# Recruitment Dynamics of Young-of-the-Year Marine Fish in the Coastal Lagoon of Lesina

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# Recruitment Dynamics of Young-of-the-Year Marine Fish in the Coastal Lagoon of Lesina

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**Abstract**

Coastal lagoons are aquatic ecosystems characterised by a high productivity. The artisanal fishing has always been practiced in these areas due to the high yield. This kind of fishery exploits the migratory movements of euryhaline marine fish species between the open sea and the lagoon. The recruitment of these economically valuable marine species to the tidal channels of Lesina Lagoon, Italy, was monitored during their maximum recruitment period and the distribution of the juveniles in the lagoon itself was studied for a year. Sampling was conducted using winged 2-mm mesh fyke-nets and a manual beach seine with a 2-mm mesh central bag. The majority of the marine species juveniles entered in lagoon during the late autumn and winter. The *Mugilidae* family was found to be the most abundant. *Liza ramada* recruited in the largest numbers, followed by *Liza aurata* and *Mugil cephalus*. The Sparidae family was represented by only two species, *Sparus aurata* and *Diplodus vulgaris* with few individuals. The highest abundances of *Mugilidae juveniles* were found at stations situated near the mouths of freshwater channels. These findings may be useful tools for the conservation and management of lagoon fish stocks in terms of essential fish habitat protection and suitable fishery management.

## 1 Introduction

Euryhaline marine fish species use coastal lagoons and estuaries as nursery grounds [30, 4, 21, 37, 13, 17]. These ecosystems provide the juveniles of euryhaline marine species with abundant food and optimal environmental conditions for rapid growth, thus helping them to quickly get through the critical phase of their life history [16, 27, 36, 32]. In addition, the shallow depth of these basins and the presence of extensive seagrass beds mean that the pressure on these organisms from predators is lower than in the nearby marine environment [2, 26].

Many of these species (including *Chelon labrosus, Liza aurata, Liza ramada, Liza saliens, Mugil cephalus, Dicentrarchus labrax, Sparus aurata*, some *Diplodus* species and the diadromous species *Anguilla anguilla*), which enter Mediterranean coastal lagoons during their early life stage, have significant economic value. Juvenile fish start to enter lagoon basins at 10-30 mm standard length (SL) [1]. When they have reached sexual maturity, they return to the sea to reproduce [7]. Artisanal fishing in Mediterranean lagoons exploits the migratory movements of euryhaline marine species between marine and lagoon environments.

Once inside these complex ecosystems, juvenile fish colonise the areas which are most favourable to their survival and growth [22, 3]. Many studies have been conducted of the functional role of shallow water environments, and correlations have been found between abundance of juveniles and environmental factors such as temperature, salinity, turbidity, availability of food, presence of predators and competitors and the structural characteristics of the habitat, especially plant coverage and substrate, i.e., type of sediment [2, 10, 25, 9, 15]. The effects of these factors seem to differ from species to species depending on the case study. Species distribution is often the result of a combination of several factors [26].

Coastal lagoons and transitional water systems in general are often strongly affected by human activities (agriculture, urbanisation, industrialisation, fishing and aquaculture) and by their position between sea and continent. The artisanal and non-selective fishing traditionally practised in lagoon systems affects the recruitment of migratory fish assemblages, as does pollution, to which lagoon ecosystems are particularly vulnerable. The high residence times of both waters and sediments mean that they tend to accumulate pollutants, often causing reduction (or degradation) of essential habitats for fish species, such as nursery grounds. As a consequence, the conservation and management of lagoon fish populations now require continuous monitoring of fishing and the designation and conservation of nursery grounds for commercially important species [37]. However, proper management is hindered by the lack of important information on the ecology of each species (including the volume of recruitment and the criteria adopted by fish juveniles for habitat selection in the lagoon basin), information which needs to be combined with data on the estimated catch [37].

In this context, the objectives of this study were 1) to verify the migration calendar of economically important marine species entering Lesina Lagoon, 2) to assess the volume of recruitment and 3) to describe the spatial distribution patterns of these species in the lagoon.

# 2 Materials and Methods

## 2.1 Study area

Lesina Lagoon is situated on the Adriatic coast of Southern Italy (15°45′ E, 41°88′ N) (Figure 1). It has been declared a Site of Community Importance and is included in the Gargano National Park. The lagoon is oblong in shape, 22.4 km long and 2.4 km wide on average. It has an area of 5136 ha and a catchment basin of about 460 $km^2$ [5]. The average depth is about 0.7 m and the maximum depth is about 1.5 m. It is separated from the sea by a sandbar about 16 km long and 1-2 km wide. At a point approximately 7 km from the western end, the lagoon narrows, effectively creating two sub-basins.

The lagoon is connected to the sea by two tidal channels, Acquarotta and Schiapparo. The Acquarotta Channel, which links the western sub-basin of the lagoon with the sea, is about 3 km long, 6 to 10 m wide and from 0.8 to 2 m deep. At its seaward end there is an unauthorised landing stage for fishing boats. The Schiapparo Channel, which joins the eastern part of the lagoon to the sea, is about 1 km long, about 25 m wide and between 2 and 4 m deep. The two channels have sluices which serve to regulate exchanges between the lagoon and the sea and complex fishing systems called lavorieri, which trap adult fish moving to the sea but allow juveniles and small-sized

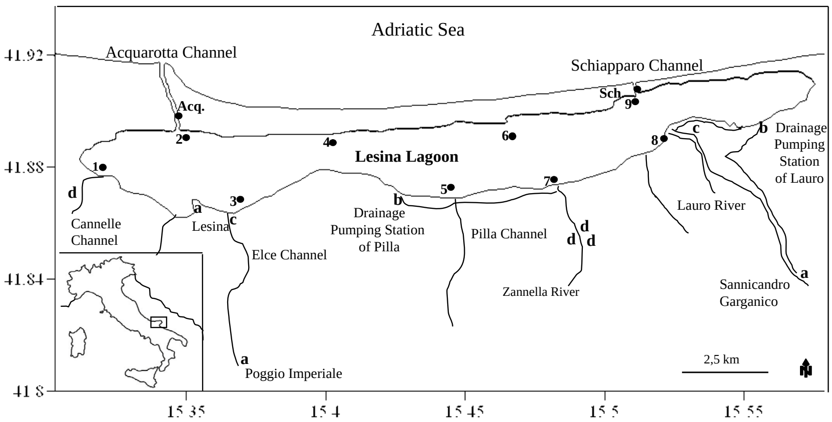


Figure 1: Location of sampling stations in Lesina Lagoon. Population centres, a; drainage pumping stations, b; urban wastewater treatment plants, c; fish farms, d.

adult fish to enter.

Freshwater inputs are supplied mainly by two year-round tributaries, Lauro and Zannella, whose waters enter the lagoon at the eastern end. There are also numerous other intermittent channels and two drainage pumping stations, Lauro and Pilla, also located in the eastern part of the lagoon, which pump waters drained from the surrounding countryside. Lesina Lagoon has a characteristic E-W salinity gradient due to the concentration of freshwater inputs in the eastern area of the lagoon, which becomes more pronounced during summer. Salinity also varies from one year to another depending on the volume of water exchange with the sea, the amount of precipitation and the pumping of surface waters for the irrigation of nearby agricultural land. Since the construction of the lavorieri in 1999, salinity has decreased continuously and currently varies from 6 to 38 [11, 29]. The gradient has also become less intense.

Fishers' cooperatives run the fishing areas under concessions which are granted at the beginning of the season. The artisanal fishing they practice in the lagoon is based mainly on the use of fixed nets, known locally as paranze. These are nylon seines with a 6-mm mesh stretched across the lagoon from one side to the other, which channel the fish into fyke-nets (also with a 6-mm mesh) positioned at regular intervals along them. These are installed in September and kept in use until February of the following year.

## 2.2 Sampling and data analysis

Between September 2006 and May 2007, every fifteen days, a fyke-net with a 2-mm mesh and wings about 130 cm long was placed near the lagoon end of each channel for 24 hours with the mouth facing towards the sea (Figure 1). The catch was removed about every six hours to prevent the animals from dying. Young-of-the-year

(YOY) fish of euryhaline marine species were separated from the rest of the sample and fixed in 4% buffered formaldehyde. In the laboratory, the specimens were identified at species level and counted. Subsamples were taken at each sampling and the SL of each specimen in the sub-sample was then measured. Between January and March 2007, the recruitment period for A. anguilla in Lesina Lagoon [34], the migration of glass eels through the Acquarotta Channel was measured daily: two fykenets, modified for the capture of the glass eels (1.6 m long, 0.43 m wide, with a 2 mm mesh and wings of different lengths - 1.3 m and 1.65 m) were placed on the two sides of the channel. The glass eels were counted in situ and a sub-sample of these was taken to the laboratory. Here the specimens were anaesthetised in Eugenol diluted in water, and their total length (TL) was measured. On waking the glass eels were returned to the lagoon.

Sampling in the lagoon basin was carried out monthly from October 2006 to August 2007 in nine sampling stations (Figure 1). Stations 1, 3, 5, 7 and 8 were located near the mouths of freshwater channels. Specifically, stations 3 and 8 were situated in areas that received the partially treated waste waters of three municipalities (with a total of about 30,000 inhabitants). Station 5 was located near the mouth of the Pilla Channel which discharges waters drained from nearby arable land. Stations 1 and 7 were positioned in areas affected by the discharge of effluent from buffalo and fish farms, by small channels on the western side and by the Zannella River on the eastern side. Stations 4 and 6 were located on the seaward side of the lagoon. Finally, stations 2 and 9 were located near the two tidal channels.

The fish were captured using a manual beach seine (11 m long and 1.30 m high, the central section having a 2-mm mesh and the two lateral sections a 4-mm mesh) with a central bag (about 3 m long and 0.8 m in diameter with a 2-mm mesh). The area sampled in each haul was about 150 $m^2$. The fish were fixed in 4% buffered formaldehyde. In the laboratory, specimens were identified at species level and counted. Only the YOY individuals of euryhaline marine species were measured for SL.

At the same time as the fish sampling, water temperature, salinity, pH and dissolved oxygen in both tidal channels and the lagoon basin were recorded using a YSI 6920 multi-parametric probe equipped with a 650 MDS data logger in order to establish the sampling stations' hydrological features.

For each species, fish collected in all samplings of the same month were pooled to study temporal variations in juvenile abundance in both tidal channels. The recruitment patterns of marine species juveniles were investigated by the construction and subsequent visual inspection of length-frequency distributions. For each species, fish from the fyke-net samplings were pooled and length-monthly frequency distributions were constructed from the observed size distributions in the samples and from the total number of individuals. At each station and for each species, the abundances from replicate seine hauls were pooled in order to study the spatial variation in juvenile abundance in the lagoon basin.

| Species | September | | October | | November | | December | | January | | February | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acq | Sch | Acq | Sch | Acq | Sch | Acq | Sch | Acq | Sch | Acq | Sch |
| *Anguilla anguilla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Chelon labrosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dicentrarchus labrax* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplodus vulgaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liza aurata* | 0 | 0 | 9 | 58 | 4 | 231 | 654 | 78 | 192 | 103 | 2099 | 297 |
| *Liza ramada* | 0 | 0 | 0 | 0 | 0 | 8 | 2253 | 48 | 5240 | 6155 | 1332 | 463 |
| *Liza saliens* | 1 | 0 | 46 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Mugil cephalus* | 0 | 4 | 1107 | 716 | 0 | 1639 | 52 | 15 | 6 | 0 | 0 | 0 |
| *Sparus aurata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 9 | 1 |
| Total | 1 | 4 | 1162 | 774 | 4 | 1878 | 2960 | 142 | 5439 | 6263 | 3440 | 761 |

Figure 2: Total number of individuals for each species caught at each tidal channel of Lesina Lagoon. Acq, Acquarotta Channel; Sch, Schiapparo Channel.

# 3 Results

## 3.1 Environmental characteristics

Temperature ranged from 5.8 °C in January to 22.9 °C in September in Acquarotta Channel and from 6 °C to 22.9 °C in Schiapparo Channel. Salinity ranged from 13.8 in January to 38 in March in Acquarotta and from 7.8 in January to 38.6 in September in Schiapparo. pH ranged from 8.6 in May to 9.1 in April in Acquarotta and from 8.5 in May to 8.9 in October in Schiapparo. Dissolved oxygen ranged from 60.2% saturation in May to 125% saturation in December in Acquarotta and from 60.6% saturation in May to 119.7% saturation in April in Schiapparo.

In the lagoon, temperature values ranged from 9.4 °C in December (station 9) to 29.3 °C in July (station 6), salinity ranged from 8.0 in March (station 8) to 37.6 in August (station 2), pH ranged from 7.63 in October (station 8) to 9.32 in March (station 1) and dissolved oxygen ranged from 49.8% saturation in May (station 9) to 200.9% saturation in December (station 3).

## 3.2 Catch composition

In the tidal channels, a total of 24,047 YOY fish of euryhaline marine species were captured entering the lagoon: 14,218 specimens were captured in the Acquarotta Channel and 9829 specimens in the Schiapparo Channel. The *Mugilidae* family had the highest number of species (i.e. five: *C. labrosus*, *L. aurata*, *L. ramada*, *L. saliens* and *M. cephalus*) and was the most abundant (Figure 2). The species that recruited to the lagoon in the largest numbers was *L. ramada*, which accounted for 66.7% of the total catch, followed by *L. aurata* (16.9%) and *M. cephalus* (15.2%). *L. saliens* and Sparus aurata had a lower number of recruits (0.5% of the total catch) and *C. labrosus*, *Diplodus vulgaris* and *D. labrax* accounted for very few specimens. Finally, a total of 306 glass eels were captured between January and February 2007.

In the lagoon basin, a total of 2,277 YOY fish of euryhaline marine species were captured during the year of study. *L. saliens* was the most abundant species, accounting for 37.4% of the total catch, followed by *L. ramada* (29.8%), *M. cephalus* (27.3%), *L. aurata* (4.1%), *C. labrosus* (1.1%) and *S. aurata* (0.3%).

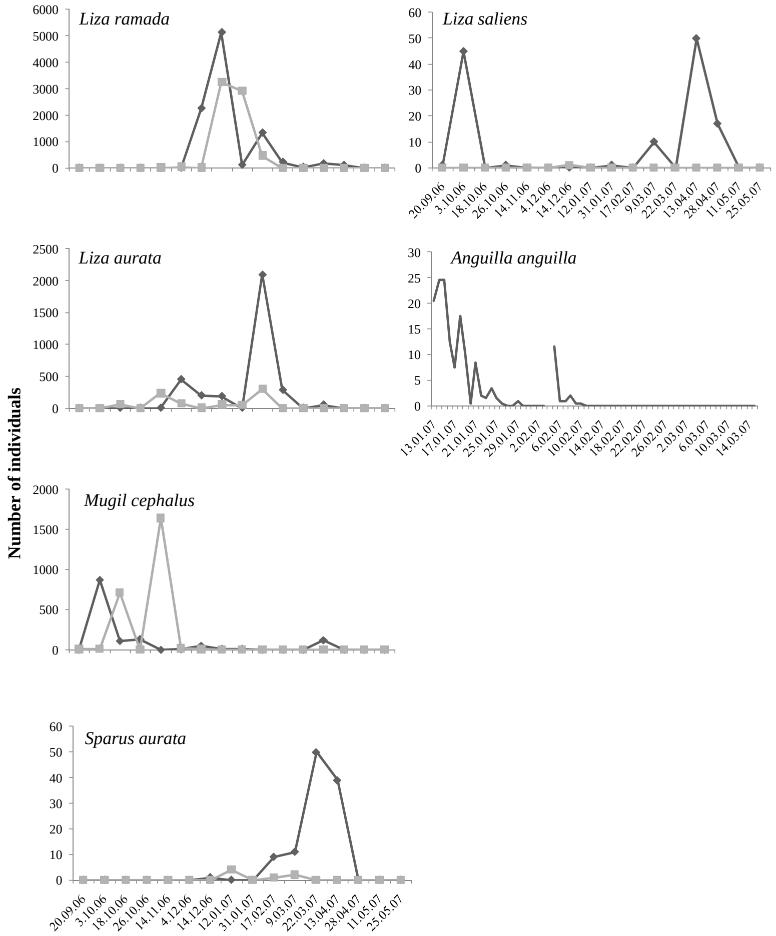


Figure 3: Abundances of young-of-the-year marine fish captured in each sampling in each tidal channel. Acquarotta Channel, black line; Schiapparo Channel, grey line.

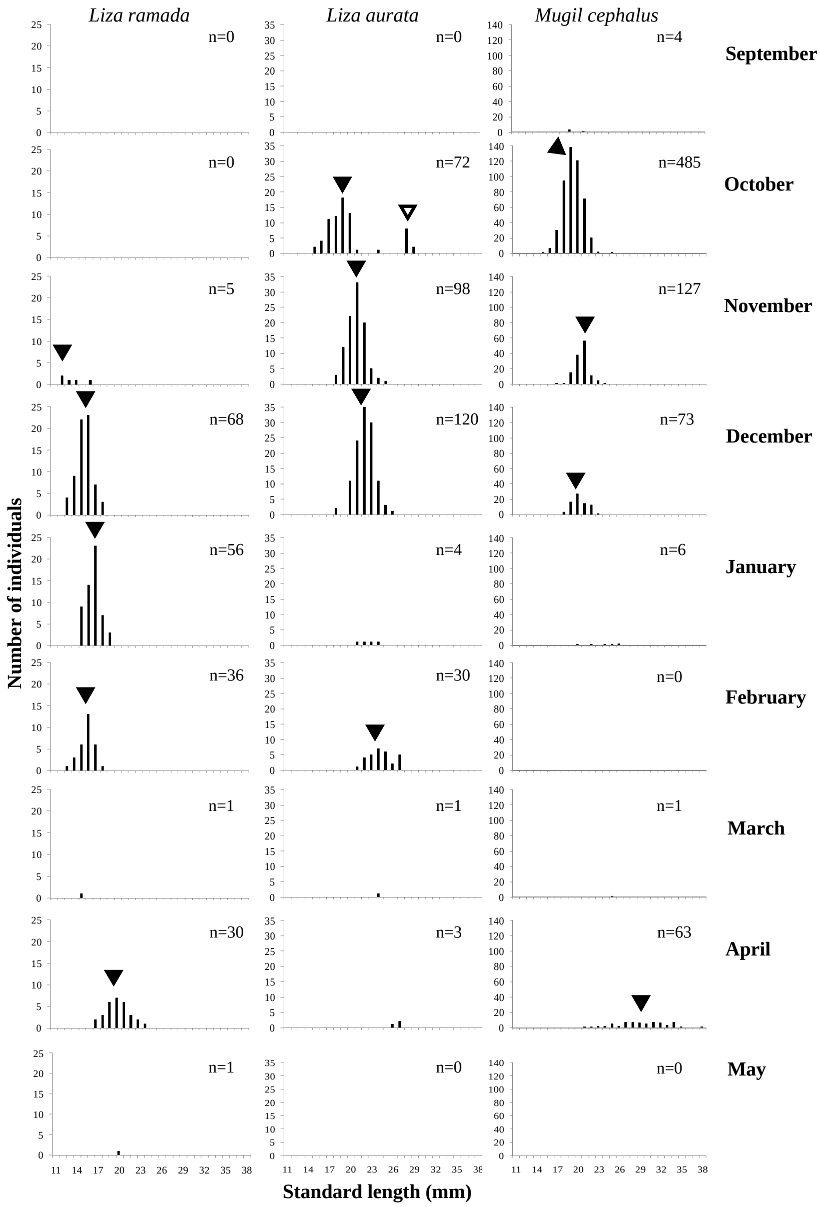


Figure 4: Monthly length-frequency distributions of Liza ramada, Liza aurata and Mugil cephalus juveniles collected in tidal channels of Lesina Lagoon. Arrowheads identify modes. Y-axes are scaled differently across species.

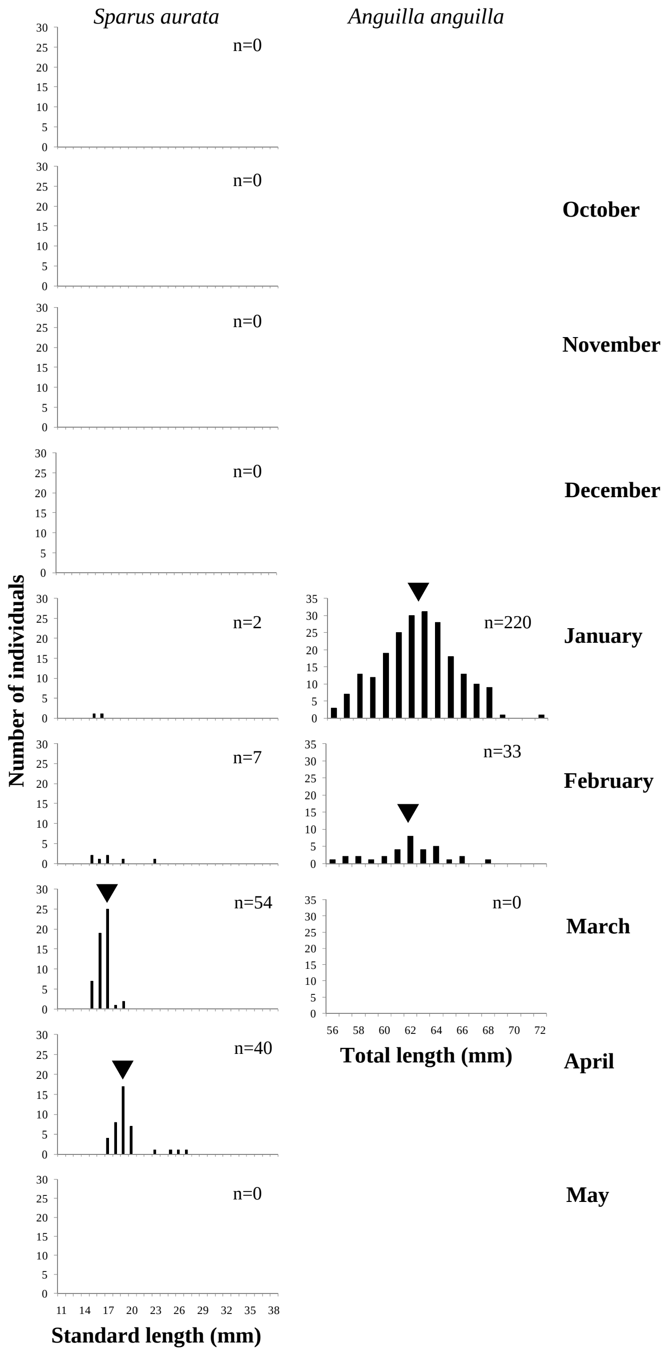


Figure 5: Monthly length-frequency distributions of Sparus aurata and Anguilla anguilla juveniles collected in tidal channels of Lesina Lagoon. Arrowheads identify modes. Y-axes are scaled differently across species.

## 3.3 Recruitment calendar, size distributions and spatial abundance patterns

***Liza ramada***

*L. ramada* juveniles were collected from November 2006 to May 2007 with SL ranging from 12.5 to 24 mm. In both tidal channels, abundance peaked in January (Figure 3). Small individuals (<15 mm) were found in the catch from November to December and in February. The length-frequency distributions showed the presence of two modes: one from December to January and one in February. Despite the presence of two modes, the length-frequency distributions showed the progression of a single abundant cohort (Figure 4).

Juveniles were caught at all stations sampled in the lagoon basin (Figure 6). The highest juvenile catches occurred at station 5 (52.9%), situated near the mouth of the Pilla Channel, and in much lower numbers at stations 2 (16.7%) and 9 (11.2%), located near the tidal channels, and at stations 1 (8.1%) and 7 (6.3%), located near the mouths of the Cannelle Channel and the Zannella River respectively.

***Liza aurata***

*L. aurata* juveniles were collected from October 2006 to April 2007 with SL ranging from 15 to 27.9 mm. Recruitment of small individuals (<20 mm) occurred from October to December. In each of the two tidal channels, two abundance peaks were recorded (Figure 3). In the Acquarotta Channel, the first peak was observed in December, and a second, higher peak was observed in February. In the Schiapparo Channel, the two peaks, of similar magnitude, were recorded in November and February. The length-frequency distributions showed the presence of two modes in October: one which progressed until February, and a second which disappeared in the following distributions, indicating the presence of two distinct cohorts (Figure 4). The collection of a few larger individuals in October suggests that recruitment of a second cohort might have occurred, but of very low abundance.

In the lagoon, YOY fish were caught at all stations investigated except station 3 (Figure 6). The highest juvenile catch occurred in station 5 (41.9%).

***Mugil cephalus***

*M. cephalus* juveniles were collected from September 2006 to January 2007 and from March to April 2007 with SL ranging from 15.6 to 38.1 mm. Recruitment of small individuals (<20 mm) occurred from October to December. In each of the two tidal channels, the highest abundances were recorded in autumn: in October and December in the Acquarotta Channel, and from October to November in the Schiapparo Channel (Figure 3). Additionally, in the Acquarotta Channel, a smaller peak was observed in April. The length-frequency distributions showed the progression of a single abundant cohort (Figure 4).

*M. cephalus* recruits were found at all stations in the lagoon (Figure 6). The highest number of juveniles was captured at station 5 (43.5%) followed by stations 7 (33.2%) and 1 (15.5%).

***Liza saliens***

A small number of *L. saliens* YOY individuals were intermittently collected during the study period with SL ranging from 11.2 to 30.9 mm. Recruitment of small individuals (<20 mm) occurred in September and October. Recruitment of *L. saliens* juveniles was very low in the Schiapparo Channel (Figure 3). In the Acquarotta Channel, two recruitment peaks were recorded: the first in October and the second in March and April. It was not possible to construct length-frequency distributions due to the small number of juveniles caught in the tidal channels. It is likely that the observations in the tidal channels started after the maximum recruitment period for this species.

In contrast, a large number of *L. saliens* YOY individuals were captured in the lagoon basin. They were found at all stations (Figure 4). The highest number of juveniles was captured at station 5 (77.1%) followed by station 2 (8.7%).

*Chelon labrosus* A low number of *C. labrosus* YOY individuals were collected in April 2007 in the Acquarotta Channel with SL ranging from 18.0 to 22.0 mm (Figure 3). In the lagoon basin, *C. labrosus* recruits were found only at stations 1, 2 and 9, with the highest abundance occurring in the latter (88.0%) (Figure 6).

*Sparus aurata S. aurata* YOY individuals were collected from December 2006 to April 2007 with SL ranging from 15 to 27.8 mm. The highest number of individuals was captured in the Acquarotta Channel in late March - early April (Figure 3). Small individuals (<20 mm) occurred in the catch throughout the recruitment period. The length-frequency distributions showed the progression of a single cohort (Figure 5).

A small number of *S. aurata* recruits were captured in the lagoon basin at stations 3 and 7 (Figure 6).

*Anguilla anguilla* Glass eels were collected from January to February 2007 with TL ranging from 56.2 to 72 mm in the Acquarotta Channel. The highest abundance was recorded in January (Figure 3). In January, the length-frequency distribution showed the presence of only one mode (Figure 5). In February, the length-frequency distribution became flatter. No glass eels were captured in the lagoon basin.

# 4 Discussion

From this study it emerges that Lesina Lagoon acts as a nursery mainly for species of the Mugilidae family, and to a lesser extent for Sparidae, in agreement with what has already been observed in previous studies conducted in the area [34]. Recruitment of economically valuable marine species continues to be modest, as evidenced previously by other authors [35, 34] although there does not appear to have been a significant reduction in the number of recruits.

The pattern observed here has been found to be similar to those recorded in the same region and in many other brackish areas of the Mediterranean, with *L. ramada*, *L. saliens*, and *L. aurata* or in some cases *M. cephalus* accounting for the largest number of recruits, together with smaller numbers of glass eels, sea-bass and Sparidae [33, 31, 18, 34, 20]. Migration of glass eels into Lesina Lagoon was found to be quantitatively limited, as along the entire Italian Adriatic coastline, though it is greater on the Tyrrhenian side [14, 35, 34, 8]. However, this reflects a marked decline in recruitment in Europe as a whole, not just the Mediterranean [28, 19].

Recruitment of juveniles to coastal lagoons is the result of complex interactions between spawning success, hydrodynamic processes, and pre-recruitment mortality. Moreover, the hydrographical regime near and within the seaward channels of these lagoons is a key factor in immigration of juveniles given their limited swimming ability during this phase of their life history [23]. The low numbers of recruits

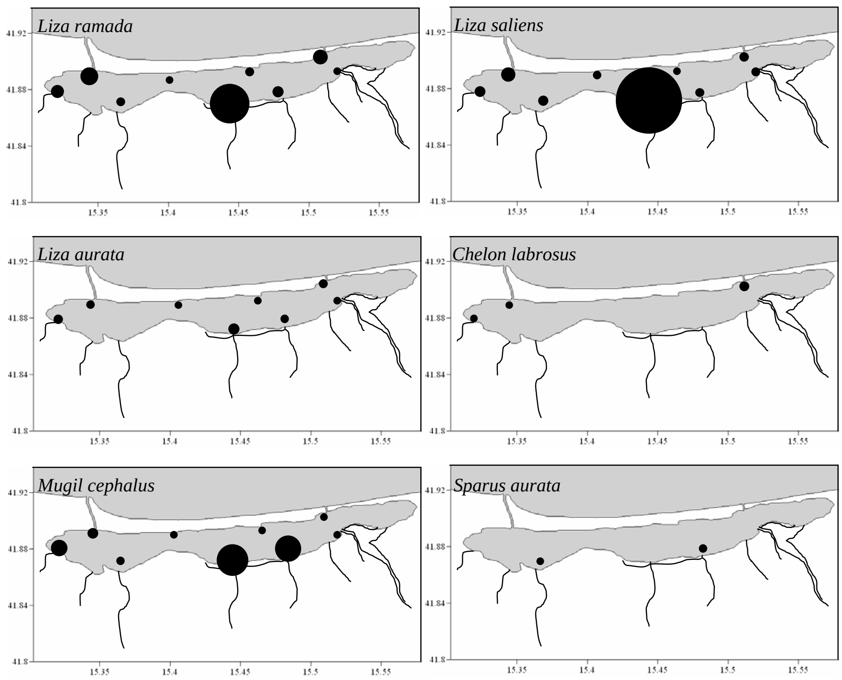


Figure 6: Spatial distribution of juveniles of six species in Lesina Lagoon. Circle size is proportional to abundance of species at each station.

of euryhaline marine species found in the tidal channels of Lesina Lagoon are in the first instance probably due to the modest flows of these channels and to the limited tidal range of the marine waters off the lagoon (about 30 cm, [12].

In this study some differences in the total number of YOY marine fish captured and in the temporal dynamics of recruitment in the two tidal channels were observed. The discrepancy in the volume of recruitment and in the temporal trend of the catch for most of the marine species found may be due to the different morphometric features of the two tidal channels in terms of total length and mean width and depth. The Acquarotta Channel is about three times the length of the Schiapparo Channel. This fact certainly has an effect on the time taken to pass through the two tidal channels by YOY marine fish, which may by itself have caused the different temporal recruitment trends observed in the two tidal channels. Further studies on the timing of YOY marine fish recruitment to the tidal channels of Lesina Lagoon with closer sampling times (e.g. daily) are essential to understand whether the different morphometric characteristics of the two tidal channels, which influence the dynamics of water exchange between sea and lagoon, may also cause a different degree of attractiveness for marine juveniles in the open sea, thus affecting recruitment pat-

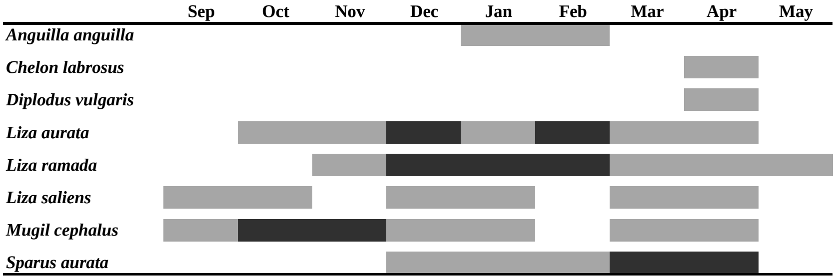


Figure 7: Recruitment calendar of marine species captured in tidal channels during study period. Present, grey; abundant, black.

terns through the two tidal channels.

In addition, the inadequate maintenance of the structures in the tidal channels (mechanical sluices often encrusted with fouling organisms and grilles occluded with weeds) clearly constitutes an obstacle to the entrance of recruits, preventing the proper exchange of waters between the sea and the lagoon basin and further reducing the "appeal" of the lagoon to juveniles of euryhaline marine species. The presence of the landing stage for fishing boats at the seaward end of the Acquarotta Channel, where the highest number of recruits was observed, may also constitute a factor of disturbance for the entry of fish juveniles into the lagoon.

This study enabled us to verify the migration calendar of economically important marine species entering Lesina Lagoon (Figure 7). The data obtained are comparable to those already available for the same study area [35, 34]. On the other hand, differences were observed with respect to brackish areas along the northern Adriatic coasts of Italy [31] and the coasts of Greece [20], where recruitment of *L. aurata* and *L. ramada* peaks in spring. This discrepancy may be due to differences in the distance between the coast and the reproductive areas and to local climatic factors [30].

All species except *L. aurata* showed one cohort, which is the result of a single spawning event. In contrast, the two cohorts of *L. aurata* may be the result of two spawning events of different intensities or of a single protracted spawning event.

In the lagoon basin, the distribution of YOY marine fish was not uniform across stations. *L. aurata*, *L. ramada*, *L. saliens* and *M. cephalus* juveniles showed a clear preference for the area near the mouth of the Pilla Channel (station 5). High abundances of *L. ramada* and *M. cephalus* juveniles were also found at stations 1 and 7, located near the mouths of the Cannelle Channel and the Zannella River, where effluent is discharged from buffalo and fish farms. These findings indicate that these areas function as nursery grounds for these two species. Moreover, high abundances of *L. ramada*, *L. saliens* and *M. cephalus* juveniles were found at stations 2 and 9, near the tidal channels, where they are assumed to have been in transit towards the nursery grounds. In a recent study on the spatial-temporal variations of chemical-physical parameters, nutrients and phytoplankton in Lesina Lagoon, Roselli et al. [29] observed high concentrations of DIN, dissolved in-organic nutrients, silicate and ammonium, the latter probably originating from the decomposition of labile organic matter on the surface of the sediments in the southern-eastern part of the lagoon as a result of agricultural runoff. High phytoplankton and diatom biomass was also found at the stations in this part of the lagoon. The presence of high phytoplankton biomass and organic substance-rich sediments near freshwater inputs may constitute a source of food for mullets [24], explaining the highest abundance of Mugilidae in these areas. In addition, the highest abundances of YOY *L. ramada* and *M. cephalus* specimens near the freshwater inputs may be related to a preference of these species for fresh or oligohaline waters as described by Cardona [6], who studied habitat selection by juveniles of Mugilidae species in Mediterranean estuaries.

## 5 Conclusions

The conservation of lagoon fish populations requires active management by human beings. Specifically, the nursery function of coastal lagoons for euryhaline marine species, many of which are economically valuable and thus often overexploited by commercial fishing both inside and outside these systems, needs to be continuously monitored and possibly enhanced.

Successful management of lagoon fish populations requires measures to ensure a high number of recruits of euryhaline marine species. The magnitude of YOY marine fish recruitment to Mediterranean coastal lagoons is heavily dependent on the efficiency of the tidal channels. The connections between Mediterranean coastal lagoons and the sea are typically unstable and inefficient due to their morphology and meagre tidal regime. In addition, the presence in the tidal channels of poorly managed sluices and lavorieri, as in Lesina Lagoon, can make this situation even worse, with repercussions for the hydrological, physical and chemical characteristics of the lagoon basin, especially salinity. The correct management of the tidal channels, protecting them from silting up, and the recovery or improvement of their flow regime are fundamental to an effective fish production strategy, which at the same time would assist in the conservation of the lagoons.

Furthermore, the identification of the areas in the lagoons with an abundant presence of juvenile fish, which in Lesina Lagoon coincide with the areas near the freshwater inputs, can certainly contribute to the improvement of the nursery function of the lagoon promoting the growth and survival of juveniles. Indeed, these areas need to be preserved by acting to halt processes associated with the deterioration and disappearance of nursery habitats, and by excluding them from non-selective lagoon fishing so as to reduce the bycatch.

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