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Research article

Preliminary investigation of the frame net sampling in the pelagic environment of Marmara Sea, Türkiye

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Abstract: This study presents the first results of frame net sampling realised in the pelagic environment of the Marmara Sea, Türkiye. Samplings were conducted from 12 stations located in the Marmara Sea with a three-frame net survey between December 2021 and March 2022. Tows were realised with oblique tows for 10 minutes. A total of 82 individuals belonging to six families and six species were identified. The late postlarvae of demersal species that distribute pelagic habitat before settlement were found to be more abundant via pelagic juveniles from the frame net catch. Although the mean biomass of the species was low, *Gaidropsarus mediterraneus* was found to be the most dominant species. It was found that frame net samplings enable the collection of postlarvae and early juveniles, which escape from plankton nets due to their high swimming capabilities and escape from seine nets due to the selectivity pattern of commercial nets.

Keywords: Late postlarvae, Early juveniles, Pelagic, Sampling, Marmara Sea.

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Introduction

As it is known, the life cycle of fish begins with the fertilization of the egg in the external environment and continues as prelarvae, postlarvae, juveniles, settlement (for demersal fish species), recruitment, first sexual maturity, and adult individuals. Fish eggs are immobile, prelarvae have partial motility; and postlarvae have moderate motility. Whereas mobility increases with the juvenile phase and reaches abilities close to those of the adult individual. Due to the lack and/or limited motion, fish eggs and prelarvae can be easily sampled by arranging the mesh size of the plankton net properly. With increasing mobility, sampling of late postlarvae and early juveniles becomes difficult, and they have potential to escape from plankton nets with their swimming ability (Methot, 1986). In addition, they have limited biomass in a unit area as a result of high mortality rates in the early life stages (Aoki et al., 2000; Oozeki et al., 2004).

Late postlarvae and early juveniles are mostly missing phases of the life stages for the reasons mentioned above. The vast majority of identification keys related to marine fish cover either eggs, larvae, or adults. The late postlarvae and early juveniles are mostly not classified. This information is necessary to determine morphological identification criteria for pelagic juveniles, reveal pelagic larval duration (PLD) of demersal species, and examine growth, and mortality trajectories for early life stages. The results of the PLD, hatch date, daily growth and daily mortality are vital for the calculation of the year class strength (Watanabe et al., 1995). The pelagic environment embodies both late postlarvae of demersal fish species and late postlarvae and juveniles of pelagic species. When the pelagic larval duration complated, the late postlarvae of demersal species settled from pelagic environments to benthic habitats, mostly shallow areas. Whereas, all phases of the early life stages of pelagic fish species take place in pelagic environments. Thus, sampling of pelagic environment with larger sampling gear against a plankton net enables us to obtain these missing phases.

For this purpose, sampling gears called frame nets, which work with the logic of the mid-water trawl, are designed. The Tucker trawl (Tucker, 1951) and Isaacs-Kidd midwater trawl (Isaacs, 1953) were defined as unproductive attempts for near-surface sampling (Methot, 1986). For this purpose, Methot (1986) developed a frame net, which has a 5 m^2 square mouth opening, and this gear became standard for CalCOFI surveys. Also, Hu et al. (2000), Hu et al. (2001), Oozeki et al. (2004), and Oozeki et al. (2012) developed new frame net samplers with modifications of Methot's (1986) frame net, with varied mouth sizes, frame designs, net mesh sizes, number of nets, net lengths, depressor sizes, and designs.

Although several ichthyoplankton studies were conducted in Turkish seas, no study has been carried out for frame net sampling yet. Accordingly, studies related to the daily growth and mortality of pelagic juveniles and the late postlarvae and early juvenile occurrence of demersal species have been missing until now. In this study, we aimed to reveal the species biodiversity and biomass of late postlarvae of the demersal species and pelagic juveniles in the Marmara Sea.

Matherial and Methods

According to knowledge on late postlarvae and juveniles, which mostly distribute in shallower waters (Jenkins et al., 1997), pre-trials were conducted at varied depth structures such as <50 m, 50-100 m, and >100 m depths. In consequence of three pre-trial frame net samplings for each depth structure, no late postlarvae and/or juveniles were found in areas deeper than 70 m. Thus, three-frame net surveys were conducted in December 2021, February 2022, and March 2022 at 12 stations located in the Sea of Marmara (Figure 1).

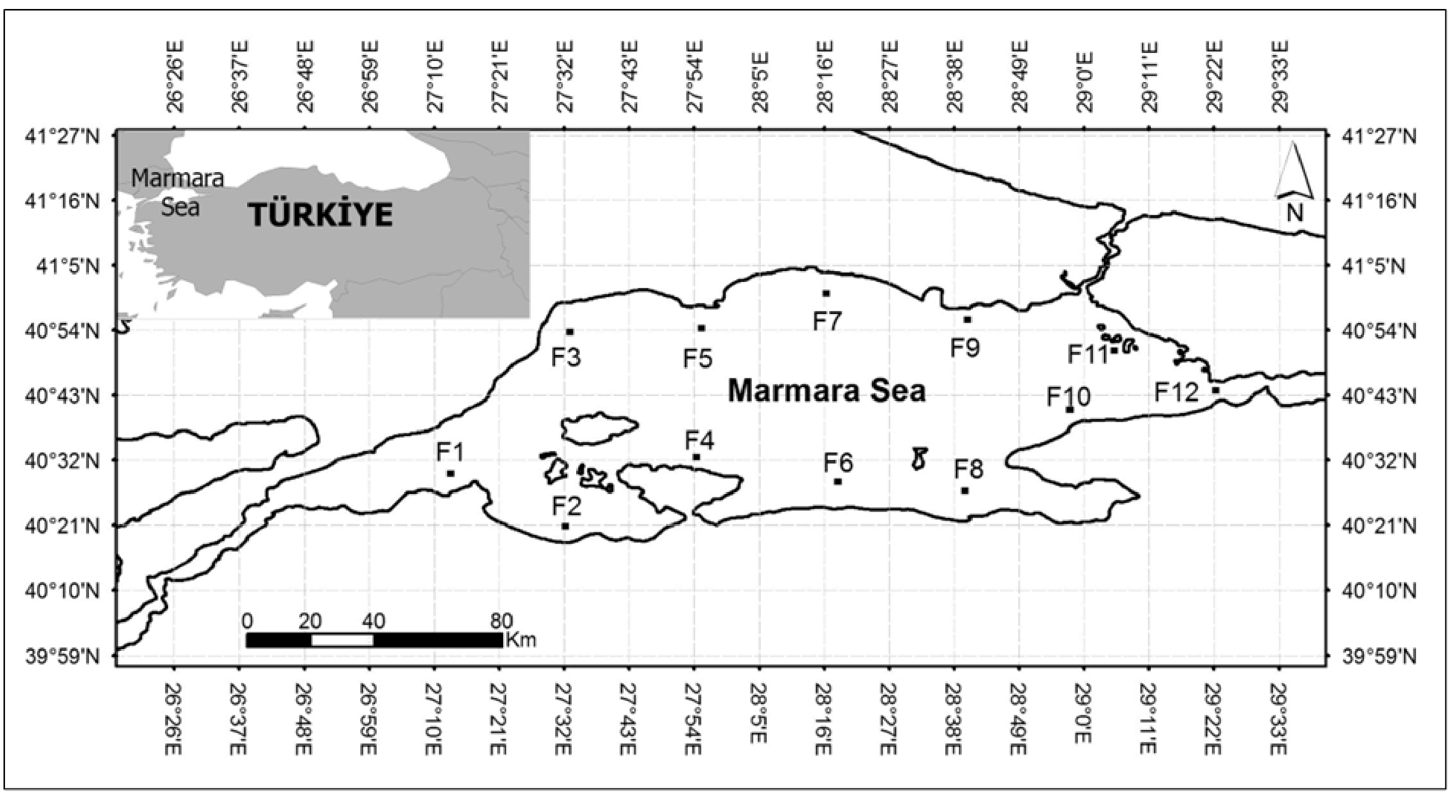

Figure 1. Sampling stations and study area

A 2x2 m length chrome square frame rigged with a 13 m length 8 mm streched mesh size fish-grading net. The net is rigged as combination of 4 equal triangle pieces of fish net. In this study, 150 kg of anchor chain was used for the flooder over the depressor. Frame net samplings were realised as oblique tows with 3 miles tow speed from depth to the surface (Figure 2). With a flow meter attached to the frame surface, the mean biomass in a unique area (n/1000 m^3) was standardised using the following formula:

$D = (N/V)*1000$

where D is the mean biomass (n/1000 m^3) of pelagic juveniles, N is the number of pelagic juveniles per haul, and V is the filtrated volume by flow meter. Using the mean biomass (D) of each location, temporal and spatial variations of biomass were calculated.

Figure 2. Frame net design and sampling

Results

A total of 82 individuals belonging to six families and six species were identified. These species, their monthly variations, and their mean biomass are shown in Table 1. In this study, 5 of 6 species were detected as late postlarvae of demersal species (Figure 3). *Sardina pilchardus* is a single pelagic juvenile fish species detected in this study. Between all species, *Gaidropsarus mediterraneus* had the highest biomass, with 16.4 ind./1000 m^3. Also, *Merlangius merlangus* was the other abundant fish species (mean: 9.5 ind./1000 m^3). Whereas, a single pelagic fish species, *S. pilchardus* had a relatively low mean biomass of 1.8 ind./1000 m^3.

None of the sampled individuals were sampled in December with a frame net. In February, slightly higher mean biomass values were detected compared to March. 81% of the total mean abundance of *G. mediterraneus* was found in February, and 85% of the total mean biomass of *M. merlangius* was detected in March. Also, 89% of total *S. pilchardus* abundance was seen in March.

In terms of the spatial variation of pelagic juveniles and late postlarvae of demersal species, the most abundant area was a F2 station (the Gonen Stream area) with a mean of 10.51 individuals per 1000 m^3 biomass. Also, stations F5 (Nato Port, Silivri) and F1 (Karabiga Shores) were the other abundant areas. A very low mean abundance were found for F8 (Trilye), F10 (Esenköy), and F12 (Yalova), whereas none of the individuals were detected from F4 (Çakıl), F6 (Karacabey), and F11 (İstanbul Prens islands) (Figure 4).

Table 1. Sampled species, mean biomass, and monthly variations of early life stages of fish living in the Marmara Sea pelagic environment.

		Biomass (n/1000 m^3)			
Species	**Life Phase**	**December**	**February**	**March**	**Mean *D***
Gaidropsarus mediterraneus	Demersal	0	13.2	3.2	16.4
Merlangius merlangus	Demersal	0	1.4	8.1	9.5
Sardina pilchardus	Pelagic	0	0.2	1.6	1.8
Callionymus lyra	Demersal	0	0.3	0	0.3
Synapturichthys kleinii	Demersal	0	1.0	0	1.0
Chelidonichthyes lucerna	Demersal	0	0	0	0.4
Total Biomass		0	16.1	13.4	29.5

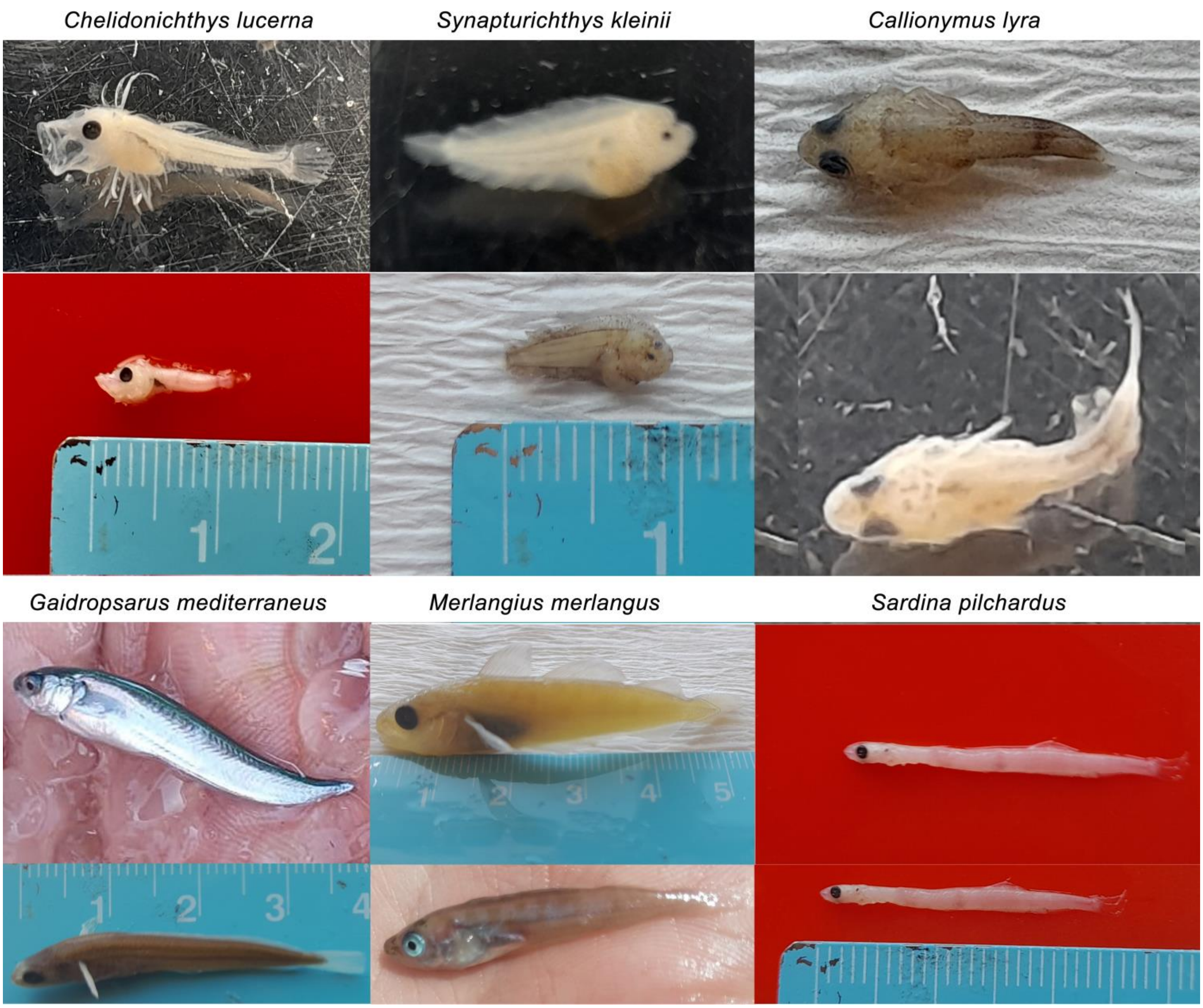

Figure 3. Early life stages of fish caught with frame net sampling in the Marmara Sea pelagic environment

Discussion

The results of the biodiversity and biomass of frame net sampling revealed surprising outputs. Although frame nets are known as pelagic juvenile sampling gear, late postlarvae of demersal juveniles were found more often than pelagic juveniles. There are two possible explanations for this pattern. Firstly, the winter season strongly caused this situation. In the winter period, two possible species (*Sardina pilchardus* and *Sprattus sprattus*) of pelagic fish could be sampled as juveniles due to the spawning season pattern. Whereas a limited number of pelagic juveniles of *S. pilchardus* and zero juveniles of *S. sprattus* were sampled. It may be a result of the low mean biomass of *S. pilchardus* fish eggs and larvae in the Marmara Sea. Although *S. sprattus* had a relatively high mean biomass, none of the juveniles were sampled. It might not be long enough for the postlarvae to reach the juvenile stage within the sampling period. Conversely, the late postlarvae of demersal fish species presented in Table 1 were caught just before settlement. Raventos & Macpherson (2001) investigated the pelagic larval duration (PLD) of 42 Mediterranean fish species and stated that winter spawners had a longer PLD than summer-spawning fish species. They explained this situation as higher fish metabolism in the summer season stemming from high sea surface temperatures than in the winter season. In addition, they estimated the PLD as 43 days for *G. mediterraneus* from the settlement mark of newly settled juvenile individuals in the winter period. A long PLD duration of *G. mediterraneus* may be another reason why late postlarvae of demersal species were sampled with a frame net.

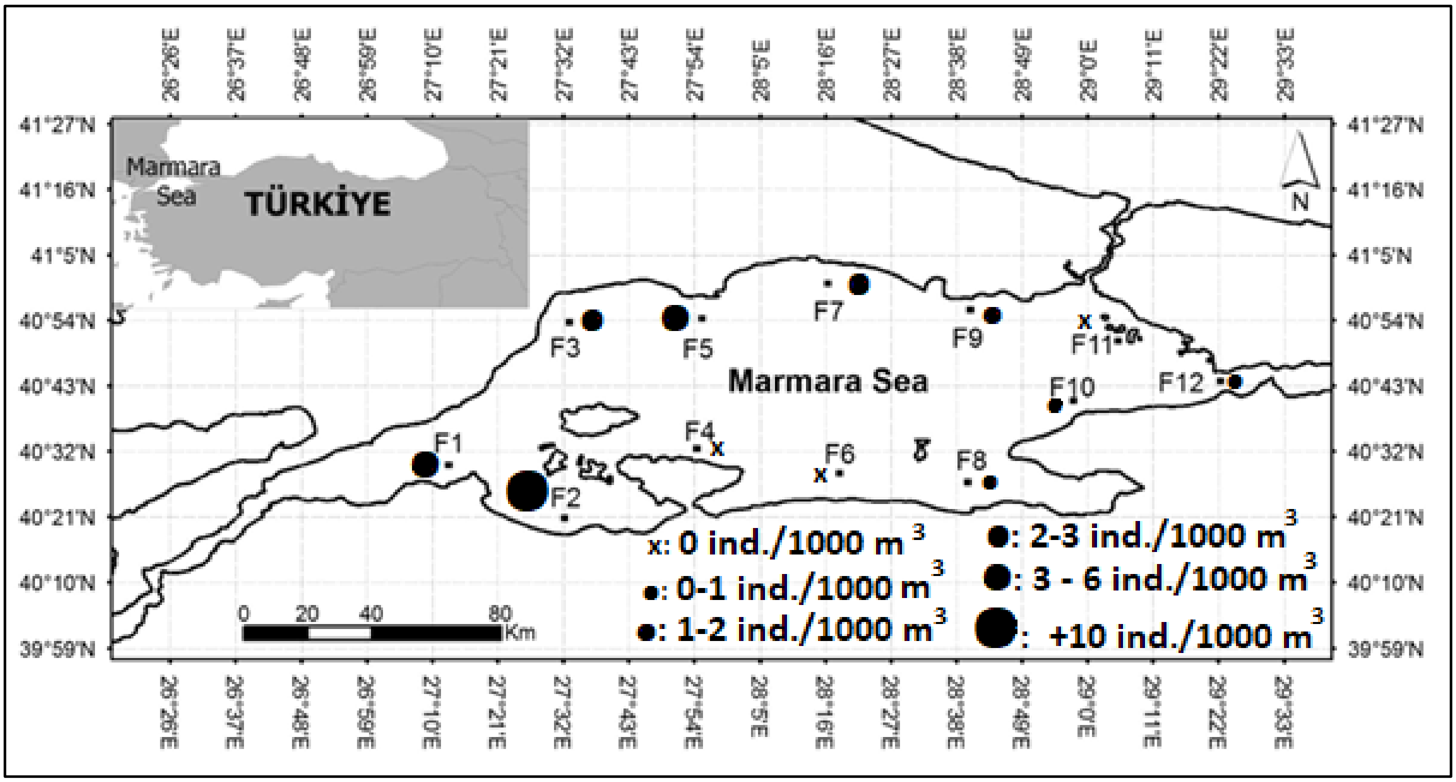

Figure 4. Spatial variation of early life stages of fish living in the Marmara Sea pelagic environment

In terms of the spatial variation of mean biomass, F2 (Gönen Stream area) was the most abundant station. Daban et al. (2023) identified the settled Gadidae and Lotidae individuals from the coastal areas of the Gönen Stream area with beach seine nets at the same sampling times. Additionally, the eggs and larvae of these species were sampled with an ichthyoplankton survey in these areas (Daban et al., 2023). Thus, it can be clearly said that the Gönen estuarine area is an important spawning area for these species. *S. pilchardus*, a single pelagic juvenile fish species, was found at only three stations (F2, F7, and F8). A common feature of these three stations was their proximity to estuarine areas. Between them, F7 was the most abundant area (1.17 ind/1000 m^3) for sardine juveniles. Daban et al. (2023) found 108 juvenile sardines in the coastal site of F7 with a beach seine net in a single tow. Also, Daban et al. (2023) detected the highest number of sardine eggs and larvae around Büyükçekmece estuarine area between 34 stations in the Marmara Sea. Thus, it can be thought that Büyükçekmece was an important place for sardine spawning.

Frame samplings were conducted between 32 m (F10) and 70 m (F5) depths. In pre-trials for determining necessity sampling depths, varied depth structures were tried, such as <50 m, 50-100 m, 100-150 m, and >150 m. Between them, none of the individuals was detected from at both 70 m depths. Thus, it was understood that the frame net samplings should be realised in shallower areas. It was found that only *M. merlangius* and *G. mediterraneus* were detected at the deepest station F5. Macpherson & Raventos (2006) clearly stated that the availability of the late postlarvae and juveniles around off shore areas is directly related to the depth range of the adults of these species. Due to Daban et al. (2023), who found juveniles of these species in the coastal areas with beach seine nets, it can be said that these species were moved through the coastal areas before settlement. Three of the six species, *C. lucerna, C. lyra*, and *S. kleinii* were found only in F1 and F2, in the southwestern part of the Marmara Sea. It can be associated with the demersal front of the Aegean Sea current from the Aegean Sea to the Marmara Sea. The other possible explanation for this situation may be the high ichthyoplankton and adult fish biodiversity of Erdek Bay (Kara, 2015).

Due to these results, revealed preliminary findings related to late postlarvae of demersal species in the pelagic environment and pelagic juveniles, it was not possible to compare the results of other studies. The frame model used in this study was modified according to Methot's (1986) model, which is used for CalCOFI surveys. We had to use an 8 mm streched mesh size instead of the 6.8 mm used by Methot's design. Additionally, we did not have the chance to use the V-shaped Isaacs-Kid depressor under the frame. It was explained that this type of depressor benefits the sinking of the frame with a proper angle mouth position during sampling. Thus, in future trials, these differences will be eliminated, and sample collection success will be compared with current results.

After seeing what can be achieved with frame net sampling, we think that it has been overlooked yet. We strongly recommend using this sampling gear for researchers who are working on the early life stages of fish. It should be used as a supplementary method for ichthyoplankton samplings due to the need collect the late postlarvae stages of demersal species before settlement. It should be beneficial for PLD studies to support the findings of the settlement mark method of newly settlers by using daily age information of late postlarvae just before settlement around the pelagic stage. Additionally, frame net sampling is sufficient to obtain larger sizes of pelagic larvae, which escape from plankton nets with high swimming capabilities. Also, frame net sampling allows revealing the missing piece of the life cycle in species-based studies. For example, the stages between eggs and early postlarvae of *G. mediterraneus* and *M. merlangus* should be collected with ichthyoplankton sampling. In addition to these, beach seine nets enable the collection of juvenile stages in coastal areas after settlement. Hovewer, the late postlarvae stages of demersal species should only be obtain by frame net sampling. The early stages of pelagic juveniles should not be obtained by commercial seine net fisheries due to the selectivity of the nets. Thus, frame net sampling has to be used by researchers, who are working on daily growth and mortality of pelagic juveniles.

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Ethical Approval

No need to ethical approval for this study.

Funding Statement

The authors don't declare any fund.

Conflict of Interest

The authors declare that they have no conflict of interest.

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