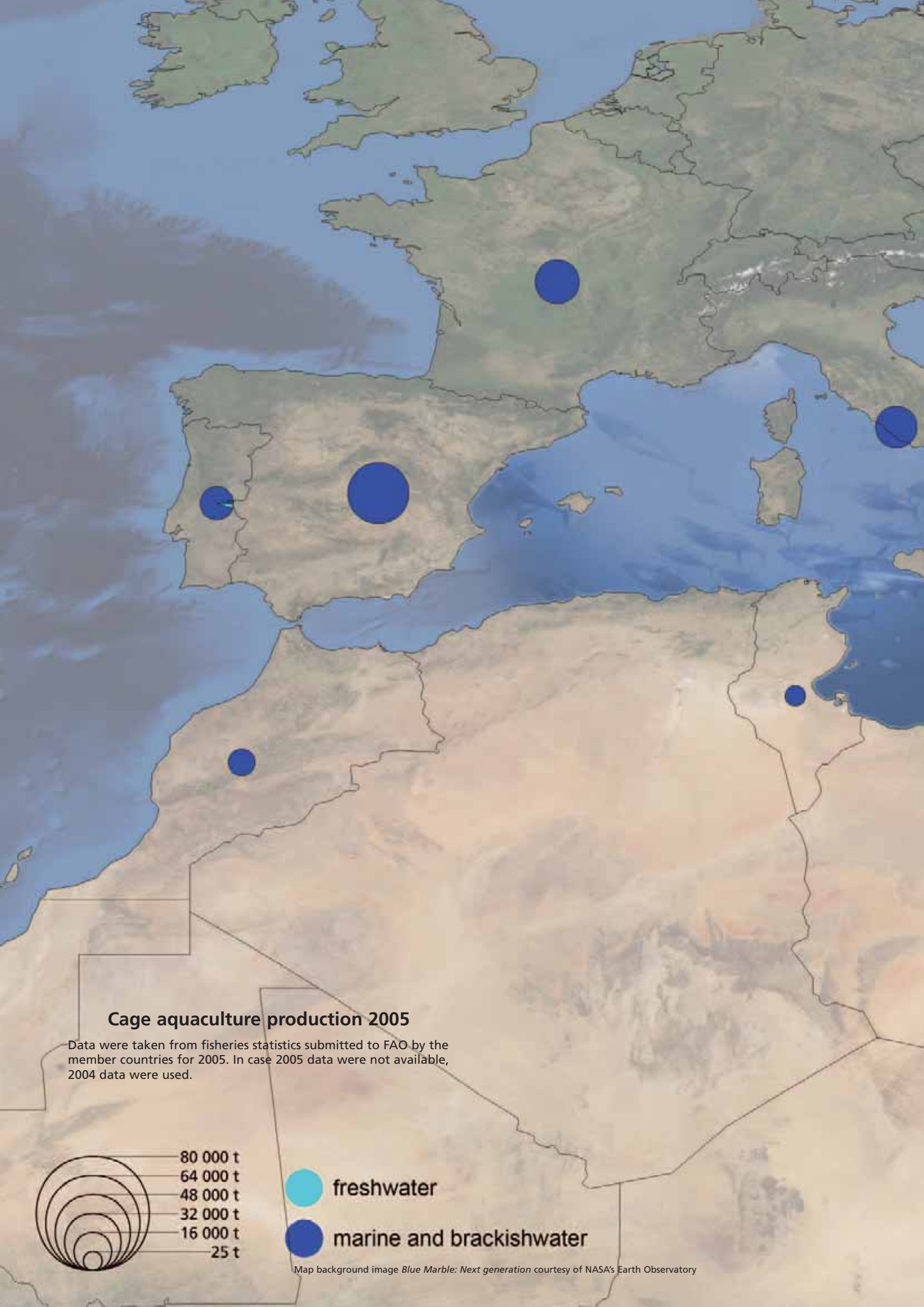
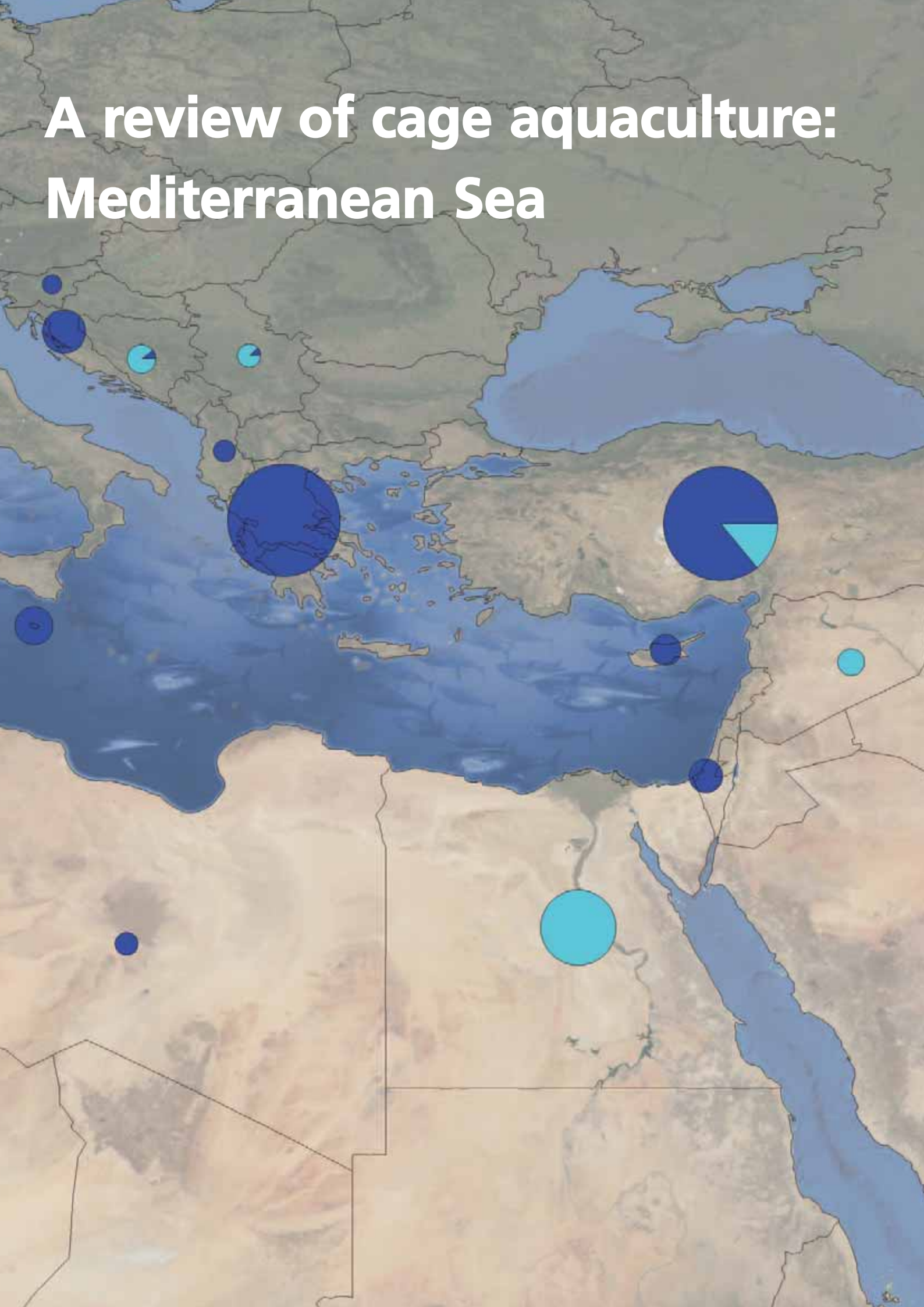


Cage aquaculture production 2005

Data were taken from fisheries statistics submitted to FAO by the member countries for 2005. In case 2005 data were not available, 2004 data were used.

Map background image *Blue Marble: Next generation* courtesy of NASA's Earth Observatory

A review of cage aquaculture: Mediterranean Sea



A review of cage aquaculture: Mediterranean Sea

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Cardia, F. and Lovatelli, A.
A review of cage aquaculture: Mediterranean Sea. In M. Halwart, D. Soto and J.R. Arthur (eds). *Cage aquaculture – Regional reviews and global overview*, pp. 156–187. FAO Fisheries Technical Paper. No. 498. Rome, FAO. 2007. 241 pp.

ABSTRACT

The Mediterranean is an intercontinental sea surrounded by Europe to the north, the Near East to the east and Africa to the south. The following 19 sea-facing nations are taken into account in this review: Spain, France, Monaco, Italy, Malta, Slovenia, Croatia, Serbia and Montenegro, Albania, Greece, Turkey, Cyprus, Syrian Arab Republic, Lebanon, Israel, Egypt, Libyan Arab Jamahiriya, Tunisia, Algeria and Morocco.

Marine cage culture in the Mediterranean area expanded rapidly in the mid 1980s, mainly in Spain and Greece, when an increasing number of farms started producing the European seabass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*). Freshwater cage culture, although marginally practiced in several countries for rearing the rainbow trout (*Oncorhynchus mykiss*) (e.g. Italy, Turkey, Cyprus), is mostly developed in Egypt, along the Nile delta branches, where from the 1990s onwards the Nile tilapia (*Oreochromis niloticus*) and silver carp (*Hypophthalmichthys molitrix*) culture expanded. In 2003 the production was 32 000 tonnes (SIPAM, 2006).

The European seabass and the gilthead seabream are currently the most widely caged fish species in the Mediterranean. Production has progressively increased over the last ten years from 34 700 tonnes in 1995 to 137 000 tonnes in 2004, with an average annual growth rate of 17 percent. In 2004, the cage production of these two species accounted for approximately 85 percent of the total production.

The controlled reproduction of the European seabass was first achieved in France and Italy in the mid 1970s. In the early 1980s fingerlings of the gilthead seabream were successfully produced. In 2002, the total European seabass and gilthead seabream fingerling production in the Mediterranean was estimated to be in the region of 650 million (Stirling University, 2005). The most common market size range for both species is between 300-400 g. In cage farming this weight is achieved in 12-18 months for the gilthead seabream and 15-20 months for the European seabass, when the production cycle commences in the spring and fingerlings of 2-4 g are used.

The rapid expansion of cage culture in the 1990s, mainly in Greece and Turkey, brought about a market crisis in the late 1990s. From 2000 to 2002 the market prices dropped to their minimum values forcing several companies out of business.

All Mediterranean countries are producing European seabass and gilthead seabream in cages. The leading countries, sorted by production volume in 2004, were Greece, Turkey, Spain, Italy, Croatia and France. Altogether these countries accounted for more than 90 percent of the total cage production of these two species (SIPAM, 2006; FAO, 2006).

Commercial activities on fattening captive Atlantic bluefin tuna (*Thunnus thynnus thynnus*) in large floating cages have been reported since the mid 1980s (Spain), but a significant expansion of this farming practice in the region started only in the mid 1990s. Atlantic bluefin tuna fattening should be viewed as a capture-based aquaculture practice considering that the fish are caught by purse seiners and stocked in cages usually from 3

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to 10 months. Harvested fish are mainly for the Japanese market. Currently the countries where this practice is carried out include Spain, Italy, Malta, Croatia, Greece, Turkey, Cyprus, the Libyan Arab Jamahiriya and Tunisia. The total recorded official production in the Mediterranean in 2003 was approximately 19 000 tonnes (FAO/GFCM/ICCAT, 2005).

Among the more important newly cultured marine finfish species are the sharp-snout seabream (*Diplodus puntazzo*) and the meagre (*Argyrosomus regius*). Several commercial trials have also been carried out with a variety of sparid species, such as the common dentex (*Dentex dentex*), common seabream (*Pagrus pagrus*), common two-banded seabream (*Diplodus vulgaris*) and some sparid hybrids.

Several constrains are currently limiting the expansion and development of marine species diversification in cages. Among others: specific tolerability to caged conditions of the candidate species, the development of suitable commercial feeds and a positive market response to the newly introduced farmed species.

The Mediterranean shoreline offers a wide choice of farming sites, both sheltered and exposed. For this reason, several cage models are used from very simple wooden frames and barrels structures to very modern and technologically sophisticated facilities, such as steel platforms or submersible steel cages with integrated feeding systems. However, the most widely used floating cages are the High Density Polyethylene (HDPE) ones as a result of their adaptability to different sea conditions.

This paper provides available information on the number of farms, reared species, cage production (quantity and values), trends of the sector in the past decade, and other issues on cage culture around the Mediterranean.

BACKGROUND AND AIM OF THE STUDY

This background technical document on Mediterranean cage aquaculture was prepared and presented at the "Second International Symposium on Cage Culture in Asia" held in Hangzhou, People's Republic of China, from 3 to 8 July 2006. The aim of this report is to provide a general overview on the Mediterranean cage aquaculture sector by comparing available data from different sources. Worth mentioning is that official national aquaculture production statistics frequently do not distinguish between different fish farming methods. The main information sources used for this exercise have been the following:

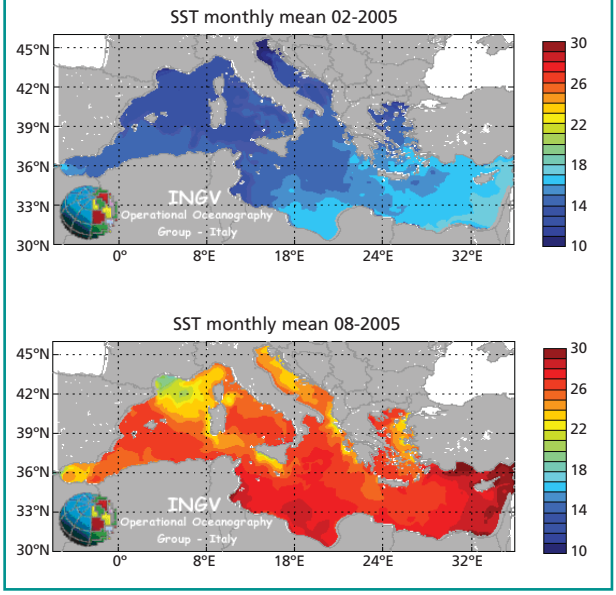
- **SIPAM** (Information System for the Promotion of Aquaculture in the Mediterranean under the General Fisheries Commission for the Mediterranean - GFCM)
  An ad hoc questionnaire was prepared and sent to all the SIPAM National Coordinators. Statistics regarding cage production have also been collected from the SIPAM Web site (www.faosipam.org);
- **NASO** (National Aquaculture Sector Overview)
  These reports, most of them published on the FAO Web site, provide a general overview of the national aquaculture sectors and are available for all the countries considered in this paper;
- **FAO FishStat+**
  Official FAO statistics have been used as main reference for values and national productions. In the case of any discrepancy with data reported in the SIPAM Web site, the FishStat+ source has been considered valid;
- **ICCAT** (International Commission for the Conservation of Atlantic Tunas)
  Atlantic bluefin tuna data has been displayed in accordance with those in the "Report of the third meeting of the ad hoc GFCM/ICCAT Working Group on Sustainable Bluefin Tuna Farming/Fattening Practice in the Mediterranean" and in the ICCAT website (www.iccat.es). When there was a lack of information, the NASOs and the SIPAM Web site were consulted;
- **Personal contacts**
  Some inputs have been provided through direct and personal contacts with BIOMAR and SKRETTING personnel and members of various producer/farmer associations.

THE MEDITERRANEAN SEA

The Mediterranean is an intercontinental sea enclosed between Europe to the north, Africa to the south, and the Near East to the east. It covers an area of approximately 2 512 000 square kilometres, including the Marmara Sea but not the Black Sea. It has an average depth of 1 500 m and a maximum depth of 5 150 m off the southern coast of Greece.

The Mediterranean is almost a completely closed water basin where the continuous inflow of surface water from the Atlantic Ocean is the sea's major source of water. It is estimated that the entire water volume of the Mediterranean takes over a century

FIGURE 1
Maps showing the Mediterranean monthly mean sea surface temperatures registered in February (top) and August (bottom) 2005



Source: INGV

to be completely renewed through the 300 m deep Strait of Gibraltar.

The limited water inflow and high evaporation makes the Mediterranean saltier than the Atlantic Ocean. Sea surface temperatures vary from a minimum average of 10 °C in winter in the Adriatic Sea to a maximum of 28-30 °C around the south eastern shores. Within this temperature range consolidated finfish farming species such as salmon and turbot, cannot be farmed (Figure 1).

Towards the south east, the Suez Channel connects the Mediterranean with the Red Sea. Many living organisms, not endemic to the Mediterranean ecosystem, have invaded the Eastern Mediterranean basin since the opening of the channel.

A low concentration of phosphates and nitrates limits the availability of food thus the total quantity of marine life in the Mediterranean. In this context, over-exploitation of the marine resources is a serious problem.

On the other hand, however, some areas, such as the Corso-Ligurian Basin and the Gulf of Lion, are characterized by higher levels of primary productivity due to the up-welling of nutrients. The total length of the Mediterranean coasts is approximately 45 000 kilometres. It is highly populated region with numerous and varied activities, including tourism, which strongly compete for sea space with the aquaculture industry.

The states facing the Mediterranean Sea are: Europe: Spain, France, Monaco, Italy, Malta, Slovenia, Croatia, Serbia and Montenegro, Albania, Greece, Turkey, and Cyprus; Asia: Syrian Arab Republic, Lebanon, Israel; and Africa: Egypt, Libyan Arab Jamahiriya, Tunisia, Algeria and Morocco. From a political point of view Spain, France, Italy, Malta Slovenia, Cyprus and Greece are member of the European Community (EU) and hence, although independent countries, they are required to act upon EU decisions and directives regulating the aquaculture industry.

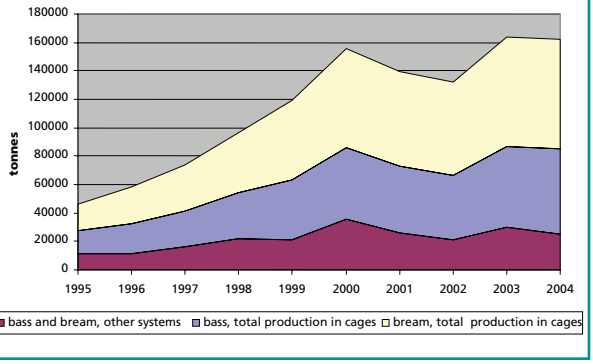
REARED SPECIES

European seabass and gilthead seabream

The most commonly farmed marine species in Mediterranean Sea are the European seabass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*). These species are produced using a large variety of aquaculture facilities and techniques. They are traditionally cultured in lagoons, where wild fingerlings are collected during the seasonal migration from the sea into lagoons, and then reared in closed basins using extensive or semi-extensive methods (e.g. *vallicoltura* in the Northern Adriatic lagoons). The European seabass and the gilthead seabream are now intensively reared in ponds, tanks, raceways and cages. In 2004, the Mediterranean production of these two species was 88 500 tonnes for the gilthead seabream and 73 800 tonnes for the European seabass (FAO/FIDI, 2006) with Greece as the leading producer with a combined production of approximately 63 000 tonnes for the two species.

Currently, most of the Mediterranean production comes from cages. This quantity has progressively

FIGURE 2
European seabass and gilthead seabream aquaculture production in the Mediterranean from cages and other farming technologies



Source: FAO/FIDI, 2006; SIPAM, 2006

increased over the last ten years from 34 700 in 1995 to 137 000 tonnes in 2004, with an average annual growth of 17 percent (Figure 2). In 2004, the combined Mediterranean cage production of these two species accounted for approximately 85 percent of their total production.

Fry production

Both the European seabass and the gilthead seabream are euryhaline species. The controlled reproduction of the European seabass was achieved in the mid 1970s and in the early 1980s for the gilthead seabream.

In the case of the gilthead seabream the natural spawning season is from December to March and from January to February for the European seabass. Following hatching the larval stages are provided with live feed (rotifers and *Artemia*), an eventually weaned with extruded feed. Bigger hatcheries are equipped with photoperiod units where broodstock are kept in batches and the temperature and light duration are artificially controlled simulating the environmental conditions which are typical of the natural spawning period.

Different fingerling sizes are used to start a cage production cycle; commonly an average weight of 2-4 g (120-160 day old fish) is used. Fingerlings represent approximately 15–20 percent of the production costs. In 2002, around 290 million European seabass and 355 million gilthead seabream fingerlings were produced (Table 1).

The average price of a two grams fingerling varies depending on the producing country; an average estimate would be approximately of €0.22 for the gilthead seabream and €0.20 for the European seabass. In Turkey the cost of fingerlings is approximately 20 percent less compared to the average.

Production cycle

Cage production usually starts in spring and market size fish of 300-400 g are produced in about 14–16 months for gilthead seabream and 16-18 months for European seabass. In the case of pre-ongrown fish (mainly gilthead seabream of 40-60 g), the goal is to harvest market size fish (300 g) before the end of the year, i.e. reducing the production cycle, making the product available in December, and avoiding the risks related to winter stocking.

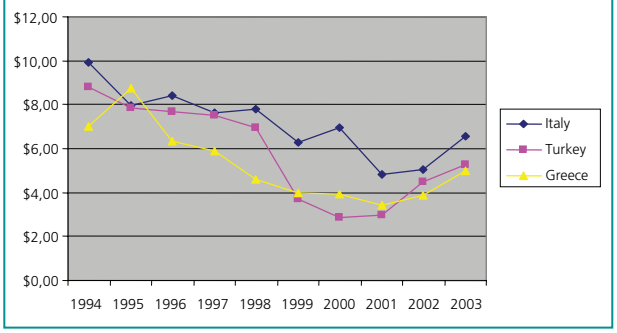
Nets with different mesh sizes are used during the whole production cycle: knotless, square or hexagonal shaped mesh, from 4 mm up to 25 mm or more depending on the size of the fish. If not treated with antifouling, nets are usually changed several times in each cycle (increasing mesh size), and the frequency varies depending on environmental conditions and the mesh size of the nets. Net washing machines to clean the cages are widely used. The fish are usually harvested when they reach an average weight of 300–400 g. The whole production is almost entirely sold fresh or iced in polystyrene boxes.

TABLE 1
European seabass and gilthead seabream fingerling production, trade and apparent use in selected Mediterranean countries

Year 2002	European seabass				Gilthead seabream			
Country	Production (million)	Imports (million)	Export (million)	Apparent use (million)	Production (million)	Imports (million)	Export (million)	Apparent use (million)
Greece	129.0	8.6	1.2	136.4	171.0	11.4	1.6	180.8
Turkey	53.7	0.0	6.0	47.7	30.8	0.0	0.0	30.8
Italy	50.0	0.0	20.0	30.0	45.0	0.0	7.0	38.0
Spain	8.0	4.7	0.0	12.7	53.0	0.0	7.2	45.8
France	23.0	0.0	10.8	12.2	20.0	0.0	15.0	5.0
Portugal	7.0	0.2	2.0	5.2	12.0	1.8	2.0	11.8
Croatia	5.0	3.3	0.0	8.3	0.4	3.8	0.0	4.2
Cyprus	4.6	0.0	2.6	2.0	15.2	0.0	9.9	5.3
Egypt	7.2	n.a.	n.a.	n.a.	7.2	n.a.	n.a.	n.a.
Tunisia	4.1	n.a.	n.a.	n.a.	4.0	n.a.	n.a.	n.a.
Total Production	291.6				358.6			

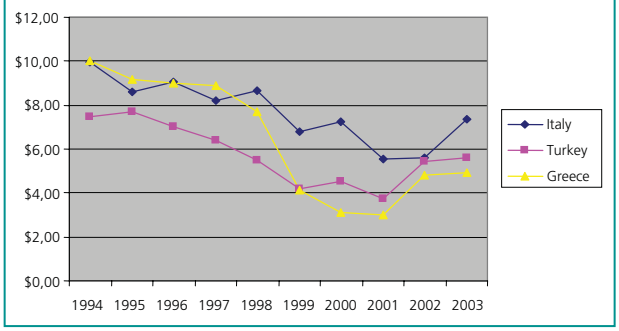
Source: Stirling University, 2005; SIPAM, 2006

FIGURE 3
Gilthead seabream market value in US$/kg from 1994–2003



Source: FAO/FIDI, 2006

FIGURE 4
European seabass market value in US$/kg from 1994–2003



Source: FAO/FIDI, 2006

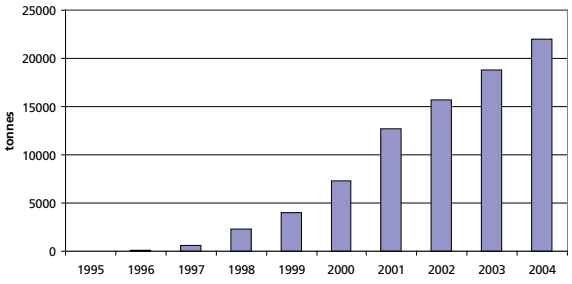
Market

Italy is the largest and most developed market; in order to satisfy the estimated consumption of more than 66 000 tonnes (Stirling University, 2004) in 2002, large amounts of fish were imported from all major Mediterranean producers (including Greece, Turkey and Spain).

The rapid and uncontrolled increase in bass and bream production registered throughout the 1990s brought about a severe market crisis. In 2000–2002 the market prices dropped to minimum values (Figures 2 and 3). This crisis was particularly felt by companies which had a high production cost (e.g. small Italian offshore cage farms and poorly performing land-based farms) and by new farms whose business plans were made with a higher value per kilogramme prevision. As a consequence of such events several producers went bankrupt.

Product availability and market prices are not stable throughout the year. Their fluctuation is related to several factors, such as the season (during and immediately after summer the cage farms reach their maximum load and there is a tendency to reduce the stocked biomass in autumn) or market demand.

FIGURE 5
Atlantic bluefin tuna cage output from 1995–2004 (estimated data for 2004)



Source: FAO, 2006; ICCAT, 2006

Atlantic bluefin tuna

Farming of the Atlantic bluefin tuna (BFT) is a capture-based aquaculture practice based entirely on the use of wild-caught "seed" material. This aquaculture practice is expanding and is still considered to be a highly profitable investment. The total official production registered in 2003 was approximately 19 000 tonnes and in 2004 the production estimate is 22 000 tonnes[3] (Figure 5).

Schools of tuna are caught by purse seiners during April to July. The fish destined for farming are then transferred to the cages which are towed using tugboats to the fattening site. The diameter of the offshore cages varies from 30 to 90 metres and the volume can reach up to 230 000 m^3. The input period is from May to August and the initial input size can vary from a few kilograms (e.g. Croatia stocks small tuna specimens of approximately 4–20 kg in size) to large adults of 300-400 kg (Table 2). The farming season can vary and normally has a duration of less than one year with the exception of Croatia as the farmers prefer to stock small tuna which foresees a fattening period of up two years.

In order to increase the weight and fat content of the farmed fish, the tuna are fed with bait fish, stored frozen and defrosted prior to the distribution. Low value fish, such as mackerel, sardine, herring, squids and other small pelagic fish are used to feed tuna. The daily feeding ratio can reach up to 7–10 percent of live biomass in the summer months. The farms usually stock several hundreds tonnes of live tuna and therefore their daily consumption of bait fish is large. Tuna feeding is one of the issues that concern

[3] The 2004 data are not complete for all the producing countries, only the production of Spain, Croatia, Cyprus and Tunisia is currently available for this year (SIPAM). The amount of 22 000 tonnes has been estimated taking into account the 2003 production data of the other BFT producing countries.

TABLE 2
Duration of the Atlantic bluefin tuna fattening/growing season (cells shaded in grey)

Country	Farming season	J	F	M	A	M	J	J	A	S	O	N	D
Croatia	04-20 months					⏩							
Cyprus	05-08 months					⏩							
Greece	07 months								⏩				
Italy	03-06 months					⏩	⏩						
Libya	05-06 months						⏩						
Malta	04-07 months						⏩						
Spain	06-09 months						⏩	⏩					
Turkey	04-09 months						⏩						

Symbols ⏩: start of farming/fattening season.
Source: FAO/GFCM/ICCAT, 2005

primarily the environmental sustainability of the practice.

The harvest period is mainly concentrated during autumn/winter months, when the wild caught tuna often reaches its minimum and the selling price is higher (Table 3).

The Atlantic bluefin tuna production is almost entirely shipped to the Japanese market and, a very small amount, to the USA. Fish are killed, one by one, while they are still in the cages, and then shipped fresh and iced, gilled and gutted or dressed, by air. Tuna production is also sold in situ, on the cage, to ships that deliver the product by sea to the market. Fish are finally sold in the Japanese fish market auctions where prices can be substantially variable, depending on the type (e.g. fresh, frozen) and the quality of the product, in terms of fat contents, meat colour and appearance.

New species

Research and trials on "new species" are continuously carried out to satisfy the need of production and market differentiation driven by the apparent saturation of the European seabass and gilthead seabream markets. Several steps must be achieved in order to close a profitable production cycle of a new species of potential interest to the consumers: i.e. broodstock management, controlled reproduction, larval culture and weaning, feed formulation, market receptivity, etc. Once such issues have been solved, the adaptability of the new species to cage farming needs to be considered and adequately dealt with.

Sharpsnout seabream (*Diplodus puntazzo*) is one of the most popular "new" species in cage culture. This sparid species is commonly produced in some of the large hatcheries and fed on a bass and bream diet. Farming is carried out in Greece, Italy, Turkey, Cyprus and several other countries, but always in small quantities compared to seabass and seabream. High stocking densities seem to be the cause of recurrent parasitic infections in caged conditions. In Greece outbreaks of *Enteromyxum leei* and consequent mortalities of cage reared fish has driven producers to reduce their production.

Other varieties of sparids, such as the common dentex (*Dentex dentex*), common seabream (*Pagrus pagrus*) and some sparid hybrids are also reared but currently only on a trial basis in order to test cage productivity and market response. An

TABLE 3
Duration of the Atlantic bluefin tuna harvesting season (cells shaded in grey)

Country	Harvesting season	J	F	M	A	M	J	J	A	S	O	N	D
Croatia	05 months									⇨	⏻		
Cyprus	02-03 months										⇨	⏻	
Italy	07 months							⇨		⏻			⏻
Malta	03 months									⇨	⏻		
Spain	04-05 months								⇨			⏻	⏻
Turkey	06 months											⇨	⏻

Symbols ⇨: start of harvesting ⏻: main harvesting months
Source: FAO/GFCM/ICCAT, 2005

interesting species with high potential is the meagre, *Argyrosomus regius*. In few years the production of this species has increased considerably, in particular in France but also to some extent in Italy, Spain and Morocco. Existing commercial hatcheries are in a position to reproduce massive quantities of this species and the response to cage rearing has given excellent results. Furthermore, meagre can be fed the same feed used for the European seabass and gilthead seabream; it also has a relatively high Specific Growth Rate as it can grow over a kilogram in one year. No significant pathological outbreaks have been registered even when farmed at high stocking densities.

The major constraint is still represented by the market which currently demands traditionally farmed species and remains rather suspicious of new farmed species.

MEDITERRANEAN CAGE AQUACULTURE

General production overview

Mediterranean cage culture expanded significantly in the early 1980s following the salmon cage culture success and the introduction and adaptation of farming technologies and know-how from Norway and the United Kingdom (Scotland). A boost to this industry came with the success in the controlled reproduction of the European seabass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*) which resulted in a massive production and availability of fry. Atlantic bluefin tuna (BFT) farming/fattening commenced in the mid 1980s in the Andalusia Province of Spain. In the late 1990s the sector expanded dramatically reaching an estimated production of approximately 18 000 tonnes in 2003 with a number of Mediterranean countries engaged in the sector.

Landings from Mediterranean cage farms have expanded over the last decade, increasing from approximately 37 300 tonnes in 1995 to just under 187 000 tonnes in 2003 (Figure 6). The share of cage fish production, as a percentage of the entire Mediterranean aquaculture production (estimated at about 1.44 million tonnes in 2003), rose from 4.2 percent in 1995 to almost 13 percent in 2003 (Figure 7). During the last decade, marine finfish cage culture gained a predominant position in the sector. The production trend clearly demonstrates the success and spreading of this technology in the Mediterranean Sea (Figure 8). It may be noted that production rose from an estimated 35 000 tonnes in 1995 to 182 000 tonnes in 2004 with an average annual growth rate of 25 percent increasing the

FIGURE 6
Mediterranean cage aquaculture production for selected finfish species

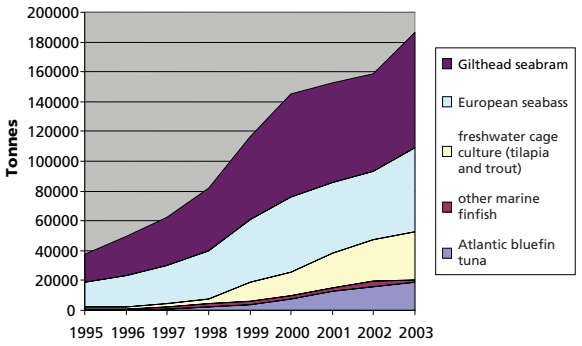


FIGURE 7
Mediterranean aquaculture production from cages and other culture systems (2004 cage production data incomplete)

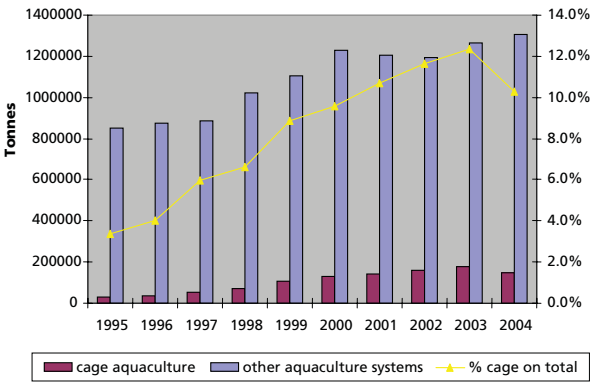


FIGURE 8
Mediterranean marine finfish production in cages and other culture systems

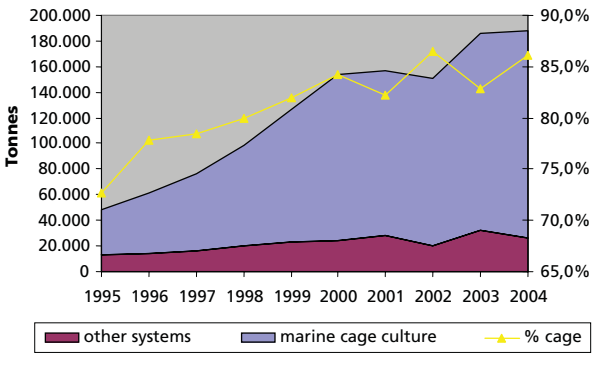


TABLE 4
Freshwater aquaculture production in 2004 (in tonnes) – species production by countries, share on total freshwater aquaculture

	Egypt	Cyprus	Italy	Serbia and Montenegro	Syrian Arab Republic	TOTAL
Nile tilapia and silver carp	32 062[a]	--	--	--	--	32 062
Common carp		--	--	400	1 080	1 480
Rainbow trout		11	50	40	--	101
Total freshwater cage production in 2004						33 643
Total Mediterranean freshwater production in 2004						272 166
% of cage production on total						12,4%

[a] Egypt production quantity data for 2004 not available, here reported is the 2003 data (Sources: FAO/NASO, 2006; FAO/FIDI, 2006).

share on total marine finfish production from 71 percent in 1996 to 86 percent in 2004.

Freshwater cage culture has developed mainly in Egypt, where the Nile tilapia (*Oreochromis niloticus*) and silver carp (*Hypophthalmichthys molitrix*) are produced in cages situated along the Nile delta branches. The cage production of these species steadily increased in the last decade from 1 977 tonnes in 1995 up to 32 062 tonnes in 2003.

Rainbow trout (*Oncorhynchus mykiss*) and common carp (*Cyprinus carpio*) are also marginally reared in freshwater cages in ponds or dams reservoirs in Italy, Turkey, Cyprus and in the Syrian Arab Republic. Table 4 provides data on freshwater cage production and its share compared to the total freshwater aquaculture production.

NATIONAL CAGE PRODUCTION OVERVIEW

Spain

Cage culture is widely practiced along the Mediterranean coast of Spain and around the Canary Islands. Due to the lack of suitably sheltered sites, cage aquaculture is mainly developed offshore. Production volumes have increased almost ten fold during the period 1995-2004. Cage aquaculture began in the mid 1980s using the European seabass and gilthead seabream as the two main farmed species. Atlantic bluefin tuna fattening began in 1985 along the coast of the Andalusia Province and in 1997 in the province of Murcia. Spain was the first country in the Mediterranean to start farming this large pelagic species (FAO/GFCM/ICCAT, 2005). Cage culture is currently practiced in all the Mediterranean provinces and in the Canary Islands (Atlantic Ocean). Table 5 provides Spanish cage production by province for 2003.

Following Egypt, Spain is the second country in the Mediterranean in terms of aquaculture production levels. In 2004 the entire aquaculture output was estimated to be over 363 000 tonnes with 93 percent of this volume deriving from the marine environment; this amount includes 294 000 tonnes of blue mussel (*Mytilus edulis*) mainly produced along the Galician coast.

TABLE 5
Cage aquaculture in Spain in 2004 - Number of farms and quantities sorted by province

Administrative province	Number of seabream and seabass farms	Gilthead seabream (tonnes)	European seabass (tonnes)	Number of tuna farms	Atlantic bluefin tuna (tonnes)	Total production (tonnes)
Andalusía	8	1 218	1 015	2	13	2 248
Baleares	1	52	3			55
Canarias	25	1 319	690			2 009
Cataluña	7	0	417	1	52	470
Levante (Valencia)	14	3 913	375			4 289
Murcia	7	1 561	750	11	3 620.8	5 933
TOTAL	62	8 063	3 253	14	3 687	15 004

Source: FAO/NASO, 2006; ICCAT, 2006; Skretting, pers. comm.; Biomar, pers. comm.

TABLE 6
Cage production in Spain from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Atlantic bluefin tuna	n.a.	77	173	1 879	3 347	3 682	4 447	4 751	3 687	6 423
European seabass	361	583	434	856	1 147	1 757	1 646	2 625	3 253	3 329
Gilthead seabream	1 624	2 418	2 569	3 533	5 000	8 042	4 728	7 607	8 063	9 669
Grand Total	1 986	3 079	3 179	6 268	9 494	13 481	10 821	14 983	15 003	19 421
Total aquaculture production	223 965	231 633	239 136	315 477	321 145	312 171	312 647	322 714	313 288	363 181
% cage	0.9%	1.3%	1.3%	2.0%	3.0%	4.3%	3.5%	4.6%	4.8%	5.3%

Source: SIPAM, 2006; FAO/GFCM/ICCAT, 2005; FAO/FIDI, 2006

TABLE 7
Total aquaculture and cage values in Spain from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture	250 015	250 131	247 943	307 611	344 357	377 800	392 112	374 696	361 547	431 990
Total cage	19 280	27 404	25 994	61 422	91 675	119 379	107 418	128 988	118 391	167 993
% cage	7.7%	11.0%	10.5%	20.0%	26.6%	31.6%	27.4%	34.4%	32.7%	38.9%

Source: SIPAM, 2006; FAO/FIDI, 2006

In 2004, the cage production quota, which progressively increased in the last decade, was in the region of 5.3 percent compared to the entire output of the Spanish aquaculture industry (Table 6). It is worth noting, however, that the quantity of seabass and seabream farmed in cages in the same year represented around 70 percent of the national production for these two species.

The economic contribution of cage aquaculture is reported in Table 7. In the past decade, the value of finfish produced in cages increased steadily and gained a considerable share of the industry. This is mostly thanks to the Atlantic bluefin tuna industry that reached the quota of 22 percent of the total aquaculture sector value in 2004.

Spain is the leading country in the Mediterranean with regard to Atlantic bluefin tuna aquaculture providing a reported total production of 6 423 tonnes in 2004. There are currently 14 farms of which 11 are located off the coast of Murcia. This powerful pelagic species is mainly farmed in large High Density Polyethylene (HDPE) cages. Most of the production is sold on the Japanese market (>96 percent), approximately 60 percent as frozen and the balance fresh. On the other hand, the production of seabass and seabream is mainly absorbed by the national market[4] with a small amount exported mainly to Portugal, which absorbs approximately 70 percent of the total export. The remainder is exported to Italy and France.

Spanish hatcheries provide the total national demand of seabream fry, but only 60 percent of seabass fry. In 2002, the estimated total production of seabream fry amounted to 53 million, of which 7.2 million was exported. In the same year, 8 million seabass fry were produced and an additional 4.7 million imported[5].

Spanish finfish netcage farms are mainly located in semi-offshore and offshore sites. The type of cages used for farming seabass and seabream are mainly circular floating cages made with HDPE pipes; their diameter varies from 15 to 25 metres. Some field trials, using cages with diameters of up to 50 metres, are currently in progress. These cages can stock up to 800 000 fingerlings/cage.

Also in use are four iron floating platforms produced by Marina System Iberica; these are large structures with an overall diameter of around 60 metres in diameter and fitted with 8-9 cages. These are moored near Tarragona (1 unit), Cadiz (1 unit) and the remaining two units are moored off the coast of Barcelona.

France

France is one of the leading European countries in terms of aquaculture production (approximately

[4] From 1998-2002 imports of seabass increased almost ten fold, from 1 175 to 11 058 tonnes with a negative export balance (2 980 tonnes in 2002); In the case of seabream 9 466 and 866 tonnes were imported and exported, respectively, in 2002.

[5] In this paper, fry production data refer to the whole production, i.e. including fry used in land-based fish farms.

TABLE 8
Cage farms in France – location of production sites and most commonly reared species

Company name	Location	Species farmed
Cannes Aquaculture	Provence	seabass, seabream, meagre
Poissons du soleil	Provence	seabass and seabream
Marée Phocéenne	Provence	seabass and seabream
Lou Loubas	Provence	seabass and seabream
Provence Aquaculture	Provence	seabass and seabream
Cachalot SCEA	Provence	seabass and seabream
Aquapeche	Provence	seabass
Cannes Aquaculture	Corsica Island	seabass, seabream and meagre
Gloria Maris	Corsica Island	seabass and meagre
Campomoro	Corsica Island	seabass
Santa Manza	Corsica Island	seabass

Source: Biomar, pers. comm.

244 000 tonnes in 2004). The sector is dominated by the Pacific cupped oyster (*Crassostea gigas*) with approximately 114 000 tonnes, the blue mussel (*Mytilus edulis*) with 55 600 tonnes and the freshwater rainbow trout (*Oncorhynchus mykiss*) with approximately 35 300 tonnes. Cage aquaculture still represents a niche sector in the industry since it has developed at a slower pace compared to other neighbouring Mediterranean countries.

Cage aquaculture began in France in 1988, with bass and bream farms mainly located along the western Mediterranean coast and Corsica. The main farm sites in the Mediterranean are located in Provence, which provides 65 percent of the country's production. The balance is produced in Corsica (Table 8).

The top farmed species are the European seabass and the gilthead seabream. In 2004, production was 2 290 tonnes, representing 47 percent of the total production (4 817 tonnes) of these two species (Table 9).

It is worth noting the increasing production of the meagre (*Argyrosomus regius*) in numerous Mediterranean farms. In addition to the Mediterranean farms, two cage operations are also located in the Atlantic coast farming rainbow trout. The share of cage production, as a percentage of the total aquaculture production, has fluctuated from 0.8 percent in 1995 to 1.2 percent in 2004.

The share of cage production value compared to the total aquaculture value remained rather stable in the last decade. A negative trend (apart from the 1997 value which excludes trout production) in 2001 and 2002, as a result of the market price drop for the European seabass and gilthead seabream, resulted in a lower income (Table 10).

The majority of the production is sold on the national market. France is also a net exporter of finfish fingerlings. In 2002, approximately

TABLE 9
Cage production in France from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Meagre	0	0	0	0	30	101	200	275	345	385
European seabass	1 440	1 224	1 135	1 300	1 625	1 100	950	1 080	1 190	1 190
Gilthead seabream	470	500	597	750	600	1 040	1 340	980	1 140	1 300
Rainbow trout	424	375	n.a.	200	279	160	114	190	150	150
Total caged	2 334	2 099	1 732	2 250	2 534	2 401	2 604	2 525	2 825	3 025
Total aquaculture production	280 786	285 526	287 243	267 850	264 857	266 802	251 655	252 008	239 851	243 907
% cage	0.8%	0.7%	0.6%	0.8%	1.0%	0.9%	1.0%	1.0%	1.2%	1.2%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 10
Total aquaculture and cage values in France from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture	663 176	600 133	626 884	560 326	487 921	425 054	453 763	501 051	580 424	655 123
Total cage	21 036	18 698	15 246	17 000	17 573	14 223	13 233	13 286	17 988	24 237
% cage	3.2%	3.1%	2.4%	3.0%	3.6%	3.3%	2.9%	2.7%	3.1%	3.7%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 11
Number of cage farms in Italy in 2004 sorted by environment and by province

Administrative Regions	Number of marine cage farms	Number of brackish water cage farms	Number of freshwater cage farms
Calabria	9	-	-
Campania	2	-	-
Friuli-Venezia Giulia	1	-	-
Lazio	3	-	-
Liguria	3	-	-
Lombardia	-	-	3
Puglia	6	-	-
Sardegna	8	4	1
Sicilia	15	-	-
Toscana	2	1	-
Veneto	1	1	-
Total	50	6	4

Source: Italian Ministry of Agriculture, 2005

43 million seabass and seabream fry were produced of which approximately 26 million were exported. Cage farms in France are commonly located in sheltered sites and are mainly of the square floating type (Jet Float units or wooden framed cages). A few circular HDPE cages are also in use.

Italy

The first commercial experience in intensive cage farming in Italy started in the late 1980s early 1990s. In 1989 the Sicily Fish Farm company began its offshore cage culture activity off the coast of Sciacca, southern Sicily. A year later a new company (Spezzina Acquacoltura) commenced a marine farm in the vicinity of the port of Genoa. In 1991 Aqua Azzurra, a company that was operating a fish hatchery and an inland rearing facility began a cage operation off the cost of Pachino, southern Sicily.

In 2004, an aquaculture survey conducted by the Italian authorities showed that 50 marine cage farming companies [6] had been registered along with six companies with cages in brackish water lagoons[7] and four operating freshwater cages (Table 11).

The Italian marine cage farms are located mainly in the southern province (e.g. Campania, Puglia, Calabria, Sicilia and Sardegna) where approximately 80 percent of the registered companies are operational. This has been the outcome of the distribution criteria of the subsidy programme (both national and EU) which mainly allocates investment funds to depressed areas of the country.

There are four freshwater cage farms producing rainbow trout. Three farms are located in Lombardia using old and abandoned marble quarries and one in Sardinia with cages positioned in an artificial dam. Their combined annual production is currently estimated to be slightly below 50 tonnes.

The most importantly farmed species are the European seabass and gilthead seabream. More recently a number of Atlantic bluefin tuna fattening farms have been established mainly in southern Italy. Occasionally, some of these farms culture a

[6] The survey includes companies that have a license but not currently in operation.

[7] These companies have small cages or small net enclosures where wild fingerlings caught in the "lavorieri" are stocked, some of them carry on a pre-growing phase before release fish in the lagoon where are extensively reared.

TABLE 12
Cage production quantities in Italy from 1995–2003 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003
Atlantic bluefin tuna	0	0	0	0	0	0	800	1 800	1 700
Gilthead seabream	330	550	700	1 350	1 500	1 850	2 600	2 850	2 950
European seabass	850	1 150	1 200	1 600	1 650	1 600	1 800	2 000	2 100
Total caged	1 180	1 700	1 900	2 950	3 150	3 450	5 200	6 650	6 750
Total aquaculture production	214 725	189 373	195 719	208 625	210 368	216 525	219 069	185 762	193 362
% cage	0.5%	0.9%	1.0%	1.4%	1.5%	1.6%	2.4%	3.6%	3.5%

Source: FAO/GFCM/ICCAT, 2005; API, pers. comm., FAO/FIDI, 2006

TABLE 13
Total aquaculture and cage values in Italy from 1995–2003 (Atlantic bluefin tuna values not available)

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total aquaculture (excl. tuna)	419 288	394 937	397 984	449 366	365 101	455 774	415 318	337 107	519 419
Total cage (excl. tuna)	9 941	15 066	15 229	24 322	20 618	24 510	22 563	25 708	34 796
% cage	2.4%	3.8%	3.8%	5.4%	5.6%	5.4%	5.4%	7.6%	6.7%

Source: FAO/GFCM/ICCAT, 2005; API, pers. comm., FAO/FIDI, 2006

variety of "new species" (mainly Sparids), but their production is estimated to be less than 1 percent of the entire caged production.

In 2003 (2004 data not currently available) the total seabass and seabream cage production was estimated to be approximately 5 050 tonnes (Associazione Produttori Italiani - API, pers. comm.). In addition to this production a further 1 700 tonnes of Atlantic bluefin tuna were also produced (Table 12). The 2003 cage production (6 750 tonnes) represented 3.5 percent of the total Italian aquaculture production [8] which is dominated by mussel, rainbow trout and clams. Cage output share has nevertheless steadily increased since 1995 although a number of factors are limiting its growth (mainly coastal use conflicts and limited availability of sheltered sites). From 1995 to 2003 the share of the cage production on total aquaculture value (excl. BFT) increased from 2.4 to 6.7 percent (Table 13).

In Italy two major hatcheries are in operation (Valle Ca' Zuliani in Veneto and Panittica Pugliese in Apulia) which produce approximately 65 percent of the national fingerling supply. In 2002 almost 95 million juveniles were produced, out of which 50 million were European seabass. Currently, fingerling production exceeds the national demand. Approximately 5 and 20 million gilthead seabream and European seabass were exported in 2002, respectively.

The Italian shoreline has limited sheltered sites and this represents a constraint to the expansion of the sector. Furthermore, tourism (a major economic sector) often competes for the use of sea and shore resources. Approximately 60 percent of marine cage farms are currently located in semi-offshore or offshore sites entailing higher production costs and the adoption of different technological solutions in terms of cage models and mooring systems. Compared to other countries in the Mediterranean, Italy operates a large number of cages specifically designed for offshore sites (i.e. REFA Tension Legs, Sadco Shelf steel cage, Farmocean and several submersible models).

Seabass and seabream production is almost entirely channelled to the national market. Italy is the most important market in Europe and the Mediterranean for these two finfish species.

In 2004, the ICCAT list of authorized Atlantic bluefin tuna farms reports six Italian companies. They are all located in southern Italy, i.e. three in Sicily, two in Calabria and one in Campania. In 2003, the harvest of Atlantic bluefin tuna was estimated to be approximately 1 700 tonnes.

Malta

In Malta aquaculture production is carried out entirely in marine cages. Cage aquaculture started

[8] Seabass and seabream are not exclusively farmed in cages, but also in inland facilities. The total official national production of these species is 18 000 tonnes in 2003 and the caged quota can be estimated at approximately 28 percent.

TABLE 14
Active cage farms in Malta, reared species and estimated production capacity in 2003

Company	Species	Production capacity (tonnes)
Pisciculture marine de Malte	seabass and seabream	1 100
Fish and Fish Ltd	seabass and seabream	300
Malta Fish Farming Ltd	seabass and seabream	150
ADJ Tuna Ltd (Sikka I-badja)	Atlantic bluefin tuna	1 500
Melita Tuna Ltd	Atlantic bluefin tuna	1 500
Malta Tuna trading Ltd	Atlantic bluefin tuna	1 200
ADJ Tuna Ltd (Comino Channel)	Atlantic bluefin tuna	800

Source: FAO/NASO, 2006

TABLE 15
Cage production in Malta from 1995–2004 sorted by species

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Atlantic bluefin tuna	0	0	0	0	0	330	1 108	1 855	3 550	n.a.
European seabass	500	396	300	80	80	234	206	53	98	131
Gilthead seabream	800	1 156	1 500	1 870	1 922	1 512	1 091	1 122	835	782
Grand Total	1 300	1 552	1 800	1 950	2 002	2 076	2 405	3 030	4 483	913

Source: SIPAM, 2006; FAO/NASO, 2006

in the early 1990s initially farming the European seabass and gilthead seabream. Only recently a number of Maltese companies shifted their interest towards the more profitable fattening of Atlantic bluefin tuna[9]. Six companies were operational in 2003, three producing seabass and seabream and three engaged in the tuna fattening. The estimated national production capacity is 1 550 tonnes for seabass/seabream and 5 000 tonnes for Atlantic bluefin tuna (Table 14).

Seabass and seabream production reached a maximum output in 1999 with approximately 2 000 tonnes produced. Subsequently, the negative production trend of these two species has been compensated by the growth of the tuna industry. In 2003 the total cage production was estimated to be 4 500 tonnes. The 2003 production values reported by the Ministry of Rural Affairs for seabass and seabream was approximately US$7 million and US$65 million for Atlantic bluefin tuna.

There are no commercial hatcheries on the island and all fingerlings are imported. In 2004, approximately 1.9 million European seabass and gilthead seabream fingerlings were supplied by France, but also from Spain and Italy. The market size European seabass and gilthead seabream are mainly exported to Italy while the BFT is almost entirely for the Japanese market and exported either chilled or frozen.

Cage aquaculture employs around 300 persons. In the seabass and seabream sector the work force consists of approximately 70 full-time employees. Tuna farming employs 130 full-time workers and 100 part-time workers.

Malta uses floating cages of different models, materials and dimensions. Seabass and seabream ongrowing is carried out in Dunlop rubber and Corelsa HDPE cages with a diameter of 18 to 22 metres. Any pre-growing is carried out in square cages 5x5 metres (Jet-float) or in Floatex HDPE cages. The BFT industry uses larger HDPE cages with a diameter of 50-60 metres (in 2003 two 90 metre diameter cages were installed) usually moored in deep waters (60 metres) fitted with 30 metres deep.

Slovenia

The Slovenia shoreline is approximately 30 kilometres long and there are only two marine cage companies located in the Bay of Piran. In 2004, a total of 40 cages (total rearing volume of approximately 17 000 m^3) were operational, producing both the European seabass and the gilthead seabream. The total official production in 2004 was approximately 78 tonnes for seabass and

[9] New sites have recently been licensed for tuna fattening. Sites where seabass and seabream are farmed are also used.

TABLE 16
Cage production in Croatia from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Atlantic bluefin tuna	0	0	390	400	672	1 200	2 500	3 971	4 679	3 777
European seabass	247	172	394	1 152	1 300	1 300	1 520	1 800	1 813	3 000
Gilthead seabream	90	80	40	595	450	800	940	700	610	700
Total caged	337	252	824	2 147	2 422	3 300	4 960	6 471	7 102	7 477
Total aquaculture	4 007	2 889	3 900	6 358	6 900	7 874	12 666	12 387	12 284	13 924
% cage	8.4%	8.7%	21.1%	33.8%	35.1%	41.9%	39.2%	52.2%	57.8%	53.7%

Source: FAO/FIDI, 2006; FAO/NASO, 2006

31 tonnes for seabream (FAO/FIDI, 2006). Cage production accounted for 40 percent of marine production consisting of 5.9 percent of the total aquaculture production. In terms of commercial value, the cage production share was approximately 20 percent of the whole aquaculture value. All seabass and seabream fingerlings are imported from France, Spain and Italy. The cages used are the floating type, rectangular (8 x 5 m) or circular of different diameters (8, 12 and 16 metres).

Croatia

Marine finfish aquaculture in Croatia is entirely carried out in floating cages. The first experience of intensive farming started in 1980. The Croatian shoreline provides numerous sheltered sites and this has, particularly in recent years, favoured and encouraged the development of cage farming. Nevertheless, there has been a tendency to switch from inshore to semi-offshore farm sites using more sophisticated and advanced facilities and cage technologies.

As indicated in Table 16, cage aquaculture production increased dramatically (more than 20-fold) with an annual average growth rate of 56,4 percent. The share of cage aquaculture in relation to the total aquaculture production grew from 8.4 percent in 1995 to 53.7 percent in 1994.

The commercial value of cage production compared with the entire aquaculture sector clearly indicates the importance of the cage farming sector even though available data does not include income from BFT sector (Table 17).

If a value of US$15/kg of tuna produced in 2004 is assumed (same as reported by Spain; FAO/FIDI, 2006), the cage production value share would have increased to 87.7 percent, further indicating the importance of cage farming in the Croatian aquaculture sector.

Croatia has a small production of fingerlings. Of the two marine species, it is estimated that in 2002 the country produced 5 and 0.4 million European seabass and gilthead seabream, respectively, and imported 3.3 and 3.8 million, respectively. National supply only provides for approximately 40 percent of the total fry demand. The fattening of Atlantic bluefin tuna started in 1996 and by the year 2002, in the counties of Zadar, Sibenik and Split, 10 farms were fully operational and a total of 65 floating cages were in operation. In Croatia BFT farming uses relative small juvenile specimens captured in May and June, when they weigh only a few kilograms. The fattening period to the commercial size can take up two or three years. In 2003, the export of tuna accounted for more than 74 percent of total fish exports.

TABLE 17
Total aquaculture and cage values in Croatia from 1995–2004 (Atlantic bluefin tuna values not available)

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture (excl. bluefin tuna)	12 472	8 963	11 303	23 037	23 481	26 488	32 597	29 245	24 096	33 295
Total cage (excl. bluefin tuna)	3 280	2 440	3 902	13 976	14 000	16 800	18 450	18 750	14 538	22 200
% cage	26.3%	27.2%	34.5%	60.7%	59.6%	63.4%	56.6%	64.1%	60.3%	66.7%

Source: FAO/FIDI, 2006; FAO/NASO, 2006

TABLE 18
Reared species, number of farms and production in Serbia and Montenegro in 2004 sorted by location

Location	Species	Number of farms	Production (tonnes/year)
Serbia	Common carp	18	400
Serbia	Rainbow trout	1	30
Montenegro	Rainbow trout	1	10
Montenegro (Adriatic Sea)	European seabass and gilthead seabream	1	20
Montenegro (Adriatic Sea)	Mussel	n.a.	40
Total cage production			500

Source: FAO/NASO, 2006

In the 1980s, the cages used for seabass and seabream farming were locally made with a wooden frame fitted with floats and nets. Although these home-made cages are still used by some farmers in sheltered sites, most operators tend now to use circular or square floating HDPE cages.

Serbia and Montenegro

Cage aquaculture in Serbia and Montenegro is dominated by freshwater production of common carp and rainbow trout (Table 18).

Freshwater cage aquaculture of these species is carried out mainly in Serbia. There are currently 20 active farms half of which produce less than 10 tonnes/year. Total annual cage production is in the region of 440 tonnes. Approximately 90 percent of the production is carp. The existing two trout cage farms are located in lakes and the maximum stocking density is around 15 kg/m^3. Carp cage farms are located mainly along rivers, channels or artificial water bodies. The stocking density varies from 20 to 60 kg/m^3.

The shoreline on the Adriatic Sea is only a few kilometres wide. In 1998 a seabass/seabream cage farm was established in Ljuta (Kotor Bay). To date, the annual marine finfish production is approximately 20 tonnes. Furthermore, in the Bay of Boka Kotorska, there are several small cage producing mussel (total annual production is approximately 40 tonnes).

According to the FAO National Aquaculture Sector Overview[10] for Serbia and Montenegro the total production of market-size fish was 7 951 tonnes in 2004, representing a value of approximately US$1.4 million. The share of the cage aquaculture is approximately 6.3 percent in terms of production (500 tonnes) and 7.2 percent in terms of value.

Albania

In Albania cage aquaculture is carried out exclusively along the Ionian coastline. Both the European seabass and the gilthead seabream are reared in floating cages. Marine finfish cage production commenced at the beginning of this decade, with a reported production in 2001 of approximately 20 tonnes. During 2004 there were seven licensed companies and a total of 63 cages which produced approximately 350 tonnes of seabass and seabream.

Although there are no reported negative interactions with the tourism sector, cage culture is yet to develop as the industry is still afflicted by several constraints such as the lack of local hatcheries and reliable feed suppliers. Furthermore, imports of fingerlings and feed from the EU has a considerable impact on the production costs.

Greece

Greece is the most developed Mediterranean country in terms of cage aquaculture with 310 licensed production sites (Table 19). It is currently the largest producer of seabass and seabream[11] in the region. This development has been favoured by several factors amongst which:

(i) coastline provides a large number of sheltered sites;
(ii)proximity to largest regional market (i.e. Italy);
(iii) encouraging European and national subsidizing policies.

The first commercial companies were established in the early 1980s: Leros Aquaculture (in Leros Island) in 1982; Selonda SA (in Korintos) in 1984; Nireus SA in 1988; and Fishfarm Sami in 1989. In the 1990s the sector expanded considerably. Seabass and seabream production from 1995-2001 increased from approximately 19 000 tonnes to more than

[10] The official statistics data are not complete with all the reared species.

[11] New species such as *Diplodus* spp., *Pagrus* spp., etc. are also reared in cages and their production is estimated to be around the 1 percent of the seabass and seabream production.

TABLE 19
Number of cage farms per administrative province in Greece in 2004

Province	Number of cage farms
Central Greece	78
Attiki	22
West Greece	28
Peloponissos	46
Ionian Islands	30
Epirus	36
South Aegean	36
North Aegean	23
Kriti	3
East Macedonia	2
Central Macedonia	4
Thessalia	2
Total	310

Source: Greek Ministry of Agriculture, pers. comm.

66 000 with a growth of almost 350 percent over this six-year period and an average annual growth rate of 24 percent.

However, the production has not been strategically planned in terms of promoting the final product, both internally and abroad. High fish surplus caused a sector crisis and prices dropped considerably below production costs (Table 21). Several companies in Greece, as well as in other seabass and seabream producer countries, went bankrupt[12]. In 2002, production dropped for the first time in the decade (Table 20).

Approximately 60 percent of the farms produce annually between 50 to 200 tonnes and the remaining 40 percent between 200 to 500 tonnes. Small farms are often merged into larger companies. In 2002, there were 25 companies which produced around 50 percent of the total production. The top three companies (Selonda Aquaculture SA, Hellenic Aquaculture SA and Nireus SA) produced a third of the total national output.

In 2004, the total value of cage production was estimated to be in the region of US$329 million and represented 90 percent of the total aquaculture income. The trend over the last 10 years has been positive, with the exception of the year 2002 when the seabass and seabream crisis effects were more marked.

[12] The Stirling Report on seabass and seabream market reports that in 2001, 377 sites were licensed and operated by 167 companies. In 2004 the official licensed sites reported by the Ministry of Rural Development (pers. com.) dropped to 310.

Due to the fact that Greek aquaculture is almost entirely represented by cage aquaculture the share of the cage production value over the total value of the sector has been steady, i.e. around 90 percent during the last ten years (Table 22).

The sector employs around 4 500 people (full-time and part-time) and most of the farms have from 5 to 20 employees.

The Greek shoreline allow establishing fish farms in sheltered onshore sites where the risk from adverse weather conditions is limited. This has allowed the use of low technology cage systems resulting in contained investment and maintenance costs. The majority of the farming structures are circular, double piped HDPE floating cages. Floating square shaped modular cages (pontoon-like) are also commonly used.

At present, there is only one Atlantic bluefin tuna farm which is operational in Greece (Bluefin Tuna Hellas SA), which was established in 2003 in the Echinades Islands, Prefecture of Kefallonia-Ithaki Islands through a joint-venture of the two largest Greek seabass and seabream companies, i.e. Selonda SA and Nireus SA. At present, no official production data are available.

Turkey

Cage farming started in 1985 with the production of European seabass and gilthead seabream. Cage culture for these two species increased dramatically and by 2003 production was approximately 37 700 tonnes from 345 farms. A small share of Turkish trout production (or 2.9 percent of the total trout production of 40 868 tonnes in 2003) was and continues to be reared in marine floating cages along the Black Sea coast[13].

The Turkish shoreline, particularly along the Aegean Sea, is similar to the Greek coast with numerous sheltered sites where cage farming can be safely practiced using conventional floating cages and mooring systems. Most marine cage farms are located in the southern Aegean coast. The production from this region is approximately 95 percent of the whole seabass and seabream production. During the period 1995-2004, cage production increased from 7 600 tonnes to 48 300 tonnes with a growth of 634 percent and an average annual growth of approximately 25 percent (Table 23). In 2003, the production share of cage aquaculture, in terms of

[13] There are also few examples of freshwater trout cage farms, whose production is not quantified but presumably not relevant in terms of production share.

TABLE 20
Cage production in Greece from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
European seabass	9 539	11 662	15 193	18 469	24 413	26 653	25 342	23 860	27 324	25 691
Gilthead seabream	9 387	13 799	18 035	21 951	32 837	38 587	40 694	37 944	44 118	37 394
Other finfish	1	122	2	38	107	86	75	83	161	316
Total caged	18 927	25 583	33 230	40 458	57 357	65 326	66 111	61 887	71 603	63 401
Total aquaculture production	32 644	39 852	48 838	59 926	84 274	95 418	97 512	87 928	101 434	97 068
% cage	58%	64%	68%	68%	68%	68%	68%	70%	71%	65%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 21
Price trends in Greece from 1995–2004 for the European seabass and gilthead seabream

Value (US$/kg)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
European seabass	7.50	7.67	7.03	6.42	5.48	4.18	4.55	3.76	5.43	5.59
Gilthead seabream	7.00	8.77	6.33	5.90	4.62	3.99	3.95	3.41	3.85	4.97

Source: FAO/FIDI, 2006

TABLE 22
Total aquaculture and cage values in Greece from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture	157 307	235 864	246 589	274 997	330 408	291 318	307 364	243 891	348 193	365 561
Total cage	137 252	210 426	220 894	248 046	285 619	265 450	276 045	219 103	318 044	329 706
% cage	87%	89%	90%	90%	86%	91%	90%	90%	91%	90%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 23
Cage production (in tonnes) in Turkey from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Atlantic bluefin tuna	0	0	0	0	0	260	3800	3 300	4 100[a]	n.a.
European seabass	2 773	5 210	6 300	8 660	12 000	17 877	15 546	14 339	20 982	26 297
Gilthead seabream	4 847	6 320	7 500	10 150	11 000	15 460	12 939	11 681	16 735	20 435
Rainbow trout	n.a.	n.a.	2 000	2 290	1 700	1 961	1 240	846	1 194	1 650
Total caged	7 620	11 530	15 800	21 100	24 700	37 358	33 525	30 166	43 011	48 382
Total aquaculture prod	21 607	33 201	45 450	56 700	63 000	81 091	71 044	64 465	84 043	94 010
% caged	35.3%	34.7%	34.8%	37.2%	39.2%	46.1%	47.2%	46.8%	51.2%	51.5%[b]

[a] Estimate.
[b] Figure not inclusive of BFT.
Source: SIPAM, 2006; FAO/FIDI, 2006; FAO/GFCM/ICCAT, 2005

TABLE 24
Total aquaculture and cage values in Turkey from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture (excl. bluefin tuna)	127 197	182 569	227 960	280 745	306 408	219 775	142 315	130 482	278 614	396 144
Total cage (excl. bluefin tuna)	70 467	97 429	121 450	160 756	174 989	134 703	87 189	79 329	179 409	241 865
% cage	55%	53%	53%	57%	57%	61%	61%	61%	64%	61%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 25
Cage production in Cyprus from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Atlantic bluefin tuna	0	0	0	0	0	0	0	0	0	1 370
European seabass	99	100	57	205	299	299	383	421	448	698
Gilthead seabream	223	527	769	828	986	1385	1 278	1 267	1 182	1 356
Other marine finfish	26	36	15	22	28	53	64	12	1	0
Rainbow trout	29	38	41	48	12	19	23	12	20	11
Total caged	377	701	882	1 103	1 325	1 756	1 748	1 712	1 651	3 435
Total aquaculture	452	787	969	1 178	1 422	1 878	1 883	1 862	1 821	3 545
% caged	83.4%	89.1%	91.0%	93.6%	93.2%	93.5%	92.8%	91.9%	90.7%	96.9%

Source: SIPAM, 2006; FAO/FIDI, 2006; FAO/NASO, 2006

quantity, was approximately 51 percent of the total national production.

Around 75 percent of seabass and seabream production is exported to EU countries. In 2004, the value of the cage production was estimated at US$242 million and represented almost two thirds (61 percent) of the entire Turkish aquaculture income (Table 24). During the period 2000-2002 the market crisis for seabass and seabream also affected Turkish producers. Cage production value decreased from approximately US$175 million in 1999 to approximately US$79 million in 2002; this was due both to a reduction in production and to a considerable drop in the market prices (Seabass: from US$7.72/kg in 1999 to US$3.00/kg in 2002; Seabream: from US$6.95/kg in 1999 to US$3.00/kg in 2002).

Factors that have promoted Turkish cage culture development include suitable and abundant shoreline sites along the Aegean coast and a favourable national subsidizing policy developed to support the sector. A premium payment is available for fingerling production and marketed fish. This subsidy is expected to continue up to 2010. European seabass and gilthead seabream producers estimated that the 2006 will amount to approximately 55 000 tonnes. A second seabass and seabream crisis is foreseen by the operators over the next few years. The Turkish producers nevertheless feel that the increased production will be almost entirely absorbed by the internal market and supported by the growing tourism industry (API, pers. comm.).

The most popular cage models in use are the HDPE floating type of different shapes and sizes. Some experienced companies have started using large circular cages with a diameter of 50 metres (i.e. Fjord Marine Turkey). Due to the constraints with the tourism sector most cage farms have left the protected inshore shallower water and relocated in more exposed offshore sites. It has, therefore, been necessary to adopt improved cage technologies and small wooden framed square cages have been replaced by HDPE circular cages.

The Atlantic bluefin tuna fattening activity commenced in 1999 and is currently carried out in six licensed sites; two off the coast of Izmir and four along the southern coast of Anatolia. The total potential production is estimated at 6 300 tonnes. In 2004, the reported production was 4 100 tonnes.

Cyprus

In Cyprus the aquaculture sector consists almost entirely of offshore marine cages. The most

TABLE 26
Total aquaculture and cage values in Cyprus from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture	4 467	7 512	8 173	9 013	9 574	10 304	9 527	10 487	11 709	34 149
Total cage	3 334	6 107	7 174	8 098	8 297	8 776	7 868	8 905	9 731	33 098
% cage	74.6%	81.3%	87.8%	89.9%	86.7%	85.2%	82.6%	84.9%	83.1%	96.9%

Source: SIPAM, 2006, FAO/FIDI, 2006; FAO/NASO, 2006

TABLE 27
Estimate rearing volumes, farmed species and total production in the Syrian Arab Republic in 2004, sorted by production site

Area	Cubic metres	Farmed species	Production (tonnes)
Latakia	11 056	Common carp	325
Al-Raqqah	36 126	Common carp	755
Total	47 182	--	1 080

Source: FAO/NASO, 2006

important farmed species are the European seabass, gilthead seabream and Atlantic bluefin tuna. All the farms are situated along the southern coast of the Island. Cage farming started in the mid 1980s with small cages moored in the harbours of Paphos and Larnaca. The first commercial offshore cage farm was established in 1986. In 2004, six offshore bass and bream farms were operational (five near Limassol and one near Larnaca). One of these farms also operates Atlantic bluefin tuna cages (Kimagro Fish Farming Ltd). Different models of cages are used, suitable to the offshore characteristics of the farm sites, such as Dunlop, Bridgestone, PolarCirkle and Farmocean. HDPE cages with a 50 metre diameter are used for tuna fattening.

In 2004, the share of cage culture production was 97 percent of the total aquaculture production (Table 25). A small seasonal production of rainbow trout is reported from cages moored in dams and reservoirs. The overall value of cage production in 2004 was estimated at US$34.1 million of which almost 60 percent was Atlantic bluefin tuna (Table 26).

Seabass and seabream produced in Cyprus are mainly sold in the local market. Approximately 30 percent of the fish are exported to Israel, Russia and the USA. Tuna on the other hand is exported to Japan and USA, mainly as a frozen product. A small part (<1 percent) is sold fresh. There are four hatcheries producing seabass and seabream[14] that supply the national demand for fingerling. Production currently exceeds the internal demand and in 2004 an estimated 7.5 million fingerlings were shipped to Greece, Turkey and Israel.

Syrian Arab Republic

In the Syrian Arab Republic only freshwater aquaculture is carried out. The most prominent species reared are the common carp and the Nile tilapia. Small amounts of grass carp, African catfish and silver carp are also produced. Cage aquaculture started in the mid 1970s by exploiting artificial water bodies. Currently there are two main cage production sites (i) Lake Assad-Eufrates (Governorate of Al-Raqqua) and (ii) Lake Tishreen (Governorate of Latakia). The available farmed volume and production outputs for 2004 are reported in Table 27.

In 2004 approximately 1 080 tonnes were produced, representing 24.4 percent of the overall carp production and 12.4 percent of the entire aquaculture output. In the same year the estimated aquaculture value was in the region of US$15 500 and the share of caged carps (US$1 620 thousand) was 10 percent. The cages used in this area are floating, mainly consisting of wooden, square shaped frames and empty barrels. The volume of the nets varies from 30 to 300 cubic metres.

Lebanon

In Lebanon aquaculture is still at an early state of development and only freshwater aquaculture is currently practiced. The most important farmed specie is the rainbow trout. In 2004, an estimated 700 tonnes were produced for a value of US$2.1 million. At present there are no operational cage farms.

Israel

Cage culture started in the early 1990s in Israel with the establishment of a commercial cage farm and a hatchery in the Gulf of Eilat. Currently four companies are operational and are located in three separate sites: two in the Gulf of Aqaba (Ardag and Dag Suf) with a combined annual production of approximately 2 000 tonnes; one inside the Ashdod Harbour breakwater, which, in 2003 produced approximately 500 tonnes; and one near Michmoret. The most commonly reared species are the gilthead seabream, accounting for 90 percent of the total cage production and the European seabass, red drum and stripped bass with a combined production of 10 percent.

[14] Also a small production of "new species" is reported including the red porgy, sharpsnout seabream, shi drum and the Japanese seabream.

TABLE 28
Number of cages, farmed species and total production in Egypt in 2003 sorted by production sites

Area	Number of cages	Species	Production (tonnes)
El Behira	920	Silver carp	8 400
Kafr El Sheikh	1 834	Silver carp and tilapia	10 500
Damyetta	1 620	Nile tilapia	12 774
Faiyum	50	Nile tilapia	260

Source: FAO/NASO, 2006

Various attempts have been made to carry out offshore cage culture; however, the severe sea conditions of the Mediterranean coast have represented a serious constraint towards the development of this industry. An estimated 10 million fingerlings were produced in 2000. The internal demand however remains high and an additional 2 million fingerlings were imported from Cyprus.

Egypt

Egypt, with a production exceeding 440 000 tonnes, is one of the most productive countries in Africa. Cage culture is common especially in the Nile and particularly in the most northern branches of the Delta where over 4 428 cages are operational and provide a total rearing volume of 1.3 million cubic metres (Table 28). The recorded fish production from these cages in 2003 was approximately 32 000 tonnes. The most commonly reared specie is the Nile tilapia (*Oreochromis niloticus*), but also the silver carp (*Hypophthalmichthys molitrix*) is reported as a caged species. In 2003, the entire Egyptian cage production represented 7.2 percent of the total aquaculture production and 6.0 percent of the total value (Tables 29 and 30). From 1995 to 2003 the total aquaculture production increased by 519 percent, while the cage production growth reached as far as 1 521 percent, providing an average annual growth rate of 63 percent.

The cage culture sector has benefited immensely from the development that has occurred in the support services sector, for example, the availability of hatcheries and feed mills, etc. Cage aquaculture has also flourished rapidly supported by the increasing availability of consultants, experts and technicians with the required knowledge to develop this activity. Furthermore, the General Authority for Fish Resources Development (GAFRD) also provided support to the development of cage aquaculture.

A pilot project in marine cage culture was carried out in the Marsa Matrouh Lagoon where ten cages were utilized to rear mainly wild fingerlings of mullet and black bream caught in the lagoon (Megapesca, 2001). The most frequently used cage models are home-made square cages built using barrels as floating devices and assembled under wooden frames where the fish nets are fixed.

Libyan Arab Jamahiriya

Various experimental cage farming trials were carried out in the early 1990s in the Lagoon of Ein Elgazala. Cages were installed to farm wildly-caught fingerlings of gilthead seabream, European seabass and Mugil spp. fished in the lagoon. A number of open sea cages are currently in use and have been installed in three sites along the Libyan coasts: Al-Garabouli and Al-Koms north-west of Tripoli, and Ras Al-Hilal on the north-eastern coast.

In Al-Koms there are currently six HDPE circular floating cages (Farmocean Power-rings) rearing European seabass and gilthead seabream. One Atlantic bluefin tuna farm is operational off the coast of Al-Garabouli while a new one-cage system (50 m diameter) has been established in Ras El-Hilal. Seabream and seabass are also farmed in Ras El-Hilal one of the few sheltered sites along the Libyan coastline. At present, four PolarCirkle submersible cages are in place (16 m diameter) and

TABLE 29
Cage production in Egypt from 1995–2003 and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total caged	1 977	1 720	2 103	2 855	12 885	16 069	23 716	28 166	32 059
Total aquaculture production	71 815	91 137	85 704	139 389	226 276	340 093	342 864	376 296	445 181
% cage	2.8%	1.9%	2.5%	2.0%	5.7%	4.7%	6.9%	7.5%	7.2%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 30
Total aquaculture and cage values in Egypt from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total aquaculture	115 194	167 902	183 879	327 263	447 146	815 046	756 980	655 565	615 011
Total cage	3 361	3 034	4 328	6 043	22 011	27 783	41 029	43 191	37 065
% cage	2.9%	1.8%	2.4%	1.8%	4.9%	3.4%	5.4%	6.6%	6.0%

Source: SIPAM, 2006; FAO/FIDI, 2006

four floating cages (22 m diameter) supplied by Fusion Marine.

In 2004, the official production data reported for seabass and seabream was 170 and 61 tonnes, respectively, although it is not clear whether or not this amount results entirely from cage culture. In 2003, Atlantic bluefin tuna farming produced 420 tonnes (for a value of approximately US$2.5 million) and 154 tonnes (for a value of approximately US$900 000) in 2004.

Tunisia

In Tunisia cage culture was first practiced in the Lagoon of Boughrara (Medenine Province) where several small cages were installed for seabass and seabream culture in the late 1980s. This activity was interrupted in 1991 and 1994 due to the occurrence of a series of algal bloom outbreak causing the loss of the entire stock of 400 and 300 tonnes, respectively. Some of these cages have now been moved to a new site near the Zarzis Harbour area. A second company (Tunipeche) is now operating in Ajim (near Jrba).

In 2004, seabass and seabream cage production accounted for approximately 14 percent of the whole national production of both species (678 tonnes of seabream and 466 tonnes of seabass). The cage share, in comparison to the total aquaculture production, has increased from 1.2 percent in 2001 to 6.5 percent in 2004, with a substantial production boost in 2002-2003 due to tuna farming (Table 31). The value of cage aquaculture (excl. BFT) in 2004 was US$1.2 million. This accounted for around 10 percent of the total aquaculture value (Table 32).

There are currently two hatcheries in operation and in 2004 the combined production of European seabass and gilthead seabream fingerlings was 4.8 and 3.1 million, respectively (SIPAM, 2006). Furthermore, Atlantic bluefin tuna aquaculture has grown rapidly during the last few years. At present four tuna cage farms are operational; two near Hergla (Sousse Governorate) and two near Chebba (Madhia Governorate). The total production capacity of these farms is 2 400 tonnes.

Algeria

Cage aquaculture is not currently practiced in Algeria although reports indicate that some projects are likely to be established in the near future. The Ministry of Fishery Resources has included cage culture activities in its National Development of Fishery and Aquaculture Plan for 2003-2007 for which potential sites have already been identified. Two projects are currently in the final phase and they are expected to be operational towards the end of 2006 (Delphine Pêche near Oran and Azzefoune Aquaculture near Tizi-Ouzou).

The planned annual production of the aforementioned farms is around 1 000 tonnes of both seabass and seabream. The production should be sold on the internal market.

TABLE 31
Cage production in Tunisia from 2000–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	2000	2001	2002	2003	2004
Atlantic bluefin tuna	0	0	0	678	1 485
European seabass	0	88	132	96	70
Gilthead seabream	0	20	22	29	80
Total caged	0	108	154	803	1 635
Total aquaculture production	1 553	1 868	1 975	2 612	3 749
% caged	0.0%	1.2%	1.8%	5.5%	6.5%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 32
Total aquaculture and cage values in Tunisia from 2000–2004

Value (US$1 000)	2000	2001	2002	2003	2004
Total aquaculture (excl. bluefin tuna)	7 107	9 196	8 746	8 418	11 947
Total cage (excl. bluefin tuna)	0	884	1 084	862	1 261
% cage	0.0%	9.6%	12.4%	10.2%	10.6%

Source: SIPAM, 2006, FAO/FIDI, 2006

Morocco

In Morocco, European seabass and gilthead seabream have been mainly reared in floating cages located in the Lagoon of Nador where a company known as MAROST was established in 1985, but ceased operating in 2005 due to marketing constraints. In the open sea on the Mediterranean coast, in Mdiq (near Tetouan), a company named Aqua Mdiq also produces seabream and seabass.

The production in 2004 was estimated to be approximately 120 tonnes. In 2004, Morocco's production of seabass and seabream was approximately 720 tonnes divided equally between the two species (Table 33).

Over the last ten years cage production value decreased from US$9 584 000 to US$2 838 000 (see Table 34) due to the reduction of production as a consequence of declining seabass and seabream prices. The average price in 1995 for both species was US$8.5/kg, which dropped to US$4.4/kg for seabass and US$3.5/kg for seabream in 2004 (FAO/FIDI, 2006). Seabass and seabream are exported primarily to Spain, and minor volumes to France and Italy. In Morocco there are two marine hatcheries one in Nador (MAROST) and one in Mdiq (Centre Aquacole de Mdiq). These hatcheries provide the great majority of seabass and seabream fries requested by the industry while the remainder are imported from Spain.

There is one Atlantic bluefin tuna cage farm (Marcomar SARL), located in the southern Atlantic coast, but no data regarding the production is currently available.

CAGE MODELS

As described above, various cage types and systems are being used by the Mediterranean finfish farms, the choice of which is usually determined by the following main factors:

- Site - The most important aspect to be considered is the site on which the cages will be set up and their suitability with regard to (i) exposure to potential sea storms, (ii) seabed characteristics and depth, (iii) prevailing sea conditions, and (iv) visual impact. An exposed site and an increased risk of heavy storms will require cages, nets and mooring systems designed to resist the maximum registered storm strength. If the site is somewhat sheltered, a simplified mooring system and lighter rearing structure will reduce the cost of the initial investment. Should negative interactions be encountered with the coastal tourism submerged or low visual impact models are often considered and/or possibly recommended by the authorities responsible for the issuance of the farming license.
- Cost of cages - The initial cost of the investment usually represents a limiting factor particularly for those investors with a fixed budget. However, the cheapest option may not take into consideration the suitability of the structures for the site.

TABLE 33
Cage production in Morocco from 1995–2004 sorted by species, total aquaculture production and share of cage on total production

Quantities (tonnes)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
European seabass	533	400	568	563	275	n.a.	374	325	389	370
Gilthead seabream	590	658	254	161	466	n.a.	304	378	378	350
Total caged	1 123	1 058	822	724	741	n.a.	678	703	767	720
Total aquaculture production	2 072	2 084	2 329	2 161	2 793	1 889	1 403	1 670	1 538	1718
% cage	54%	51%	35%	34%	27%	n.a.	48%	42%	50%	42%

Source: SIPAM, 2006; FAO/FIDI, 2006

TABLE 34
Total aquaculture and cage values in Morocco from 1995–2004

Value (US$1 000)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total aquaculture	12 254	11 970	8 907	8 036	8 610	5 054	3 375	4 478	4 726	5 887
Total cage	9 584	9 113	5 324	4 642	3 683	n.a.	2 692	2 740	3 019	2 838
% cage	78.2%	76.1%	59.8%	57.8%	42.8%	n.a.	79.7%	61.2%	63.9%	48.2%

Source: SIPAM, 2006; FAO/FIDI, 2006

- Production plans - The size of the farm and cage model may vary depending on the target pursued by the investors. For instance, farmers aiming to produce a niche product, or attempting to diversify production with fish of various sizes, may prefer a large number of small cages rather than a few large ones so that only a reduced percentage of volume can be engaged in a selected production.

High density polyethylene cages

High density polyethylene (HDPE) cages are the most popular ones used in Mediterranean fish farm (Figures 9, 10 and 11). The HDPE pipes can be assembled in various ways in order to produce collars of different sizes and shapes. There are many HDPE cage supplier companies (Floatex, Corelsa, PolarCirkle, Fusion Marine, etc.), however home made cages are also commonly used (Figure 12). These cages are often composed of two (sometimes three) rings of HDPE pipe 15-35 cm diameter, and held together by the base of several stanchions disposed throughout the entire circumference. The rings can be floating (filled with polystyrene) or sinkable (i.e. provided with flooding water/air hoses). The net is fixed at the base of each stanchion and is completely closed with a cap. The bottom of a submersible cage has weights and sometime a sinker tube. Collars are available, in various diameters, onto which nets, as deep as the site allows, are fixed.The mooring system can be quite complicated and the most commonly used is a square shaped grid of ropes, iron plates and buoys. The cages are moored onto the plates. The grid is moored with anchors through several orthogonal mooring lines.

Advantages: versatility of the materials; net changing simple; frequent visual check of the fish; relatively cost effective (especially for bigger cages).

Disadvantage: complicated mooring system requiring frequent checking and maintenance. Time is required to submerge the submergible models and constant weather forecast checks are required.

FIGURE 9
Square Dunlop floating cages and smaller circular HDPE cages used for pre-ongrowing in Cyprus

FIGURE 10
A 50-m diameter HDPE floating cages for Atlantic bluefin tuna fattening in Vibo Valentia, Italy

FIGURE 11
Fish harvesting in an 18-m diameter HDPE floating cage in Rossano Calabro, Italy

FIGURE 12
HDPE self-built floating cages measuring 7x14 equipped with automatic feeder system (pipes are visible)

Farmocean

These cages are defined as semi-submergible rigid cages designed with a rigid steel framework developed in the 1980s as a result of an offshore farming system researched in Sweden. The net is fixed inside the main floating hexagonal frame and its shape is maintained by a sinker tube attached to the bottom. The volume of the cage can range from 2 500 to 5 000 m^3 and each cage is moored through three main radial lines. A feed system is usually placed on the top of the floating frame storing up to 3 000 kg of feed; energy is supplied by solar panels. A winch on the top of the steel frame lifts the sinker tube together with the bottom of the net to simplify the harvesting process.

Advantages: cages have been tested over almost 20 years in a variety of sea conditions; suitable also for exposed sites; integrated feeding system; stable holding volume.

Disadvantage: high initial capital costs; complicated access when harvesting; net changing difficult; high maintenance costs; high visual impact.

Famocean International also produces HDPE circular floating cages (two or three pipes) equipped with iron stanchions (Power-rings cages).

REFA tension legs

These cages are made of a net kept in shape by submerged buoys and an inferior rigid frame. The mooring system is composed of six bottom concrete blocks located vertically under each cage (Figure 14). The top of the cage is fitted with a circular HDPE collar to ensure access and feeding. During adverse weather conditions the cage will submerge entirely causing a loss in the rearing volume. The nets are fitted with a zip which allows the removal of the top portion of the cage during fish harvesting and to allow positioning of the net on a larger HDPE floating collar.

Advantage: simple design and automatic response to adverse sea conditions; cost effective; small bottom area occupied by the mooring system; easy to repair; few components requiring maintenance; very low visual impact.

Disadvantage: closed cage and poor visual check of the fish; small surface for feeding; difficult to change the nets.

Floating platforms

These structures have been installed in Spain and in Italy (Figures 14 and 15). The first were built in Spain by Marina System Iberica (MSI). Two such structures are moored near Barcelona, one near Cadiz and one near Tarragona. These structures are square or hexagonal in shape and hold 7-8 net cages. The mooring system is composed by several mooring lines (rope-chain-dead body) fixed at the corners. The platforms are provided with sinking systems that permits buoyancy control.

In the 1990s a pilot project was developed in Italy and a platform built which included facilities such as a packaging room and staff lodgings. This structure became operational in 2000 and consists of a 60 metre wide circular iron collar where six nets of 5 500 m^3 each are fixed. The platform has a 10x20 m building divided in two floors (ground floor: packaging area, cold store and ice room; 1st floor: staff lodgings, kitchen/canteen, meeting room). It is currently moored in deep waters (80 m) and moored by a single line of 300 meters which allows the structure to freely rotate over a

FIGURE 13
A REFA tension legs cage farm. Only some floats and the floating collars are visible (Sardinia, Italy)

FIGURE 14
Cultimar floating fish farming platform from Marina System Iberica near Barcelona (Spain)

FIGURE 15
A floating fish farm platform fitted with six large cages and a central 2-story work building (Naples, Italy).

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large water surface to better disperse fish waste. The power is supplied by two generators and a sinking system allows raising the floating level of the structure during the storms.

Advantage: excellent logistic; possibility of feeding with any sea condition; constant visual check of the fish; supposedly a highly durable structure.

Disadvantage: high initial investment cost; high maintenance costs; net changing difficult; extremely high visual impact.

Bridgestone and Dunlop

These types of floating cages are designed for severe offshore conditions (Figure 9). Bridgestone and Dunlop provide cages made by assembling rubber oil hoses with junctions placed "face to face". Iron stanchions are clamped on the hoses to allow the net to hang.

The cages have a square, hexagonal or octagonal shape. Square cages can be assembled in multiple cage modules. Different volumes are available up to (theoretically) 60 000 m^3. Such cages are used in Spain, Italy, France and Cyprus.

Advantages: modular nature of the components permits a variety of configuration; extremely resistant; suitable for exposed sites; long durability.

Disadvantage: limited external walkway; expensive at lower volumes.

Jetfloat system

This is a modular component system: plastic cubes can be assembled to create a floating structure where nets are fixed (Figure 16). Originally projected for harbour and piers use, this system can be used in sheltered sites where square cages can be built thanks to several accessories made exclusively for aquaculture purpose (i.e. stanchions and mooring devices). This specific technology is used mainly in France, Greece and Malta. As mentioned these structures are used mainly in sheltered sites and are also used as pre-ongrowing units.

Advantage: versatility of the system (any size and side ratio cages can be assembled); easy replacement of the damaged module; easily dismantling and storage.

Disadvantage: not suitable for very exposed sites; more expensive compared with traditional HDPE cages; relatively expensive at lower volumes.

Sadco Shelf

This Russian company produces and distributes two types of steel cages both of which are submersible. The Sadco series (1200, 2000 and 4000) have been evolving since the early 1980s (Figure 17). A tubular structure holds a completely closed net kept in shape by a sinker tube connected to the

FIGURE 16
Cannes Aquaculture (France) using floating cages built with Jetfloat components

FIGURE 17
A Sardo-Shelf cage in a submerged position. The waterproof automatic feeding system is visible (Italy)

main structure through steel cables. On the top of the cage a waterproof integrated feeding system is installed and equipped with an underwater video system remotely controlled. This type of cage is available in various models and sizes from 1 200 to 4 000 m^3. A new type of underwater cage (Sadco-SG) has been developed over the past few years. This cage is made of a polygonal steel tubular frame, a sinker tube and a submerged tank for buoyancy control. The cage can be submerged through the inflow of water inside the tank. It does not have a self-contained feeder but can work with a manual feeding pipe or centralized feeding system. These cages are designed for exposed sites in offshore conditions. Sadco cages are installed mainly in Italy.

Advantage: suitable for all site (also very exposed); resistant and durable; low visual impact; no reduction in the culture volume also in strong current conditions.

Disadvantage: difficult to change nets (in the Sadco series); expensive at low volumes; automatic feeder still being properly tested.

MAIN ISSUES

Cages are open systems with a continuous exchange of the water body. The risk of pollution to the environment represents a major concern for this sub-sector of the aquaculture industry. Furthermore, conflicts with other costal areas users are often reported, mainly with the tourism sector.

All Mediterranean countries where cage culture is more widely developed require an Environmental Impact Assessment (EIA) which is an important tool used by the authorities when approving a project proposal. In most Mediterranean countries an EIA is mandatory, but there are also exceptions in which the EIA is required only if the production estimate exceeds a certain limit (e.g. >20 tonnes in France). The Environmental Monitoring Programme (EMP), as part of licence conditions, also represents an important tool to supervise the potential polluting effects of any given fish farm. However, an EMP is not always required.

The main impacts that must be taken into account within an EIA are:

- Modification of natural currents - a project will have to take into account this aspect, analysing the available historical data and assessing potential risks related with the farm location.
- Chemical pollution - this risk is related to several factors such as (i) estimated production and soluble wastes; (ii) use of copper-zinc based antifouling on net and moorings; (iii) antibiotic treatment; and (iv) chemical baths to treat parasitic infections.
- Organic matter discharge - this may represent a hazard for the benthic population under and around the cages, as well as a source of self-pollution for the reared fish.
- Visual alteration of scenic places - a serious problem if the farm site is near a coast stretch with a particularly scenic landscape and/or a well developed tourist industry.
- Farmed fish escapes and interaction with local species - escapees represent a risk for the environment as the fish could have a predatory behaviour. In the case of massive break outs the prey/predator ratio of the surrounding ecosystems may be critically altered. Furthermore, escapees may induce "genetic pollution", i.e. interbreeding with indigenous specimens as well as compete for specific ecological niches.

The Commission of European Communities defines Integrated Coastal Zone Management (ICZM) as "...a dynamic, multi-disciplinary and iterative process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICZM uses the informed participation and co-operation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICZM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics" (CEC Communication 2000/547). This strategy, with the support of

the EIA and EMP tools, could well represent a valid technical approach for the development of a sustainable aquaculture management system. Several Mediterranean countries, including non-EU members (e.g. Croatia), have embraced the idea and are in the early stages in applying the system.

Disease control and health management

Evidence exists that pathogenic exchanges may occur in cage culture systems and therefore particular attention is required to minimize these exchanges in both directions (i.e. between farmed and wild fish and vice versa). This is aggravated by the evidence that certain pathogens (mainly monogean parasites) can easily switch their host from a wild one to a farmed one therefore increasing their pathogenic action.

To minimize the risk of wild fish stock contamination, high quality and certified fingerlings are essential. Large commercial hatcheries are almost pathogen-free producing fingerlings which are strictly monitored for known pathogens. Veterinary certificates are usually release for each fry batch. There are, however, a large number of smaller hatcheries that may not reach satisfactory standards and may represent a risk in spreading diseases.

Pathogen contamination between wild specimens and reared fish is more difficult to control. Disease outbreaks depend on several factors including rearing conditions, animal welfare and fish stress (due to stocking density, water quality, diet, oxygen availability, handling, etc.). In cage farms the use of antibiotics should be minimized and this can be partly achieved by vaccinating fingerlings against the most common pathogens. In case of the European seabass the two most important pathogens are the *Vibrio anguillarum* (causing vibriosis) and *Photobacterium damselae* (causing pasteurellosis). For both these disease vaccines are available. Vaccination against vibriosis is often administered to the early stage fingerlings while treatment against pasteurellosis is usually carried out upon specific request.

Furthermore, it is important to mention that the current legislation dealing with health management issues are not homogeneous throughout the Mediterranean countries, especially with regards to the licensing of chemicals and health products.

Technology

The use of automation and mechanization in the production process has been increasing in order to reduce production costs. Efforts are being made to install and enhance the use of automatic feeding systems, sometimes with sensors which provide a feedback on feed consumption. These tools can reduce considerably labour costs as well as reduce feed dispersion which has a positive impact on both environment and production costs. Feeding systems must nevertheless be frequently monitored and properly tuned. Grading machines and harvesting pumps are increasingly used.

Tuna aquaculture

Atlantic bluefin tuna farming is an activity that clearly overlaps with fisheries. The risks and issues that should be considered to define the sustainability of this recent activity are strictly related with both sectors. The tuna fattening industry has expanded over the last few years and the value output has increased considerably. The sector is based on the use of "wild-seed". The amount of tuna which can be annually harvested is fixed by ICCAT and quotas assigned to the signatory parties. Although a strict control is practiced throughout the production cycle, several gaps may still facilitate the exploitation of the resource beyond the allowable quota.

One of the main aquaculture challenges in the coming years will be the domestication of the BFT. Although research results have been promising, more work is required preferably through international collaboration arrangements.

Market and product differentiation

In the beginning of the 1990s the consolidation of rearing techniques and the availability of new technologies pushed an increasing number of entrepreneurs to produce the European seabass and gilthead seabream using marine cages (Note: In 1990 production cost in Italy for these two species ranged between US$19-21/kg).

Ten years later, due to the availability of EU Structural Funds, the lack of a sector growth strategy and poor market planning and promotion, brought about a market crisis of the sector. The current low prices and narrow profit margins are unsuited for a "high risk" activity such as marine cage culture. For these reasons many producers are focusing on (i) promoting their products on new or poorly exploited markets (such as Russia, Germany, United Kingdom, USA); (ii) considering new culture candidates from both technical and marketing points of view; (iii) adding value to their products (now sold mainly as whole fresh fish) and supporting marketing campaigns.

Offshore "migration"

Sheltered sites have always been preferred for installing a cage farm. These are the easiest places to practice cage aquaculture, both for the initial lower investment cost and for managing of the farm. A sheltered site allows the use of light cages that require a simple mooring system. As farms are generally close to the shoreline, powerful and fast boats are not needed and routine farm activities can be done carried out without to many difficulties. However, a sheltered site is usually in shallow waters with low currents and with a carrying capacity which may be insufficient for supporting an intense farming activity. Furthermore such sites are often in the vicinity of beaches, bays or areas highly frequented by tourists.

The aspects highlighted above along with the ever improving cage technologies are driving producers, licensing authorities and regulators to move fish farms further offshore. Such sites have however a number of inherent disadvantages, among which:

- cages, mooring systems and nets must be suitable for exposed sites and are consequently more expensive;
- deeper operational working routine for divers;
- difficulty in approaching the cages during severe weather conditions
- reduced number of feeding days during adverse sea conditions in the absence of an automatic feeding system;
- higher transportation costs;
- strong currents may increase feed loss; and
- higher risks of fish escaping.

The constraints listed certainly contribute to an increase in capital and operational costs however they are counterbalanced by a series of advantages. Cages moored in deeper waters (>35 m) and exposed to stronger currents will certainly reduce bottom sedimentation and accumulation of organic matter, thus promoting waste dispersal and minimizing the risk of pollution and self-pollution. Moreover, a higher water quality and renewal implies better rearing conditions and animal welfare with (i) lower risk of disease outbreak and use of chemicals; (ii) potential higher stocking density; (iii) higher oxygen saturation resulting in better growth and lower feed conversion rates; (iv) lower visual impacts and reduction of conflicts with other resource users; and (v) higher fish quality with a lower fat/meat ratio.

THE WAY FORWARD

The development of cage aquaculture in Mediterranean is generally based on the principles of biodiversity conservation and sustainable use of the natural resources. Cage aquaculture is expanding rapidly throughout the region requiring more than ever planning and regulatory frameworks for the strategic and controlled development of the sector. Furthermore, additional scientific research is required to address the biological and technological constrains currently limiting the performance of the sector. Some of the major actions that require further attention are summarized as follows:

- strengthen the EIA and EMP tools and promote their application;
- promote an Integrated Coastal Zone Management (ICZM) approach in support of a developing mariculture industry;
- reduce the use of antibiotics;
- promote Mediterranean products in poorly and unexploited markets;
- strengthen research on species diversification for aquaculture;
- further develop value-added products using traditionally farmed species;
- work on the domestication of the BFT and develop an adequate commercial feed;
- strengthen the collection of reliable information on cage culture activities; and
- support offshore "migration" of cage farms.

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