Critical life stage and spatial analyses of shark and ray species in the Albanian territorial waters

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ABSTRACT

Chondrichthyans represent a diverse group of cartilaginous fishes that includes sharks, skates, rays, and chimaeras. The conservation of Mediterranean chondrichthyans faces challenges not only from the fishery industry itself, but also from the significant unreliability of official catch data. The species in this group often occupy upper trophic levels, displaying K-selected life history traits characterized by slow growth, late maturity, low fecundity and long gestation periods. The Mediterranean Sea is known to be a chondrichthyan-rich area inhabited by 88 species, of which almost half are consistently recorded in the basin. The Adriatic Sea represents a sub-basin and falls within the northeastern part of the Mediterranean Sea. Based on the data collected in the frame of MEDITS survey programme (International bottom trawl survey in the Mediterranean) during the year 2023, we conducted the relative analyses for identifying the recruits and spawners abundance of Mediterranean starry ray (*Raja asterias*), brown ray (*Raja miraletus*), blackmouth catshark (*Galeus melastomus*) and lesser spotted dogfish (*Scyliorhinus canicula*). In addition, we did some preliminary spatial analyses in order to identify the spatial hotspots of each considered species spawners and recruits in Albanian territorial waters. These are the first reported spatial analyses data so far and other analyses would be required to identify important shark and ray areas in Adriatic Sea.

Keywords: Chondrichthyans; Critical Life Stage; Territorial Waters; Adriatic Sea; Albania

INTRODUCTION

Chondrichthyans represent a diverse group of cartilaginous fishes that includes sharks, skates, rays, and chimaeras (Serena *et al*., 2020). The conservation of Mediterranean chondrichthyans faces challenges not only from the fishery industry itself, but also from the significant unreliability of official catch data (Cashion *et al*., 2019). The species in this

group often occupy upper trophic levels, displaying K-selected life history traits characterized by slow growth, late maturity, low fecundity and long gestation periods (Serena *et al*., 2020). The Mediterranean Sea is known to be a chondrichthyan-rich area inhabited by 88 species, of which almost half are consistently recorded in the basin (Serena *et al*., 2020). The Adriatic Sea represents a sub-basin and falls within the northeastern part of the Mediterranean Sea. In addition, it represents a heavily exploited basin, where chondrichthyans have been depleted historically (Maioli *et al*., 2023).

MEDITS survey program is coordinated by the Ministry of Agriculture and Rural Development with the support of General Fisheries Commission in the Mediterranean (GFCM). Based on the data collected in the frame of MEDITS survey programme, during the 2023 bottom trawl surveys, we conducted the relative analyses for identifying the recruits and spawners abundance of different sharks and skate species, which are represented by Mediterranean starry ray (*Raja asterias*), brown ray (*Raja miraletus*), blackmouth catshark (*Galeus melastomus*) and lesser spotted dogfish (*Scyliorhinus canicula*), respectively.

Mediterranean endemic starry ray (*R. asterias*) is one of the few demersal skates that are still present in Mediterranean exploited ecosystems (Coll *et al*., 2013). Previous information on the Mediterranean starry ray from various areas of the Central-Western and Central-South Mediterranean Sea (the Ligurian Sea, Tyrrhenian Sea and north coast of Tunisia) indicate that this skate preys on crustaceans, fishes, cephalopods and polychaetes and is likely an ecologically important predator of the demersal community in the Mediterranean Sea (Serena *et al*., 2005, Romanelli *et al*., 2007). The other investigated skate species, brown ray (*R. miraletus*),

exhibits a pronounced benthic ecology, with most records from 10 m to 150 m on sandy and hard bottoms (Neat *et al*., 2015) and a generalist feeding behavior (Šantić *et al*., 2013). Due to its high and stable abundance over its distribution, small body size and early maturation, it was considered highly resilient to exploitation and was assessed globally and in the Mediterranean region, as Least Concern (LC) in the International Union for Conservation of Nature (IUCN) Red List (Dulvy, 2023), differently from the other ray species, which is considered as Near Threatened (NT). The two considered shark species represent demersal elasmobranchs, *G. melastomus* and *S. canicula*, which are better able to resist high fishing pressure (Ramírez-Amaro *et al*., 2016), due to early maturation (Camhi *et al*., 1998), short generation time, faster population dynamics (Rey *et al*., 2005), morpho-functional adaptation of gastroenteric and sensorial systems (Lauriano *et al*., 2019), and a continuous reproductive cycle. All these biological features helped them adapt to the most exploited environments and be considered as LC in the Mediterranean Seaaccording to IUCN (D'Iglio *et al*., 2021). It means thanks to early maturation, short generation time, faster population, and a continuous reproductive cycle, they can maintain their population, concluding their reproductive cycle before being caught (unlike most elasmobranchs), despite a high fishing effort (D'Iglio *et al*., 2021). Based on the MEDITS data preliminary analyses, we did the evaluation of the relative location of nursery and spawning areas of mentioned sharks and rays.

MATERIAL AND METHODS

The source of data correspond to the accumulated data during all the years MEDITS

campaign/survey programme, but the available data regarding sharks and skates used in this study are from 2023. The sampling period was in spring 2023 and the MEDITS protocol was implemented with aim to determine the sex and do the relative measurements for all the sampled specimens. In order to identify the maturity stages for each of the species based on the length-classes to catch for each of the species we used the R-script in R studio (Ogle *et al.*, 2023). In addition, we used the R-scripts developed for the training and conducted analyses during the organized WG-ANALYSIS Essential Fish Habitat (EFH)-Vulnerable Marine Ecosystems (VME) meeting by GFCM on 4-6 December 2023 in Rome GFCM HQ. It means that we plotted abundance indexes on the Albanian territorial waters and later we used spatial interpolation techniques, including Kriging and Inverse Distance Weighted (IDW) (Chen *et al.*, 2016), while the latter one resulted to run perfectly based on the availability of the considered species data. Due to this, all the presented results are only based on the IDW interpolation, because the other method does not fit well. In Fig. 1 are shown the 4 fishing ports of Albania.

RESULTS AND DISCUSSION

Albanian fisheries are mainly marine, contributing about 2/3 of total catches within its Exclusive Economic Zone (EEZ), where there is an extensive easy-to-trawl shelf in the north and deep waters with a rocky seabed in the south (Bakiu *et al.*, 2023). The fishing fleet consists mainly of bottom trawlers, which contribute approximately 23.0% (110 out of 480 fishing vessels) (FAO, 2022) and 94.6% of the total Albanian fishing fleet and landings (Bakiu & Gurma, 2018), whereas the remaining parties covered by other forms of large-scale and small-scale fisheries,

respectively (Bakiu *et al.*, 2018; 2022). Though it has been highlighted the existing uncertainty on fisheries landing data (Bakiu & Soldo, 2021), still exists low taxonomic resolution of catch statistics at the national level. It is also interesting to note that finally we are having sharks and rays data, which would be extremely useful for the EFH and VME identification, although MEDITS survey programme has been implemented since 1996 in the Adriatic region.
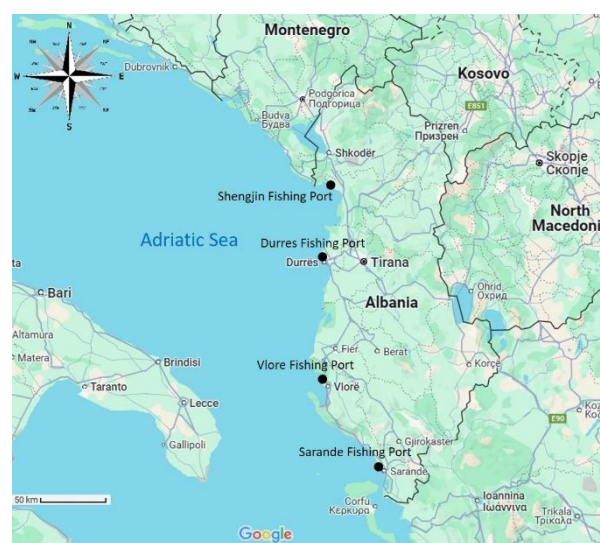

Figure 1. Map of Albania, which includes the fishing ports of Albania, as reported in Google Maps.

As it is shown in Fig. 2, the highest number of individuals in the maturity stage 1, which correspond to the juveniles or recruits are represented by females in the case of *S. canicula* and the females proportion remains dominant even in the maturity stage 2, where the individuals are under maturation and have not reached the sexual maturity yet, to be considered as spawners. In the case of maturity stage 3, it is evident that we have a drastic reduction of *S. canicula* female spawners in comparison to male spawners. Differently happens with the other shark species, which shows male catch level dominance toward females ones in each of the maturity stages,

though the *G. melastomus* catches abundance is far less than *S. canicula*.

Regarding the considered skate species (Fig. 3), we can note that most of the caught individuals of *R. asterias* are represented by juveniles, while the spawners are less abundant. In the case of *R. miraletus*, the highest caught individuals in the recruit maturity stage are represented by males, while the spawners are mostly represented by females, though generally the brown ray resulted to be less abundant than the Mediterranean starry ray during the trawling survey in the Albanian territorial waters.
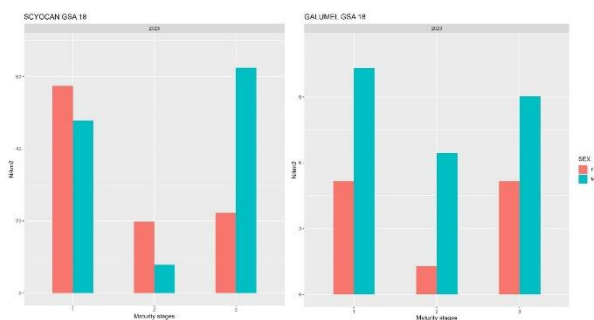

Figure 2. Graphical representation of the abundance (expressed in number of fished individuals per square km of bottom trawl net) for each of the identified maturity stages regarding the two considered shark species: left *S. canicula* and right *G.melastomus*.
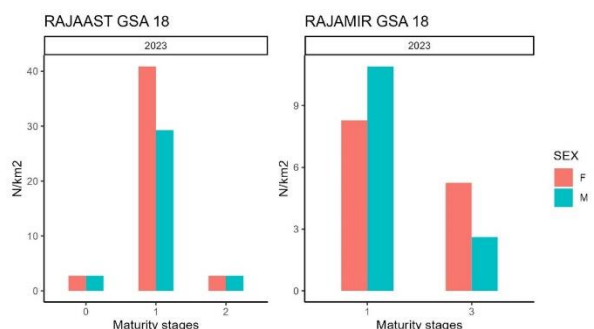

Figure 3. Graphical representation of the abundance (expressed in number of fished individuals per square km of bottom trawl net) for each of the identified maturity stages regarding the two considered skate species: left *R. asterias* and right *R. miraletus*.

Regarding the plotted shark catch abundance plotted in the shown maps of Fig. 4, it is evident that most of the small-spotted catshark recruits were fished in the Southern Albanian coast, close to the Bay of Vlora (represented by the yellow dot), while the spawners are shown to be distributed along the coast and the number of the spawners increased while the distance from the Albanian coast is increasing too, which shows that the catch abundance increased in correlation with the depth increase. Regarding the other considered shark species (blackmouth catshark), we can observe in the map the location of the recruits and spawners are close to Karaburun Peninsula, which has been proclaimed as Area of Interest by IUCN shark specialist group members and experts, during the Important Shark and Ray Area (ISRA) identification process in the Mediterranean Sea, recently.

In the maps of the Fig. 5 are shown the plotted catch abundance values corresponding to the recruits and spawners of the considered skate species in the presented study. As it is shown, the Mediterranean starry ray recruits and spawners were mostly fished close to the fishing area close to Durres, except some spawners fished close to Shengjin (black dot on the right graphic). Regarding the brown ray, most of the recruits were fished during the survey close to Durres, while the spawners were fished by going not only on higher depths (similarly to the other skate species), but even toward south direction.

From the graphics of the Fig. 6, which shows the *S. canicula* IDW and Hot Spot analyses results, that there is an overlapping of the relative results, which indicate that most probably the most appropriate and probably essential fish habitat for spawners could be the area from Vlora Bay to Saranda area (bordering the Corfu Island), while the most frequented or hot spot area for the spawners of
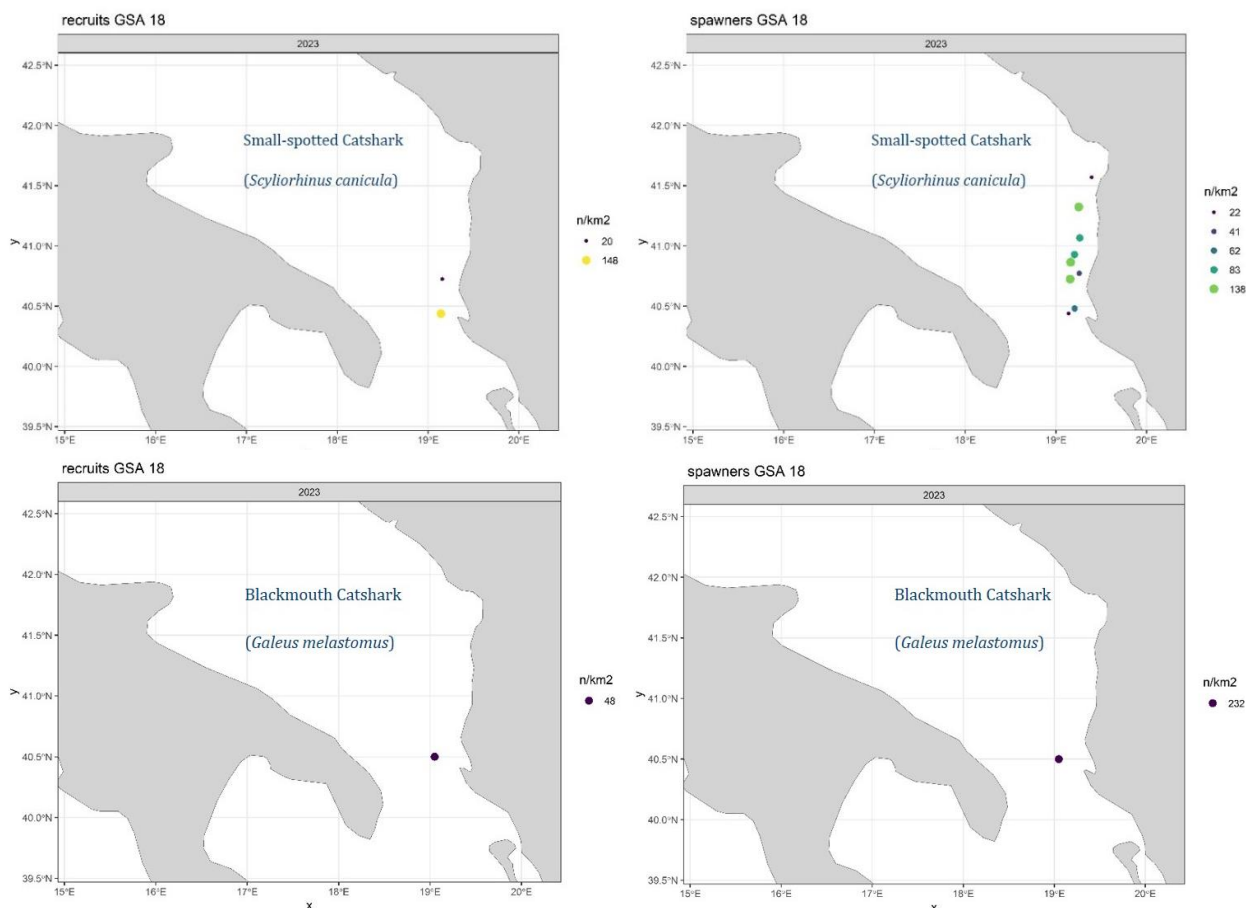
Figure 4. Graphical representation of considered sharks recruits and spawners abundance plotted in the map showing Albanian and Southern Italian coasts, respectively.

this shark species is the area close to Durres.

In the graphics of Fig. 7 are shown the considered skates IDW analyses results, where it is interesting to note that the suggested EFH would be the area close to Durres regarding the recruits of the endemic ray of Mediterranean (*please see the graphics on the top*), while the spawners can be presents in any habitat along the Albanian coast from Durres to Saranda, though the most appropriate (by the colour) it is shown the area close to Durres. Regarding the other skate species (brown ray), IDW results indicate as probable nursery area, where are located most of the brown ray recruits, the area between Durres (on the north) and Vlora (on the south), while the probable spawning area (characterised by the highest number of spawners) is the area close to Durres (*please see the graphics at the bottom*).

In Fig. 8 are shown the skates Hot Spot Analyses results, which show a lower resolution level regarding the suggestions on nursery and spawning areas for the Mediterranean starry ray (*please see the graphics on the top*), while the graphics corresponding to the other species (brown ray) shows an opposite location of the relatively suggested EFH in comparison to the brown ray graphics of the Fig. 7.

However, it should be clear for the reader that these are the first reported spatial analyses data so far regarding Albania, but it is important to go further with similar surveys in order to have additional analyses, which are needed not only for EFH or VME identification, but even for the identification of important shark and ray areas (ISRAs) in Adriatic Sea.
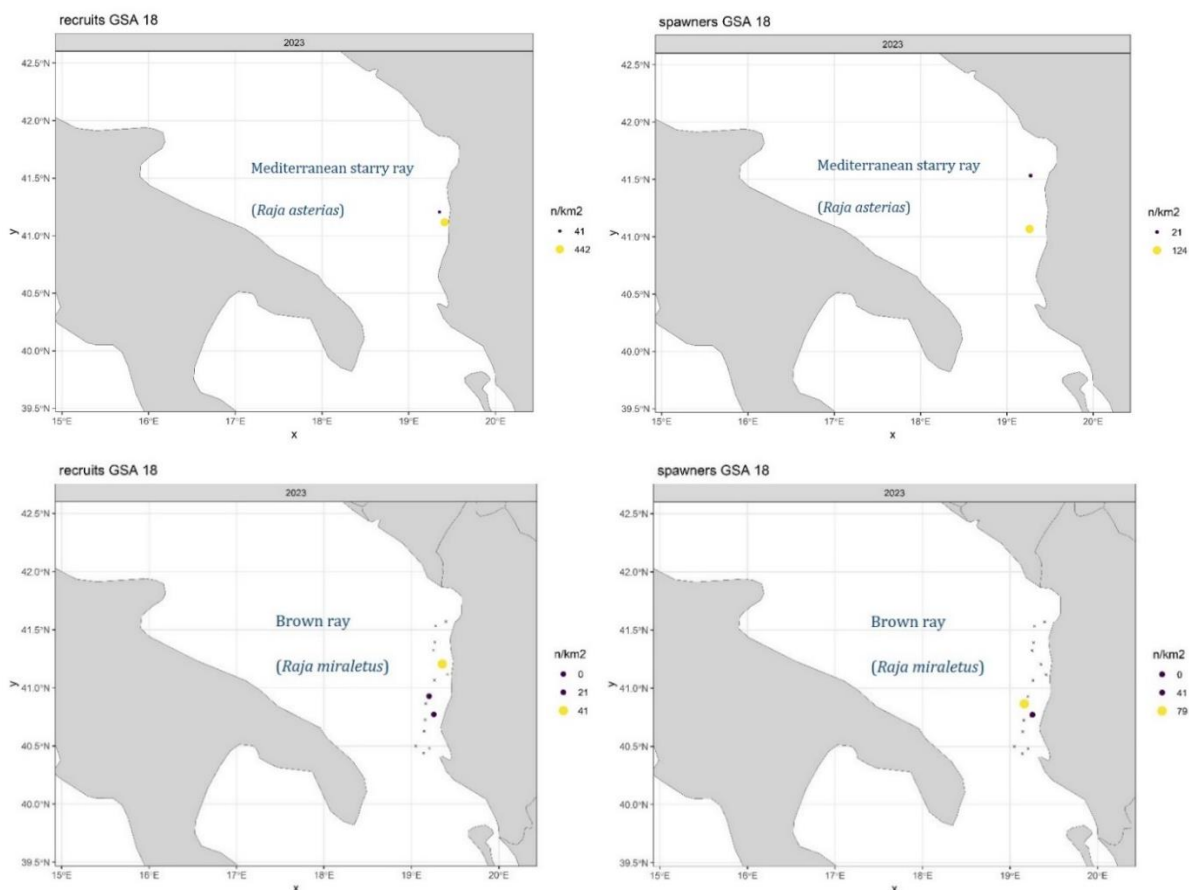
Figure 5. Graphical representation of considered skates recruits and spawners abundance plotted in the map showing Albanian and Southern Italian coasts, respectively.
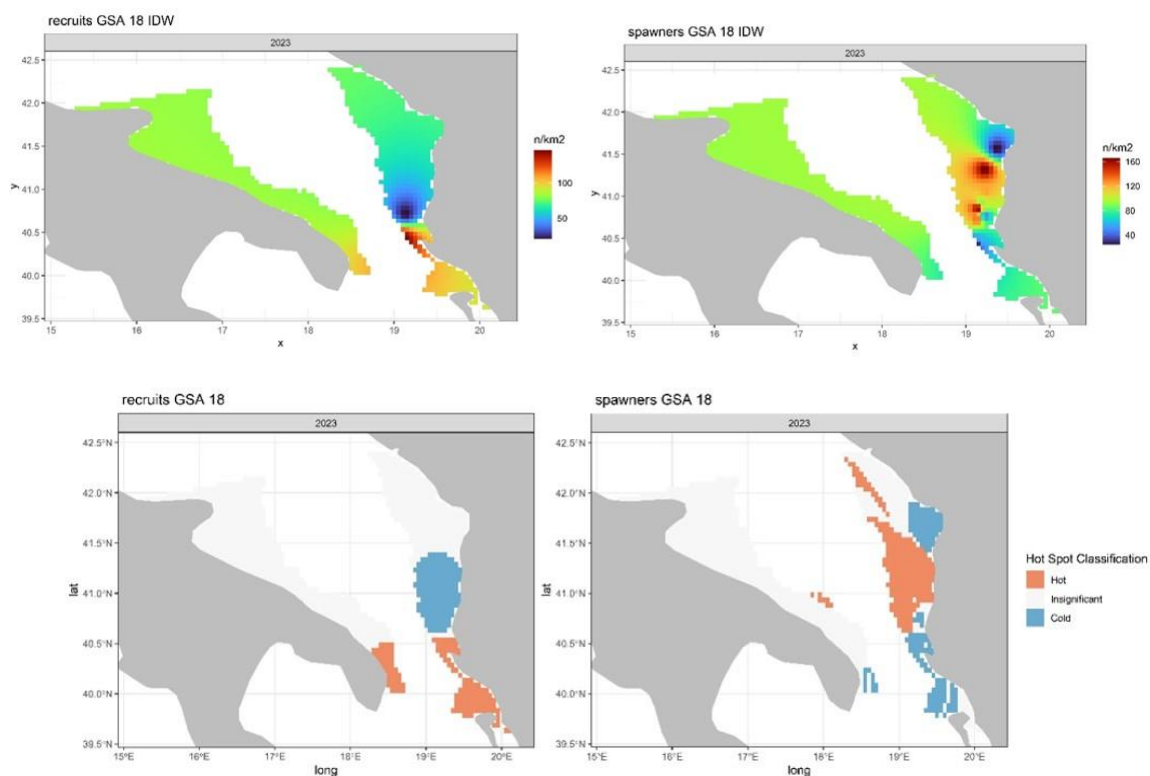

Figure 6. Graphical representation of *S. canicula* IDW analyses (on the top) and Hot Spot analyses (at the bottom) results, respectively.
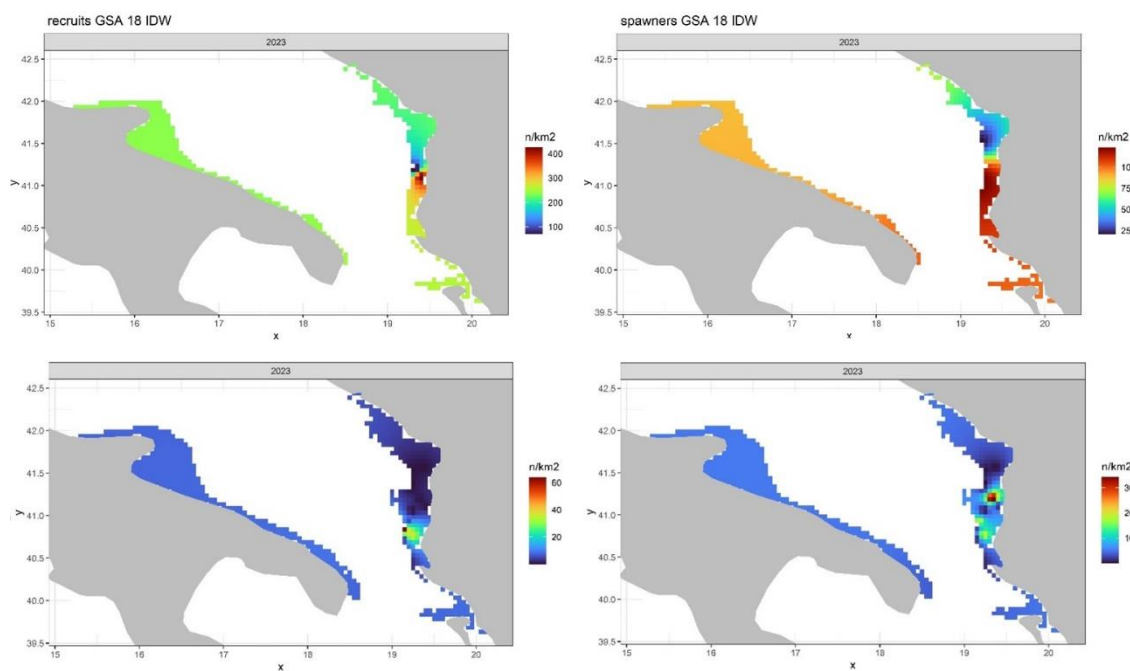
Figure 7. Graphical representation of *R. asterias* (on the top) and *R. miraletus* (at the bottom) IDW analyses results, respectively
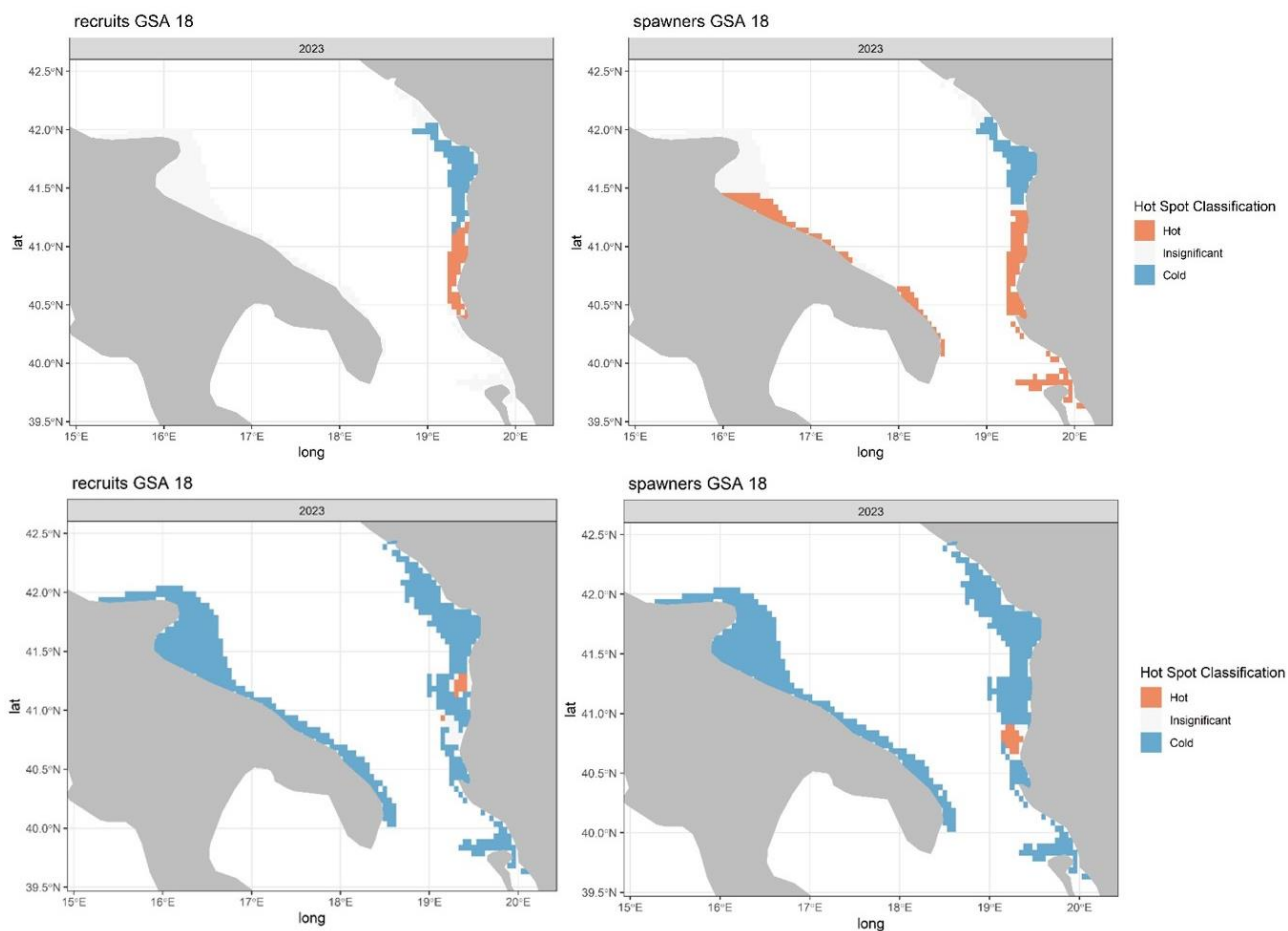
Figure 8. Graphical representation of *R. asterias* (on the top) and *R. miraletus* (at the bottom) Hot Spot analyses results, respectively.

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Kritični životni stadijumi i prostorna analiza ajkula i raža u albanskim teritorijalnim vodama

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SAŽETAK

Chondrichthyans predstavljaju raznoliku grupu hrskavičnih riba koja uključuje ajkule, klizaljke, raže i himere. Očuvanje mediteranskih hondritija suočava se sa izazovima ne samo zbog same industrije ribarstva, već i zbog značajne nepouzdanosti zvaničnih podataka o ulovu. Vrste u ovoj grupi često zauzimaju više trofičke nivoe, pokazujući K-odabrane osobine istorije života koje karakteriše spor rast, kasna zrelost, niska plodnost i dugi periodi gestacije. Poznato je da je Sredozemno more područje bogato hondritijama i naseljeno sa 88 vrsta, od kojih se skoro polovina stalno beleži u slivu. Jadransko more predstavlja podsliv i spada u severoistočni deo Sredozemnog mora. Na osnovu podataka prikupljenih u okviru programa istraživanja MEDITS (Međunarodno istraživanje pridnene koćarske mreže u Mediteranu) tokom 2023. godine, uradili smo relativne analize za identifikaciju mlađi i mrijestećih jedinki zvezdopjege raže (*Raja asterias*), barakokule (*Raja miraletus*), crnouste mačke (*Galeus melastomus*) i morske mačke bljedice (*Sciliorhinus canicula*). Pored toga, uradili smo neke preliminarne prostorne analize kako bismo identifikovali prostorna žarišta mrijestećih jedinki i mlađi svake razmatrane vrste u albanskim teritorijalnim vodama. Ovo su do sada prvi prijavljeni podaci prostorne analize i druge analize bi bile potrebne da bi se identifikovala važna područja morskih pasa i raža u Jadranskom moru

Ključne riječi: hrskavičave ribe, kritični životni stadijum, teritorijalne vode, Jadransko more, Albanija