

# Capture-based aquaculture of mullets in Egypt

**Magdy Saleh**

*General Authority for Fish Resources Development*

*Cairo, Egypt*

*E-mail: salehmagdy2000@gmail.com*

**Saleh, M.** 2008. Capture-based aquaculture of mullets in Egypt. In A. Lovatelli and P.F. Holthus (eds). Capture-based aquaculture. Global overview. *FAO Fisheries Technical Paper*. No. 508. Rome, FAO. pp. 109–126.

## SUMMARY

The use of wild-caught mullet seed for the annual restocking of inland lakes has been known in Egypt for more than eight decades. The importance of wild seed collection increased with recent aquaculture developments. The positive experience with wild seed collection and high seed production costs has prevented the development of commercial mullet hatcheries. Mullet are considered very important aquaculture fish in Egypt with 156 400 tonnes produced in 2005 representing 29 percent of the national aquaculture production. Current legislation prohibits wild seed fisheries except under the direct supervision of the relevant authorities. In 2005, 69.4 million mullet fry were caught for both aquaculture and culture-based fisheries. A parallel illegal fishery exists, undermining proper management of the resources. The effect of wild seed fisheries on the wild stocks of mullet is not well studied. The negative effect of the activity is a matter of debate between fish farming and capture fisheries communities. Data on the capture of wild mullet fisheries shows no observable effect of fry collection on the catch during the last 25 years.

## DESCRIPTION OF THE SPECIES AND USE IN AQUACULTURE

### Species presentation

Mullets are members of the Order Mugiliformes, Family Mugilidae. Mullets are ray-finned fish found worldwide in coastal temperate and tropical waters and, for some species, also in freshwater. Taxonomically the family is usually treated as the sole member of the order Mugiliformes, but as Nelson (1994) reports, “.... there has been much disagreement concerning the relationships ....” of this family. Most species commonly reach about 20 cm in total length, but some (e.g. *Mugil cephalus*) may attain 80–120 cm. The head is broad and flattened dorsally in most species. The snout is short and the mouth is small. The gill arches of many species are specialized, forming a characteristic pharyngobranchial organ that has an expanded, denticulate pad used for filtration of ingested material. In many species of mullet, the tiny teeth are positioned on the lips.

The eyes may be partially covered by adipose tissue. There are two short, well-separated dorsal fins, the first with four spines and the second with eight to ten segmented rays. The anal fin is short; with two or three spines, and seven to twelve

segmented rays in adults. The pectoral fins are high on the body, and the caudal fin is weakly forked. The lateral line is absent. The scales are moderate to large in size, with one or more longitudinal grooves. There are two or more pyloric caeca associated with the stomach, which also has a thick-walled, muscular gizzard in most species. Mullet are usually grayish green or blue dorsally, and their flanks are silvery, often with dark longitudinal stripes. They are pale or yellowish ventrally (Harrison, 1999; Nelson, 1994).

Most mullets are found in coastal marine and brackish waters. They are nektonic, usually in shallow inshore environments, such as coastal bays, reef flats, tide pools, and around harbor pilings and in brackish water estuaries, lagoons and mangroves. They usually swim over sandy-muddy bottoms and seagrass meadows, in relatively still waters. They commonly occur at water depths of 20 m but may be found offshore or in deeper waters. Many species are euryhaline and move between marine and freshwater environments of rivers and flooded rice fields. Some species occasionally swim far up river, while a few species spend their entire adult lives in rivers (Smith and Smith, 1986; Cardona, 2006).

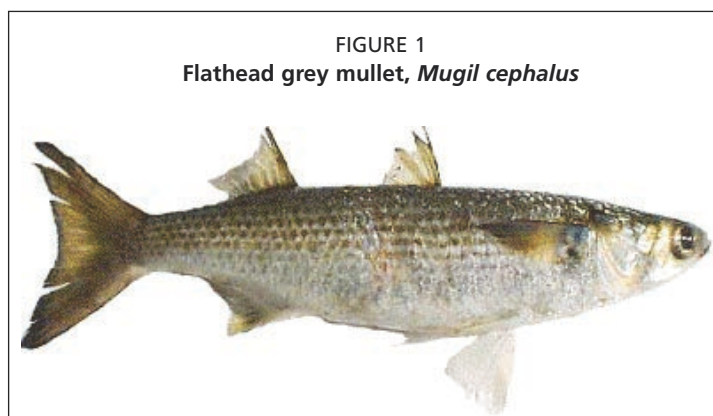
Mullet migrate in large aggregations from their feeding grounds in rivers, estuaries, lakes or lagoons to the sea for spawning in a single spawning cycle each season. Spawning seasons differ according to species and regions. Fecundity is high in all species and is estimated at 0.5–2.0 million eggs per female depending on the size of the adult. Eggs are scattered on the bottom substratum in open waters and left unguarded. The eggs develop at sea and hatching occurs about 48 hours after fertilization, releasing larvae of approximately 2.4 mm in length. When the larvae reach 16–20 mm they migrate to inshore waters and estuaries (Saleh, 2006; Maitland and Campbell, 1992).

Out of the 17 genera and 80 species belonging to the family Mugilidae (Nelson, 1984) only three species are of aquaculture importance. Due to its higher growth rates and market acceptance, the flathead gray mullet *Mugil cephalus*, thinlip mullet *Liza ramada* and the bluespot mullet *Valamugil seбели* are the most commonly cultured species of mullet in Egypt.

The flathead grey mullet, *Mugil cephalus*, is a very important aquaculture species in the Mediterranean, Southeast Asia, Taiwan Province of China, Japan and Hawaii (Saleh, 2006). The species can reach a length of up to 120 cm making it the largest mullet species (Figure 1). Externally, males are difficult to distinguish from females, except for the more slender shape of males when sexually ripening (Virgona, 1995). Their color is olive-green dorsally, with sides that are silvery shading to white ventrally. They have thin lips and the pectoral fins are short, not reaching the first dorsal fin. They have thin lips and the pectoral fins are short, not reaching the first dorsal fin.

The grey mullets, found in coastal waters of the tropical and subtropical zones of all seas, are catadromous, frequently found in estuaries and freshwater environments (Figure 2). Adult mullet have been found in waters ranging from zero salinity to 75 ppt, while juveniles can only tolerate such wide salinity ranges after they reach lengths of

4–7 cm. Adults form large schools near the surface over sandy or muddy bottoms and dense vegetation and migrate offshore to spawn in large aggregations (Eschmeyer, Herald and Hamman, 1983). The larvae move inshore to extremely shallow water, which provides protection from predators as well as a rich feeding ground. After reaching 5 cm in length, the young mullets move into slightly deeper waters (Saleh, 2006).



The species is mainly diurnal and feeds on zooplankton, benthic organisms and detritus. Adult fish tend to feed mainly on algae while inhabiting freshwater. Reproduction takes place in the sea from July to October. Females spawn 5 to 7 million eggs provided with a notable vitellus.

The flathead grey mullet was the first species of mugilidae used for aquaculture. In Egypt, this species has been used for traditional aquaculture and culture-based fisheries since the late 1920s and is still of major importance today also in other Mediterranean countries and Taiwan Province of China (Faouzi, 1936; Saleh and Salem, 2005; Basurco and Lovatelli, 2003).

The thinlip grey mullet, *Liza ramada*, although the second choice in the aquaculture of mullet constitutes the majority of the aquaculture harvest of mullet in Egypt. This species has a lower growth rate than *Mugil cephalus*, but exceeds that of all other Mediterranean mullet species. The availability and abundance of the wild fry of this species as compared to those of *Mugil cephalus* makes it the dominant aquaculture species (Sadek and Mires, 2000) (Figure 3).

Thinlip grey mullet can reach a body length of up to 70 cm. The species is characterized by an elongate fusiform body; slightly compressed from side to side, with a massive short head, flattened above the eyes and with a broad terminal mouth with very small, barely visible, teeth. The upper lips are thin and smooth and the snout is short and blunt. The thinlip grey mullet has two well-separated dorsal fins, the first with 4 to 5 spines. The pectoral fins are placed high on the flanks and the caudal fin is deeply forked. There is no external lateral line and the scales are large and adherent. Scales on the top of the head extend forward to the anterior nostrils and the eye is not covered by a thick adipose lid. At the base of pectoral fin there is a scaly appendix. The colour on the back is grey-dark brown, while the belly whitish-grey often with 6–7 lengthwise stripes (FAO, 1973; Rochard and Elie, 1994).

The thinlip grey mullet is a fast swimmer, leaping out of the water when disturbed. It enters estuaries and rivers for feeding, but spawns in the sea. Juveniles often concentrate

FIGURE 2  
Global distribution of the flathead grey mullet, *Mugil cephalus*



FIGURE 3  
Thinlip grey mullet, *Liza ramada*

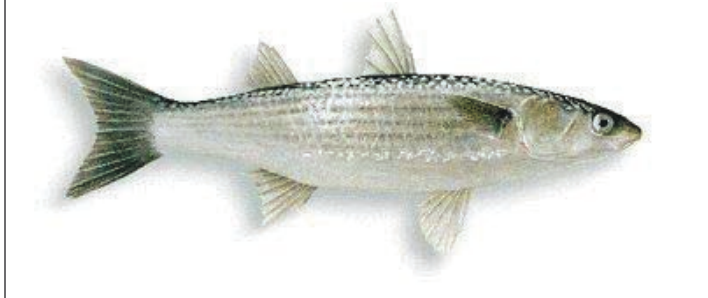


FIGURE 4  
Global distribution of the thinlip grey mullet, *Liza ramada*



FIGURE 5  
Bluespot mullet, *Valamugil seheli*

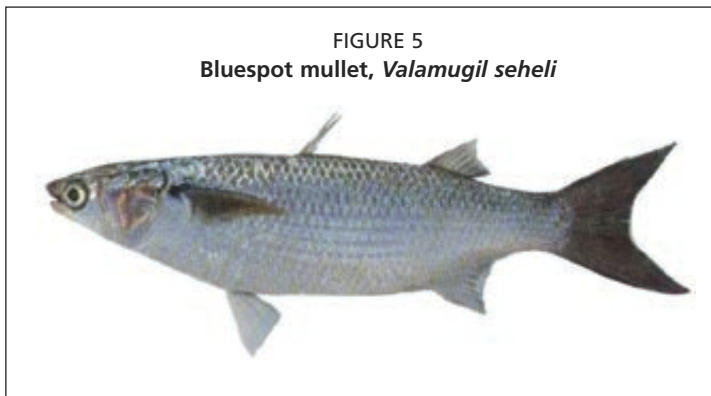
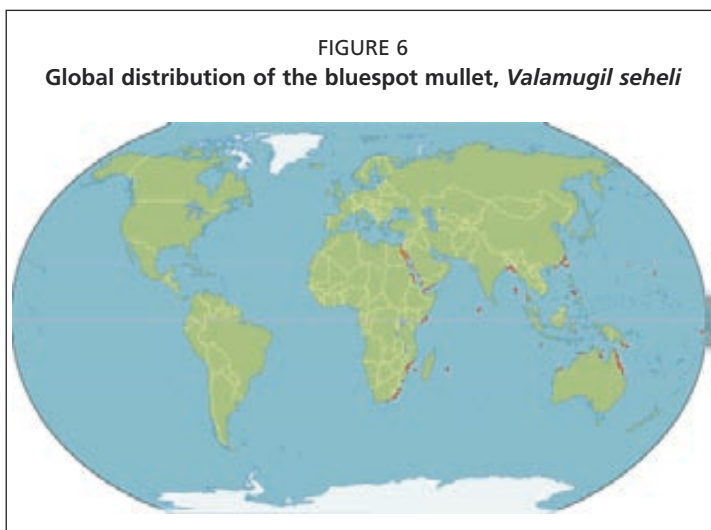


FIGURE 6  
Global distribution of the bluespot mullet, *Valamugil seheli*



in the vicinity of freshwater outflows. It feeds on minute bottom-living or planktonic organisms (e.g. diatoms and amphipods) and also on suspended organic matter. *Liza ramada* is native in the Eastern Atlantic from the coasts of southern Norway to Morocco, including the Mediterranean and the Black Sea (Figure 4) (Wonham *et al.*, 2000).

The bluespot mullet (*Valamugil seheli*) although it has a lower growth rate, fetches a higher market price compared to the other cultured mullet in Egypt. The fish is highly appreciated for its taste and usually consumed at an individual body weight of 120–180 grams. The bluespot mullet can reach a body length of 60 cm. The body is compact, pressed from both sides and the head is small (Figure 5). Adults are bluish brown or green dorsally, flanks and abdomen silvery with a dusky spots on the upper row of scales, giving indistinct longitudinal stripes. The dorsal and upper lobe of the caudal fin has a dark-blue tip. Anal, pelvic,

and pectoral fins are yellow. Pectoral fins are also with dark blue spot dorsally at origin (Harrison and Senou, 1997).

The species usually swims in schools and inhabits coastal waters, but enters estuaries and rivers where it feeds on microalgae, filamentous algae, forams, diatoms, and detritus associated with sand and mud (Harrison and Senou, 1997). The bluespot mullet is found in the Indo-Pacific and the Red Sea all the way south to South Africa; to the east its distribution reaches the Hawaiian and Marquesan islands; north to southern Japan, and to the south to New Caledonia and Norfolk Island (Figure 6). In Egypt, the species is caught mostly from the Red Sea, Gulf of Suez, Suez Canal and the Bitter Lakes. On the Mediterranean coast of Egypt, the bluespot mullet is only caught in the coastal waters of the area extending from Damyitta to the northwest of the Sinai Peninsula.

### Mullet fisheries

Mullets are an important component of Egyptian fisheries and are considered as one of the most important cash crops from artisanal fisheries in the numerous lagoons throughout the country. The fish is commonly caught with gill, trammel and veranda nets by artisanal fishers operating in the sea, lakes and coastal lagoons. Based on the statistics published by the Food and Agriculture Organization of the United Nations (FAO) the world total catch of mullet in 2004 was about 261 000 tonnes representing only 0.3 percent of the world fish catch (FAO, 2004).

In Egypt, the 2005 production of mullets was recorded by the General Authority for Fish Resources Development (GAFRD) at 186 000 tonnes, representing about 21 percent of the total national fish production (GAFRD, 2006). Mullet harvest was about 30 000 tonnes in 2005, 81.6 percent of which was from lakes and coastal lagoons.

While production of the capture fisheries slightly increased during 1985–2005, harvest of cultured mullet sharply increased during the last ten years (Figure 7).

The aquaculture harvest of mullet increased from 15 percent of the total aquaculture production in 1980 to 29 percent in 2005 (Figure 8). The percentage of mullet in the catch of the Egypt fisheries increased from 6.1 percent in 1980 to 8.4 percent in 2005 (Figure 9).

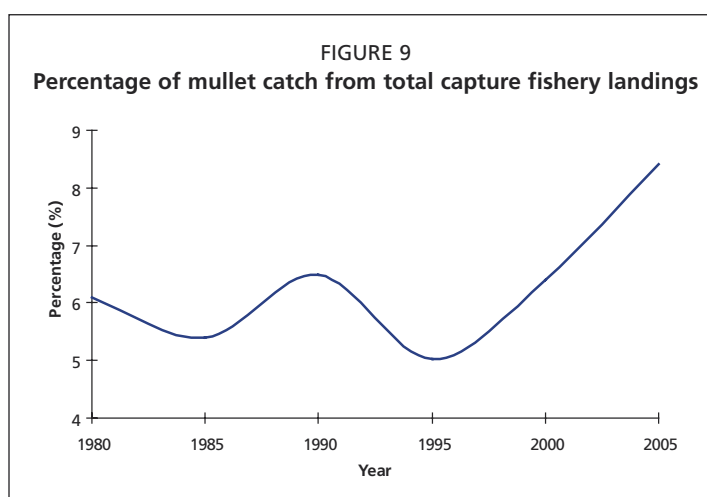
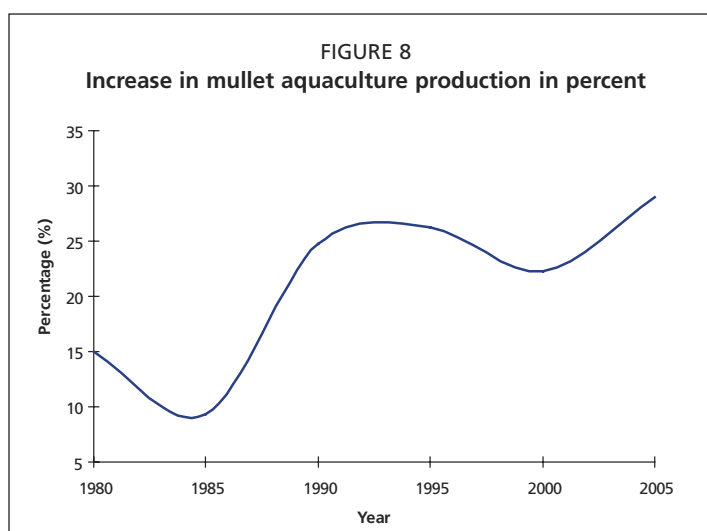
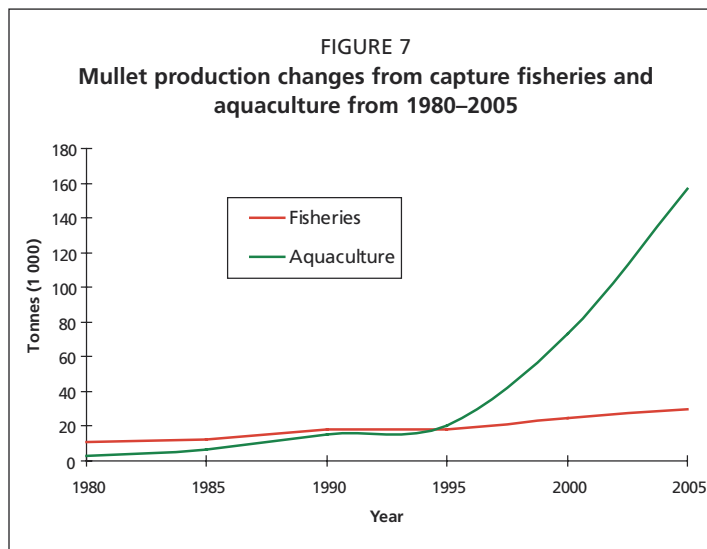
Although there is no accurate published statistics on the catch of the five species of mullet found in Egypt, estimates were found in the landing records in some landing sites. According to these estimates, during the last ten years, the thinlip grey mullet, *Liza ramada*, constituted an average of 58 percent of the catch, while the flathead grey mullet *Mugil cephalus* was only 23 percent and the three other species (*Valamugil seheli*, *Liza aurata* and *Liza saliens*) together constituted the rest.

### Mullet aquaculture

Mullet are cultured in a large number of countries worldwide, usually in extensive and semi-intensive pond systems. Egypt has a long history of mullet aquaculture, which was traditionally practised in the “hoshā” system in the Nile Delta region for centuries (Eisawy and El-Bolok, 1975). Currently, Egypt is a leading country in mullet aquaculture with a record production of 156 400 tonnes in 2005.

Most mullet aquaculture activities rely on the use of wild seed, e.g. Egypt (Saleh, 1991; Suloma and Ogata, 2006), Taiwan Province of China (Yeh, 1998), the Philippines, Italy (Landoli, 2000), Greece, Israel, Tunisia and Turkey (Sadek and Mires; 2000). Reliance on collection of wild seed was a result of either insufficient supply of hatchery produced seed or its higher price.

Commercial hatchery production of mullet seed is carried out in some countries. Induced spawning and production of fry has been achieved on an experimental and semi-commercial basis in the United States of America and Taiwan Province of China. The production of mullet fry on a limited scale for aquaculture has been reported in



Italy, Israel and Egypt (Saleh, 2006). The development of hatchery production techniques are only practiced commercially for flathead grey mullet as the techniques for seed production of other important species (e.g. thinlip grey mullet) are not yet developed.

In Egypt, mullet fry were first produced in a hatchery near Alexandria through a project in the early 1990s funded by the United States Agency for International Development (USAID). The hatchery production capacity was limited and was capable of producing annually 1–2 million fry of flathead grey mullet. The production cost was high and the fry sold for as much as 15 times the price of wild fry. The failure of marketing the product resulted in shifting the production to species with higher market value and demand, such as the European seabass, gilthead seabream and shrimp. The availability and abundance of mullet fry in the coastal waters of Egypt and accumulated experiences in collecting wild fry developed over more than eight decades are the main reason preventing the development of hatchery production of mullet seed (Saleh, 1991).

In Italy, mullet farming is almost entirely based on extensive techniques, with coastal lagoons and semi-intensive ponds being restocked with wild juveniles. Artificial reproduction trials are currently underway, attempting to establish standard reproduction techniques for mullet (Landoli, 2000).

Mulletts are usually grown in extensive, semi-intensive ponds and netted enclosures in shallow coastal waters. Mullet can be polycultured successfully with many other fish, including common carp, grass carp, silver carp, Nile tilapia and milkfish, and can be reared in fresh, brackish and marine waters.

In Egypt, where most of cultured mullet are produced, pre-farming preparation of ponds is of great importance. Prior to stocking, aquaculture ponds are prepared by drying, plowing and manuring with cow dung. Ponds are then filled to a depth of 25–30 cm and kept at that level for 7–10 days to build up a suitable level of natural feed. The water level is then increased to 1.5–1.75 m and the fingerlings are stocked. Productivity is kept at the required level by adding chicken manure and/or chemical fertilizers. Optimal dissolved oxygen is maintained by the use of various types of aerators, especially after sunset. Extruded feed is supplied to semi-intensive ponds to cover the feeding requirements of both carps and tilapia grown in the same ponds.

The growing season is normally about 7–8 months. If mullet are monocultured, manuring may be sufficient to reach the required feed level. In many cases, mullet have been found to feed directly on chicken manure and good levels of production have been recorded. Growth is checked by sampling, and if growth rates are not as expected, rice and/or wheat bran is added daily as a supplement to the natural feed in ponds. When mullet are reared in polyculture feeding and fertilization programmes usually target the other cultured species while mullets feed on the natural feed, detritus and feed leftovers.

Acclimatized to the appropriate salinity, and stocked as 10–15 g individuals at about 6 200–7 400/ha, a harvest of 4.3–5.6/tonnes/ha/crop can be obtained. In semi-intensive polyculture with tilapia and carp, mullet fingerlings are stocked at about 2 500–3 700/ha together with 1 900–2 500/ha of 100 g common carp juveniles and about 62 000–74 000/ha of 10–15 g Nile tilapia fingerlings. Total harvests are typically 20–30 tonnes/ha/crop of which 2–3 tonnes are mullets. After an on-growing season of 7–8 months in the subtropical region, flathead grey mullet reach an individual weight of 0.75–1 kilogram. Mullet grown for two successive seasons, reaches 1.5–1.75 kilograms. The choice of rearing period and technique depends on market demand and economics.

## WILD SEED FISHING

### Legal aspects

In Italy, the collection of wild fry is managed by the authorities that issue limited fishing licenses each year between September 16 and December 31 after an assessment

of relevant environmental parameters. Each licensee is allowed a quota of fry catch. Fishing is prohibited at the outlets of rivers and in brackish lagoon channels up to 400 m from the sea. Fishers must be equipped with oxygen supplied transport tanks (Sadek and Mires, 2000).

In Israel, special licenses are required to collect wild mullet fry. The department of fisheries and aquaculture, which also monitors the implementation of the law by means of inspectors, issues these licenses on a yearly basis. No fishing quotas are established (Sadek and Mires, 2000).

Wild fry collection in Egypt is controlled by the Fisheries Law No. 124/1983. According to this law, it is prohibited to fish, collect, handle or transport wild fish fry unless an official permit is obtained from the competent governmental authority (i.e. GAFRD). Fishing for wild fry is also allowed in limited sites supervised and managed by the governmental fry collection stations. Fry collection stations are distributed mainly on the Delta coast of the Mediterranean especially at the outlets of the major agriculture drainage canals, branches of the Nile and the connecting canals of lagoons and lakes to the sea. The mullet harvest at the ten Mediterranean stations is mainly flathead and thinlip grey mullet (98.9 percent of the total mullet fry catch in 2005). Two other stations at the Great Bitter Lake (Suez Canal) and the Gulf of Suez specialize in bluespot mullet.

Fry collection is conducted by teams of private fishers. The team leader and the teams are nominated and checked by the Coast Guard Intelligence before receiving a permit to work in the coastal areas. Each collection station may employ one or more teams. Fishers bring their own fishing gear and other collecting and handling equipment. All the collected fry are brought to the station where the catch is inspected for condition, presence of unwanted species and quantified by estimating the number of fish. Fishers are paid 50 percent of the sale price of the collected fry. The other 50 percent is kept for covering the running cost and maintenance of the stations.

The fry collection stations also act as the distribution and marketing sites for wild fry. Fry price is decided by the government authority and may fluctuate each year according to market demand. Changes in prices are decided and announced by a GAFRD board decree. Collected fry are usually sold directly or transported to GAFRD nursing stations where they are grown out and sold as fingerlings. According to local legislation, fry and fingerlings are sold only to licensed fish farms. Each fish farm is allocated a quota of 6 250–7 500 fry/ha of flathead or thinlip grey mullet or up to 12 500 fry of bluespot mullet. This quota system has created numerous management and control problems. In fact many mullet farmers state that the quota decided by the authority is much less than what is effectively required for a profitable production. The government authority, on the other hand, considers the quota to be more than enough if the farmers carry out the recommended handling, acclimatization and nursing procedures that prevents heavy losses of fry. Mulletts are usually produced in semi-intensive polyculture with other fish where it only constitutes less than 20 percent of the reared stocks.

The development and expansion of aquaculture was motivated by high profitability that attracted many agriculture land owners, especially those with newly reclaimed land of marginal profitability, to shift to aquaculture. Due to the shortage of water and agriculture land resources in Egypt, the transformation of agriculture land to aquaculture is contrary to the relevant agriculture, irrigation and fisheries legislation. In a recent field survey carried out by GAFRD, Ministry of Environmental Affairs, and the Aquatic Police and Land Reclamation Authority, it was reported that 36 400 hectares of reclaimed agriculture land were used for aquaculture activities in two Delta Governorates. The 2005 GAFRD statistical yearbook estimated the total area of this activity at 55 200 hectares representing about 52 percent of the total aquaculture area of the country. According to current legislation, GAFRD cannot license such farms.

These farms are not allowed to purchase seed from the governmental hatcheries or fry collection stations and they can only depend on illegal sources for their stocking needs. The recorded mullet production from such farms was 82 000 tonnes in 2005 (GAFRD, 2006) representing about 47 percent of the production of cultured mullet in the country.

As a result, fish farmers seek other sources of seed supply. This has created an illegal activity of fishing and marketing of wild-caught seed by gangs of illegal fishers. These unlicensed fishers sneak into the coastal areas or banks of drainage canals, well equipped with seine nets, light boats and pickup trucks. The illegally harvested fry are transported very early in the morning along country roads to a fry market in the fish farming areas where they are sold by the thousands. The number of fry collected through this illegal activity is not recorded and is uncontrolled. The size of this illegal trade is believed to be very large and the number of collected fry may exceed those collected through the official stations.

### Fishing techniques

Mullet are known to have a seasonal breeding migration when large shoals of adults leave lakes, coastal lagoons and rivers and move to breeding grounds in the open sea. Breeding seasons differ according to species and regions of the world. Hatched larvae drift with surface water currents (Rossi, 1986) and then swim in large aggregations towards the shallow coastal waters to reach the rich feeding grounds in the estuaries and coastal lagoons. Mullet seed reach the estuaries and shallow coastal waters as fry that are 12–20 mm long. Mullet fry are fished as they reach the coast or from the inlets of the coastal lagoons and openings of agriculture drainage or irrigation canals.

In Egypt mullet have been commercially fished for restocking saline inland lakes since the early 1920s (Wimpenny and Faouzi, 1935; Faouzi, 1936). The Suez Canal, its adjacent lakes, the Nile effluents and discharge canals leading to the Mediterranean have been the main source of the seasonal mullet and other euryhaline fish fry catches (El-Zarka and Kamel, 1965). The early techniques used for commercial wild fry collection were described by El-Zarka, El-maghraby and Abdel-Hamid (1970). The gear was made from mosquito nets fitted to a rectangular metal frame with a wooden roll bar fixed to the front edge of the frame and pushed in the shallow coastal water by a team of three fishers. The reported fry catch of such gear was about 20 000 fry per hour. With the increased demand for fry in the late 1990s, shoals of fry were collected in coastal water using larger fine seine nets (Figure 10).



The commonly used seine is 50–150 m wide and 2.25 m deep. Netting material is made of strong monofilament threads of synthetic fibers with 1 mm stretched mesh size (Figure 11). The material is manufactured mainly for household use, window and fishpond screens. The purchased material is prepared by the fishers by fixing cork and lead lines, side wooden bars and pulling ropes. Scoop nets are also used to collect fry from the agriculture drainage canals especially near the outlets of pumping stations leading to the sea (Sadek and Mires, 2000).

Collected fry are scooped from the fishing net by small fine hand



nets, carried in buckets filled with seawater and kept in *hapas* or shore aggregation tanks for a few hours. At this point fry are sold to customers or moved to transport trucks to be sold at the fish farms. Fry are also transported by trucks to separate nursery units, or nursery facilities in grow-out farms to produce fingerlings.

Fry collection activities are carried out by artisanal fishers. Techniques are simple and the gear is developed from locally available materials. The highest cost is for the seine net. The cost of fabric is about US\$60 and about US\$50 for cork, ropes and lead. A light wooden boat can sometimes be used to stretch the net in deeper water (Figure 12). Such a boat can cost US\$200–250 but it is used for other activities beside the seasonal and temporary fry collection. In an interview with a team leader working with the governmental station near Port Said, the overall cost of gear, equipment and fees were calculated to be around US\$500–520 for each fishing cycle of 3–4 months. The season of mullet fry collection extends to 10 months in three cycles each year.

Annual data on mullet seed collection in Egypt is found in the GAFRD records for the last three decades. The annual catch of mullet fry during the early 1980s was around 50 millions per year (53.7 million in 1980). In 1985, the total number increased to 83.2 million fry. Most of the collected fry (64 percent) were used to stock inland lakes (culture-based fisheries) the rest was used for aquaculture.

The magnitude of mullet fry collection activities varied greatly with the fluctuation in demand associated with the status of aquaculture development. Increase in the demand for seed was associated with the rapid development of aquaculture in the 1990s (Figure 13). The official record for the last 10 years is not comprehensive, as the illegal fry catch

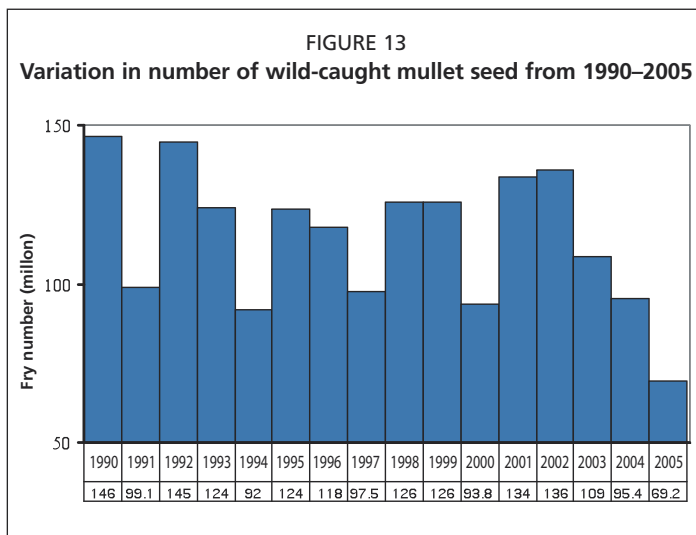
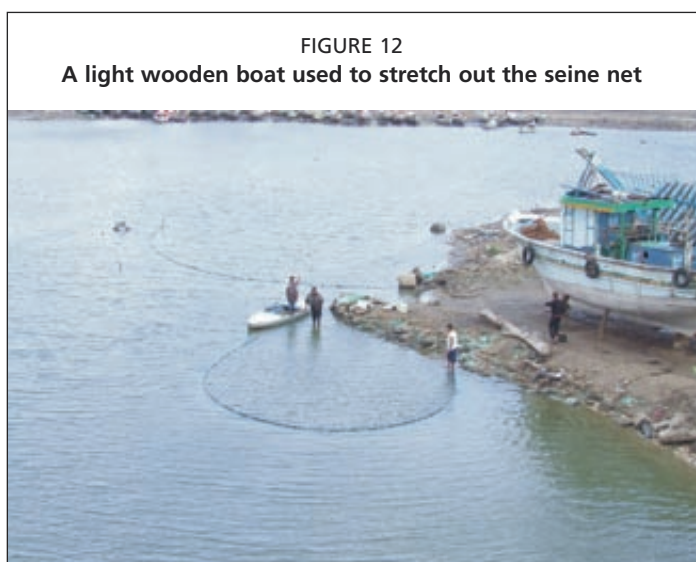


TABLE 1  
Recorded and estimated mullet seed catch, fish production, and numbers of utilized seeds in licensed and unlicensed farms

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Production – licensed farms (1 000 tonnes)	13.6	9.7	13.6	10.4	22.7	21.6	46.8	62	67.3	74.5
Production – unlicensed farms (1 000 tonnes)	6.5	6.4	14.8	32.6	57.6	66.6	66.2	73.6	65.4	82
Fry used in licensed farms (million)	41.0	35.3	36.4	38.3	44.8	85.8	102.4	75.5	64.6	65.0
Estimated fry used in unlicensed farms (million)	19.6	23.3	39.6	91.8	113.7	264.6	144.8	89.6	62.8	71.5
Fry used for restocking lakes (million)	77.0	62.0	89.6	87.7	49.0	48.2	33.6	33.5	30.8	4.4
Estimated total fry collected (million)	137.6	120.8	135.6	217.8	207.5	398.6	280.8	198.6	158.2	140.9

generally is unreported. According to GAFRD illegal fry collection has increased sharply during the last five years as a result of the unlicensed fish farms built illegally on newly reclaimed agriculture land.

The recorded catch of mullet fry during the past 15 years varied between 90–145 million fry per year with the highest catches in 1990 and 1992 when about 146 and 145 million fry were collected, respectively. Starting from 2003, fry catch began to decline. The sharp decline in 2005 was due to the reduced number of legally caught mullet seed used in restocking inland lakes, from 32 million in 2004 to about 4 million in 2005 (GAFRD, 2006). The recorded number of fry used for production on licensed farms can be used to extrapolate the number of fry used on unlicensed farms, as both apply the same technology and management systems.

In 1996, mullet production from unlicensed farms was estimated at 6 500 tonnes representing approximately 32 percent of the total cultured production, while in 2005 the harvest increased to 82 000 tonnes representing 52 percent of the annual output.

Table 1 show the recorded mullet production from both licensed and unlicensed farms from 1996 to 2005 along with the total recorded number of fry (all three species) officially collected during the same year. The table highlights the fact that mullet production is not related to the number of fry utilized.

Production from 2003 to 2005 increased even though the number of fry utilized dropped considerably. During this same period the government increased the price of fry from US\$3.5 to 17.6 per thousand resulting in both positive and negative effects. On the positive side, it led to an improvement in fishing, transport, handling and acclimatization techniques and a more responsible and rational utilization of the resources. On the negative side, the increased profit from the sale of fry encouraged additional illegal fry fishing.

Table 2 indicates the change in the relative importance and number of collected seed from each of the three species farmed in Egypt. The data shows that the catch of *Liza ramada* seed was always the highest at about 59 percent of the total mullet seed collected in 2001 to over 79 percent in 2005. This was also the case in Greece where seed of this species was the most abundant and represented over 54 percent of mullet fry found (Koutrakis, 2004).

TABLE 2  
Changes in the relative importance and number of collected seed of different mullet species

Year	<i>Liza ramada</i>		<i>Mugil cephalus</i>		<i>Valamugil seheli</i>		Total (millions)
	Fry No. (million)	%	Fry No. (million)	%	Fry No. (million)	%	
2001	78.9	58.9	40.6	30.3	14.5	10.8	134
2002	101.5	74.6	15.4	11.3	19.3	14.2	136
2003	76.0	69.7	20.9	19.2	12.1	11.1	109
2004	66.6	69.8	12.8	13.4	16.0	16.8	95.4
2005	55.1	79.4	8.0	11.5	6.3	9.1	69.4

The percentage of *Mugil cephalus* declined during the same period from about 30 percent in 2001 to 11.5 percent in 2005 whereas the catch of *Valamugil seбели* was more stable. The decline in the catch of *Mugil cephalus* in 2002 was balanced by an increase in the catch of *Liza ramada* seed from 79 million in 2001 to a record of 101.5 million in 2002. Two reasons have been identified for the decline of *Mugil cephalus* fry. The first was the increased production of dried mullet roe and the second that most of the illegal seed fishing activities concentrated on the higher priced flathead grey mullet.

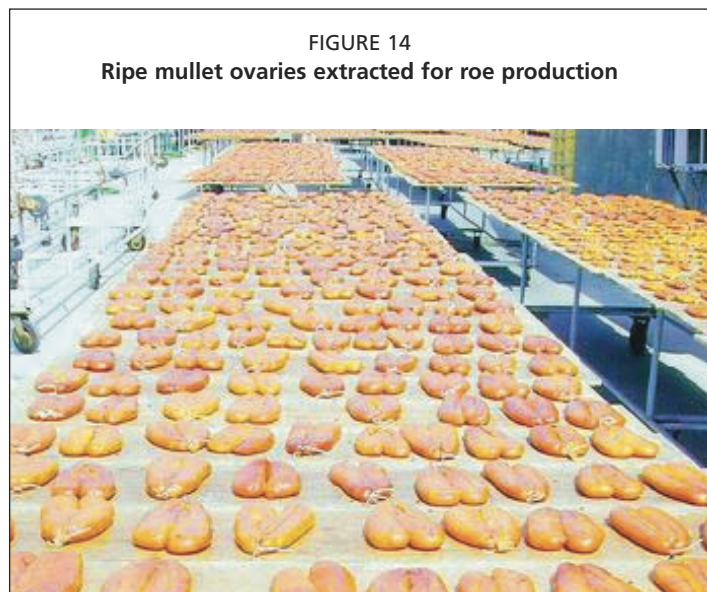
Fishing mullet to extract the ovaries is an old practice, which is expanding rapidly in the Mediterranean, Asia and the United States of America (Figure 14). The activity is a real threat to the species considering the high fecundity of the flathead grey mullet. Each migrating ripe female killed to extract the ovaries means losing 2–4 million eggs and at least many hundreds of thousands of seeds.

Mullet seed collection is carried out by men as are all other commercial fishing activities in Egypt. Women, on the other hand, are mainly involved with the manufacturing and repairing of the fishing gear. The mullet seed fishery is practised by resident fishers living in the coastal areas near the lakes and coastal lagoons. The activity is territorial and each group of fishers works in their area without intruding into neighboring areas.

Utilization of wild fry was known to be associated with a high seed mortality attributed to trauma of rough handling during collection and transport. As a result of effects initiated in the mid-1920s Egyptian experts attained extensive experience in handling mullet fry on a large-scale that dramatically reduced the losses during handling.

Fry collected using different fishing gear are usually retrieved in small buckets filled with seawater and collected in *hapa* cages or shore tanks. These aggregation tanks and *hapas* are also used to inspect the catch and remove unwanted species or traumatized fry. During sale, fry are scooped by hand nets, counted and emptied into polyethylene bags, insulated pickup trunks or loaded onto specialized fry transport trucks (Figure 15). Fry tanks (usually 1 m<sup>3</sup>) can carry up to 15 000 fry for a transport period of up to 4 hours and densities vary according to the travel distance. Cooling with ice bags is usually applied during summer.

If oxygen inflated bags are used, these can be carried on any vehicle. Owners of small farms usually carry 4–6 bags in the trunks of their cars. Each of the fry bags can carry up to



2 000–3 000 fry and are used for short distance transport (<2–3 hours). The bags are usually filled with 1/5 water and 4/5 compressed oxygen. If the bags are carried by pickup trucks, they are usually protected from the sun with rice straw mats sprayed with water for cooling. Fry are sometimes transported in plastic bags by motor boats if the farming site is near a water body.

Upon arrival, fry are usually acclimatized to the receiving pond environment. For transport in plastic bags, the bags are first immersed in the ponds and the contents eventually emptied. If transport was by pickup trucks, fry are first collected into plastic buckets. Dead and weak fry are usually removed and the number of stocked fry in each pond is recorded. If transport was by specialized trucks, a large volume of transport water is substituted with pond water before releasing fry into ponds.

High fry mortalities are reported in many farm sites as a result of insufficient acclimatization. In a three year study on the utilization of wild mullet fry for restocking inland lakes in Egypt (Kleijn, 1988), losses during transport (6–8 hours) varied between 0.9–1.4 percent. In the same study, the mortality of fry during four months in nursery ponds was up to 35 percent.

Saleh (1991) reported that mortality rates of 96 percent of the transported fry may occur during the first 7 days if the fry are directly transferred from seawater to the nursing ponds with a salinity level <2.6 ppt. Mortality was reduced to 6 percent through gradual (6–8 hours) acclimatization.

High losses can also be expected during the nursery period due to inadequate pond preparation and management. Most of the losses are associated with predation by other fish (African catfish, *Clarias gariepinus*, and the red bellied tilapia, *Tilapia zilli*) commonly found in poorly prepared ponds. Large losses also occur in heavily fertilized ponds due to oxygen depletion and during the harvesting of the fingerlings.

### AQUACULTURE DEPENDENCY ON WILD SEED

Commercial aquaculture of mullet in Egypt and other producing countries relies exclusively on wild-caught fry even though hatchery techniques have been successfully developed (Saleh, 1991; Landoli, 2000; Yeh, 1998; Sadek and Mires, 2000; Suloma and Ogata, 2006). The high cost of hatchery-produced seed compared to wild fry, and the interest of most commercial hatcheries to produce seed of higher valued marine species (e.g. European seabass and/or Gilthead seabream), are the main reasons for continued reliance on wild seed.

Fishing wild fry for aquaculture has always been a matter of debate between environmental groups, capture-fisheries communities and fish farmers. The increasing rate of seed collection in the mid-1990s was considered as a major threat to the capture fisheries. Artisanal fishing cooperatives organized extensive campaigns against wild seed collectors. This legal practice was also considered as an unjustified government policy in support of wealthy fish farmers at the expense of the larger, poorer fishing community. Environment groups believe that wild seed collection will reduce stock recruitment even though the authority claimed that the number of collected fry will have a negligible effect to the wild mullet population. The argument is based on the fact that mullet are characterized by a very high fecundity, which means that the number of collected fry for aquaculture is a very small fraction of the seeds produced by these fish. It is also claimed that the fry losses for aquaculture are considerably less than that from natural predation. This debate is not yet settled, but the stability of mullet fisheries over more than a decade in spite of a growing aquaculture industry has reduced the level of opposition even though the capability of the wild resources to cover the future growth of the sector is unknown due to limited scientific data.

Hatchery-produced mullet seed are not likely to become available in the near future in Egypt and aquaculture will continue to rely on wild seed. The cost of hatchery seed in Egypt was found to be very near or even sometimes higher than that

for other locally cultured marine species such as the Gilthead seabream, European seabass, meager and shrimp. As a result, unless a total effective ban on wild seed collection is imposed, mullet aquaculture in Egypt will continue to depend on wild seed.

### FISH FEED

The success of mullet aquaculture is also a result of its feeding habits. Mullet are usually farmed in polyculture with other fish species in earthen ponds. Enhancing natural food production in the ponds through artificial fertilization is important as this reduces considerably the requirements for manufactured feed. In the Egyptian polyculture system, natural food covers 25–50 percent of the food requirement of the cultured fish (tilapia, carps) while the farmed mullet depend totally or to a very large extent on natural food (Figure 16). Cultured mullet are sometimes supplied with wheat or rice bran during the late nursery stage or when cultured as the main component of the fish stocks.

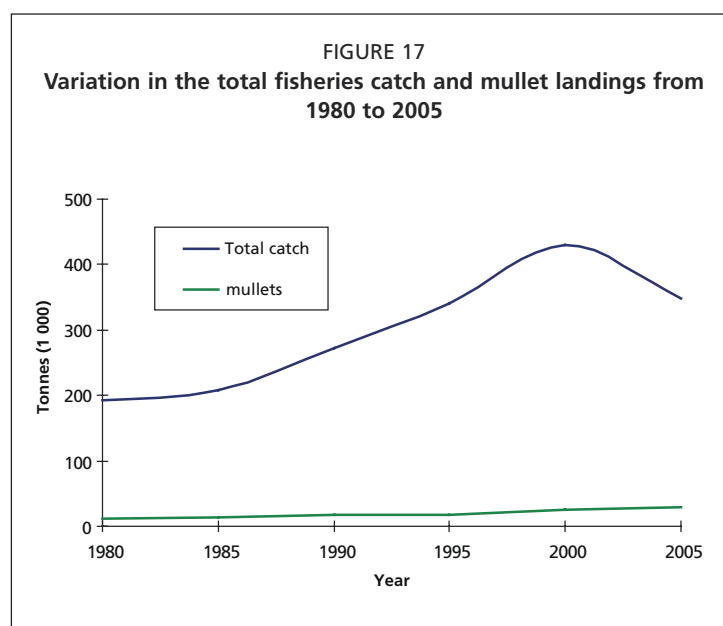
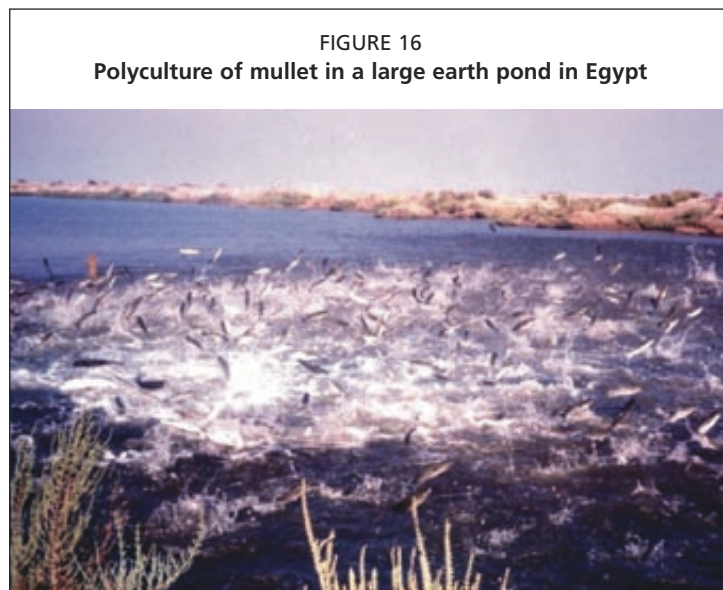
The fish feed industry is well developed in Egypt where more than 450 000 tonnes of different forms of formulated feed (mostly extruded pellets and powder mixes) are produced annually (GAFRD, 2006). Chicken manure is also used successfully as feed for mullet in nursery and on-growing ponds.

### ENVIRONMENTAL IMPACT OF MULLET SEED FISHERY

Although the collection of mullet seed in Egypt goes back many decades, there is no published scientific study on the impact of this activity on the wild stocks. Most of the available information is based on comparing mullet catches in relation to the recorded number of collected fry. The extrapolated results are of limited value as landing estimates are not accurate enough (e.g. illegal catches are excluded) to evaluate possible impacts of wild seed collection.

Figure 17 compares total fish landings in Egypt with the landings of mullets over a 25-year period and clearly indicates that mullet catches have not decreased. Based on these figures it seems that the mullet fishery is not affected by the wild seed fisheries.

Mullet seed fishing is a seasonal activity and fishers tend to know when the fishing grounds are likely to receive large volumes of mullet fry of each species. During these periods, fry of the target species are found in large shoals and, since



the presence of unwanted species greatly reduces the market price of mullet seed, the fishers carefully inspect their catch and return unwanted fish species, if any, back to the sea.

The presence of other species with mullet seed was studied the mid-1980s (Kleijn, 1988). Kleijn (1988) showed that 87 percent of the collected seed (sample size 78 000 fry) were mullet, 6.9 percent ribbonfish (*Lepidopus* sp.), 3.1 percent silverside (*Atherina* sp.) and halfbeaks (*Hemiramphus* sp.) and 2.9 percent *Gammarus* sp.

Finally mullet seed fishing is carried out in shallow coastal waters on sandy and muddy substrates. The impact of the fishery on bottom biota has not been evaluated, however, the impact is likely to be minimum compared to impacts of fishing activities on other sensitive ecosystems (e.g. coral reefs).

## SOCIAL AND ECONOMIC IMPACTS OF MULLET FARMING

### Social impacts

Although a small number of people are involved in seed collection, it is an important economic and social activity. The rapidly growing aquaculture industry in Egypt depends largely on mullet production, which accounted in 2005 for about 29 percent of the production and 48 percent of the market value of cultured fish (GAFRD, 2006). Aquaculture presently employs more than 300 000 persons and supports an additional 450 000 jobs in complimentary activities (fish feed production, transport, marketing, processing, etc.). Limiting or discontinuing mullet production will affect the economy of the semi-intensive aquaculture industry, a critical component of Egyptian aquaculture.

The development of pond aquaculture created a new competitive seed market. Before the mid-1980s, most of the wild-caught seed were used by the government for restocking programmes of inland lakes. Fry were collected at a single government station near Alexandria from 1926–1984. During the early days of aquaculture development, common carp and mullet were the major cultured species in Egypt while tilapia was considered only a bycatch crop accounting for 10–25 percent of the production.

The increase demand for mullet seed resulted in the establishment of nine additional fry collecting stations along the Mediterranean coast from 1986–1987, marking the beginning of organized mullet fry fisheries.

Mullet seed collection is carried out by groups of artisanal fishers which often include people from the same village or district and frequently involve members of the same family. Each group may consist of 6–10 persons working under a team leader who generally oversees more than one group. In 2005, 460 registered fry collecting fishers were working in eight major government stations (6 in the Northern Delta and two in Suez Canal region).

Fisher groups work grounds allocated by the authority in their home range and supervised by the government fry collection station in the area. The team leader is usually someone with a strong influence on the group members and is usually a head of a local cooperative or a large fishing family. The team leader is responsible for nominating group members, collecting fishing licenses and other documents required by the competent authorities to issue the work permits. The team leader is also responsible for delivering the collected seed through the official channels and is in charge of bookkeeping and recording all catch.

The earnings of each group member differ according to their role. The work is divided into three tasks; the first is the fishing operation itself, which requires 4–6 fishers to spread and pull the seine net. The second task involves the transport of the buckets which requires 1–2 younger, less skilled persons. The third task is the sorting, cleaning and counting the catch, which is usually done by the most experienced in the group. This latter task involves the removal of weak, injured, dead or unwanted

species from the *hapa* or shore tank and counting the fry. The money earned by the group is divided into equal shares; members of the third group gets three shares per person, while those of the first group get two shares per person and members of the less skilled second group get one share per person.

Illegal gangs of fishers are involved in fry collection mostly outside the territory covered by the authorized teams even though they frequently invade these territories to find better stocks. Illegal fishers are well organized and usually reach the fishing ground in the early hours of the morning before the arrival of the authorized fishers and working in teams of four to five persons. The collected fry are stocked in pickups and sold directly to the owners of unlicensed farms or to fish farmers who are not satisfied with their government allocated quota (Figure 18). The number of fishers working in the illegal seed fisheries, transport and marketing is not known.

A group of seed fishers can earn between US\$1–1.2 million/year. This money is tax free and is distributed by the team leaders according to the share distribution system described above. Seed fishers, although rich, are considered as lower middle class by city people based on their education and cultural levels, but they are considered as the elites in their lagoon fisher communities.

A group of seed fishers can earn between US\$1–1.2 million/year. This money is tax free and is distributed by the team leaders according to the share distribution system described above. Seed fishers, although rich, are considered as lower middle class by city people based on their education and cultural levels, but they are considered as the elites in their lagoon fisher communities.

### Economic issues

Aquaculture is the fastest growing fisheries sector in Egypt and mullet aquaculture is an important contributing component (Salem and Saleh, 2004). Land-based aquaculture in Egypt is labor intensive and employs a large number of people with different technical skills. This economic activity is characterized by high returns on the initial investment even though profits have declined following the rise in production during the last five years. This type of aquaculture has prompted an important restructuring of the fish farming communities and production systems.

Traditional aquaculture was practised by fishers over extensive wetlands and brackish water lakes owned by the government. The activity was primitive; it required a low investment input and generated a low production per unit area. Furthermore, the work was carried out exclusively by members of the family, with limited numbers of part-time workers were hired during harvest or preparation for the new season. As a result of extension programmes supported by the government and the increased demand for fish, aquaculture was rediscovered by a new generation of well educated investors with professional backgrounds. As a result, technically advanced aquaculture systems were introduced, such as semi-intensive and intensive pond aquaculture on traditional aquaculture land or purchased from the government. These lease arrangements usually included an agreement to pay a certain amount of money to the inhabitants of the farmed areas, which in turn was used by traditional farmers to modernize their own farming activities.

The development and growth of aquaculture sector in Egypt was not possible without mullet as an important cash crop. Wild seed fisheries are a year around activity. The sequence of spawning times for the different target species (mullet, meagre, European seabass and gilthead seabream) makes fry collection a full-time activity

FIGURE 18  
A pickup truck carrying illegally caught mullet fry



and involves numerous groups of fishers. Based on official data each fisher earns US\$1 900–2 700/year, an income higher than the average annual per capita income in Egypt (about US\$1 700 in 2006).

### MANAGEMENT

Aquaculture and fisheries activities in Egypt are regulated by the Fisheries Law No. 124/1983. The sector is administered by the General Authority for Fisheries Resources Development (GAFRD), established by Presidential Decree No. 190/1983, under the Ministry of Agriculture. According to Article 18 of the above law, fish fry may not be collected or removed from the sea, lakes or other water bodies except with an official permit issued by GAFRD. The violation of Article 18 may provide grounds for imprisonment of 3–6 months or a fine up approximately US\$90. The sentence is more severe in case of repeat violations.

Application of the law somewhat guarantees control of the activity and rational utilization of the resources. The increase in illegal seed fishing indicates a weakness in enforcement which is divided between the Ministry of Interior and Ministry of Defense. The Coast Guard (Ministry of Defense) is in charge of enforcing the law in coastal areas while the Aquatic Police covers other water bodies.

### CONCLUSIONS

- Collection of wild mullet seed for aquaculture and restocking of lakes is an old practice known for many decades in Egypt and other Mediterranean countries.
- Flathead and thinlip grey mullet are the most important aquaculture species.
- Egypt is the major producer of cultured mullet with a production 156 400 tonnes in 2005.
- In most producing countries, mullet aquaculture depends exclusively on wild seed.
- Hatchery production of mullet seed is carried out in some countries, but its commercial production in Egypt has proven not to be economically viable.
- Wild fry fisheries are legally managed in most of the countries, and this activity is also supervised in Egypt by the competent authorities.
- Illegal wild seed fisheries in Egypt result in resource management problems.
- Demand for mullet seed increased greatly in Egypt during the last ten years as a result of the expansion of aquaculture.
- The official recorded numbers of wild-caught mullet seed in Egypt decreased during the last four years, at the same time that production of cultured mullet has increased.
- Increase in the price of mullet seed resulted in more rational utilization of the resources and a reduction in handling losses.
- The fast growing activity of fishing ripe flathead grey mullet females for roe production in many countries may affect the future of the wild stocks.
- Mullet is an important cash crop for the aquaculture industry in Egypt.
- There is no reliable scientific information to ensure proper management of the mullet seed fisheries in Egypt.
- The present Egyptian legislation is considered adequate; however, enforcement may not be sufficient to control the fishery.
- Dependence on wild seed does not provide for long-term planning of the sector and hatchery production of mullet seed may be necessary.
- The government may adopt a policy of subsidizing hatchery production of mullet seed followed by a ban on wild seed fisheries to encourage hatchery development.



## REFERENCES

- Basurco, B. & Lovatelli, A. 2003. The aquaculture situation in the Mediterranean Sea, Prediction for the future. *Ocean Dacs-Africa Marine Science. Oceanography-Fishery-Miscellaneous*.
- Cardona, L. 2006. Habitat selection by grey mullets (Osteichthyes: Mugilidae) in Mediterranean estuaries: The role of salinity. *Scientia Marina*, 70(3): 433–455.
- Eisawy, A.M. & El-Bolok, A. 1975. Status of aquaculture in the Arab Republic of Egypt. *CIFA Tech. Pap.*, (4. Suppl. 1).
- El-Zarka, S. & Kamel, F. 1965. Mullet fry transplantation and its contribution to the fishery of the inland brackish lakes in Egypt, U.A.R. *Proc. Con. Fish Coun. Mediterr.*, 8: 209–226.
- El-Zarka, S., El-Maghraby, A.M. & Abdel-Hamid, K.H. 1970. Studies on the distribution, growth and abundance of migrating fry and juvenile of mullet in a brackish coastal water lake (Edku) in the U.A.R. *Stud. Rev. Gen. Coun. Mediterr.*, 46 p.
- Eschmeyer, W.N., Herald, E.S. & Hammann, H. 1983. A field guide to Pacific coast fish of North America. Houghton Mifflin Company, Boston, USA. 336 p.
- Faouzi, H. 1936. Successful stocking of Lake Qarun with mullets (*Mugil cephalus* L.) and (*M. capito* Cuv & Val.) from the Mediterranean Sea. *Int. Rev. Ges. Hydrobiology*, 33(516): 434–439.
- FAO. 1973. FAO Species Identification Sheet for Fishery Purposes. Mediterranean and Black Sea, Fishing area 37. FAO, Rome.
- General Authority for Fish Resources Development. 2006. The 2005 Statistics Yearbook, Ministry of Agriculture Publications. Egypt.
- Harrison, I.J. 1999. "Mugilidae" in FAO Species Identification Guide for Fisheries Purposes. *The living Marine Resources of the Western Central Pacific, Vol. 4. Bony Fishes, Part 2*, (Mugilidae to Carangidae), edited by K. Carpenter and V. H. Neim. Rome: FAO.
- Harrison, I.J. & Senou, H. 1997. Order Mugiliformes. Mugilidae. Mulletts. p. 2069–2108. In K.E. Carpenter and V.H. Niem (eds.) FAO species identification guide for fishery purposes. *The living marine resources of the Western Central Pacific. Volume 4. Bony fishes part 2 (Mugilidae to Carangidae)*. FAO, Rome.
- Kleijn, L.K. 1988. Release of mullet fry in Fayoum Governorate, Egypt. Final Report. *Netherland Institute for Fishery Investigation*.
- Koutrakis, E.T. 2004. Temporal occurrence and size distribution of grey mullet juveniles (Pisces, Mugilidae) in the estuarine systems of the Strymonikos Gulf (Greece). *J. Appl. Ichthyol.* 20, 76–78.
- Landoli, C. 2000. Marine Fish Farming in Italy. In Muir J. and Basurco B. (eds). *Mediterranean offshore mariculture*. Zaragoza: CIHEAM-IAMZ, 2000. p. 33
- Maitland, P.S. & Campbell, R.N. 1992. Freshwater fishes of the British Isles. HarperCollins Publishers, London. 368 p.
- Nelson, J.S. 1984. Fishes of the world. 2nd edition. John Wiley & Sons, Inc., New York.
- Nelson, J.S. 1994. Fishes of the World. Third edition. John Wiley and Sons, INC. N. York, ISBN 0-471-5713-1.
- Rochard, E. & Elie, P. 1994. La macrofaune aquatique de l'estuaire de la Gironde. Contribution au liv e blanc de L'Agence de l'Eau Adour Garonne. p. 1–56. In Mauvais J. L. and Guillard, J.F. (eds.) *E tat des connaissances sur l'estuaire de la Gironde*. Agence de l'Eau Adour-Garonne, Bordeaux, France, 115 p.
- Rossi, R. 1986. Occurrence, abundance and growth of fish fry in Scardovari Bay, a nursery ground of the Po River delta (Italy). *Arch. Oceanogr. Limnol.*, 20, 259–280.
- Sadek, S. & Mires, D. 2000. Capture of wild finfish fry in Mediterranean coastal areas and possible impact on aquaculture development and marine genetic resources. *The Israeli Journal of Aquaculture - Bamidgeh*, 52(2): 77–88.

- Saleh, M.A.** 1991. Rearing of Mugilidae. A study on low salinity tolerance by thinlip grey mullet (*Liza ramada* Risso, 1826). In the proceeding of the FAO Workshop on Diversification of Aquaculture Production, Valetta, 1–6 July 1991.
- Saleh, M.A.** 2006. *Mugil cephalus*, Cultured Aquatic Species Information Program. *Inland Water Resources and Aquaculture Service (FIRI)*, FAO.
- Saleh, M.A. & Salem, A.M.** 2005. National Aquaculture Sector Overview-Egypt, *FAO Inland Water Resources and Aquaculture Service (FIRI)*.
- Smith, M.M. & Smith, J.L.B.** 1986. "Mugilidae" in *Smith's Sea Fisheries*, edited by M.M. Smith and P. C. Heemstra. Berlin: Springer-Verlag.
- Suloma, A. & Ogata, H.Y.** 2006. Future of Rice-Fish Culture, Desert Aquaculture and Feed Development in Africa: The Case of Egypt as the Leading Country in Africa. *JARQ*, 40(4): 351–360.
- Virgona, J.** 1995. Sea mullet. NSW Fisheries Fishnote. DF/49, 4 p.
- Wimpenny, R.S. & Faouzi, H.** 1935. The breeding of the grey mullet, *L. ramada*, in Lake Quarun, Egypt. *Nature Lond.*, 135: 1041.
- Wonham, M.J., Carlton, J.T., Ruiz, G.M. & Smith, L.D.** 2000. Fish and Ships: Relating dispersal frequency to success in biological invasions. *Marine Biology* 136, 1111–1121.
- Yeh, S.P.** 1998. Marine fish seed industry in Taiwan. p. 154–167. *In* Proceedings of the Workshop on Offshore Technologies for Aquaculture, 13–16 October 1998. Technion, Faculty of Mechanical Engineering, Haifa, Israel.