

Grey mullet, *Mugil cephalus*

Life cycle

Grey mullet is a marine cosmopolitan fish and a member of the Mugilidae family. Like other marine-breeding teleosts, grey mullets breed only in seawater. Nevertheless, these fish are euryhaline, and can tolerate wide range of salinities, from fresh water to hyper-saline environments (Oren, 1980; Yousif et al., 2010; Whitfield et al., 2012; Crosetti and Blaber, 2016). Grey mullets are iteroparous (have multiple spawning cycles after sexual maturation) and achieve sexual maturity at the ages of three to four years old. Spawning occurs in a single batch, once a year, during the fall, and a single female (~2½ kg body weight) can spawn up to five million eggs. Immediately after spawning the males release their milt and fertilization takes place in the open water. The eggs are pelagic, floating in the water, and hatching will occur approximately 48 hours post fertilization, depending on the water temperatures.

From each egg hatches a single, three-millimeter long, yolk-sac larva. During the first two-three days post hatching the larvae feed exclusively on yolk stored in a yolk sac, while their basic capabilities: vision, feeding (mouth opening) and digestive system are developing. Following absorption of the yolk sac, the larvae feed on phyto and zoo-plankton, continue to grow, develop swimming capabilities and complete their metamorphosis. Young fry gather along the coastline in lagoons and estuaries, and many of them swim upstream, taking advantage of their euryhaline nature, to inland-protected habitats.

Aquaculture

Grey mullets are raised in many countries, especially in the Mediterranean basin and in Asia (Table 1). The largest producer is Egypt producing over 100,000 tons of mullets every year (not only *M. cephalus*). Other important producers are Indonesia, South Korea, Taiwan and Israel. Aquaculture of this species is captured-based, and all fingerlings (~300 million/year) are harvested from the wild prior to stocking them in inland fish farms. This method is limiting and has several major disadvantages, including unpredictable and limited supply,

inefficient grow-out procedures and lack of selection or any type of genetic improvement. For example, in many cases mullet fingerlings of three species are harvested, while the preferable species for aquaculture is the *M. cephalus*. In addition, female grey mullets have superior growth rate, as compared to males, and can be harvested for their pricy gonads to produce the gourmet food Botarga/karasumi. However, since working with wild-harvested fingerlings, genetic improvements, as all-female populations, are impossible.

Table 1. World mullet production for 2013 (ton x 1000), Source FAO.

Egypt	116	Italy	0.53
Indonesia	8.02	Iraq	0.50
S. Korea	4.81	Greece	0.39
Taiwan	2.64	Tunisia	0.32
Israel	2.24	Spain	0.16
Hong Kong	0.89	Saudi Arabia	0.04
Singapore	0.54		

Research

Basic attempts to breed grey mullets in captivity took place during the 1960's in the Dor Fisheries Research Station (Israel) and in Tainan Fish Culture Station (Taiwan Fisheries Research Institute, Taiwan, China; Tang, 1964; Abraham et al., 1966; Yashouv, 1969). Independently, during the early 1970's, the Oceanic Institute in Waimanalo, Hawaii, reported on successful breeding trials (Kuo et al., 1973; Nash et al., 1974; Liu and Kelley, 1991; Tamaru et al., 1993). Work on closing the life cycle in captivity of the grey mullet continued throughout the 1980's, mainly in Hawaii (Lee and Menu, 1981; Lee et al, 1987), and commenced a decade later both in Israel and in India (De Monbrizon et al., 1997; Abraham et al., 2000). These works led to the development of the current grey mullet breeding protocol (Aizen et al., 2005), and routine breeding takes place in the National Center for Mariculture (Eilat, Israel) every year. Successful breeding was achieved also in Egypt (Meseda and Samira, 2006) and in Abu Dhabi (Yousif et al., 2010).

During the last two decades, the research on breeding grey mullets has expanded to additional fields, such as biological mechanisms controlling sexual maturation (Nocillado et al., 2007), Improving hatchery techniques (Tamaru et al., 1992), restocking (Nishimoto et al., 2007) and developing all-female populations (Meiri-Ashkenazi et al., 2011). Furthermore, the species was identified as one of Europe's most promising fish for Aquaculture. A glimpse on latest ongoing research is available on the 'Diversify' project web page (7FP-KBBE-2013-GA 602131; <http://www.diversifyfish.eu>).

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