper flesh color, the cages are covered, and pellets containing astaxanthine are used for feeding. Feeding with feed used in sea bream culture, FCR is calculated as 1.62 during 15 months in cages. In Kılıç Marine Products Inc, red porgy with 173.3±28.4 gr weight and to 20.42±2.04 cm total length at 12th months, reached up to 487.1+66.3 gr weight and 28.31±1.16 cm total length at end of the 27 months (ÖZDEN, 2005).

Larval period for red porgy can be considered problem free compared to common dentex culture, but coloration negatively affects the market prices. Resolving this problem indeed would increase the market value of this species. In addition to red porgy, culture of common pandora (*Pagellus erythyrinus*) is being continued in Kılıç Marine Products Inc. and so far larviculture and ontogeny studies has been accomplished (SUZER et al., 2006).

3.3. Meagre (*Argyrosomus regius*)

Meagre productions studies have started in 2001 at Egemar Marine Products Inc. Fingerlings were collected from nature when they are about 10 gr in weight. In culture conditions, breeders could reach up to 10 kg in 4 years and spawned first time in 2005. Fecundity was calculated to be 80.000-100.000 eggs/kg. One million larvae are produced at the end of the larviculture, In larviculture for this fish, sea bream production process and green-water technique was used. The 200 mg size larvae were transferred to 5X5 cages in June 2005. On-growing cages had 16-22 m diameters, and were placed at

10-12 m depths. Fish were fed with sea bass pellets according to water temperature-fish weight relation. In December 2006, fish reached 800-1000 gr weight, and FCR was calculated as 1.4. Nevertheless, Meagre is not a widely known species, and did not reach to high prices in domestic market. In respect to exportation laws, the providing of provenance certificate and its bureaucratic process is the main problem for the producers and enterprises (TOKŞEN and GAMSIZ, 2005).

3.4. Sharpsnout Sea Bream (*Diplodus puntazzo*)

Recently, sharpsnout sea bream became one of the most important candidate species for aquaculture in Turkey. In our region, spawning season is between September–October. Currently, larviculture is achieved with green water techniques. Development of fry is usually extended to spring, because transfer season is in winter. There are several different studies for fry catching from nature and growing of this fish. There are also several scientific studies about broodstock management, egg incubation and larviculture for this species in Turkey (KAMACI et al., 2005). About 57±1.35 gr size individuals caught from nature could reached to 189.5±3.2 gr at 8 month, and survival rate was determined to be 90% (KOP, 2006).

Also, 2–3 gr fingerlings taken into 14 diameter PE cages in February 2006 were reached up to 180 gr in December 2006, in Pınar Marine Product Inc. Over the last 3 years, about 30 tones of fish came to the markets from Akuvatur Marine Product Inc.

3.5. Striped Sea Bream (*Lithognathus mormyrus*)

Striped sea bream is also new candidate fish for aquaculture in Turkey, and this species is adjacent to extensive culture. At the beginning of the culture, fry fish is caught from nature. In larval culture, post larval feeding have several problems because of small egg diameter (0.714±12.86 mm) and larval length (1.737±33.17 mm). In June–August 2003, eggs were obtained from 200–400 gr size breeders in Pınar Marine Product Inc. Total 35000 juvenile fish (about 1 gr) produced from these breeders egg. On-growing process was continued in 5*5*5 dimensions cage, and feeding was practiced with sea bream. Fish were reached 200-250 gr weight 24 month later, and survival rate was determined 90%.

3.6. Research of Other Species

In addition to species mentioned above, larval and cage culture of several other species studies are continuing in Turkey such as Shi drum (*Sciaena umbra*), Red Drum (*Umbrina cirrosa*), White Sea bream (*Diplodus sargus*), White Grouper (*Epinephelus aenaus*), Leer fish (*Lichia amia*) and Red Banded Sea Bream (*Pagrus auriga*). Although, culture studies of these new candidate fish are proceeding slowly, marketable sized fish are produced over last few years. In future, it is think that total production of these species will be increased together with achievement of larviculture.

4. GENERAL PERSPECTIVE

In recent years, marine fish culture studies have been gradually increasing in Turkey and aquaculture investment reached to 1 billion USD. Total aquacultural production, export income and total fish value are reached to 80000 tones, 250 million and 600 million USD per year, respectively. However, there are some problems in this sector, which are classified as formal procedures that are required during the establishment of hatcheries, hatchery management, feed production, sea cage technologies, between aquaculture - environment interactions, and marketing strategies.

Continuity of accomplishments and increases in production quality in aquaculture could be enhanced by biological and technological developments as well as “know–how” production. In this case, it is inevitable that biotechnological research should be increased and enhanced. Especially, sex control, determination of optimal period for artificial sex conversion and optimal experimental conditions for ploidical manipulation (monosex, gynogenesis, etc.) are main topics for scientific approaches. Also, further studies on biotechnological developments including obstruction of premature females, reduction in deformation rate and enhancement of growth would have tremendous positive effect on production stages.

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TROUT FARMING

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1. INTRODUCTION

Turkey has met with trout farming first among the other aquaculture activities. Therefore, the trout farming activities have significantly influenced the subsequent developments in both marine and freshwater aquaculture. Coastline of Turkey, 8333 km in total (including islands), exhibits different hydrographical and ecological features. Turkey also has rich freshwater resources including lakes, ponds and dams covering a total of 1 344 759 ha, with variable altitudes and differing water qualities. In addition to these water resources, rivers with a total length of 177 714 km make up significant portion of the freshwater resources

The relationship between fish and human exists as of B.C. 1700 in Anatolia in terms of aquaculture. The Balıklı Göl (The Lake with Sacred Fish) is the best example to this (Alpbaz, 1984). However, in terms of modern aquaculture, first aquacultural activitiy has started in 1971 in Bilecik-Bozhöyük with “trout farming” (Figure 1). The water was taken from the Karasu River and a simple hatchery was established at a facility where the most of the ponds were earthen ponds and the species farmed was rainbow trout (*Oncorhynchus mykiss*). In the following years, new enterprises have been established in the neighbouring cities (Figure 1), and scientific studies have been carried out in a state-owned production facility in Central Anatolia. Afterwards, the rainbow trout have been produced in the facilities owned by the Ministry of Agriculture, Forestry, Energy and Natural Resources. In early 1990s, trials on Atlantic salmon (*Salmo salar*) and rainbow trout farming in the sea cages along the Black Sea coast were initiated. Although Atlantic salmon initiative has to be terminated after a few years, rainbow trout mariculture is an ongoing commercial practice. The native brown trout species (*Salmo trutta abanticus*) from Lake Abant has been produced in hatchery environment owned by the Ministry of Forestry with the aim of restocking. In the Black Sea Region, brook trout or char (*Salvelinus fontinalis*) and sea trout (*Salmo trutta labrax)* species have been produced as second species in rainbow trout farms. Similarly, mountain trout (S*almo trutta macrostigma)* has also been produced locally in rainbow trout farms in the Mediterranean Region in small scale. However, the rainbow trout is the major species produced in inland waters and also coastal waters of the Black Sea.

Figure 1. Different type of Trout farms in Bozhoyuk (1971) and Fethiye (2006).

2. OVERVIEW OF FISHERIES AND AQUACULTURE PRODUCTION

The total fisheries production from capture fisheries and aquaculture was 544 773 tons in 2005 (Figure 2). Contributions of marine and freshwater capture fisheries and aquaculture in total production between 1995 and 2005 are presented in Figure 3. These figures clearly highlights that production from aquaculture sub-sector is increasing rapidly.

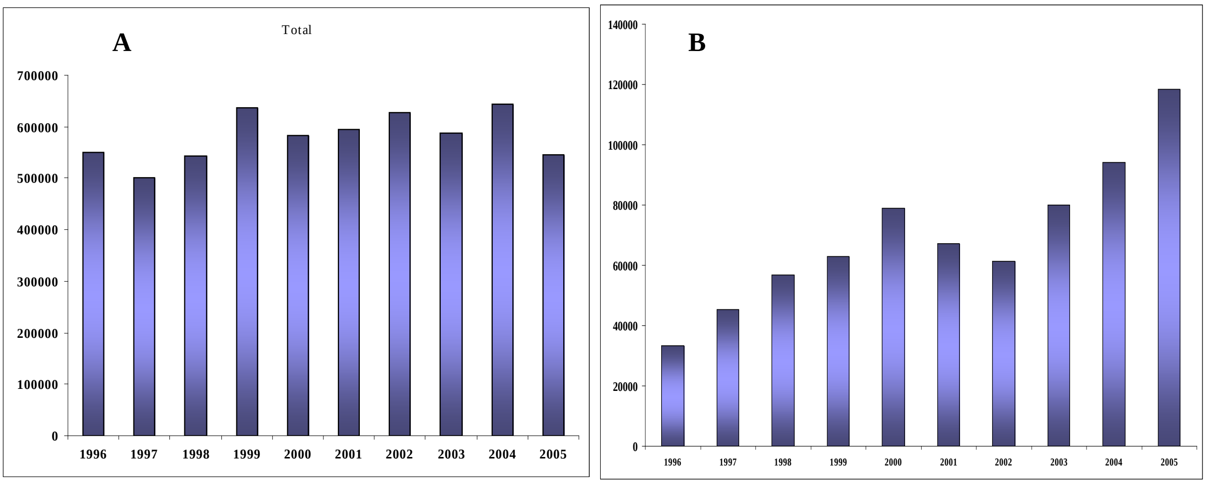

Figure 2. Total fisheries, including aquaculture (A) and aquaculture (B) productions by years 1996-2005 (tones).

As seen in Figure 3, contributions of capture fisheries and inland aquaculture to total fisheries production were 89.8%, 6.9% and 3.3% in 1995, and were 70%, 8% and 22% in 2005, respectively.

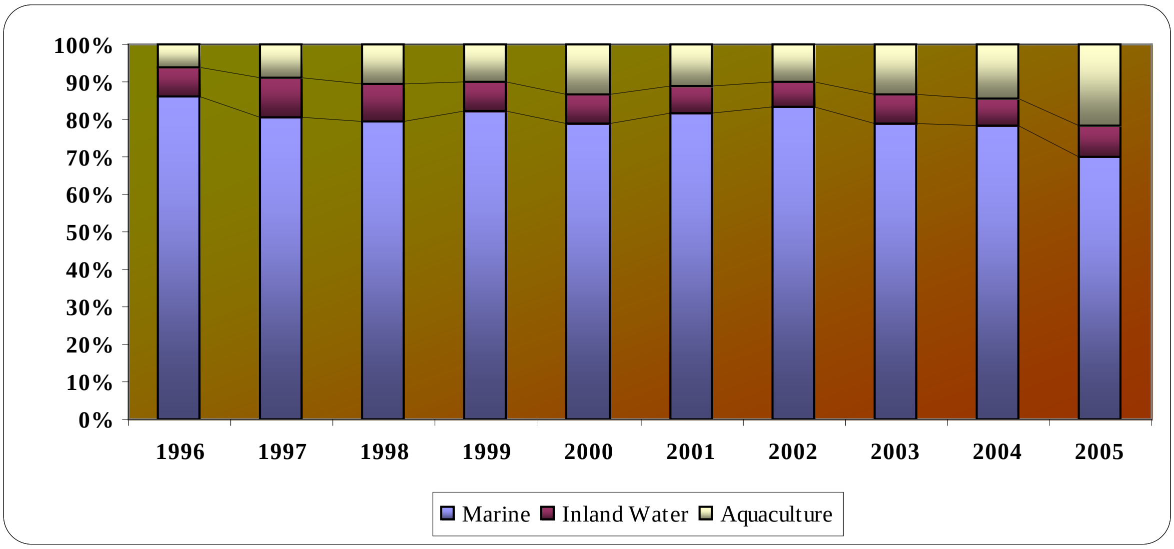

Figure 3. Proportional changes in marine and inland capture fisheries and aquaculture production during 1996-2005.

Trout production has a considerable place in overall aquaculture production (Figure 4). Trout production increased from 19 180 tons in 1996 to 57 659 tons in 2006. This production come from 1215 trout farms distributed around the country. Vast majority (57%) of the inland trout farms have an annual production capacity of less than 10 tons. Beside active farms, there are also 361 farms at project or construction stages with a total production capacity of about 12 111 tons/year (ANONYMOUS, 2006).

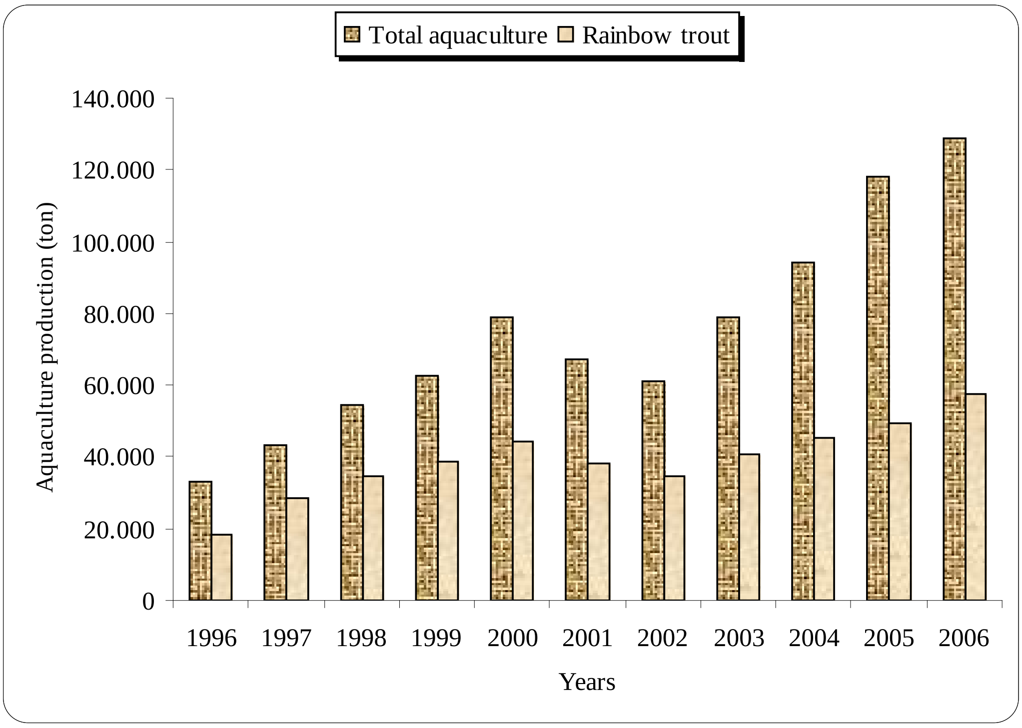

Figure 4. The changes in trout production between 1996 and 2006 (tones).

Trout production in Turkey has undergone different developmental phases in different geographical regions between the years 1999-2005 (Table 1). There have been considerable increases in Aegean, Black Sea, Mediterranean, Central Anatolia and Marmara Regions, but the developments have been very slow in the regions of Eastern and South-Eastern Anatolia. Market and suitable water resources are the major forces behind the developments in trout production.

Table 1. Trout Production by regions (tons)

REGIONS	1999		2000		2001		2002		2003		2004		2005	
		%		%		%		%		%		%		%
Marmara Region	7 500	19,5	7 669	17,2	6 714	17,6	6 427	18,6	6 884	16,8	7 157	15,9	7 043	14,3
Aegean Region	9 300	24,1	9 987	22,4	8 529	22,4	7 554	21,9	10571	25,9	12039	26,7	14059	28,5
Mediterranean Region	5 700	14,8	6 572	14,8	5 682	14,9	4 929	14,3	5 644	13,8	6 379	14,1	7 094	14,4
Central Anatolia	5 010	13,0	6 574	14,8	5 666	14,9	5 389	15,6	6 151	15,1	6 646	14,7	7 430	15,1
The Black Sea Region	9 130	23,7	11570	26,0	9 506	25,0	8 505	24,6	9 831	24,1	10890	24,2	11487	23,3
Eastern Anatolia	1 610	4,2	1 799	4,0	1 540	4,0	1 410	4,1	1 398	3,4	1 559	3,5	1 890	3,8
South-eastern Anatolia	300	0,8	339	0,8	410	1,1	339	1,0	389	1,0	412	0,9	279	0,6
TOTAL	**38550**		**44510**		**38047**		**34553**		**40868**		**45082**		**49282**	

3. JUVENILE PRODUCTION

Most of the trout farmers maintain their broodstocks and produce their own eggs and juveniles. This may cause irregularities in egg and fry production since in some years heavy losses occur leading shortages in supply. There are around 250 large trout hatcheries producing eggs and fry both for their own needs and for sale. Although practices such as photoperiod and feminization are carried out in some hatcheries, there are no well-established broodstock management programs with all year around production and biotechnological applications. There are 85 hatcheries in investment stage (ANONYMOUS, 2006).

As a result of the capacity building efforts especially in the last two years, there have been increases in egg and juvenile demand. Therefore, in addition to establishment of new hatcheries, there have been increases in eyed eggs imports. Factors such as shortage in domestic supply, quality and production season are increasing egg imports.

Between the years 1999-2006 eyed eggs were imported from countries such as USA, France, Italy, South Africa, Ireland, Britain, Denmark and Norway. As it is illustrated in Figure 5, while 26 286 000 eyed eggs were imported in 2000, the egg import figures declined to 3 935 000 because of lack of sufficient demand resulting from the economic crisis in 2002. In the following years, it is observed that the figures have gradually increased and reached eventually to 26 347 500 in 2006 (ANONYMOUS, 2006).

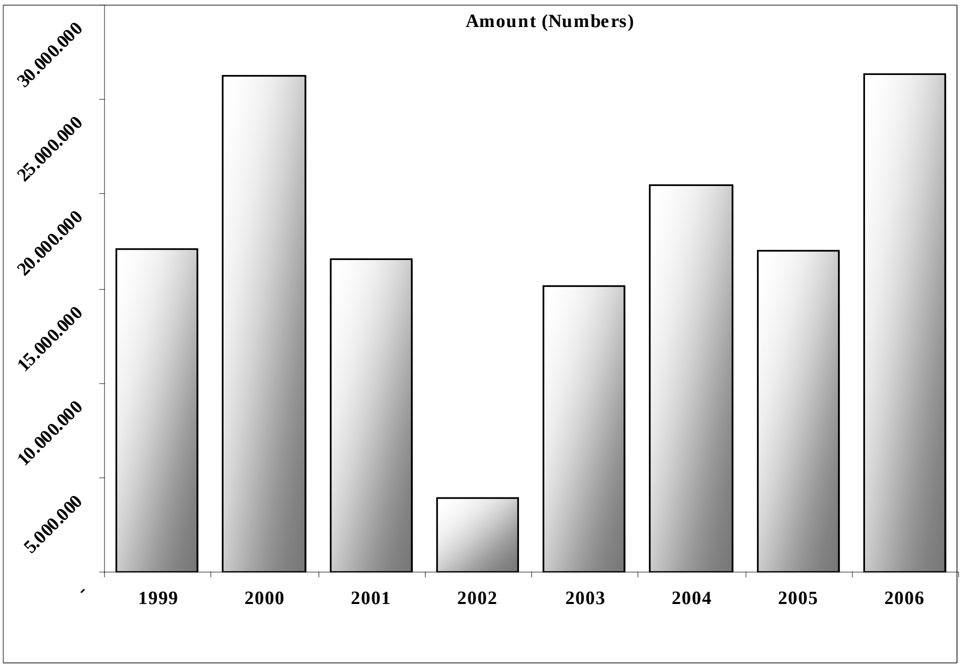

Figure 5. Number of imported trout eggs by years

4. ON-GROWING

4.1. Water resources

Turkey, three sides surrounded by seas, (8 333 km long coast line, with several rivers (177 714 km), lakes and reservoirs covering 26 million ha surface area (1 344 759 ha inland and 24 607 200 ha. Marine), is quite suitable for fishing and fish farming. This water resources are greater than country’s forests and almost equal to arid land area have great potential for fisheries (Table 2).

Table 2 Turkey’s fisheries resources

Production Areas	Number	Area (ha)	Length (km)
Lakes	200	906 118	-
Dam lakes	223	409 841	-
Small dam lakes	1000	28 800	-
Rivers and Streams	33	-	177.714
Seas		24 607 200	8333 coast line
Total		25 951 959	

4.2. Systems Used

Trout farming is done generally in concrete ponds and cages. Some years ago marine trout farming started in Black sea, however, later slowed down (ÜSTÜNDAG *et al*., 2000). In Black sea region, 78.8% of farms use concrete ponds for trout rearing. However some farms uses earthen pondss (4.6%) along with concrete ponds. On the other hand, 7.9% square cages, 3.3% circular cages 3.3% raceway + cage ponds production systems are also used (ÜSTÜNDAG *et al*., 2000). According to another study conducted in the Black sea region, 83.4% of farms are on the land and 16.6% are in the sea (ZENGIN and Tabak ,1997), in other words capacity of farms using pond system cover 86%, while farms using cage systems cover 9% of total capacity (BALCI *et al*., 2002). In the Mediterranean region, there are 24 cage farms (7 on the rivers and 17 on the dam lakes) in the same region 139 farms are located on the land using rectangular, circular and square ponds. In 4 regions, while on land pond systems is dominantly used, cage systems are also widely used. This fact applies to other remaining regions as well.

Around 55% of farms operating in the provinces of Mediterranean region posses small or large hatcheries while this ratio is 45% in Black sea region (ÜSTÜNDAĞ *et al*., 2000) 45% for Eastern and Southeastern region (BALCI *et al*., 2002) 80% for southern Marmara region (ÇETIN and Bilgüven 1991). The hatcheries use both basin and vertical cupboard incubation systems. While basins use pan, vertical cupboard systems use sieve-pans for incubation.

4.3. On – Growing Period

In Turkey, geographic conditions and systems employed play an important role in present farming practices. Under optimal water quality conditions, it is possible to obtain market size trout from eggs produced in the late October during the following summer in raceways. In freshwater and marine cages, this on-growing period may be as short as 6 to 9 months after hatching. Mostly, eggs are obtained from November to March, juveniles are transferred on-growing remises in early Summer or Autumn and harvest takes place during second Summer after 18 months. However, in extreme conditions it takes two years. In many hatcheries, photoperiod practices are successfully applied. These practices certainly effect the growing periods.

5. TROUT AND SALMON MARICULTURE IN THE BLACK SEA

Turkey used to supply 85% of the country's annual marine fishery production from the Black Sea. However, the rich fishing resource of the Black Sea has diminished dramatically towards end of 1980s due to enforcement of multi-factors including over-fishing and pollution. Turkish fisheries sector experienced a serious crisis known as "anchovy crisis". This has resulted in increased efforts being directed towards development of coastal aquaculture in the Black Sea. Coastal aquaculture developments in north-western European countries (e.g. Norway, Finland and Scotland) were evaluated and commercial Atlantic salmon and rainbow trout culture were initiated without any research & development activity.

5.1. The Black Sea from Coastal Aquaculture Point of View

Lack of sheltered areas and narrow sublittoral zone (excluding northern coastline) are the two major geomorphologic features of the Black Sea. There are no islands and well-sheltered bays along the Turkish coastline. Thus Turkish coast of the Black Sea coastline is quite exposed.

The salinity of the coastal waters is quite stable (‰15-18) (Figure 1). One of the major hydrographical features of the Black Sea is the high seasonal variations in the water temperature. During the winter, it varies between 6-9°C in the southern waters, while the summer temperatures in the summer can be as high as 24-28°C (Figure 6). A summer thermocline forms at a depth of 30-40 m.

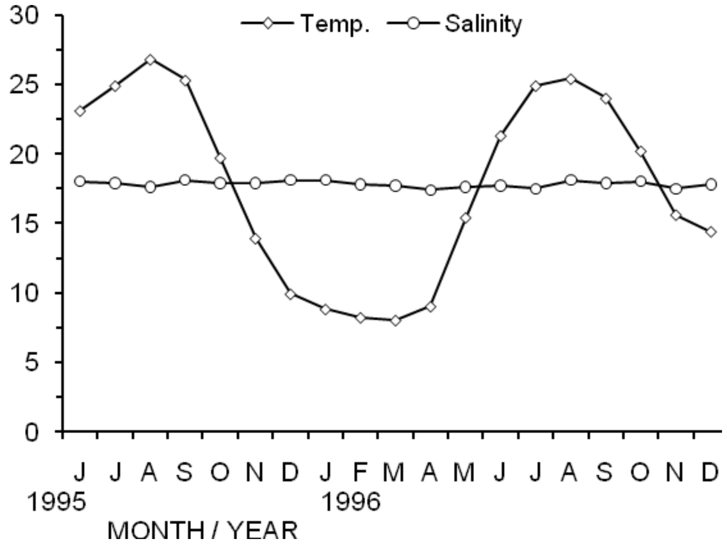

Figure 6. Seasonal temperature and salinity variations in the coastal waters of the Black Sea, recorded in a cage farm in Trabzon (CELIKKALE *et al*., 1999b).

Strong winter waves are restricting for particularly development of cage culture. Although it depends on exposure and local sea bed, waves as high as 5-6 m has been reported are quite often.

Similar to other temperate and subtropical coastal waters, there are two peaks, spring and autumn blooms, in primary production. Productivity is very high in the northern and northwestern continental shelf where shellfish (mainly mussel) culture has been practiced. Unfortunately there are no regular widespread monitoring programmes on blooms/red tides, therefore toxic blooms reported only from Russian coasts (*Dinophysis sp*).

Barnacles, sea squirts, molluscs (mussels), hydroids and small sea weeds are the common fouling organisms. Particularly mussel sprats may create considerable problem for cage nets.

5.2. Development and Current Status of Rainbow Trout Mariculture

Rainbow trout mariculture started along the Turkish Black Sea coast during early 1990s. At the beginning, exaggerations in extension activities (giving high return expectations), over-encouragement and cheap credit supply attracted many investors. However, at the end of the first growing season, high water temperature in July (Figure 6) caused compulsory harvest and price crashes and most of the investors left the sector.

Farms were situated either inside fishing harbours or in relatively sheltered bays such as Kefken, Sinop, Persembe, Şana and Rize along the coastline. The locally constructed wooden square (5x5 or 7x7 m), semi-flexible 22 m original `Polarcirkel' with the nets of 10 m depth and high density polyethylene circular (ϕ 8-22 m) cages were used depending on mooring site (Figure 7). In practice, juveniles of 20-30 g were transferred to cages during October – December when seawater temperature drops below 20ºC and they were harvested after 5-6 months, i.e., at the end of June. During this period fish reach size of 0.5-0.7 kg (Figure 8A).

Figure 7. Rainbow trout marine cages in Bay of Perşembe, Black Sea coast of Turkey. **A**: Old wooden cages; **B**: Semi-flexible HDPE (ϕ 12-22 m) cages (Photo: Ibrahim Okumuş).

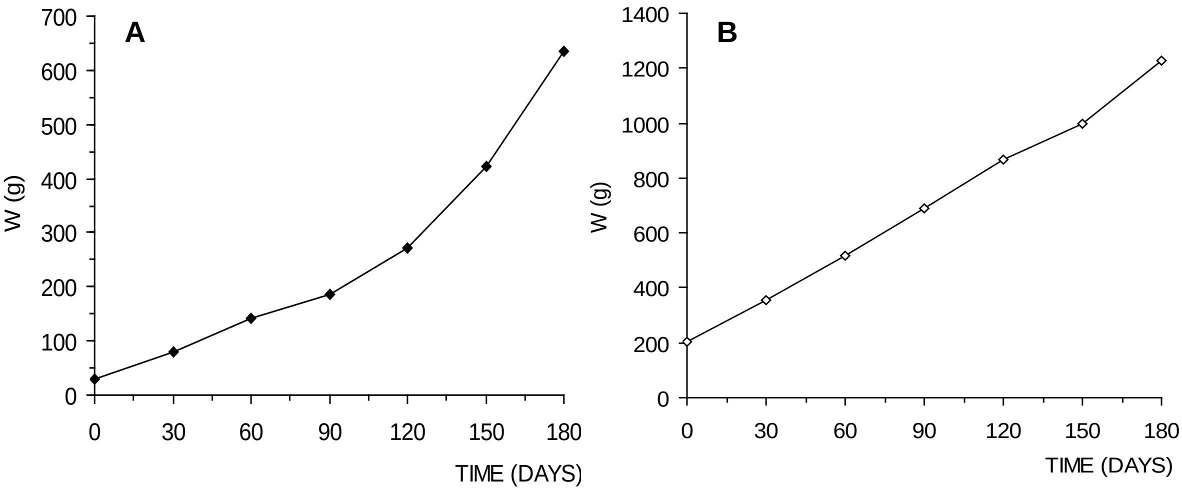

Figure 8. Growth (in weight) of rainbow trout reared in marine cages from December to June (ŞAHIN *et al*.,1999).

At present, there are 12 rainbow trout marine farms with total annual capacity of around 2000 tons and officially producing 1250 tons marketable fish annually (TURKSTAT, 2006). Half of these farms are found in Persembe Bay causing management problems, environmental degradations and local protests (Figure 7). Others are situated in Sinop, Şana (near Trabzon) and Rize Bays. Currently three stocking strategies are employed:

a) stocking 20-30 g juveniles and harvesting portion size (200-250 g) or over 0.5 kg fish (Figure 8A),

b) stocking portion size (200-250 g) and harvesting 1.0-1.5 kg fish (Figure (B),

c) stocking large fish of around 300-500 g from freshwater cage farms and harvesting 1.5-2.5 kg fish (Figure 9A).

Figure 9. **A)** Sea cage grown trout from the Black Sea marketed as Black Sea somon (salmon), **B)** Pigmented large sea grown trout steaks (Photo: Ibrahim Okumuş).

As it has been mentioned above, fish are transferred to cages during October – December and partial harvesting may start after 2 months, but fish has to be harvested before July when seawater temperature reaches lethal levels. Fish are fed manually twice a day with pellet feeds and fresh anchovy during winter. Some farmers use pigmented feed and produce pigmented large trout (Figure 9A,B). Nets may be changed once during a production season. Stocking density at harvest ranges between 15 to 30 kg/m^3. Fish are mainly marketed fresh and whole as Black Sea somon (salmon). Most of these farmers have got freshwater farms and transfer some of the fish to these farms and market during summer.

Trout mariculture in the Black Sea presents great potentials, including multiple portion size harvesting during 6 months period and producing fish at various sizes. Main advantage of marine cage farming is the rapid growth. Since trout in land based freshwater farms reach portion size within 12-18 months, growth rate is particularly important for the Black Sea region. In addition, cage farming creates some kind of product diversity such as various sizes and flesh colour, and marketing advantage since the people in the region used eating sea fish. However, there are various constraints limiting development of the trout mariculture in the region. Trout (and also salmon) farming in the Black Sea started at a commercial level without any R&D or pilot scale production trials. There is no doubt that this had major impact on development. Among the major limitations, high summer temperatures and lack of sheltered sites are the major ones. Compulsory harvesting during June due to rising temperatures force the farmers drop prices. Although some farmers transfer market size fish to freshwater farms, volume of fish transferred is very limited. There seems to be no easy solution for this natural phenomenon. Currently farms are located in relatively sheltered few bays. Sometimes they are very near to shore and also each other as in Perşembe Bay. This is causing various problems including fish health and environmental managements, and competing claims among various stakeholders. Recently aquaculture regulation has introduced recommendations on distance between farms.

5.3. Atlantic Salmon Farming Trial in the Black Sea

Atlantic salmon (*Salmo salar*) trials were started in 1990 with rainbow trout mariculture and lasted until mid 1990s. The species was introduced in 1988 with egg imported from Norway and production started in 1989 – 90 growth season. There were two big salmon farms. One of these farms was started in western Black Sea region,around Kefken Island and abandoned the sector after 2 years trial. The second farm was in coast of Sinop, continued salmon farming activities, including establishing broodstock, for sometime. Central Fisheries Research Institute in Trabzon also established broodstock keeping fish in marine cages during cold season and transferring them to freshwater in summer.

At the beginning, smolts were transferred to seawater after smoltification in spring, but almost all of them were died due to high temperatures. Later, a similar culture practice with rainbow trout culture was tried. Parr of 30-40 g were introduced to marine cages in November - December, fed until end of June. The fish reached approximately 500 g during that period. They were maintained in cages during summer, but feeding is reduced to minimum or completely ceased and only compulsory net changes were allowed. Around 20% mortality and 80-100 g weight losses occured until November when feeding re-started. Fish reached to an average weight of 1.5-2.5 kg and marketed to international hotels and restaurants or smoked. Salmon production in Turkey once reached over half a thousand tons. There is a smoking plant in Istanbul, but fresh salmon is mainly imported from northern Europe (ÇELIKKALE *et al*., 1999a, b).

Salmon farming in the Black Sea does not seem to be feasible with current production technology and practice, particularly considering the production of large-trout or salmon-trout relatively easy. However, employing land-based flow through systems by pumping seawater under thermocline or recirculated systems can make it economically feasible.

6. MARKETING

Cultured trout is generally consumed locally as fresh or smoked product at a size of between 200 and 250 grams. On the other hand, larger fish with a size of between 600 and 1000 grams, such as trout cultured in sea cages, is sold at the local market and/or exported fresh or smoked (DOĞAN, 2003). General marketing routes are in Turkey is presented in Figure 10.

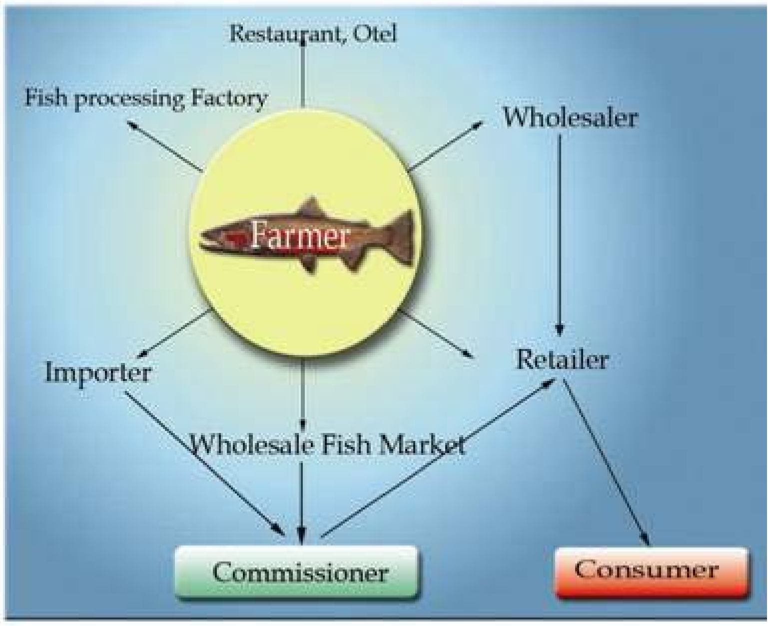

Figure 10. Marketing diagram of trout operations in Turkey

Studies conducted at the regional level have revealed the following findings. Enterprises based in Mediterranean region sell fish directly to retail markets (20.4%), wholesale markets (7.2%), and processing establishments (2.3%) or distribute to their own restaurants or processing establishments. Besides, fish is sold through a combination of marketing channels comprising wholesale market, retail market, enterprise restaurants, which accounts for 63,5 percent of overall regional enterprises (EMRE *et al.*, 2003). On the other hand, the primary fish marketing patterns in the Black Sea are retail sale and distribution to restaurants. The enterprises that sell fish directly to retail markets represent a significant portion in this region, accounting for 23.3% of overall enterprises. The percentage of enterprises that markets fish to retail markets plus restaurants or to both wholesale markets and retail markets are 25 and 19.6 percent of overall enterprises, respectively.

In the Black Sea Region, 8 percent of enterprises market their fish to neighbouring cities. Fish is also sold to domestic (6%) or external markets (4%) (ÜSTÜNDAĞ *et al*., 2000). A similar study aiming to investigate marketing structure in the East and South-East Anatolia found that a major portion of enterprises (45%) distribute their own fish to retail markets. Of the enterprises operating in these regions, 18 percent market fish through retail or wholesale channels, 12 percent market fish both through retail channel and sales from restaurants market, 12 percent only sell fish in restaurants that cook it, and the rest, 8 percent, market fish only by wholesale channels. Sale of fish to local market is the most dominant type of marketing in the East and South-East Anatolia. The ratio of enterprises that market fish to cities where the enterprises located, to neighbouring states and outside the region are 63, 46 and 2 percent, respectively (BALCI *et al*., 2002).

7. GENERAL EVALUATION

Trout, namely rainbow trout, farming started in Turkey in early 1970's and developed at a steady state levels until 1990s. This stage can be evaluated as "introductory stage", in which "farmed fish" were introduced to Turkish consumers. There were rapid developments during 1990s both in terms of production volume and diversification in production systems used. This development lasted until general economic crisis during 2000/2001, which hit the sector badly. Second development wave started after 2003 due to rapid recovery from crisis and subsidies for production. These rapid developments have associated with various problems and constraints.

a) Regulatory rules and procedures for leasing a site where aquaculture facilities would be operating differ among provinces, frustrating most of the producers. Common criteria for this procedure should be set.

b) The approach of local authorities and social environment surrounding fish farms has paramount effects on both management of the farms and management plans formulated for the future. Such effects should be taken into consideration during the evaluation process and production potentials.

c) Site selection, criteria for farm design, construction and the other technical arrangements require precise planning. In this context, on-going investments require revision and improvement accordingly with active sanctions and measurements.

d) Supply of year-around healthy fry is still a problem. As mentioned above, supply of fry is provided through both domestic and external channels. There is a need for a better pattern of supply in order to ensure healthy and balanced distribution of fry. Enterprises producing eggs and fry in high capacity at regional level should be promoted. This will facilitate disease follow-up at local production sites. On the other hand, breeding programmes/improvements to be conducted at such enterprises would show their results at the farms growing fish that originate from the breeding programmes.

e) For land based farms, fluctuations in seasonal water temperature, water quantity and quality may create problems of importance for the farms that use stream waters. Filtration and the other technological implementations can be used for elimination of these problems. In case of declines in water quantity additional oxygen supplement and capacity rearrangements are the only possible resolutions.

f) Insufficient water currents at dam lakes where cage culture is performed and broad fluctuations in seasonal temperature creates critical problems.

g) In the Black Sea, increasing water temperature during summer months has impacts on the production. Introduction of various types of cages can be employed as a resolution

h) Preventive and protective health measurements should be taken both in hatcheries and on-growing farms. Likewise, early diagnosis and treatment should be taken under the supervision of a licensed veterinaran, in accordance with regulatory rules laid down. Availability of fish disease experts at universities, public and/or government institutions, or at existing diagnosis laboratories will lead better success in the treatment and fish health monitoring, in particular at the regions where dense production take place.

i) Although establishment of Producer Organisations and Unions is an initiative of great importance, these type of organisations have failed to generate an effective administrative structuring to an extent that they did not have predominant role in problem-solving. Despite this, these organisations are expected to be involved in resolving the sector's problem in the near future. If these organisations undergo a well re-structuring towards effective management with increased responsibilities and roles, marked progress with regards to issues of egg, fry, vaccination, and general fish health, feeding and marketing will be made.

j) Compliance with water discharge and other environmental regulations is of importance for the development of the sector. In this respect, in addition to subsidies given for promotion of production, new subsidies should be in place for improving discharge waters.

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DEVELOPMENTS IN TURBOT FARMING

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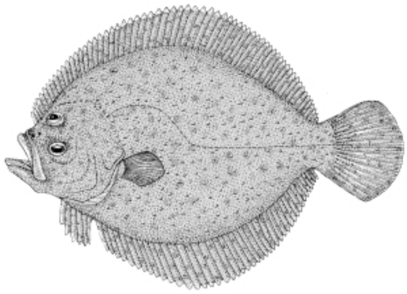


Psetta maxima **Linnaeus, 1758 [Scopththalmidae]**
English: Turbot Turkish: Kalkan

1. HISTORICAL BACKGROUND OF TURBOT CULTURE

1.1. In Europe

Turbot aquaculture started in the 1970s in Scotland (UK). It was subsequently introduced to France and Spain. At first, the number of farms in Spain was rather limited due to the scarcity of juveniles. The technological development of juvenile production changes this. At the beginning of the 1990s, there were already 16 producers in Spain. A significant crisis in turbot culture occurred in 1992; there was an increase of 52 percent in production but the industry lacked a consolidated commercial marketing network. Another factor that contributed to this crisis was that the farms were small and had very high production costs. This crisis caused the closure of some farms. From that moment onwards a reorganization of the sector began, which gave rise to a growth both in production and in the number of countries where turbot is farmed. Spain, with its highly suitable oceanographic conditions, is now the major producer worldwide but turbot is also currently farmed in some other European Countries (Table 1), the natural distribution of the turbot includes coastal waters of all these countries. Turbot has also been introduced to other regions (notably Chile in the late 1980s) and, more recently in China.
Besides commercial investment in improved facilities or the construction of new farms, other decisive factors have assisted in the consolidation and development of the sector. These have included the production of dry feeds and the development of vaccines for the most important diseases affecting turbot.

Table 1. Producers in Europe (2005)

Country	tons
Spain	5572
France	791
Portugal	214
Nederland	75
Germany	68
UK	58
Island	46
Denmark	8
Ireland	6
Total	6838

1.2. In Turkey

In the National Development Plans implemented since 1990, the Government of the Republic of Turkey placed a high priority on the fisheries development, aiming at enhancing fisheries production and thus increasing the domestic consumption and export of fisheries products. These policies were succeeded in the 7^{th} and 8^{th} National Development Plans.

Under such circumstances, in May 1994, the Government of Turkey requested the Government of Japan to implement project-type technical cooperation encompassing studies on the development of seed production and farming techniques, disease control and feed development for important aquaculture species, and counterpart training in relation to these activities.

In response to this request, the Japan International Cooperation Agency (JICA) dispatched the preliminary survey team in January 1995, and conducted supplementary survey from September to October 1996 for detailed investigations and preparatory arrangements.

Based on these preparatory arrangements and after a serious discussion, the "Fish Culture Development Project in the Black Sea" was signed by the Japanese and Turkish representatives and finally the Project started in April 1997.

This project aims to transfer the appropriate technology on the broodstock management, seed production, food and feed development and basic farming methods for flatfish to the counterparts through the research activities for the technical development on the seed production and rearing of selected flatfish in the Black Sea. The turbot was selected as target species based on aquaculture potential and Trabzon Central Fisheries Institute was chosen as project site (North East of Turkey).

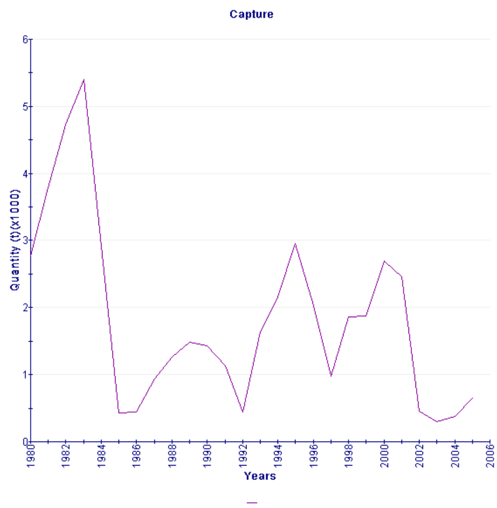


Figure 1. Capture fisheries of turbot in Turkey

Fish farmers need to develop farming techniques for new fish commodities as the market becomes saturated with farmed sea bass and gilthead sea bream. The turbot (*Psetta maxima*, also called *Scophthalmus maximus*) is one of the most valuable fish marketed in the European countries and also in Turkey. Until recently, consumer demand for turbot has been filled by capture fisheries. The species found in the market came from the wild, caught mainly by gill net along the Black Sea coastal waters off Turkey. Major period of catch is during spawning season from April to May, while during off-season there is limited catch due to the migratory behaviour of the fish. As it is seen on Figure 1., yearly catch of turbot has been very fluctuating and reached maximum level (5398 tons) in 1983 and minimum level in 2003 and 2004 (300 and 376 tons respectively).

However, in Turkey, cultured turbot has not contributed to the market so far, because the seeds of turbot are not available.

As a consequence, the fish culture development project jointly implemented by the Central Fisheries Research Institute under the Ministry of Agriculture and Rural Affairs, Republic of Turkey and Japan International Cooperation Agency (JICA) selected turbot as the target species for seed production technology development in Trabzon, which is located in the eastern coast of the Black Sea. The project was implemented from April 1997 to January 2007. In order to conduct project activities, an existing hatchery upgraded and a new sea water intake system was constructed. Since April 1997, the Project had worked for the sustainable seed production of turbot. The target production of the Project was 10,000 juveniles of 10 cm TL per year. In addition, knowledge of the different aspects of seed production has been accumulating. From the yearly achievement of the project, it seems that sustainable experimental seed production is viable.

2. HATCHERY PRODUCTION PROCEDURES OF TURBOT

2.1. Biological Features

Flatfish with asymmetric and almost round body (eyes on the left side). Scaleless skin but with bony protuberances irregularly distributed. Big mouth and small eyes. Dorsal and anal fins expand widely over the dorsal and ventral sides. Blind side of whitish colour and eye side with variable colour, generally grey–brownish with dark spots. *Psetta maxima* is a benthic marine species, living on sandy and muddy bottoms, from shallow waters to 100 m. Younger individuals tend to live in shallower areas. Cryptic, imitating the colour of the substrate. Carnivorous, juveniles feeding on molluscs and crustaceans, and adults mainly on fish and cephalopods. Spawning (sequenced, every 2-4 days) usually takes place and between April and early June inclusive in the Black Sea. Eggs have a single fat drop. Larvae are initially symmetric, but by the end of metamorphosis (day 30-70, 17-43 mm) the right eye has moved to the left, giving rise to asymmetry. Formerly known as *Scophthalmus maximus*.

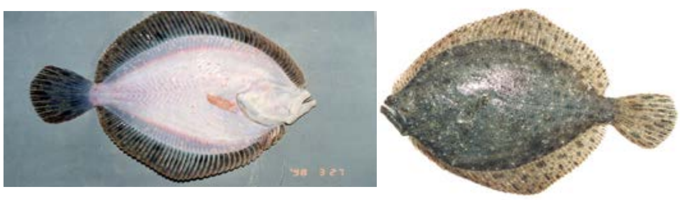


Figure 2. Blind side (left) and eye side (right)

2.2. Annual Schedule of Seed Production

Preparation for seed production starts on October that is painting of production tanks after the harvest and shipment of turbot seeds on September. The next activity is stock maintenance and scale-up of algae and rotifers. On February, equipment maintenance and repair works for seed production and disinfections of seawater supply lines become the major activities. On March just one month before the start of the spawning season, mass culture of algae and rotifers is the priority. On April and May, full-scale seed production activities that include mass culture of algae and rotifers, artificial insemination and larval rearing are carried out. On June and thereafter, larval and juvenile rearing become the main activities. On September, the first batch of juvenile fish is harvested and shipped to private farms (Table 2).

Items	**Months**											
	10	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
I. Facility maintenance and repair												
Checking of intake pipe												
Maintenance in hatchery												
Disinfection of water supply pipes												
II. Equipment maintenance and repair												
III. Propagation of natural food organisms												
Algal culture												
Stock maintenance												
Scale-up culture												
Mass culture												
Harvest and concentration												
Rotifer culture												
Maintenance												
Scale-up culture												
Mass culture												
Harvest and enrichment												
Artemia												
Acquisition of cysts												
Hatching and enrichment												
IV. Procurement of fertilized eggs												
Contact with fishermen and set up of stock tank												
Capture and transport of wild caught broodstock fish												
Egg collection and artificial insemination												
V. Fingerling production												
Acquisition of artificial food, medical materials etc.												
Incubation												
Larval rearing												
Juvenile rearing												
Harvest and shipping												

Table 2. An annual working schedule for the seed production of turbot

2.3. Production of Live Feeds

Like many other marine species, the early life stage of turbot is zooplankton-feeder. As no artificial larval diet can at present totally fulfil its nutritional requirements, its successful rearing still depends on an adequate supply of high quality live feeds, usually in the form of rotifers (fed on unicellular algae) and brine shrimp *(Artemia spp)*. This chapter only describes scale up culture methodology applied in CFRI (Fig. 3.a&b). The equipment and operation to mass produce these organisms are very well presented in literature given at the end of document.

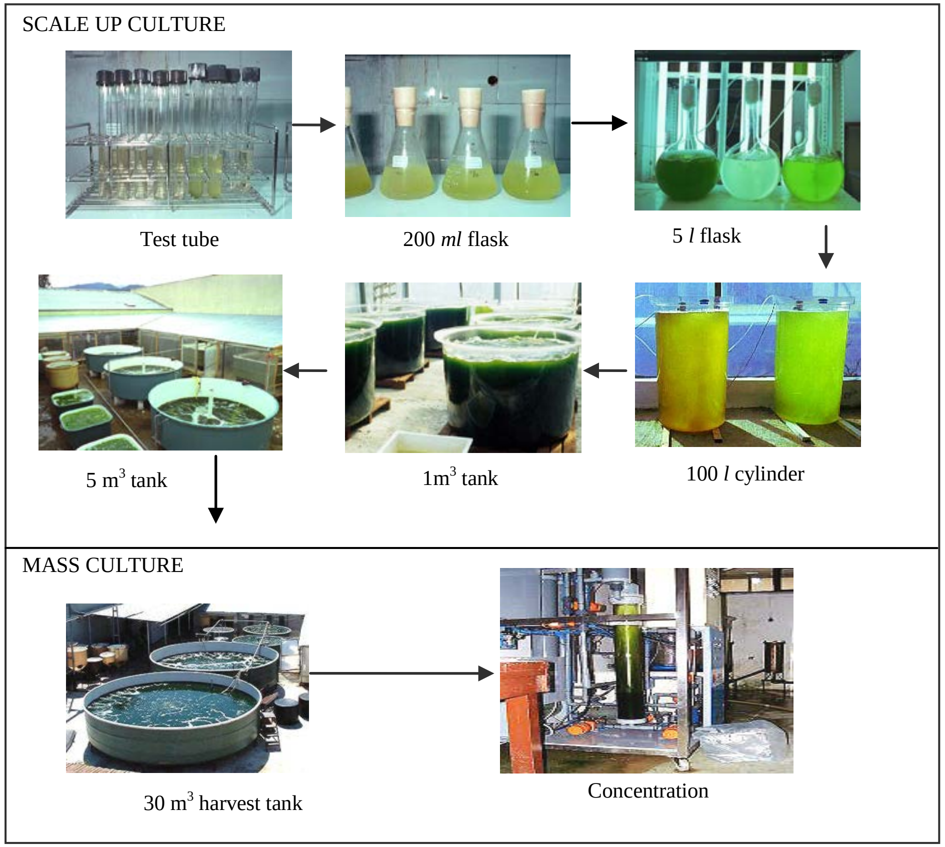


Fig. 3. a. Algae culture flow **b.** Rotifer culture flow

3. BROOD STOCK MANAGEMENT

3.1. Establishing the broodstock

There are two sources of broodstock to obtain fertilized eggs for the seed production of turbot. One is from the wild and the other is from hatchery-bred broodstock. Usually, fertilized eggs are sourced from the wild spawners before the maturation of hatchery-bred broodstock.

The turbot migrate from deep waters to shallow water in the Black Sea between mid March and mid May during the spawning season. Over two-year old male and over three year- old females can be used as spawners. During this spawning period, temperature at the water surface increases from 8.5 °C in March to 17 °C in May off Trabzon in the Black Sea.

The turbotis usually caught using gill net (Fig. 4. a). The spawners captured by this method are usually not in so good physical condition as source of fertilized eggs. The fish kept in the gill net for a long time (usually 3-5 days) are physically stressed and stress has negative effect on egg quality. Spawners caught using trawl net (Fig. 4.b) are physically in good condition because of shorter time of capture.

3.2. Broodstock Selection

To select good quality fish and to minimize disease infections of the captive fish by the wild fish, initial check of the fish is necessary. This is done by checking on disease occurrence and preventive measures undertaken before transferring the fish to the restocking tanks (Fig. [4.c and d]).

This is done by checking on disease occurrence and preventive measures undertaken before transferring the fish to the maturation tanks for artificial insemination purpose. Fish is preferably fed by whitting.

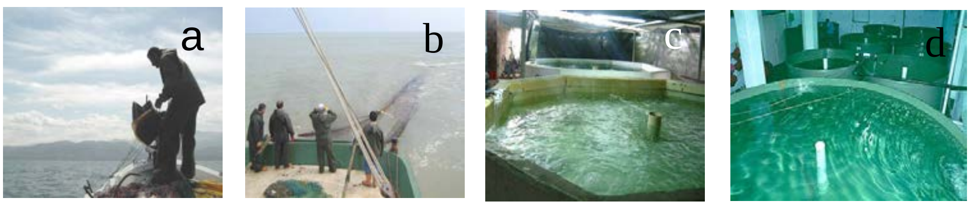
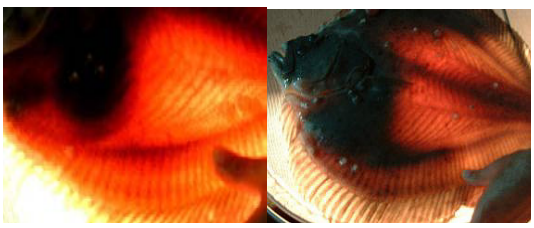


Figure 4. Turbot is cought by **a)** gill-net or **b)** trawl-net and kept either in **c)** concrete or **d)** FRP tanks



During spawning season, one of the first things to observe is the general appearance of the fish. If the abdomen of the fish is swollen, it is a female, and if it is flat and hard, it is a male. If the sex is difficult to determine, the desk light irradiation method can be used for this purpose (left, male; right, female).

The wild cought or hatchery bred spawners are transferred to an acclimation and maturation tank (1 x 2 x 0.5 m) wherein fish slowly adapt itself from ambient temperature to 15 °C within a day. The spawners can be stocked at 2-4 fish (2-7 kg/ind.) per m^2 in a maturation tank (Fig. 5.a). Over-stocking should be avoided to prevent physical stress of broodstock. Light intensity in the room is controlled at around 100 lux using fluorescent bulbs but during daytime it is under ambient condition. Adequate water exchange rate is approximately 900 % in a day and aeration (4 *l*/min. x 1 air stone/m^2) is provided. During spawning period, temperature is controlled at 15 °C. In order to check maturity;

For male: A gentle pressure is applied a few times, starting from the area just prior to the pelvic fins and ending near the urogenital pore. If the fish is fully mature, milt is usually extruded from the urogenital pore. Milt is watery and whitish in color. If no milt is extruded, this fish is either immature or spent, and is not used for fertilization purpose.

For female: Female fish can be checked by hand stripping or by cannulation to determine their maturity. For mature females, eggs are easily extruded from the genital pore after gentle abdominal press. If the fish is already mature, the fish should be stripped immediately (Fig. 5. b).

Figure 5. a)maturation tank, b)checking spawners, c)stripping and d)incubation tanks

3.3. Induced spawning

Egg release can be obtained either by natural spawning or inducing it by hormonal treatment. Natural spawning of turbot has not been managed successfully. Only mature male with milt and maturing female with oocytes more than 0.4 mm in diameter are used for hormonal treatments. The hormonal treatment following stripping is needed. However, if eggs have not yet reached the late-vitellogenic (or post-vitellogenic) stage, the treatment does not work, hence the need for an ovarian biopsy.

Eggs are obtained by abdominal press towards the genital pore (Fig. 5. c). If blood is mixed with stripped eggs, egg collection is stopped. Mature fish ovulates at once, while maturing fish requires about 2-10 days. It is necessary to compress the abdomen of the female time to time to observe if ovulation occurs, and then eggs can be collected daily after the first ovulation. Ovulation of both maturing and mature fish occurs for 7-13 consecutive days at an average. An average of 510,000 eggs per kg of fish can be obtained from a maturing fish while 300,000 eggs can be easily produced by a mature fish.

3.4. Incubation of eggs

Egg incubation can take place either in dedicated incubation tanks (Fig. 5. d). or directly in the larval rearing tanks. The latter choice has some drawbacks that fully justify the inclusion of a separated hatching sector as the ideal solution. After hatching, only the hatched larvae are moved to the clean larval tanks, whereas the hatching facilities are easily emptied, washed, disinfected and refilled for the next egg batch. Moreover, in this way the management of egg batches with poor hatching rates is facilitated by the smaller size of the hatching facilities. To incubate eggs, plastic or fiberglass round tanks with a conical bottom and a 100 to 250 l capacity represent the most common technical solution adopted by many hatcheries. The cylindro-conical shape gives a good water circulation pattern, provided that a central aeration source is placed near the tip of the conical bottom, and a better separation of not viable eggs and hatching debris. Their inner surface is smooth to prevent any damage to eggs and newly hatched larvae.

Fertilized eggs are spherical, pelagic and nonadhesive, with single oil globule, with no special structures on the chorion, and with a narrow perivitelline space. They measured 1.08-1.21 mm in diameter. Hatching occurs at about 110 h after fertilization at temperatures of 14-15 °C (Fig. 6).

Figure 6. a) 10 hrs Morula stage; b) 107 hrs after insemination, just before hatching under incubation temperature at 14.3 -15.3°C; c) 110 hrs. newly hatched larvae.

3.5. Larval Rearing

Before being stocked in the larval rearing tanks, the newly hatched larvae are checked to assess their viability and condition (Fig. 7.a, b). The evaluation criteria listed below is used for most of the species.

- overall shape and dimensions;
- integrity of the larval (primordial) fin, that should not present malformations and/or erosions;
- absence of external parasites;
- disposition of internal organs;
- proper pigmentation.

The larvae hatched in the incubation tanks are easily transferred to the larval rearing tanks. To make this operation easier and faster, it is advisable to stock the incubator with enough eggs so as to get the right amount of larvae to stock one larval rearing tank. In this way the larvae produced by an incubator are transferred into one larval rearing tank.

The larval rearing of turbot is a typical intensive rearing technology involving complete control over the environmental parameters and fish population.The rearing protocol takes place in a lighted environment using rotifers as first feeding and adding microalgae in the initial culture (same as gilthead seabream).

3.6. Rearing Facilities

3.6.1. Tanks

All rearing tanks are placed indoors. The shape of the tanks varies from circular, square or a raceway if water current in the tank is important. The sizes of larval rearing tanks range from 2 to 5 m^3 in volume with the depth of 0.75 m. (Fig. 7. c).

3.6.2. Aeration

The tank should be equipped with an aeration system. Aeration and circulation of the water are two of the most important issues in larval rearing. Aeration and circulation are usually both performed at the same time by a well-designed unit. In the Project, it is practiced to use many air stones (5 cm long, 3 cm diameter) which provide gentle aeration (2.5 *l*/min./air stone) rather than to use only a few air stones with strong aeration. 2-3 air stones/m^3 are set hanging around the wall and center of the tank.

3.6.3. Water Quality

To maintain suitable larval rearing conditions, water is filtered by 5 µm and UV- sterilized. Water temperature is maintained at 18 to 21 °C by equipping heat exchanger in rearing tanks.

3.6.4. Illumination

Illumination is one of crucial factors during feeding of larvae. It is avoided that light intensity is high or low. Facility is illuminated from 08:00 to 19:00 h at the intensity of 200-500 lux using fluorescent lamps and avoiding direct sunlight. 24 hours If the green water rearing system is applied, 24 h. continuous illumination is provided.

3.7. Stocking to Rearing Tank

3.7.1. Stocking Density

Initial stocking density of the eggs or larvae is around 20,000-30,000 ind./m^3. Whenever fertilization rate of eggs is low (<80%), all batches of those eggs are discarded.

3.7.2. Stocking Method

Before transferring eggs or newly hatched larvae to the rearing tanks, water temperature of the rearing tank is set the same degree as incubation tanks. Just before transferring eggs or hatched larvae to rearing tank, aeration is stopped for a while in order to allow undeveloped eggs and detritus to sink to the bottom of incubation tank and larvae or eggs to float at the water surface. Then, the undeveloped eggs and dirt are removed by siphoning or via the hose connected to the bottom of the incubator, and the eggs or larvae are transferred gently to the rearing tanks by using beaker or 10-15 *l* pail.

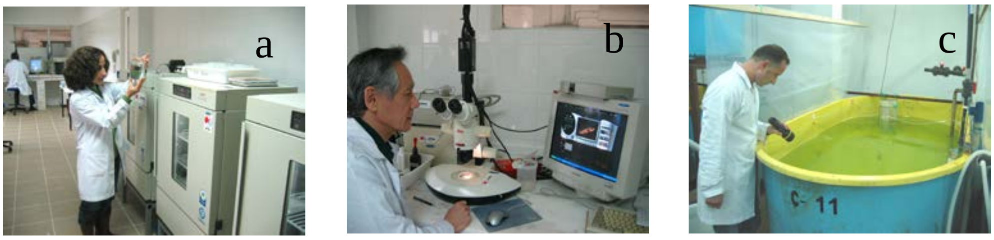


Figure 7. a)Checking viability, b)deformity and c)overall condition in larval rearing tank

3.8. Feeding

3.8.1. Schedule

Three kinds of food items are used for the larvae: rotifer *B. plicatilis*, nauplius of *Artemia* and artificial diet. Table 3 and Table 4 show the feeding scheme and feeding regime for rearing turbot larvae.

3.8.2. Algae

The green algae, *Nannochloropsis* are maintained at 0.5×10^6 cells/*ml* in rearing tank. Algae in larval rearing tank serve as food for rotifers. Apart from the high nutritional value, the other positive effects in the intensive rearing environment are thought to be a certain bacteriostatic capacity and a shading effect that reduces the larval aggressive behaviour. Larval culture in clear water is also feasible, but it gives lower average results in terms of survival and size homogeneity.

3.8.3. Rotifers

On D-3, when the mouth opened, enriched rotifers (*B. plicatilis*) are given and introduced slowly into the rearing water by using beakers. The density of rotifers in the rearing tank depends on larval stage, and is maintained at 2 to 5 rotifers/*ml* (Table 4). The density of rotifers in the tank is examined twice a day at 10:00 & 14:00 h. Additional rotifers are provided when the density of rotifer is lower than the required density to be maintained.

3.8.4. Artemia

On D-12 to D-15, newly hatched nauplii of *Artemia* (See III-3-a) are given to the larvae. From D-16 to D-17, both newly hatched and enriched *Artemia* (III-3-c) are given followed by enriched *Artemia* from D-18 to D-40. The density of *Artemia* fed to larvae increases from 0.2 to 0.4 ind./*ml* (Table 5) and is adjusted based on consumption by the larvae. In general, *Artemia* are consumed by the larvae within two hours.

Notes: Early termination of rotifer feeding and early feeding of enriched *Artemia* are recommended for reducing the malpigmented fish based on recent research. Recommended schedule of feeding is as follows: Termination of rotifer feeding: D-12 to 15; Start of *Artemia* feeding: D-12 to 15.

3.8.5. Artificial feeds and feeding

Artificial diets developed for larvae are named microparticulate diet or micro diet. Microdiets are initially fed to the larvae on D-20. When rotifers or *Artemia* are available in the rearing water, larvae prefer the live food than microdiet. As a result, weaning them to artificial diet is difficult. It is therefore recommended not to overfeed them with live food. Excess feeding of microdiets will cause the deterioration of water quality. Accordingly, they should be used in adequate quantity. Feeding regime of micro diets for turbot larvae are presented in Table 5. Selection of microdiet is based on the quality aspect, since this affects further larval survival and growth. Microdiet to be given to the larvae must satisfy the following conditions:

- Meet the nutritional requirements of the larvae.
- Can be suspended in the water column for several minutes.
- Nutrients in diets should not leach out in the water. The binder can avoid the high leakage of water soluble nutrients.
- Show the reasonable stability in the water.

Microdiets are classified into three types; microencapsulated diet (MED), micro-bound diet (MBD) and micro-coated diet (MCD), from the differences of manufacturing processes and properties. Generally speaking, the unit cost for high quality microdiets is over 70 US $/kg.

Table 3. Feeding regime for rearing larval turbot

Days	3-5	6-11	12-15	16-17	18-20	21	22-23	24-25	26-29	30-40	N+1
Algae (cells/*ml*)				0.5×10^6							
Rotifer (ind./*ml*)	2	5	5	5	5	4	3	2			
Artemia nauplius (ind./*ml*)			0.2	0.1							
Enriched *Artemia* (ind./*ml*)				0.1	0.4	0.4	0.4	0.4	0.4	0.4	
Artificial feed: Particle size (µm)							250	400	700		
Artificial feed: Quantity (g/10x10^3 larvae)							10	15	18		

Table 4. Timetable for feeding larval turbot

Days after hatching	Time								
	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
3-11		R					R		
12-15		R		A			R		
16-17		R		A			R	AE	
18-20		R					R	AE	
21-23	AF	R	AF				R	AE	
23-25	AF		AF					AE	
25-40	AF		AF		AF			AE	
>40	AF		AF		AF		AF		AF

*AF; artificial feed, R; enriched rotifer, A; *Artemia* nauplius, AE; enriched *Artemia*

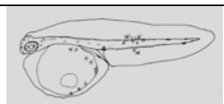
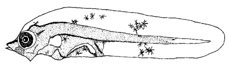
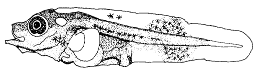
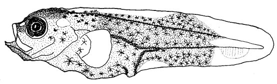
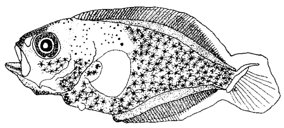
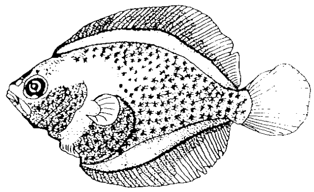
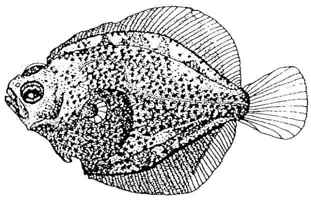
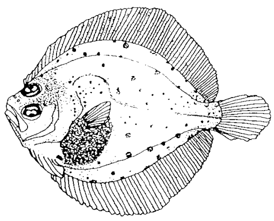
Table 5. Feeding rate of artificial diet for rearing different-size turbot fingerlings (based on 1,000 fish)

Total length (mm)	Basal feeding rate (%)	Size of diet (mm)	Daily amount of diet (g)
8-11	10	0.25	> 1.0
12-17	7	0.25 - 0.4	1.0 - 1.5
18-20	7	0.4 - 0.7	1.5 - 1.8
21-24	5	0.7 - 1.0	1.8 - 3.0
25-30	5	1.0 - 1.2	3.0 - 5.0
31-35	4	1.2 - 1.5	5 - 15
36-40	3	1.5	15 - 30
41-55	3	2.3	30 - 60
56-80	3	2.3-3.0	60 - 200
81-100	2	3.0	200 - 400

3.9. Development and Growth

The morphological development and behaviour of turbot larvae during the 70 days rearing period at water temperatures of 16-19 °C, are described below (Table 6). These developmental stages are divided into three stages as 1) **Pre-larval stage** (On the day of hatching, D-0 to D-2); **Post-larval stage** (D-3 to D-29) and **Metamorphosis stage** (D-30 to D-70: transition period from larval to juvenile).

Table 6. Morphological development of turbot under rearing condition

Age (days)	Size in total length (mm)	Characteristics	Illustration
0	2.5	Newly hatch larvae have unpigmented eyes, unformed mouth and closed anus. Melanophores are distributed on the central notochord	
5	4.0	The pectoral fin membrane appears.	
10	4.8	The pectoral fins are well developed. Melanophores are distributed on both the dorsal and ventral parts of the notochord	
15	6.3	Differentiation of the anal fins from the common finfold begins and melanophores on the notochord are well developed except in the posterior region	
20	9.6	The dorsal, anal and caudal fins are all differentiated; the flexion of the notochordal end has advanced rapidly and the membrane of the ventral fins appears. Many melanophores are distributed in the posterior region of the notochord.	
25	14.1	All the fin rays are functionally differentiated. Many melanophores are distributed on the notochord except the anterior region of the head	
30	17.6	The migration of the eye from a symmetrical position to one side begins	
70	43.3	The migration of right eye advances slowly compared to the relative growth of the other body parts. Fish is completely transformed at D-70.	

3.10. Tank Management

3.10.1. Temperature: Larval turbot seems less resistant to changes of water temperature during the early stages. It is important that in transferring eggs or newly hatched larvae, the water temperature from their source is the same as in the tank where they will be stocked. After stocking, the water temperature is gradually increased from 15 to 18 or 21 °C in 4 days.

3.10.2. Water Exchange

No water change takes place until D-3. On D-4, water is changed initially at a rate of 0.3 turn/day to maintain adequate rotifer density and to avoid water deterioration. The water change is simply allowed to flow through. The rate of change is gradually increased to1.0 turn /day at D-10.

3.10.3. Bottom Cleaning

The tank bottom is cleaned daily starting on D-5 with an improvised bottom cleaner to remove the dead larvae, uneaten food, fecal matter and detritus. This detritus is suspected to be a hotbed for disease. The cleaner is made of a PVC pipe 20 mm diameter with the suction mouth attached to its tip and a flexible hose (25 mm in diameter) attached on the other end. A piece of sponge is attached to clean the bottom more effectively (Fig. 52). Aeration is stopped during siphoning and care must be taken not to stir up the organic matter on the bottom of the tank, and not to siphon larvae swimming near the bottom of the tank. Dead or escaped larvae are collected in a 70 *l* plastic container.

3.10.4 Grading

To minimize cannibalism and for efficient feeding, fish size is sorted. Fish are harvested around 20 mm TL to grade them with a selector, which is a pen net, made of plastic or nylon materials. Fish, which are schooling on the surface and corners of the tank, are scooped with pail and poured into the selector set in a new tank.

4. JUVENILE REARING

Although nursery rearing starts around D-40 to D-42, fish are still sensitive to handling/transport stress. Rearing is extended until the commercial size of 100 mm TL. Weaning lasts from approximately D-40 to D-110. Research results confirmed that survival rate at this stage is high (over 75%). Improvement of survival of the juveniles can reduce the required nursery tank volume and labor to meet the target production of the hatchery.

4.1. Tank and Facility

Since larvae start to set on the tank bed at 20 mm TL, the surface area of tank bed becomes more important than the tank volume. The stocking density of fish is calculated based on the surface area from this phase. Fish are reared in shallow concrete or FRP tanks of 0.3 to 0.5 m depth. The tank could be circle, square or could be raceways of about 5-7 m^2 surface. The tank should be well designed to drain the waste in the rearing water and detritus on the tank bed by utilizing water circulation: centripetal force of water. In order to enhance the water circulation, seawater is supplied through the water diffuser. The rearing tanks are aerated with two air-stones/m^2 placed at the wall and centre of the tank. Illumination is maintained at 200-500 lux with a fluorescent lamp placed above the rearing tanks between 08:00 and 19:00 h. Oxygen level should not be below 4 mg/*l*. Since the juvenile fish during nursery stage is fed artificial diet and feeding rate is increased with fish growth, there is a great possibility for water deterioration. Thus water exchange rate should be more than 15 times a day throughout the nursery phase. The temperature and salinity of the rearing water ranged from 18 to 24°C and 18-19 psu, respectively. It is also recommended to clean the bottom twice a day, in the morning and in the afternoon (Fig. 8).

4.2. Grading and Stocking

During juvenile stage, fish are graded as shown in Fig. 9 a and b. for the following reasons:
-Removal of malpigmented or deformed juvenile (Fig. 10)
-Size sorting
-Determination of the exact stock number
-Cleaning of tank

Only normal and size-graded juveniles are transferred to the new tank by pail. Grading should be minimized since frequent grading cause injury to the fish. If stocking density is low, feeding rate must be lowered. The stocking density depends on the size of the fish and carrying capacity of the rearing water. Standard stocking density in the Project is shown in Table 7.

Figure 8. Cleaning

Figure 9.a&b Grading and sorting

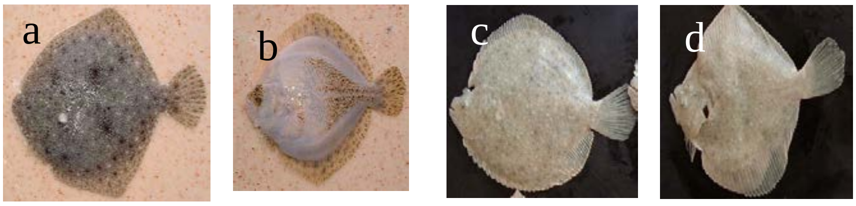


Figure 10. Normal (a), malpigmented (b) and deformed (c and d) turbot juveniles

Table 7. Relationship between the size and stocking density of turbot

Total length (mm)	Stocking density (ind./m^2)
20 -50	400 - 500
50 -80	250 -300
80 - 100	120 - 150

4.3. Feeding

Crumbled pellet, 0.7 to 1 mm diameter, is used at the start of juvenile rearing. As fish grew, crumbled pellet is gradually replaced by pelletized diet. The amount of feed taken by the juvenile tends to be affected by the size of diet. Too small or too big size, feeding is low. A 20 to 50 mm TL fish are fed four to six times a day. When fish grow to 50 mm TL, feeding frequency is decreased to three to four times a day until satiated. Apparent satiation is determined by the termination of voluntary feeding activity of juveniles. Feeding rate of juvenile turbot start at 4 to 5 % of the body weight at about 20 mm TL and gradually decreases between 2 to 3 % at about 100 mm TL.

5. ON GROWING

During this phase, young fish grows from a few tens of grams to market size in two to three years. It is also the period during which certain economic factors (power, labour and diet) are at their most critical stage and where the environmental parameters and nutritional factors play the greatest part in the profitability of the culture system. On the other hand, technical requirements at this stage are relatively low and investments are moderate. Older and juvenile turbots have similar water quality requirements with a cessation of feding around 5-6°C and above 23°C. Growth is favoured by a stable environment, although there is more resistance in earlier stages. From a practical point of view, to optimize performance in the rearing unit, water turnover must be constantly adjusted so that the level of dissolved oxygen in the outflow does not fall below 5 ppm at 16°C. The flow of water is decreased with the size of the fish by a factor of 4 between 10 and 1000 g for turbot. Under these conditions, theoretically, the fish is maintained in a satisfactory environment. Turbot shows a preference for low light intensities (250-500Iux) and appears to be relatively sensitive to vibration.

The on-growing of turbot is essentially an intensive operation. Best performances come from the use of fresh food, given *ad libitum*. The daily ration, in dry weight, is around 1% of the biomass and, at least on a small scale, meals can be reduced to one per day. The mean conversion efficiency, is around 1:1 which is considered to be satisfactory (dry weight food/wet weight fish produced) as compared to around 2:1 for salmonids. Turbot of around 100 g tolerate densities of up to 25kg/m^2, in a depth of less than 20 cm of water. This density is achieved with the fish stacked in two or three layers. Mean densities maintained in rearing operations are around 30-40 kg/m^2/m^3 (water depth about 1 m) and sometimes there is a supply of oxygen as a back-up to increase the security of the system. There has been little investigation on the use of semi-extensive or extensive systems as a complementary system of rearing for the future.

On land, rearing tanks with a volume of 20-100 m3 can be divided into two types:
- excavated tanks which may be waterproofed with a plastic or concrete lining,
- circular selfcleaning tanks or
- raceways fed with pumped water. In most systems the tanks are covered. Water often enters the tanks through tidal movements with a complementary pumping system. This is an economically sound solution, but the tanks are seldom completely emptied, which makes the removal of the fish and cleaning operations difficult. This type of structure is particularly suited to semi-extensive on-growing where water requirements are low, in an operation which is complementary to other activities. Surface cages with a rigid base are adapted for the on- growing of turbot in the sea or in coastal lagoons. These do not require pumping of water but need sheltered sites because of the resistance to the wind and to currents. They are not as accessible as land-based tanks, which makes the monitoring of the stock more difficult. They are usually 1-2 m deep so that the fish at the bottom of the cages are protected from the maximum light intensity at the surface of the water. Cages may sometimes be partly shaded to further decrease the light intensity. Different prototypes of cages have been tested in France and Great Britain, although their use remains limited. This system has been found unsuitable for Black Sea where surface temperature decrease to around 7 ^{o}C in winter and increase 26 ^{o}C in summer. In practice, the choice of structure used is based on technical and economic criteria and depends on the chosen site for the installation.

The potential for turbot is good, but mean growth is often poor and obtaining 2kg turbot in 3 years without additional intervention is the exception rather than the rule. Such figures can be obtained only in precise feeding regimes (fresh fish or pastes incorporating a minimum of 20% fish) and in a favourable temperature regime. There is generally a growth spurt during the second summer and a decrease in growth after the third summer; this is related to sexual maturation which begins at 3 or 4 years old for females. The growth of cultured turbot is faster than that in the wild. However, malfunctioning of general metabolism linked with imperfect diet may have a bad effect on the overall state of growth and survival of the fish. All experts agree that turbot have a high growth potential, but there are major differences in actual performance which depend on general rearing conditions. In optimal rearing conditions, 3 kg turbot can be obtained in three years, with a production of several tons each year. An objective of a mean weight of 2 kg in three years seems reasonable although this would require a separate nursery stage and also slight adjustments to the temperature regime, using groundwater in winter and summer.

6. FUTURE OF TURBOT CULTURE IN TURKEY

Having started the JICA supported Project, the Central Fisheries Research Institute (CFRI) has encouraged several investors to initiate turbot culture in country. Many farmers have already experienced to culture it in different culture methods. Some in cages and some in earth or concrete ponds. The water is pumped either from sea or wells. But the first and serious attempt was made by IDAGIDA in 2000 by buying juveniles from CFRI. Not many farmers has continued turbot mainly due to long farming cycle and limited number of production sites. West cost of Black Sea and South Aegean region where lots of brakishwater sources seem potential sites for intensive rearing. Additionaly, developing techniques in recirculation aquaculture systems make farm this valuable fish. It is hoped that year 2008 will be turning point for intensive turbot production in Turkey. The CFRI will continue its efforts until the mission completed.

Figure 11. a) concrete ponds at IDAGIDA, b) transfer of fish to KILIC, c) pvc coated earth ponds in Milas (KILIC).

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STURGEON AQUACULTURE

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1. INTRODUCTION

Sturgeons, a family of fishes Acipenseridae, order Acipenseriformes, have a circumpolar distribution with seven species found in North America and eighteen species found in Europe and Asia (BIRSTEIN, 1993). The Black Sea consists of 6 representatives of the two genuses (*Huso* and *Acipenser*): Beluga (*Huso huso*), sturgeon (*Acipenser sturio*), Russian sturgeon (*Acipenser guldenstadti*), Stellate sturgeon or Sevruga (*Acipenser stellatus*), Sterlet (*Acipenser ruthenus*), Ship (*Acipenser nudiventris*).

According to statistics, in 1980, about 90% of sturgeon catches in the world took place in the Caspian Sea, Black Sea and Sea of Azov. Of greatest commercial importance, these sturgeons are: *A. gueldenstaedtii* and *A gueldenstaedtii colchicus*, *A. stellatus*, and *H. huso*. Catches also include *A.baeri*, *A. nudiventris*, *H. dauricus*, and *A. ruthenus* (BARANNIKOVA, 1987). However, Black Sea sturgeons now are listed as endengared species and any type of sturgeon fishing is forbidden in Black Sea basin.

According to the number of chromosomes, sturgeons can be distinguished clearly: (1) sturgeons that have number of chromosomes close to 2n=120 (60 macro and 60 microchromosomes and 3.2-3.8 pg DNA; this group includes *S.platyrbyncbus*, *Huso huso*, *Acipenser sturio*, *A.ruthenus*, *A.nudiventris* and *A. stellatus*; (2) an octoploid with approximately 4n=240 and twice as much DNA; this group includes *A.naccarii*, *A baeri*, *A gueldenstaedtii*, *A. transmontanus* and *A. sinensis*; and (3) DNA measurements (14 pg) suggest a 16n ploidy and 500 chrosmosomes (e.g., *A. brevirostrum* and *A. mikadoi*) (FONTANA et al. 1996;BILLARD and LECONINTRE, 2001).

Sturgeons are late maturing and long lived fish with sexually dimorphic growth rates having long life expectancies and intermittent spawning frequencies. These species have a spindle shaped body, elongated snout, inferior mouth and heterocercal caudal fin.They are also characterized with 5 rows of scutes or bony plates (one dorsal, two laterals and two abdominal rows). Scutes are sharper in younger and softer in older sturgeons. Four barbels are present on the anterior part of the mouth.

Sturgeons include anadromous species (living in the sea and migrating into rivers to spawn), semianadromous species (which spend most of their life in rivers and migrate into pro-estuarine regions, but do not go to the open sea), and river-resident (freshwater) species which spend their entire life in rivers. Some species, for example *A. baeri* and *A. ruthenus*, have both semianadromous and river-resident forms (DETTLAFF et. al.,1993).

Among many environmental factors, the most important factors for fish are the water temperature, dissolved oxygen, salinity and the pH. The main physical and chemical environmental factors, the deviations of which may result in pathologic changes in fish, are the following: water temperature, dissolved oxygen, hydrogen rate, free carbon dioxide, hydrogen sulfide, biogenic elements, organic matter, chlorides and sulphates. The optimal temperature for sturgeons is 19-24 ^{o}C. Oxygen is required for fish breathing and for water self-cleaning from organic and inorganic matter. Oxygen requirements for sturgeons are relatively high (6-8 mg/l). While many fish may endure wide fluctuations of pH indices, the most recommended pH for commodity sturgeon rearing is 6,5–8,5. Optimal concentrations of carbon dioxide for sturgeons are 1,5–10 mg/l, allowable up to 30 mg/l. Natural ammonium sources are excrements of fish and aquatic organisms. Sturgeons are very sensitive to ammonium. The threat of toxicosis and gill disease appears at pH 8,5–9,0 and water tempearture over 18^{o}C. The maximum concentration of ammonium is 0,1 mg/l. The norm is up to 0,07 mg/l (DETTLAFF et. al.1993; MIMS et al. 2002).

The sturgeons that are intensively cultured in Russia are more often diagnosed with the following diseases: flavobacteriosis, dysbacteriosis (Candidomycosis), trichodinosis, argulosis, nutritional toxicosis, nutritional anemia, and gas bubble diseases. The invasive diseases caused by parasites having the direct vital rhythm, the bacterial infections followed by stress and non contagious diseases associated with the use of unbalanced and poor quality feeds are the some of the registered diseases in sturgeons during intensive aquaculture in Russia (MOKHAYER and MASOULEH, 2005).

2. STURGEONS AS AN ALTERNATIVE AQUACULTURE

The first experiment of artificial propagation of sturgeon was carried out in 1869 when OWSJANNIKOW (1871) artificially inseminated A. ruthenus eggs, incubated then, and obtained prelarva. In subsequent years, insemination and incubation were also performed for some other sturgeon species: A.fulvescens by Seth Green in 1875, *A. sturio* by Fraunen in 1881, A. stellatus in 1884 and *A. gueldenstaedtii* in 1899 by BORODIN. These and similar experiments were aimed mainly by obtaining materials for investigation. The first experiment especially for fish culture was carried out in 1886 by Mohr who released 500 000 *A.sturio* larvae in Elbe. Due to the difficulties in obtaining mature spawners, at the beginning, artificial propagation could be carried out only at small-scales. After developing a method of pituitary injections for stimulating maturation of sturgeon, large amounts of eggs suitable for fish breeding from females could successfully be obtained (DETTLAF et. al. 1993).

Work on artificial propagation of sturgeon has recently been started in many countries: USA, France, Italy, Hungary, Poland, China, Japon, etc. In USA, successful attempts to produce *A. transmontanus*, *A. oxyrhynchus*, and *A. brevirostrum* have been made. A major advance has been made with *A. transmontanus* (DOROSHOV et al. 1983).

For centuries, most sturgeon species have been highly valued for their caviar and boneless meat. The extinction of wild sturgeon stocks has promoted a strong interest for rearing sturgeon for its caviar, meat and for restocking of depleted water bodies. Fifteen years ago sturgeon farming according to the FAO was restricted to the Soviet Union and Ukraine both of which produced a total of 250 tonnes of farmed sturgeon. Recently many countries have established sturgeon hatcheries. China is by far the largest sturgeon producer with 73% (11.269 tonnes) of the total production, followed by Russia with 2.400 tonnes and Italy with 1.118 tonnes (Eurofish Magazine, 2006). Wild stocks in the Caspian Sea used to provide ninety percent of the world’s caviar, but today a overfishing, pollution, poaching and environmental degradation has left the stocks in a precarious state. The UN body responsible for administering the export trade in sturgeon and sturgeon products has strictly limited quotas for wild sturgeon products from Danube River where the stock is jointly managed by Romania, Bulgaria and Sebia-Montenegro, CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (DIMITROV, 2006).

Sturgeon aquaculture can be the only solution to the conservation of wild populations through restocking and by providing a consistent supply without exploiting wild populations. The main species used in aquaculture production worldwide are white sturgeon (*A.transmontanus*), Siberian (*A.baeri*), osetra (*A.gueldenstaedtii*), sterlet (*A.ruthenus*), and a hybrid called bester (beluga female x sterlet male) (MIMS et. al., 2002).

CHEBANOV and BILLARD (2001), reported that in the Sea of Azov basin, all rivers are dammed and there is no natural recruitment. Present stocks have been, over the last 10 years, entirely supported by stocking. The average commercial return was 0.46% of these fish stocked over the last 20 years. Commercial fishing now prohibited except for a quota of 150 tonnes of spawners (male and females) allowed for the production of juveniles. They must ensure the production of nearly 30 million juveniles. The selection of spawners from nature is restricted to females maturing in spring in the sea, in the mouth or in the lower course of rivers (dams are constructed not far from the sea, e.g. 150 km on the Kuban river). CHEBANOV and SAVELYEVA (1999), also reported that the research on stocking operations were made to expand the period of reproduction, to make a better use of the hatcheries and nursery capacities and to produce more genetically diversified populations taking early and late spawning runs or fish migrating far upstream. By a combination of thermal and hormonal manipulations, ovulation and spermiation can be obtained 5 months earlier or 6 months later than normal. The process of maturation can be slowed down by exposure of females to low and slightly oscillating temperatures (average 5 ºC). Nowadays the traditional sturgeon pituitary injections to induce ovulation are still practised in many hatcheries but they are being replaced by synthetic analogues of the luteinizing hormone releasing hormone (LHRHa). Besides maintaining permanent captive broodstocks, sperm banks were established by research institutions for ex situ conservation of endangered populations; for instance, the federal living gene bank of the Sea of Azov and Black Sea, located at the Krasnodar Institute of Fisheries, contributes to the stocking programme of the local hatcheries.

3. STURGEON NEW SPECIES FOR TURKEY

Turkey brought fertilized Russian sturgeon eggs from Krasnodar Research Institute of Fisheries, Russia. In this first restocking project was carried out between İstanbul University Fisheries Faculty and Private Sector. The purpose of this project was to stock sturgeon to Sakarya River and to improve larval rearing techniques and hatchery procedures according to local conditions in Sakarya region.

The fertilized eggs of *A. gueldensteadtii* were brought from the Krasnodar Research Institute to the University of Istanbul in 12.01.2001(Fig. 1). After receiving the permits, the eggs were brought to the Hatchery of the Faculty of Fisheries of the University of Istanbul Sapanca Fish Production Institute**.** Sapanca trout hatchery was designed for sturgeon hatching in a waving system in that this model was made according to Yushenko apparatus at 14-15 ºC water temperature (ÇELİKKALE et. al., 2003; ERCAN et. al, 2007).

Figure 1. Bringing the Sturgeon eggs to the The Sapanca Inland Water Fish Research and Applied Station SIWFRAS.

Approximately 5 kg of fertilized Russian sturgeon eggs were placed on the plates. The eggs with fungi were isolated in the hatchery. Eggs were kept at 15ºC using water heating system by means of water paddles continuously in action (Figure 2). After the eggs transferred to the incubator system, the fungal infection was isolated and malachite green was used for treatment before putting them on incubation system.

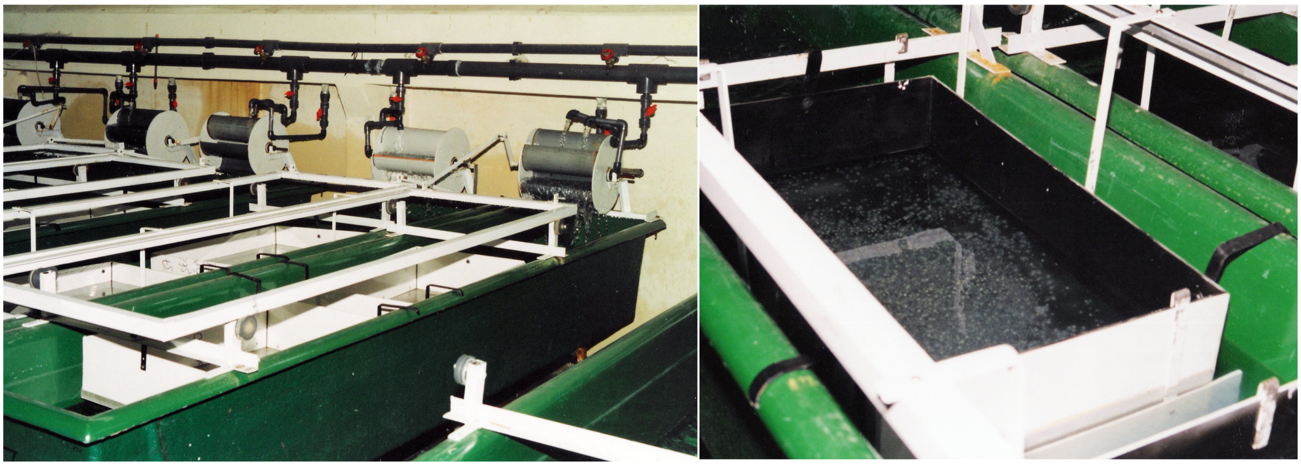

Figure 2. The hatchery system of sturgeon in SIWFRAS (The Sapanca Inland Water Fish Research and Applied Station).

During the incubation period, the water was about 20 cm deep. It was recorded that the larvae hatched after 1-2 hours (Figure 3) and started to swim actively and then some of them began to form groups in corners of the canals. The larvae were taken from the moving plates and were transfered to the fiberglass canals. (Figure 4).

Figure 3. Newly hatched Russian sturgeon prelarvae

Figure 4. The larvae were transferred to the fiberglass rectangular tanks.

After hatching the water temperature was gradually raised to 18 ºC. The oxygen content and pH was about 9 mg/l, and 7,5 respectively. After the second day, the number of pigmentation of the larvae became intensive. The number of free-swimming post-larvae increased. In this period, the top of the canals were covered to protect larvae from excessive light. During exogenous feeding, post-larvae were fed by artemia, tubifex and daphnia (MEMİŞ et. al., 2007). One month later, commercial sturgeon food was (granule size 80-1200µm) used for the juvenile sturgeons (Figure 5).

Figure 5. Feeding with commercial food of the sturgeon juveniles

Russian sturgeon juveniles were transferred to the Sakarya River after they reached to average of 4-6 g in weight (in oxygen-supported tanks) in March 2001. The river is 50 km away from the establishment. Approximately 50.000 fry were carried to the river in this first project. They were released to the Sakarya River 10-15 km before the river reached to the Black sea (Figure 6). The water temperature was slowly decreased to 16 ºC and then to 13 ºC, (13.9 ºC, Sakarya River temperature during fish release). No mortality was observed after this adaptation trial (ÇELİKKALE et. al., 2002).

Figure 6. Releasing from to the Sakarya River of Russian sturgeon juveniles (in March 2001).

Limited information is available on the optimum growth porformance of Russian sturgeons. Therefore, the newly stocked fish fed at various feeding levels and stocking densities in cages. ÇELİKKALE et al. (2005) studied two different stocking densities to determine growth performance and survival. The study was performed in Sapanca Lake. At the end of the study, many of the cage-raised sturgeon grew better than pond conditions from late spring to late autumn (approximately 7 months) and reached over 1 kg in Sapanca Lake (Figure 7,8).

Figure 7. Cage culture studies in Sapanca Lake (2003).

Figure 8. *Acipenser gueldensteadtii* (Russian Sturgeon) from SIWFRAS.

Studies continued on with feeding and growth experiments. MEMİŞ et. al. (2006) investigated the potential use of commercial trout and carp feeds and their effects on growth performance and body composition on Russian sturgeons (Figure 9).

Figure 9. Feeding trials on Russian sturgeon juveniles.

4. RUSSIAN STURGEON RESTOCKING AND MONITORING PROJECT

Istanbul University's second restocking of juvenile hatchery sturgeon (*A. gueldenstaedtii*) from mouth of Sakarya River to the Black sea is done July 16-18, 2006. Sturgeon juveniles were grown in Istanbul University Fisheries Faculty Sapanca Inland Water Fish Research and Applied Station (SIWFRAS) where they have been reared since their arrival from Russia in January 2001. The release projects are part of an ongoing cooperative effort of the Local Municipality, Sakarya Government agencies, Ministry of Agriculture and Rural Affairs, local fishermen, and some other organizations. The goal of the initiative is to ensure the long-term viability of naturally reproducing sturgeon populations in the upper Sakarya River or rivers in the vicinity. Although Sakarya River has some local pollution, it still has some fish such as European catfish (*Siluris glanis*), mullets, common carp and some Cyprinid species.

The purpose of this second releasing program was based on the hypothesis that "Hatchery rearing and release intervention is necessary to preserve the diversity of the remaining sturgeon population". So this kind of studies will be followed by the University in the future. Since 1970´s, sturgeon fishing in Turkey is restricted to protect current sturgeon populations.

The reasons behind decline of this ancient species is pollution due to municipal and industrial water discharge, over fishing and dams and dikes which were built on the migration routes etc. Russian sturgeon (*Acipenser gueldenstaedtii*) can live for more than a century and grow up to maximum weight of 115 kg, and a length of 235.0 cm and the reported age of 46 years. Found mainly near the shore over sand and mud. Feed on molluscs, crustaceans and small fishes (anchovies, sprats, gobies). Spawning occurs from May to June in Black sea region.

4.1. TAGGING AND TRACKING ELEMENTS

In June, each young fish was implanted with a small yellow T-Bar (Floy tag), which provides information on the background of individual fish for monitoring purposes. Each fish also had a unique number provide an external identification mark. About 500 Russian sturgeon around 2-3 kg-weights were released in Sakarya River between July 16-18, marking University's second effort to recover declining populations of oldest fish in the Black Sea (Figure 10, 11). They were marked with a T-Bar tag on which the university name, telephone number and fish numbers were indicated All area fisherman and the ministry were informed about the tagged fish release and requested that the sturgeons should be released back to where they were caught and the tag information should be recorded and reported to the project related authorities.

Figure 10. Tagging of Russian sturgeons

Figure 11. Around 2-3 kg Russian sturgeons released to the Black Sea after tagged, in 2006.

Information regarding to the Russian sturgeon restocking program, on-going sturgeon monitoring work and suggestions on what Fishery Faculty Aquaculture Department research groups and individuals can do to help, when they can be found can be found at http://www.istanbul.edu.tr/suurunleri/main.htm .

4.2. MOVEMENT OF FISH

First tagged sturgeon was recorded from mouth of Sakarya River on 7 August, 2006 to the upper 5 km back of the River. A sportsfisherman who caught a tagged sturgeon by line where up- Sakarya River, around 5 km back from river mouth a few weeks after release date. He has to give back it again to the river because of fish power effort. It was no taken tag information. Second information from fishermen came to us almost one and half month later in 29 August 2006 below the İhsaniye town 1 km west of Sakarya River. Sportsfisherman took tag's information from sturgeon and fish is given the back. Later one tagged fish reported from Bulgaria cost and one from north Marmara Sea.

5. OBJECTIVES AND OTHER FACILITIES

The first objective of the study is to determine the sturgeon migration path and feeding areas. Plans currently call for continuing the sturgeon-rearing program at Sapanca Fish Hatchery until a feasibility study can be completed to determine the best options for a complete private sturgeon hatchery operation in Turkey. Local people or the citizens are informed by various media types such as TV, newspaper etc. In addition to this, every summer local people and government personal gather and discuss about sturgeon recuperation effort in Sakarya Yenimahalle town. "The hatchery sturgeon release will act as a 'stop gap' measure to ensure juvenile recruitment into the population while the recovery team works on other measures to increase natural reproduction.
These fish are an important fixture in Sakarya region and have also become popular with artificial culture. Collectively, we need to work to bring this ancient species back from the brink of extinction and to retain this piece of our heritage.

Recently, Ministry of Agriculture and Rural Affairs and Central Fisheries Research Institute Trabzon started on a project titled “Research on Present Status of Sturgeon Population and Rearing Possibilities”. The main aim of the project is to determine current status of the stocks, habitats, genetic variation and to develop conservation and management strategies and plans during three years (2006-2009). This project will cover Turkish Black Sea coastline and Yeşilırmak, Kızılırmak ve Sakarya Rivers. Sampled and/or accidentally caught specimens will be tagged using PIT tags and released after taking required measurements and tissue samples for genetic analyses. Also in this project, wild sturgeon will be kept in cages and tanks for broodstock management. Between 2007-2008, seven years old sturgeons will be investigated regard to artificial spawning. Thus, sturgeon broodstock monitoring will be done by the İstanbul University with Tubitak project. Apart from these sturgeon facilities, one private company is trying to establish a new sturgeon aquaculture farm in Turkey.

6. CONCLUSIONS

There is no doubt that there should be more collective research and investment for this alternative fish species in commercial aquaculture. Future studies can provide more understanding of this ancient fish. In Black Sea basin conservation aquaculture should be raised by interested countries and cooperative studies should be planned among interested countries. Especially, countries such as Russia that are expert especially in sturgeon rearing should help and play a leading role for other countries for the conservation of endangered Black Sea sturgeon species by means of aquaculture. Black Sea countries must take measurements, common strategy and share their scientific knowledges. Also, sturgeon organizations such as WSCS (World Sturgeon Conservation Society) should be manage to solve problems and make cooperation among Black Sea Countries.

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FISHING AND FARMING OF THE BLUEFIN TUNA (*Thunnus thynnus* L.)

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The bluefin tuna is a commercially important and heavily exploited teleost fish in the world's oceans and seas, and occupies a significant place in Turkish marine fisheries. Moreover, it is one of the most important species of aquaculture. An expansion in aquaculture is directly related to the interest and development of the Japanese market. The culture is specifically aimed at producing tuna that have the optimal fat content sought by the "sushi" and "sashimi" market, and both fresh and frozen farmed tuna products are exported to Japan.

Taxonomy recognizes three bluefin tuna species. The southern bluefin ranges from waters off New Zealand and Australia throughout the Indian Ocean and into the South Atlantic. The northern bluefin ranges primarily throughout the North Pacific and North Atlantic, mainly in temperate and subtropical waters. Atlantic and Pacific northern bluefin are genetically dissimilar enough to be considered separate species *Thunnus thynnus* and *Thunnus orientalis* (BLOCK AND STEVENS, 2001).

Bluefins are by far the largest tunas, reaching 650 kg, and living upward of 30 years (Fig. 1). They are characterized by late maturation, slow growth, cool-water life histories, and long generation times. Atlantic bluefin spawn from mid-April to June in the Gulf of Mexico and Florida Straits, and late May to July in the Mediterranean. For management purposes, Atlantic bluefin tuna have been separated into west and east stocks in the Atlantic, divided at 45°W meridian, by the International Commission for the Conservation of Atlantic Tunas (ICCAT, 2006).

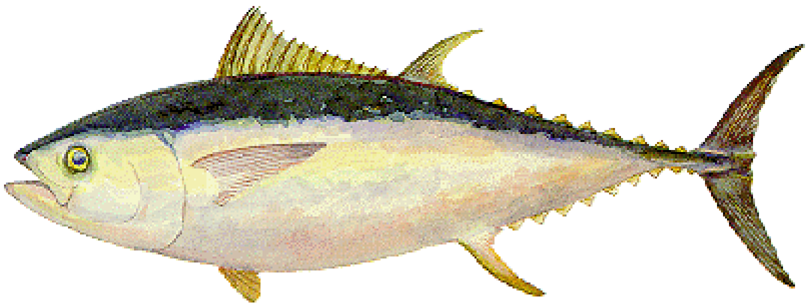

Figure 1. Atlantic bluefin tuna (*Thunnus thynnus* L. 1758)

Commercial activities for farming the bluefin tuna began in the 1970's in Japan and later in Canada. These were based on catching bluefin tuna in the wild and growing them in large cages located offshore for time periods of a few months up to a couple of years. More recently, in the late 1980's and throughout the 1990's, new enterprises were established in other parts of the world in the Mediterranean (Croatia, Cyprus, Greece, Italy, Libya, Malta, Morocco, Tunisia, Turkey and Spain), Portugal, Mexico and Panama, Australia and the US. The operation of some of these activities was terminated due to a lack of available bluefin tuna a lack of know-how, and a shortage of financial resources (MIYAKE *et al.*, 2003). Nevertheless, a few countries (e.g. Syria and Lebanon) have made a strategic decision to farm bluefin tuna.

The supply of capture-based farmed tuna is mainly destined for Japanese "sashimi" but constitutes only 4% of the total amount of tuna required by the Japanese market. The supply of tuna (all species) to the Japanese market ranged from 451.000 to 507.000 tonnes during the four year period between 1998 and 2001, but the ratio of fish with a high product value ("*toro*") is decreasing (IKEDA, 2003). "*Toro*" form only approximately 30% of the fishery catches, but the capture-based farmed tuna are almost entirely considered to be "*toro*". The advantages of cultured tuna are its low price (a third or a half the price of captured tuna) and its availability in supermarkets, fresh fish shops or "kaiten-zushi" restaurants throughout the year (IKEDA, 2003).

Mediterranean tuna farming is based on capturing bluefin tuna in the wild by purse seine during or just after breeding, transferring them to special transport cages, towing the cages to offshore facilities, and feeding them with fish (sardine, herring, mackerel) and cephalopods with a high lipid content. The fish are then kept in large floating cages for variable time periods, ranging from a few months to multiple years depending on the farming location and the fish size. The fattened fish are sold fresh and frozen to Asian markets, and mainly to Japan (DOUMENGE, 1999; OTTOLENGHI *et al.*, 2004).

The fattening of bluefin tuna was initiated in Turkey in 2002 by 3 farms (ORAY and KARAKULAK, 2003). Presently, there are six bluefin tuna farms; two were established in the Aegean Sea (Çeşme-İzmir), and four in Antalya Bay (Alanya-Antalya). The names of Turkish bluefin tuna farms, the dates of their establishment and their capacities are shown in Fig. 2 and in Table 1.

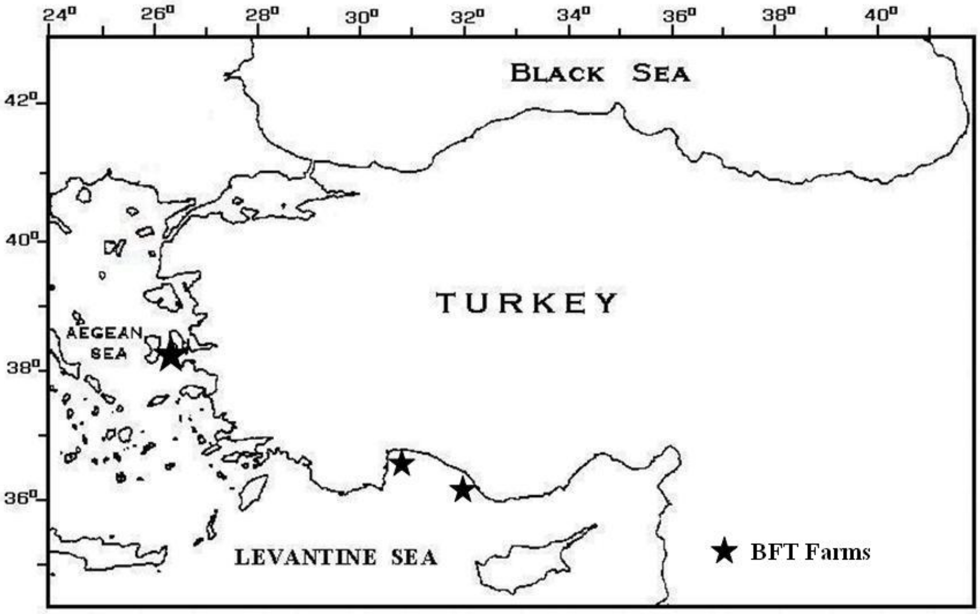

Figure 2. The locations of the bluefin tuna farms in Turkey

Table 1. The bluefin tuna companies, the locations and capacities of their farms in Turkey

Company	Location	Installation date	Capacity (MT)
Dardanel Fishing Ltd.	Gazipaşa-Alanya	2002	1.700
TSM Fishing Ltd.	Antalya	2002	1.000
Akuadem Fishing Ltd	Çeşme-İzmir	2002	800
Akuakocaman Fishing Ltd.	Çeşme-İzmir	2003	800
Aktuna Fishing Ltd.	Gazipaşa-Alanya	2003	1.000
Başaranlar Fishing Ltd	Gazipaşa-Alanya	2004	1.000

The bluefin tuna fishery to catch fish to be fattened is carried out by purse seines in the Levantine Sea between May and July. After tuna are captured by purse seines, divers join the seine to the towing cages underwater, and the live bluefin tuna are transferred to the towing cages (Fig. 3). During the transfer, a net cover designed for this operation is opened, which directs the fishes to the cage. The divers usually count the fish trapped within the seine while cameras are used to count the fish when they pass from the seine to the towing cage. The average weight of the tuna is initially estimated from the dead fish in the seine. There have been some problems associated with fish schooling in the cages and in the estimation of average weight.

Figure 3. The transfer of the bluefin tunas from the purse seine nets to the towing cages.

The live bluefin tuna in the towing cages are brought to fattening farms by tugging the towing cage with an average speed of 1-1,5 miles (Fig. 4). During that time, fish are continuously monitored by the divers and dead fish are taken on board. It generally takes 7-10 days to bring the bluefin tuna in towing cages to the feeding cages depending on the fishing areas. It takes 30-35 days to bring the towing cages to the farms in İzmir (Çeşme), which is the farthest farm from the fishing area. The percentage of fish that die during the fishing operation is 1%, while the percentage of fish that die during transport to the farming area is 3% (FAO, 2005).

Figure 4. The transportation of the towing cages to the fattening farms

In the bluefin tuna fattening farms, cages are made of high density polyethilene (500 mm Ø) pipes with a diameter of 50 m (Fig. 5). Nets with a depth of 20-30 m and a mesh size of 80-110 mm are bound to these round cages. These cages are installed in areas with high currents and depths of at least 50 m and 1000-1200 m away from shore. The cages are fixed to the base with an anchoring system which is dependent on the regional conditions, and which was investigated before installing the cages. Generally, plow-type anchors with a weight of 750-1000 kg are used. The volumes of the surface buoys used in towing cages are between 260 and 1250 lt. At a density of roughly 2-3 kg/m^3, up to 130 tonnes of fish can be stocked in each cage.

Figure 5. The towing cages using for the transfer of the fish after catching

After the transfer of the bluefin tuna to the feeding cages, fish were found to be under stress and some wouldn't feed for up to one month. Bluefin tuna were fed twice a day 6 days a week. In some farms, bluefin tuna were fed once a day. The following species were used as feed: imported herring (*Clupea harengus*), capelin (*Mallotus villosus*), shad (*Alosa alosa*), sardine (*Sardina pilchardus*), and Atlantic mackerel (*Scomber scomber*) from Spain, Mauritania, Norway and Holland. Apart from these fish, horse mackerels, anchovies and calamares caught in Turkish waters were also provided as feed. The feed was administered to the bluefin tuna by shovels and automatic feeding systems (Fig. 6).

Figure 6. The feeding of the bluefin tuna by shovels and automatic feeding systems

The bluefin tuna are stocked in the cages between May and July and are fed for 4-9 months before being harvested between October and January (Table 2). During harvesting, bluefin tuna are crowded in a small area using a net, and are then killed with a spike to the brain or by electricity underwater before being taken from the cages (Fig. 7). Tuna are sold as fresh or frozen and most of the fresh tuna are sent to Japan market by air. Vessels from eastern countries and those in the Mediterranean Sea buy tuna from the Turkish farms and sell it as frozen tuna in the Asian market (Fig. 8 and Fig. 9).

Figure 7. BFT harvesting at sea

Table 2. The capacity of the farms and the total weight of the bluefin tunas before and after fattening periods according to the years (FAO, 2005).

Year	Flag of origin of seed fish	No of cages	Total farm volume (m^3)	Input season (month)	BFT introduced (tonnes)	BFT size range (kg)	BFT produced (tonnes)	BFT size range (kg)
2002	Turkey	18	835 000	06	1600	25-450	2060	35-580
2003	Turkey	38	1 625 000	06-07	3300	45-450	3800	65-600
2004	Turkey, Tunisia, Libya, Korea	47	1 865 000	05-07	2700	35-400	3300	50-600
2005	Turkey, Tunisia, Libya, France, Spain	47	1 865 000	05-07	3476	15-300		25-360

Figure 8. A vessel from an eastern country buying tuna from the Turkish farms

When compared with aquaculture of other species, tuna fattening yields a higher economic benefit in a short period of time. The quantity of fish sent to Japan and the economical profit between 2004 and 2006 are shown in Table 3.

Figure 9. The sold fish from the Turkish farms are immediately cutting on board and frozen in the ships

Table 3. Japan Imports of Turkish Fresh & Frozen Bluefin Tuna 2004-2005-2006 (WWF, 2006).

Year	Kilos	Value in Euros
2004	2.804.591	47.949.676,92
2005	2.827.432	49.648.896,30
2006*	1.144.660	19.008.602,84

** The data from the first six months of 2006*

Mass mortality has been noted in cages of the Turkish bluefin tuna farms due to effects of the storms and currents, as a result of loose cage strings which have broken off from the bottom, and because of shrinking nets. In addition, a mass mortality of bluefin tuna (700 tonnes) at a farm in Antalya was caused by sudden changes in marine water due to a flood in 2003 (Fig. 10). Other factors causing mortality at fattening farms are: a) stress during the transfer to cages after catch; b) high stocking density in the cages; c) a rich fish fauna around nets, caused by high quantities of fish feed in the area, which may cause tuna to be trapped nets when they attack small pelagic fishes entering into the cage; d) stress caused by being trapped in a confined space during thundery weather and e) sudden changes in oxygen concentration and water turbidity during flooding or during snow when in farms located close to areas where the river drains into the sea, (e.g. the farm Alanya - Antalya).

Figure 10. The damaged and broken cages and dead fish after the storm (the farm Alanya)

After January, the farming operations are negatively affected by high winds, currents and rainfall, and by storms and decreased water temperatures. Decreases in water temperature cause a decrease in food consumption and, accordingly a decreased growth rate of the fish. Generally, food consumption changes depending on the water temperature. The highest food consumption occurs at 23-25ºC, which may be up to 10% of body biomass per day. It may decrease at 18^{o}C when daily food consumption does not exceed 2% to 3% of body weight. It is obvious that tuna can tolerate a wide range of temperatures. The anatomical, physiological and biochemical features makes this fish to maintain its body balance even during the wintertime when the fish were taking food at 11ºC (KATAVIC *et al.*, 2003). For these reasons, the fattening operations are carried out only until January. In the wintertime, both the feeding and harvesting become, and consequently most of the companies start harvesting in the autumn and end the sale of tuna in December and January, which are the best times for selling in terms of the tuna market.

In recent years, there has been a decline in stocks of tuna and tuna-like species. Therefore, conservation of these species has become an important issue. ICCAT (International Commission for the Conservation of Atlantic Tunas) works on the conservation of bluefin tuna stocks in the Atlantic Ocean and the Mediterranean Sea.

Catching quotas for the bluefin tuna fishery in the Mediterranean Sea were introduced in 2002 by ICCAT. Since Turkey became a member of ICCAT in 2003, it has not been assigned any specific catch quota. The fishery quota of seven non-member countries, allocated in the “other” category including Turkey was 1146 -823 tonnes during the 2003-2006 period. This quota totally used by Turkey. Firms can buy fishery quotas from other countries (Table 4 and Fig. 11).

Table 4. The bought amount of the bluefin tuna from the Turkish fishermen and import amount from other countries by the Turkish farms. The catch amount, the growing rate of the fish and the export rate of the Turkish bluefin tuna farms.

Year	Catch	Import	Carry over	Growth	Expected outputs of farms	Lost fish	Allowable max. export	Realised export
2003	3.300	0	0	1.650	4.950	500	4.450	4.250
2004	1.075	1.590	170	1.460	4.295	225	4.070	3.963
2005	990	2.486	100	1.813	5.389	0	5.389	

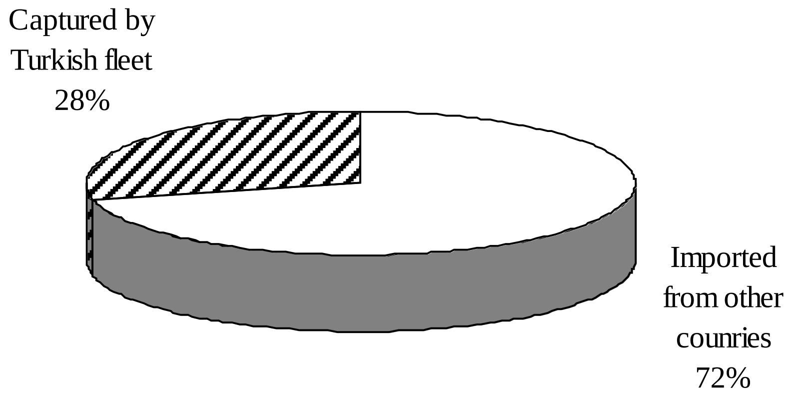

Figure 11. The percentage of fish which are fattened in Turkish bluefin tuna farms (2005)

ICCAT has made a new recommendation for the period between 2007 and 2010 for the East Atlantic & Mediterranean stock. The TAC (Total Allowable Catch) for 2007 was set as 29.500 tons whereas the TAC for 2010 was decreased to 25.500 tons. In Table 5, the definitive allocation is shown. Libya unilaterally objected to ICCAT’s management scheme; Turkey accepted the ICCAT’s management scheme and unilaterally allocated 1958.68 tonnes of bluefin tuna.

Table 5. Catch quotas of the countries in 2007 (ICCAT, 2006).

	Catch Quotes (ton)
European Community	16779.55
Algeria	1511.27
China	65.78
Croatia	862.31
Island	53.34
Japan	2515.82
Korea	177.80
Tunisia	2333.58
Libya	1280.14
Morocco	2824.30
Norway	53.34
Syria	53.34
Taiwan	71.12
Turkey	918.32
Others	1 184

Turkey is a peninsular country surrounded by three seas with a total coastline of 8333 km. Its fishing fleets are well-developed and the history of the bluefin tuna fishery in Turkey dates back to ancient ages. However, Turkey’s catch quota was determined without taking into consideration the history of the fishery in Turkey.

CONCLUSIONS

Due to economic competition between the countries, bluefin tuna farms are becoming widespread day by day. There is a concern that, increases in the number of bluefin tuna farms, which yield high economic profits, could negatively affect the sustainability of natural stocks. Although the environmental impacts of farms are still unknown, it is frequently discussed in scientific institutions and public opinions. The advantages and the potential disadvantages are mentioned below:

1. In Turkey, the price and export values of bluefin tuna captured between May and June are quite low; during May and June the fishery is carried out intensively in the Mediterranean Sea and the quality of meat does not meet the expectations. After being caught by purse seines, fish are kept in the net for a long time before being taken onboard. However, for the quality of meat, fish are required to be killed as quickly as possible. Because of the above-mentioned activity carried out in Turkey, the export prices are low in the Japanese market. The bluefin tuna in the farms reach the highest level of meat quality, and are exported to Japan when the demand of fish is high. The increase in economic value yields an economic benefit for producers and farmers, and also for the national economy.

2. The bluefin tuna fishery for fattening fish is carried out between May and July. It is inevitable that the fishing, which is carried out during the spawning period (KARAKULAK *et al*., 2004; CORRIERO *et al*., 2005) and in the spawning area of bluefin tuna (GARCIA *et al.*, 2005), has a negative impact on natural stocks (Fig. 12). The fish in stages of gonadal development are under stress after being transferred to the cage. Accordingly the possibility of fertilization and the survival of the fertilized egg is low, and consequently future reduction in recruitment could be expected. As a result, there could be a decrease in the natural stocks.

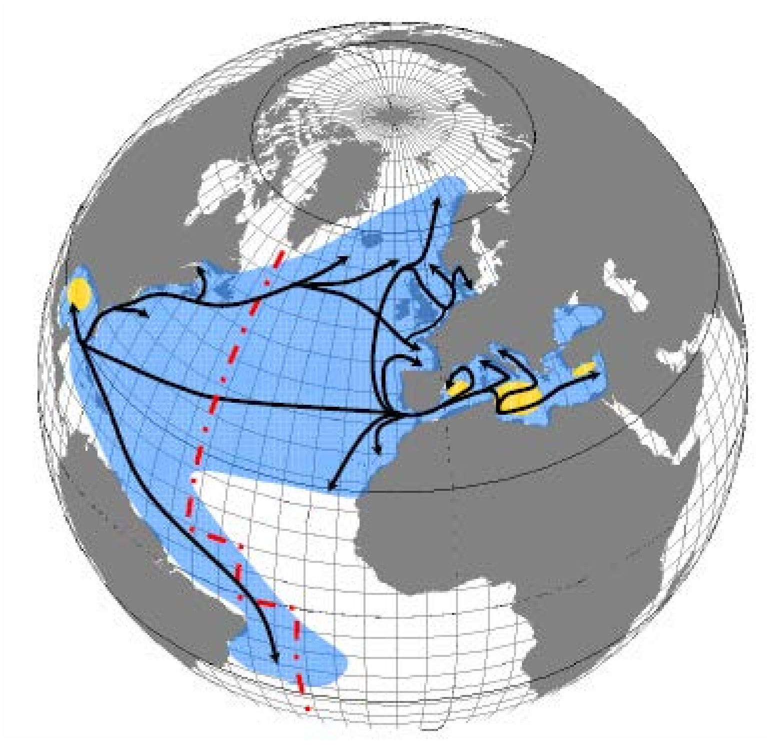

Figure 12. Spatial distribution of Atlantic bluefin tuna (gray shading), main migration routes (black arrows) and main spawning grounds (dark dotted gray areas) (FROMENTINE and POWERS, 2005)

3. Bluefin tuna farming and farming-related activities have created a lot of new job opportunities. Each farm employs 40-50 employers, and also the bluefin tuna fishery employs approximately 2000 employers.

4. The food and metabolic waste of fish, as well as the potential use of chemicals and antibiotics in the future could be a source of pollutants. As a result of accumulation of pollutants in the basin, the destruction of sea-grass (*Posidonia oceanica*) beds under the cages, and an increase in sedimentation and organic richness is

inevitable. The sea-grass is under protection and is the most abundant living resources in the sea. (TUDAV, 2002).

5. A decrease in the small pelagic fish and invertebrate stocks used in feeding of tuna.

6. To minimize the negative impacts of sea bass and sea bream culture on the environment, the Ministry of Agriculture and Rural Affairs has directed companies to locate farms off-shore instead of in coastal areas. In Turkey, in spite of this fact, the bluefin tuna farms have been installed only 1000-2000 m away from the coast. This situation could negatively affect the coastal area. The environmental pollution to coastal areas could be reduced by off-shore farming practices.

7. The impacts of farms on the environment necessitate regular monitoring. The cages should be constantly observed and controlled in order to clean non- consumed feed.

8. Since the farming of tuna yields a high economic benefit in a short time, the number of entrepreneurs will be high. Therefore, in parallel with the quota implementation and to conserve the stocks, the number and capacities of farms should be limited

According to the stock assessment which was carried out in 2006 by ICCAT, the biggest problem was the lack of statistical data concerning fishing and farming (ICCAT, 2006). Quantities of bluefin tuna caught, shipment vessels and cages, also the stocking density should be recorded, and the records should be regularly sent to ICCAT.

Bluefin tuna fishing in the Mediterranean Sea in June, when tuna spawn intensively, causes a decrease in recruitment. Scientific institutions and non-governmental organizations expect ICCAT to take more protective measures in this time period.

The companies which carry out bluefin tuna farming activities must support and finance research on bluefin tuna hatching, taking into account the decrease in stocks and economic investments. In this manner, the stocks will be conserved and the future of farms will be guaranteed.

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CRUSTACEAN AND SHELLFISH PRODUCTION

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1. INTRODUCTION

Production of crustaceans and shellfish has long been practiced as collection and capture from the wild in Turkey. Majority of the production in crustaceans come from mainly marine shrimps and freshwater crayfish (Table 1). A high percentage of shrimps are caught in the Sea of Marmara, whilst crayfish are fished in cooler regions of the Anatolia. The major bivalve and gastropod groups in order of abundance in natural waters are clam, oyster, mussel and whelk. These are mainly distributed in northern, north-eastern and western coastal regions of Turkey. Clam and whelk constitutes the bulk of the shellfish production in the country.

Crustacean and bivalve aquaculture has received considerably less attention compared to fish culture in Turkey. Despite farming activities, which were initiated in the early 1980's with carp and trout, just a few attempts have been made concerning crustacean farming (penaeid shrimp) in the country though there has been a great increase in the interest by researchers and the fast developing aquaculture sector in the frame of diversification of species. At present, production of all crustaceans in Turkey (except those produced for experimental purposes) is carried out by fisheries. Similarly, shellfish farming started in the early 1990's with mussel, but despite several attempts it has not showed much progress over the past 15 years.

2. CRUSTACEANS

2.1. Capture

Table 1. Captured Quantity of Crustaceans in Turkish Waters (Tons) between year 2000 and 2004.

	YEARS				
Group	2000	2001	2002	2003	2004
Shrimp	2000	3000	4000	6000	5279
Crayfish	1681	1634	1894	2183	2317
Crab	181	251	218	172	169
Spiny lobster	11	18	19	11	22
Homarid lobster	15	10	9	25	15

The most commonly captured groups are a number of marine shrimp species and the narrow-clawed crayfish *Astacus leptodactylus*. The highest capture production of shrimps occur (67.6%) in the Sea of Marmara and the main species caught in this region is the deep-water pink shrimp *Parapenaeus longirostris* (Bayhan et al., 2005). The Agean Sea contributes 18.3% and the Mediterranean Sea 13.8% to the total catch. The main commercial species caught in Turkish waters, are; *P. longirostris* (mainly in the Sea of Marmara), *Melicertus kerathurus* (Aegean Sea and Mediterranean Sea), *Marsupenaeus japonicus*, *Penaeus semisulcatus*, *Metapenaeus monoceros* (mainly in north-eastern part of the Mediterranean Sea) as well as *Melicertus hathor* (Kumlu et al., 2002; Gokoğlu and Kaya, 2005) and some other species i.e. *Aristaeomorpha foliacea* and *Plesionika heterocarpus* to a lesser extent.
The only freshwater crustacean species with an economical importance in the country is what is known as the Turkish crayfish *A. leptodactylus*. This species is naturally and widely distributed in lakes, ponds, reservoirs and river systems throughout temperate regions of the country. Turkey used to be the major supplier of crayfish to Europe before the plague disease caused by *Aphanomyces astacii* which struck the populations in the mid 1980's. Because of the plague disease, over-fishing, pollution, and water withdraws for agricultural irrigation purposes, the annual harvest of *A. leptodactylus* in Turkey declined from approximately 8000

tons in 1984 to as low as 200 tons in 1991. More recently, the crayfish populations have started to recover and the harvest has gradually increased from 1681 tons in year 2000 to 2317 tons in 2004 (Table 1). However, the plague is still observed in this species at certain localities and that the present harvest of *A. leptodactylus* is still much lower than the catch in 1980s (Harlioglu and Harlioglu, 2006). Despite loosing the position as a major exporter of crayfish to Europe, so far, there has never been any attempt to introduce any plague-resistant alien species into the country for restocking or aquaculture purposes.

In Turkish marine coasts, two clawed lobster species *Homarus gammarus* and *Nephrops norvegicus*, one spiny lobster species *Palinurus vulgaris* (*elephas*), as well as three slipper lobsters *Scyllarides latus*, *Scyllarus arctus* and *Scyllarus pygmaeus* are being captured for commercial purposes. Among these, landing statistics of only the spiny- and clawed-lobsters are available (see Table 1).

Although abundant in numbers particularly in waters adjacent to lagoon systems and in estuaries in various parts of the country (for example north-eastern part of the Mediterranean Sea), the blue crab *Callinectes sapidus* and the blue swimmer crab *Portunus pelagicus* populations are still under-utilized in the country.

2.2. FARMING AND FUTURE CONSIDERATIONS

Among the crustaceans occurring in the Turkish waters, only marine shrimp has been farmed in the country, so far. The first commercial cultivation effort in the shrimp culture began in a private farm in large ponds by using semi-intensive method in the early 1990s in Adana on the coast of northeastern Mediterranean Sea. Later on, in 1995 another company built a modern shrimp farm with a production capacity of 650 tons in the Manavgat area by the Antalya Gulf, but was closed down a few years later. Unfortunately, the shrimp farming has not been able to sustain itself in the country for various reasons and currently no commercial activities are present in the country, but research on various aspects are underway in state research laboratories as well as private farms. Among the drawbacks for failure of shrimp farming in the country at that time were lack of expertise, poor marketing strategies, inadequate farm system design to cope with cold winter conditions, weak pond-management etc. So far, two Indo-Pacific species i.e. *P. semisulcatus* (Fig. 1) and *Mar. japonicus* and an imported species *P. monodon* have been tested under local conditions of southern Turkey with limited success.

Figure. 1. Green tiger shrimp *Penaeus semisulcatus*, the most commonly studied shrimp species for aquaculture.

Since the mid 1990's, great efforts have been spent to study biological aspects (Kumlu et al., 1999a; Bayhan et al., 2005; Turkmen and Yılmazyerli, 2006) and cultivation prospects of local species in various research centers located along the coast of Mediterranean Sea (Aktas and Kumlu, 1998; Kumlu et al., 1999b; Kumlu and Eroldogan, 2000; Kumlu et al., 2001a,b; Soyel and Kumlu, 2003; Aktaş et al., 2003; Kumlu et al., 2003; Aktaş et al., 2004; Kır et al., 2004; Kiris et al., 2004; Kumlu and Kır, 2005; Kır and Kumlu, 2006) and the Aegean Sea (Turkmen 2003; 2005; 2007a,b) in Turkey. At present, much more experience on biological requirements and adequate production techniques as well as management of our shrimp species under local environmental conditions have been gained over the past decade. Fast developing sea bream, sea bass and trout farming sector in the country has also resulted a vast accumulation of experience in the fish feed production, manufacturing aquaculture machinery equipments, marketing strategies etc. At present and in the very coming years, saturation of market with sea bream, sea bass and rainbow trout is expected to divert research into production of other fish species, various bivalves and crustaceans particularly marine shrimps.

Subtropical climate conditions, long coastline, clean coastal waters and close proximity to the European Markets are main reasons favoring shrimp farming in Turkey. The biological attributes of marine shrimp tend to promote a production cycle based on late-spring stocking followed by harvest in the late-autumn of the same year, with all harvesting taking place at the end of the summer season when demand is naturally falling. Unlike in the tropics, within the limited grow-out period in this climate (5-6 months), one crop per year can only be realized. A number of strategies may be suggested to produce more crop or increase final marketable size of shrimps grown in farms in the sub-tropics. The first may be to produce post-larvae (PL) pre-seasonally in order to allow shrimp farms to stock grow-out ponds with shrimps earlier in the year. To achieve this, spawning, larval and nursery culture of penaeid shrimps has to be carried out in greenhouses during winter months until water temperature of grow-out ponds is warm enough for fast growth. Another strategy could be to utilize geothermal waters or to over-winter PLs throughout the cold season at the cheapest possible cost and then stock them into grow-out ponds in the next warm season (Kumlu et al., 2003; unpublished data). In either case, holding shrimp over the winter leads to extra cost and would naturally reduce competitiveness of the farms.

Figure 2. The narrow-clawed crayfish captured from Keban Dam Lake.

Currently, most of marine fish production in the country is based on cage farming that is mostly concentrated in the Aegean region and that there is neither cage farming nor land-based pond production systems in the warmer coastal Mediterranean zone, which is considered to be suitable for shrimp culture. Other groups of crustaceans such as crabs particularly *C. sapidus* and *P. pelagicus*, which are abundant in lagoon systems in the region, have also aquaculture potential in southern part of Turkey. However, the main factors affecting future development of crustaceans' production in the land-based systems are availability of comparatively large suitable sites, easier licensing procedures, more proper production planning, economical over-wintering solutions, and well marketing strategies if to become successful and remain competitive.

Concerning inland waters, our endemic crayfish species *A. leptodactylus* (Fig. 2) does not appear to emerge as a candidate for farming in the country in the coming future because of its susceptibility to crayfish plague disease and slow growth rate. If we are to grow crustaceans in our inland waters, we will have to consider and discuss possibilities of farming foreign species in temperate and warm regions. Among these, the giant prawn *Macrobrachium rosenbergii* and the red-claw Australian crayfish *Cherax quadricarinatus* will have to be considered for cultivation in land-based pond farms along the sub-tropical regions of the Mediterranean region. These species are fast-growing crustaceans which are capable of reaching to marketable size within one growing season (5-6 months).

3. SHELLFISH

3.1. Capture

Shellfish production is largely based on natural stock collection and the most important groups are clams i.e. *Venus gallina*, *Tapes decussatus*, which are collected from inter-tidal areas, and whelk (*Rapana* sp.). Total bivalve production (wild and farmed) has been unstable during the last 14 years (Table 2) Values were drastically rose from 15900 tons in 1990 to 42013 tons in 1994, but production showed a sharp decrease to 6293 tons in 1999. The latest statistics on shellfish production revealed a total shellfish production of 24339 tons in 2004 (SIS, 2006). Of the total harvest of 40157 tons in 2000, about 90% was sea snail (*Rapana* sp.). Despite the harvesting difficulties, good market prices, principally at the Japanese market, encouraged the *Rapana* catches. In 2004, clam and whelk production constituted of 80.6% of the total country production of shellfish (38373 tons).

Table 2. Shellfish production values (mt) in Turkey

	BIVALVE				GASTROPODS		
YEAR	Oyster	Mussel	Clam	Scallop	Veined whelk	TOTAL BIVALVE	TOTAL SHELL-FISH
1990	2471	6328	13207	1	6100	15900	22007
1991	2185	6263	12427	-	3730	20835	24605
1992	2226	6757	20412	-	3583	29395	32978
1993	1222	7086	30134	202	3698	38644	42342
1994	1803	8033	31869	308	2607	42013	44620
1995	1836	6042	11864	23	1198	19765	20963
1996	1140	3500	10925	52	2447	15617	18064
1997	1495	6450	7150	95	2020	15190	17210
1998	1050	3880	3550	50	4000	8530	12530
1999	840	1800	3585	68	3638	6293	9931
2000	150	1200	10000	570	2150	11920	14070
2001	10	1500	7500	150	2650	9160	11810
2002	70	5000	10000	470	6241	15540	21780
2003	120	8915	19700	1300	5500	30035	35535
2004	130	5734	16899	1576	14034	24339	38373

The principal species collected in Turkish coasts on a regular basis are the stripped clam (*Venus gallina*), Mediterranean mussel (*Mytilus galloprovincialis*), European flat oyster (*Ostrea edulis*) as bivalve species and veined whelk (*Rapana venosa*) as a gastropod species (Table 3). Among the shellfish groups, 8 species (*) are regularly harvested in commercial quantities for local consumption and exportation.

At earlier times, shellfish used to be collected for use as bait. However, more recently, they have been utilized more and more commonly as human food along the coastline of mainly western-Turkey. The dominant bait species, which is mainly used for the long-line fishery, are the razor clams (*Solen marginatus*) and banded dye–Murex (*Hexaplex trunculus*).

Wild shellfish collection at commercial level has been ongoing since 1974. Most of the Turkish shellfish fishery has been concentrated mainly along the coasts of the Black Sea, Marmara Sea and Aegean Sea. Collections are mainly done by dredging with small vessels near the coasts as well as far offshore. Only a small part of shellfish was gathered by divers (Fig. 1). The two major shellfish, the gastropod *R. venosa* is mainly collected on the eastern Black Sea Coasts by dredges and divers, while clams are fished from Black Sea to Aegean Sea by dredges, divers and shovels.

Table 3. Shellfish species, their production methods and aims

GROUPS AND SPECIES	DISTRIBUTION	PRODUCTION METHOD	PRODUCTION PURPOSE
Bivalve			
*Venus gallina** (striped clam)	Black Sea, Marmara Sea and Aegean Sea	Fishery	Human consumption
Mytilus galloprovincialis * (Mediterranean mussel)	Black Sea, Marmara Sea and Aegean Sea	Fishery and culture	Human consumption
*Ostrea edulis** (flat oyster)	Marmara and Aegean Sea	Fishery	Human consumption
*Tapes decussatus** (carpet clam)	Marmara and Aegean Sea	Fishery and culture	Human consumption
*Ruditapes philippinarum** (Manila clam)	Marmara and Aegean Sea	Fishery and culture	Human consumption
*Venus verrucosa** (warty clam)	Aegean Sea	Fishery	Human consumption
*Pecten jacobeus** (scallop)	Marmara and Northern Aegean Sea	Fishery	Human consumption
Callista chione (smooth clam)	Aegean Sea	Fishery	Human consumption
Cardium tuberculata (tuberculate cockle)	Aegean Sea	Fishery	Human consumption
Modiolus barbatus (horse mussel)	Marmara and Aegean Sea	Fishery	Human consumption
Donax trunculus (truncate donax)	Marmara and Aegean Sea	Fishery	Human consumption
Arca noea (Noah's ark)	Aegean Sea	Fishery	Human consumption
Solen marginatus (razor clam)	Aegean Sea	Fishery	Bait
Gastropod			
*Rapana venosa**	Black Sea and Marmara Sea	Fishery	Human consumption
Hexaplex trunculus (banded dye-murex)	Aegean Sea	Fishery	Bait
Murex (Bolinus) brandaris (purple dye-murex)	Aegean Sea	Fishery	Bait

*regularly harvested species

Figure 3. Clam (*Tapes decussatus*) fishery in the Aegean Sea.

3.2. Culture

Although there have been several scientific studies on bivalve culture in the Aegean Sea (Alpbaz et al., 1991; Yolkolu and Lök 2000; Hindioglu et al., 2001; Serdar and Lök, 2005; Lök et al., 2006; Lök and Acarlı, 2006; Lök et al., 2007; Serdar and Lök, 2007; Serdar et al., 2007), Marmara Sea (Yıldız and Lök, 2005a; Yıldız et al., 2005b; Yıldız et al., 2005) and Black Sea (Karayücel et al., 2002), commercial activities are developing slowly and there is only one functioning bivalve farm at present in Turkey.

Shellfish farming in Turkey began in the early 1990's with mussel *Mytilus galloprovincialis* in the Dardanelles in the Marmara Sea. This farm carried out the first mussel raft culture in Turkey with two rafts at a size of 20x20 m and 12x12 m with 1000 and 250 ropes, respectively. Each rope was 12 m long. The farmers collected the mussel spats from adjacent waters in that area. Unfortunately, this farm was active for only a few years before being closed. Second farm was active in the Ayvalık region of the Aegean Sea between 1996 and 1998. This farm used a kind of bouchot culture technique. The farmers used only under-marketable size mussels (4-5cm) for a further growth of 3-5 months until reaching marketable size. This farm also closed down 3 years later and there has been no farm since then practicing bouchot technique in the country. This farm had also depuration plants for bivalve species and is still running. The third farm started to produce mussel (*M. galloprovincialis*) in raft and long-line culture systems in Mersin Bay (Izmir) in 2000 and is still active with a production capacity of 1000 mt/year. The farm has 42 rafts

(6x6 m) with 150 ropes on each raft (Fig. 4). The long-line culture system itself is relatively simplistic and consists of a series of buoyed horizontal lines from which an extensive series of vertical substrates are hung. The horizontal lines are approximately 200 m long, with 30-L plastic air-filled drums attached for flotation at intervals of approximately 5m. Each horizontal line is securely anchored at each end using large suitable anchoring systems. The distance between horizontal lines is generally about 3 m. The vertical substances are spaced at intervals of approximately 50 cm along the horizontal lines. The length of the verticals has been standardized at 4-5 m. Twelve vertical substrates are generally hung between each of the flotation drums. In the existing pilot culture operations, all mussel spat is collected naturally directly on the long-line systems. Main peak for larval settlement for this area is the late fall (November-December) (Lök, 2001). Water depths in the region of these basins are generally less than 20 m.

Figure 4. Mussel culture on rafts in Izmir

M. galloprovincialis attains sexually maturity at 40-50 mm, or 6-7 months of age and can reach marketable size of 70-75mm in 15-18 months in the Aegean region. The mussels with ripe gonads can be found throughout the year, but two major spawning seasons (early spring and late autumn) are evident in the Aegean Sea (Lök, 2001; Lök et al., 2007). The clam *T. decussatus* in size of less than 2 cm are cultured to marketable size of 3.5-4 cm within 6-8 months with a method which may be considered as extensive. These culture sites do not receive any special preparation before juvenile clam deployment. Fisherman chooses shallow waters or lagoon areas in Izmir and Çanakkale with appropriate bottom for clam growth. Juvenile clams were planted directly on the bottom.

In the future, clam harvest and culture activities are expected to increase along the Turkish coasts to meet high international demand.

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AQUAFEED INDUSTRY

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1. INTRODUCTION

The increase in the demand for aquatic food, mainly because of its high nutritional quality and also as a source for essential nutrients of vital importance for human health, has driven up the fisheries sector leading to an increase in the seafood market prices. With the decrease of marine resources due to uncontrolled catch and even depletion of some marine species, climate changes and the increase in demand for fish as food, much more attention is paid to aquaculture industry throughout the world. Therefore, this industry has become a profitable and highly developed branch of the economics of many countries all over the world. As the aquaculture sector develops its share in the fisheries industry, the sectors related to this branch (e.g. the feed production, cage and tank construction, etc.) are continually gaining significance. Because nutrition in aquaculture activities mainly depends on feed, the use of aquafeed plays an important role in aquaculture development and production. The cost of feed and feeding management accounts for 50% - 60% in aquaculture operations. Therefore, feed quality and feeding strategies are of great importance in the development of fish farming industry.

2. BRIEF HISTORY OF FEED PRODUCTION

Before introducing the aquafeed industry, the livestock feed industry of Turkey can be briefly analyzed. The first feed mill in Turkey was founded in 1955 by the private sector. One year later, "Yem Sanayi Türk A.Ş." was founded by the State. During the next decade, 26 feed mills, supported by "Yem Sanayi Türk A.Ş.", joined the feed sector of Turkey. The private feed sector has developed after 1965 and nowadays, there are 646 feed mills, 468 of which are currently operating and producing feed to meet the requirements of livestock, poultry, fish farming as well as pet food production. Due to the privatization policy of the Turkish government the feed mills of "Yem Sanayi Türk A.Ş." were privatized in 1996.

The numbers, capacities, and the rate of capacity use of feed mills between 1999 and 2006 are given in Table 1 (MARA, 2007). From this table it can be seen that the number of feed mills in 1999 was 486, while this number in 2006 increased by 33% to reach 646. Due to the economic crisis in 2000 in Turkey, the rate of capacity use of feed mills has decreased below 50% during 2001 and 2002, though during the last four years, only 60% of the capacity of the feed mills is employed.

Table 1. The numbers, capacities, and the rate of capacity use of feed mills between 1999 and 2006.

Year	Feed Mills Numbers	Total Capacity (Thousand tones/year)	Not operating feed mills		Rate of capacity use (%)
			Number	Capacity	
1999	486	11714	90	1518	59
2000	519	12584	98	1708	61
2001	540	12964	110	1017	48
2002	569	13590	147	2614	48
2003	589	14056	143	2514	54
2004	610	14634	155	2672	58
2005	631	15136	172	3142	57
2006	646	15598	178	3090	60

According to the official information from the Ministry of Agriculture and Rural Affairs, the total feed production increased from 5791 tonnes in 1960 to 7.467.081 tonnes in 2006, the main feed production being for the poultry and ruminant farming (Table 2). It is predicted that actual production is about 10 million tonnes.

Table 2. Feed production in Turkey between 1960 and 2006 (MARA, 2007).

Year	Poultry Feed (tonnes)	Ruminant Feed (tonnes)	Other Feeds (tonnes)*	TOTAL
1960	3.475	2.172	145	5.791
1970	129.100	84.613	4.362	218.975
1980	609.703	834.280	5.008	1.448.991
1990	1.416.110	2.537.137	22.835	3.976.082
1995	1.706.787	2.748.846	17.779	4.483.412
1996	2.012.001	2.462.876	27.905	4.502.782
1997	2.126.932	2.796.851	35.928	4.959.711
1998	2.217.391	2.996.242	61.917	5.275.550
1999	2.666.459	3.338.852	40.795	6.046.106
2000	3.012.483	3.606.788	42.955	6.662.226
2001	2.456.645	2.677.066	44.619	5.178.330
2002	2.498.744	2.625.624	51.713	5.176.081
2003	2.775.169	3.015.949	62.279	5.853.397
2004	3.163.394	3.664.651	77.525	6.905.570
2005	3.054.349	3.718.610	61.314	6.834.273
2006	2.872.860	4.516.646	77.575	7.467.081

(*Other feeds includes aquafeed.)

Although there is a constant increase in all feed types production quantities, the ratio of poultry feed to the total feed production has decreased from 60% in 1960 to 38,5% in 2006. Furthermore, this decrease in the ratio of poultry feed quantity is not related with a decrease in poultry production, but is related with the use of improved poultry stocks and the use of feed with better efficiencies and conversion ratios. On the other hand, the ratio of ruminant feed to the total feed production has increased from 37.5% in 1960 to 60.5% in 2006 (Figure 1). Also, the fish feed production in Turkey has favorably increased in the last decade.

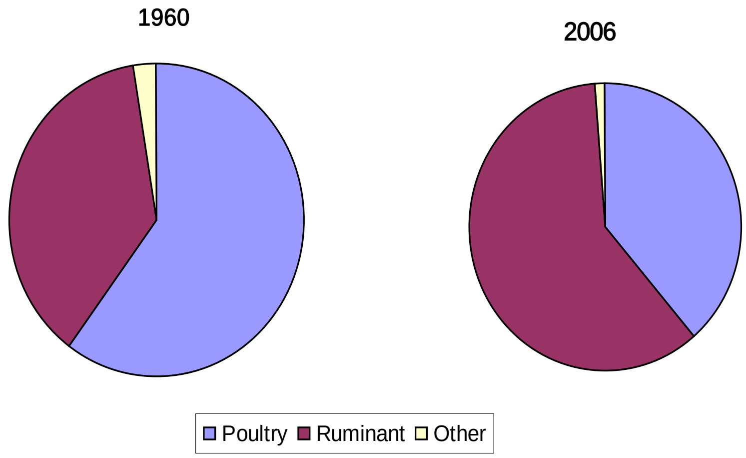

Figure 1. Poultry, ruminant and other feed production in 1960 and 2006 in Turkey (MARA, 2007).

3. AQUAFEED PRODUCTION

Although fish farming in Turkey began during 70s with the foundation of a rainbow trout farm by the government in conjunction with research institutes, and the first sea bream and sea bass farm was founded in 1985, the first fish feed production started in 1986 and the first shrimp feed was produced in 1999. Currently, though there is no shrimp farming in Turkey, shrimp feed is produced and exported.
Today, the aquafeed industry of Turkey has two main segments: the freshwater fish, mainly trout and marine fish, mainly sea bass and sea bream.

Based on the official statistics, the aquafeed production quantities are given in Figure 2. Despite the fact that intensive aquaculture production started in the 1980s, aquafeed production data statistics have been evaluated by the authorities since 1999.

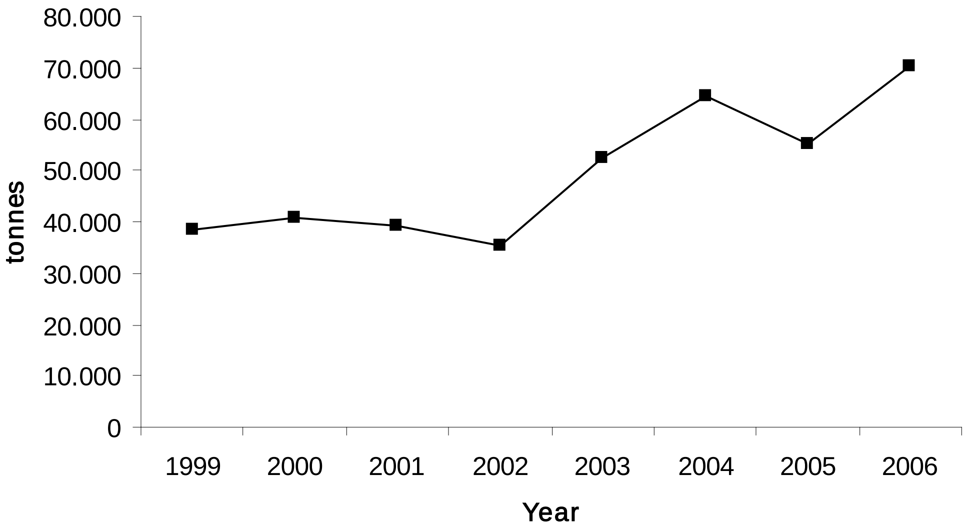

Figure 2. Aquafeed production in Turkey (1999 – 2006) (TURKSTAT, 2007)

From Figure 2, it can be seen that there are fluctuations in the aquafeed production. These fluctuations are related not only to the economic crisis in 2000, but also to the problems in the documentation of the production quantities. For instance, according to the total aquaculture production and the estimated economic Food Conversion Ratio (FCR) for trout and marine fish for 2005, the total aquafeed used in Turkey is estimated to be 172.693 tonnes, while the sum of the official aquafeed production and aquafeed import is around 71.000 tones (Table 3, 4 and 5). Given the steady increase in Turkish aquaculture production quantities, it is expected that the demand for aquafeed will increase by approximately 40% by 2010.

Table 3. Estimated rainbow trout feed market of Turkey

	2001	2003	2005	2010
Total production (tonnes)	38.067	40.863	49.282	59.434
Estimated economic FCR	1,3	1,2	1,1	1,0
Estimated Total Feed Consumption (tonnes)	49.487	49.036	54.210	59.434

Table 4. Estimated marine fish (sea bass, sea bream) feed market of Turkey

	2001	2003	2005	2010
Total production (tonnes)	28.485	37.717	65.824	114.862
Estimated economic FCR	2,0	2,0	1,8	1,6
Estimated Total Feed Consumption (tonnes)	56.970	75.434	118.483	183.779

Table 5. Estimated total aquaculture feed market of Turkey*

	2001	2003	2005	2010
Total production (tonnes)	66.552	78.580	115.106	174.296
Estimated Total Feed Consumption (tonnes)	106.457	124.470	172.693	243.213
Feed Production (tonnes) **	39.396	52.260	55.058	-
Feed Import (tonnes) **	6.473	12.812	15.925	

* Estimates only for rainbow trout, sea bream, and sea bass
** TURKSTAT, 2007

The aquafeed production in Turkey is mainly concentrated in the Western Part of Turkey especially in the Aegean Region where most of the aquaculture production facilities are located. Currently, there are 15 feed mills producing fish feed in Turkey. The aquafeed producing companies together with the type of produced feed are listed in Table 6 (STO, 2001, TFMA, 2007). Most of these feed mills produce not only aquafeed but also livestock feed and pet food. Also some fish farming facilities produce feed only to meet their own feed needs.

Table 6. Important Aquafeed Producing Companies in Turkey (STO, 2001, TFMA, 2007)

Aquafeed Producing Companies	Type of feed	Capacity tonnes/h	Fish species
ÇAMLI Yem Bes. San. ve Tic. A.Ş.	Extruded	40	Trout, sea bass, sea bream, red sea bream, turbot, carp
ABALIOĞLU Yem Soya Teks. San.A.Ş.	Extruded	50	Trout, sea bass, sea bream
ÇAĞATAY Yem San.Ltd.Şti	Extruded	5	Trout, sea bass, sea bream
AGROMARİN	Expanded		Trout, sea bass, sea bream
BAĞCI GIDA	Extruded	3	Trout, sea bass, sea bream
BİLYEMTAŞ BİLECİK Yem San.ve Tic.A.S.	Pelleted	8	Trout, sea bass, sea bream
KORKUTELIM Yem Gıda San. ve Tic.A.Ş.	Pelleted	10	Trout, sea bass, sea bream
ERZURUM Yem Ür.San. ve Tic.Ltd.Şti.	Pelleted	20	Trout
SAMSUN Yem San.ve Tic.A.Ş.	Pelleted	45	Trout
MUAMMER KUZUCU Yem.San. ve Tic.Ltd.Şti.	Pelleted?	24	?
KAR Yem Gıda San.İth.İhr.Tic.Ltd.Sti.	Pelleted	5	Trout
SİBAL Yem	Extruded	4	Trout, sea bass, sea bream
KILIÇ Yem	Extruded	8,5	Marine fish
HAKAN Yem	Pelleted	5	Trout, sea bass, sea bream
SÜRSAN Yem	Extruded	10	Trout, sea bass, sea bream

4. AQUAFEED PRODUCTION TECHNOLOGIES USED

In general, based on the moisture content, compound fish feed can be classified as dry and moist (or wet) feeds. The dry feed types usually contain 6-10% moisture depending on the processing and environmental conditions, while moist feeds have 45-70% water content. Since the dry pellets have longer shelf-life and their storage conditions are less energy consuming, the fish farmers in Turkey prefer using dry feed. As a result, dry feed is predominantly produced in Turkey. Dry feeds are forced mechanically to form cylindrical shapes, known as pellets. These pellet forms support the effective feed intake of fish and decrease the loss of uneaten feed into the environment.

Three basic fish feed manufacture technologies have been developed: pellet, extrusion and expansion technologies. In general, the basic fish feed production steps include: grinding, mixing, shaping and/or cooking (e.g.: pelleting, extrusion or expansion), drying, oil coating, cooling and packaging. Usually, the conventional machinery required for the feed mills are: storage tanks, weighing machines, grinders, mixers, elevators, conveyor bands, steam boilers, feed shaping and/or cooking apparatus (pelleting machines, extruders or expanders) dryers, oil sprayers, coolers, packaging unit.

The first aquafeed production facility founded in Turkey, Pınar Yem, used pelleting technology. Nowadays, the aquafeed sector uses pelleting, extrusion and expansion manufacturing technologies in order to meet the requirements of the fish farmers. Usually, the equipment and machines of the fish feed mills are imported. The Turkish aquafeed manufacturing facilities are using the technology used throughout the world and modern feed mills are fully-automated. The pelleting technology, which is the older one for aquafeed production, is continually giving way to the newer technologies such as extrusion and expansion. The fish farmers' attitude towards extruded and expanded aquafeed are constantly rising as these more developed technologies enable the production of environmentally friendly feed with lower FCR, higher digestibility, better water stability and improved chemical and physical properties as well as better hygienic quality. Furthermore, through extrusion and expansion aquafeed production, floating and sinking feed are produced to meet the requirements of the fish farming operations. Moreover, more digestible feed, with lower microbiological load and less dust is produced with the higher thermal applications during extrusion and expansion. These technologies also give the opportunity of producing aquafeed from different feedstuffs. Also, vacuum coating equipment and machinery has already been used in Turkish aquafeed manufacturers to enable the application of higher oil inclusions into fish feed thus production of high energy diets is achieved.

Fish feeds are classified as starter, fingerling, grow-out and broodstock feeds based on the growth stage of the fish at which they are targeted. These types of feed are formulated to meet the needs of the fish at different growth stages and have different protein, fat, energy, essential nutrients contents. Nowadays, pellets, 0.5 – 12 mm in diameter, are produced and sold in Turkey. During 90s, most of the starter and fingerling aquafeed was imported, but nowadays successfully, starter trout, sea bass, and sea bream feed are produced in Turkey and used in fish farming. Furthermore, some of the Turkish aquafeed mills, in cooperation with international and Turkish institutes are working in developing better feed formulations with higher digestibility and reduced costs. Recently, some of these mills give technical support to the fish farmers in better handling and feeding of fish but these attempts are relatively new and much effort should be spent in this area.

5. AQUA FEED INGREDIENTS USED IN TURKEY

The major aquafeed ingredients used in Turkey are fish meal, soy products, corn products, wheat, and brewers yeast meal. Fish oil continues to be the main lipid source, although recently plant oils are also gaining importance in fish feed production. Also, feed additives such as vitamin premix, mineral premix, immuno-stimulants, attractants, toxin binders, enzymes, some essential amino acids are incorporated into fish feed rations.

5.1. Fish Meal and Oil

There are a number of fish meal factories that are mainly situated in the Black Sea Region of Turkey, where most of the catch of Turkey is realized. The production of these factories is still not enough to meet the requirements of both livestock and aquafeed industries. Therefore, substantial amount of fish meal and oil are imported. To achieve higher feed quality, some of the aquafeed manufacturers prefer imported fish meal and oil because of their better production quality and higher protein and energy values.

The world fish meal production appears to be quite stable and currently no increase in fish meal production is expected. On the other hand, the aquafeed production is expected to grow, with the share of aquafeed industry in fish meal use is also increasing. Recently, it was estimated that the global aquaculture sector uses about 35% of total fish meal supply. There is a significant increase in the fish meal use by the aquafeed industry when compared to the 10% estimated use in 1988. By 2010, share of fish meal use in aquafeed industry is estimated to increase to 48% (FAO, 2006). The growing demand for fish meal by the global feed industry has influenced the fish meal prices and in the near future it is speculated that the prices will continue to rise. In fact, the prices of imported fish meal in 2001 and 2006 were 494,1 and 997,7 USD/ton respectively (TURKSTAT, 2007). The fluctuations in the prices of the raw materials will inevitably affect the feed production costs. Thus, the constant increase in the fish meal prices has lead to the development of new feed formulations including plant protein sources.

5.2. Plant Products

The main plant sources used in the fish feed production in Turkey are soy and corn products. The major soybean products used in aquafeed production are soybean meal, de-hulled solvent extracted soybean flour and extruded full fat soybean meal. Soy products have gained significance in protein substitution, especially because they have the most suitable amino acid profile of all protein rich feedstuffs required for fish nutrition. Furthermore, soy products are considerably less expensive than marine animal feedstuffs. As soybeans contain some anti-nutritional factors such as protease inhibitors, phytates, saponins, lectins, etc. and also the essential amino acids such as lysine and methionine in soybeans are not in the required quantities, special thermal processing technologies are applied to soy products and if necessary, amino acids are incorporated into feed in the form of additives. In Turkey, the major fish species of industrial importance, rainbow trout, sea bream and sea bass, are typically carnivorous and have higher protein, amino acid and energy requirements than the omnivorous species. De-hulled solvent extracted soybean meal has been successfully used in the trout and marine fish feed formulations, with a digestibility coefficient of 85% which is close to the digestibility coefficient of fish meal. But the lipid content of this soy product is quite low and therefore the energy is not sufficient. On the other hand, extruded full fat soybean meal is more suitable as this product also supplies the required energy content. Recently, new products such as soy protein concentrates have a great potential in replacing fish meal in the aquafeed formulations because of its high protein content, suitable amino acid profile, low levels of indigestible carbohydrates, and low phosphorus content.

Research on the substitution of marine protein and lipid feedstuffs in fish feed with plant feedstuffs such as canola products, rapeseed, as well as plant protein extracts obtained from cereals, legumes and oil seeds reveals that these products may be readily used in aquafeed. Field studies show that plant protein concentrates not only serve as high protein plant feedstuff with high digestibility coefficient, but can substantially reduce the phosphorus load from fish feaces, leading to the production of low polluting aquafeed production.

When compared with plant proteins, fish meal contain higher levels of protein, energy, essential amino and fatty acids, phospholipids, minerals and attractants These differences in the nutritive value and the attractiveness of the feeds can be overcome by the supplementation with amino acids, lipids and minerals.

5.3. Animal Products

Before the ban in the European Union for the use of terrestrial animal by-products as feedstuffs, meat and bone meal, blood meal had been used in Turkey. Nowadays, these products are not used in fish feed production.

5.4. Single Cell Products

Brewers' yeast meal is used as a microbial protein source in the trout and marine fish feed production, because of its balanced amino acid profile.

6. FEEDING STRATEGY

One important aspect for the aquaculture operations is the feeding management of fish. In field practices, feeding fish presents some difficulties for three principal factors. First, the farmer should have to distribute the feed evenly in the tank, cage, and raceway so that all the fish is fed equally. Second, it is important to ensure that no uneaten feed is left due to economic and environmental reasons. Last, because the feeding requirements of fish vary with physical parameters of the environment (e.g. temperature, oxygen), the feeding should be adjusted according to the changes in these parameters.

In the decisions of feeding regime, there are three important questions "what, when, and how" after the type of feed is selected according to the size and species. The effective feeding of fish depends on intrinsic and extrinsic factors. Intrinsic factors include the genetics and physiology of stock, age, and species. Extrinsic factors comprise seasonal, water temperature, light density, and physical-chemical characteristics of feed.

The selection of appropriate ration size and feeding regime is important aspect in effective feed management. Feed regime can be provided by feeding to satiation, feeding tables, and special feeding tables.

6.1. Satiation

Feeding to satiation is done by supplying the fish with the maximum amount of feed they will consume. Practically, this is quite difficult to achieve without any feed wastage. Therefore, feed is wasted and this may lead to economic loss as well as environmental pollution. This method is usually applied to fish in 0.5 – 150 grams

6.2. Feeding Tables

Feeding tables are generally given by the feed suppliers to the fish farmers. These tables are prepared from estimates of biomass, feed conversion, and expected growth. This feeding method is dependent on two main parameters: fish size and water temperature. Since different fish farming facilities have special characteristics, these feeding tables are not always efficiently used.

6.3. Special Feeding Table

Recently, special feeding tables are prepared by taking account not only the species, size of fish and water temperature of the environment, but also by considering the energy requirements of the fish species and dietary energy. The energy requirements are estimated from the maintenance requirements, growth rate of the fish losses during feed utilization by the fish in relation to the water temperature. Unfortunately, the data required to prepare this tables is available only for a limited number of fish species (e.g. trout) and much field research should be made for establishing such tables for marine species.

The restricted feeding of fish with special table feeding will lead to lower feed consumption and will minimize the wastage of feed. Therefore, the fish farmers will be able not only to reduce the costs but also more environmentally friendly farming will be achieved by applying efficient feeding strategies.

7. CONCLUSION

During the recent years, the aquaculture sector has become the fastest growing agricultural sector globally. One of the highest inputs affecting the cost of the aquaculture activities is fish feed. Since the early 90s, there has been a significant development in the Turkish aquafeed sector in terms of production quantities and quality, technologies used and production of feed focused on the customers' requirements.

Today, though the fish feed import to Turkey has drastically decreased and aquafeed is being exported, the starter feed production technology meeting the requirements of the specified species is still in its nursery stage and should be developed, both in terms of quality and technology. Furthermore, with the rise in the prices of fish meal throughout the world, more attention should be paid to the applicability of new plant protein sources as fish meal substitutes.

The aquafeed manufacturing facilities should work in cooperation with the universities and research institutes in developing new feed formulations leading to cost-effective aquafeed with higher digestibility and lower polluting effects. Diet formulations for high energy and environmentally friendly fish feed should be developed. The technology of fish feed production should be enhanced through the widespread use of twin-screw extruders. Furthermore, the production of aquafeed should be standardized through improved feed quality control, so that the feed with standard parameters and characteristics are manufactured.

Currently some new species like turbot (*Scophthalmus maximus*), red porgy (*Pagrus pagrus*), sharp snout sea bream (*Diplodus puntazzo*), dentex (*Dentex dentex*), and grouper (*Epinephelus guaza* and *E.aeneus*), with higher market prices are gaining importance in Turkish aquaculture due to higher market prices. The research and development units of the aquafeed facilities should develop new formulations for the above mentioned fish species.

Since aquaculture is expected to play an increasingly significant role in supplying fishery products to the global market in the future, the aquafeed industry will have to develop so that more profitable, cost effective and environmentally friendly fish feed is produced.

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MARINE FISH FEED AND FEEDING

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1. INTRODUCTION

Aquaculture is a new but a fast growing sector in Turkey. Although Turkey has a big potential for freshwater and marine aquaculture, the production and consumption of aquatic products is not at the desired level. In order for this sector to continue to develop in Turkey, it is essential that reasonable sets of strategic plans should be developed and put into action. It is necessary that a sustainable fisheries and aquaculture and their interactions with the environment should be considered as the most important factor within the strategic plan. It is essential that the aquaculture sector does not interfere with the tourism sector, because the later is one of the most important economic revenues for the country.

The fish consumption per capita in Turkey is 7 - 8 Kgs. Most of the fisheries and aquaculture products are consumed in local markets. There is also export of fish and aquaculture products; in fresh and frozen form from Turkey to Spain, Italy, Greece, United Kingdom, Germany, Sweden, Poland, Republic of Czech and Lebanon. Keeping all of these aspects, aquaculture in Turkey needs development in a sustainable manner in the future.

The fish-feed industry in Turkey has been benefited from the well- established animal feed industry, i.e for poultry feed industry. There are only 18 plants producing aquafeeds and 10 other animal feed factories are partly producing aquafeeds. Turkey has a rich experience in producing formulated animal feeds except fish feed. Nowadays, on the other hand, there are some companies using modern feed processing equipment for aquafeed production. Main problem for the aquafeed industry is the source of cheap and continual ingredients and feed additives in Turkey. Starter feeds for especially marine fish larvae, therefore, are imported from other countries such as Chile and China and more expensive than the other feeds.

2. FISH FEED PRODUCTION

Fish feed production has started in 1973 in parallel to rainbow trout (*Oncorynchus mykiss*) farming Turkey. When marine fish farming just started in mid-eighties using sea cages to farm sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*), aquafeeds produced by the traditional technologies became insufficient and especially starter feeds for marine aquaculture were imported from foreign countries. History of the animal feed production in Turkey goes as far back as 1950. In these years, all feed factories have been operating as a government entity. Today all feed factories are owned and operated by private companies.

Vitamins, minerals and the other additives used in feeds are expensive and usually imported from European countries. High costs of the fish feeds are attributed to these imported feed ingredients and additives. Although, animal feed manufacturing is a growing industry, it is not enough to meet the requirements in Turkey. Animal feed production in Turkey is below of total capacity. Main problem in this sector are troubles in obtaining quality ingredients, modern technological capabilities and cost of production.

Table 1. Number of animal feed factories and their production capacities in Turkey

Years	Number of feed factory	Total capacity (Tone/year)	Available capacity %
1960	4	56. 000	10
1970	23	280.000	77
1980	94	1.650.000	87
1990	271	5.277.000	75
2000	519	12.584.000	61
2001	540	12.964.000	48
2002	575	13.714.000	49

According to the recent official data, 45.400 tons freshwater fish (mainly rainbow trout), and 79.781 tons marine fish (sea bass and bream) were produced in fish farms in Turkey (ANON., 2007a).

All animal feed factories producing aquafeeds are built on the western Turkey and they are close to marine fish farms in this region. Most of the fish farmers in the Black Sea costs of Turkey manufacture their traditionally farm made feeds with fish meal and fish oil both of which could be obtained locally in the region. Adana is a very important and a developed city because there are number of national and international companies in food sector. Most of the feed ingredients required for aqua feed production (extracted corn meal and soybean meal) are obtained from Çukurova Region. Çukobirlik, the largest integrated vegetable oil company in this Region can meet the demands for required oil cakes for feed factories. Fish meal and fish oil productions mainly depend upon the anchovy fishing in the Black Sea Region. Although fish meal and oil produced this region are highest in quality, most of the fish meal and oil producing plants were closed in this Region due to lack of raw material.

2.1. Fish Meal and Fish Oil Production in Black Sea Region of Turkey

Fish meal and fish oil are two important ingredients for aqua feeds. Fish meal provides essential amino acids and omega- 3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) Fish meal protein is a highly digestible form of protein and also a very valuable source of minerals and trace elements. In addition, fish meal contains a realtively high levels of fat soluble vitamins (TURAN et al., 2007). Demand for fish meal and fish oil for animal nutrition is increased in recent years. However, fish stocks which processed as fish meal and fish oil are very restricted. Total fish meal production of the world is around 6.5 million tons per year according to the latest figures and most of the products are used in other animal feeds except aqua feeds. Fish meal and fish oil manufacturing depends on the fisheries of Black Sea region in Turkey. Anchovy (*Engrauliis encrasicolus*) is the main fish for fish meal and fish oil industry in this region. Approximately % 42 (156.000 tons) of the total annual anchovy catch (Approximately 400,000 tons) is processed to fish meal and fish oil according to recent data (ANON., 2002). Chemical composition of fish meal and fish oil varies according to the environmental conditions and production processes. Crude protein contents of the fish meal produced in Turkey varies between 65% and 72% and it is considered as high quality fish meal. Polyunsaturated fatty acid contents, especially omega-3, are also acceptable values of fish oil produced in Turkey.

Main local raw materials used in animal feeds in Turkey;
Raw starch by products: Corn gluten, corn meal.
Miller by products: whole wheat flour, bran.
Sugar industry by products: molasses, sugar beet pulp
Oil seed by products: sunflower oil, sunflower meal
Animal by products: Meat and bone meal, fish meal

3. AQUACULTURE FEEDS

As it is the case for other farm animals, fish also needs essential nutrients such as protein, fats, carbohydrates, vitamins and minerals. Growth of an animal can be defined as the increase of the body mass in a definite time according to the characteristics of the the species. However, nutrient requirements of fish differ according to their environments. Fish require lower energy than the other farm animals because their body heat is similar to their environments. Fish feeds contain more protein than the other farm animal feds because they profit proteins from their feeds. Fish meats have quality proteins and polyunsaturated fatty acids such as linlonenic (ω-3) series. Thus, fish feeds must include all nutrients in enough levels.

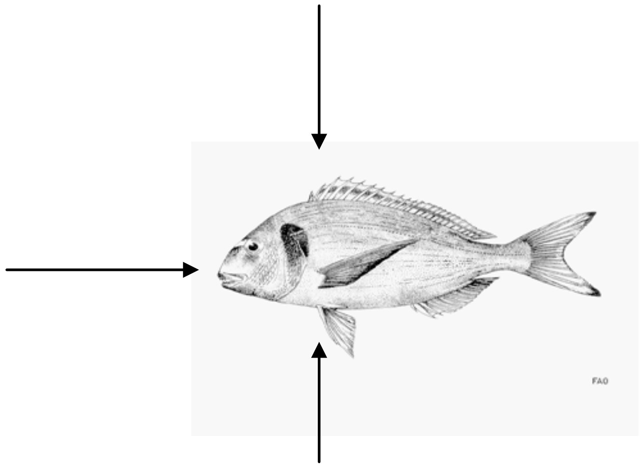

Figure 1. Effects of the main factors on fish growth

Ddifferent fish have different feeding behaviours and different sizes. Even the same fish species require different levels of nutrients. Because of this and other differences, it is natural that the aquafeeds vary depending on the fish. Although the knowledge about nutrient requirements of aquacultured fish are not complete, fish feed industry could produce quality commercial feeds for the most farmed fish.

Commercial aquafeeds must be:

1. Fish friendly: healthy and not include harmful substances,
2. Environmental friendly: not damage the environment
3. Consumer friendly: not damage the human health

Formulated aquaculture feeds are produced either by adding some raw materials to existing natural fish feed or using different ingredients.

Commercial feeds change feeding behaviour of the cultured fish. Feeds must be suitable to the mouth size of the fish. Commercial feeds can be produced with extrusion technology and this technology provides some advantages to fish farmers. This feeds are;

1. floating
2. slowly sinking
3. water stable

Aquaculture feeds are usually produced according to the fish size and there are four types feed used in fish farms. These feeds are;

Starter feeds for larvae
Juvenile feeds for fingerlings and young fish
Grower feeds for marketing fish and
Breeding feed for mature fish.

Starter feeds are produced usually as micro capsule and granule and the others are prepared as different size pellets.

4. RAINBOW TROUT FEEDS AND FEEDING

Rainbow trout nutrition is a well known research area and our knowledge about this fish advance to nutrition of other farmed fish (BARNABE, 1990a; NRC, 1981; WATANABE, 1996). Although water temperatures and other environmental factors change to nutrient requirement of rainbow trout, crude protein 38-55%, crude lipid 10-20% (at least 1% EFA) and carbohydrates as simple sugars 20% in the starter feeds are favourable (AUSTRENG, 1979; BARNABE, 1990a; HALVER, 1972). In addition, rainbow trout diets have to include 1% 18:3 n-3 fatty acids for normal growth (BARNABE, 1990a; OTHA and WATANABE, 1996; EMIDIO *et al.*, 1993).

Rainbow trout also require n-3 and n-6 fatty acids as the other fish does and if essential fatty acids are not found their diets, some typical deficiencies and/or symptoms may occur in these fish (GODDARD, 1996). Fish generally have high level highly unsaturated fatty acid (HUFA) from n-3 series in their tissue differently from the other farmed animals. Different essential fatty acid (EFA) rrequirements of the fish are characteristic in freshwater and marine fish species. HUFA from n-3 series are high level in the marine fish and these EFA get better growth performance (OTHA and WATANABE, 1996; YILDIZ and ŞENER, 1997).

As all other fish require, rainbow trout also require three fatty acids: eicosapentaenoic acid (20:5n-3), docosahexaenoic acid (22:6n-3) and arachidonic acid (20:4 n-6) in diets provide best growth performance (KIESLING *et al.*, 2001; KOVEN *et al.*, 1993; OTHA, and WATANABE, 1996; SANZ *et al.*, 1994; SARGENT *et al.*, 1997). These fatty acids are important for membrane functions, survival and growth performance during the larval period. According to the recent studies, essential fatty acids in the diets affect body composition and total liver fats of the rainbow trout (EMIDIO *et al.*, 1993; ROUHONEN *et al.*, 1998; REINITZ and YU, 1981).

5. MARINE FISH NUTRITION AND MARINE FISH FEEDS

5.1. Green Water Technique in Marine Aquaculture

Algae take place the first part of the food chain. In this respect, algae are widely used in aquaculture. Their main application is related to fish nutrition. They are used as feed additives and pigment sources. For healthy aquaculture products, algae containing feeds are strictly necessary (BARNABE, 1990b).

Macro algae are studied as alternative feed additive material due to their high protein and fatty acid contents. Micro algae have also efficient nutritional properties and they are used in green water technique in hatcheries. In this technique, microalgae can be added directly to the larvae rearing tanks. Larvae of molluscs such as Oyster *(Crassostrea gigas)* and Manila clam *(Ruditapes phillipinarum)*, crustaceans such as shrimp *(Penaeus monodon)*, some fish larvae such as gilthead sea bream (*Sparus aurata)*, sea bream *(Pagrus pagrus)*, white grouper *(Epinephulus aeneus)*, turbot *(Psetta maxima) and* tilapia *(Oreochromis niloticus)* feed on micro algae (BARNABE, 1990b).

Green water technique has some advantages. They support nutritional quality of zooplankton which is used as prey for culturing organisms. For example, the use of live plankton feeder prey, rotifer *Brachionus plicatilis*, is still essential live prey for better growth and survival of fish larvae like sea bream and flat fish. Rotifers can be feed with yeast-based artificial feeds, but this is much less efficient than with phytoplankton feeding. Micro algae is the most suitable food source for rotifers to achieve the best nutritional quality (BORGNE 1990, BARNABE, 1990c).

Micro algae may have an effect to the water column in larvae rearing tank. Adding micro algae into the tank causes shadow and lower light intensity. Appetite of fish larvae is affected positively from this light homogeneity. Green water technique also provides lower bacterial contamination especially from *Vibrio.* Other beneficial effects of adding micro algae are improved and stabilized water quality by oxygen production, pH stabilization, etc (BORGNE 1990, BARNABE, 1990c).

5.2. Nutrition of Sea Bass and Sea Bream

Marine fish farming plays an important role in Turkish aquaculture; the increase in demand for aquatic products and difficulties in fishing are encouraging the development of marine fish farming. Marine fish farming first developed in Turkey in 1986 (ANON., 1988). Gilthead sea bream *Sparus aurata* and European sea bass *Dicentrarchus labrax* are the most important marine finfish species, cultured in the Mediterranean, and aquaculture production of both species is still expanding rapidly (ALEXIS, 1997; LUPATSCH et al., 2003). Similarly, intensive aquaculture of these fish species in

Turkey has been greatly expanded during the last two decades. In Turkey, the total production of sea bream and sea bass was started at 34 metric tones in 1986 (ANON., 1988) and then it reached to about 79.000 metric tones in 2007 (ANON., 2007a). One of the possible ways to sustain the future of intensive aquaculture is to develop quality feed in order to meet the increasing demand of that species. Following the expansion in the use of the extrusion technique in feed production, the extruded feeds which contain high level and fat are used widely in feeding of cultured marine fish species (AUTIN, 1997; LANARI *et al.*, 1999).

Feeds play an important role within intensive culture systems, and should contain all essential nutrients, including all the proteins, lipids, carbohydrates, vitamins, and minerals required the farmed by fish species. Sea bass and sea bream are known as the carnivorous species and feeds of both cultured fish must include high levels of protein. Proteins are most expensive ingredients in the formulated feeds and must be formulated to the energy balance of the fish (ALAM et al., 2002; MENTE et al., 2003). Fish meal is the main protein and essential amino acid (EAA) source for the feed industry, and the production of fish meal is limited throughout the world. A quality fish meal is an ideal protein source for aquafeeds. (METNE et al., 2003). Fish oil is the main lipid and energy source in traditional fish feeds. If fish oil has high levels of digestibility, it would meet the essential fatty acid requirements, especially polyunsaturated fatty acid such as n-3 HUFA requirements of marine fish larvae (SARGENT, 1999; MONTERO, et al., 2003). Some vegetable oil sources were also used in fish feeds but these ingredients could affect meat quality negatively (MONTERO, et al., 2003; ROBIN et al., 2003).

5.2.1. Protein

Extensive research is being conducted on the protein requirements of fish under the laboratory conditions. According to the data, optimal protein requirement of sea bass and sea bream is minimum 40% of diet. It is important to know essential amino acid (EAA) requirement of fish for the production of cheap and palatable feeds (ALAM et al., 2002). Ten amino acids are essential for cultured fish. These are arjginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, triptophane and valine. Just only four essential amino acid requirements are known for juvenile sea bass. These are arginine, lysine, methionine+cysteine and triptophane (Table 2).

Tablo 2. Essential amino acids for sea bass (LIM, 2004).

Amino acids	Protein (% in diet)	Amino acids in Protein %	Amino acids in diet %
Arginine	34	5.0	1.7
Lysine	34	5.0	1.7
Methonine+cyistine	34	4.0	1.4
Triptophane	34	0.6	0.2

Current knowledge about the essential amino acid requirements for sea bass is limited. However, it is known that at least ten amino acids are essential for sea bass and sea bream (LIM, 2004).

5.2.2. Lipids

Since of carbohydrates are used at limited levels for energy needs for fish, lipids are very important source in fish nutrition. Lipids in the fish diets have a sparing effect on diet protein (GODDARD, 1996; WATANABE, 1996). However freshwater fish require linoleic (18:2n- 6) and linolenic acids (18:3n-3) generally, marine fish such as sea bas and sea bream prefer highly unsatureted fatty acids (HUFA) such as eicosapetaenoic acids (EPA, 20:5n-3), docosahexaenoic acids (DHA, 22:6n-3) and arachidonic acids (ArA, 20:4n-6) (SARGENT et al., 1997; SMITH et al., 2004).

5.2.3. Carbohydrates

Fish do not require specific carbohydrates in their diet. However, carbohydrates are cheap energy source have the pellet binding capacity (NRC, 1993). Carnivore aquaculture species such as rainbow trout, sea bass and sea bream do not need carbohydrates in their diets as much as herbivore and omnivore aquaculture species. (LIM, 2004).

5.2.4. Vitamins

Vitamins are organic compounds necessary in the diet for normal fish growth and health. They often are not synthesized by fish, and must be supplied in the diet. There are the two groups of vitamins, water-soluble vitamins and fat-soluble vitamins. Water-soluble vitamins include: the B vitamins, choline, inositol, folic acid, pantothenic acid, biotin and ascorbic acid. Of these, vitamin C probably is the most important because it is a powerful antioxidant and helps the immune system in fish. The fat-soluble vitamins include A, D, E and K vitamins (CRAIG and HELFRICH, 2002). No report exists about vitamin deficiency of farmed marine fish in Turkey. IZQUIERDO et al. (1997) studied some fat soluble vitamin needs of sea bass and bream but knowledge about vitamin requirements of marine fish are very limited. Usually, water soluble and fat soluble vitamin requirements of salmonids are considered to be appropriate for the farmed marine fish.

5.2.5. Minerals

Minerals are inorganic elements necessary in the diet for normal body functions. They can be divided into two groups (macro-minerals and micro-minerals) based on the quantity required in the diet and the amount present in fish. Common macro-minerals are sodium, chloride, potassium and phosphorous. These minerals regulate osmotic balance and aid in bone formation and integrity. Micro-minerals are required in small amounts as components in enzyme and hormone systems. Common trace minerals are copper, chromium, iodine, zinc and selenium. Fish can absorb many minerals directly from the water through their gills and skin, allowing them to compensate to some extent for mineral deficiencies in their diet (CRAIG and HELFRICH, 2002). Sea bass and sea bream, like other aquatic animals, require minerals for their normal life processes. However, there are limited information on the dietary mineral requirements of sea bass and sea bream.

6. RECENT STATUS OF MARINE FISH FEED PRODUCTION AND FEED QUALITY

There are seven aquaculture feed factory that can produce extruded marine fish feeds. One of these factories has the expanded technology whereas the rest of them have steam pressured pellet feed technologies. In these plants, different pellet sizes for marine fish can be produced, except for starter feed for the marine fish larvae. Some grower feeds for marine aquaculture are imported from European countries and some feeds are also produced in Turkey under licences from foreign companies. According to the a recent research (YILDIZ et al., 2006a, 2007a), proximate composition in most of the grower feeds used in sea bass and sea bream farms were found sufficient (Table 3). Extensive research on essential nutrients needs of sea bas and sea bream are conducted in Turkey.

Table 3. Average proximate composition of the commercial grower feeds for sea bass and sea bream in Turkey.

	Feeds **			
	A (pelleted)	**B (extruded)**	**C (pelleted)**	**D (extruded)**
Proximate composition (%)				
Moisture	9.8±0.67[a]	8.7±0.34[ab]	8.7±0.46[ab]	7.9±0.40[b]
Crude protein	44.9±0.71[a]	44.6±0.26[a]	45.4±0.18[a]	45.1±0.31[a]
Crude fat	14.0±0.36[b]	20.4±0.41[a]	12.6±0.26[c]	20.6±0.24[a]
Ash	8.7±0.17[b]	11.7±0.33[a]	10.8±0.45[a]	8.5±0.32[b]
Crude fiber	3.2±0.45[a]	2.7±0.36[a]	2.6±0.34[a]	2.5±0.22[a]
Nitrogen free extract	19.3±0.55[a]	11.8±1.10[c]	19.4±0.50[a]	15.5±0.69[b]

*: Results represent means ±standard error, n=6.

**: Feeds A, B, C and D were produced by different commercial companies. Results in each row with different superscript letters were significantly different ($P<0.05$). Means were tested by ANOVA and ranked by Tukey's multiple range tests.

7. FISH FARM WASTES

Unconsumed feeds, faces and soluble excretory products are main organic materials produced in fish farm as wastes during the fish farming. Some of the feeds distributed in fish cages are not consumed by the fish. Some factors affecting the feeding are appetite of the fish, suspended solids and the currents. Wastes are potential harmful material for both fish and the environment of the fish farm. In addition some metabolic by products such as CO_2 and NH_4 are released from from the gills (GODDARD, 1996). Waste output loading from aquaculture operations can be estimated using simple principles of nutrition and bioenergetics. Ingested feedstuffs must be digested prior to utilization by the fish and the digested protein, lipid and carbohydrate are the potentially available energy and nutrients for maintenance, growth and reproduction of the animal. The remainder of the feed (undigested) is excreted in the faeces as solid waste (SW), and the by-products of metabolism (ammonia, urea, phosphate, carbon dioxide, etc.) are excreted as dissolved waste (DW) mostly by the gills and kidneys.

The total aquaculture wastes (TW) associated with feeding and production is made up of SW and DW, together with apparent feed waste (AFW): TW = SW + DW + AFW SW, DW and AFW outputs are biologically estimated by: SW = [Feed consumed x (1-ADC)] DW = (Feed consumed x ADC) - Fish produced (nutrients retained) AFW = Actual feed input – Theoretical feed requirement in which ADC is the apparent digestibility coefficients of diets. ADC for dry matter, nitrogen and phosphorus should be determined using reliable methods by research laboratories where special facility, equipment and expertise are available (ANON., 2007b). There are two methods on the analyses of the waste. These are the analyses done using the marine water and the analysis of sediment samples.

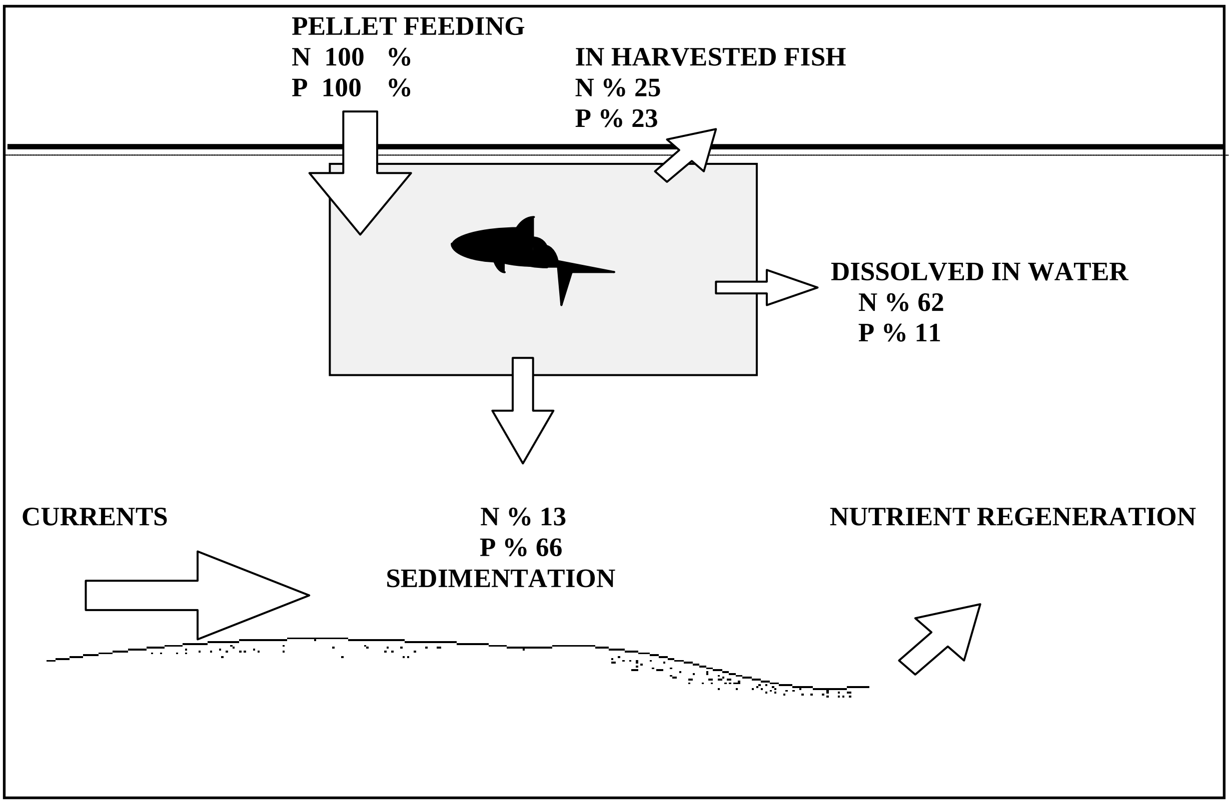

Figure 2. Main nutrients budget in a fish farm (From FOLKE and KUTSKY, 1989)

With increasing environmental awareness, more effort is being devoted to minimising the impact of aquaculture. Feed is the largest source of nutrient loading to the environment in aquaculture. In these reasons, feeds in the aquatic environment must become environmentally friendly diets and feeding must be better for minimising the waste of aquaculture. Feeds are being continuously improved to increase its digestibility, reduce feed conversion ratio (FCR) of cultured fish and reduce the total nitrogen and phosphorus content (ALVARADO, 1997). In Turkey, the government works with the aquaculture industry to ensure compliance with pollution requirements and to ensure that waste discharged from aquaculture facilities is minimized. The Ministry of Environment and Forestry (MEF) leads the delivery of pollution prevention initiatives in Turkey. In 2006, new performance-based waste standards were introduced in regulation. Farmers must monitor the marine environment around the farm and MEF performance annual environmental monitoring and auditing to assess industry compliance with the standards and to assess effects on the marine ecosystem. According to public opinion South Aegean (Bodrum Peninsula) and Middle of Black Sea costs are known to be highly polluted areas due to aquaculture activities in Turkey.

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IMPORTANT BACTERIAL, VIRAL DISEASES AND TREATMENT IN MARINE AQUACULTURE

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1. INTRODUCTION

As many other agro industries, Turkish finfish aquaculture has developed in relation with the technoeconomic and environmental legislations of EU over the last two decades. The rapid expansion of the aquaculture industry in the last decade has increased the losses caused by systemic bacterial infections in marine fish farming throughout the world.

In intensive culture systems, fish diseases constitute one of the most important problems and challenges confronting fish farmers. Diseases occur in both natural and cultured animal and can be categorised broadly into two groups: a) Infectious diseases where the causative agent is bacterial, viral or parasitic b) Non-infectious diseases caused by toxic substances, improper nutrition, poor water quality, physical damage or genetics.

The appearance and development of a particular fish disease is the result of the interaction among pathogen, host and environment. Therefore, only multidisciplinary studies involving the characteristics of potential pathogenic microorganisms for fish, aspects of the biology of the fish as the host as well as a better understanding of the environmental factors affecting such cultures, will allow the application of adequate measures to prevent and control the main diseases limiting the production of marine fishes. Regarding the infectious diseases caused by bacteria in marine fish, although pathogenic species have been described in the majority of the existing taxonomic groups, only a relatively small number are responsible for important economic losses in cultured fish worldwide (TORANZO et al., 2005).

We should never forget that disease management depends upon good culture practice in combination with chemotherapeutic agents.

2. BACTERIAL DISEASES

The most important marine bacterial fish diseases appeared in publications in Turkey are Vibriosis, Pasteurellosis, Motile Aeromonad Septicaemia, Yersiniosis, Atypical Furunculosis, Marine Flexibacteriosis, Bacterial kidney disease (BKD), and Rickettsia-like organism infections. Bacterial and viral fish diseases reported in Turkey are shown in Table 1.

2.1.Vibriosis

Vibriosis occurs in cultured and wild marine fish in salt or brackish water, particularly in shallow waters during early spring and late summer. Vibriosis is one of the most prevalent fish diseases all over the world caused by bacteria belonging to the genus *Vibrio*. Fish pathogenic Vibrio species belonging to Vibrionaceae family are *Vibrio anguillarum*, *V. alginolyticus*, *V. ordalii*, *V. vulnificus*, *V. salmonicida*, *V. damsela*, *V. carchariae*, *V. tubiashii*, *V. marinus*, *V. campbellii*, *V. nereis*, *V. paraheamolyticus*, *V.viscosus*, *V. cholerae non*-O1, *V. splendidus*, *V. pelagius* (REED and FRANCIS-FLOYD, 1996, AUSTIN and AUSTIN, 1999, ACTIS et al., 1999). In addition, *V. xuii and V. brazilliensis*, *V. neptunis* are two last Vibrio species that are added to the list. However, vibriosis caused by *V. anguillarum* and *V. vulnificus* is the most significant disease for the Mediterranean region. *V. anguillarum* was first described as the aetiological agent of vibriosis in gilthead bream (*Sparus aurata*) by CANDAN in 1993 in Turkey. *V. ordalii* infection has been also reported in *Sparus aurata* (CANDAN, 1993, ÇAĞIRGAN & YÜREKLITÜRK, 1996, TÜRK, 2002). Since 1993, vibriosis outbreaks have been reported in Atlantic salmon (*Salmo salar*) produced in Black Sea (CANDAN et al., 2000), sea bass (*Dicentrarchus labrax*) (ÇAĞIRGAN AND YÜREKLITÜRK, 1996, AKAN et al., 1996, TÜRK, 2002) and sea bream (*Sparus aurata*) (ÇAĞIRGAN and YÜREKLITÜRK, 1996, AKAYLI and TIMUR, 2002, TIMUR et al., 2004). Although *V. anguillarum* rarely causes disease in marine water, recently this bacterium was isolated from rainbow trout in fresh water (TIMUR and KORUN, 2004).

The characteristic clinical signs of vibriosis include red spots on the ventral and lateral areas of the fish and swollen and dark skin lesions that ulcerate, releasing blood exudates. There are also corneal lesions, characterized by an initial opacity, followed by ulceration. However, in acute and severe epizootics, the course of the infection is rapid, and most of the infected fish die without showing any clinical signs (ACTIS et al., 1999).

Vibrio species isolated in Turkey have been diagnosed on the basis of standard biochemical tests. ELISA assays were used to determine the induced antibody levels of sea bream (*S. aurata*) against vibriosis infection by AKAYLI and TIMUR (2004). Recently, DEMIRCAN and CANDAN (2006) described a PCR protocol based on the amplification of *rpoN* gene for rapid identification of *V. anguillarum* from infected fish. Antibiotics and other chemotherapeutic agents like Oxytetracycline, Flumequine are used as feed additives to prevent and treatment for vibriosis. Although most of the sea bass are vaccinated every year with commercial vibriosis vaccines, few outbreaks of vibriosis still cause problems with different vibrio strains like *V. alginolyticus, V. paraheamolyticus* and *V. ordalii.* Moreover, ÇAĞIRGAN (2005) developed a dip vaccine against vibriosis which caused by *V. anguillarum* serotype O1 for sea bass fry. However, effective commercial vaccines including more strains against this disease have not been yet available in Turkey.

2.2. Pasteurellosis

Pasteurellosis, also described as photobacteriosis (due to the change in the taxonomic position), is caused by the halophilic bacterium *Photobacterium damselae* subsp. *piscicida* (formerly *Pasteurella piscicida*). It is an important pathogenic microorganism affecting several species of farmed fish. The disease has great economic impact both in Japan, where it affects mainly yellowtail cultures, and in the Mediterranean area, due to the losses it causes in seabream and seabass farms (ROMALDE 2002).

Pastereullosis is also known as pseudotubercullosis because it is characterized by the presence, in the chronic form of the disease, of creamy-white granulomatous nodules or whitish tubercles in several internal organs, composed of masses of bacterial cells, epithelial cells, and fibroblasts. The nodules are most prominent in internal viscera, particularly kidney and spleen, and the infection is accompanied by widespread internal necrosis (ROMALDE, 2002; BARNES et al., 2005). Anorexia with darkening of the skin as well as focused necrosis of the gills is the only external clinical signs often observed. These lesions are generally missing in the acute form. The disease is difficult to eradicate with antibiotic treatments, and there is evidence that carriers under stressful conditions could suffer from reinfection (LE BRETON, 1999).

Pasteurellosis outbreaks have been reported in sea bass and sea bream from many Mediterranean countries such as France, Italy, Spain, Greece and Turkey. This disease was first observed in cultured sea bream in 1993 (ÇAĞIRGAN, 1993, ÇAĞIRGAN and YÜREKLITÜRK, 1996). Since then it was isolated from sea bass cultured in marine water and low salinity (CANDAN et al., 1996, TIMUR et al., 1999, TÜRK, 2002, KORUN and TIMUR, 2005) and from the natural populations of *Mugil cephalus* and *Chelon labrosus* (TANRIKUL and ÇAĞIRGAN, 2001). The presumptive identification of the pathogen is based on standard biochemical tests such as commercially available Bionor agglutination kits and API 20E rapid identification system. Although *Ph. damsela* subsp. *piscicida* is not included in the API 20E code index, all strains display the same profile (2005004) (TORANZO, 2004). API 20E code index of *Ph. damsela* subsp. *piscicida* isolated from sea bass cultured in Turkey display the same profile (CANDAN et al., 1996). No molecular methods are currently employed for the diagnosis of this bacterium.

Recently, vaccination practices using commercial vaccines against pasteurellosis are becoming more popular. Divalent vaccines against *V. harveyi* and *P. damsela* subsp. *piscicida* cultured sole strongly suggest that it is a promising prophylactic measure against mortalities caused by both pathogens (ARIJO et al. 2005)

2.3. Aeromonad Infections

Aeromonas salmonicida has been recognized as a pathogen of fish for over 100 years (HINEY and OLIVER, 1999). In Turkey, typical furunculosis caused by *A. salmonicida* was first diagnosed in 1995, in cultured rainbow trout (TIMUR et al., 1999). There were no external and internal signs of disease with the exception of darkening in colour, and it was determined that the case was acute furunculosis. Since then, no other report has been published about it. Diseases caused by atypical strains have been referred to as ulcer disease or atypical furunculosis (HUBBERT and WILLIAMS, 1980, WIKLUND and DALSGAARD, 1998). The number of hosts from which atypical *A. salmonicida* isolates have been cultured is rapidly increasing and includes several species of salmonids and non-salmonids, wild or cultured, in fresh, brackish or sea water (HINEY and OLIVIER, 1999). The first description of the atypical aeromonas in Turkey occurred in sea bass cultured in Black Sea during July 2002 (KARATAŞ et al., 2005). Researchers reported that petechial haemorrhages on the bottom of the fins, lesions on the sides and at the ventral side on the bodies of sea bass were observed.

Motile Aeromonads of the *A. hydrophila* complex cause haemorrhagic septicaemia in fish. The bacterium is distributed widely in fresh water and bottom sediments containing organic material, as well as in the intestinal tract of fish (AOKI, 1999, KARATAŞ DÜĞENCI and CANDAN, 2003). Although motile Aeromonads are typically recognized as opportunistic pathogens or secondary invaders, cases have been reported of *A. hydrophila* acting as a primary fish pathogen. The infection was found in cultured Atlantic salmon in the Black Sea. Heavy mortalities due to bacterial infections in Atlantic salmon have occurred when the temperature has reached above 23 ºC (CANDAN et al., 1995). Afterwards, *A. hydrophila* was isolated from diseased sea bass (*Dicentrarchus labrax*) cultured in marine and brackish water (ŞAHRIKOĞLU and CANDAN, 2002). Researchers reported that avoidance of stress (as overcrowding, temperature, and low oxygen) is the best method of prevention.

Aeromonads can grow on most bacteriological media. The identification of bacteria is typically based on their biochemical and morphological characteristics. No molecular and serological identification methods are used in survey of *Aeromonas* strains in Turkey.

Whenever *Aeromonas* outbreaks occur, every attempt should be made to identify and eliminate sources of environmental stress. This alone will often correct the disease problem. Avoiding fish handling when the fish are in a weakened state or when environmental conditions are less than optimal. Fish should never be handled or transported during an *Aeromonas* outbreak (CAMUS et al., 1998).

2.4. Enteric Red Mouth (ERM) Disease

Enteric red mouth (ERM) is an acute or chronic infection of fish caused by *Yersinia ruckeri*, a Gram negative, enteric bacterium. *Y. ruckeri* is one of the most significant pathogens for farmed rainbow trout in Turkey. These bacteria firstly were isolated by TIMUR and TIMUR (1991). Following this first recognition, other researchers began to identify the pathogen from the same species, cultured fresh water and sea water (ÇAĞIRGAN and YÜREKLITÜRK, 1991, DÜĞENCI KARATAŞ and CANDAN, 1997, KARATAŞ and CANDAN, 2004). *Y. ruckeri* can be successfully identified by standard methods. Furthermore, CANDAN & YAZICI determined the time and temperature correlation when using API 20 E for the identification of *Y. ruckeri* to avoid from misidentification (CANDAN AND YAZICI, 2000). SAVAŞER and DILER (1997) investigated the morphological, physiological and biochemical characteristics of *Y. ruckeri* strains isolated from cultured rainbow trout in Turkey. These researchers showed that cultural characteristics of *Y. ruckeri* strains isolated from cultured rainbow trout in Turkey are homogeneous. TOPAL et al. (1997), made a comparative analysis of plasmid contents and antibiotic sensitivity of 15 *Y. ruckeri* strains isolated in Turkey and 5 reference strains. This study found 6 different plasmid profile models which are ranging from 73 kb to 4.4 kb. ELISA and IFAT assays were used to determine the induced antibody level of rainbow trout immunized with *Y. ruckeri* bacterin by KUBILAY and TIMUR (2001). Studies on the development of vaccines against yersiniosis have been conducted; however effective commercial vaccine against this disease has not been available in Turkey (ÇAĞIRGAN and TANRIKUL, 1998).

2.5. Rickettsia-like organisms

Rickettsia-like organism (RLO) infections of fin-fish have been reported in several salmonid and non-salmonid species in both fresh and seawater since 1939 (MAUEL and MILLER, 2002). Although *Piscirickettsia salmonis* is the only rickettsial pathogen of fish that has been characterized, other RLO have been noted. *Piscirickettsia salmonis,* a fastidious, obligate intracellular, Gram-negative bacterium is the causative agent of piscirickettsiosis, a chronic, systemic infection of coho salmon, (*Oncorhynchus* kisutch), Atlantic salmon (*Salmo salar*), rainbow trout (*O. mykiss*), chinook salmon (*O. tshawytscha*) and European sea bass (*Dicentrarchus labrax*). Piscirickettsiosis was first described in 1989 in Chile, but has now been detected in diseased fish from different regions of Europe, from both Atlantic and Pacific coastlines of the North American continent and in Tasmania. The clinical signs of the disease are well documented, with typical pathological changes being found in the liver, kidney and spleen.
A systemic infection of Rickettsia like organism (RLO) in cultured sea bass in Turkey was described by TIMUR et al. (2005) for the first time.

Although *P. salmonis* is sensitive under in vitro conditions to certain antibiotics (e.g. tetracycline, erythromycin, oxolinic acid) commonly used against other infectious diseases, the efficacy of antibiotics in the treatment of *P.*

salmonis has not been clearly demonstrated. The lack of effective chemotherapeutants available to fish culturists for treatment of *P. salmonis* has focused attention on vaccine development; however, no efficacious preparations are currently available (LANNA et al., 1999).

2.6. Marine Flexibacteriosis

Marine tenacibaculosis is a serious bacterial disease affecting a great variety of valuable cultured fish species, as well as wild fish, in Japan, North America, several countries in Europe and Australia (HIKIDA et al., 1979; BAXA et al., 1986; DEVESA et al., 1989; BERNARDET et al., 1990). Several other names as bacterial diseases of sea fish", "black patch necrosis" and "eroded mouth syndrome" were used to designate the diseases caused by this bacterium. In Turkey, the disease cases were described in gilthead sea bream (*Sparus aurata*) since 1991 (CANDAN, 1991).

The aetiological agent of this disease is *Tenacibaculum maritimum* [formerly *Flexibacter maritimus* (FMM)], a Gram negative and filamentous bacterium, which directly attacks the body surface of fish, causing ulcerative skin lesions, necrosis, eroded and haemorrhagic mouth, frayed fins and tail rot (SUZUKI et al.2001, MAGARIÑOS et al., 1995, CAMPBELL and BUSWELL, 1982; BAXA et al., 1986; DEVESA et al., 1989). As these lesions favour the entrance of other pathogenic bacteria such as Vibrio spp. and saprophytic organisms such as ciliated protozoans, *T. maritimum* thus often appears in mixed infections. From a microbiological point of view, one of the major constraints on detection of *T. maritimum* is the lack of methods to distinguish this microorganism from other phenotypically similar ones, particularly from other marine flavobacteria (SUZUKI et al. 2001). In addition, obtaining pure cultures of *T. maritimum* from external lesions is difficult, because of the slow growth characteristics of these pathogens which allows other opportunistic species to overgrow it. However, polymerase chain reaction (PCR) methodology has proved to be a powerful tool for accurately identifying the pathogen from plate cultures as well as from fish tissues (TOYAMA et al. 1996, BADER and SHOTTS 1998). Although the phenotypic, antigenic and molecular characteristics of *T. maritimum* have been examined by several authors, the actual factors determining the virulence of this pathogen have not yet been elucidated. Some synergistic interactions of the toxins contained in extracellular products and hemolysin might be involved in *T. maritimum* infections. Moreover, pathological properties of the bacterium, such as a strong adherence to the skin mucus of different fish species and the capacity to resist its bactericidal activity, have been pointed out as possible virulence factors. (BERNARDET et al., 1990; CHEN et al., 1995; OSTLAND et al., 1999; AVENDAÑO-HERRERA et al., 2006).

This pathogen primarily attacks skin, mouth, fins and tail of fish, causing severe necrotic and ulcerative lesions on the body surface (TORANZO et al., 2005). Up to now, most treatments proposed for the tenacibaculosis outbreaks are based on the administration of drugs through feed. However, studies indicated that the effect of a repetitive therapy with the same antimicrobial agent has originated the emergence of resistant strains of *T. maritimum* within the population further diminishing the effect of chemotherapy. An alternative therapy to the use of drugs is the surface-acting disinfectants administrated by bath. Formalin and iodophors are the most widely used disinfectants in aquaculture. However, some hatchery managers have expressed concern about user sensitivity to formalin and its environmental impact. This compound is expensive, difficult to use and store. On the other hand, organic iodine compounds have been recommended mainly for eggs and equipment disinfection procedures. Another prophylactic treatment, hydrogen peroxide, has recently received attention for its effective control of numerous external pathogens to fish, particularly against those of the genera *Flavobacterium* and *Cytophaga* that are phenotypically similar to *T. maritimum* (DERKSEN et al., 1999, THOMAS-JINU and GOODWIN, 2004). AVENDAÑO-HERRERA et al. (2006) demonstrated that a minimum 30 min exposure to H_2O_2 at a concentration of 240 ppm effectively removes high proportion of *T. maritimum* in the sea water. Authors of this study recommended the use of H_2O_2 only as a general disinfection method for treating water culture and surface of tanks before the introduction of fish because of the stress H_2O_2 causes.

The treatment of this disease with antibiotics doesn't offer satisfactory results and currently there are no commercial vaccines available on the market to prevent the disease. But a Spanish University has patented an anti-*Flexibacter maritimus* vaccine (FM-95) for the prevention of the flexibacteriosis marina disease in turbot and salmonid fish and process for producing this vaccine. The vaccine can be administered by injection and confers to the fish efficient protection against flexibacteriosis. The developers are looking for a license agreement (http://www.invenia.es/bbs:GA:PSFM:4003).

2.7. Bacterial Kidney Disease (BKD)

Bacterial kidney disease (BKD) is one of the most important infectious diseases of cultured and wild salmonid fish worldwide. The causative agent, *Renibacterium salmoninarum*, is a small Gram-positive rod producing creamy yellow, convex, smooth colonies of varying sizes on agar media. The causative organism has also been isolated in the absence of disease from several non-salmonid fish species (FRYER and SANDERS, 1981, FRYER & LANNAN 1993, SANDERS& FRYER 1980). It is highly fastidious and requires cysteine for growth (FRYER & SANDERS, 1981). Several media have been developed to enhance its growth, including cysteine blood agar, kidney disease medium (KDM2), charcoal agar and selective kidney disease medium (SKDM), which is now widely used for diagnostic purposes. Growth from specimens with macroscopic lesions usually occurs within 4–10 days, but in chronic or subclinical infections, growth from fish tissues is slow on all media, often requiring several weeks of incubation. Incubation for a minimum of 12 weeks for primary cultures has been recommended in order to detect low numbers of bacteria in the tissues of healthy carrier fish (BENEDIKTSDOTTIR, HELGASON & GUDMUNDSDOTTIR 1991; GUDMUNDSDOTTIR, HELGASON & BENEDIKTSDOTTIR 1991, BULLER, 2004).

The disease has been reported from North and South America, Japan, several European countries including Denmark, England, Finland, France, Germany, Iceland, Norway, Scotland and Sweden (FRYER and SANDERS, 1981, HOFFMAN et al., 1984). Bacterial Kidney Diseases (BKD) has been reported by HALICI et al. (1977) for the first time in rainbow trout in Turkey. Subsequently, aetiological agent from cultured Black Sea salmon in Turkey was isolated and identified by SAVAS et al. (2006).

Even though considerable knowledge exists concerning BKD and the causative agent, *R. salmoninarum*, many aspects of the epidemiology of the disease are still poorly understood. Vertical transmission of the disease through infected eggs has been investigated and it is known to play an important role in the maintenance of *R. salmoninarum* infection in fish populations. Horizontal transmission through water is known to occur in natural conditions. However, *R. salmoninarum* has been reported to have a limited capacity to survive in the aquatic environment.

R. salmoninarum species isolated in Turkey have been diagnosed using Gram stain, biochemical tests, polymerase chain reaction (PCR) and indirect fluorescent antibody technique (IFAT) (SAVAS et al., 2006).

Because BKD can not be cured by chemotherapeutics and no vaccine is available, the only effective solution to the problem is the disinfection of the eggs, disposal of infected fish and disinfection of the fish farming environment. It is especially dangerous to transfer fish or eggs from wild to fish farms. A thorough health check should be carried out on the brood fish and the eggs should be held in quarantine until all monitored agents are confirmed negative. As moribund fish releases bacteria, they should be removed from the tanks immediately. Only pathogen-free eggs or fish should be introduced to the facility (WIENS and KAATTARI, 1999, SAVAS et al., 2006).

3. VIRAL DISEASES

3.1. Lymphocystis

Lymphocystis is probably the best known viral disease of marine and freshwater fish. Although lymphocystis disease has a low mortality rate, it may leave an individual disfigured. This disfigurement can have several consequences. If the gills are affected, the fish can have difficulty breathing. If the lesion is located around the mouth, the fish may have difficulty in feeding or may be unable to feed. Also, infected fish in confined environments or in the wild may be more likely to be targets of aggression or cannibalization. In addition, lymphocystis may be complicated by secondary bacterial or mycotic infections. Principal transmission of lymphocystis is by waterborne virus, the virus enters the fish through the gills or epidermal abrasions. Lymphocystis has been reported from representatives of about 30 families of fish but not from the Salmonidae. The disease is benign and chronic, seldom lethal. Iridovirus related infections which has been described for a large number of species, occurs in juveniles of sea bream in Turkey. It has been firstly reported in 1991 by CANDAN from juvenile sea bream. The prevalence of the disease in the affected fish is always important but the mortalities are low unless additional stress is associated with the disease. Generally fish recover from the disease in less than one month with reduction of the biomass, addition of vitamins to the feed and general husbandry precautions.

4. ANTIMICROBIAL DRUGS USED IN MARINE AQUACULTURE IN TURKEY

The use of anti-microbial drugs has greatly contributed to improvements in animal and human health. However, overdose and misuse of anti-microbial agents have favored the emergence of resistant organisms. This so-called "antimicrobial resistance" may spread to other microbial populations. Infectious diseases that have become resistant to standard anti-microbial treatment present a threat to human and animal health.

The treatment of fish diseases is relatively unsophisticated. Administration of drugs may be by solution in water, incorporation in feed or by injection. Many of the drugs used are traditional remedies although antibiotics and anaesthetics are being increasingly employed. The efficacy of the drugs may be affected by various environmental factors such as pH, the presence of organic matter and temperature. Some of the drugs may themselves affect the environment by destroying plants or bacterial filters (STUART, 1983, SHAO, 2001).

A range of chemicals are used in marine aquaculture in Turkey, and these may be categorized as chemotherapeutic agents (antibiotics, anesthetics, ectoparasiticides, endoparasiticides, and vaccines) and other chemotherapeutic agents (disinfectants, antifoulants). They are used to control external and internal parasites, or microbial infections (COSTELLO et al., 2001). Antibacterial drugs authorized for use in aquaculture in Turkey are shown in Table 2.

4.1. Chemotherapeutic Agents

Chemotherapy is defined as the use of drugs and chemicals for treatment of infectious diseases. To be useful, the chemicals must be effective against the pathogen without having significant adverse effects to the fish host. Antibacterial chemotherapy has been applied in aquaculture for 50 years, with early attempts to use sulphonamides in the treatment of furunculosis in trout and tetracyclines against a range of Gram-negative pathogens. However, they didn’t come into general use until the 1970s. Since then, their use has grown both in numbers and quantity, as the problem of bacterial disease has increased (INGLIS, 2000).

Chemotherapeutant usage in aquaculture is predominantly by three methods of administration; oral therapy (in feed), immersion therapy (bath, dip, flow or flush), and injection. Topical therapy, oral and bath is used in Turkish aquaculture.

A review of the currently available chemotherapeutants is given below.

4.1.1. Antibacterial Drugs

Antibiotics are drugs of natural or synthetic origin that have the capacity to kill or to inhibit the growth of microorganisms. Typical modes of action of common antibiotics are damage to cell membrane (bactericidal), inhibiton of bacterial cell wall synthesis, inhibiton of folic acid synthesis, inhibiton of DNA function, and inhibiton of protein synthesis.

The extreme use of antibiotics has decreased, especially in 1980s prior to the introduction of vaccines. The amount of antibacterial agents used in Norwegian aquaculture in 2003 was only 2% amount applied in treatments of fish in 1987. The reason for this substantial reduction in drug consumption are the introduction of effective vaccines, selection of more optimal farm sites and a general improvement of farm hygiene (GRAVE et al., 1999).

The tetracyclines are broad spectrum bacteriostatic drugs. Two of the natural tetracyclines, oxytetracycline (OTC) and chlortetracycline, have been used in aquaculture. OTC in particular has been widely used because in most markets it is not only available but also cheaper than other broad-spectrum antibacterial drugs (TREVES-BROWN, 2000).

Penicillins are part of the larger antibiotic group, the beta-lactams, which includes the cephalosporins. Benzylpenicillin (Penicillin G) is a natural antibiotic produced by fungus, *Penicillum notatum*; it has a narrow spectrum of action. Other penicillins are produced by chemical treatment of benzylpenicillin and hence are known as semi-synthetic. Two of them, ampicillin and amoxycillin have similar spectra of activity, which are broader than that of benzylpenicillin and they are widely used in aquaculture. The drugs have used to against many bacterial diseases such as *Vibrio* spp., *Yersinia ruckeri, Pasteurella* (TREVES-BROWN, 2000).

Potentiated sulphonamides are combinations of two antibacterial drugs, a sulphonamide and a pyrimidine potentiator. The combination is synergistic, that is, the antibacterial potency of the combination is greater than the sum of the potencies of the two separate drugs. Trimethoprim(TMP) and Sulfadiazine (SZD), also know as co-trimazine, with the trade mark ‘Tribrissen’ has been widely used in aquaculture. Potentiated sulfonamides are active against a wide range of bacterial infections (TREVES-BROWN, 2000).

Macrolides are medium-spectrum antibiotics active mainly against Gram-positive bacteria, *Chlamiydia* and *Rickettsia*. Erythromycin is macrolide antibiotic used against bacterial kidney disease and streptococcosis.

Antibiotics authorized for use in aquaculture in Turkey are shown in Table 2. Chloramphenicol, furazolidone, furaldatone specifically banned for use on all food producing animals in Turkey.

4.1.2. Anaesthetic Agents

Anaesthetic agents are used primarily in fish farm/laboratories to provide immobilization of the fish prior to transportation and for minor procedures. Many factors influence the efficacy of an anesthetic agent, i.e. number of fish in the bath at a time, fish size, and body fat, fish diseases state, as well as environmental factors such as pH and temperature (SHAO, 2001).

Anaesthetics used in aquaculture are MS-222 (Tricaine methane-sulfonate), Benzocaine (Ethyl para-amino-benzoate), Phenoxyethanol (phenoxyetol, 2-phenoxy-ethanol), Quinaldine sulphate. But in many countries MS-222 is the only anaesthetic with a market authorization for fish; and in the EU member states where it is authorized the use of any other anaesthetic for fish is, strictly speaking, illegal (TREVES-BROWN, 2000).

Anaesthetics authorized for use in aquaculture in Turkey are shown in Table 2.

4.1.3. Other Chemotherapeutic Agents

4.1.3.1. Disinfectants

Medical disinfectants are used to disinfect fish eggs and to clean ponds, and equipment. They include iodophores, formalin, hydrogen peroxide, and sodium chloride. Formalin and iodophores are the most widely used disinfectant in Turkish Aquaculture. Formalin is used routinely against many protozoans parasitic on the skin or gills of fish, including *Chidonella* spp., *Epistylis* spp., *Ichthyobodo necator*, *Ichthyophthirius multifiliis*, *Tricodina* spp. It has little activity against a majority of bacteria but has been used for bacterial gill disease which is a mixed infection caused by *Flavobacterium branchiophilum* together with protozoans. It is also useful for the monogenetic fluke parasites (*Dactylogyrus* and *Gyrodactylus* spp.) of fish gills and skin, respectively Formalin is a standard general disinfectant used in hatcheries for the prevention of infections eggs, the most important being fungi of the genus *Saprolegnia* (TREVES-BROWN, 2000, SHAO, 2001).

Iodophore is a general name for any compound in which a surfactant acts as a carrier and solubilizing agent for elementary iodine. The combinations retain the cleansing properties of the detergents. Disinfection of eggs is necessary not only for prevention of fungal infection but also to prevent the importation of infections into hatcheries on eyed eggs. In this respect, iodophores are used to control fungal infections of eggs (TREVES-BROWN, 2000).

Hydrogen peroxide degrades only to oxygen and water and so is considered essentially safe both to consumer and the environment. Sodium chloride is one of the most widely used substances in the medication of fresh water fish. In Turkey, hydrogen peroxide and sodium chloride have been used to control of ectoparasites (*Costia*, *Trichodina, Ichthyophthirius*) of fish. Anti-parasitic agents such as Dimetridazole, Malachite green, Neguvon banned for use on all food producing animals in Turkey.

Disinfectants authorized for use in aquaculture in Turkey are shown in Table 2.

4.1.3.2. Antifoulants

The present generation of antifoulants are mainly copper based and are sold under many trade names (copper, copper oxide, copper oxide and dichlofluanid, copper oxide and dichlofluanid and zinc oxide, 2,4,5,6-tetrachloro isophthalonitrile, 2,4,5,6-tetrachloro isophthalonitrile and copper sulphate, 2,4,5,6-tetrachloro isophthalonitrile and copper oxide). Copper and zinc are listed under the EU Dangerous Substances legislation. Antifoulants are biocides and are not directly used on food fish.

5. RESULTS AND SUGGESTIONS

Aquaculture has shown a large expansion in most of the Mediterranean countries over the last two decades. Turkish aquaculture production has grown exponentially in the last few years and became the second largest mariculture producer after Greece. Development of aquaculture has been inevitably accompanied by the occurrence of pathologies in increasing numbers. Bacterial and viral fish diseases reported in Turkey are shown in Table 1.

Except the standard biochemical tests, some type of commercial kits are used to diagnose bacterial diseases in Turkey. These kits are API Systems, BIONOR Agglutination Kits (Mono-Pp, Mono-Va, Mono-Yr, Mono-As, Aquarapid-Va, Aquarapid-Pp). The most recent developments in the diagnosis of fish and shellfish diseases have centered around molecular biology, and in particular the use of the polymerase chain reaction (PCR), which has been developed for the detection of several pathogens.

Antimicrobial agents are commonly used to prevent and treat diseases; both in cultured marine and fresh water fish in Turkey. The antimicrobial agents are usually administered in feed. However, they must be used in appropriate manner. Potential risks include the creation of antibiotic resistance, food residues and environmental toxicity. However, the future lies in the prevention of the diseases and not in their treatment which should be applied only as an emergency solution. This can be achieved by an increase in the hygiene procedures and in a near future, the application of Quality Assurance schemes in the sites of production which represent a new approach to solve disease problems. The importance of vaccination is becoming more and more actual in Turkey, since the drastic decrease of vibriosis outbreaks in sea bass with successful vaccination programs achieved. Except Vibrio, there is a big gap of an effective Pasteurella vaccine and also for other bacterial and viral diseases mentioned in this paper. Vaccination strategy covering the whole life of the fish needs to be developed further together with programs of preventive treatments, using immunostimulants, vitamins or anti-stress factors.

In general, mentioned papers above are mostly case studies and especially more works about the virulence factors and the pathogenecity of these diseases and their molecular identification techniques needs to be investigated.

Table 1. Bacterial and viral diseases of cultured marine fish in Turkey

Diseases	**Causative agent**	**Host Range**	**Referans**
Vibriosis	*Vibrio anguillarum*	*Salmo salar* *Sparus aurata*	Candan, 2000, Candan, 1993
Vibriosis	*V. ordalii*	*S. aurata,* *Dicentrarchus labrax*	Candan, 1993, Türk, 2002 Akaylı and Timur, 2002
Motile Aeromonad Septicaemia	*Aeromonas caviae, A. hydrophila*	*S. salar* *D. labrax*	Candan et al., 1995 Şahrikoğlu and Candan, 2002
Atypical Aeromonas	*A. salmonicida achromogenes*	*D. labrax*	Karataş and Candan, 2005
Pasteurellosis	*Photobacterium damsela* subsp. *piscicida*	*S. aurata* *D. labrax*	Çağırgan, 1993, Candan et al., 1996, Timur et al., 1999, Tanrıkul and Çağırgan, 1997,
Enteric Red Mouth	*Yersinia ruckeri*	*Oncorhynchus mykiss* Marine rainbow trout (*O. mykiss*)	Timur and Timur, 1991, Çağırgan and Yüreklitürk, 1991, Düğenci Karataş and Candan, 1997, Karataş and Candan, 2004, Karataş and Candan, 2004
Rickettsia-like organism	*Piscirickettsia salmonis*	Sea bass (*D. labrax*)	Timur et al. 2005
Bacterial kidney diseases (BKD)	*Renibacterium salmoninarum*	Black Sea salmon (*S. trutta labrax*)	Savas et al. 2006
Staphylococcosis	*Staphylococcus epidermis, S. aureus*	*O. mykiss* *S. aurata*	Timur and Akaylı, 2003, Kubilay and Uluköy, 2004
Lymphocystis	Lymphocystis iridovirus	*S. aurata*	Candan, 1991

Table 2. Major antimicrobial drugs and other chemotherapeutic agents in Turkish aquaculture

Antibiotics		
Agent	**Species**	**Diseases**
Oxytetracycline(T)	All fish species	Gr(-) bacteria
Amoxycillin(P)	Salmonids	Bacterial Diseases
Sulfadiazine(S)	All fish species	Vibriosis, Flexibacteriosis
Trimethoprim-Sulfadiazine(D/S) Trimethoprim-Sulfamerazine(D/S)	All fish species	Flexibacteriosis Vibriosis
Ampicillin(P)	All fish species	Pasteurellosis Bacteriosis
Erythromycin(A)	Salmonids	Bacterial Kidney Diseases, Streptococcosis Other bacteriosis
Enrofloxacin(Q)	All fish species	
Neomycin(A)	All fish species	Bacteriosis
Thiamphenicol©		Vibriosis(freswater), Visceral flexibacter
Florfenicol©	All fish species	Vibriosis(freshwater), Visceral flexibacter
Sarafloxacin(Q)	Salmonids	Yersiniosis, Frunculosis
Anaesthetics		
MS222(Tricaine methane-sulfonate)	All fish species	Handling and spawning
Anti-parasitics		
Hydrogen peroxide	All fish species	All Ectoparasites
Fenbendazole	Salmonids	Tapeworm
Azamethiphos	Sea bass, Sea bream Salmonids	Monogenean flukes, Arthropods
Albendazol	All species	Tapeworm
Levamisole		Antihelmints
Ivermectin	All fish	Sea lice

	Species	
Other Agents		
Formalin	All fish species	Protozoas
Iodophors	Egg	Fungal infections, disinfection
Sodium Chloride	Salmonids	Ectoprotozoans
Peracetic Acid	Salmonids	Sea lice
Ascorbic Acid		
Thiamine		
Beta glucans		
(Groups:T=Tetracyclines, P=Penicillin, D=Diamino irimidins, S=Sulfonamides) (Groups:Q=Quinolones, A=Aminoglucoides, C=Chloramphenicol)		

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MARKETING AND ECONOMIC PERSPECTIVE

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1. MARINE AQUACULTURE PRODUCTION IN TURKEY

The history of aquaculture in Turkey is quite new while it dates back to 3000's B.C. in the world. A total of approximately 50 million tons of aquaculture products produced by means of aquaculture all over the world, 51 % is constituted by finfish, 22 % by sea-weed, 23 % by shellfish like mussel, and 4 % by shrimp (FAO, 2005). Share of capture fisheries in total aquaculture production all over the world has been decreasing continuously. The aquaculture products constitute one of the leading sources of animal protein especially in underdeveloped countries. However, consumption per capita is higher in developed countries. The problems such as increasing pollution as a result of industrialization, and diminished amount and quality of aquaculture products due to unplanned fishing activities have promoted aquaculture to the forefront in the world as well as in Turkey. The recent technological and economic developments in aquaculture all over the world have accelerated aquaculture in Turkey. Since Turkey is not sided by the oceans, it is not one of the leading countries in the world in terms of producing or trading aquaculture products (ÇELİKER, 2003).

Turkey has significant geographical and physical advantages for aquaculture and fisheries in terms of both internal waters and marine aquaculture farming opportunities. Turkey is among few countries that cannot realize its full potential within the geographical region it is located in. Owing to the fact that it is surrounded by a very productive sea with a quite long shoreline, Black Sea, Turkey is the most rapidly developing country in the Mediterranean Basin in terms of marine aquaculture. 'Aquaculture production decreased as a result of closing down or shrinking of small scale businesses due to the increased input prices between 2000-2002 in Turkey but has started to increase upon inclusion of sea bass, gilthead seabream and trout aquaculture as of 2003 under the scope of Decision on Subsidizing Livestock Farming (2000 / 467, inclusion of abovementioned varieties in subsidies, and entering into force of Aquaculture Farming Regulations as of June 2004 ensuring conduct of production activities in accordance with specific rules. As a result of this action, aquaculture farming that was just 3% of total marine aquaculture production in Turkey in 1994 increased up to 15 % in 2004 (TURKSTAT, 2005)

2. THE MARKETING SYSTEM AND THE MARKET ENVIRONMENT

2.1. Total Supply of Marine Aquaculture in Turkey

Sea bream and seabass are the two important products in marine aquaculture, whose production reached 17 thousand tons and 29 thousand tons in 2006 respectively. These fish are mainly cultured along the coasts of Aegean region. Marine aquaculture production exceeded 48 thousand tons in 2006, showing a 18.2 % increase compared to production in 2005 (Table 1).

Table 1. Marine Aquaculture Production in Turkey during 1999-2006 (tons) (FEAP,2007)

Species	**Product**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006***
Sea Basses	European Sea Bass	12,000	17,877	15,546	14,339	15,000	17,050		29,000
	European Sea Bass 400/600 gr							4,500	
	European Sea Bass 200/300 gr							6,500	
	European Sea Bass 300/400 gr							9,500	
	European Sea Bass 600/800 gr							600	
Sea Basses Total		12,000	17,877	15,546	14,339	15,000	17,050	21,100	29,000
Sea Bream	Gilthead Sea Bream	11,000	15,460	12,939	11,681	12,000	13,950		17,000
	Gilthead Sea Bream 300/400 gr							9,500	
	Gilthead Sea Bream 200/300 gr							7,000	
	Gilthead Sea Bream 400/600 gr							1,000	
Sea Breams Total		11,000	15,460	12,939	11,681	12,000	13,950	17,500	17,000
Trout	Large Rainbow Trout	1,700	1,961	1,240	1,240	2,000	2,000	2,000	2,000
Trout Total		1,700	1,961	1,240	1,240	2,000	2,000	2,000	2,000
Grand Total		24,700	35,298	29,725	27,260	29,000	33,000	40,600	48,000

* Provisional

2.2. Marketing System and Market Planning

Culturing an aquaculture product to market size may be the most difficult task faced by the aquaculture industry, but finding a market for the product may be the most important task. Product marketing must be considered during the planning phase of the enterprise. All too often, the product is produced and then a market is sought. Marketing must be considered before the product is grown and not as an afterthought.

As an aquaculturist, the producer has the unique advantage of first knowing what the market wants and then producing it. The aquaculturist can shift away from a strict "production mentality" to a "market mentality", where the market drives the production decisions, within technological limitations. Adjustments in the production schedule, i.e., time of stocking, stocking density, grow-out period and harvest period, can lead to higher prices and higher profits when market information is included in production management. To take the best advantage of the market, the industry must develop and keep an up-to-date marketing plan. Due to the uncertainty of yields and prices, planning the marketing strategy becomes very important. Market planning is not a one-stage process, it must be continuous throughout the year. A successful market plan must be flexible, the market plan must address several critical points including:

- Market location
- Competition
- Required volume for the market
- Market demand for the product
- Harvest time specifications
- Quality necessary to satisfy the market
- The market requirements (size, form)
- Product delivery and handling
- The cost/price relationship.
- The market plan should be reviewed and revised often.

Market planning is not to "predict" but to "interpret" the pricing and market alternatives. Pricing and market decisions should be made when the odds are that realistic pricing and financial goals can be reached based on the outlook. Market planning requires discipline and tough decision-making but can determine the success and failure of the aquaculture operation. A marketing plan should be prepared for each individual outlet and product chosen by the producer (POMEROY, 2001).

The relationship, which exists between the producer and the consumer is a continuous and a dynamic one. The factors which affect this relationship are the need for a product, its availability, its quality and - last but not least - its price. Because of the delicate fragility of this relationship, it should be part of an integral set of company objectives that aim towards the launching of a product, which offers a differential advantage over competition. Understanding the competition enables the development of production and marketing programs around specific species and/or product types for the markets that will yield the greatest profits. Any such products should be carefully presented to the consumer and accompanied by a marketing schedule, which combines the variables of product, price, promotion and distribution into the most effective form. This dynamic approach is necessary in order to ensure the establishment of an on-going exchange relationship with the consumer (PAPAGEORGIOU, 2000).

The contemporary seafood industry is globally well established and highly competitive. It is of prime importance to comprehend that aquaculture products are not in competition with other seafood products only. The market in which the aquaculture sector operates is the wider food market. New customers must be sought for, not only within the seafood consumer group or the "animal-protein" consumers. The industry should consider as potential customers the entire group of food-consumers because competition is merciless in the present era of consumer awareness. Habits are altered and largely internationalised. No company with prospects for growth should oversee the potential the wider food market presents. Customer loyalty can hardly be taken for-granted with the variety of alternatives offered.

In this sector, trout constitute more than 60% of the total aquaculture production in Turkey. This fish is preferred because of its delicious taste and suitability to the water temperatures of the rivers and reservoirs in Turkey. Producers of trout are mainly concentrated in the Aegean region where approximately 25% of the total production is obtained. Furthermore since this fish has the ability to live in slightly salty water as well as in freshwater, which is its natural habitat, trout are also grown on farms in north-east part of the country, mainly Ordu, Rize and Sinop. These are provinces in the Black Sea region, where the salt content is lower than in other seas of Turkey. Other products gaining importance in marine aquaculture are new species like common dentex, sharp-snout sea bream, red sea bream, shi drum, brown meagree and mussels.

The fact that Turkey has a large and growing population but relatively small-scale aquaculture production results in low consumption of aquaculture products per capita, only 8.9 kg in Turkey now. The figure is 24.6 in Italy, 31.2 in France and 44.7 kg in Spain. Consumption per capita is at least 60-70 kg in Japan.

Based on only sea bass, gilthead seabream and trout, marine aquaculture production in 2005 constitutued a volume of 159,6 million Euros in overall economy based on average prices. After adding trout production in freshwater sources, the figure increases up to 235,2 million Euros. Based on interim figures regarding year 2006, it was predicted that economic volume of aquaculture production will be 199,2 million Euros. It is expected that this figure will be increased to 275 million Euro after adding production in inland waters. Fourty four percent of the total sea bass production and 18 % of the total gilt head bream production was exported within the last two years while the rest was consumed in domestic market

The monetary values of production and average prices for different Marine Aquaculture Products are given in Table 2.

Table 2. The monetary values of production and average prices for different marine aquaculture products (Millon €) (FEAP 2007)

Species	Product	Data	2001	2002	2003	2004	2005
Sea Basses	European Sea Bass	Production (tons)	15.546	14.339	15.000	17.050	21.100
		Value in € per Kg	€ 4.89	€ 4.68	€ 6.08	€ 4.60	
		Value in M €	M€ 76.0	M€ 67.1	M€ 91.2	M€ 78.4	M€ 0.0
	400/600 g	Production (tons)					4,500 t
		Value in € per Kg					€ 5.04
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 22.7
	200/300 g	Production (tons)					6,500 t
		Value in € per Kg					€ 3.87
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 25.1
	300/400 g	Production (tons)					9,500 t
		Value in € per Kg					€ 4.74
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 45.0
	600/800 g	Production (tons)					600 t
		Value in € per Kg					€ 6.41
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 3.8
Sea Basses Value in € per Kg			**€ 4.89**	**€ 4.68**	**€ 6.08**	**€ 4.60**	**€ 4.58**
Sea Basses Value in M €			M€ 76.0	M€ 67.1	M€ 91.2	M€ 78.4	M€ 96.7
Sea Breams	Gilthead Sea Bream	Production (tons)	12.939	11.681	12.000	13.950	17.500
		Value in € per Kg	€ 4.10	€ 4.12	€ 4.90	€ 4.30	
		Value in M €	M€ 53.0	M€ 48.2	M€ 58.8	M€ 60.0	M€ 0.0
	300/400 g	Production (tons)					9,500 t
		Value in € per Kg					€ 3.32
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 31.5
	200/300 g	Production (tons)					7,000 t
		Value in € per Kg					€ 3.15
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 22.1
	400/600 g	Production (tons)					1,000 t
		Value in € per Kg					€ 3.65
		Value in M €	M€ 0.0	M€ 0.0	M€ 0.0	M€ 0.0	M€ 3.7
Sea Breams Value in € per Kg			**€ 4.10**	**€ 4.12**	**€ 4.90**	**€ 4.30**	**€ 3.27**
Sea Breams Value in M €			M€ 53.0	M€ 48.2	M€ 58.8	M€ 60.0	M€ 57.2
Trout	Large Rainbow Trout	Production (tons)	1240	1240	2000	2000	2000
		Value in € per Kg	**€ 2.42**	**€ 2.39**	**€ 2.46**	**€ 2.50**	**€ 2.84**
Trout Value in M €			M€ 3,0	M€ 3,0	M€ 4,49	M€ 5,0	M€ 5,68
Grand Total (tons)		-	**29.725**	**27.260**	**29.000**	**33.000**	**40.600**
Total Value in M €			**M€ 132,0**	**M€ 118,3**	**M€154,49**	**M€ 143,4**	**M€159,58**

3. DISTRIBUTION SYSTEM OF AQUACULTURE PRODUCTS

How can a new producer gain access to the Turkish Aquaculture market? A small producer may find direct sales to consumers as the best alternative. A larger producer may be able to contract with an established buyer. A number of market outlets are available. These include (Figure 1):

- Sales through a cooperative
- Sales through a seafood broker
- Sales to chain outlets - restaurants, supermarkets
- Sales to institutions - government, food service companies
- Catering companies
- Sales for export
- Sale to a processing plant
- Contract to a processing plant to process the product that are then sold by the producer
- Operate own processing and marketing facility
- Local sales to stores - fish markets, food markets, specialty stores, restaurants.

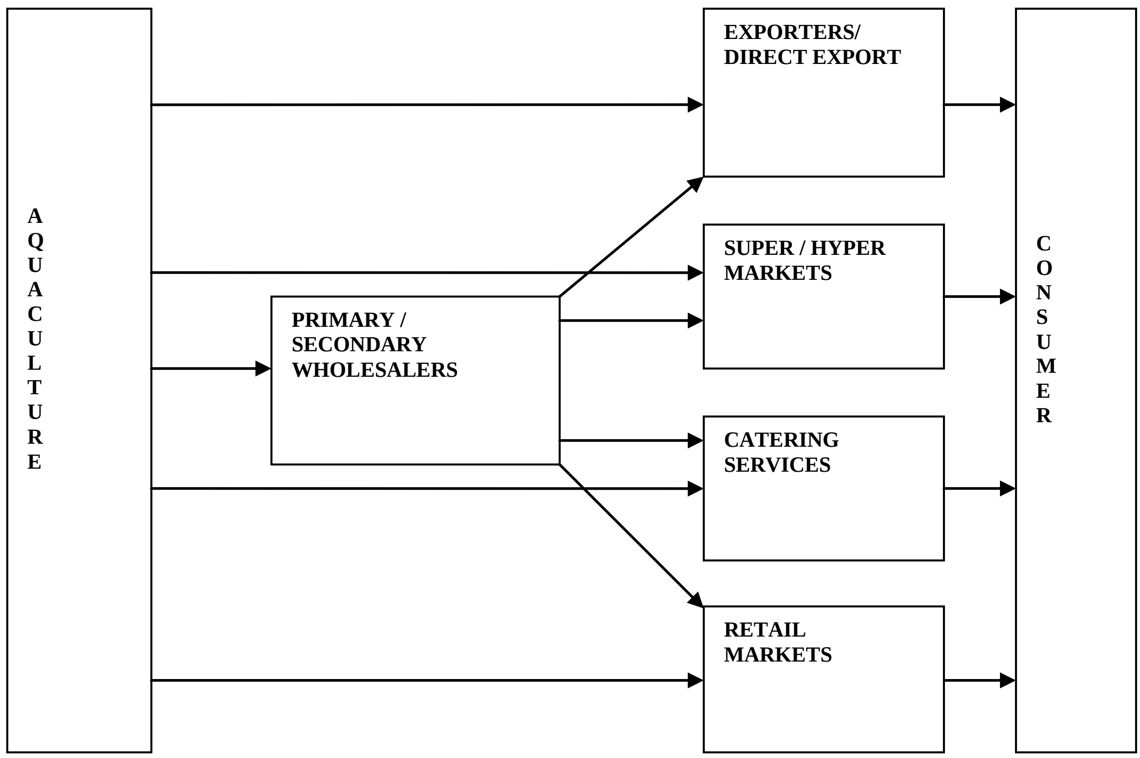

Figure 1. Distribution Channels For Aquaculture Products in Turkey.

3.1. Wholesalers (First Hand Sales)

The coastal regions of Turkey are generally well-equipped with harbours and landings where fish can be brought to shore. Good road access to these harbours and landings allows fish to be handled at any convenient point and transported to the most profitable markets by trucks.

Wholesales constitute 70-80% of the marine fish sales in Turkey. The primary wholesale markets are located in Istanbul, Izmir, Trabzon and Samsun. Istanbul and Izmir wholesale markets are the largest in terms of volume of trade. Ankara handles both primary and secondary wholesale trade. The wholesale markets are managed by local municipality. The share of fisheries co-operatives in overall trade of marine fish is not significant. In 1997 the overall share of co-operatives was only 4.0%. Aquaculture products follow the same pattern as in the case of capture fisheries products. Farmers or commissioners transport the fish (boxed and iced) to major markets such as Istanbul, Izmir and Ankara. Packing of cultured products is much better than that of captured fish. Farmers may have contracts with particular wholesalers or deal directly with retailers.

Research on Turkish aquatic food (seafood) market has been neglected both by academic institutions and the industry. Therefore, it is very difficult to get access to specific data on consumption patterns of seafood, retail outlets, catering services and marketing channels. The only comprehensive survey was carried out by Ministry of Agriculture and Rural Affairs (conducted by Macalister Elliott and Partners Ltd) with the support of World Bank and published in 1996. Data presented in this report on characteristics of consumption and distribution channels, household expenditure on seafood, consumer preferences and marketing channels are based on findings published in this survey (RAD, 2002).

Obvious changes in procurement processes of consumers have been spotted in particular due to the increasing investments of multinational chain stores in Turkey in recent years.

3.2. Retail Outlets

Fish bazaars (markets) and specialty fish shops are two important retail outlets in Turkey (Table 3). Three other less significant outlets are local bazaars, mobile (travelling) sellers and direct sales from fishers. Innovative approaches developed by Hypermarkets and Supermarkets (including being consumer-oriented, high standards, guaranteed product quality, etc) have led consumers to meet their needs predominanlty at collective shopping centers, and the process has started to influence marketing and distribution strategies of aquaculture products in addition to other consumer goods (Table 4).

Multinational chain stores that boost investments have increased their total share in aquaculture product sales a figure which was 0.5 % in 1995 (ALBAYRAK, 2000). At the present, this share is estimated to be around 6 % (Table 3). Nevertheless, it should be pointed out that the share of hypermarkets in overall Turkish retailing market is increasing in the recent years. The value of Turkish retailing market is estimated to be 70 billion US$. Along with many national companies, many international supermarket chains (Metro, Tesco, Champions, Carrefour) have already entered Turkish retail market. Most of these supermarkets have seafood departments and are engaged in sea food sales. Therefore, the new trend is developing in favour of supermarket chains in the metropolitan areas.

Table 3. Retail Outlets for Aquaculture Products (% purchases) (RAD, 2002)

	Total	**Urban**	**Semi-urban**	**Rural**
Fish market/bazaar	34.0	48.3	32.0	24.2
General market/bazaar	0.8	1.7	0.3	0.4
Fish shops	9.4	13.6	11.8	5.0
Supermarkets	0.5	1.2	0.2	0.2
Fishermen	8.5	7.5	6.9	10.0
Mobile sellers	31.5	15.0	25.7	47.0
Local market/bazaar	9.9	9.5	16.6	7.0
Others	5.4	3.2	5.3	6.2

Table 4. Sale Frequencies of Processed Fish Products in Hypermarkets (SAYGI AND ŞENGÖR, 1997)

Preferred seafood item	%
Canned fish	32.0
Smoked fish	3.5
Frozen fish	14.3
Frozen cephalopods	10.7
Frozen shellfish	10.7
Fresh fish	25.0
Surimi	3.5
Total	100

3.3. Catering sector

The data presented below on catering service are the findings of a survey carried on covering 200 catering points in Turkey. Sixtythree percent of catering points (hotel, tourist restaurants) covered by the survey were found to serve fresh fish regularly. Twentysix and a half percent served smoked fish regularly while, 21.0% regularly served frozen and 18.5% served canned fish. The total consumption of aquatic products by catering sector in Turkey in was estimated 9200 t . The shares of aquatic products served regularly or irregularly are given in Table 5.

Table 5. The shares of aquatic products served by catering sector

	Hotel and tourist restaurants	Other catering points
Fresh fish	93.7%	93.5%
Frozen fish	58.4%	39.5%
Canned fish	43.2%	27.5%
Smoked fish	64.2%	43.0%

Species most favoured by customers and served regularly by catering sector were bluefish, sea bass, sea bream, turbot, bonito, shrimp, anchovy, cuttlefish, painted comber, red mullet, sole, whiting, trout and striped bream .

4. BRAND BUILDING IN AQUACULTURE

Aqauculture products can be marketed to the customers using different types of preservation and distribution methods. The same product can be distributed as a raw material or a branded product to catch the loyalty of customer. Usually the raw fresh product has all the characteristics of non branded product and it is very difficult to distinguish its image to the end consumer. Üretici firmaların marka geliştirme çalışmaları aşamasında plastik materyallerin (kulakçık) kullanımı, paketleme maliyetlerinin artmasına ve süre kaybına neden olabilir. Producer may encounter problems in building a desired product concept with the product being marketed due to difficulties associated with the label retention. The raw product can have a brand that can be recognised by the wholesaler or retailer that are using this product but it is unlikely that the end user can recognise the brand.

Brand trough packaging is surely a way to diffuse the culture of the product, how to consume it and its importance. The choice of a good packaging diffusing the image of a brand and the choice of the right distributor that assure a polite way of sales and conservation are the secret for a certain success in the distribution of acquaculture product (PEDOL, 1996).

Branding is a mean to secure steady or increasing prices to the benefit of the primary producer. Supermarket buyers have less market power to put pressure on the price development of branded products which are a constant factor in their product mix. It is important to understand the "new emotional consumer" and his/her needs. Branding becomes a key to success for major fish processors but while ensuring that consumers get quality, safety and reliability (AUSIELLO, 2003).

‘If you are proud of your product, you should be proud of your name ,you want buyers and consumers to ask for your fish by name, how can they do this if your name is not on the fish?’ (TUNCER, 2006).

5. CONSUMER BEHAVIOUR AND PRODUCT TYPE DIFFERENTATION

For an aquaculture company, to be successful in the modern competitive food-market environment, such information must be carefully analysed and the results appropriately considered, in order to serve as a guide for the research and development of potential products, whether or not this is for a new species or product type. On the other hand, this approach does not merely entail identifying customer need and leaving the production specialist to raise the selected species, or yield new product types.

An understanding of the market requirements and a commitment to fulfill them are fundamental to success. For some products, such as fish, it is virtually impossible to differentiate among consumers on the basis of product characteristics, simply because the product does not lend itself to this approach. However, it may be possible to change the characteristics of a product in ways that will have particular appeal to different segments of the wider consumer population. The potential product can be thought of as a bundle of characteristics, which appeal to different consumers in different ways. Hence, product differentiation should be the next step following a market segmentation that determines which set of product attributes should be incorporated in the version of the product targeted at each market segment. It should be noted that, of the most important determinants of a product's success are likely to be the price of the product compared to similar products, and the degree to which consumers perceive the product as a different offering (PAPAGEORGIOU, 2000).

Table 6. Share of Different Food Items in Food Expenditure of Turkish Households (TURKSTAT, 2000)

Food item	**Budget share (%)**
Fish	1. 1
Bread	9. 2
Cereals	9. 2
Meat	15. 7
Poultry	1. 8
Milk and dairy products	10. 3
Eggs	2. 3
Animal fats	2. 0
Vegetable oil	5. 3
Pulses	4. 3
Others	38.

Table 7. Meat, Chicken and Fresh Fish Consumption Frequencies at Home (expressed as percentage of respondents) (MACALLISTER AND PARTNERS, 1996)

	Meat	Chicken	Fish
Everyday	18. 9	1. 1	0. 8
Once Every Two days	11. 5	4. 9	2. 1
Twice a Week	10. 8	9. 6	5. 8
Once a Week	20. 6	28. 1	29. 8
Once a Fothnight	11. 5	21. 8	18. 6
Monthly	17. 6	25. 5	25. 7
Three / Four Times a Year	7. 8	8. 3	16. 6
None	1. 2	0. 8	0. 7
Base	2164	2164	2164

In many situations, the volume, quality and price may be determined by the buyer. Consequently, the producer must be willing to work with the buyer and meet the market requirements. Quality and consistency of the product are key factors in successful marketing. Quality is vital for successful marketing, as is the ability to provide good service at competitive prices. Major factors of importance to fish buyers at the time of purchase include:

- Appearance
- Flavor
- Freshness
- Consistent supply
- Quality guarantee
- Price

The development stage will probably take at least a year or longer to perfect, but at the end, the company will have seabass and bream which will taste superior to any other farmed seabass and bream on the market. In the case of chicken, for the most part, from the richest to the poorest eats the same chicken., it looks the same, it tastes the same and everyone seems to willing to accept this same idea for seabass and bream. In France, there are certain superior tasting species of chicken which are grown for the upper market. A producer may want to do the same for seabass and bream and want to develop a whole new concept of how consumers look at these two fishes (TUNCER, 2006).

Table 8. Consumers attitude towards on fish (%) (RAD, 2002).

	Agree	Neither agree nor disagree	Disagree	Do not know
I like trying new species	56.8	8.4	30.9	3.9
Difficult to eat	70.0	6.6	22.7	0.7
Would consume more if it was cheaper	79.6	5.5	14.1	0.8
Male prefer red meat to fish	49.3	12.7	31.6	6.4
Canned fish as good as fresh fish to you	14.0	7.9	39.2	38.9
Marine fish is more delicious than freshwater fish	63.8	8.7	17.5	10.0
Fish consumption is good for health	97.7	1.0	0.8	0.5
Smell is the problem in cooking fish	79.7	5.1	14.7	0.5
Children like fish	74.4	12.6	10.4	2.6
Prefer to offer fish to my guests	56.2	14.3	28.0	1.5
Buying fresh fish is really easy	68.4	8.7	18.2	4.7
My family prefers chicken to fish	48.4	16.5	33.8	1.2

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AQUACULTURE LEGISLATION

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1. INTRODUCTION

The results of recent studies have brought up that fishery stocks are depleted because of ineffective management models and/or problems put into practice on the renewable resources of fish stocks in the world. The experiences on the capture fisheries showed that an effective management is vital for optimal and sustainable usage of the stocks and this undoubtful fact is also confirmed with the related scientists at national and international institutions. In the light of this fact, especially in the last 30 years, extraordinary efforts have been expended for the development of both global and local management models and encouraged national measures.

Aquaculture provides widespread advantages and opportunities, such as effective use of resources, aid to provide an equilibrium of supply-demand, depending on whether it is at the local or country level to prevent starvation, reduce unemployment, rural development, development of agricultural industry and input exchange (FAO, 1989; PILLAY, 1990; NEILAND *et al*., 1991; CURTIS AND CLONTS, 1993; FAO, 1997; SHANG and TISDELL, 1997).

Aquaculture, probably the fastest growing food production sector, now accounts for almost 50 percent of the world's food fish and is perceived as having the greatest potential to meet the growing demand for sea food. This sector has grown at an average rate of 8.8 % since 1970. In the same period, fisheries and livestock production was grown 1.2 % and % 2.8, respectively. This value also reveals the importance of aquaculture. While the contribution of aquaculture production to total production was 3.9 % and 27.1% in 1970 and 2000 respectively, this value was reached 32.4% in 2004 (FAO 2007).

It is expected that the value of aquaculture production and consumption will be sharply increase and in case of the same population value, it will reach to 83 million tons in 2003 (FAO 2006a).

Recent researches showed that sustainable aquaculture development is provided with a general policy, appropriate institutional, legal and supported by management substructure and enabling environment directly (FAO 2007).

Contrary to fisheries, aquaculture is generally an activity that carried out by countries own boundary, these activities are managed, monitored and governed by the frame of their own laws. For this purpose, key documents have been produced for countries to develop aquaculture in responsible way (FAO 1995; INFOFISH, 1997; NATS, 1998; FAO/NACA, 1995).

Recent researches clearly indicate that key trend is enhanced regulation and better governance to develop and manage the aquaculture (FAO 2006b).

In Turkey, up to the Planned Development Period, fisheries activities were carried out the regulations that put into force in 1287 and 1299 during Ottoman Empire Period. These regulations were transformed to the law numbers 465, 721 and 820 in Republic period (Atay 1993; Elberk et al., 2001). Fisheries Law 1380, including all fisheries subjects and activities, put into force in 1971. To adapt the innovative conditions, some amendments were done and the consortiums were developed (ÇAKMAK and ÇOLAK, 2004).

In parallel with the world's trend, important steps have been taken to provide environmental, economic and social sustainability in Turkey's fastest growing sector aquaculture with constitution of legal framework and development of effective management strategies in recent years.

In this scope, some laws came into force on the subjects of planning aquaculture national macro-level and project or farm-based micro level, using land and water, selecting field for aquaculture and designing farm, determining of appropriate production models, product quality and marketing, organization and supporting.

Although there is a lot of information on the Aquaculture and Fisheries in Turkey, the data on aquaculture legislation system is lacking. The aim of this study is to emphasize and review the basic laws related to aquaculture in Turkey.

2. OVERVIEW

Law No. 1380 of 1971 is the main legal basis for fisheries including aquaculture and specifies that Ministry of Agriculture and Rural Affairs (MARA) is also the component authority responsible for aquaculture. The General Directorate of Agricultural Production and development (GDAPD) of MARA is the responsible authority for development and management of aquaculture.

Article 13 of the Fisheries Law, as amended by law 4950 of 2003, sets up the aquaculture activities. With this revision, important expansions were provided to set up aquaculture facilities management till that time. Article 13 of the Fisheries law states that those who wish to establish a fish farm are obligated to apply to MARA by informing the Ministry about the location, characteristics and management of the facilities, and submit the enterpriser's project and plans. In addition, a last paragraph was added to the Article 13 to obligate the publishing of the Aquaculture Regulations. In this scope, aquaculture regulations came into force in 2004, revised in 2005 and 2007 to adapt the innovative conditions. In addition, article 36, item (c) was added to the Fisheries Law for the penal provisions of the fish farms. In this scope, illegal fish farms shall be fined substantially. If illegality is not eliminated, court of law will decide to close these fish farms.

The aims of the aquaculture regulations are; to use water resources potential productively, to provide sustainable aquaculture, to conserve environment and ensure quality/safe food, to carry out investment of aquaculture in plan, to provide active control during production.

This regulation covers and sets out rules for the following issues:

- Site selection for inland and marine farms
- Application and evaluation procedures for fish farming licenses
- Approving the projects and issuing licenses
- Improving production capacity, species etc, cancellation (closing down farms), site changes and sales
- Other aquaculture activities (tuna fattening, organic farming, integrated production systems)
- Importing brood stock, egg and fry,
- Compulsory technical staff employment,
- Fish health management
- Environmental impacts and protection
- Monitoring and control of farming activities

In this scope of this regulation to determine the implementation of principles 'Application Principles With Regard To The Regulation On Aquaculture communiqué was put into force in 2004 and this communiqué was revised in 2006. With this communiqué fry, egg and brood stock importation principles were determined. In addition, implementation based technical details were determined. One of the innovations of the discussed communiqué is to some responsibilities which were carried out in the central office, were evolved into the Province Directorates of the Ministry.

In accordance with the discussed regulations and communiqués determined technical principles related to fish farms are:

All aquaculture producers must have an aquaculture license of registration from the GDAPD, Department of Aquaculture. The details of the application, issuing and cancellation of the aquaculture license are described in the Aquaculture Regulation and Application Principles with Regard to the Regulation on Aquaculture, 2004 as amended in 2006. Entrepreneurs or applicants need to submit their applications to the Provincial Directorates of MARA with all the relevant supporting documentation - for example a written application with species, capacity and production system clearly mentioned and a map of the area.

A team of experts from the provincial office then visits the site and prepares a preliminary survey report. If the report is positive, a preliminary license is issued for 8 months and can be extended up to 12 months. Supporting documentation submitted for the preliminary license must include a site map (1/25.000 scale), the preliminary survey report and a water quality report (FAC 2007).

The entrepreneur can then prepare the full project documentation, which includes a farm or hatchery design and feasibility report and an environmental impact assessment (EIA) report given by the Ministry of Environment and Forestry. Approval is also needed from other related institutions dependent on the nature of the project (e.g., Ministry of Environment and Forestry, Ministry of Health, Maritime Affairs, Department of Transport, State Hydraulic Works, Ministry of Culture and Tourism, Coast Guard Command). The project can be rented or purchased during the preliminary license period whilst all of this documentation is submitted for the (full) license by the local authorities. If the project is approved the license (Fish Farming Document) is issued; this usually takes about 1 year. According to Tendering Law No: 2886 of 1983, the lease period for marine cages sites is a maximum of 15 years and the contract can be terminated earlier by the government.

Moreover, with MARA, a communiqué came into force in 2004 concerning intensive, semi intensive and extensive production with sportive fisheries in the ponds. In addition, in 2006, a communiqué was also published “concerning fish production in moving systems” that made the production of fish possible in the ships which are converted to the fish farms

Production facilities on dam lakes, important potential for aquaculture, carried out a protocol frame that was signed among Ministry of Energy and Natural Resources, General Directorate of State Water Works, and MARA, GDAPD. This protocol firstly came into force in 1994, and revised in 2004 and 2007 to give opportunity for semi intensive and extensive aquaculture in dam lakes.

Construction of fish farms and technical details including determination of conditions for production procedures and excluding laws carried out from MARA; there are a lot of basic laws of other public institutions in both construction and production in stages. (App.1).

There is an intensive debate concerning environmental effects of aquaculture in Turkey. Not only Fisheries and Aquaculture Regulations, but also Water Quality Regulation and Environmental Impact Assessment Regulation are included in legal and technical arrangements in this subject. Environmental Impact Assessment Report, one of the necessities in construction stage and required detailed study and analysis, brings up the risks and precautionary measures of the environmental effects of aquaculture.

In case of aquaculture in forest and different degree of protected areas, some laws carried out with related institutions with obligations of international agreements, is also a limited sector. One of these, Environment Law, published in May 13th 2006, includes important articles about aquaculture sector. Discussed law includes an article 9, item (h) “Marine aquaculture facilities shouldn’t be constructed in sensitive areas such as closed bay and gulf with natural and archeological protected areas” decision and with temporary article 2 in Environment Law No. 2872, “fish farms contrary to Article 9, item (h) will be closed after 1 year of the publishing of this law” decisions are included. Published communiqué, on the frame of this law repealed by Council of State.

As mentioned above, MARA is the mainly responsible all kinds of Fisheries and Aquaculture activities by the Fisheries Law. But both the nature of the aquaculture facilities as a multidisciplinary activity and new arrangements about other shareholders, aquaculture activities exists inside of many of activity areas of other public institutions. So the laws and related regulations of these institutions are taken into consideration in the stages of the aquaculture activities. Some of these institutions are shown below:

- Prime Ministry (State Planning Organization (DPT),
- Turkish Statistical Institute (TURKSAT),
- DG Customs,

- Under secretariat of the Foreign Trade
- Turkish Standardization Institute (TSE)
- Ministry of Finance (DG Incomes)
- Ministry of Environment and Forestry
- Ministry of Interior (Coastguards)
- Ministry of Health
- Municipalities (Quality control and conservation in the local open markets)
- Bank of Agriculture (Credits)

3. RESULTS

Aquaculture sector in Turkey has a proportionally crucial role with increasing fish supply and marketing. When concerned laws are examined, a control and arrangement mechanism is existed at the start of the site selection of fish farms, production facilities and post harvest procedures. These arrangements, constituting framework of sustainable aquaculture brings hopeful point of view for the future of the sector. But more effort can be strived when applying and developing of existing laws. In this scope, training activities can be concentrated on and these implementations can be supported by an effective administrative structure and country wide policy.

Monitoring of environmental effects of aquaculture is one of the key issues of developing aquaculture sector to provide the environmental sustainability.

New administrative and legal arrangements are needed to simplify and shorten the complex structure of aquaculture procedures.

The steps after restrictive repealing of decisions of Environment Law and Communiqué by Council of State, plays key role on the future of the aquaculture sector.

LAWS

NAME OF THE LAW AND PUBLICATION DATE	**SCOPE**
Fisheries Law No:1380 of 1971 (As amended by Laws 3288 of 1986 and 4950 of 2003	The law arranges the principles of the aquaculture activities and penalty of illegal fish farms.
Environment Law no: 2872 of 1983 (as amended by Law 5491 of 2006)	The areas which fish farms should not be constructed are decided and inappropriate farms are closed after 1 (one) year as required by law
Animal Health and Control Law (number 19109 in official gazette in 16.05.1986)	The main law is about preventive measures from animal diseases including aquatic animals and determines the principles of preventive efforts from them.
Government Tendering Law No: 2886 (No. 18161 in official gazette in 10.9.1983)	The law arranges the principles of the leasing of freshwater and marine water areas, field and river for aquaculture activities.
Agriculture Insurance Law (No. 25852 in official gazette in 21.06.2005)	The law arranges the principles of insurance of agriculture activities including aquaculture.
Agricultural Producer Association Act (No. 25514 in official gazette in 06.07.2004)	The purpose of this Act is to ensure that the agricultural producers join efforts together on production of a product or product group and establish agricultural producer associations with a legal identity in order to plan the production according to the demand, improve the product quality, offer markets such products as complying with the applicable norms and standards provided that it does not take possession of the same, and to take measures enhancing the marketability power of the products at the national and international level. This Act covers provisions relating to the establishment, operation, management, tasks and duties and supervision of the agricultural producer associations.
Cooperative Law (No. 13195 in official gazette in 10.05.1969 as amended in 1988)	The law determines the principles of relation to establishing agriculture cooperative including fisheries and aquaculture.
Soil conservation and Land Use Law (number 25880 in official gazette in 19.07.2005)	The law determines the conservation of soil, prevent soil lost through natural and artificial means, environmental priority, appropriate principles for sustainable development and provides land use in plan. In addition, it gives opportunity for aquaculture in special product lands.
The Pasture Law (No. 23272 in official gazette in 28.2.1998 as amended in 2002,2003,2004,2005 and 2007)	Article 27, item (d), make aquaculture possible in pasture areas, in specific conditions.
The Forest Law (No. 9402 in official gazette in 08.09.1956 as amended in 1945, 1986, 1987, 2003 and 2004)	The law arranges the activities on the forest areas.
The National Parks Law (No. 18132 in official gazette in 11.08.1983 as amended in 2005)	The law includes some restrictions, conducting activities in National Parks.

IMPLEMENTING REGULATIONS

NAME OF THE LAW AND PUBLISHED DATE	SCOPE
Regulation on Aquaculture (no. 25507 in official gazette in 29.06.2004 as amended in 2005 and 2007)	The objective of this Regulation is to ensure that the investments for aquaculture production are made in a planned way and efficient supervision is put in place during production with a view to securing efficient use of the fisheries potential in our country, sustainability in aquaculture production, environmental protection and supply of high-quality/safe food.
Regulation of Fisheries (No. 22223 in official gazette in 10.03.1995)	This regulation includes the rules improved for fisheries, production areas, manufactured and semi-manufactured fishery products, marketing procedures and prohibitions, limitations, liabilities, precautions, quality control and safety inspection and proper management of stocks.
Environmental Impact Assessment Regulation (No. 25318 in official gazette in 16.12.2003)	This regulation arranges administrative, technical way and the principles of Environmental Impact Assessment in details.
The Water Quality and Control (No. 25687 in official gazette in 31.12.2004)	The regulation determines the legal and technical ways of conserving the quality of potential water resources, protecting and improving water quality for sustainable development targets.
Regulation on Wholesale and Retail Fish Markets (24790 in official gazette in 19.6.2002 as amended 2004 and 2007)	This regulation was prepared with the purpose of providing fish and fishery products to the consumers, in conformity with hygiene, quality and standards, within the free competition conditions, in a fast and reliable manner.
Animal Health and Control Law Regulation (No. 20109 in official gazette in 15.03.1989)	The main law is about preventing aquaculture species from animal diseases including aquatic animals and determines the principles of controlling the diseases.
Regulation on the establishment Procedures and Principles of Agricultural Producer Associations (No. 25702 in official gazette in 16.01.2005)	This regulation is intended to set out the procedures and principles relating to by which product or product group the associations of the agricultural producers will be established on a voluntary basis at the minimum district level, determining the total production quantity of the association by product and regarding the alignment of the existing agricultural organizations.
Regulations of the Protection and Use of Agricultural Land (No. 25766 in official gazette in 25.03.2005)	The regulation determines the way and the principles of appropriate use of the agricultural land the conditions of the land use outside of the agriculture land.
Regulation on the working way and principles of Agricultural Insurance Pool (No. 25944 in official gazette in 22.09.2005)	The regulation determines the working principles of the pool by Agricultural Insurance Law.
Fishing Port Regulations (No. 22846 in official gazette in 13.12.1996 as amended in 1999 and 2002),	This regulation is prepared in order to define the procedures and principles for site selection, specifications rental and management of fishing ports.
Conservation of Wetlands Regulation (No. 25818 in official gazette in 17.05.2005)	It determines the conservation of the selected wetlands. Permission should not be granted for this kind of areas.
National Parks Regulation (No. 19309 in official gazette in 12.12.1986)	The regulation includes the activities that can be made in the boundary of the national parks in details.

COMMUNIQUES

NAME OF THE LAW AND PUBLISHED DATE	SCOPE
Communiqué on Leasing Aquaculture Areas (No. 25348 in official gazette in 16.01.2004)	The communiqué determines the principles of the leasing of marine and land areas for aquaculture.
Communiqué on the Fisheries and Aquaculture Production (breeding) of Bluefin Tuna (*Thunnus thynnus*) (No. 25057 in official gazette in 23.03.2003)	The communiqué determines the principles of the Fisheries and Aquaculture Production (breeding) of Bluefin Tuna (*Thunnus thynnus*).
Regulation of Animal Support (No. 26492 in official gazette in 13.04.2007	The communiqué determines the principles of animal supports including aquaculture.

MINISTRIAL COMMINUQUES

NAME OF THE LAW AND PUBLISHED DATE	SCOPE
Application Principles With Regard To The Regulation On Aquaculture (2004 as amended 2006)	The ministrial communiqué includes the procedures of aquaculture regulations.
Ministrial Comminique of Aquaculture in ponds (28.07.2004)	The ministrial communiqué arranges the aquaculture activities in ponds.
Ministrial Comminique of Aquaculture on Movement Systems (01.11.2006 and 19.01.2007)	Parallel with innovative technology, the ministrial communiqué includes some arrangements to get permission for aquaculture on floating vehicles and possibility to provide fry.
The Use of Water and Quality Control on Fish Products Processing Factory (2005/24)	The ministrial communiqué determines the minimum quality criteria for water in fish products processing factory with harmonization of EU 98/83/EEC directive.
Purification of Live Bivalve Mollusks (2001/02)	According to the microbiologic analysis, the ministrial communiqué determines the standards for live bivalve mollusks to appropriate for human consumption. For this purpose bivalve mollusks must be free of microbial agents before human consumption.

CIRCULARS

NAME OF THE LAW AND PUBLISHED DATE	SCOPE
37/1 no Circular on marine and inland waters commercial fishing activities for 2006-2008	The circular arranges the fishery activities which also affects the aquaculture activities.
37/2 no Circular on marine and inland waters amateur (sportive) fishing activities for 2006-2008	The circular arranges the sport fisheries activities which also affects the aquaculture activities.

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