Marine aquaculture in Turkey and potential finfish species

Deniz H.

Recent advances in Mediterranean aquaculture finfish species diversification

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 47

2000
pages 349-358

Marine aquaculture in Turkey and potential finfish species

H. Deniz
Fisheries Department, General Directorate of Agricultural Production and Development,
Ministry of Agriculture and Rural Affairs, Ankara, Turkey
E-mail: hayri@marketweb.net.tr

SUMMARY – Turkey is a country of which three sides have been surrounded by the seas with four different characteristics and it has total sea coastline of 8333 km. Being in half closed position, these seas have different characteristics in respect of biological, physical, chemical and ecological points. In addition; Turkey, with its favorable geographic position between the Black Sea and Mediterranean Sea, has access to the fish resources of both of these water bodies. There is a great potential for the development of aquaculture in Turkey. Marine aquaculture is a relatively new industry in Turkey. The first commercial ventures were set up in 1985 and the increase in marine aquaculture production has been rapid since then. Marine aquaculture production has already increased from 35 tons in 1986 to 18,000 tons in 1997. Sea bream (*Sparus aurata*) is first marine cultured species and sea bass (*Dicentrarchus labrax*), shrimp (*Penaus japonicus*), salmon (*Salmo salar*), sea trout (*Salmo trutta*) have followed it, and double banded bream (*Diplodus vulgaris*) and mussels (*Mytilus galloprovincialis*). A number of other secondary native species that could be considered for marine aquaculture are: groupers (*Epinephalus* spp.), Black Sea turbot (*Psetta maeoticus*), eels (*Anguilla anguilla*), oysters (*Ostrea edulis*), sharpnosed sea bream (*Puntazzo puntazzo*), common sea bream (*Pagrus pagrus*), Black Sea sea trout (*Salmo trutta labrax*), lobster (*Hommarus gammarus*), sturgeon (*Acipenser* spp.) and sole (*Solea* spp.). A number of species that are exotic to the Mediterranean or Black Sea that are possible species for marine aquaculture in Turkey was also considered. These were Atlantic turbot (*Psetta maxima*), Indian redtailed shrimp (*Penaus indicus*), rabbitfish (*Siganus rivulatus*), Japanese sea bream (*Pagrus major*) and landlocked salmon (*Salmo salar*). In addition, a joint project on Black Sea turbot with Japan International Cooperation Agency (JICA) is undertaken on the Black Sea coast. The first results has been obtained fingerlings of turbot which is about 8000 are being reared. Studies on growing, feeding and broodstocks management are continuing.

Key words: Potential, cultured species, native species, exotic species.

RESUME – *"Aquaculture marine en Turquie et espèces de poissons potentielles". La Turquie est un pays qui possède trois façades sur la mer avec quatre caractéristiques différentes, et dont la ligne littorale fait un total de 8333 km. Etant en position semi-fermée, ces mers présentent différentes caractéristiques concernant les aspects biologiques, physiques, chimiques et écologiques. En outre la Turquie, avec sa position géographique favorable entre la Mer Noire et la Mer Méditerranée, a accès aux ressources halieutiques de ces deux masses d'eau. Il existe un grand potentiel pour le développement de l'aquaculture en Turquie. L'aquaculture marine est une industrie relativement nouvelle en Turquie. Les premières exploitations commerciales furent entamées en 1985 et l'augmentation de la production aquacole marine a été rapide depuis cette date. La production aquacole marine a déjà augmenté passant de 35 tonnes en 1986 à 18 000 tonnes en 1997. La daurade (*Sparus aurata*) est la première espèce marine cultivée suivie par le bar (*Dicentrarchus labrax*), la crevette (*Penaus japonicus*), le saumon (*Salmo salar*), la truite de mer (*Salmo trutta*), ainsi que le sar à tête noire (*Diplodus vulgaris*) et les moules (*Mytilus galloprovincialis*). Un certain nombre d'espèces autochtones secondaires qui pourraient être considérées pour l'aquaculture marine sont : les mérous (*Epinephalus *spp.*), le turbot de la Mer Noire (*Psetta maeoticus*), les anguilles (*Anguilla anguilla*), les huîtres (*Ostrea edulis*), le sar à museau pointu (*Puntazzo puntazzo*), le pagre commun (*Pagrus pagrus*), la truite de la Mer Noire (*Salmo trutta labrax*), le homard (*Hommarus gammarus*), l'esturgeon (*Acipenser *spp.*) et la sole (*Solea *spp.*). Un certain nombre d'espèces sont considérées, exotiques en Méditerranée ou dans la Mer Noire, et qui sont des espèces possibles pour l'aquaculture marine en Turquie. Il s'agit du turbot de l'Atlantique (*Psetta maxima*), de la crevette royale blanche des Indes (*Penaus indicus*), du sigan marbré (*Siganus rivulatus*), de la daurade japonaise (*Pagrus major*) et du saumon atlantique (*Salmo salar*). En outre, un projet conjoint concernant le turbot de la Mer Noire avec le JICA a été entrepris sur le littoral de la Mer Noire. Les premiers résultats ont été obtenus avec des alevins de turbot dont environ 8000 sont élevés actuellement. Des études de croissance, alimentation et gestion des reproducteurs se poursuivent.*

Mots-clés : *Potentiel, espèces cultivées, espèces autochtones, espèces exotiques.*

Introduction

With over 8300 km of coastline and 25 million square hectares of useably sea, Turkey has particularly bright future in aquaculture. Established in the 1980's with the help of state support, production has expanded rapidly, doubling between 1994 and 1997 from around 16,000 tons to over 45,450 tons/year (MARA, 1998; SSI, 1998). Interest has centred on such species as trout, sea bream, sea bass, carp and salmon, and more recently prawns and turbot. Those are most favourable have been the Aegean and Western Mediterranean coasts. Government statistics show that over 300 certificated fish farms have been established in the west and south of the country with many more operating on a semi-official basis. Marine aquaculture is a relatively new industry in Turkey.

The first commercial ventures were set up in 1985 and the increase in marine aquaculture production has been rapid since then. Marine aquaculture production has already increased from 35 tonnes in 1986 to 18,000 tonnes in 1997 (Fig. 1). There are 97 available sites for marine aquaculture in Turkey (Macalister *et al.*, 1996a,b).

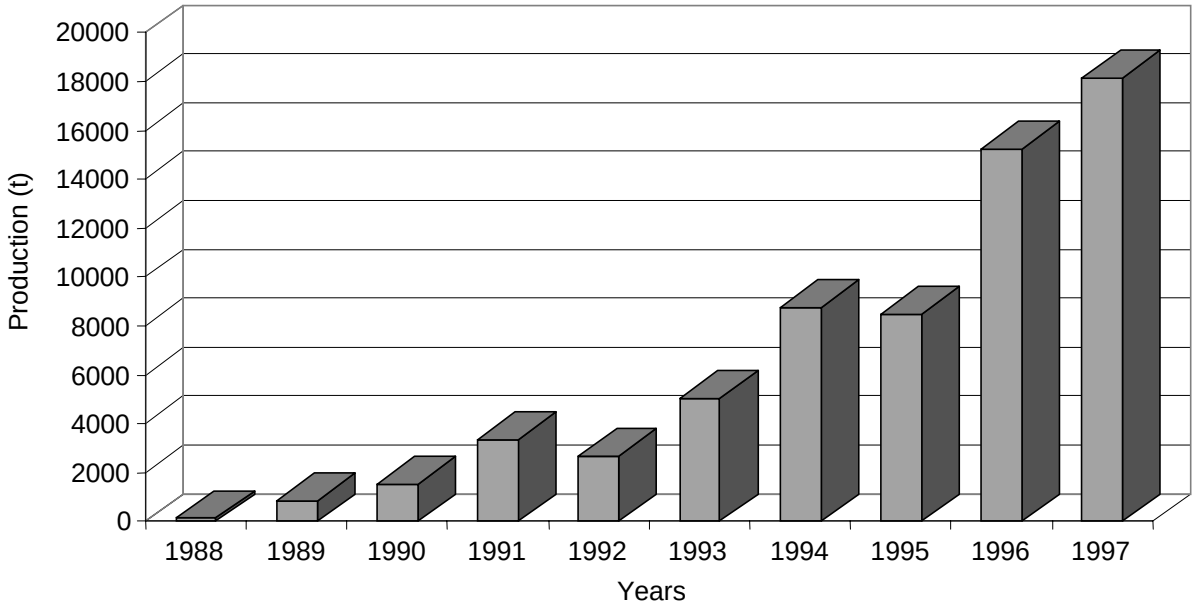

Fig. 1. Trend of aquaculture production in Turkey, 1988-1997.

Coastal areas

The coast of Turkey can be divided into four distinct and different environmental areas, Black Sea, Marmara, Aegean and Mediterranean.

Black Sea

Environment

The Black Sea has a temperature range of 7 to 25.5℃. There is a strong thermocline during summer located between 15 and 30 m. At a depth below 30 meters, the water remains at a relatively stable temperature between 8 and 10°C. The salinity is relatively low ranging between 17 and 20 ppt and the water is less dense than full strength seawater. There is a strong permanent halocline at a depth of between 100 and 200 m. The predominant winds are from the north-west and storm winds are generally from the north-west.

Potential species

The naturally occurring species that are candidates for intensive aquaculture in the Black Sea are the sea trout (*Salmo trutta*), sturgeon (*Acipenser* spp.), and turbot (*Psetta maeoticus*), kalkan. Other species occur in the Black Sea such as the double banded bream, mullet and sea bass which could be cultured on a semi-intensive basis in cages or lagoons. The Atlantic salmon, which is not native to the Black Sea has been introduced and is being cultured. There is also the possibility of introducing the Atlantic turbot which is very closely related to the kalkan. Both species are susceptible to high seawater temperatures and so the site must have access to deep water below the thermocline so that the supply water temperature is below 22℃.

Sea bass can tolerate the lower salinity that is found in the Black Sea. The average seawater temperatures of the Black Sea are lower than for the Aegean or Mediterranean which will reduce the growth rate of sea bass however, sea bass growth rate will be slightly faster in lower salinity. Now, a joint project on Black Sea turbot with Japan International Cooperation Agency (JICA) is undertaken at Black Sea coast. The first results has been obtained fingerlings of turbot which is about 8000 are being reared. Studies on growing, feeding and broodstocks management are continuing.

Aquaculture sites

The Turkish coastline of the Black Sea totals 1695 km along the mainland and 6 km around the islands. The majority of the coastline is very exposed to winter storm winds and waves and the coastline is prone to erosion. There are very few sheltered sites and most natural enclosed bays are shallow. The majority of sites that were identified were small, land-based sites with access to deep water. Three general areas were identified for the installation of family-run salmon or trout cage farms. These areas are protected from the damaging north-east storm winds and have sufficient depth (40 to 50 m) for locating small floating or submersible cages.

The study identified 33 potential aquaculture sites in the Black Sea region (Table 1).

Table 1. Potential sites: Black Sea coastline

Province	Identified sites	Potential annual production (tons)	Culture system
Artvin	0	700	Cages
Rize	2	1250	Cages, tanks
Trabzon	5	1510	Cages, tanks
Giresun	4	590	Tanks
Ordu	3	60	Cages
Samsun	1	1250	Cages, tanks
Sinop	7	1280	Cages, tanks
Kastamonu	5	440	Cages, tanks
Zonguldak	2	1110	Cages, tanks
Sakarya	1	20	Tanks
Kocaeli	0	–	–
Istanbu1	2	230	Tanks
Kirklareli	1	1250	Cages, tanks
Total	33	9690	

Marmara Sea

Environment

The Marmara Sea is the crossing point of the low salinity surface waters leaving the Black Sea and the higher salinity seawater from the Mediterranean entering the Black Sea. Due to the counter flow of

waters the currents can be strong. The surface seawater temperatures range between 15 and 20℃. The eastern Marmara is generally warmer than the western Marmara. The salinity ranges between 21 and 22 ppt in summer and 38 and 39 ppt in spring.

Potential species

The range of potential species is similar to that of the Black Sea. However, seawater salinities are subject to rapid seasonal changes and therefore more tolerant species such as sea bass and mullet should be considered. The Marmara Sea has high phytoplankton levels and supports a large clam fishery and wild oyster and mussel catch. The seawater does not reach such high temperatures as the Black Sea and so may be more suited for the culture of salmon and turbot than the Black Sea.

Aquaculture sites

The coastline of the Marmara Sea is 927 km along the mainland and 252 km around the islands. Three potential sites were identified in this study (Table 2). The most suitable areas for aquaculture are in the small bays on the north of Kapıdağı and the islands of Marmara, Turkeli and Paşalimani. There are also site areas available for mussel, oyster and clam culture.

Table 2. Potential sites: Marmara Sea coastline

Province	Identified sites	Potential annual production (ton)	Culture system
Balikesir	3	750	Cages, tanks

Aegean Sea

Environment

The seawater temperature in the Aegean generally increases from north to south. It ranges from 10 to 22°C in the north and from 16 to 25°C in the south. The difference in temperature between north and south Aegean can be 6 to 7°C. The salinity increases from north to south and is influenced by the lower salinity water exiting from the Black Sea via the Dardanelles.

Potential species

The most suitable species for culture in the Aegean are sea bass and sea bream with faster growth rates achieved in the south due to the longer growing season. There is a number of lagoons with wild populations of mullet, doublebanded bream, etc. The fry of these species are available from the wild and they could be on-grown in cages or ponds. Other species that could be suitable are dentex (*Dentex dentex*), sinagrit, for culture in cages or sole (*Solea* spp.), in ponds.

Aquaculture sites

The Aegean coastline from the Greek border to Dalaman measures 2805 km and 679 km of coastline surround the islands. The study identified 37 potential sites in this area (Table 3) excluding the area between Bodrum and the Menderes river.

Table 3. Potential sites: Aegean coastline

Province	Identified sites	Potential annual production (tons)	Culture system
Canakkale	10	2800	Tanks and ponds
Izmir	25	2860	Ponds and cages
Aydin	2	350	Ponds
Total	37	6010	

Two general areas that are particularly suitable for aquaculture are between Dalaman and the Menderes river and between Çesme and Edremit. However, in much of the area from Dalaman to Bodrum aquaculture is prohibited within the Special Protected Areas (SPAs).

There are 5 coastal SPAs along this coast, Köycegiz, Datça Bozburun, Gokova and Foça. The development of aquaculture is prohibited within the SPAs, reducing the number of potential aquaculture sites on the Aegean. Many parts of this coastline have been developed for tourism, secondary housing and recreational purposes, conflicting with the development of aquaculture (Deniz and Kilic, 1998).

Mediterranean

There is no clear physical boundary between the Mediterranean and the Aegean. The cut-off point in this report was Dalaman.

Environment

The seawater temperature in the Mediterranean increases from west to east and ranges from 18 to 29°C. There can be a difference of 2°C between the west and east Mediterranean. There is a wide temperature variation in the Iskenderun Bay during spring ranging from 21°C in the south-east to 27°C in the north-west. At depths of below 200 m, the seawater temperature remains stable at 15 to 16°C. The salinity is relatively stable and only ranges between 38 and 39.5 ppt.

Potential species

The species suitable for culture on the Mediterranean coastline differ from the Aegean because of the higher seawater temperature found in summer. Species such as sea bass are not as tolerant of high temperatures as sea bream. Other species prefer the warmer water such as shrimp and grouper. There are many potential sites for development of ponds which would suit the culture of sole.

Aquaculture sites

The coastline on the Turkish Mediterranean measures 1577 km on the mainland and 130 km around the islands.

The area to the north of Iskenderun Bay to the east of Mersin is a low-lying river delta area, potentially suitable for the development of fish or shrimp ponds. The area between Mersin and Manavgat is mountainous and with poor access and so is unsuitable for aquaculture development. The area between Manavgat and Kemer is limited because of tourism and coastal developments.

The most potential is in the area between Kemer and Dalaman but much of this area is within the SPAs. The area between Antalya and Dalaman is mountainous with many areas having poor road access, however there are some good areas for cage culture. The area between Dalaman and Ula is suitable for cage culture and hatchery development but is severely restricted by SPAs. However 24 suitable sites were identified (Table 4).

Table 4. Potential sites: Mediterranean coastline

Province	Identified sites	Potential annual production (tons)	Culture system
Mugla	4	1080	Cages, tanks, ponds
Antalya	9	3500	Cages, ponds
Içel	3	350	Cages
Adana	4	600	Ponds
Hatay	4	800	Ponds
Total	24	6330	

Culture species

The major part of Turkish aquaculture production comes from the farming of salmon, sea bream, sea bass, double banded bream, mullet and mussels. There are however a number of species presently under research and being produced on a pilot scale which would be suitable for culture in Turkey.

Suitable finfish species for marine aquaculture in Turkey

*Sea bass (*Dicentrarchus labrax*)*

Sea bass are found in the south-west Black Sea, Marmara, Aegean and Mediterranean waters of Turkey. The 1997 wild catch was 3450 tons in Turkey. The hatchery production of sea bass started in 1983 and present production for sea bass and sea bream combined is estimated to be 65 million juveniles and is projected to reach 100 million in 2000.

The growth rate for sea bass in the Aegean is 18 to 20 months to reach a market size of 330 g from 2 g. Growth rates will be slower in the north Aegean due to lower average temperatures but will be faster in the south Aegean and western Mediterranean. Sea bass are sensitive to very high temperatures and there may be problems with their culture in the eastern Mediterranean during the summer.

The recommended culture system involves the use of large wooden cages in sheltered areas or large metal cages in more exposed sites. The advantage of large wooden cages (5 x 5 x 5 m deep) or larger metal cages (15 x 15 x 10 m deep) is the reduced management required when compared to operating a larger number of smaller cages. However the risks are slightly higher as there are more fish per cage which could be lost through storm damage, predation, disease, etc. Other alternatives include culture in concrete raceways (30 x 3 x 1.2 m deep) and in plastic lined ponds (30 x 40 x 18 m deep). There are advantages in growing fish onshore, because of increased control of the environmental conditions and improved husbandry. However the capital costs and operating power costs are higher.

*Sea bream (*Sparus aurata*)*

Sea bream is found in the Marmara, Aegean and Mediterranean coasts of Turkey. Sea bream is not tolerant of low salinity and so only very small quantities are found in the Black Sea. The 1997 wild catch was 1200 tonnes in Turkey. The growth rate in the Aegean is faster than for sea bass, requiring between 16 to 18 months to reach market size of 330 g from 2 g. Growth will be faster in the southern Aegean and Mediterranean. The recommended culture systems and hatcheries are identical as for sea bass and ventures are likely produce both species at the same time.

*Salmon (*Salmo salar*)*

The Atlantic salmon does not occur naturally in the Black Sea. They are able to tolerate the natural environment in the Black Sea except for the surface water temperatures above 22°C. The smolts are introduced from freshwater to saltwater at a size of between 40 and 100 g in April and May. In the Black Sea, they will reach a size of 1 kg by December, and 3.5 kg by the following August. Salmon have to be protected from the high summer surface temperatures or there will be outbreaks of disease or mortalities.

The recommended method for culture of salmon in the Black Sea is in rubber cages with very deep nets (15 x 15 x 20 m deep) or developing a new design of submerged cage where the bulk of the capacity is below 15 m depth. The advantage of the submerged cage is that there is only a small volume of cage close to the surface which is subject to wave action in winter and high temperatures in summer. Alternative systems involve the culture of salmon in onshore plastic-lined metal tanks measuring 20 m diameter by 3 m deep. Water would have to be pumped from a depth below 20 m to avoid the high surface temperatures during summer.

*Sea trout (*Salmo trutta*) or rainbow trout (*S. gairdneri*)*

The majority of marine trout farmed in the Black Sea are rainbow trout. This species originated from the west coast of North America but is now farmed worldwide. The recommended system for culture involves the use of large rubber cages or submerged cages as for salmon. The production of trout onshore is not economically viable due to the high capital expenditure required and the lower market price for trout.

Trout can be introduced to the sea from freshwater at a size of 250 g in the spring and on-grown in seawater. Trout are also sensitive to the seawater temperatures above 22°C and must be protected from the high temperature surface waters found during summer in the Black Sea. Some of the production of sea trout is being sold as salmon or salmon-trout in Turkey. If trout are transferred to seawater at 250 g size in spring, they will grow to a size of 1.6 kg by December. The price for small portion sized trout is low and so by on-growing them in seawater to a larger size their market price can be increased.

*Doublebanded breams (*Diplodus vulgaris*)*

The doublebanded sea bream is found in all the coastal areas of Turkey. The wild catch is around 800 tons per year and an estimated 100 tons is cultured. The fry are collected from the wild although there have been attempts to produce them in hatcheries. The doublebanded sea bream does not grow fast but fish grown in cages reach 250 g from 10 g in 20 months.

*Mullet (*Mugil *spp.)*

The wild catch of mullet in Turkish coastal waters has increased rapidly from under 3000 tons in 1985 to over 20,500 tons in 1997. Mullet are caught predominantly in the Aegean. It is no longer farmed in Turkey.

Potential native finfish species for marine aquaculture in Turkey

A number of secondary species is presently being studied in Turkey or has the potential for culture. Some of these species are mentioned below.

*Groupers (*Epinephalus *spp.)*

The culture of Mediterranean groupers is not yet performed on a commercial scale. Research is being undertaken on the hatchery and on-growing methods for *Epinephalus guaza* and the pilot-scale production of *E. aeneus* is being undertaken in Turkey. The recommended culture system would involve the use of cages in the Mediterranean region at a density of between 12 and 15 kg/m^3 or plastic lined ponds at a lower stocking density.

*Black sea turbot (*Psetta maeoticus*), kalkan*

Over 1000 tons of kalkan are caught each year in Turkish waters with the majority of the catch from the west Black Sea. Kalkan are not found in significant quantities in the Aegean or Mediterranean due to their sensitivity to temperatures over 22℃.

There is some hatchery production of kalkan undertaken in Russia. The hatchery technology for Atlantic turbot is well established in Britain, Spain and Chile and is likely to be similar to that required for kalkan. There has not yet been any attempt to culture kalkan in Turkey.

The estimated growth for kalkan in the Black Sea is to a size of 50 g in 4 months from 4 g size, and reaching a market size of 1.8 kg after a further 36 months. Kalkan must be grown in tanks or raceways and it is recommended to take water from below 20 meters deep to avoid the high surface seawater temperatures during summer.

The recommended system of culture incorporates large concrete raceways (30 x 3 x 0.6 m deep) covered by shade netting. The water would be used three times. The water flows from one series of

raceways into a collecting canal where it is re-oxygenated before flowing through the next series of raceways. The water would be pumped from a depth of below 20 m.

*Eels (*Anguilla anguilla*)*

The wild catch of eels in Turkey was 400 tons in 1997. There are no statistics for the wild catch of eels in Turkey. Eels are euryhaline. They can tolerate a wide range of salinities from freshwater to full strength seawater. However the majority of aquaculture production comes from eels grown in fresh or brackish water. There is no hatchery production of eels due to the complex early life history. All small eels (elvers) of between 0.2 and 0.4 g are collected from the wild as they enter rivers and lagoons in spring.

The recommended culture system for eels involves stocking 0.3 g elvers into 2 m diameter nursery tanks for 3 to 4 months and then transferring the 2 g eels to concrete raceways covered by shade netting. The water is used twice by taking the water that flows from one series of raceways and re-oxygenating it before it flows to the second series of raceways. Raceways should have sufficient pipework, etc. to allow grading in the tanks.

*Sharpnosed sea bream (*Puntazzo puntazzo*)*

Hatcheries in the Mediterranean have produced the sharpnosed sea bream on a pilot scale. They are generally stocked in cages with other species of fish such as sea bass and sea bream to reduce algal fouling on the nets.

*Common sea bream (*Pagrus major*)*

The wild catch of the common sea bream is only between 50 and 100 tonnes per year from the Aegean and Mediterranean. Hatcheries in the Mediterranean are producing the common sea bream on a pilot scale. They are cultured in cages, and the growth rate is similar to that of jilted sea bream.

*Black Sea sea trout (*Salmo trutta labrax*)*

This is a native species of sea trout found in the rivers and coastal seas of the eastern Black Sea. This species has natural spawning grounds in the rivers between Giresun and the border with Georgia. However, there has been overfishing of this species and efforts are being made to restock the rivers. The Fisheries Research Institute in Trabzon is researching their culture potential. As this species is a native to the Black Sea, it may be less sensitive to temperatures over 22°C. The landing of sea trout is legally banned but there is illegal fishing in the sea and rivers of the Black Sea or fish are caught accidentally as a secondary catch.

*Sturgeon (*Acipenser *spp.)*

Historically there were wild fisheries catches of 300 tonnes per annum in the late 1960's but these collapsed to an estimated 10 tonnes per year. The fishery for sturgeon has been banned since 1979 except for beluga of more than 140 cm in length. The hatchery production of sturgeon has been developed commercially in Russia, America and France. A number of farms have started to culture sturgeon for flesh and for eggs (caviar). There used to be a large restocking programme for sturgeon in the Black Sea by Russia. The culture of sturgeon is not recommended at this time due to the limited and unproven market for flesh, and the great length of time required for the fish to reach maturity for sale of caviar.

*Sole (*Solea *spp.)*

The annual wild fishery catch of sole is 2300 tonnes in 1997. The majority of the catch is from the Aegean, Marmara and Mediterranean. Small quantities of sole are being produced from hatcheries and pond farms in Spain.

Potential exotic finfish species for marine aquaculture in Turkey

There are a number of species which are not found naturally in the Mediterranean Sea but have been introduced for culture. Some of these species should be considered for culture in Turkey.

*Atlantic turbot (*Psetta maxima*)*

The Atlantic turbot resembles very closely the Black Sea turbot and can successfully hybridise indicating that it may be a sub-species. If Atlantic turbot are reared in low salinity, they acquire the same morphological features (large skin bumps) as kalkan.

The Atlantic turbot is successfully grown on a commercial scale in Britain, France, Spain and Chile with pilot production in China and Greece. The Atlantic turbot is suitable for culture in onshore tanks on the Black Sea. The growth rate for Atlantic turbot is predicted to be exactly the same as for Black Sea turbot. The Atlantic turbot is sensitive to seawater temperatures over 22°C, and therefore water must be taken from below the summer thermocline.

*Rabbitfish (*Siganus rivulatus*)*

The rabbitfish has passed from the Red Sea to the Mediterranean via the Suez Canal and is now an important fishery in the eastern Mediterranean. There is a high demand for rabbit fish and good market price in the Middle East. It is presently cultured in Saudi Arabia and Singapore in cages or ponds. It is vegetarian, eating algae. It is particularly suited for polyculture together with other species (with sea bass, sea bream, shrimp, or mullet), as it will eat algae growing on the nets or pond walls. A stocking density of 1:100 sea bass or sea bream, or one piece per 5 m^2 of pond is sufficient to eat excess algae. Rabbit fish are very sensitive to low oxygen levels.

*Japanese sea bream (*Pagrus major*)*

Japanese sea bream are cultured in the Mediterranean in the former Yugoslavia and Greece. The market for Japanese sea bream is strong in Japan with high market value but markets in Europe are not yet established. The survival of fry from egg is very high (up to 40%) and growth is good in cages.

*Marbled grouper (*Epinephalus fascogattatus*)*

Groupers have a worldwide demand and high market value especially in the Middle East. Many countries are conducting research into hatchery and on-growing methods for groupers. One of the most promising species is the marbled grouper which is found in the Red Sea and South East Asia, but not in the Mediterranean.

The marbled grouper has successfully been produced in the hatchery in Singapore and Saudi Arabia. The on-growing of groupers in cages is well established in Singapore and Malaysia. Groupers require high seawater temperatures and would be suitable for culture in the eastern Mediterranean. Although the marbled grouper is not naturally found in the Mediterranean, it is found in the Red Sea. Other species of grouper have transferred from the Red Sea to the Mediterranean via the Suez Canal such as the Malabar grouper (*E. malabaricus*).

*Landlocked salmon (*Salmo salar*)*

The landlocked salmon is a true species of *Salmo salar* the Atlantic salmon, but during their evolution, they became landlocked and now complete their life cycle totally in fresh water. Landlocked salmon offer advantages over the Atlantic salmon as they can be grown to a size of 100 g or larger in freshwater before being stocked into the sea. Atlantic salmon have to be transferred to seawater when they become smolts at 30 to 60 g. Landlocked salmon transfer easily into seawater, reducing smolt losses by up to 30% and will grow to 2 to 3 kg in 12 to 14 months from 100 g. Landlocked salmon eggs have already been imported, and are being on-grown at Kirkpinar.

References

Deniz, H. and Kilic, H. (1998). Tussle between Recreation and Tourism. FAO Eastfish Magazine, Turkey Special, May 2/98 C 44346, FAO EASTFISH, UN Center Copenhagen, pp. 18-19.

Macalister, E. *et al.* (1996a). *Identification of Fish Culture Sites in Marine and Brackish Water*. General Directorate of Agricultural Production and Development, Ministry of Agriculture and Rural Affairs, Ankara, Turkey.

Macalister, E. *et al.* (1996b). *Environmental Impact of Aquaculture in Turkey and its Relationship and Sites of Special Protection*. General Directorate of Agricultural Production and Development, MARA, Ankara, Turkey.
MARA (1998). Fisheries Statistics. General Directorate of Agricultural Production and Development, Ministry of Agriculture and Rural Affairs, Ankara, Turkey (unpublished).
SSI (1998). *Fisheries Statistics*. State Institute of Statistics of Prime Ministry, Ankara, Turkey.