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1. Background

Unwanted catches are a widespread and critical problem in fisheries worldwide (Kelleher 2005). They represent the fraction of the total catch that is returned to sea, and essentially include undersized (under the minimum legal size) or damaged specimens of commercial species, commercial species with low market value, and non-marketable species. The amount of the unwanted catch depends mainly on the exploited fishing ground (e.g. geographic area, habitat) and the fishing gears adopted, being bottom trawling the fishing practice producing the highest discard rates. Other factors that influence the production of unwanted catch include technical characteristics of the vessels, fishing strategies, fishing season, environmental conditions. Nonetheless, the decision of discarding the entire or part of the catch back to sea is a choice that fishermen ultimately do, mainly driven by economic reasons or compliance with fishing regulations (until recently it was expressly forbidden to land undersize individuals).

The discard level produced by bottom trawlers in European Atlantic regions is about 60% of total catch, reaching levels as high as 90% in some areas (STECF 2006). Indeed, high amount of catches subject to quotas results in discarding smaller individuals, even when they are above the minimum legal size (Catchpole et al. 2005).
Discard rates in the Mediterranean seem to be lower than in the Atlantic because a wider size range of fish is routinely marketed and no quota system is in place (STECF/SGMOS 2008; Lleonart and Maynou 2003; Condie et al. 2013). In the Mediterranean, estimates of annual discards rates range between 13.3 and 26.8% of total catches (Tsagarakis et al., 2014). According to Sanchez et al. (2004), estimated discards in bottom trawl fisheries in the north western Mediterranean is around 1/3 of total catch in biomass.

Under the current trawl net selectivity pattern, undersized individuals predominate in the catches of some species such as European hake and red mullet in the Mediterranean, especially during the recruitment period (Sala and Lucchetti 2011).
The recent introduction of the “landings obligation” by the reform of the Common Fisheries Policy (Reg. EC n. 1380/2013) has the objective to reduce the wasteful practice of discarding unwanted catch at sea. While promoting the introduction of technical measures aimed at reducing and discouraging the capture of undersized specimens, it requires at the same time fishermen land all the catch. According to the new CFP, the introduction of the landing obligation is a gradual process that should follow a specific schedule. The landed discards will be limited to purposes other than human consumption (e.g. fish oil, fish meal, pet food, cosmetics, pharmaceuticals, and food additives), and exceptions (e.g. high survival; excessive costs; de minimis) from the obligation to land discards are also introduced. Given the specific characteristics of each region, local management plans are needed as solutions to set up the most appropriate measures at regional level. However, it is still unclear the potential use of unwanted catches under landings obligation as well as the protocol for their preservation and storage.

The spatial distribution of potentially unwanted catches is an important source of information to contribute to lower production of discards. In this report (Demonstration) we summarize the characteristics of a spatial database elaborating raw data from different types of fishing surveys regarding undersize fish of selected species. The exact spatial analysis methodology used varied in each case study, but the overall goal was to produce high-resolution maps of potentially problematic fishing areas vis-a-vis the generation of discards. The spatial objects created by the analyses described here will be accessible through a GEONODE portal and be used throughout the lifetime of the MINOUW project as input data for other Tasks, especially Task 3.3 in Workpackage 3. This report is complemented by Deliverable D1.3.

2. Description of the datasets available

In order to fulfil the project milestones and deliverables, an exploratory survey of the data available for each case study was performed. Different main sources of data were identified: i) international scientific bottom trawl surveys in Case Study 1.2 (IBTS) and Case Studies 1.4, 1.5, 1.6, 1.7 and 1.8 (MEDITS) and ii) acoustic survey in Case Study 1.7.

(CASE STUDY 1.2)

The Portuguese International Bottom Trawl Survey (PT-IBTS) is part of the IBTS programme and consists in a number of bottom trawl surveys with the aim of improving standardisation and collaboration between surveys in different countries. Starting in 1989 with a sampling design based in 97 locations stratified by depth strata covering 12 sectors along the Portuguese coast, was latter modified in 2005 with fixed and random trawl positions and the Autumn groundfish and the Winter groundfish surveys were introduced. These surveys have different main objectives, the Autumn is to monitor abundance and distribution of hake and horse mackerel recruitment and the Winter to monitor the abundance and distribution of hake in the spawning season, additionally both these surveys also estimate abundance indices and biomass of the most important commercial species among other biological parameters and biodiversity indicators. This survey data permits producing maps of relative abundance of small size individuals that are in the same area where the commercial trawl fleet operates.

(CASE STUDY 1.4, 1.5, 1.6-1.8)

The Mediterranean International bottom trawl survey (MEDITS) is routinely carried out in the Mediterranean with the primary aim of monitoring and assessing fisheries resources status. Data from MEDITS surveys provide an accurate picture of the population structure and spatial distribution of species. The main drawback is that the surveys cover a single season during the year, which is mostly during summertime, and use a codend net with a smaller mesh size than the commercial mesh size permitted. These two aspects make the MEDITS data not entirely comparable to the mapping that

would be obtained from using high-resolution discards data from the commercial fishery (which is not available). However, it permits producing maps of relative abundance of small size individuals that are informative and allow identifying areas were the likelihood of the commercial fleet encountering undersize fish is high.

(CASE STUDY 1.7)
The Mediterranean International Acoustic Survey (MEDIAS) is routinely carried out in the framework of the European Data Collection Framework since 2008 with the primary aim of monitoring and assessing small pelagic fisheries resources status in the EU part of the Mediterranean Sea. Here we used acoustic data collected in Aegean Sea to analyse the potential spatial distribution of Mediterranean horse mackerel (Trachurus mediterraneus) juveniles following the approach used in the MEDISEH project (Giannoulaki et al, 2013). As the acoustic surveys cover only a certain limited area, we used survey data and applied spatial analysis techniques in order to identify locations that are more likely to be density hot spot areas or are being more suitable for fish nurseries.

3. Objectives

Under the framework of the Task 1.3, whose objective is the “Characterization of habitats where case-study fisheries producing unwanted catches take place”, the main goal of Deliverable 1.2 is to produce GIS maps showing the spatial distribution of juveniles of commercial species under the discard ban regulation in each case study area. Figure 1 show the location of each case study involved in the present deliverable.

Databases and results of Task 1.3 are intended to serve as preparatory knowledge for the development of GIS and modelling tools under WP3.

The CNR-IAMC staff, in collaboration with the responsible of Task 3.3, prepared an Excel template to collect and store the available data. In this spreadsheet, biomass and abundance data per haul was entered for the following categories i) species below the minimum conservation reference size (MCRS) according to EU or national regulations, ii) species above the MCRS according to EU or national regulations, iii) all other commercial species without MCRS, specifying if the species is retained (i.e. commercial by-catch: C) or discarded (i.e. non commercial by catch: N).

A GIS working group took place in Barcelona (17-18 November 2015) with the goal of updating and standardizing GIS procedures and protocols among the participants and the WPs. After the working group, a Skype meeting between the coordinator of the project, the responsible of Tasks 1.3 and 3.3, and several GIS experts involved in the project allowed to define the procedures and methodologies to be adopted. The overall outcomes are reported hereafter.

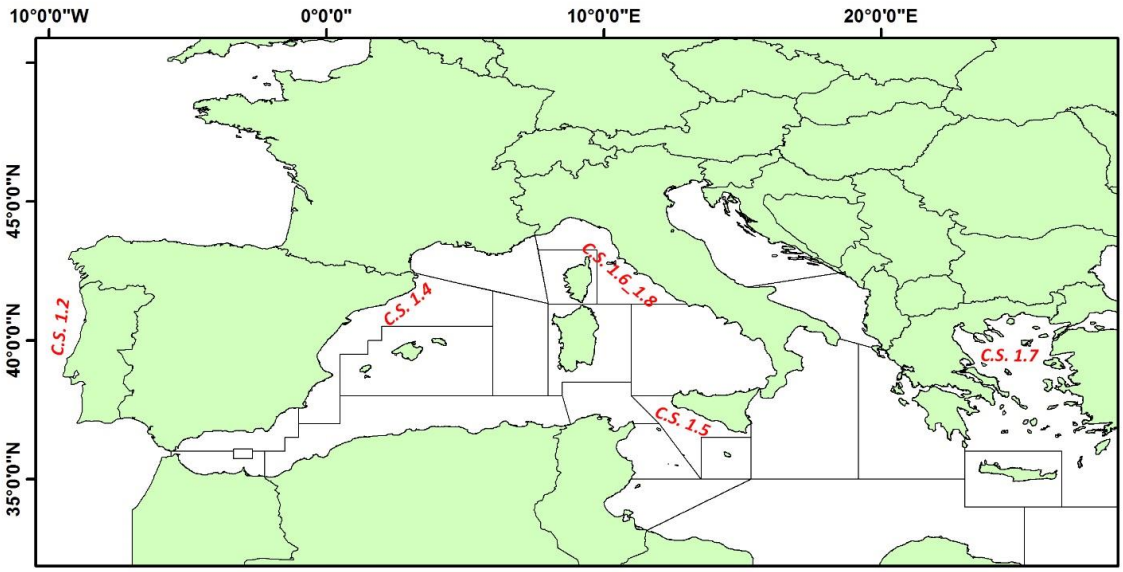


Figure 1 Spatial location of the Case Studies.

4. Target species

The selection of species for the production of GIS maps was based on the importance of each species as potential unwanted catch, hence relevant to discarding.

Under the framework of the GIS working group, it was decided to consider the following common set of case study species because of their importance in bottom trawl catches and the problems associated with low selectivity of this fishing gear: Mullus barbatus (Mullus surmuletus in the Atlantic), Merluccius merluccius and Parapenaeus longirostris for the time period 2009 to 2014, and Trachurus spp. for a shorter time interval, 2011 to 2014. Moreover, other species under MCRS regulation that are locally important were identified and included by each CS leader (Table 1).

Table 1. List of mandatory species among key studies.

CASE STUDY	SPECIES	PROVIDED BY:
1.2	*Boops boops*	CCMAR
	Merluccius merluccius	CCMAR
	Micromesistus poutassou	CCMAR
	Mullus surmuletus	CCMAR
	Parapenaeus longirostris	CCMAR
	Scomber colias	CCMAR
	Trachurus spp	CCMAR
1.4	*Merluccius merluccius*	CSIC
	Mullus barbatus	CSIC
	Trachurus trachurus	CSIC

1.5	*Merluccius merluccius*	CNR
	Mullus barbatus	CNR
	Parapenaeus longirostris	CNR
	Trachurus trachurus	CNR
1.6 – 1.8	*Merluccius merluccius*	CIBM
	Mullus barbatus	CIBM
	Parapenaeus longirostris	CIBM
	Trachurus trachurus	CIBM
1.7	*Merluccius merluccius*	HCMR
	Mullus barbatus	HCMR
	Parapenaeus longirostris	HCMR
	Trachurus trachurus	HCMR
	Trachurus mediterraneus	HCMR

5. Material and methods

The datasets used in each case study area are reported in the Table 2.

Table 2 Source and type of data used in each case study

CASE-STUDY	TYPE OF SURVEY	YEARS
1.2 – Gulf of Algarve	PT-IBTS	2002-2011
1.4 – Catalan sea	Scientific trawl survey - MEDITS	2009-2014
1.5 – Strait of Sicily	Scientific trawl survey - MEDITS	2009-2013
1.6 – 1.8 - Ligurian and N.Tyrrhenian sea	Scientific trawl survey - MEDITS	2009-2014
1.7 – Aegean sea	Scientific trawl survey - MEDITS Pelagic and acoustic survey	2001-2007, 2013

Figure 2 shows an example of the Excel template used to collect and store the available data (Fig.2). In this spreadsheet, data on abundance of the selected species were stored. In particular, for every species a cut-off length equal to the minimum landing size established in the Reg. EC n. 1967/2006 has been used. For each haul, the number of individuals whose length was smaller than the cut-off length was counted and standardized to the area (num. ind. km-2) assuming a catchability coefficient equal to 1. This resulted in a density index of undersize specimens (UDI) by haul, which formed the input of following spatial analysis.

									TL<MLS		TL>MLS	
									Juveniles *	Juveniles *	Adult**	Adult**
Case Study	GFCM/ICES Fishing Area	Data source	Sampling gear	Year	Haul.(	Lat	Lon	Species	juv_den	Log_juv	adu_den	Log_adu
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	67	40.10483333	0.283333333	HKE	179.7801992	5.197281924	5.211020266	1.826325176
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	70	40.031	0.897	HKE	94.93430546	4.563663639	10.54825616	2.446534444
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	71	40.05716667	0.515166667	HKE	923.6234458	6.829386569	14.62752064	2.749033503
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	72	40.1285	1.151666667	HKE	1798.553559	7.49529389	60.76194455	4.123287391
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	73	40.28516667	1.263	HKE	1621.677268	7.391832699	130.1345956	4.876224243
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	74	40.32316667	1.1325	HKE	376.9566772	5.934779578	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	75	40.43633333	1.056666667	HKE	241.2878545	5.490126501	1.945869794	1.08040412
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	76	40.54433333	1.040166667	HKE	127.6935355	4.857433884	12.76935355	2.622445365
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	77	40.62983333	1.107166667	HKE	92.2651744	4.535446773	2.14570173	1.146036991
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	78	40.94933333	1.222666667	HKE	142.0959147	4.963515138	12.17964984	2.578673961
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	79	41.083	1.3665	HKE	229.2606453	5.439211908	32.75152076	3.519025476
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	80	41.00583333	1.351666667	HKE	484.6234681	6.185433567	6.173547364	1.970400283
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	81	40.91766667	1.404166667	HKE	14.37064775	2.7324597	2.052949678	1.116108231
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	82	40.89566667	1.541166667	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	83	40.849	1.468333333	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	84	41.17183333	2.428666667	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	85	41.21033333	2.295166667	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	86	41.2885	2.3455	HKE	235.524955	5.46605372	8.854321617	2.287910102
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	87	41.29816667	2.260333333	HKE	182.3616194	5.211460266	5.470848583	1.867307257
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	88	41.4065	2.321166667	HKE	26.50094741	3.314220455	17.66729827	2.926773238
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	89	41.42983333	2.5315	HKE	24.50630926	3.238925844	2.227846296	1.171815134
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	90	41.42016667	2.765333333	HKE	267.7666009	5.593843348	7.236935159	2.108628328
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	91	41.28183333	2.778166667	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	93	41.95166667	3.525833333	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	94	42.17033333	3.640666667	HKE	0	0	0	0
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	95	42.08833333	3.577166667	HKE	0	0	1.815593772	1.035173171
CS1.4_CS3.4	GSA06	Medits	Trawl	2003	96	42.10716667	3.366333333	HKE	593.35754	6.387481057	5.345563423	1.847755895

Figure 2 Excel template used to collect and store data from each case study.

The analytical methodology to create the maps was based on the recent publication by Colloca et al. (2015); additionally, the results of the MEDISEH1 project were used when consistent with the objectives of the present deliverable.

Methodology used in case studies:

1.2 – *Gulf of Algarve*
1.4 – *Catalan sea*
1.5 – *Strait of Sicily*
1.6 – 1.8 - *Ligurian and North Tyrrhenian sea*

Data were received from the partners involved in the Task 1.3 according to the format required (Fig.1) with the exception of data from case study 1.2 which were analysed directly by CCMAR. The criteria used by CCMAR as cut-off separating juveniles from adults was MCRS, except for Micromesistius poutassou where size at first maturity was used because in Portugal the species is not regulated by MCRS.

For each species and year, the spatial analysis of undersized specimens distribution was performed using geostatistical methods (variogram analysis and kriging) whose fundamentals may be found in the works by Goovaerts (1997) and Petitgas (1996).

The total number of hauls, the number of positive hauls and their percentage were calculated for each year. The surveys in which the presence of a few positive hauls (in absolute number or percentage) precluded structural analysis (variogram modelling) were excluded from subsequent analyses. Different exploratory plots (contour plots, scatter plots of density indices versus geographical components, normal q-q plots) were examined to check for significant deviations from stationarity and normality (the

[1] The MEDISEH project(Mediterranean Sensitive Habitats) is project nº 2 in the DGMARE Tender "MAREA" (MARE/2009/05 - LOT 1 – Mediterranean). It ran from Sept. 2011 to March 2013. The results of the project (http://www.mareaproject.net/medviewer/) were kindly made available to the MINOUW Research and Innovation Action by the "MAREA" coordinator, Dr. Maria Teresa Spedicato.

basic assumptions of linear geostatistics). The logarithm transformation of UDIs values was applied in order to improve normality.

The successive step was to characterize the spatial structure of UDIs data through variogram analysis. The experimental variograms were computed and fitted using asymptotic models such as spherical, exponential or Gaussian models. Anisotropy was not analysed because data were insufficient to characterize the possible directionality in spatial correlation. Following estimation of variogram parameters (range, nugget, sill), ordinary kriging was applied for estimating undersized specimens densities at not sampled locations and mapping their distribution. Grids were constructed using 1×1 km cells. Cross-validation procedures were applied to check the goodness of fit of selected variogram models and the choice of kriging parameters.

Density hot spots were outlined on the annual maps using a threshold calculated on the basis of the cumulative distribution of the UDIs. This analysis has been performed in ArcMap using Hot Spot Analysis (Getis-Ord Gi*) tool. This tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). Z-score, p-value, and confidence level bin (Gi_Bin) are the final results of the analysis. Features in the +/-3 bins reflect statistical significance with a 99 percent confidence level; features in the +/-2 bins reflect a 95 percent confidence level; features in the +/-1 bins reflect a 90 percent confidence level; and the clustering for features in bin 0 is not statistically significant. The Getis' G statistic with a 0.95 significance level was selected among the local methods for spatial hot-spot identification. This approach was applied separately in each case study and for each year of the time series in order to identify and locate spatial clusters of undersized organism with significantly higher density.

A persistent zone of undersized organisms was defined as an area consistently occupied by the highest density of under-MLS organisms, hence it was identified by means of GIS tools, extracting the area where the overlap of hot spots occurred over time. The overlap rate for each grid cell was quantified and named the index of persistence (PI) (Fiorentino et al., 2003; Colloca et al., 2009), measuring the relative persistence of cell i as an annual potential zone of undersized organisms. This index was obtained as a percentage ratio of the number of times that a given area was classified as a hot spot to the total number of years according to the formula:

$$PI_i = 100 * \frac{1}{n} \sum_{j=1}^{n} \delta_{ij}$$

where δij = 1 when grid cell i is included in a hot-spot in year j and δij = 0 otherwise, and n is the number of years. The PI decreases to zero where density hot spots have never been observed, while it increases to 100% where density hot spots occur year-by-year throughout the time series. Results were plotted in the maps of persistence reporting a scale of different persistence classes.

Methodology used in case study:
1.7 – Aegean sea

Data from this case study were elaborated directly by HCMR. Methods and results obtained in MEDISEH project were used, because they were considered consistent with the objective of the present deliverable.

For semi-pelagic species (Trachurus trachurus and Trachurus mediterraneus) spatial analysis was based on abundance data collected by both acoustic surveys and MEDITS surveys in order to identify locations that are more likely to be density hot spot areas for fish nurseries. Specifically, as Trachurus trachurus spawns during the winter-early spring thus summer period corresponds to high juveniles abundance. Thus MEDITS trawl survey data were used as more suitable for the identification and the modeling of nursery grounds of Trachurus trachurus. The selection of juveniles for Trachurus trachurus was based on the established MCRS. Based on the inspection of annual density maps we defined a density level where Trachurus trachurus juveniles were considered as present. Thus at each haul location x, an indicator of Trachurus trachurus juveniles presence I(x) was defined as I(x) = 1 if the Trachurus trachurus juveniles catch was 100 ind/km2 (in high abundance areas) or 50 ind/km2 (in low abundance areas like GSAs 20,22,23), and I(x) = 0 otherwise. Then, trawls with sufficient Trachurus trachurus juveniles measurements were considered as positive.

The spawning season of Mediterranean horse mackerel is known to take place during summer. Thus MEDITS surveys were unsuitable for the identification of the species nursery grounds. Thus the output of the modeling approach followed within the MEDISEH project was used for this purpose. Within the framework of the MEDISEH, acoustic surveys oriented to estimate the stock of small pelagic fish from 2003 to 2008 were used to model the potential habitat of juvenile Trachurus mediterraneus.

Subsequently, habitat suitability modeling techniques and environmental data were used in order to define both species potential juvenile grounds. The approach was based on available publications for other small pelagic species by e.g. Giannoulaki et al., 2011; Giannoulaki et al., 2013. Generalized Additive Models (GAMs, Hastie and Tibshirani, 1990) were applied to define the set of environmental factors that describe Trachurus trachurus and Trachurus mediterraneus juveniles' distribution. GAMs were applied in a presence absence approach and as "presence" we considered the positive hauls as defined above. Annual probability maps were obtained based on the estimated GAM model. Mean probability maps were estimated based on the annual probability maps and up to 400 m depth. Finally, habitat allocation maps (Bellier et al 2007) with persistent (high mean, low std), occasional (high mean, high std) and rare habitat (low mean, low std) were defined at a spatial resolution of 1 km*1km.

For demersal species (M. barbatus, M. merluccius and P.longirostris), the analysis was based on abundance data, expressed in terms of numbers/km2, collected during the MEDITS surveys carried out in the period 2001-2014 in the Aegean Sea (seven surveys in total).

Due to the high frequency of zero values in the data set, a Delta-X – error GAM model was employed for obtaining standardized abundance estimates, following the same approach described in past comparable studies carried out in the area (e.g. Tserpes et al 2008, Maravelias et al 2012). The Delta-X approach makes possible to treat separately the question of whether an abundance rate is zero or not, and the size of a rate given that it is non-zero (Vignaux 1996). After obtaining model predicted values for the sampled stations for: (a) the probability, p, of non-zero rate and (b) for the expected rate, λ, conditional on it being positive, the unconditional abundance of each station is given by $p\lambda$ (Ye et al. 2001). The predictor variables of the GAM model were: Year, Position (entered as the latitude - longitude interaction) and Depth. Hence the general form of the model was:

$$\text{Abundance} = a + Year + s(Position) + s(Depth) + e,$$

where a is a constant, s is the cubic-spline smoother function of the corresponding independent variable and e is a random error term.

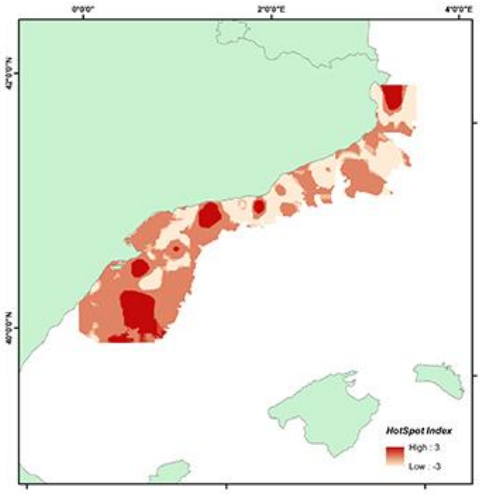
The logit function was used as a link between the linear factor component and the binomial error model. For the analysis of the non-zero abundance rates, a Gamma error model accompanied by a log link function was found to be adequate, based on residual plots. Model fitting was accomplished under the R language environment using the “zigam” function of the “COZIGAM” package (Liu and Chan 2010).

The predicted values obtained from the GAM model for a spatial grid of 1x1 km were used for constructing the density maps. To facilitate interpretation and given that the model estimates a “mean” distribution pattern for all studied years, model predictions P_i were rescaled to the range 0-1 according to the formula: P_i - P_{min}/P_{max}-P_{min}. In that sense, 1 represents maximum abundance and 0 the minimum one.

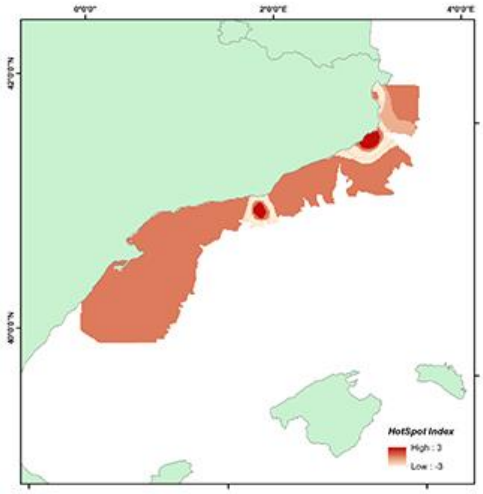
6. Results

Maps of Hot-Spot index in the case study 1.4

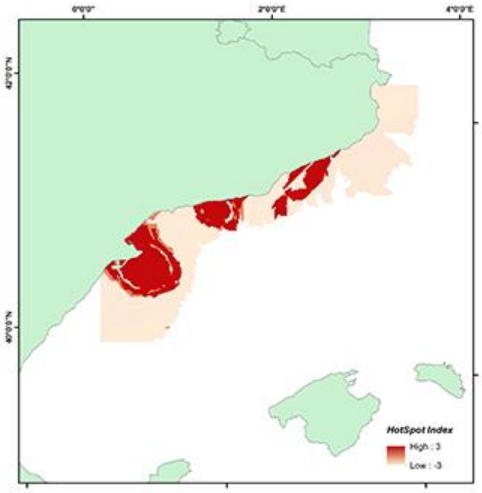
2009



Merluccius merluccius



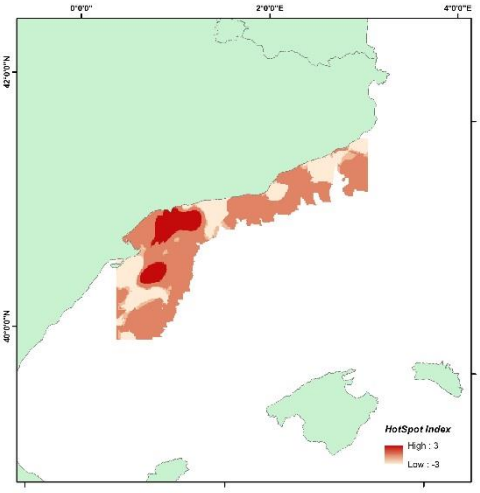
Mullus barbatus



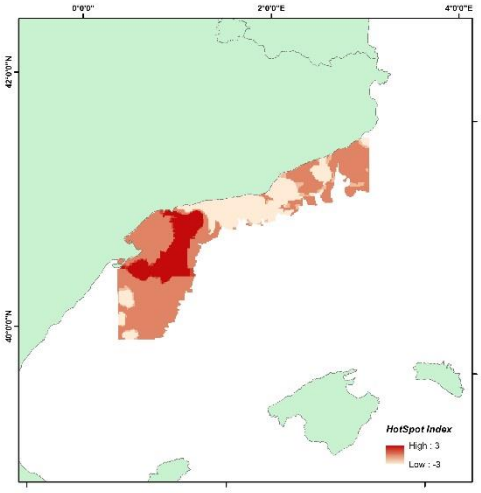
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.4

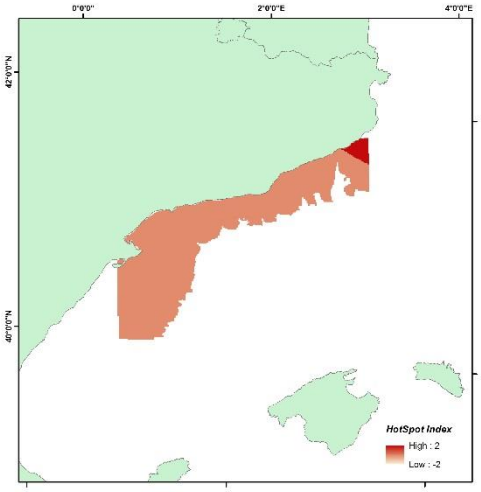
2010



Merluccius merluccius



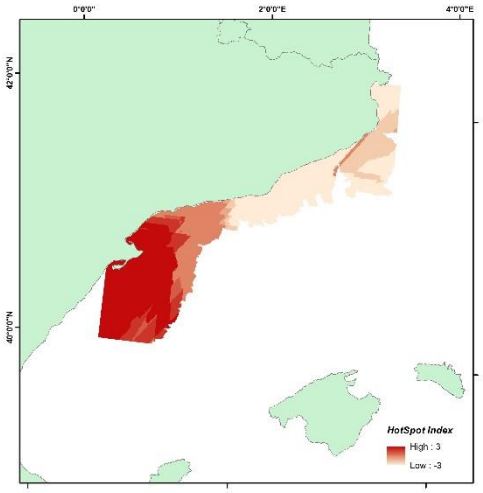
Mullus barbatus



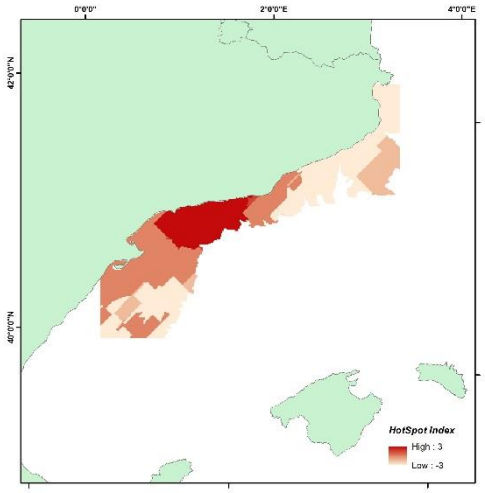
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.4

2011



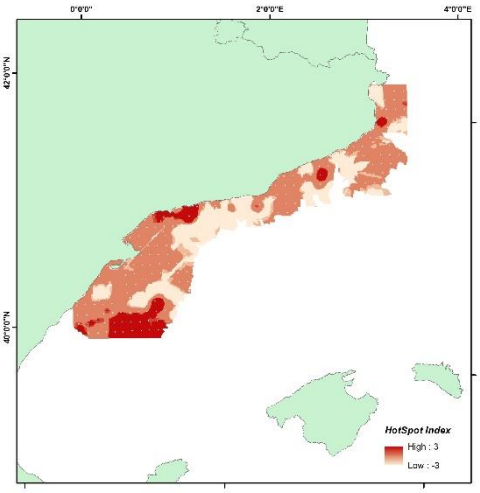
Merluccius merluccius



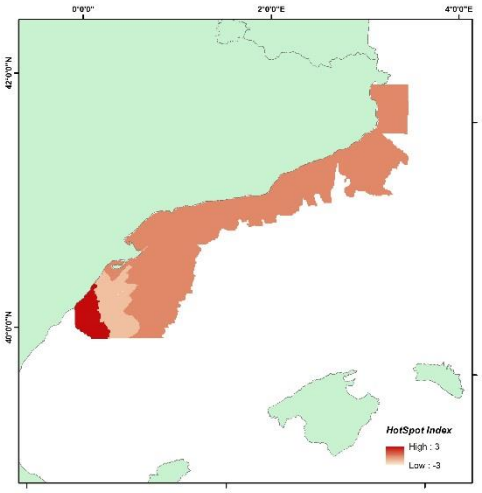
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.4

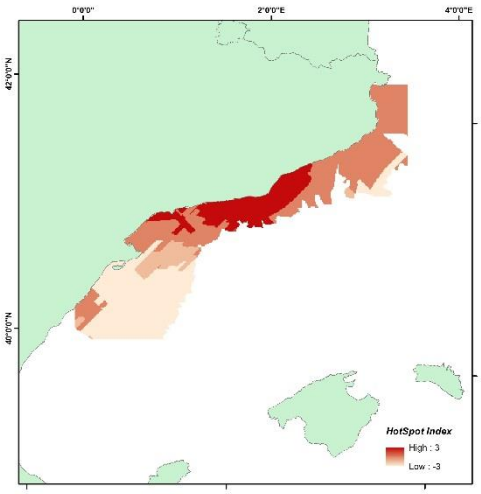
2012



Merluccius merluccius



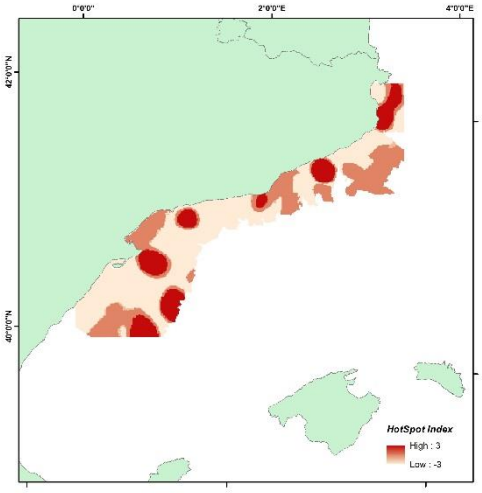
Mullus barbatus



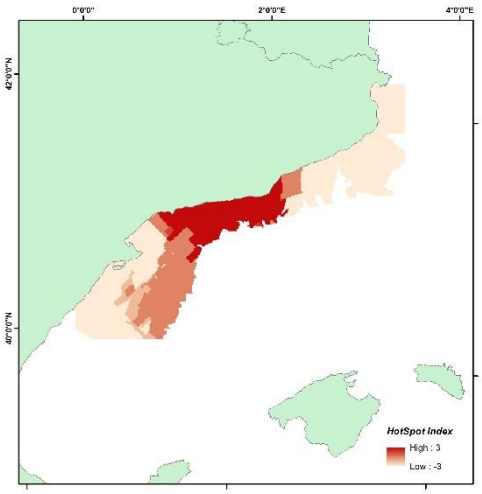
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.4

2013



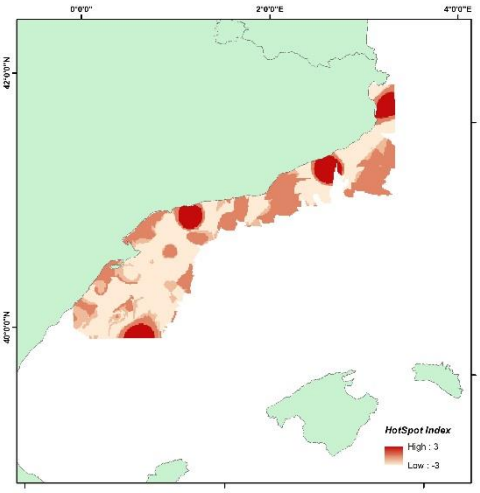
Merluccius merluccius



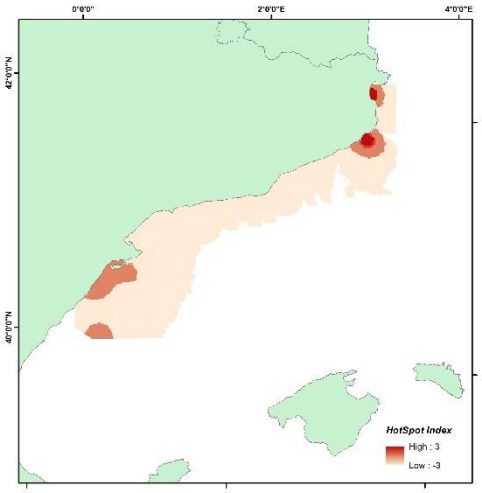
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.4

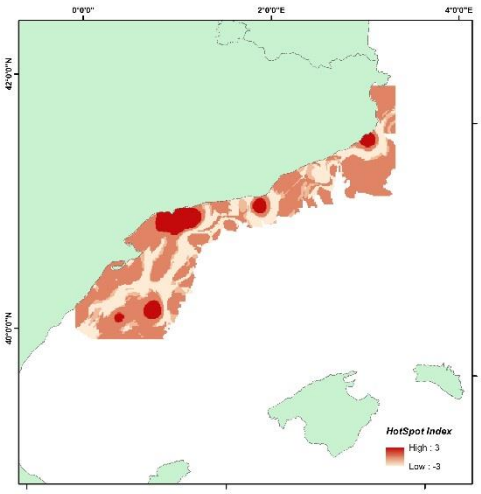
2014



Merluccius merluccius



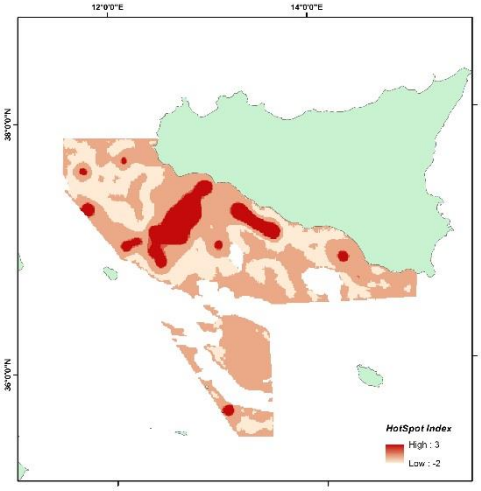
Mullus barbatus



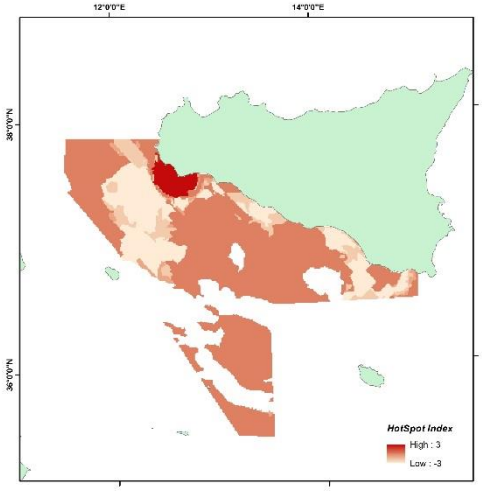
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.5

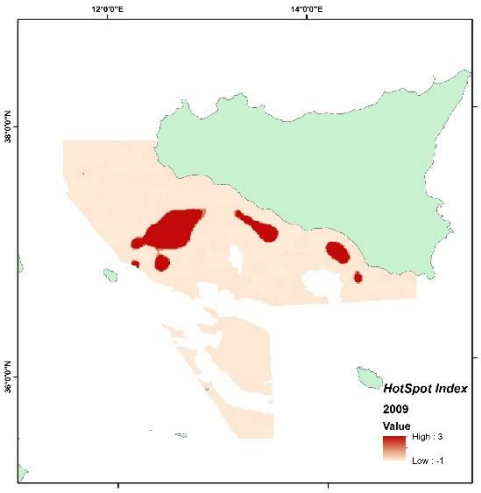
2009



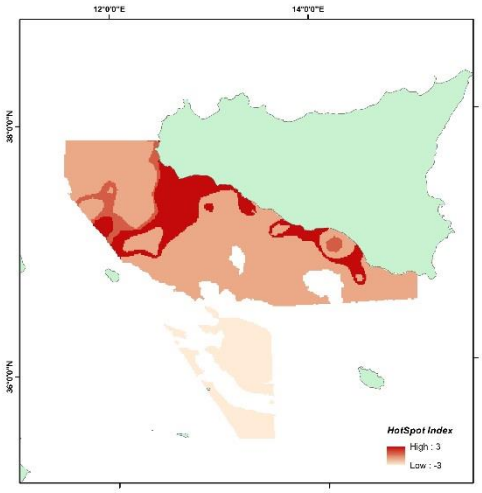
Merluccius merluccius



Mullus barbatus



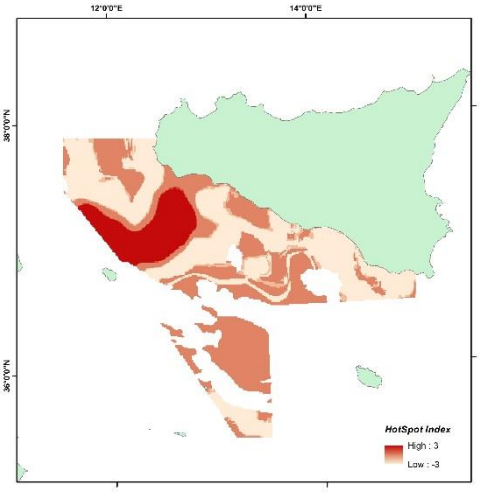
Parapenaeus longirostris



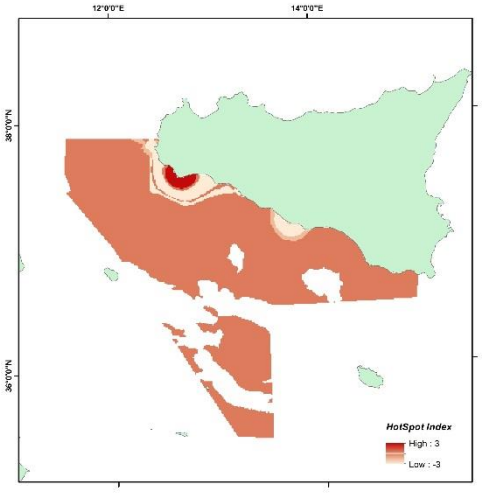
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.5

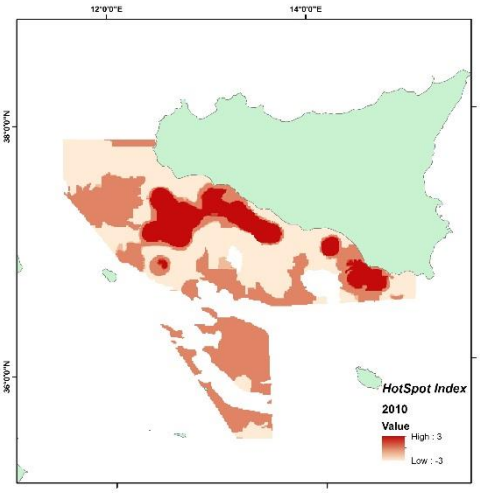
2010



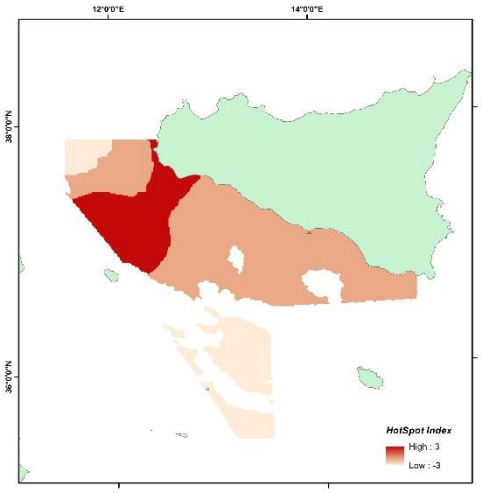
Merluccius merluccius



Mullus barbatus



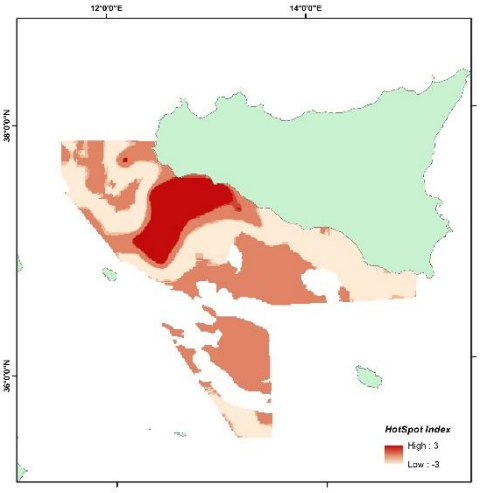
Parapenaeus longirostris



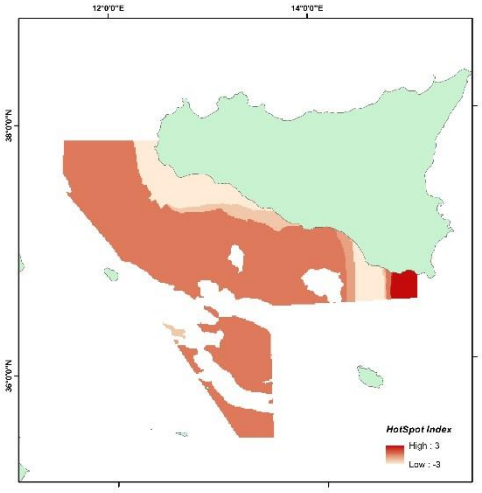
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.5

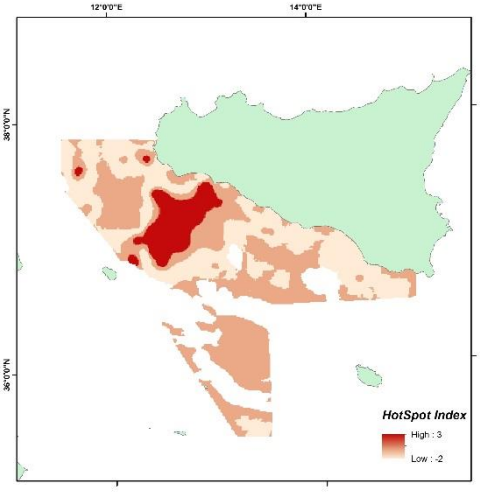
2011



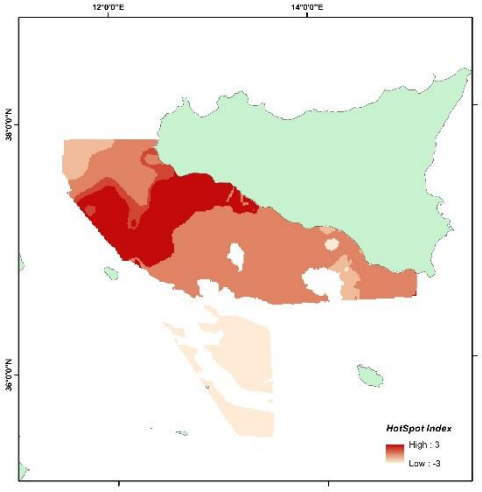
Merluccius merluccius



Mullus barbatus



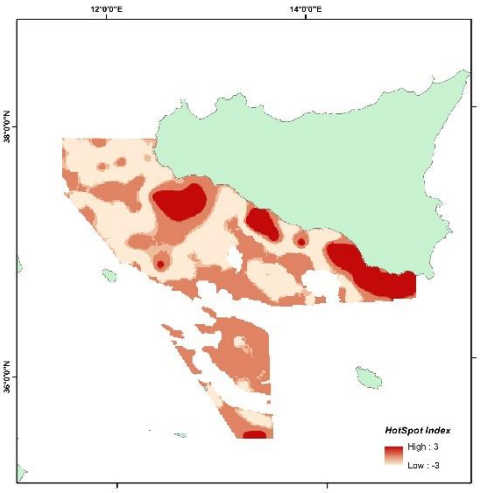
Parapenaeus longirostris



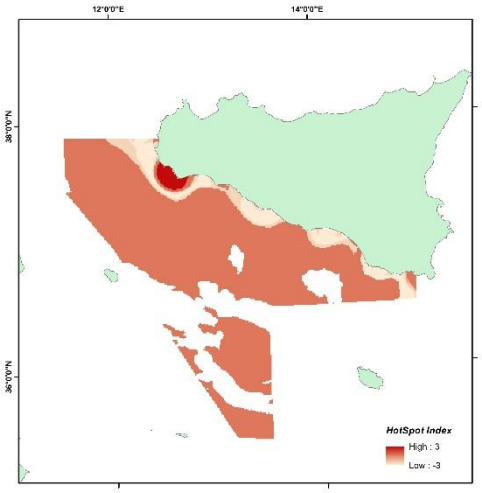
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.5

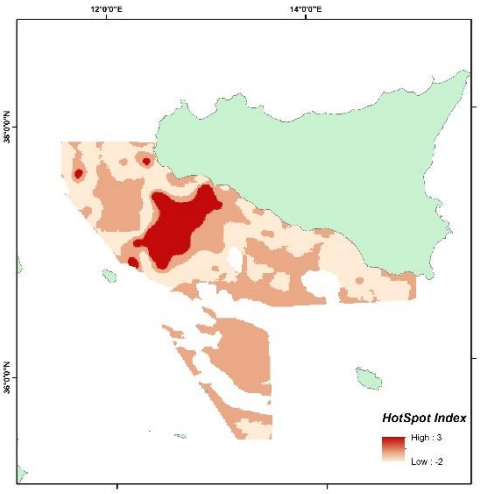
2012



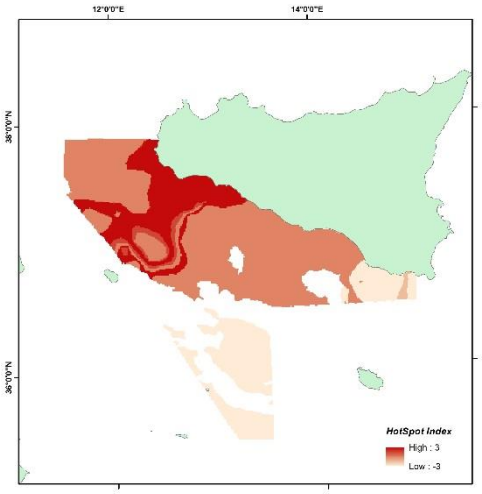
Merluccius merluccius



Mullus barbatus



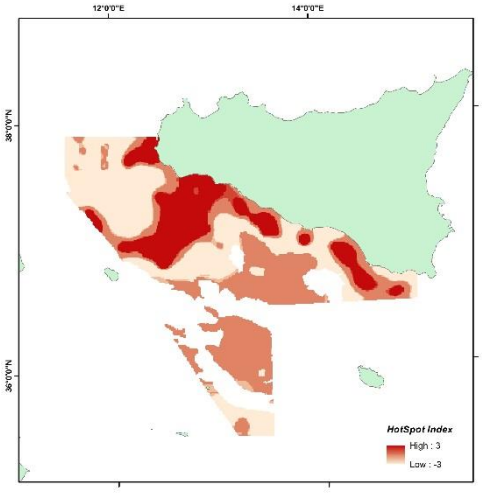
Parapenaeus longirostris



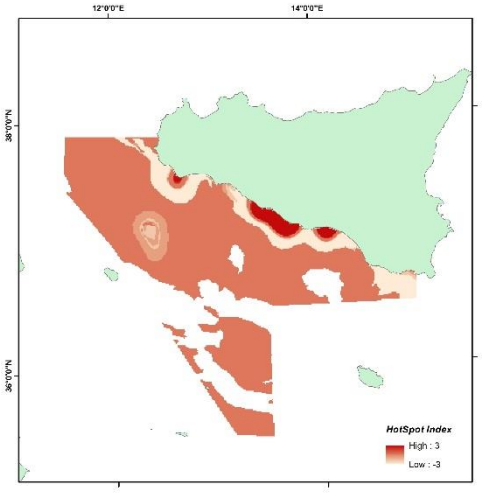
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.5

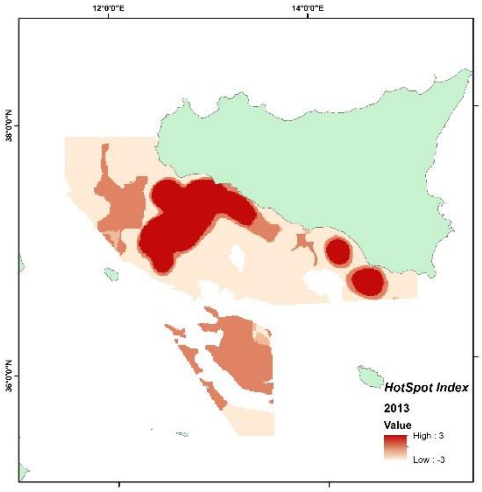
2013



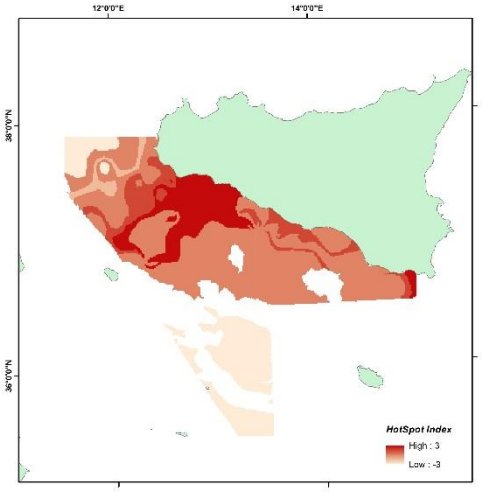
Merluccius merluccius



Mullus barbatus



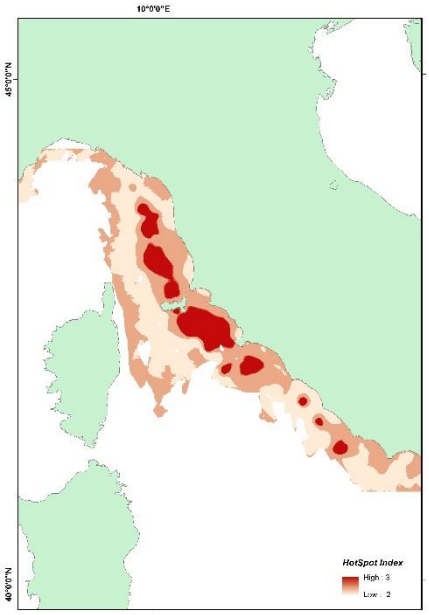
Parapenaeus longirostris



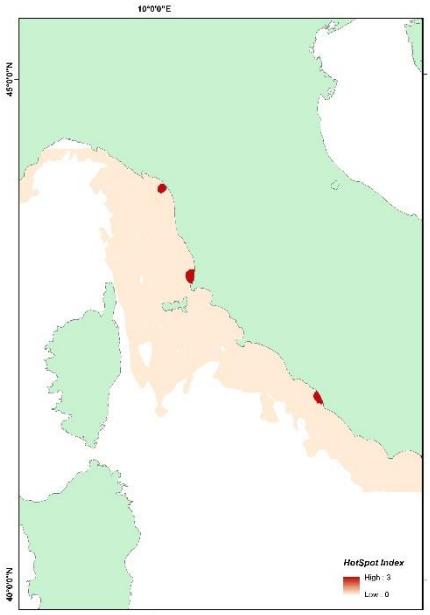
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.6_1.8

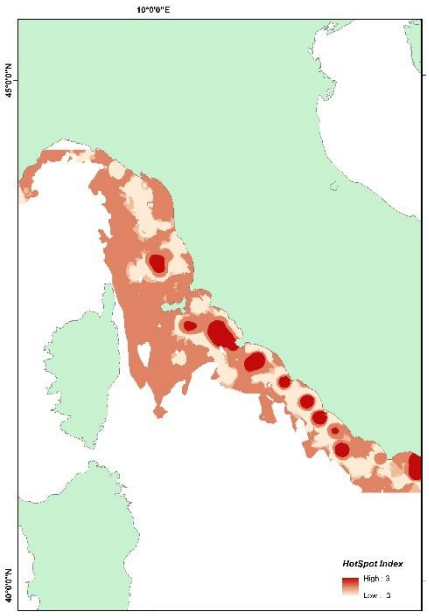
2009



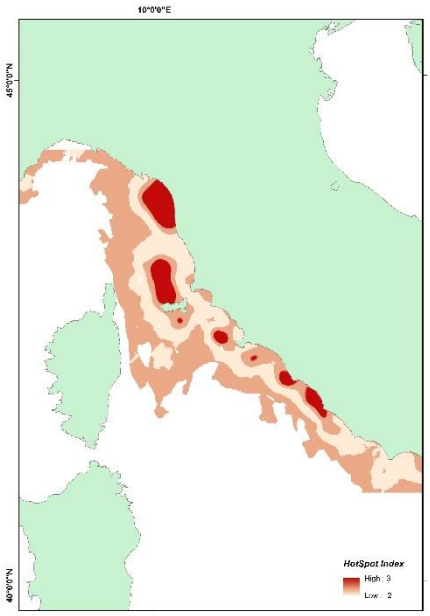
Merluccius merluccius



Mullus barbatus

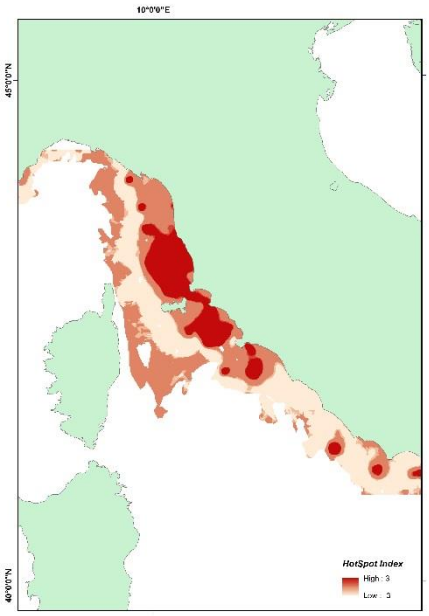


Parapenaeus longirostris

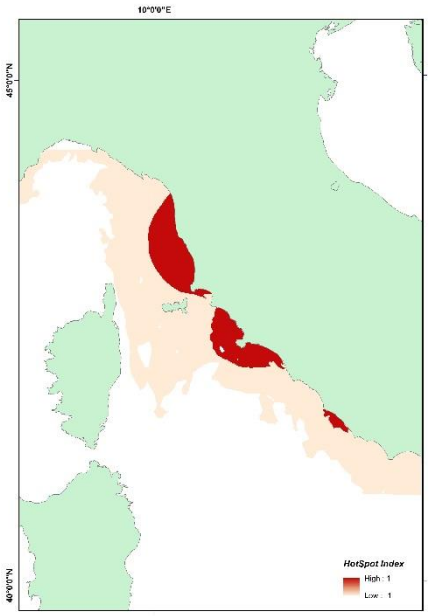


Trachurus trachurus

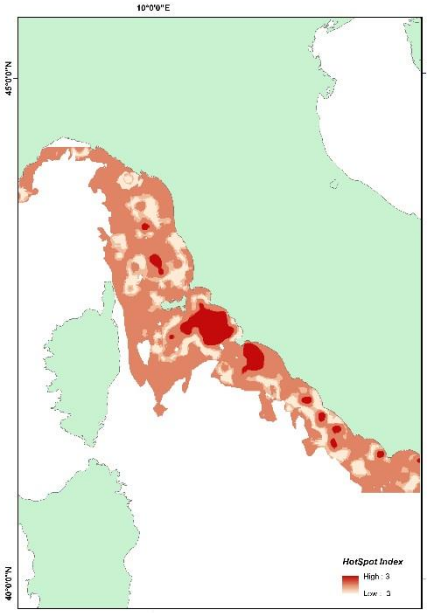
Maps of Hot-Spot index in the case study 1.6_1.8
2010



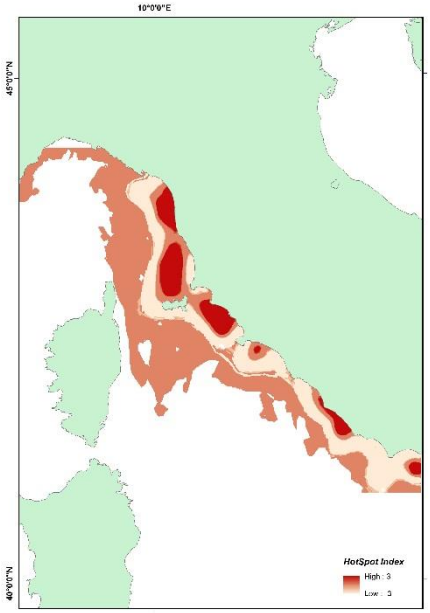
Merluccius merluccius



Mullus barbatus



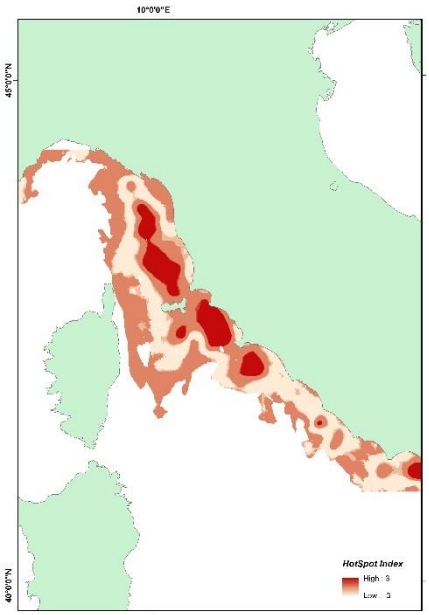
Parapenaeus longirostris



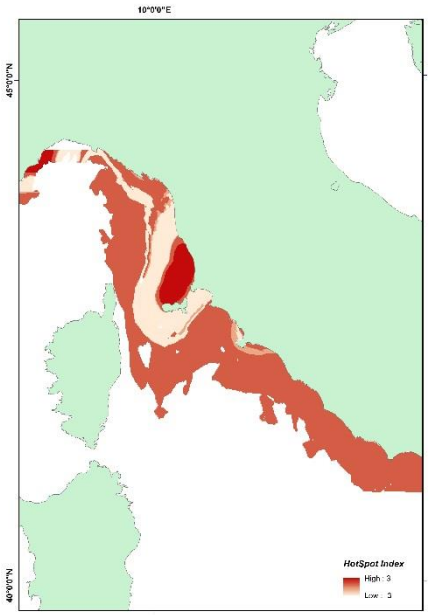
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.6_1.8

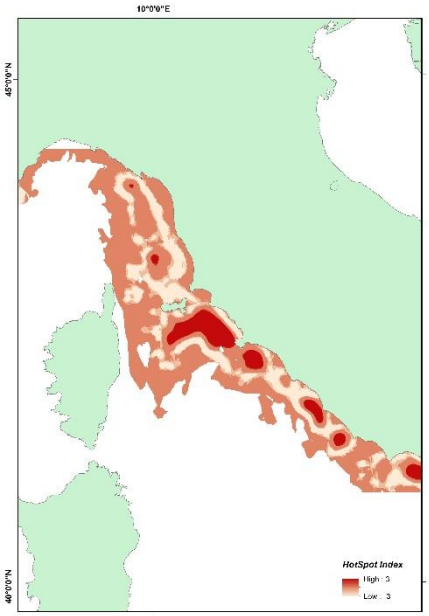
2011



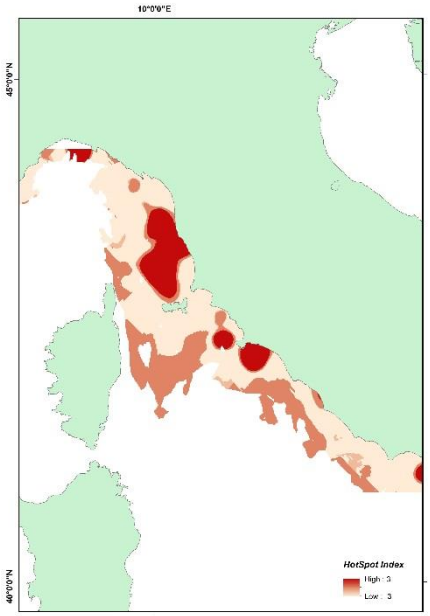
Merluccius merluccius



Mullus barbatus



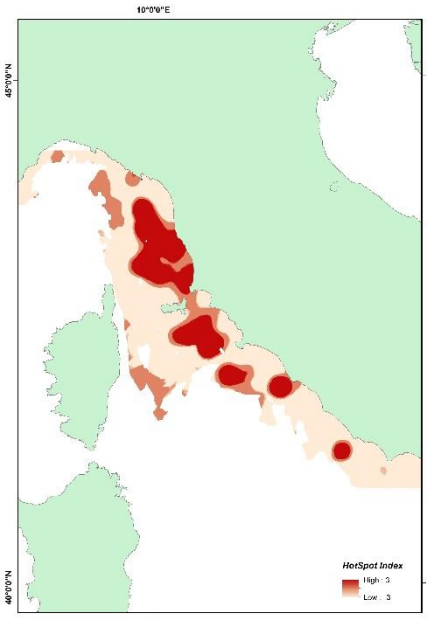
Parapenaeus longirostris



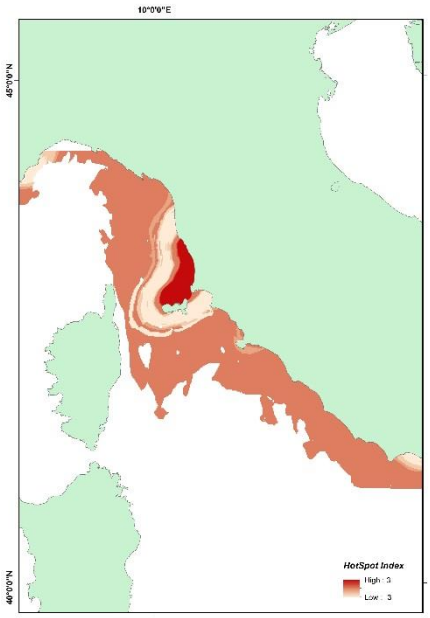
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.6_1.8

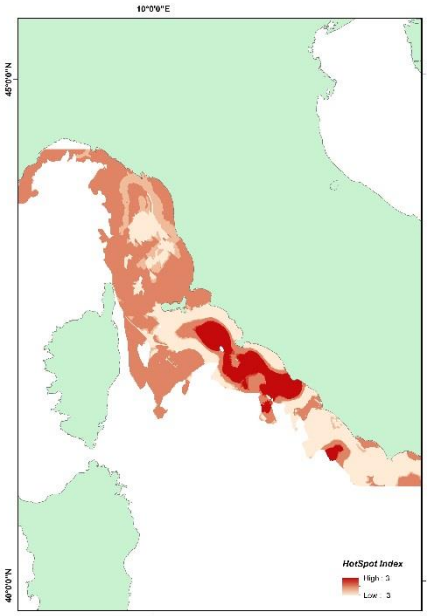
2012



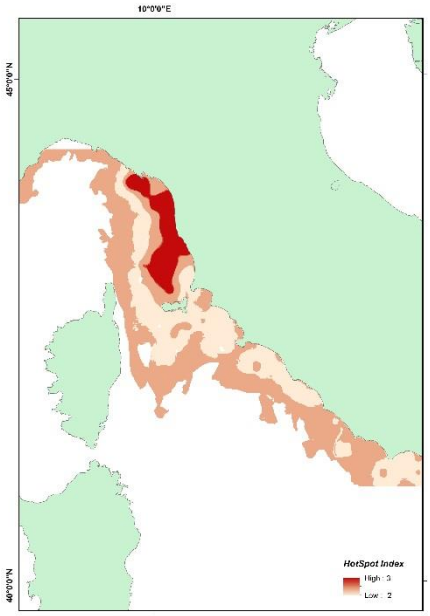
Merluccius merluccius



Mullus barbatus



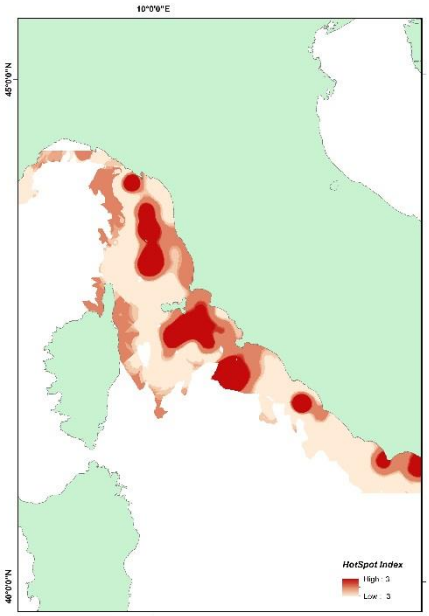
Parapenaeus longirostris



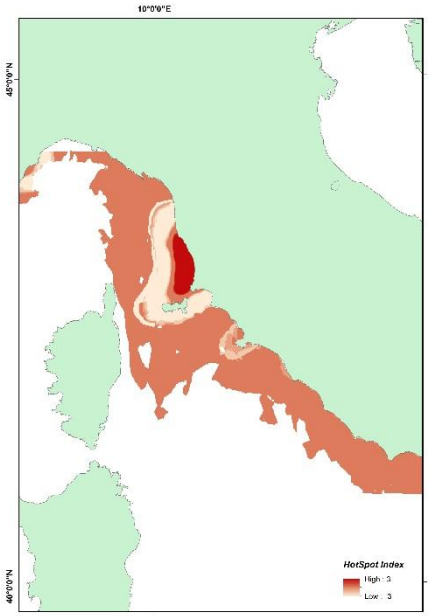
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.6_1.8

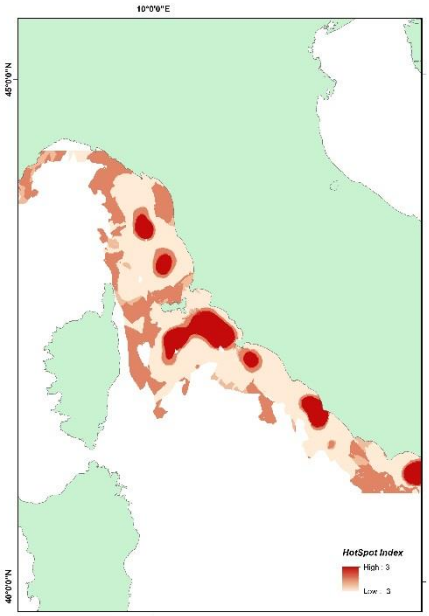
2013



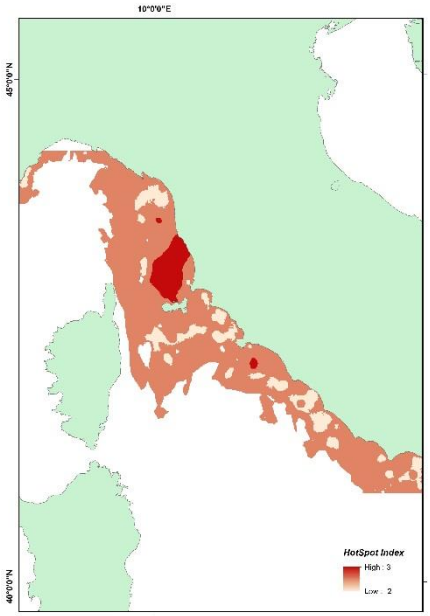
Merluccius merluccius



Mullus barbatus



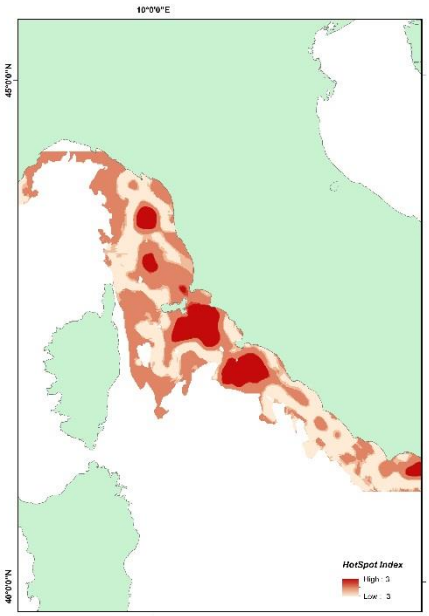
Parapenaeus longirostris



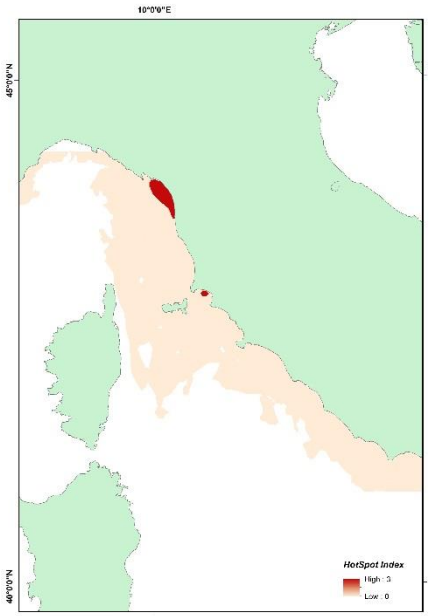
Trachurus trachurus

Maps of Hot-Spot index in the case study 1.6_1.8

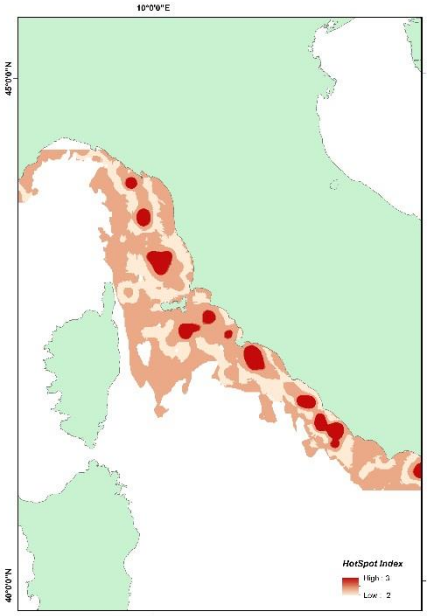
2014



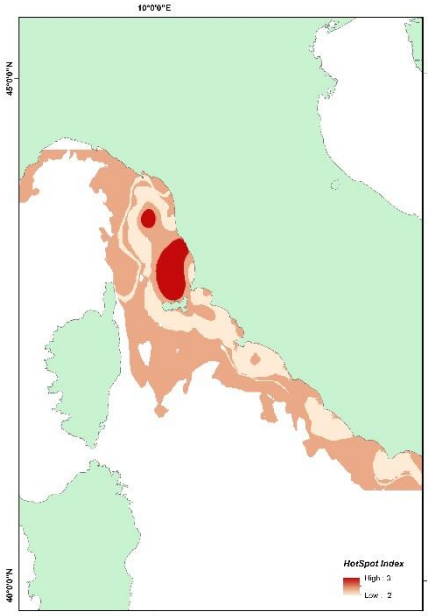
Merluccius merluccius



Mullus barbatus

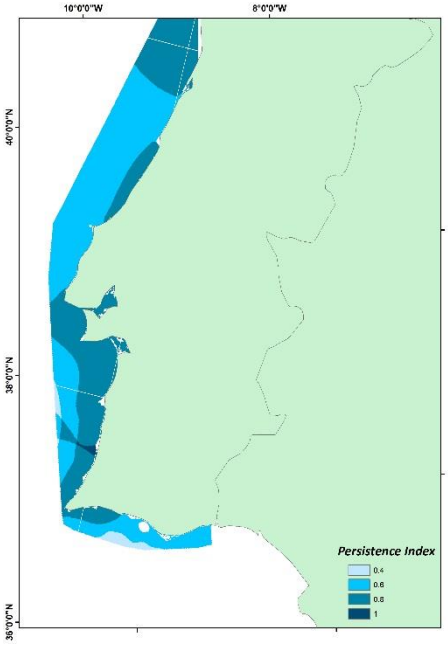


Parapenaeus longirostris

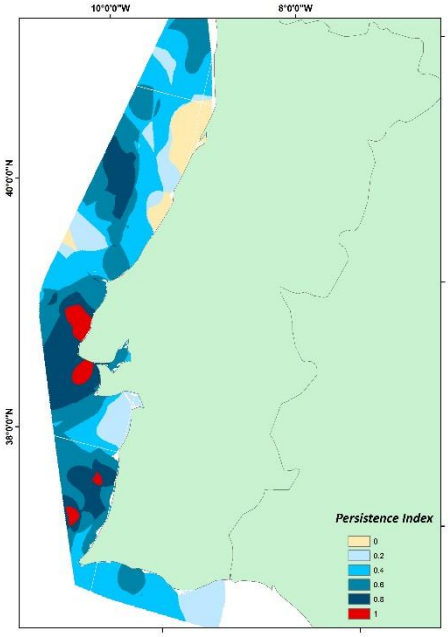


Trachurus trachurus

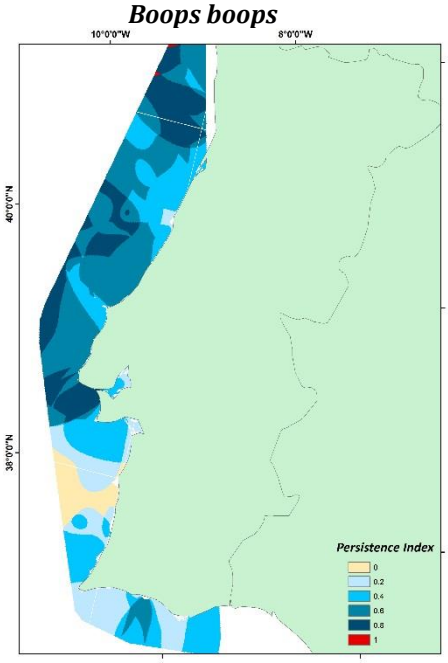
Maps of persistence index in the case study 1.2



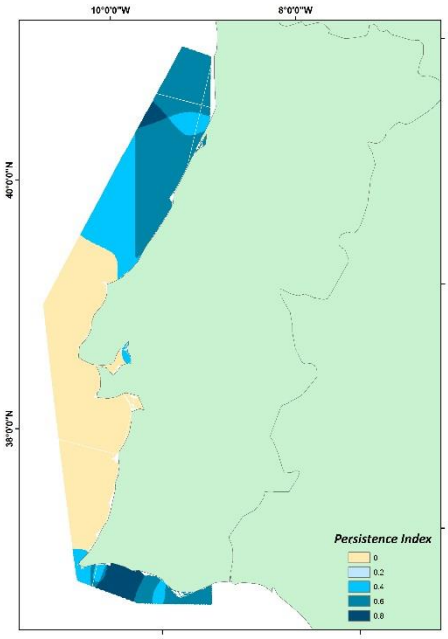
Boops boops



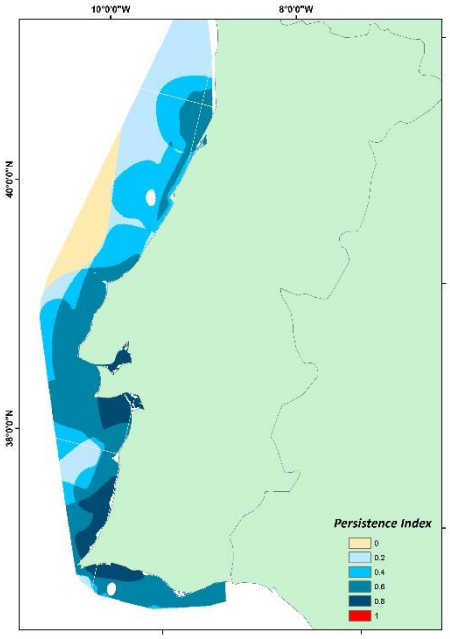
Merluccius merluccius



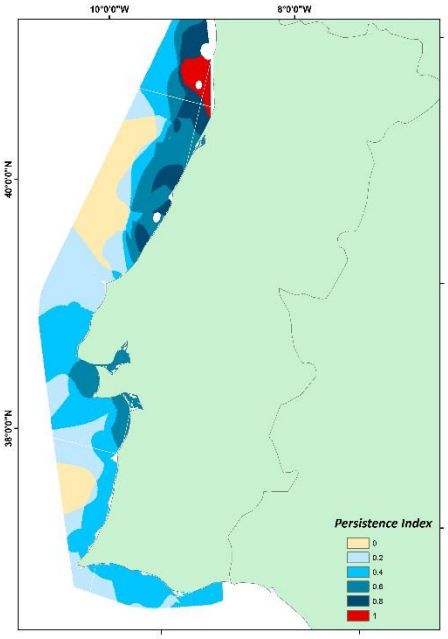
Micromesistius poutassou



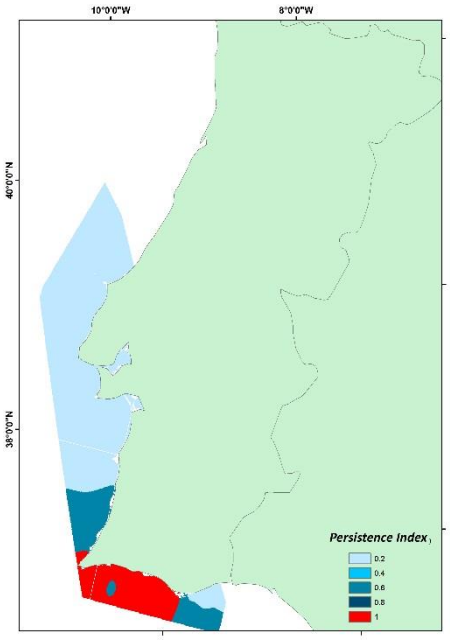
Mullus spp.



Scomber colias

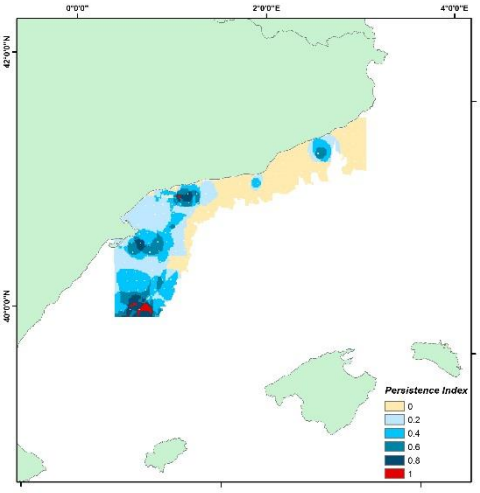


Trachurus spp.

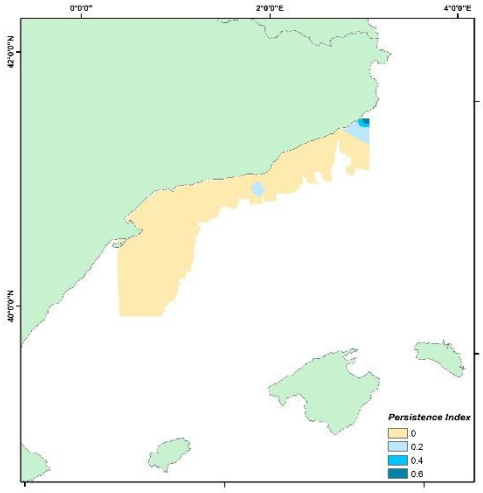


Parapenaeus longirostris

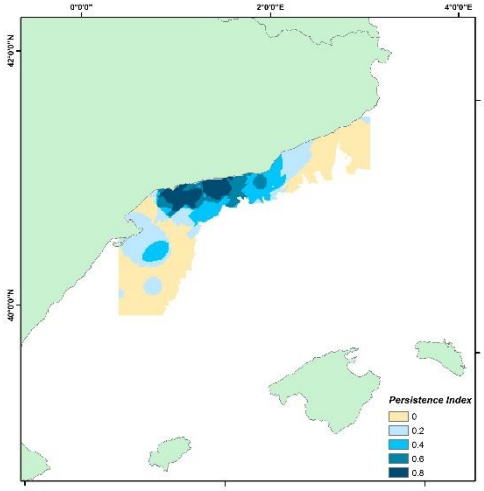
Maps of persistence index in the case study 1.4



Merluccius merluccius

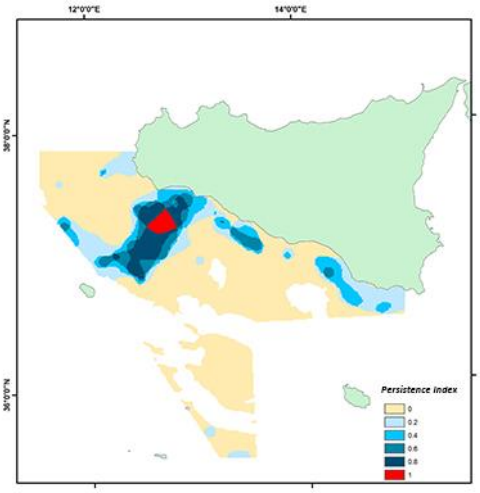


Mullus barbatus

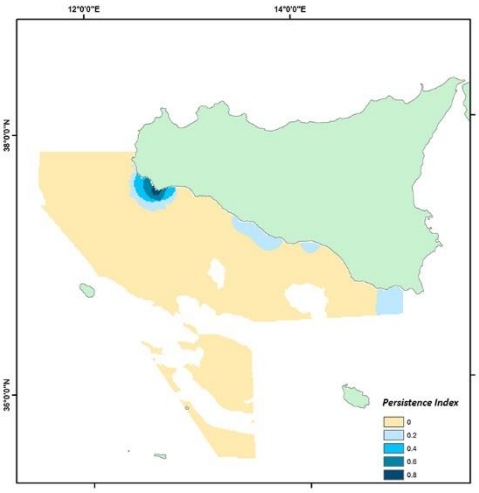


Trachurus trachurus

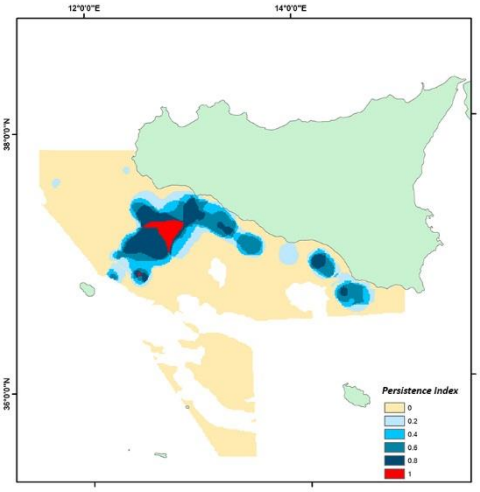
Maps of persistence index in the case study 1.5



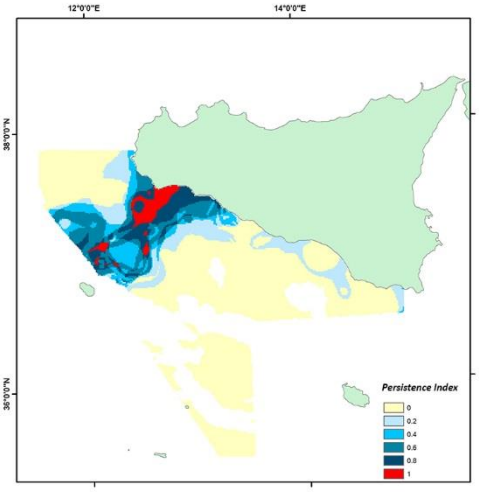
Merluccius merluccius



Mullus barbatus

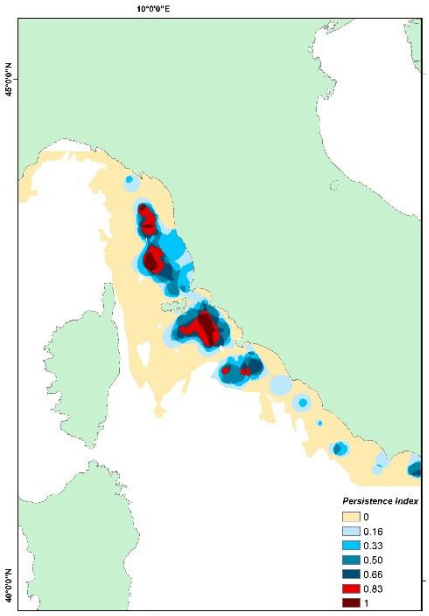


Parapenaeus longirostris

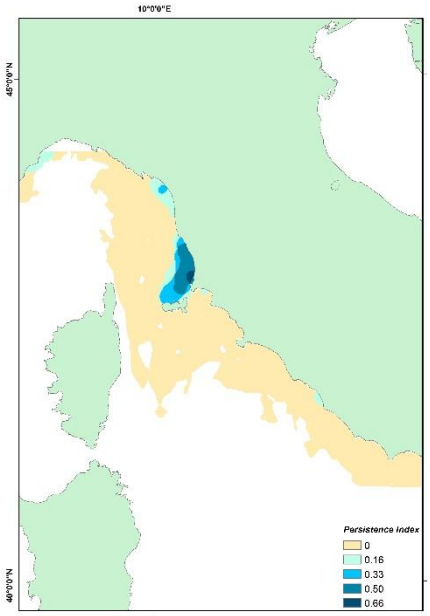


Trachurus trachurus

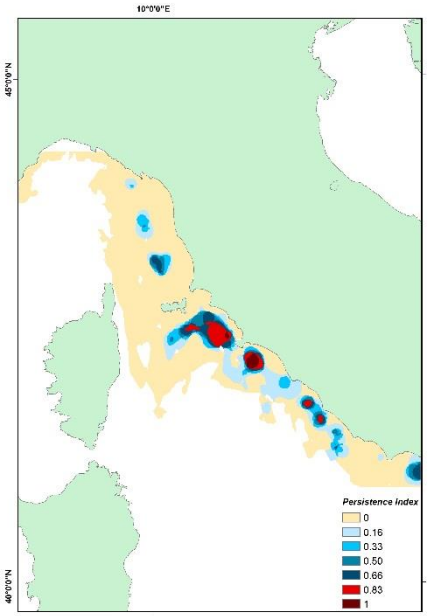
Maps of persistence index in the case study 1.6_1.8



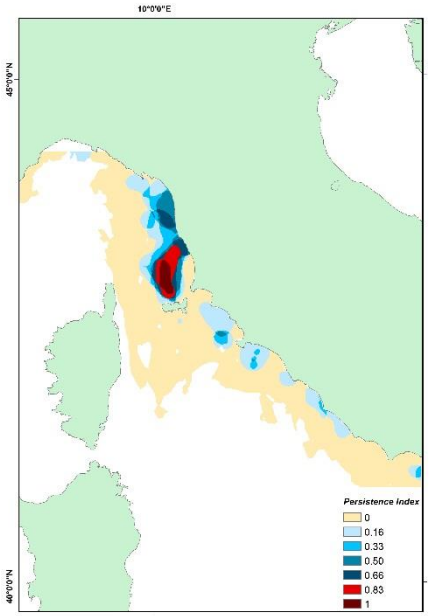
Merluccius merluccius



Mullus barbatus

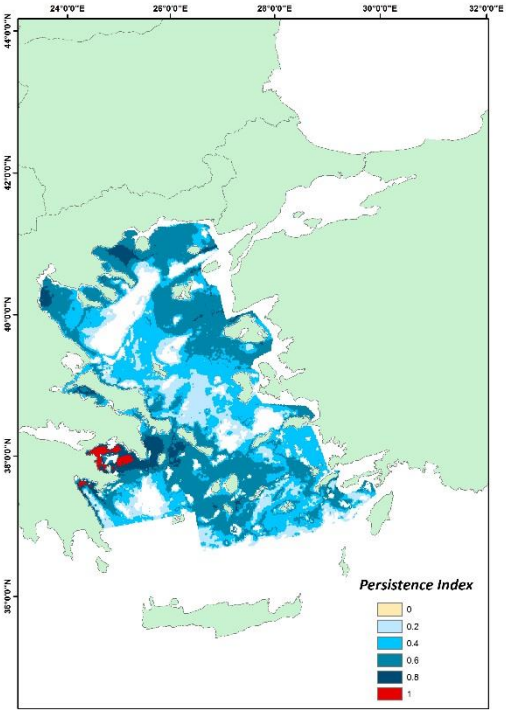


Parapenaeus longirostris

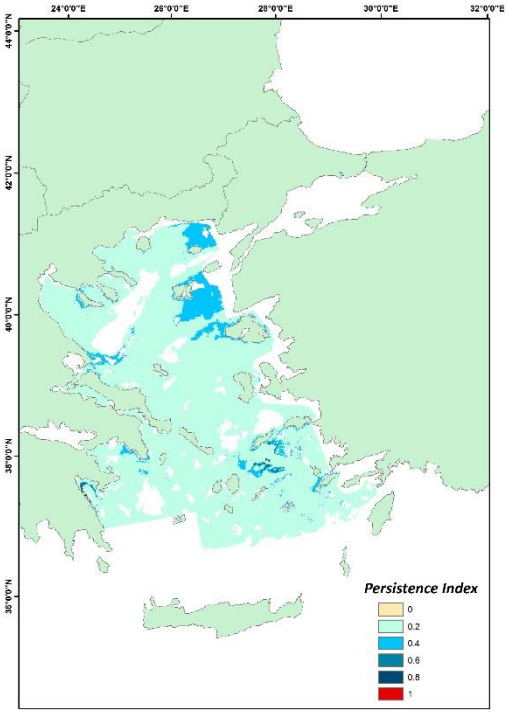


Trachurus trachurus

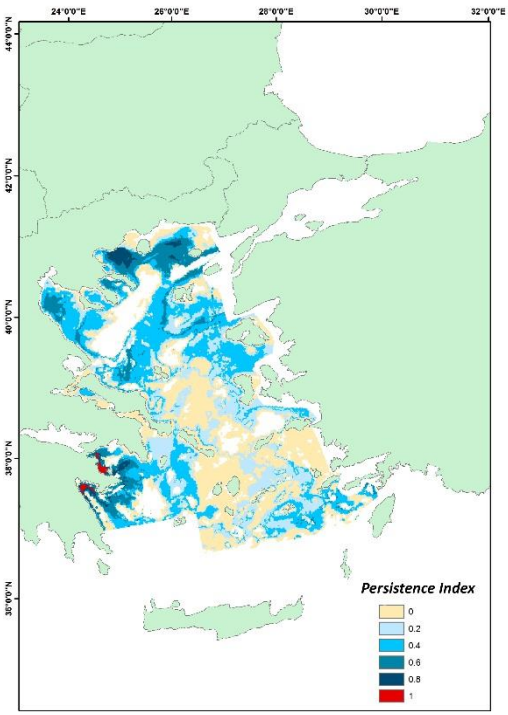
Maps of persistence index in the case study 1.7



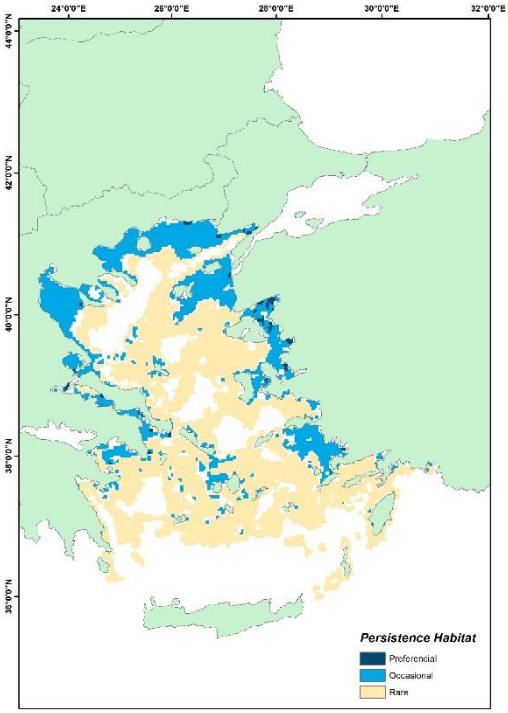
Merluccius merluccius



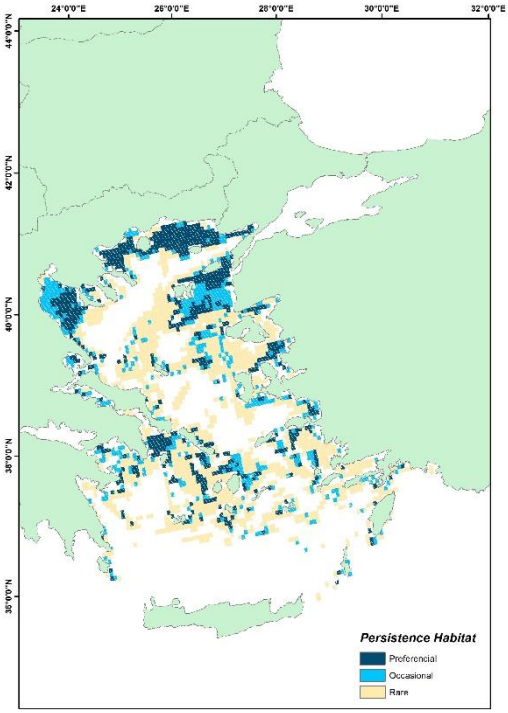
Mullus barbatus



Parapenaeus longirostris



Trachurus mediterraneus



Trachurus trachurus

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