

**Model-derived maps of EFH and SH for selected Priority species projects**

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## 1 - Information from JRC Fish Habitat

A Joint Research Centre institutional activity, aimed at the identification of the daily habitat of key marine species, mainly fish of market value, using satellite-derived data of the sea surface, in support of the management and control of fisheries and the implementation of spatial protection measures.

Source: EC – Joint Research Centre – jean-noel.druon@ec.europa.eu

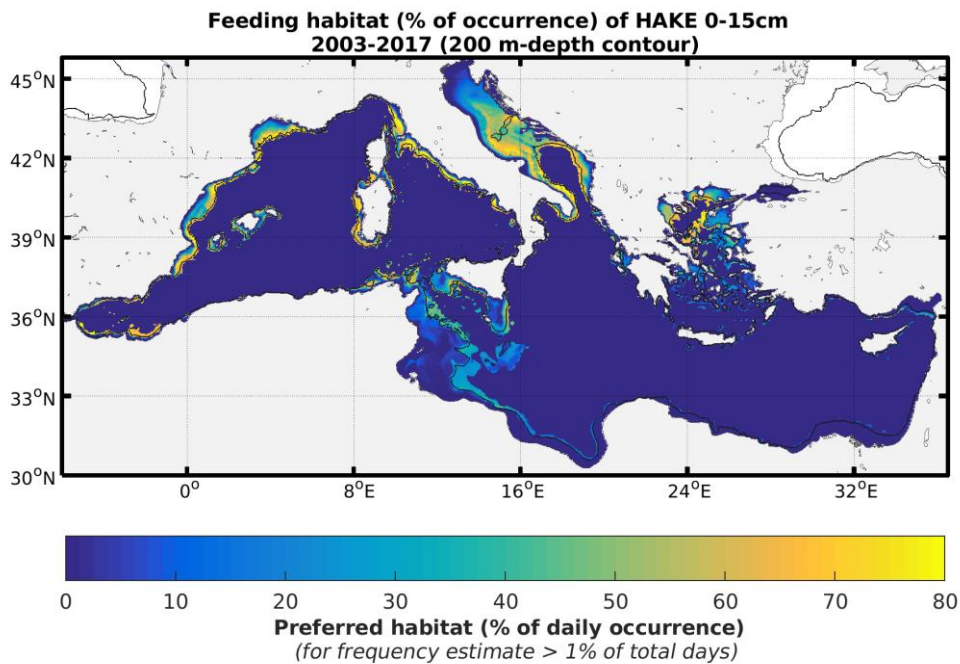
*Modelling method:* Deterministic Ecological Niche Modelling

The JRC habitat model uses satellite data of surface chlorophyll content (CHL) from NASA sensors, i.e. SeaWiFS (1998-2010) and MODIS-Aqua (since July 2002) to compute daily habitats.

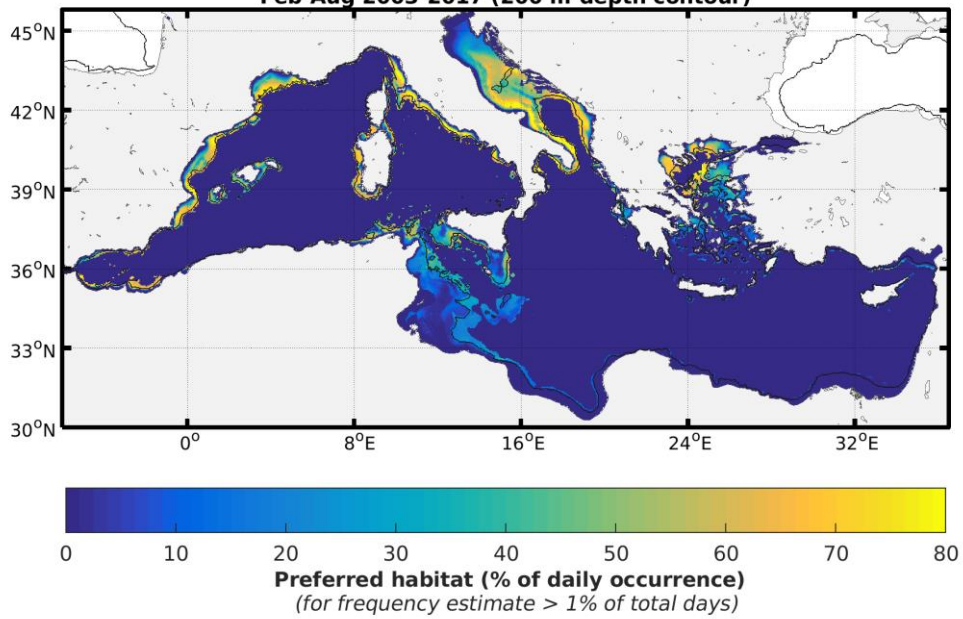
The approach used for mapping the potential habitat relates to the ecological niche modelling (environmental envelope) with specific covariates and parametrisation for each species. Water depth is used for the hake nurseries (maximum depth). The feeding habitat was mainly traced by horizontal changes of surface chlorophyll content created by currents (CHL fronts).

*Reference years:* 2003 – 2017

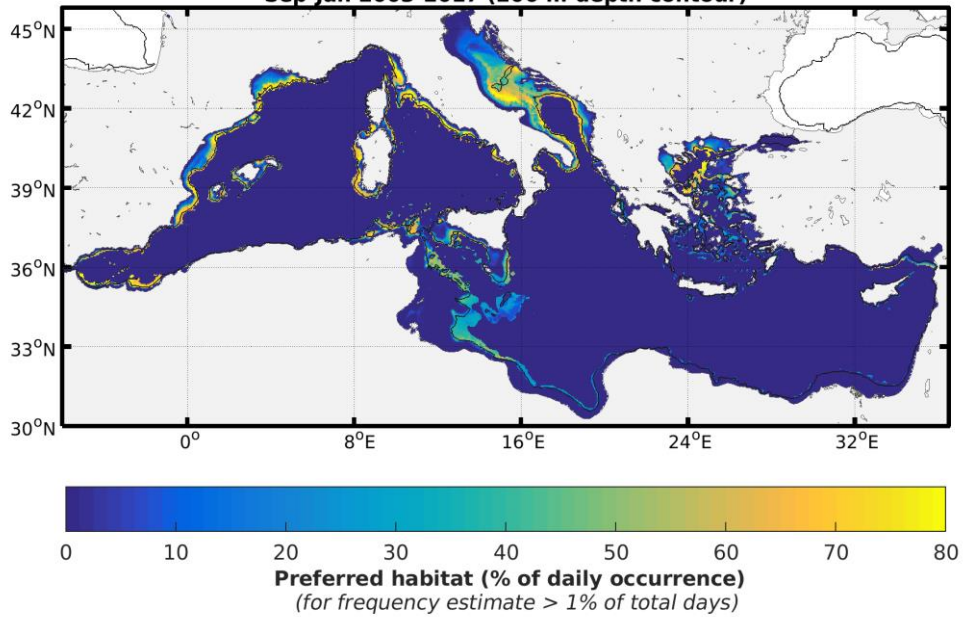
### 1.1 - *Merluccius merluccius* nursery grounds



**Feeding habitat (% of occurrence) of HAKE 0-15cm  
Feb-Aug 2003-2017 (200 m-depth contour)**



**Feeding habitat (% of occurrence) of HAKE 0-15cm  
Sep-Jan 2003-2017 (200 m-depth contour)**



## 2 - Information from MEDISEH Project

A specific contract of the European framework “Marea”, aimed at compiling information for the identification and location of nursery areas and spawning aggregations of the pelagic and demersal species included in the Data Collection Framework for the Mediterranean and subjected to minimum landing size, based on Council Regulation No 1967/2006-Annex II.

Source: Giannoulaki M., A. Belluscio, F. Colloca, S. Frascchetti, M. Scardi, C. Smith, P. Panayotidis, V. Valavanis M.T. Spedicato (eds.) (2013). Mediterranean Sensitive Habitats. DG MARE Specific Contract SI2.600741, Final Report, 557 p.

*Modelling method:* Generalized Additive Models

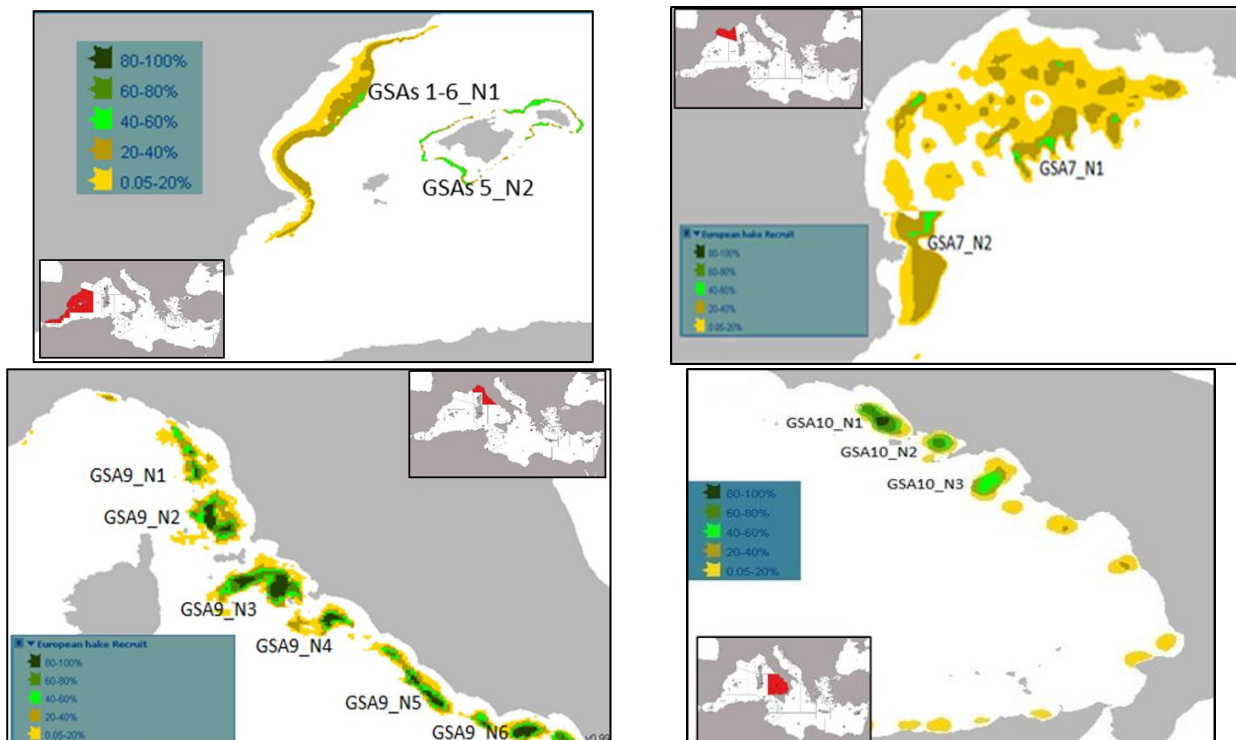
Regarding the demersal species, as most of the factors changed significantly across species and areas, different regression approaches (e.g. GAM, GAMM, applications for zero inflated data sets such as COZIGAM and ZIGAM) have been adopted as main methods for modelling the spatial distribution of the target species. Classical geostatistical approaches, such as kriging, eventually in a simplified Bayesian framework (e.g. INLA approach) have been adopted as an alternative approach in the case of failure of regression methods or in combination with them.

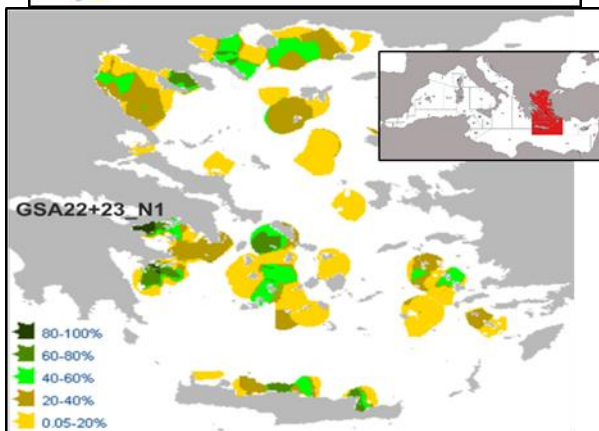
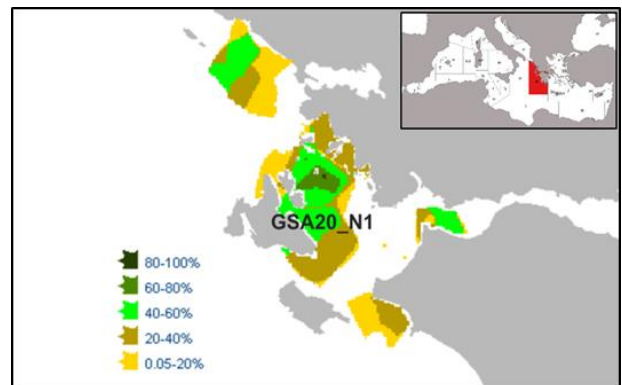
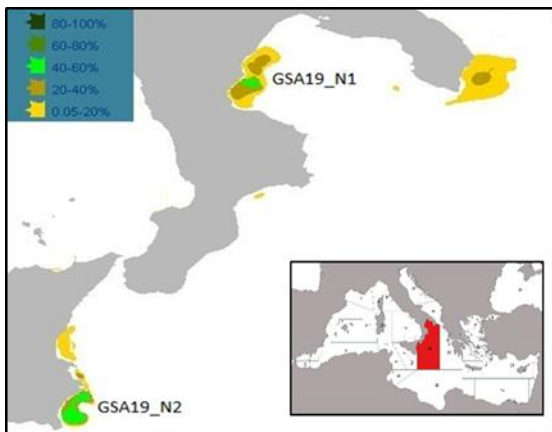
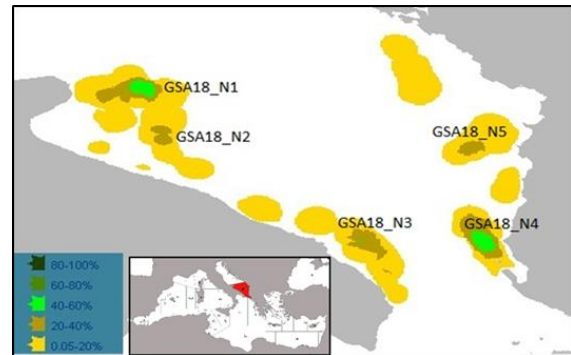
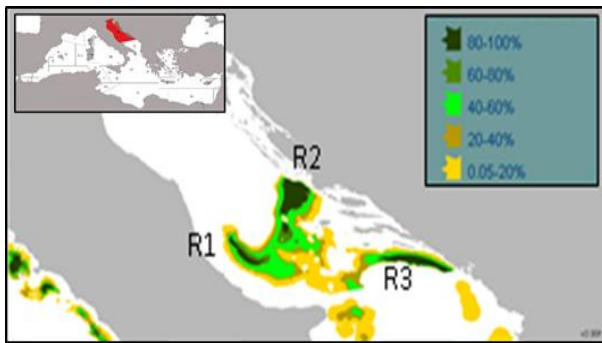
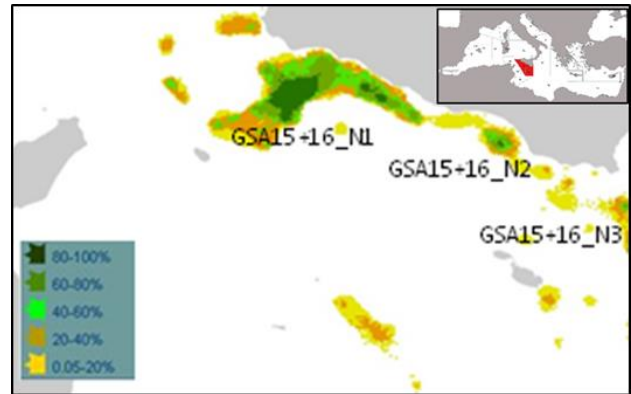
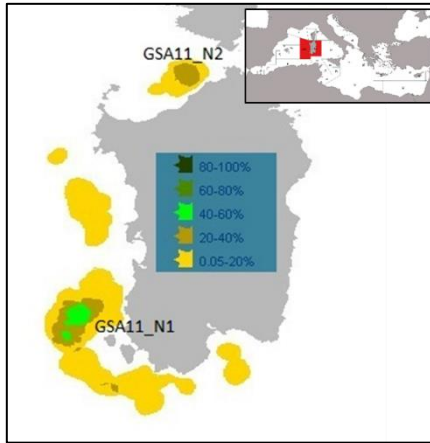
Concerning the small pelagic species, Generalized Additive Models were applied to define the set of environmental factors (satellite environmental data as well as bottom depth) that described the distribution of each species in the study areas. The selection of the GAMs smoothing predictors was done using the ‘MGCV’ library in the R statistical software. For *Scomber colias*, the Maximum Entropy Models (MAXENT) was applied due to the very small number of available presence data that made other statistical approaches not suitable to apply.

*Reference years:* 2003 – 2013 (unless specified)

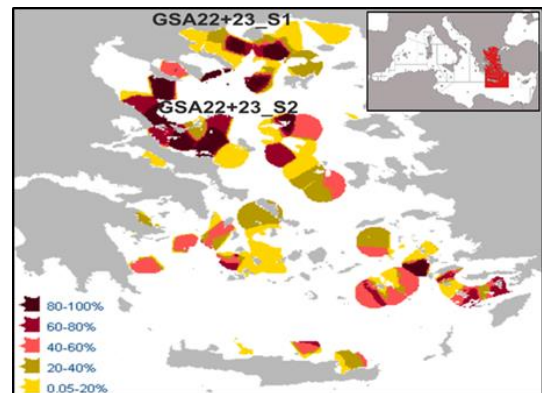
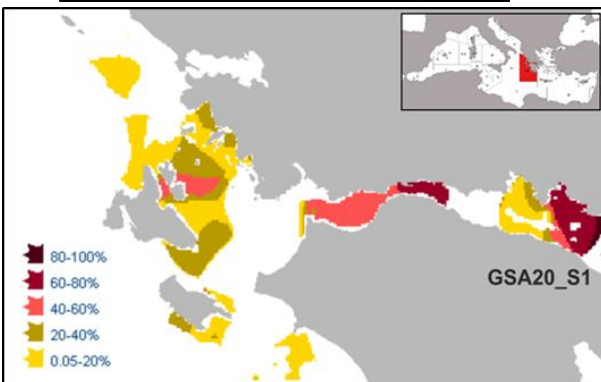
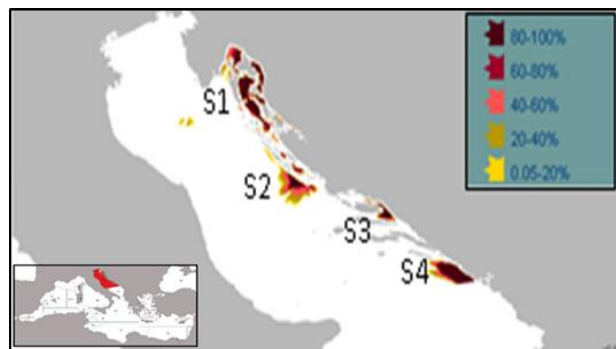
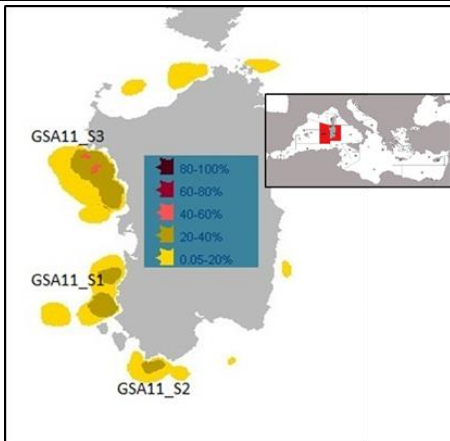
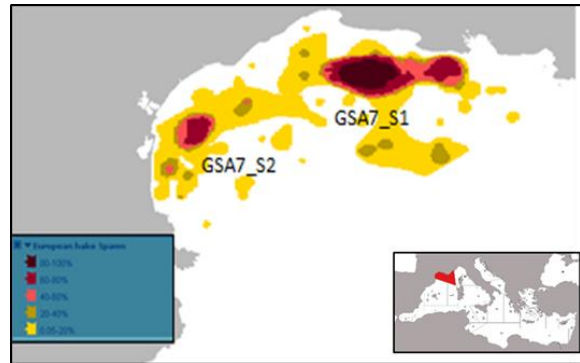
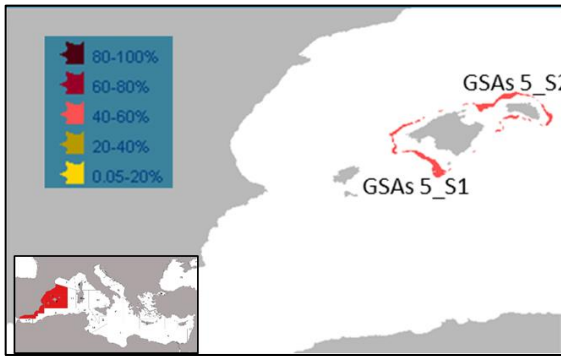
### Priority species - Demersals

#### 2.1 - *Merluccius merluccius* nursery grounds



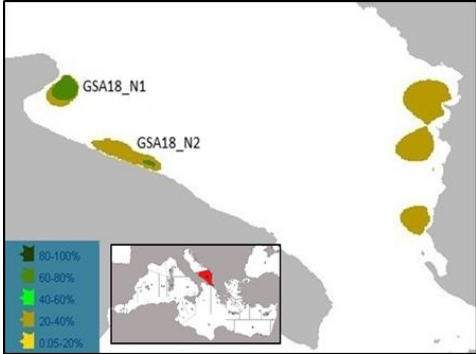


## 2.2 - *Merluccius merluccius* spawning grounds

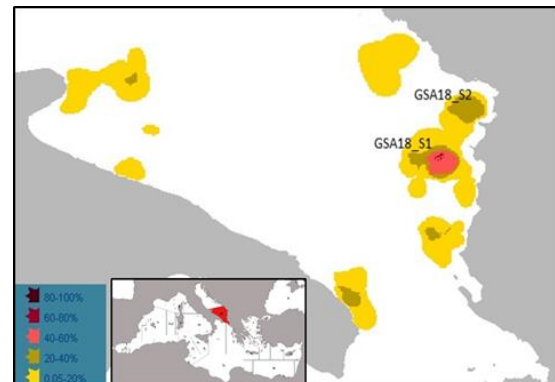
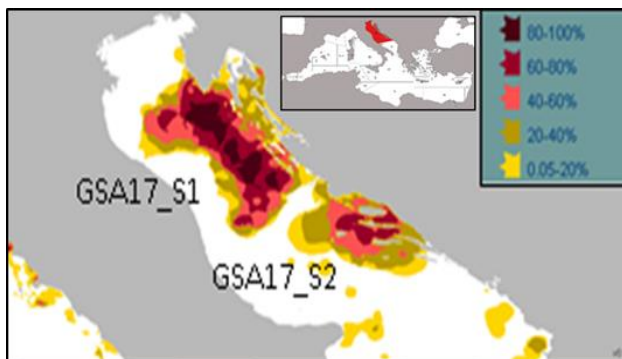
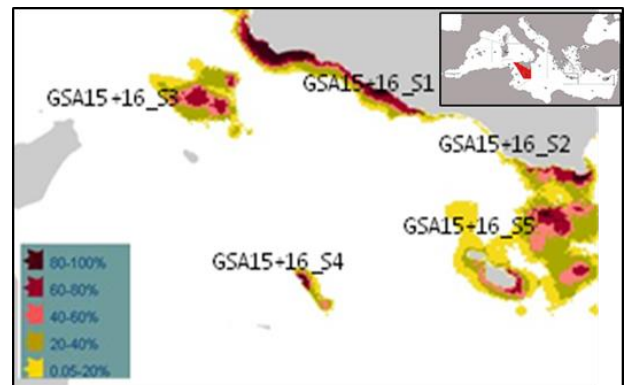
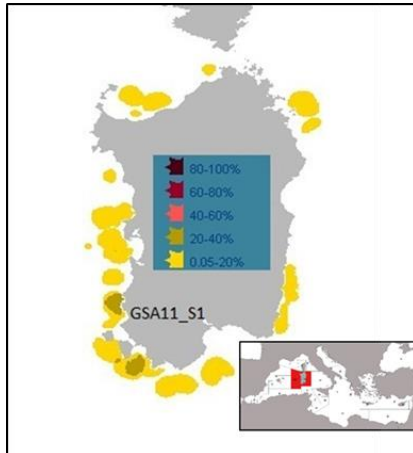
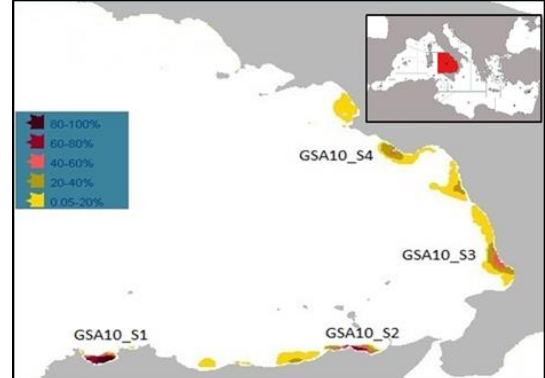
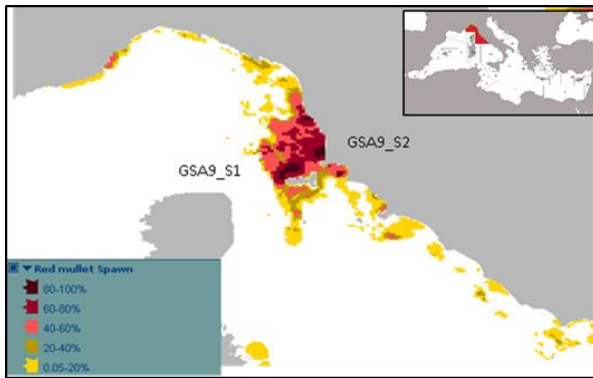
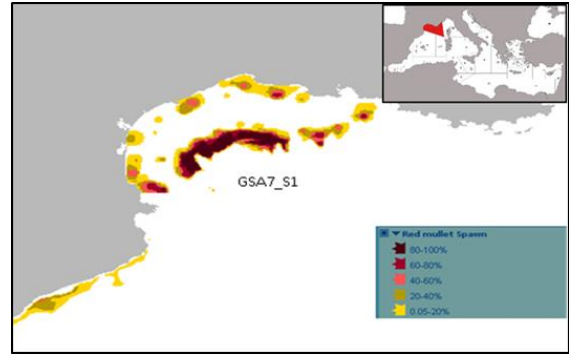
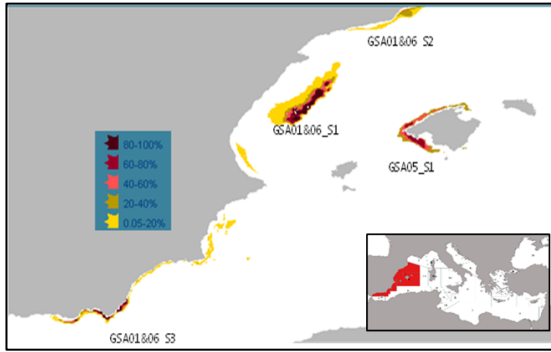


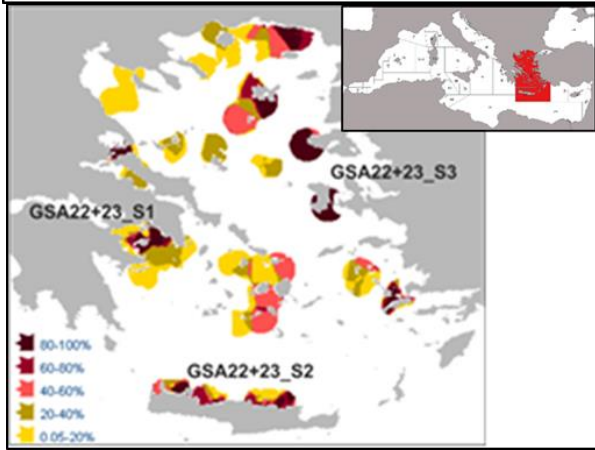
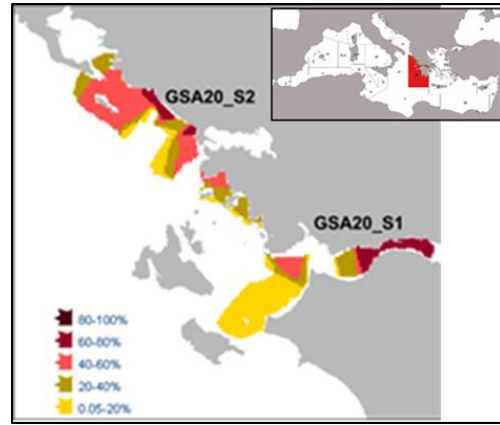
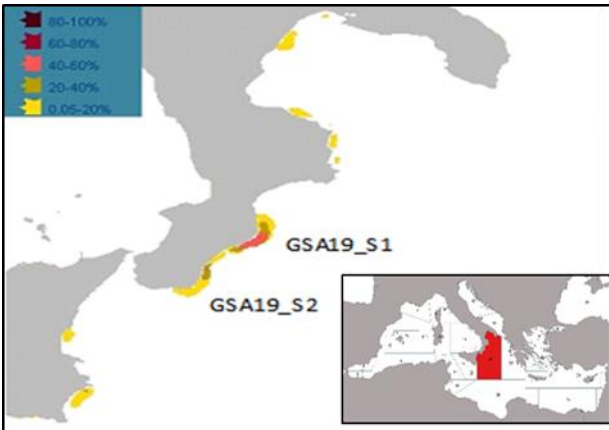


2.3 - *Mullus barbatus* nursery grounds

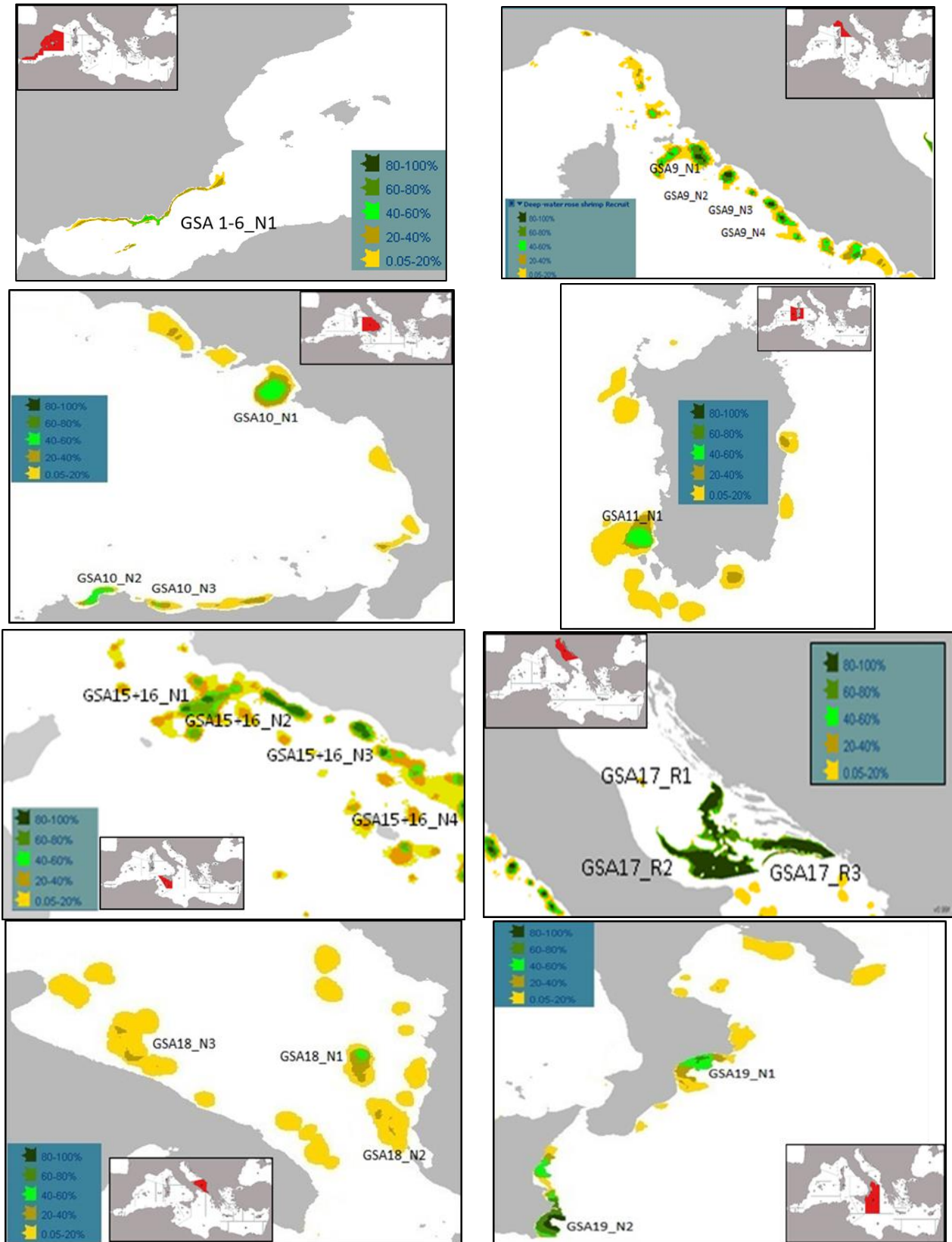


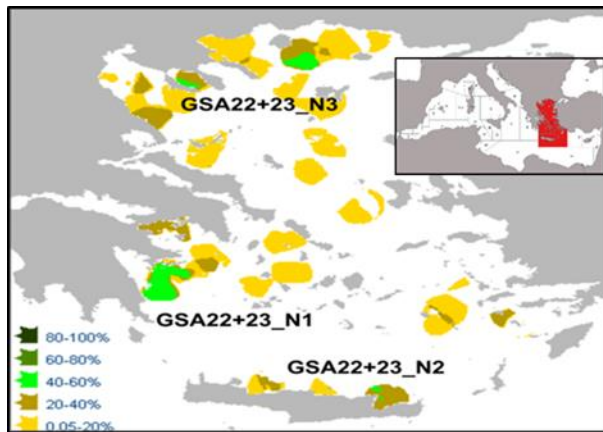
## 2.4 - *Mullus barbatus* spawning grounds



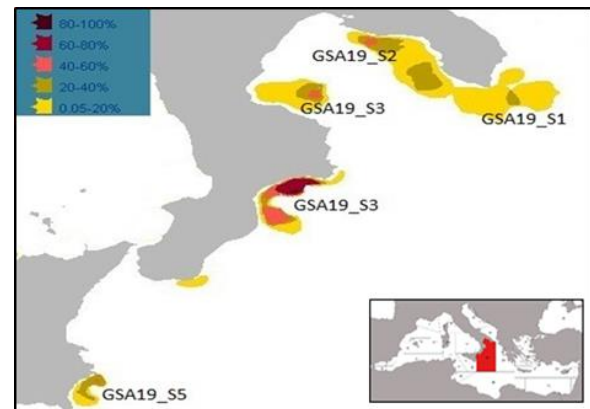
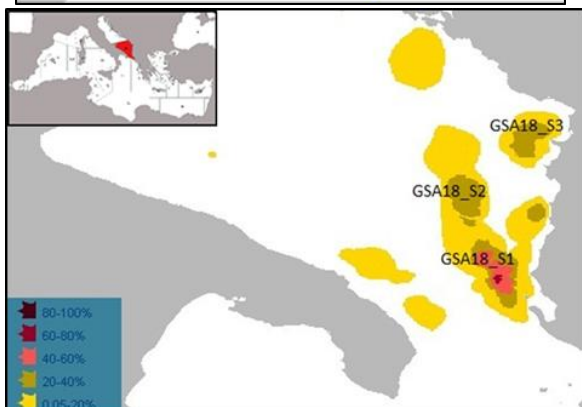
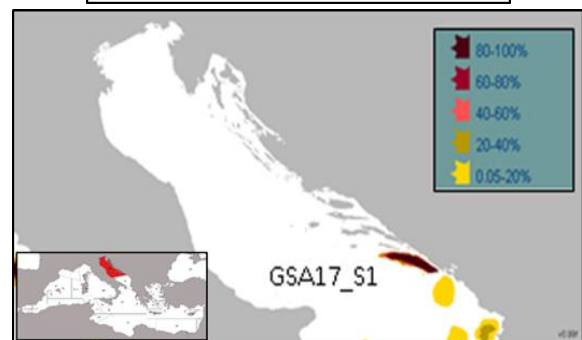
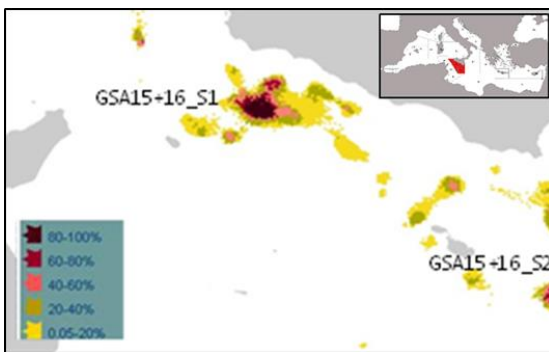
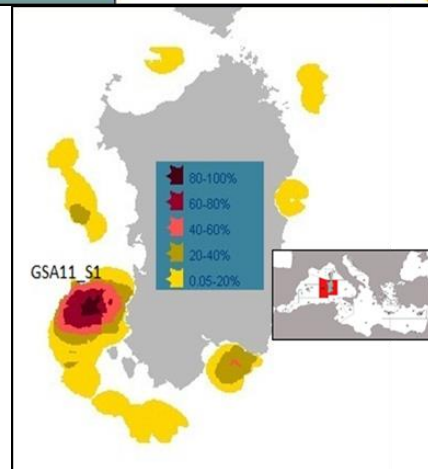
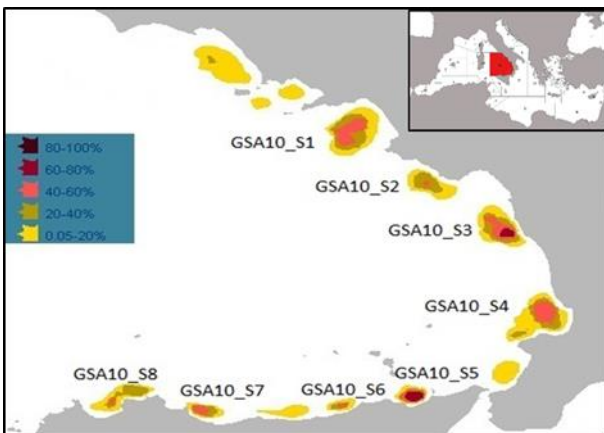
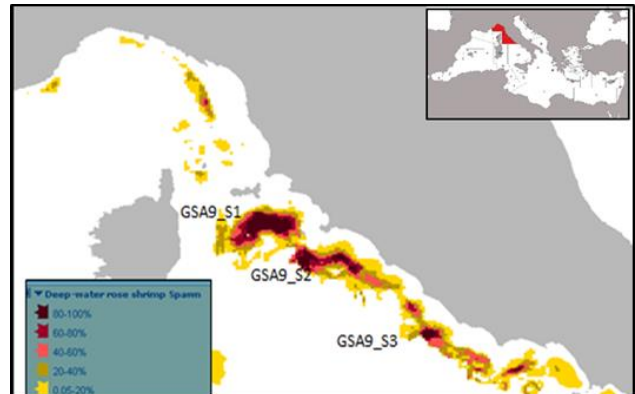
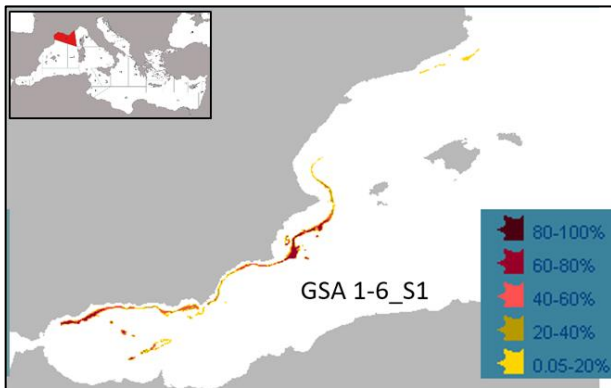


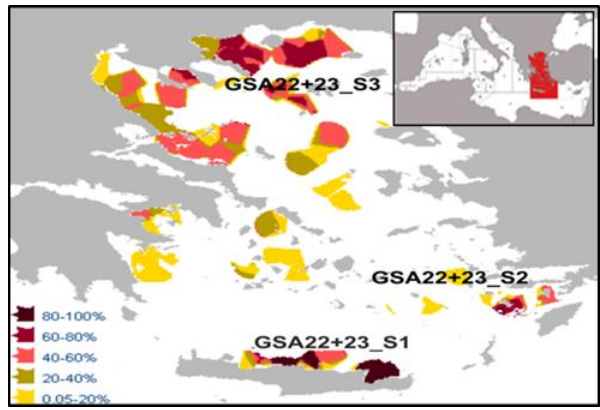
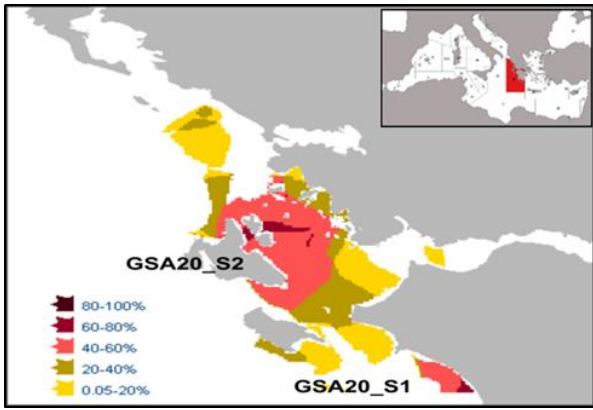
## 2.5 - *Parapenaeus longirostris* nursery grounds





## 2.6 - *Parapenaeus longirostris* spawning grounds

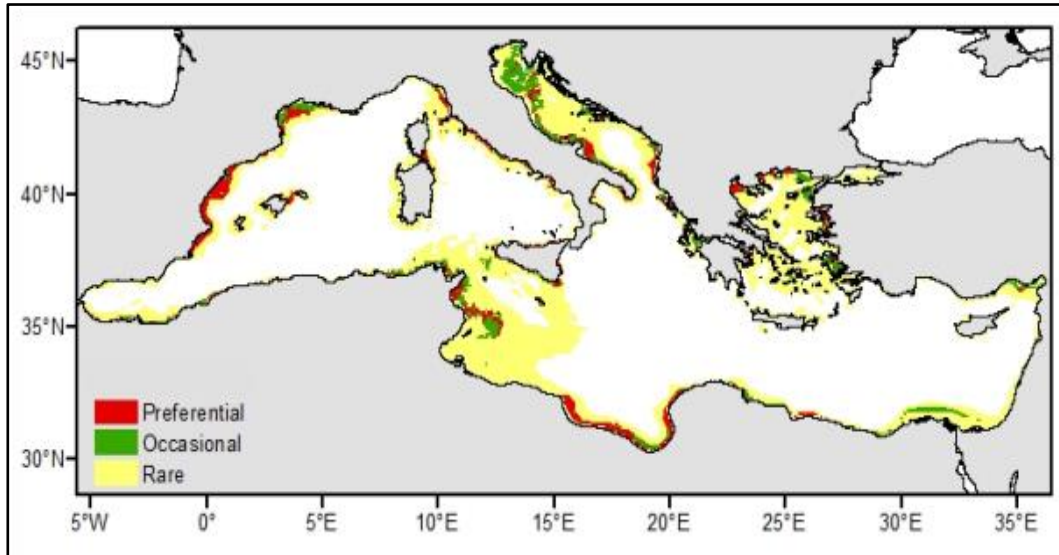




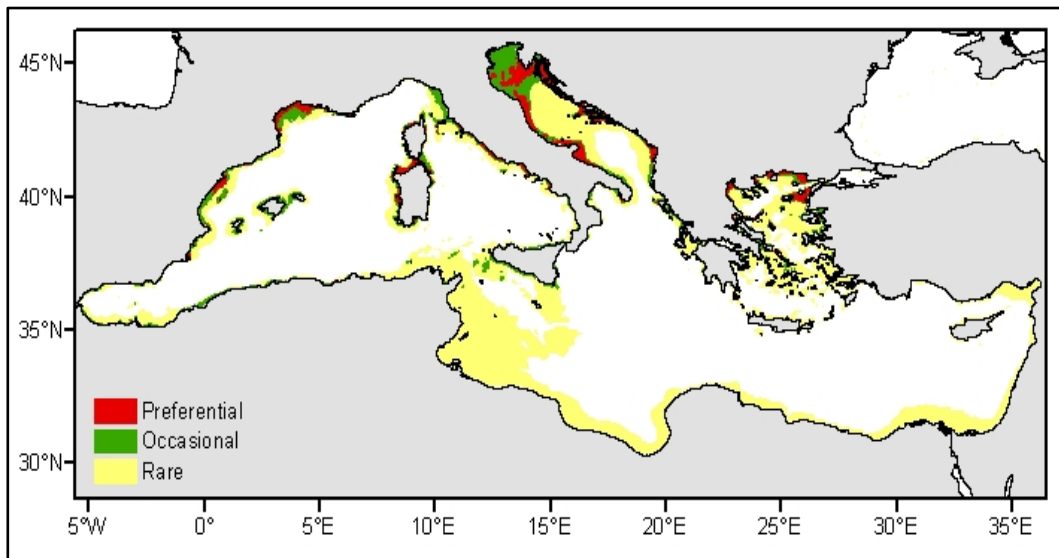
## Priority species - Small pelagics

### 2.7 - *Engraulis encrasicolus* nursery grounds

Reference years: 2003 – 2008



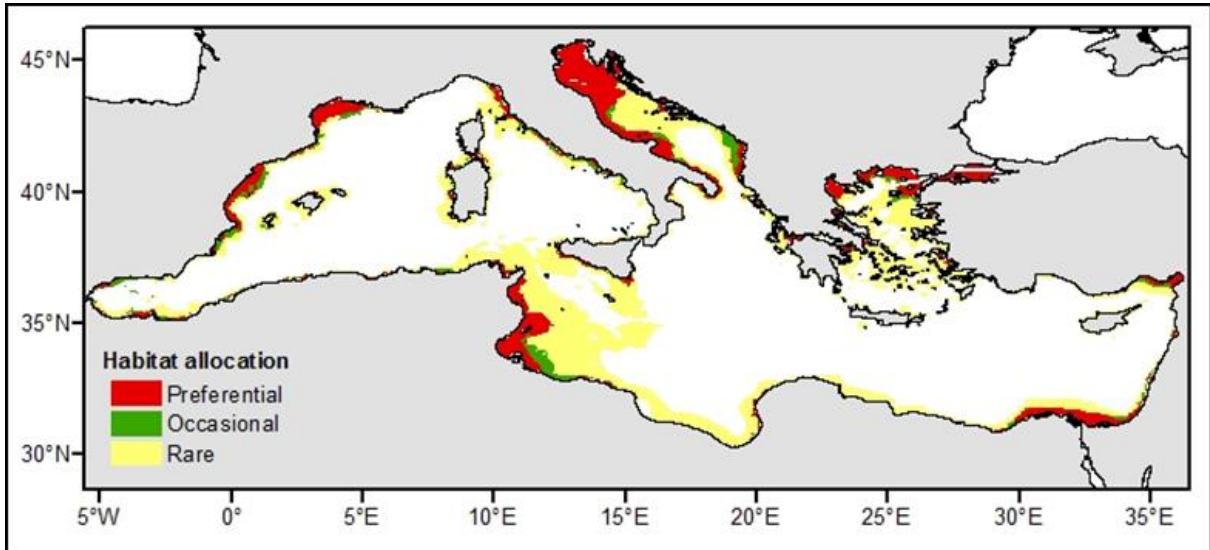
Reference years: 1998 – 2000





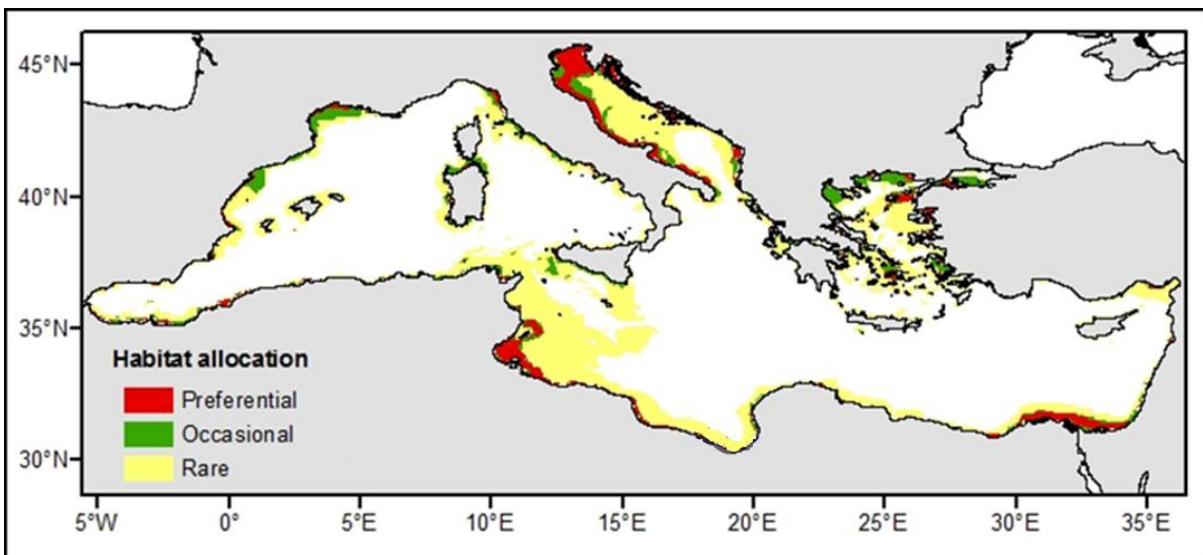
## 2.8 - *Engraulis encrasicolus* spawning grounds

Reference years: 2003 – 2008



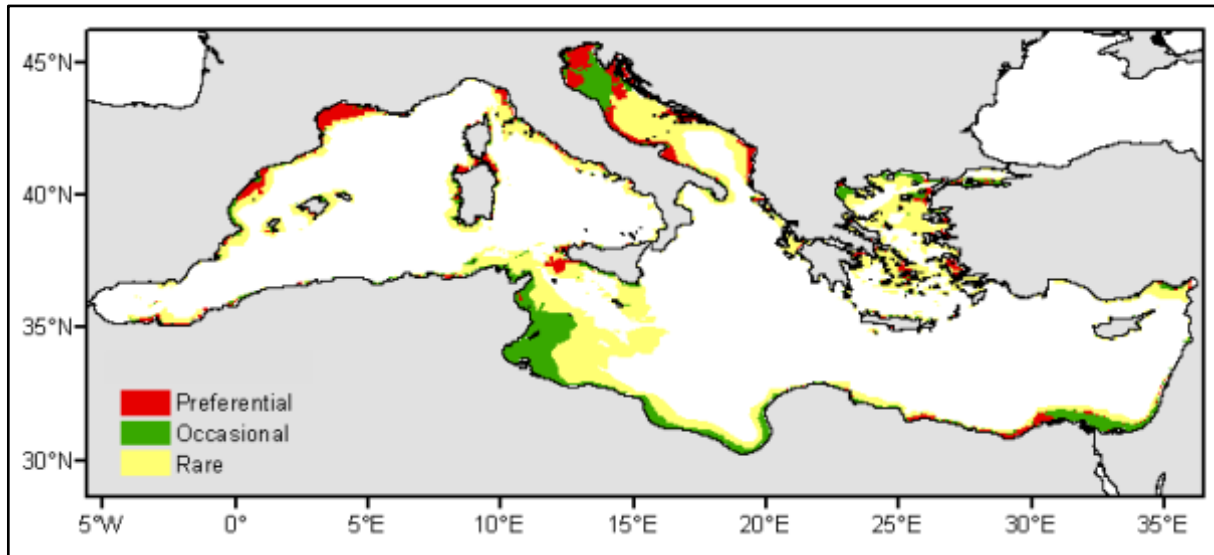
## 2.9 - *Sardina pilchardus* nursery grounds

Reference years: 2003 – 2008



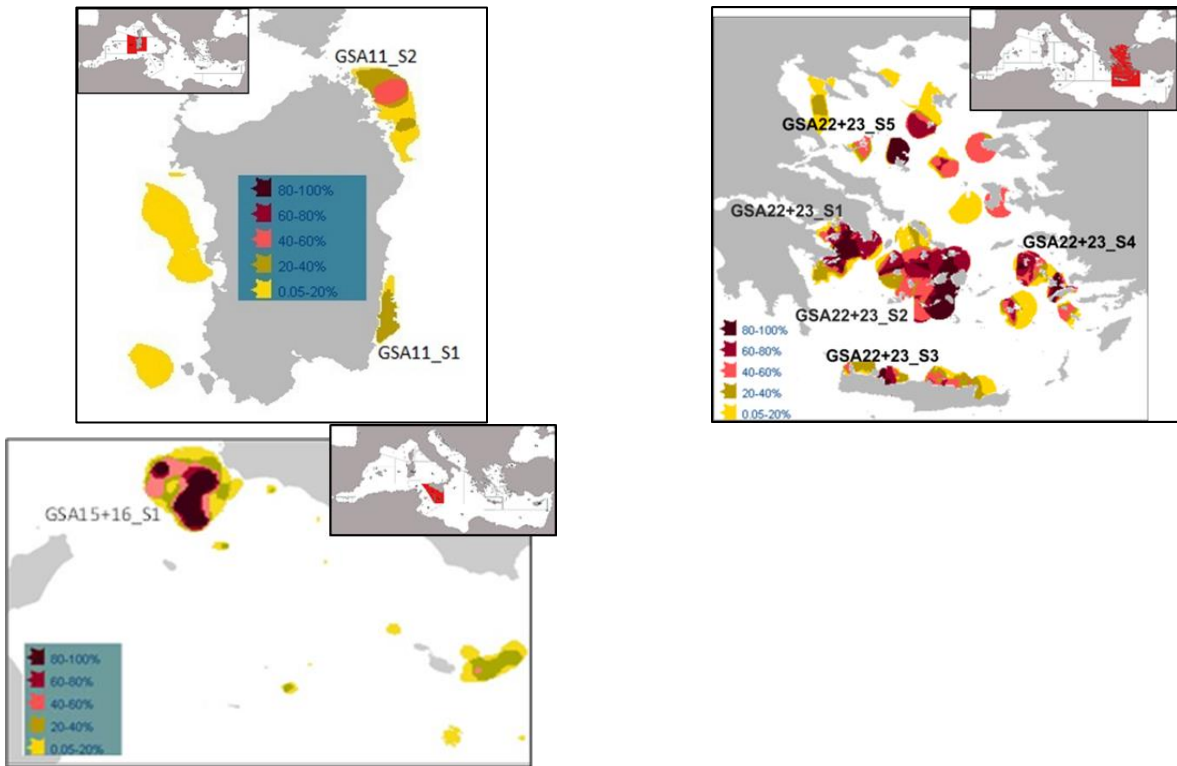
## 2.10 - *Trachurus mediterraneus* spawning grounds

Reference years: 2000 – 2010

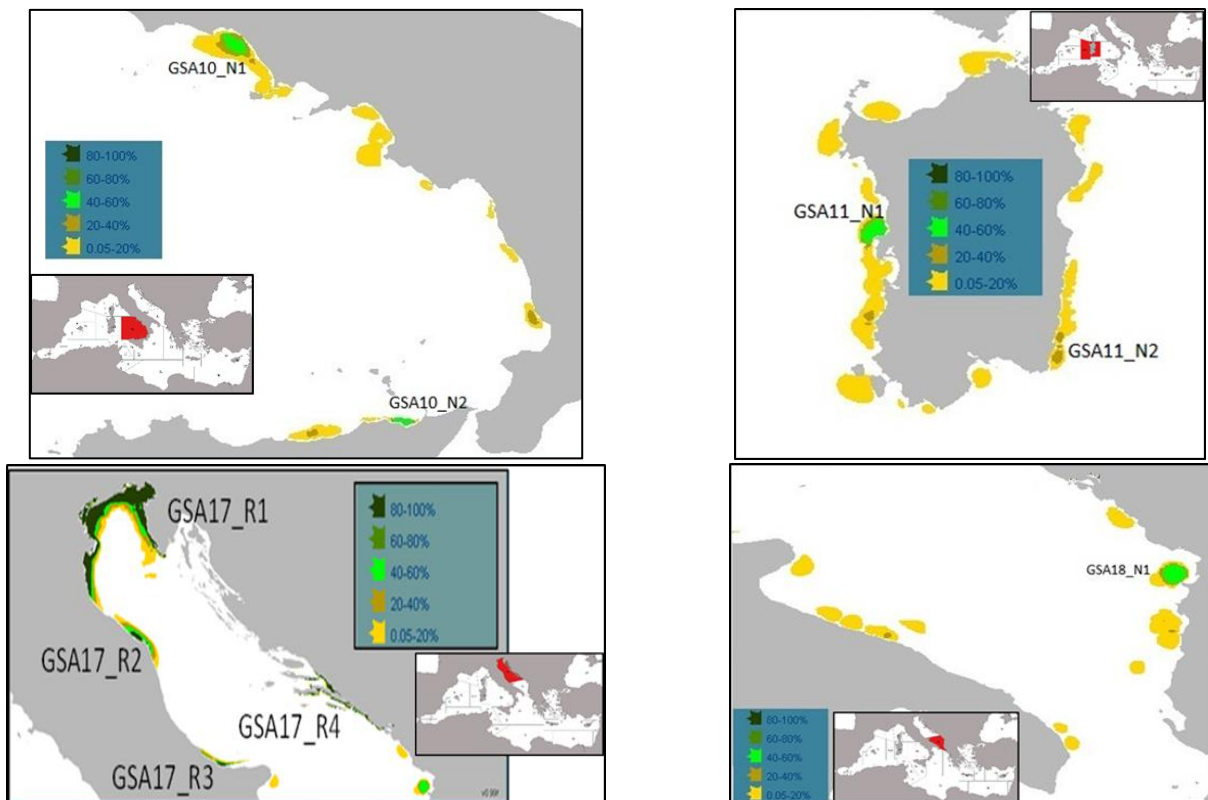


## Other species - Demersals

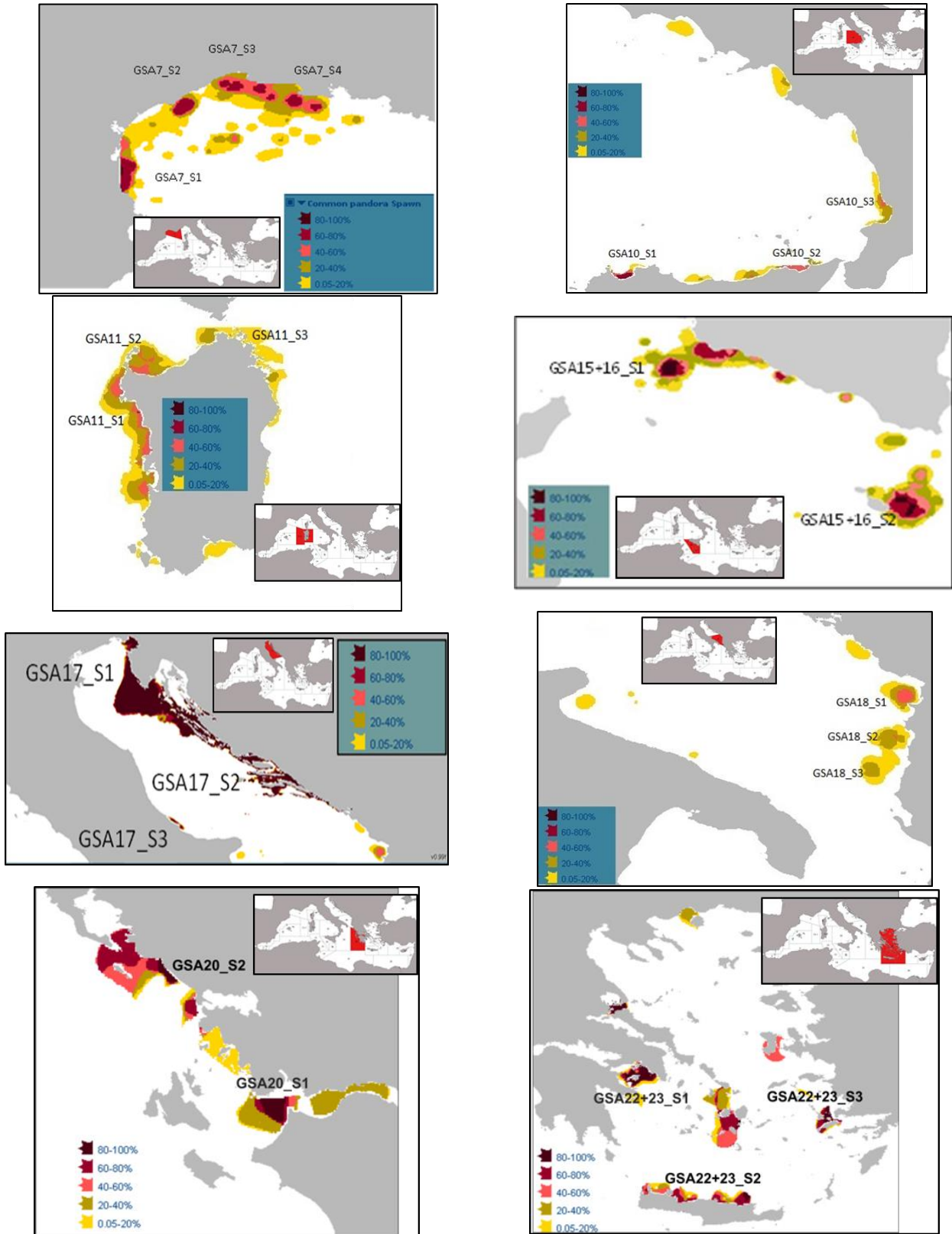
### 2.11 - *Mullus surmuletus* spawning grounds



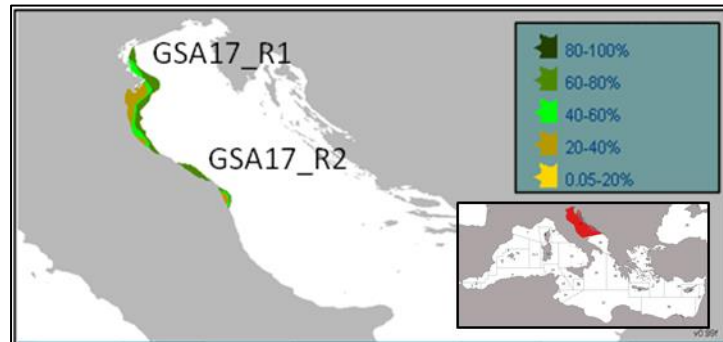
### 2.12 - *Pagellus erythrinus* nursery grounds



## 2.13 - *Pagellus erythrinus* spawning grounds



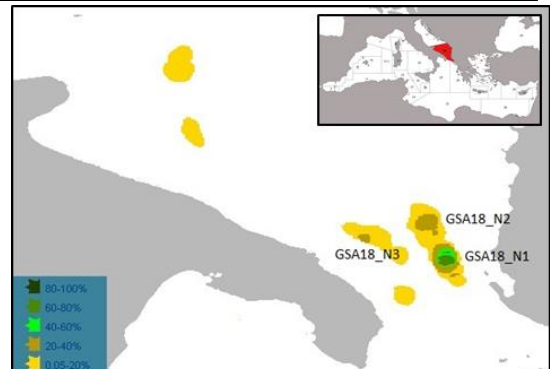
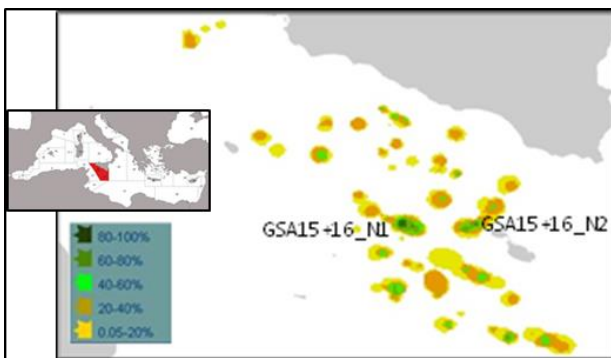
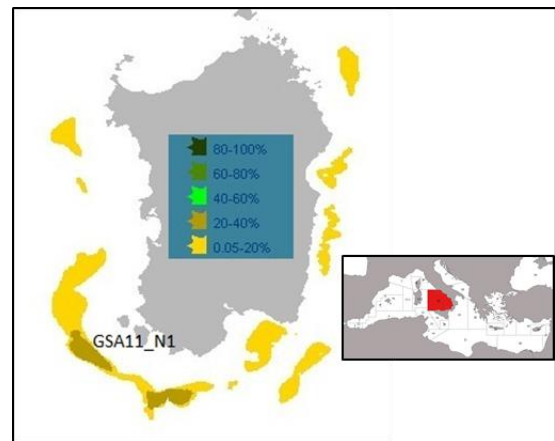
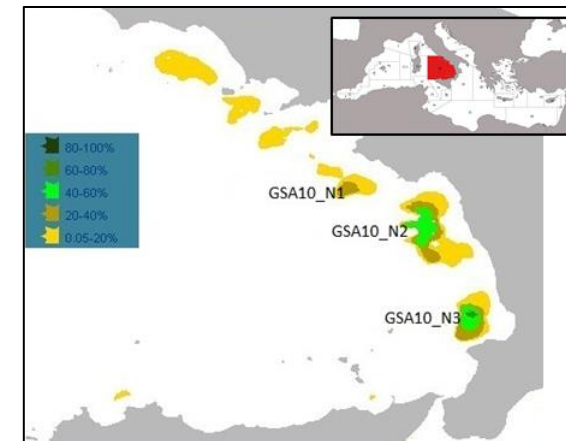
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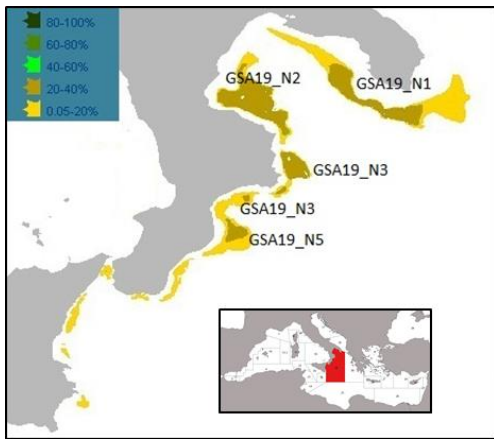


### 2.15 - *Solea solea* spawning grounds

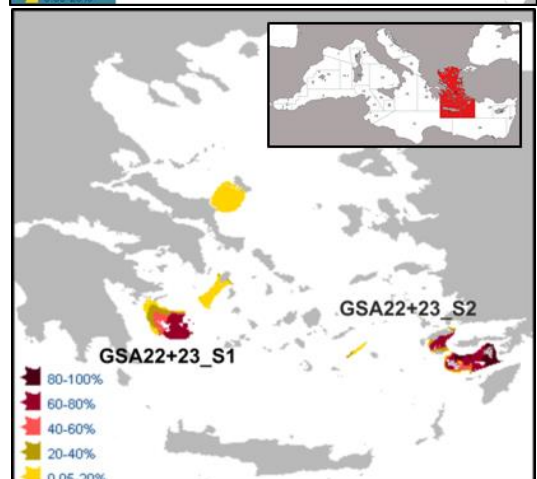
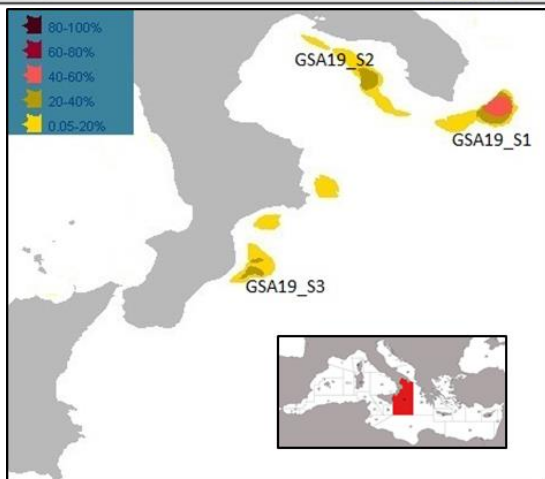
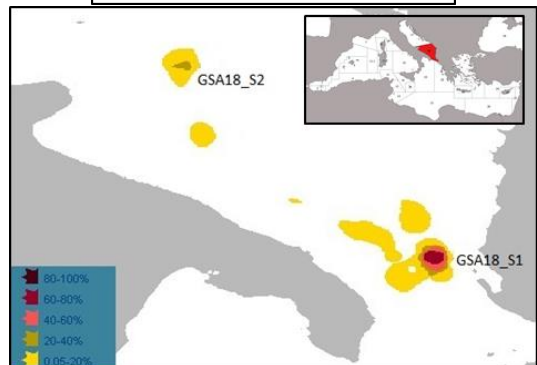
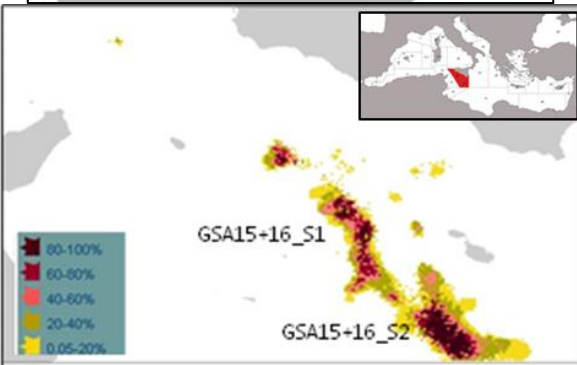
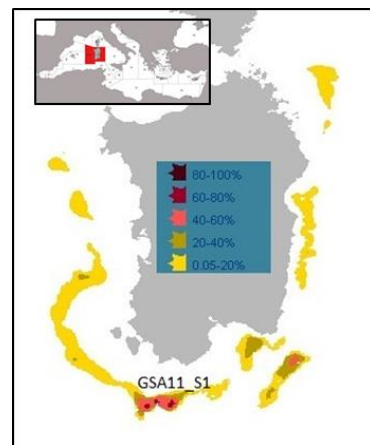
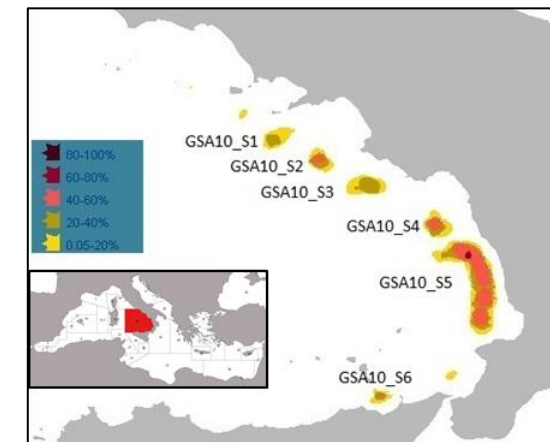


### 2.16 - *Aristaemorpha foliacea* nursery grounds

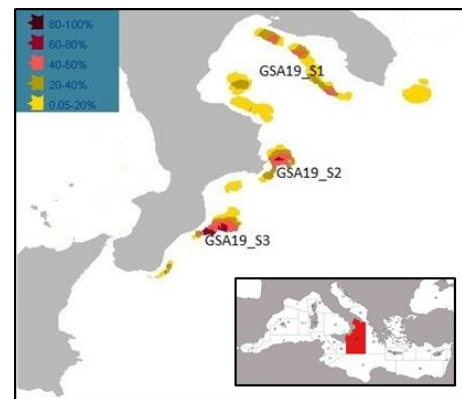
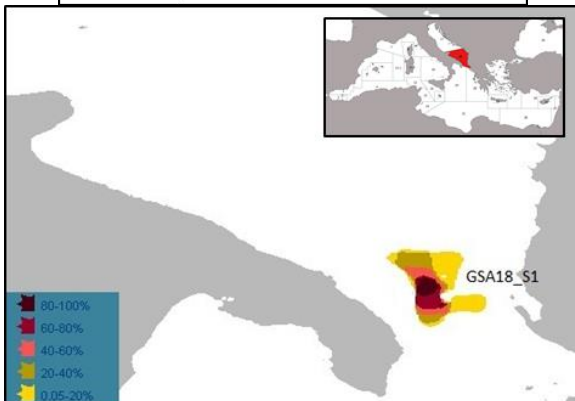
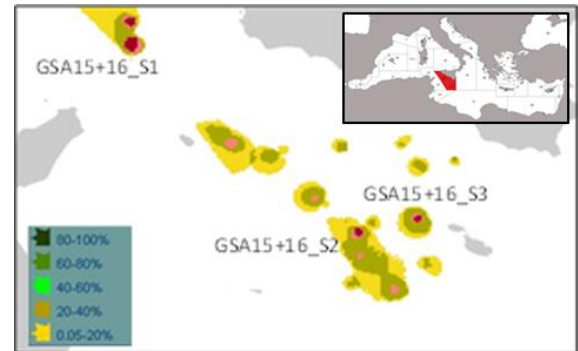
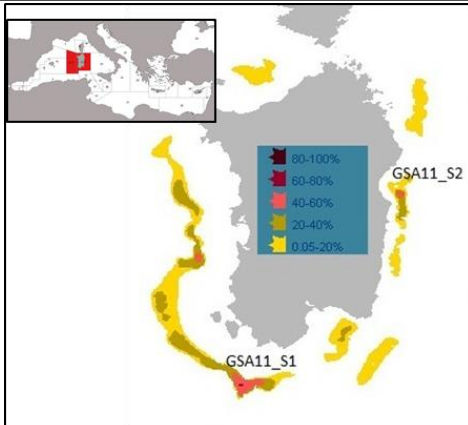
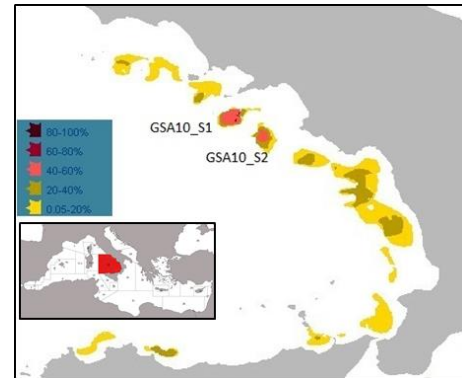
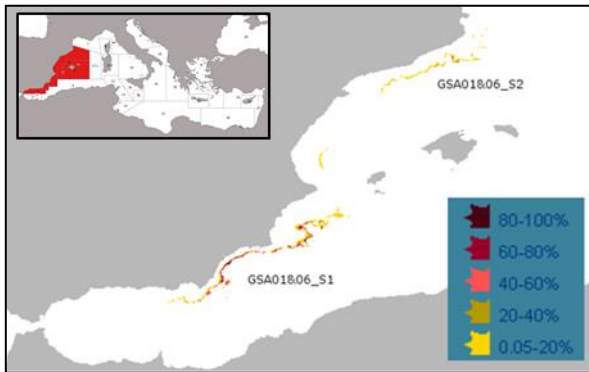




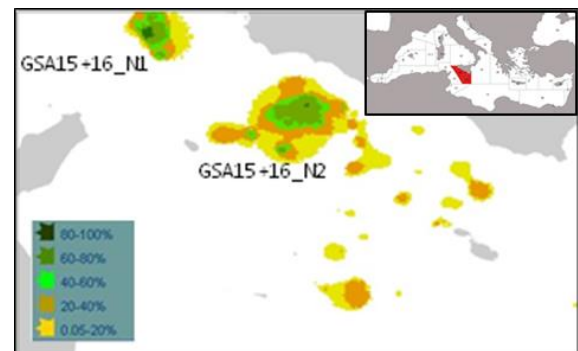
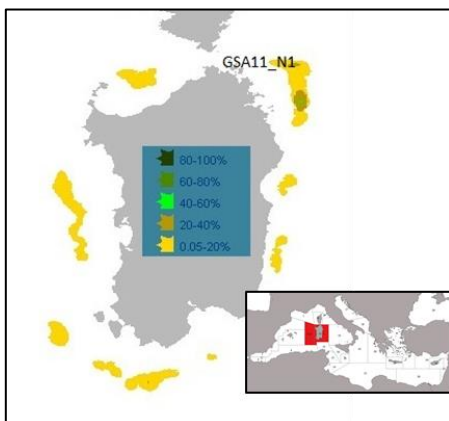
2.17 - *Aristaemorpha foliacea* spawning grounds

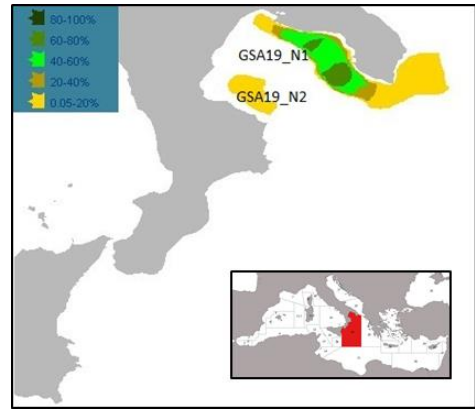
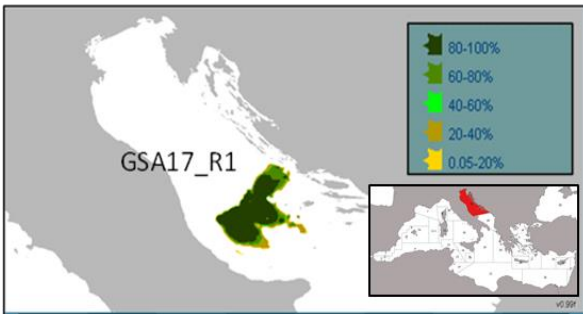


## 2.18 - *Aristeus antennatus* spawning grounds

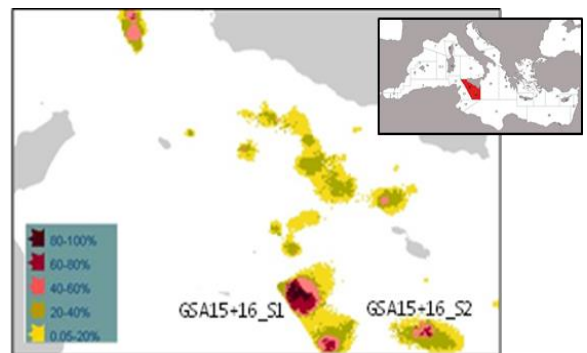
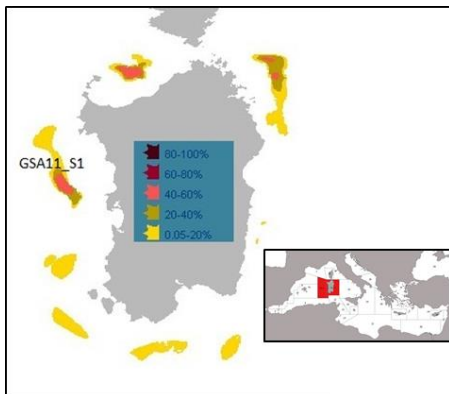
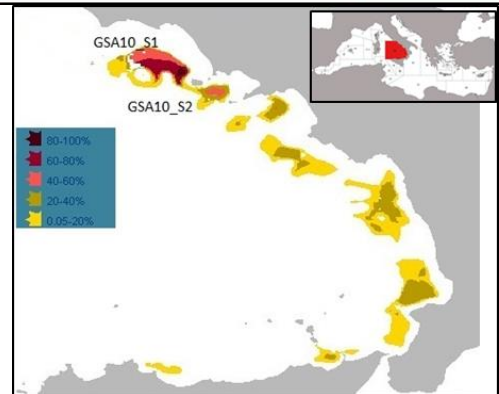
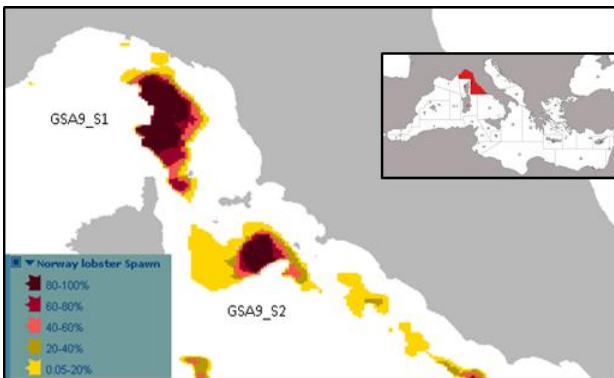
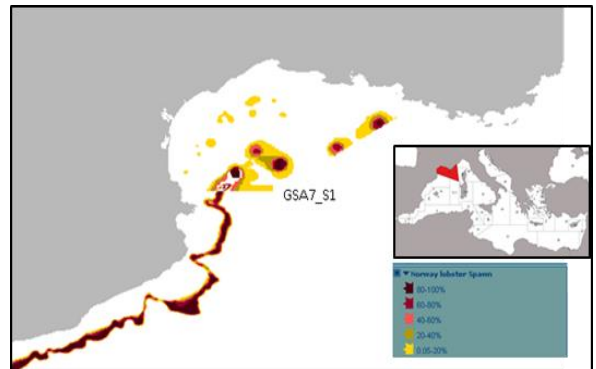
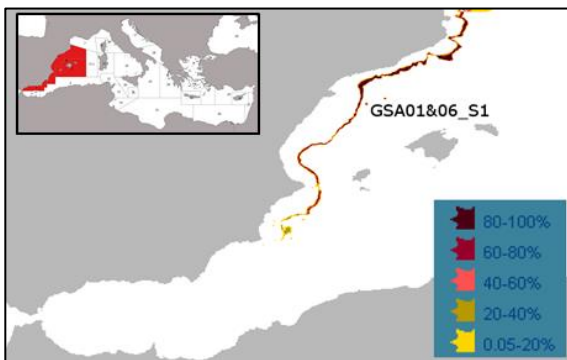


## 2.19 - *Nephrops norvegicus* nursery grounds

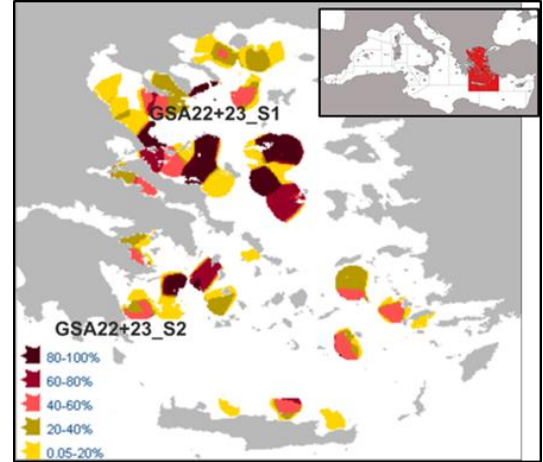
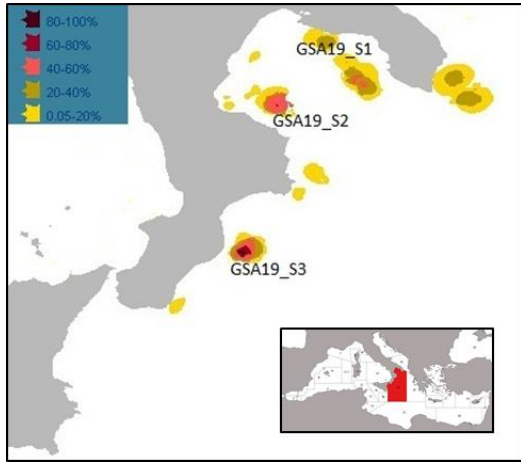
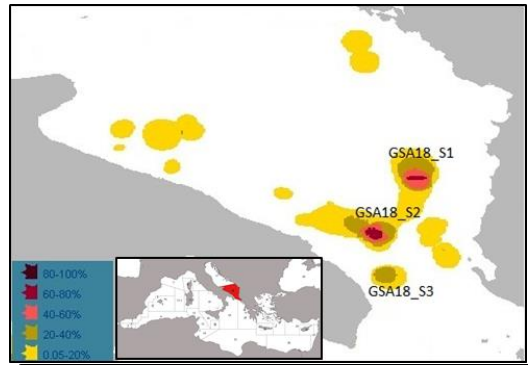
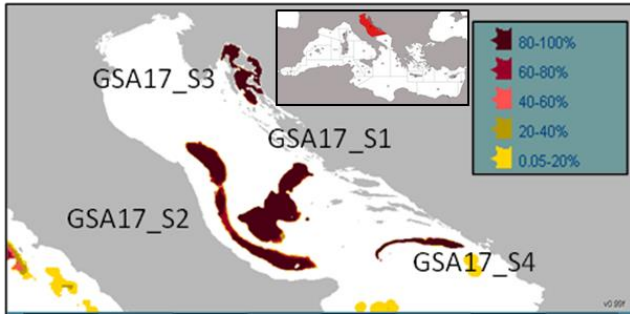




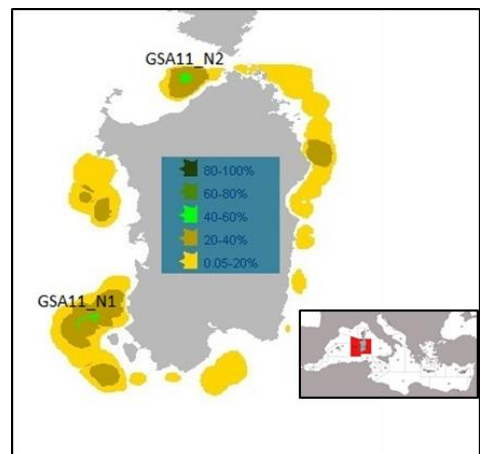
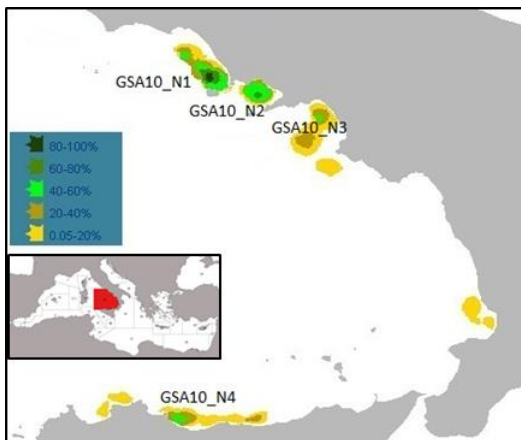
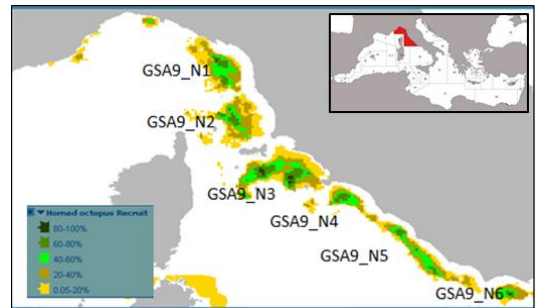
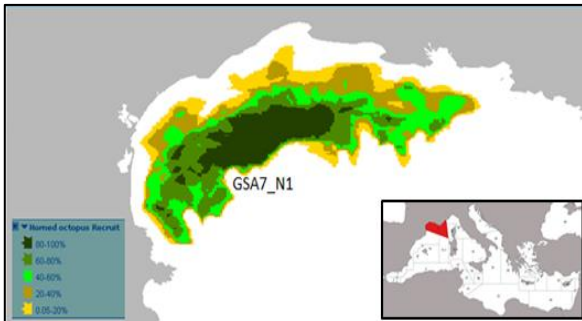
2.20 - *Nephrops norvegicus* spawning grounds

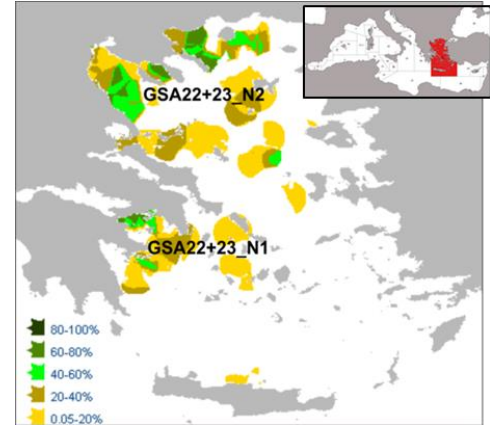
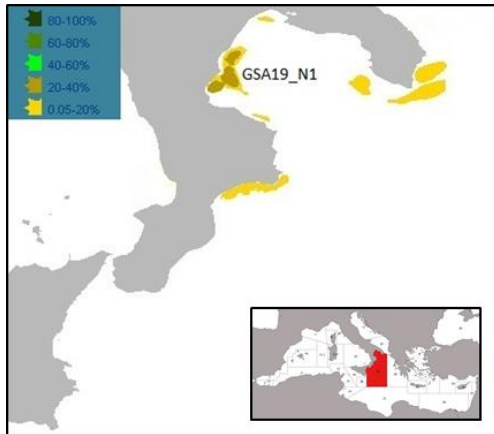
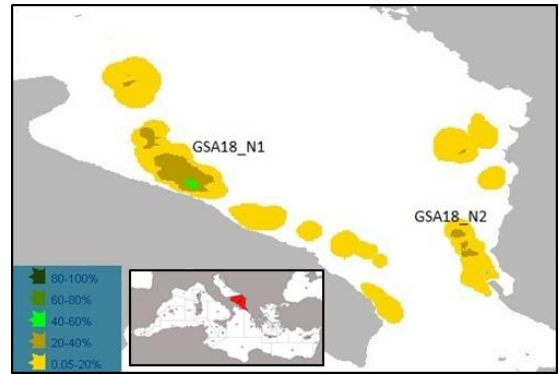
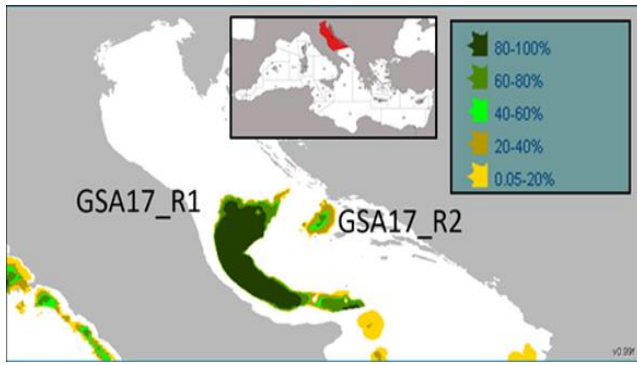




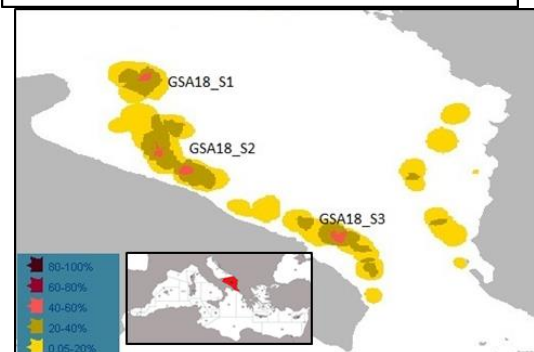
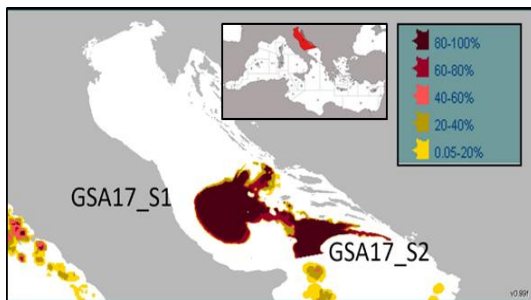
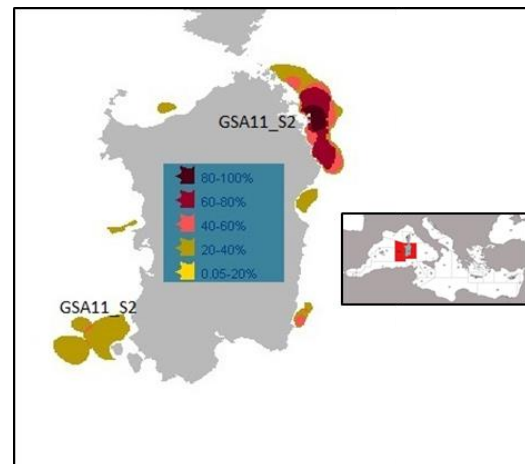
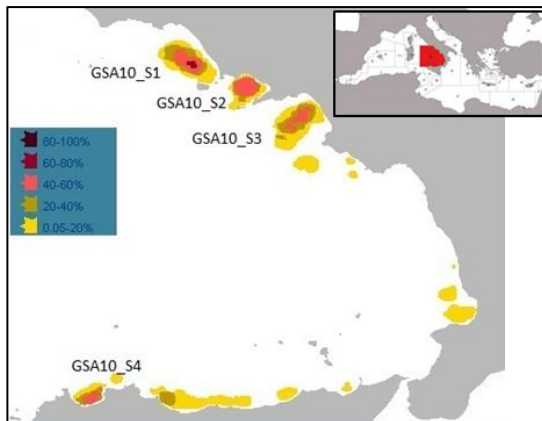


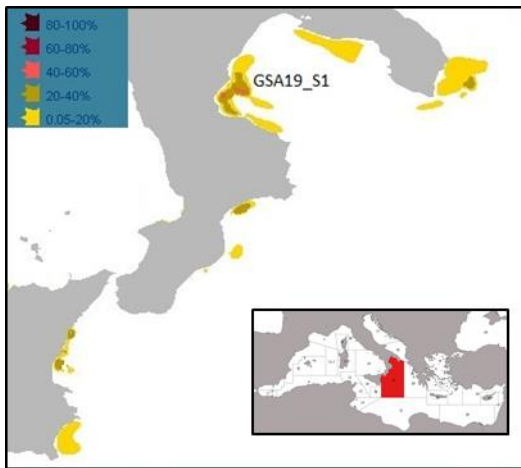
2.21 - *Eledone cirrhosa* nursery grounds



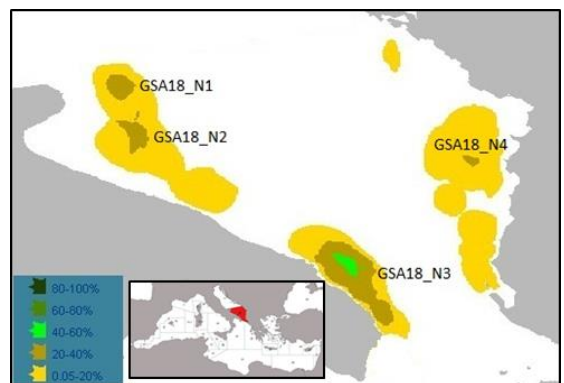
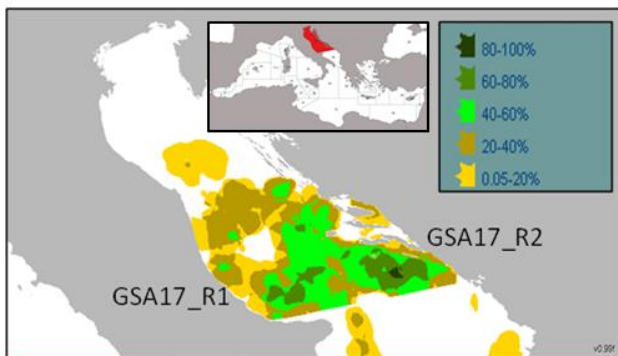
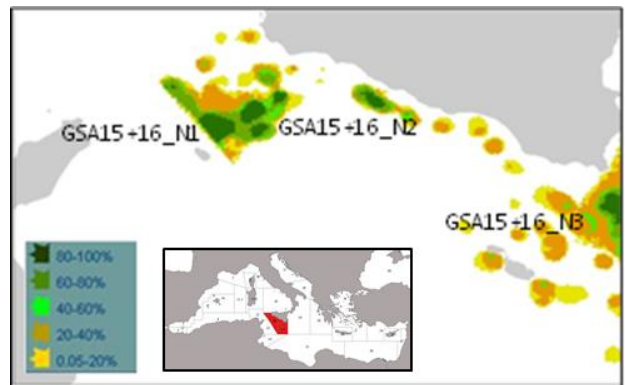
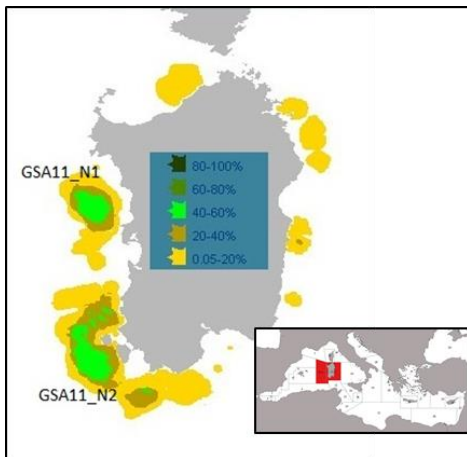
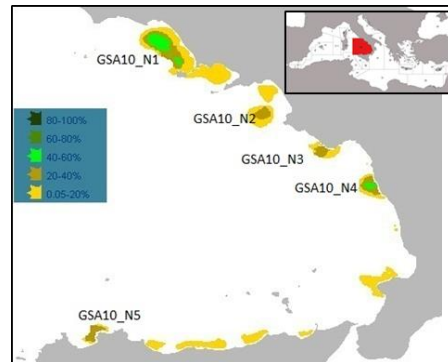
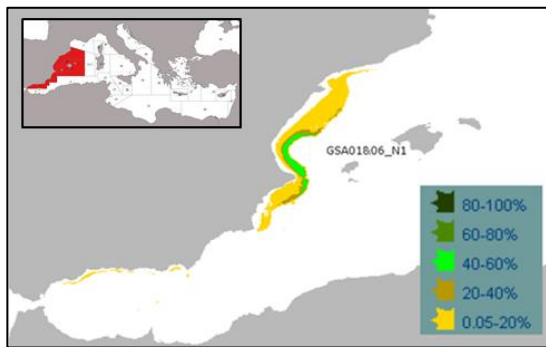


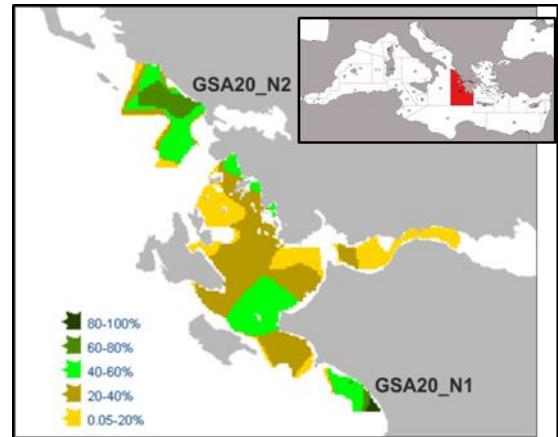
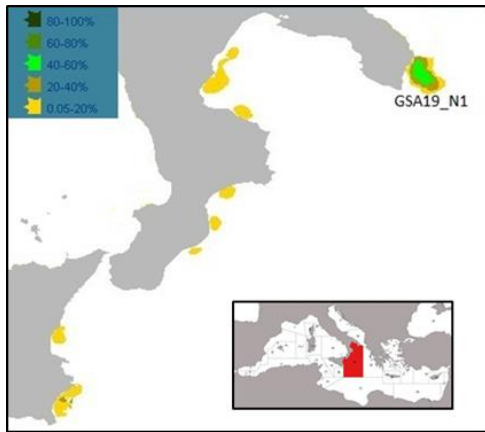
## 2.22 - *Eledone cirrhosa* spawning grounds



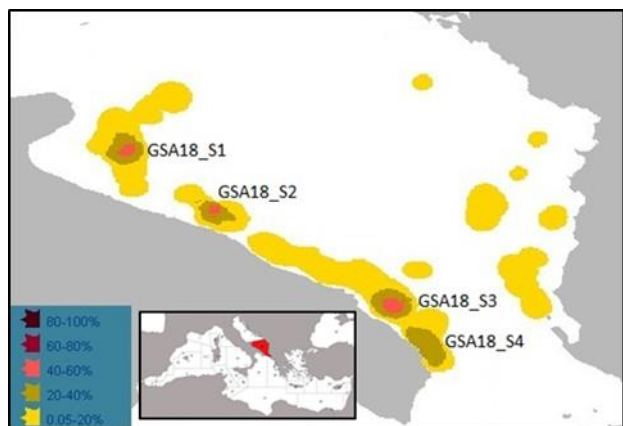
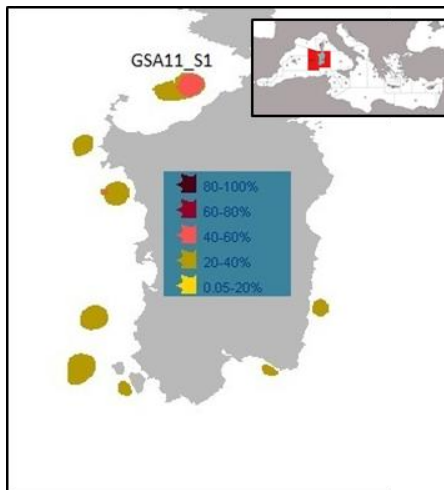
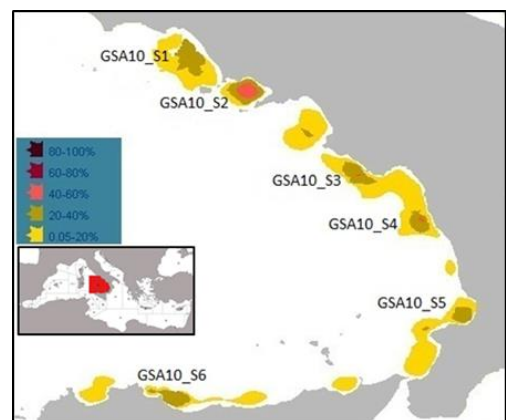
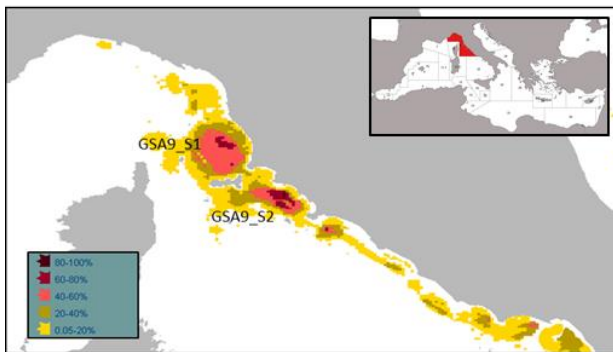


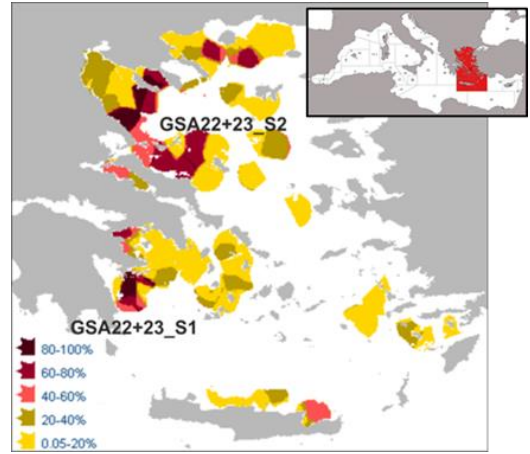
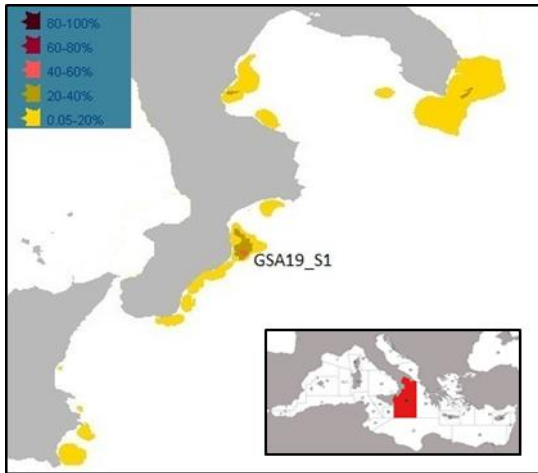
2.23 - *Illex coindetii* nursery grounds



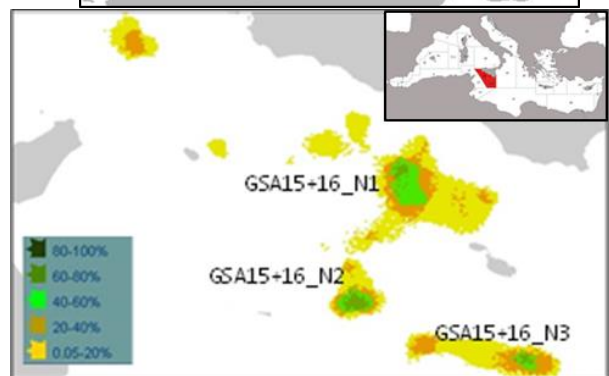
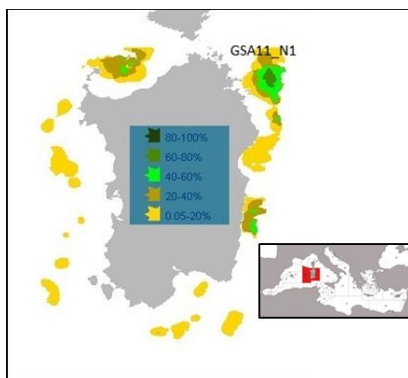
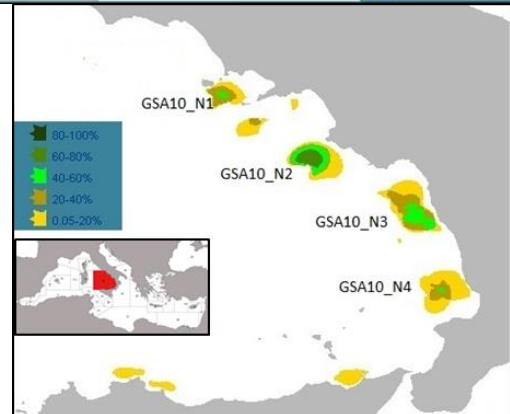
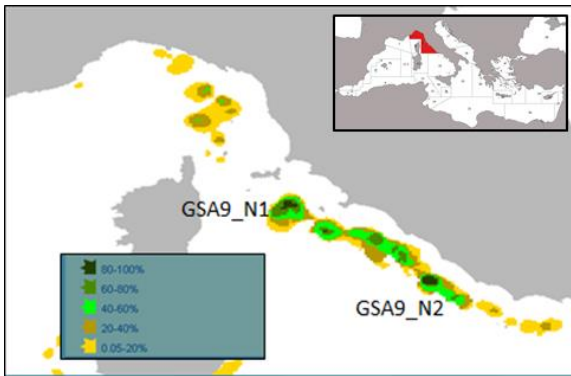
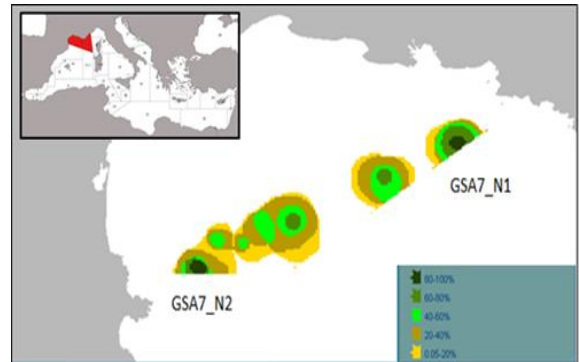
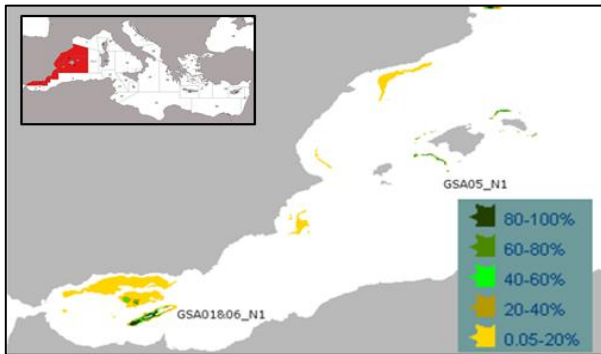


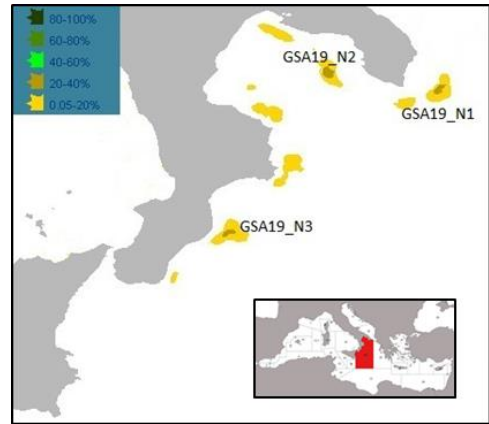
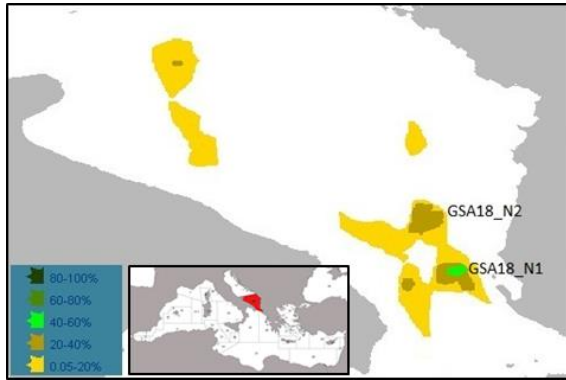
## 2.24 - *Illex coindetii* spawning grounds



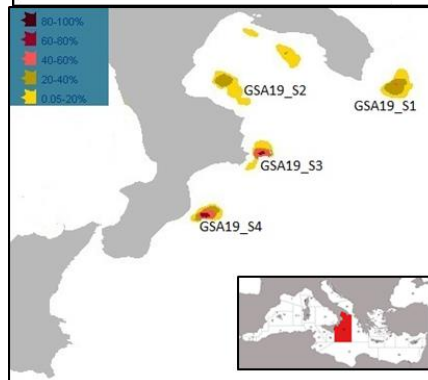
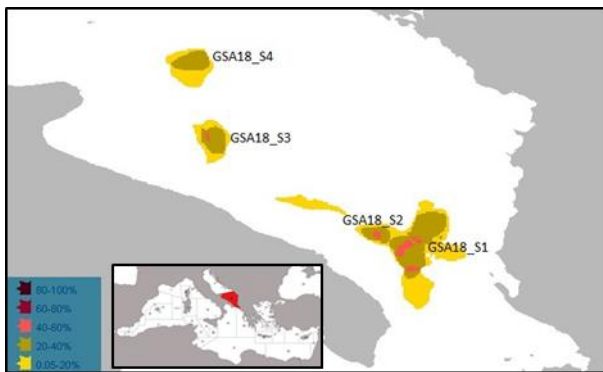
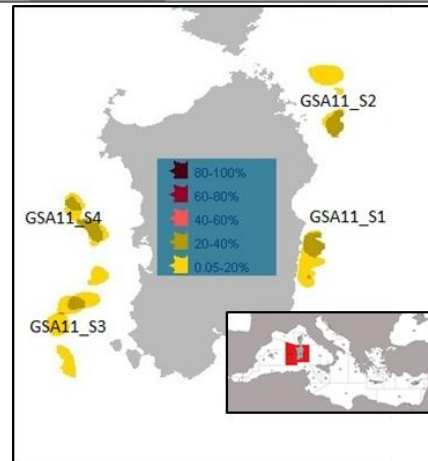
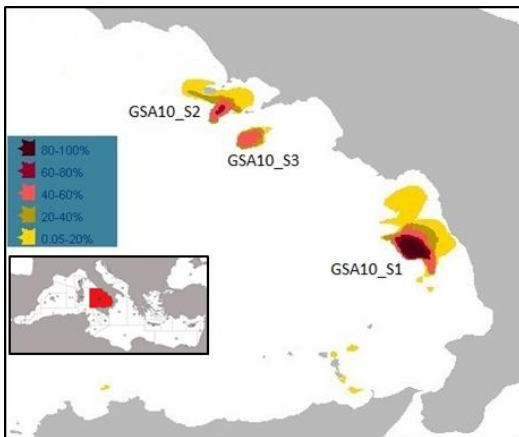
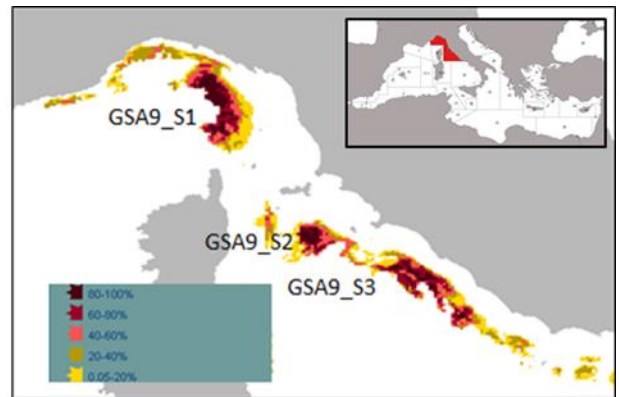
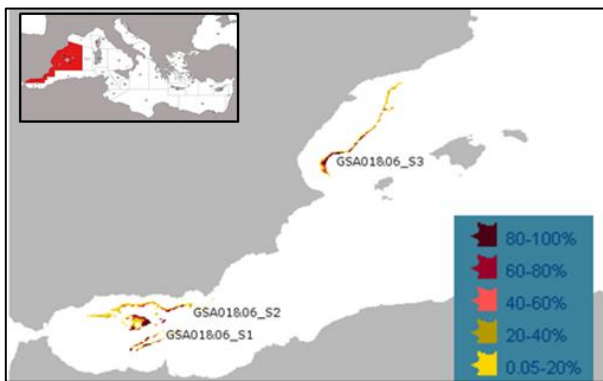


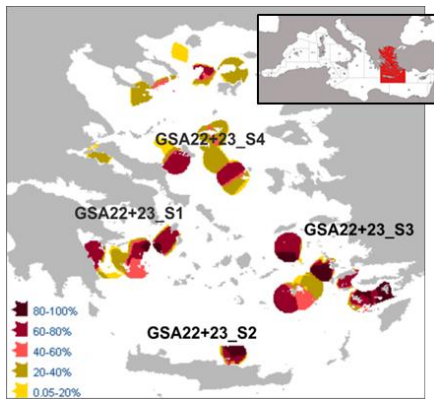
2.25 - *Galeus melastomus* nursery grounds



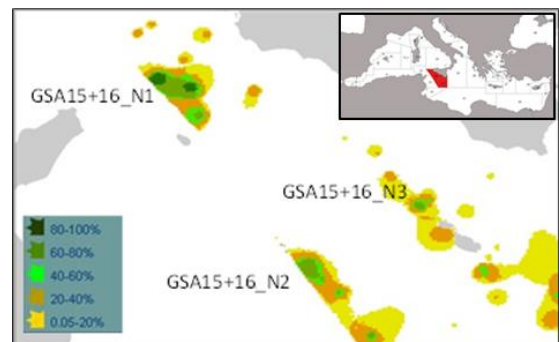
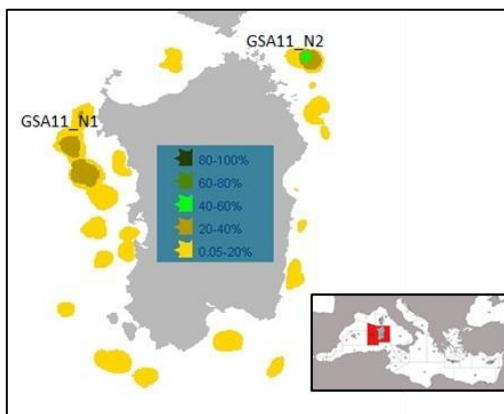


2.26 - *Galeus melastomus* spawning grounds

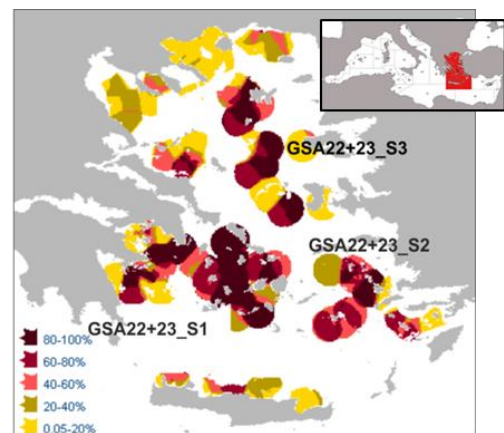
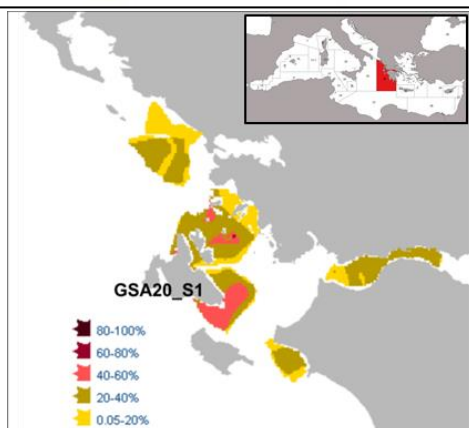
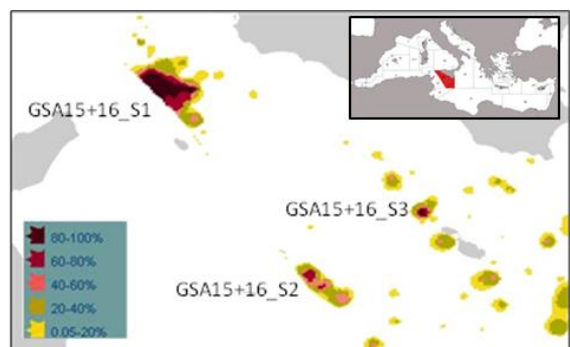
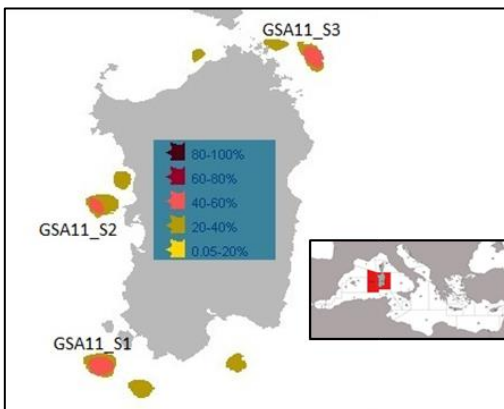




2.27 - *Raja clavata* nursery grounds



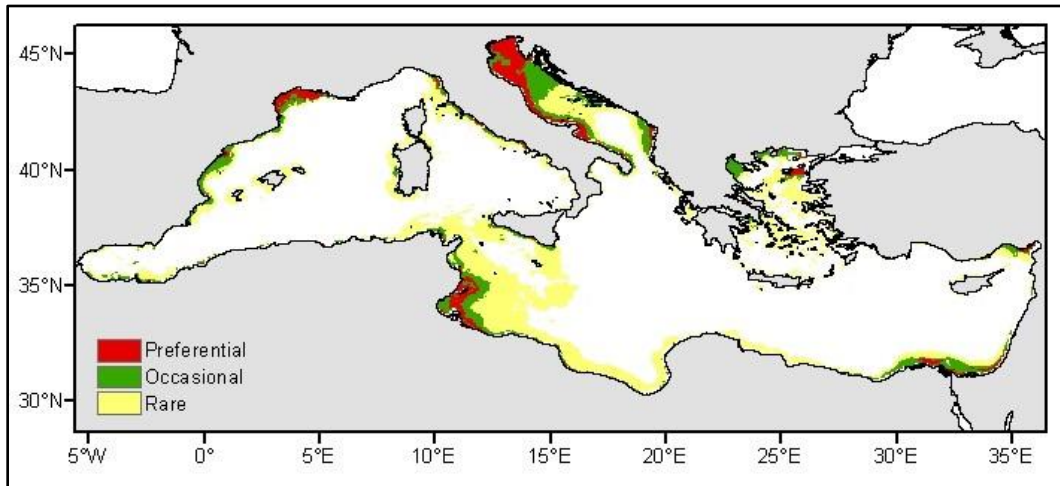
2.28 - *Raja clavata* spawning grounds



## Other species - Small pelagics

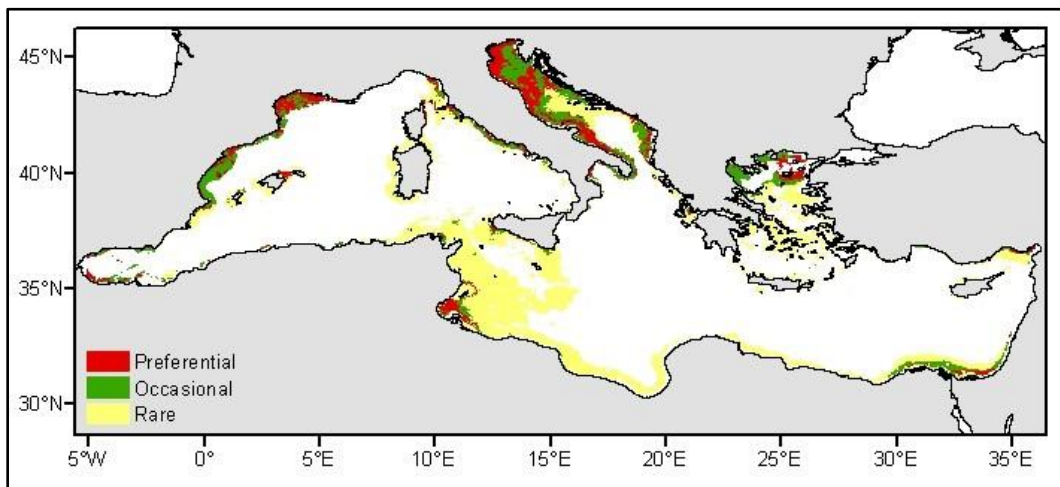
### 2.29 - *Scomber colias* nursery grounds

Reference years: 2001 – 2010



### 2.30 - *Scomber colias* spawning grounds

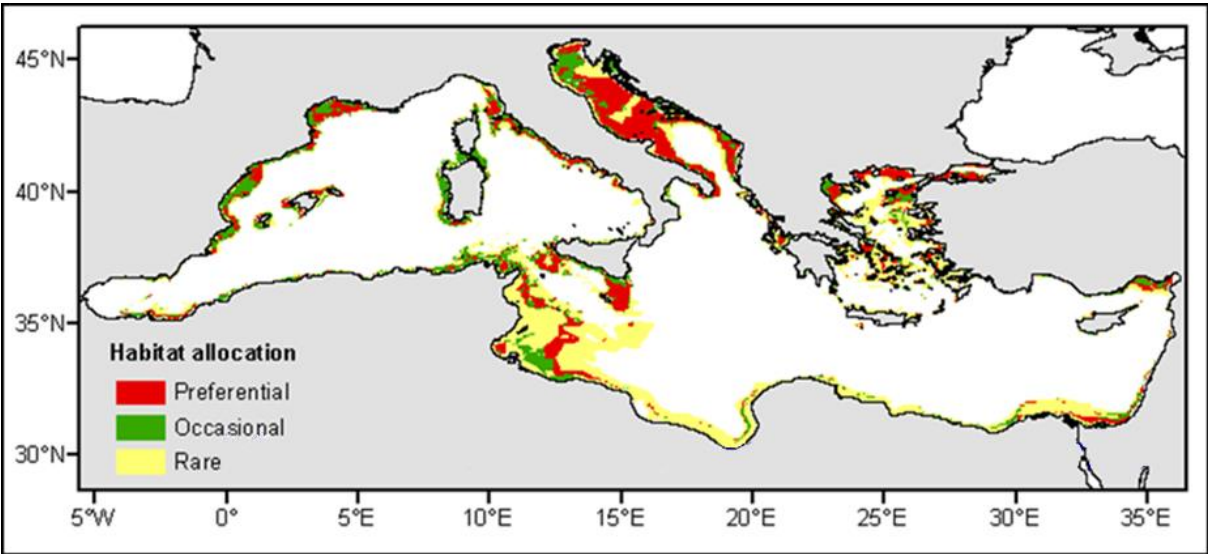
Reference years: 2006 - 2008 - 2010





2.31 - *Trachurus trachurus* nursery grounds

Reference years: 2000 – 2010



### 3 - Information from PROTOMEDEA Project

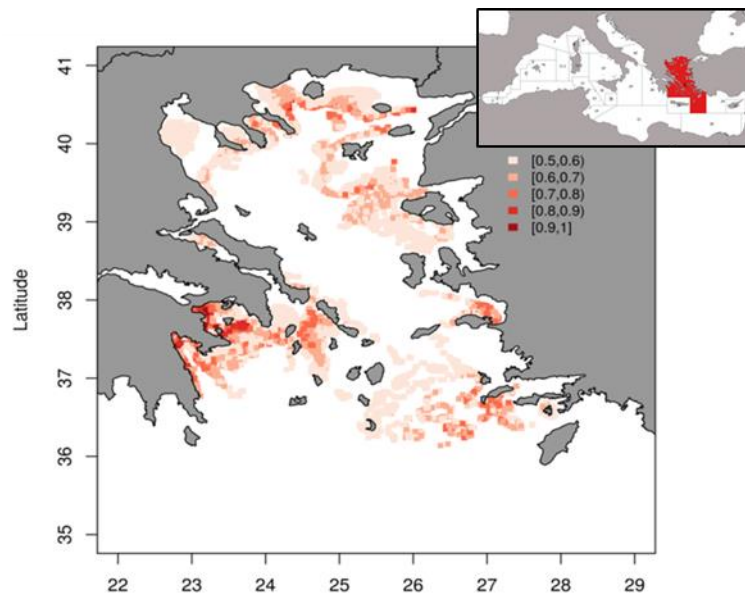
Protomedea is a project funded by the European Union DG MARE, whose objective is to design a Marine Protected Area network in the Eastern Mediterranean study areas, taking into account the protection of ecological characteristics and Essential Fish Habitats (EFH), significant areas for fisheries, as well as their socio-economic impacts through a participatory bottom-up process.

*Modelling method:* Generalized Additive Models

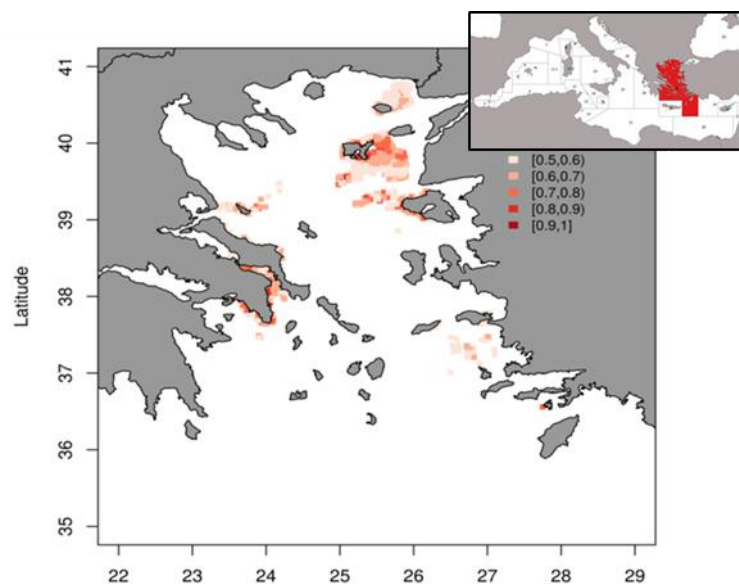
*Reference years:* 2003 – 2014

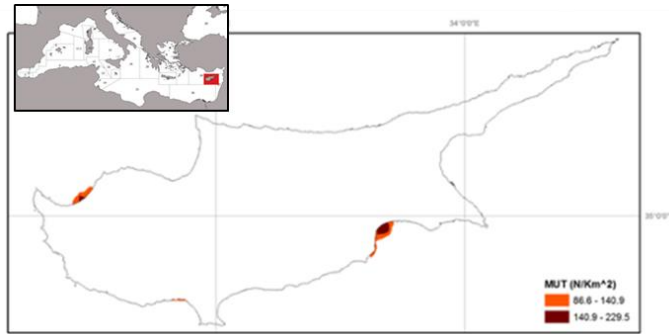
#### Priority species - Demersals

##### 3.1 - *Merluccius merluccius* spawning grounds

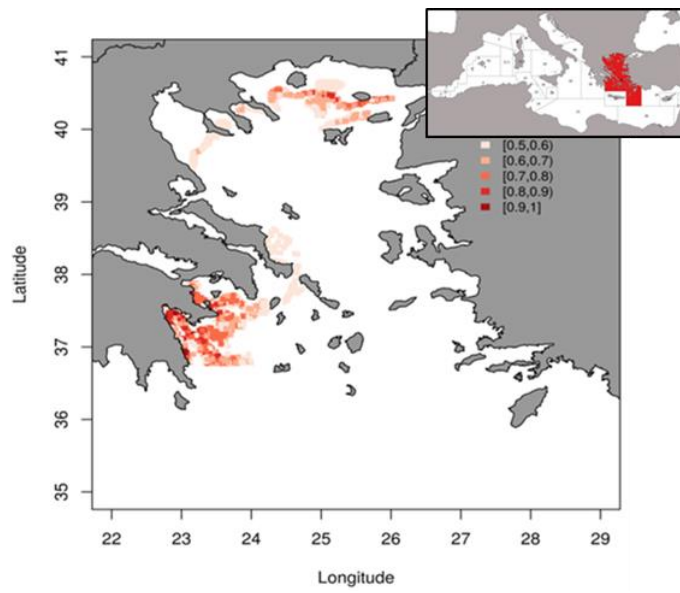


##### 3.2 - *Mullus barbatus* spawning grounds



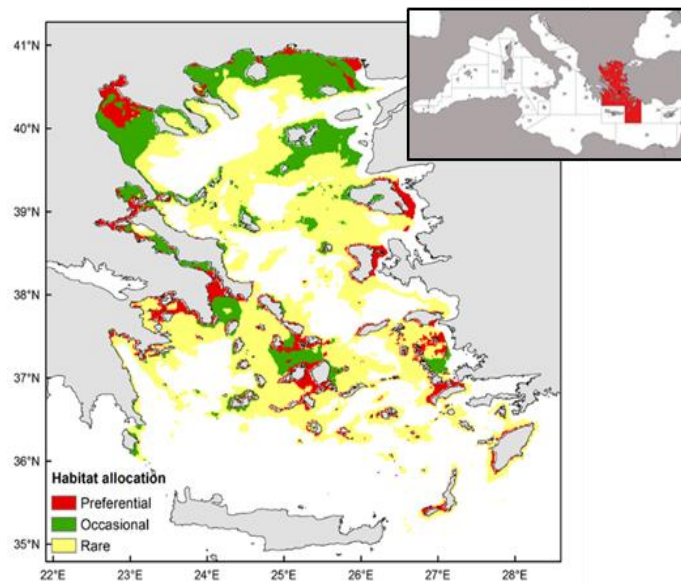


### 3.3 - *Parapenaeus longirostris* spawning grounds

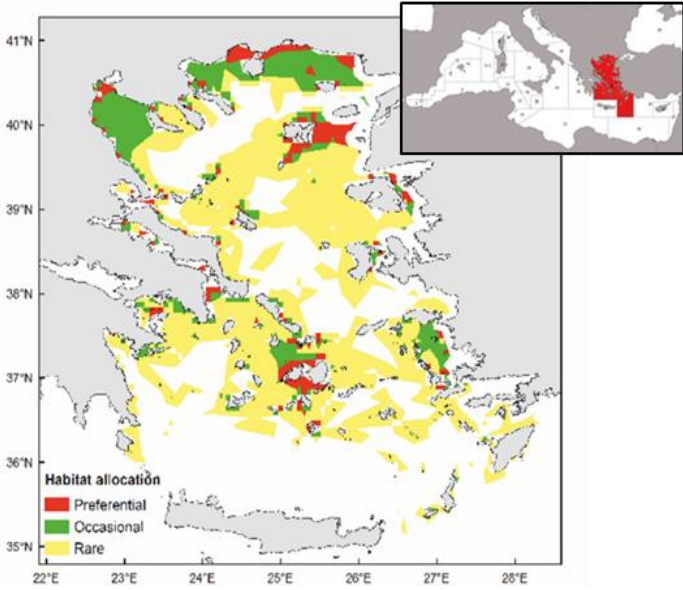


Priority species – Small pelagics

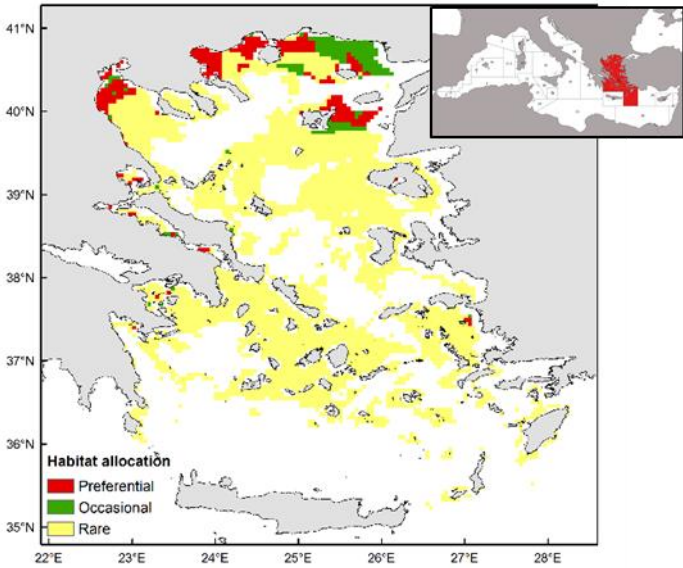
### 3.4 - *Engraulis engrasicolus* nursery grounds



3.5 - *Sardina pilchardus* nursery grounds

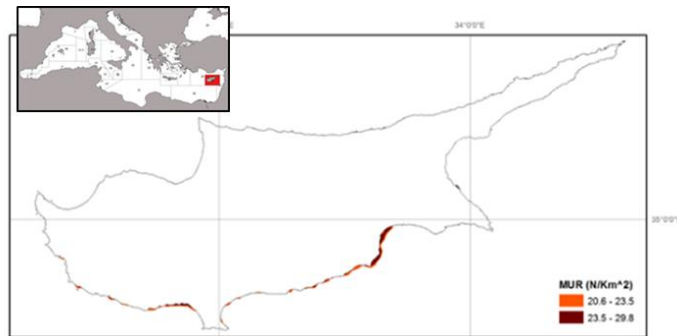


3.6 - *Sardinella aurita* spawning grounds



Other species - Demersals

3.7 - *Mullus surmuletus* spawning grounds

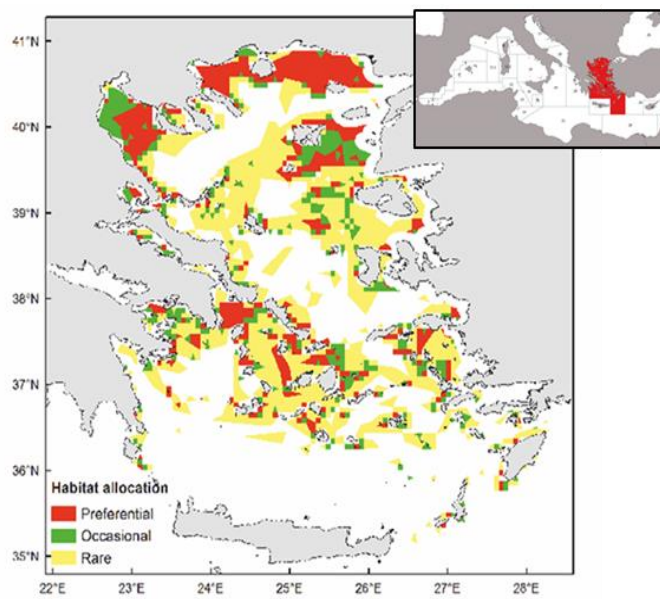


3.8 - *Pagellus erythrinus* spawning grounds



Other species – Small pelagics

3.9 - *Trachurus trachurus* nursery grounds



## 4 - Information from NURSERY project

The main objective of the project was the identification of areas where juvenile stages of commercial species are concentrated and the analysis of their time persistence.

### Sources:

1) Lembo G. (ed), 2010. Identificazione spazio-temporale delle aree di concentrazione dei giovanili delle principali specie demersali e localizzazione geografica di aree di nursery nei mari italiani - Nursery. Progetto di ricerca SIBM-MiPAAF n.6A92. Relazione finale, Società Italiana di Biologia Marina, Genoa:120 pp + cartography.

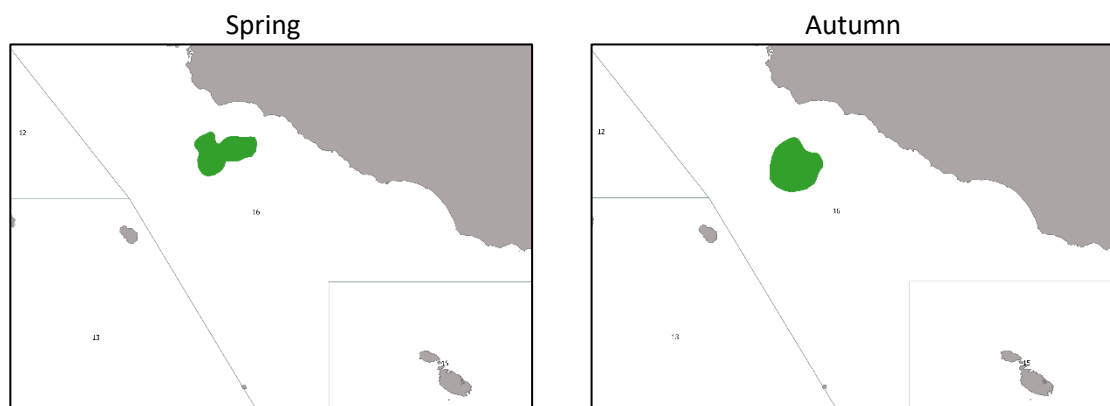
2) Garofalo G., Fortibuoni T., Gristina M., Sinopoli M. and Fiorentino F., 2011. Persistence and co-occurrence of demersal nurseries in the Strait of Sicily (Central Mediterranean): implications for fishery management. *Journal of Sea Research*, 66:29-38.

*Modelling method:* Kriging interpolation of species density indices, annual hotspot analysis, time persistence index.

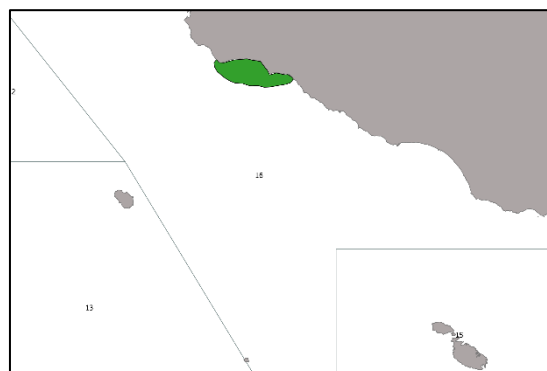
*Reference years:* 1994 – 2004

### Priority species - Demersals

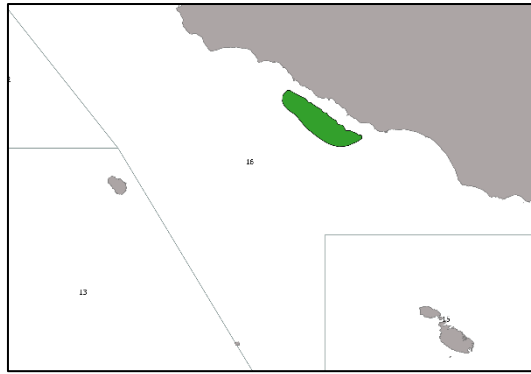
#### 4.1 - *Merluccius merluccius* nursery grounds



#### 4.2 - *Mullus barbatus* nursery grounds

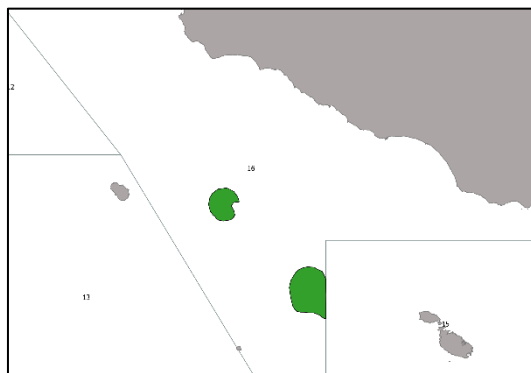


#### 4.3 - *Parapenaeus longirostris* nursery grounds

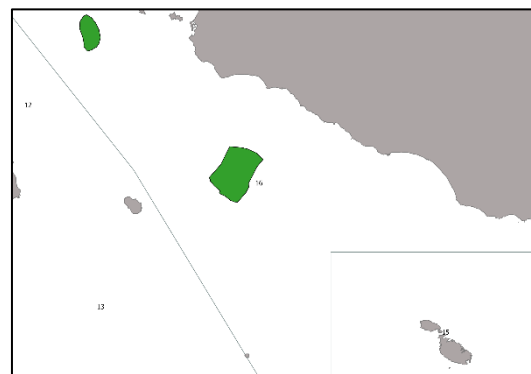


Other species - Demersals

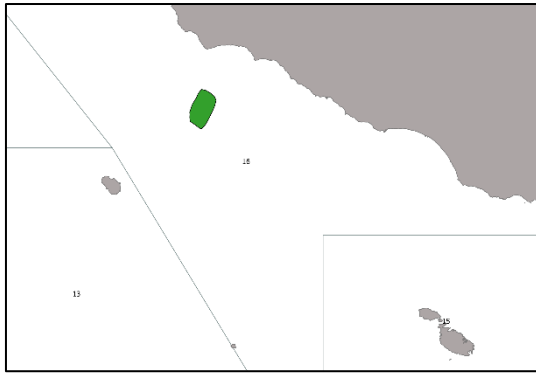
4.4 - *Aristaeomorpha foliacea* nursery grounds



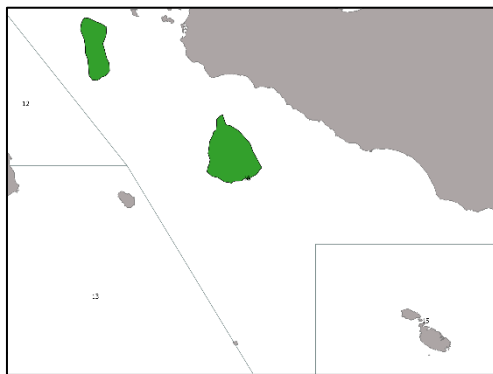
4.5 - *Nephrops norvegicus* nursery grounds



4.6 - *Eledone cirrhosa* nursery grounds



4.7 - *Phycis blennoides* nursery grounds





## 5 - Information from Criscoli et al., 2017

This research is focused on the identification and characterization of five nursery areas highly persistent through time using spatial interpolation techniques.

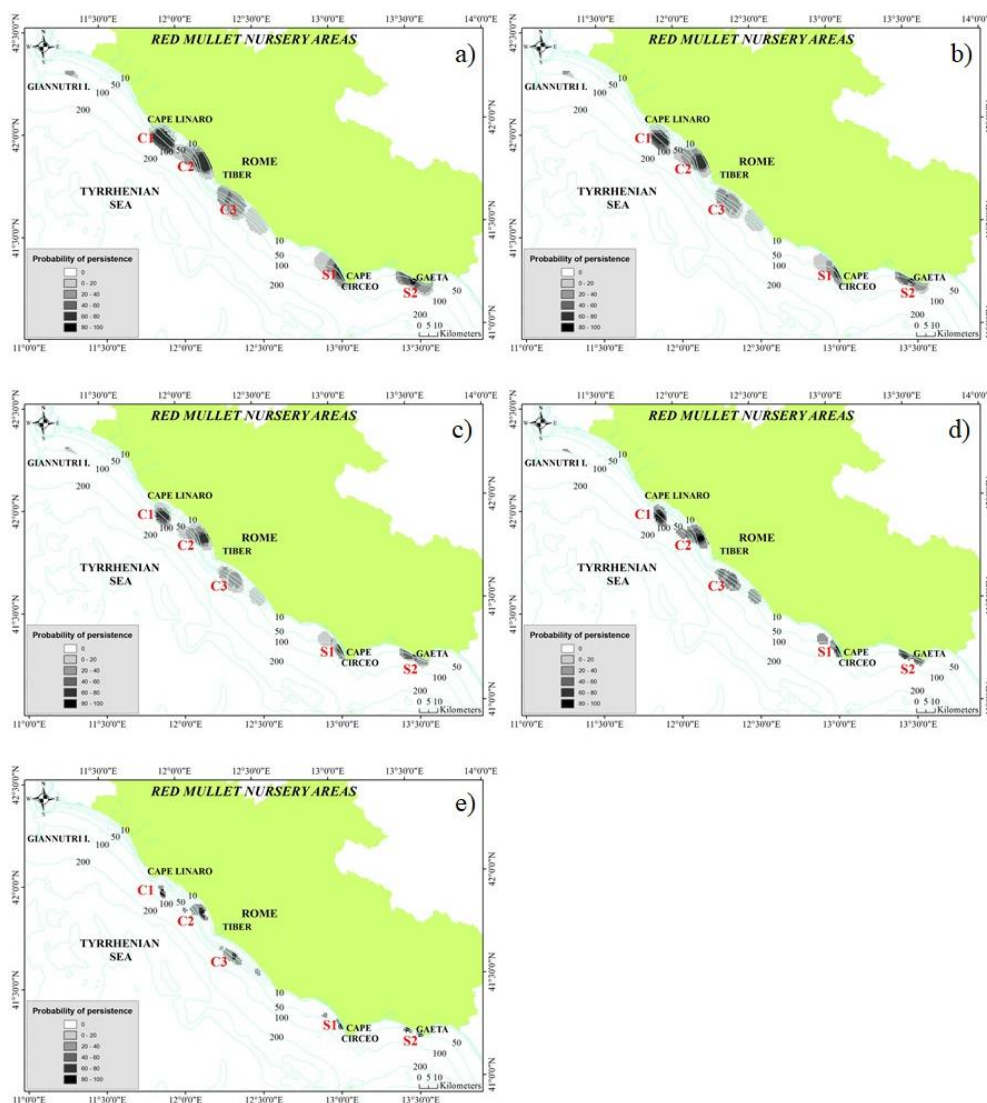
Source: Alessandro Criscoli, Paolo Carpentieri, Francesco Colloca, Andrea Belluscio & Giandomenico Ardizzone (2017) Identification and Characterization of Nursery Areas of Red Mullet *Mullus barbatus* in the Central Tyrrhenian Sea, Marine and Coastal Fisheries, 9:1, 203-215.

Modelling method: Spatial interpolation (Kriging indicator)

The indicator kriging was used to assess where juveniles were annually aggregated, predicting the probability that the values of the density numeric index ( $N/km^2$ ) were higher than a specified threshold value. The maps below show 5 scenarios, corresponding to different probability threshold ( $a=0.8$ ,  $b=0.6$ ,  $c=0.5$ ,  $d=0.4$ ,  $e=0.3$ ).

Reference years: 1994 – 2006

### 5.1 - *Mullus barbatus* nursery grounds



## 6 - Information from Colloca et al., 2015

This study identifies nursery grounds of exploited stocks and analyses the distribution of nursery areas of 11 important commercial species of demersal fish and shellfish in EU Mediterranean waters, describing the results of MEDISEH project.

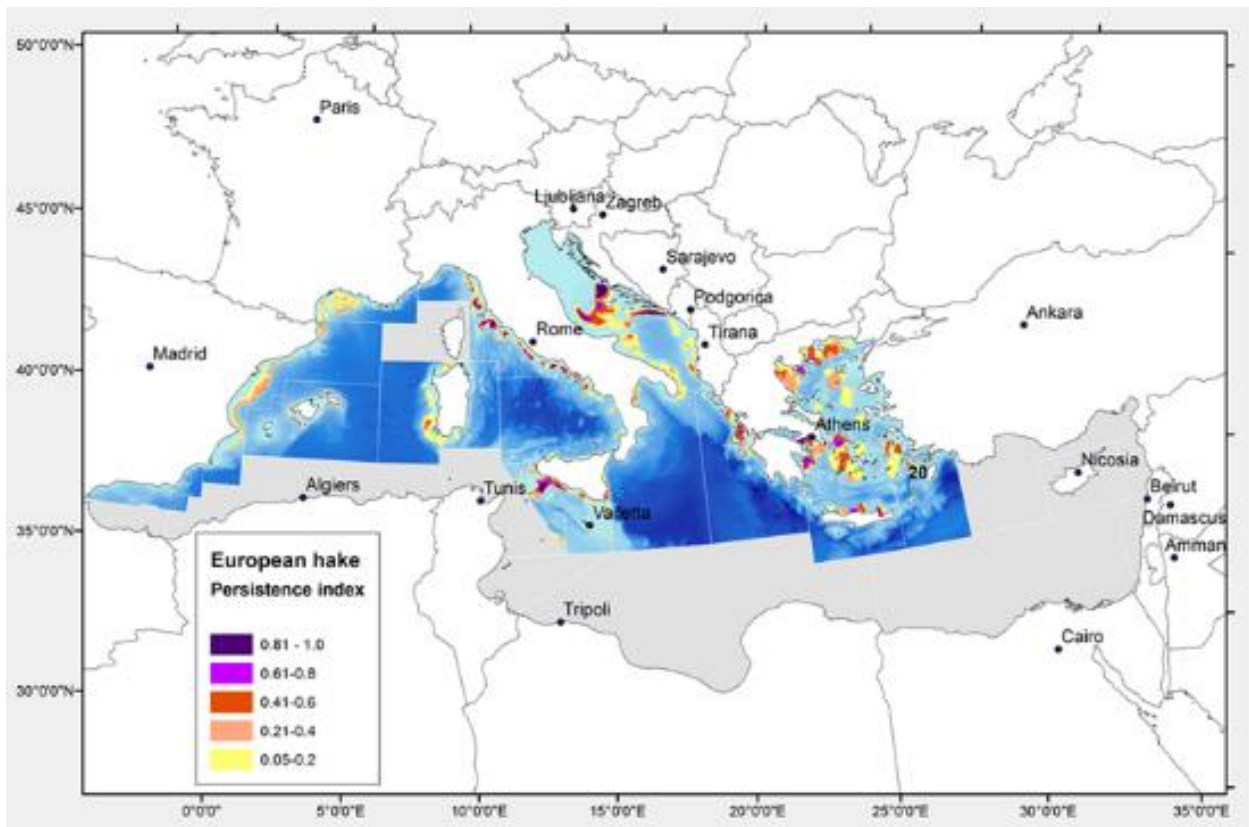
Source: Colloca F, Garofalo G, Bitetto I, Facchini MT, Grati F, Martiradonna A, et al. (2015) The Seascape of Demersal Fish Nursery Areas in the North Mediterranean Sea, a First Step Towards the Implementation of Spatial Planning for Trawl Fisheries. PLoS ONE 10(3): e0119590. doi:10.1371/journal.pone.0119590

Modelling method: Generalized Additive Models

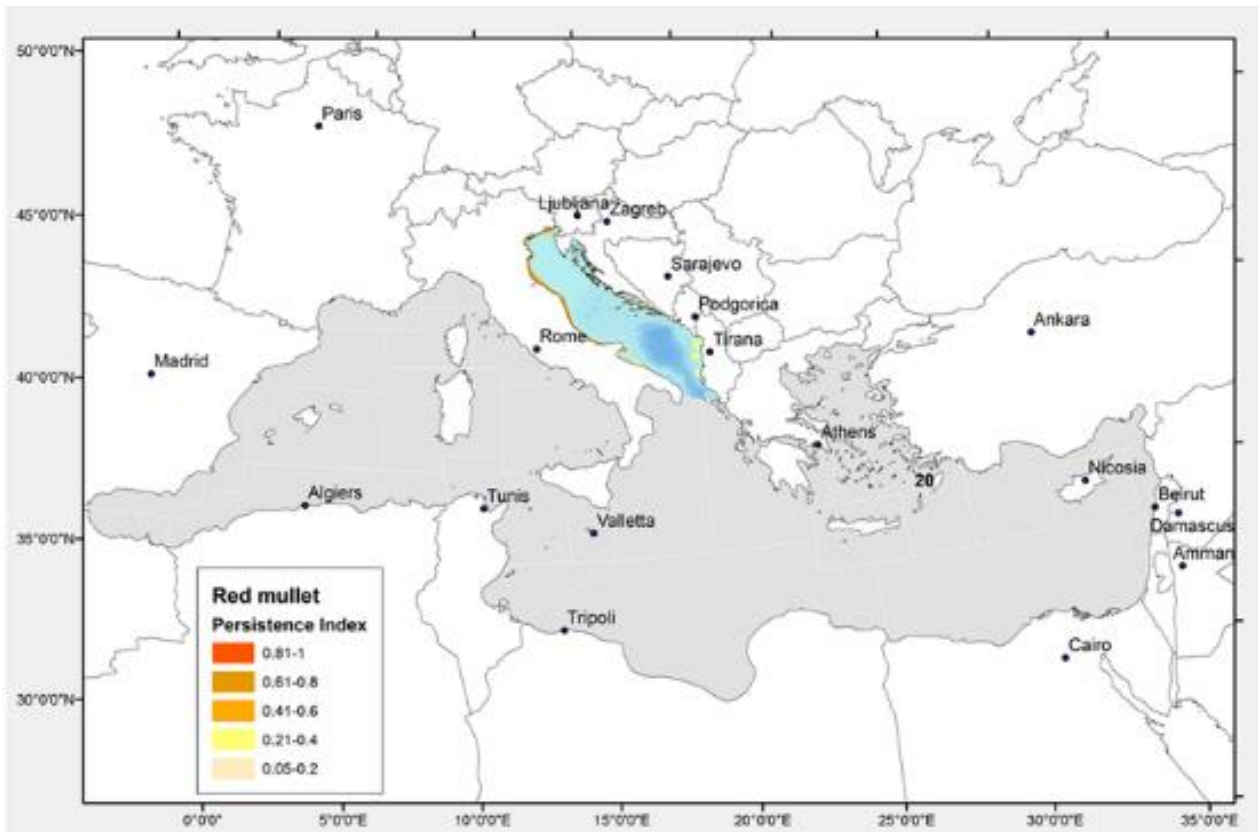
Reference years: 2003 – 2013

Priority species - Demersals

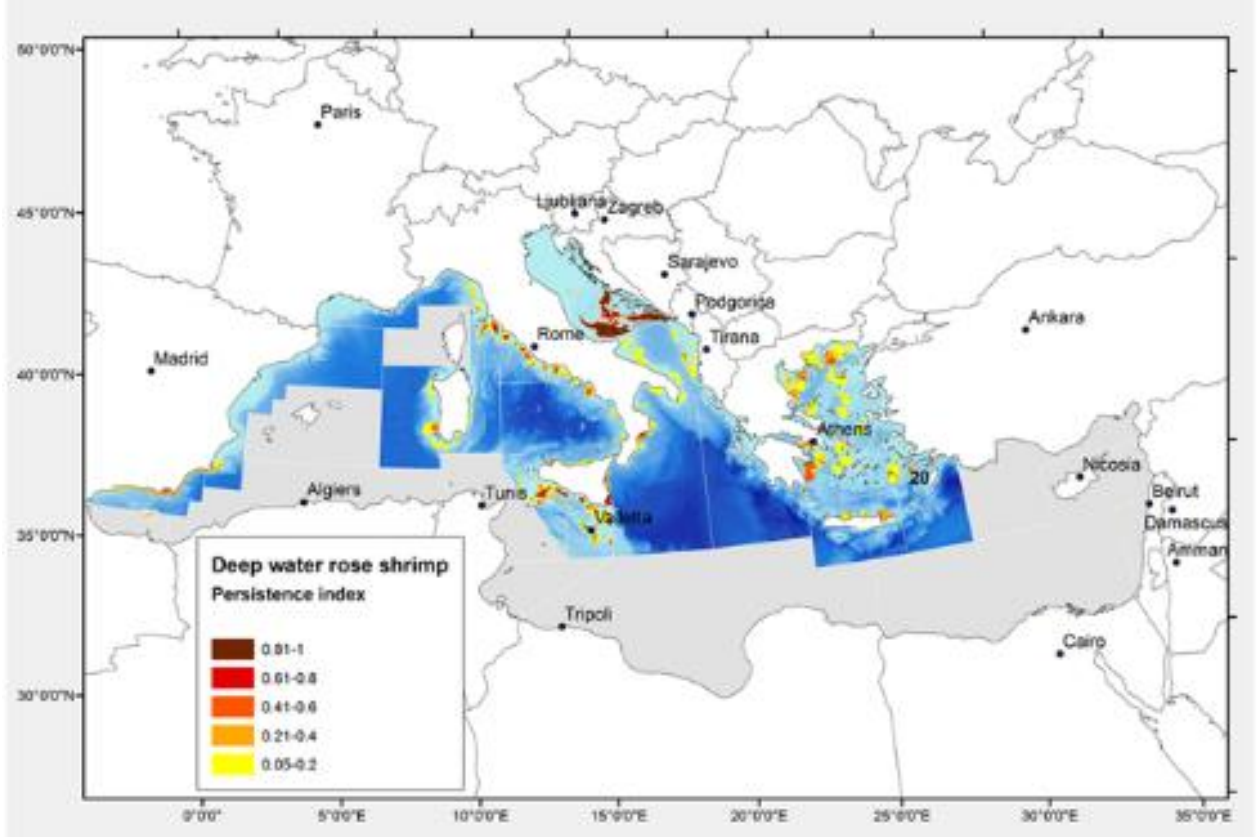
### 6.1 - *Merluccius merluccius* nursery grounds



### 6.2 - *Mullus barbatus* nursery grounds

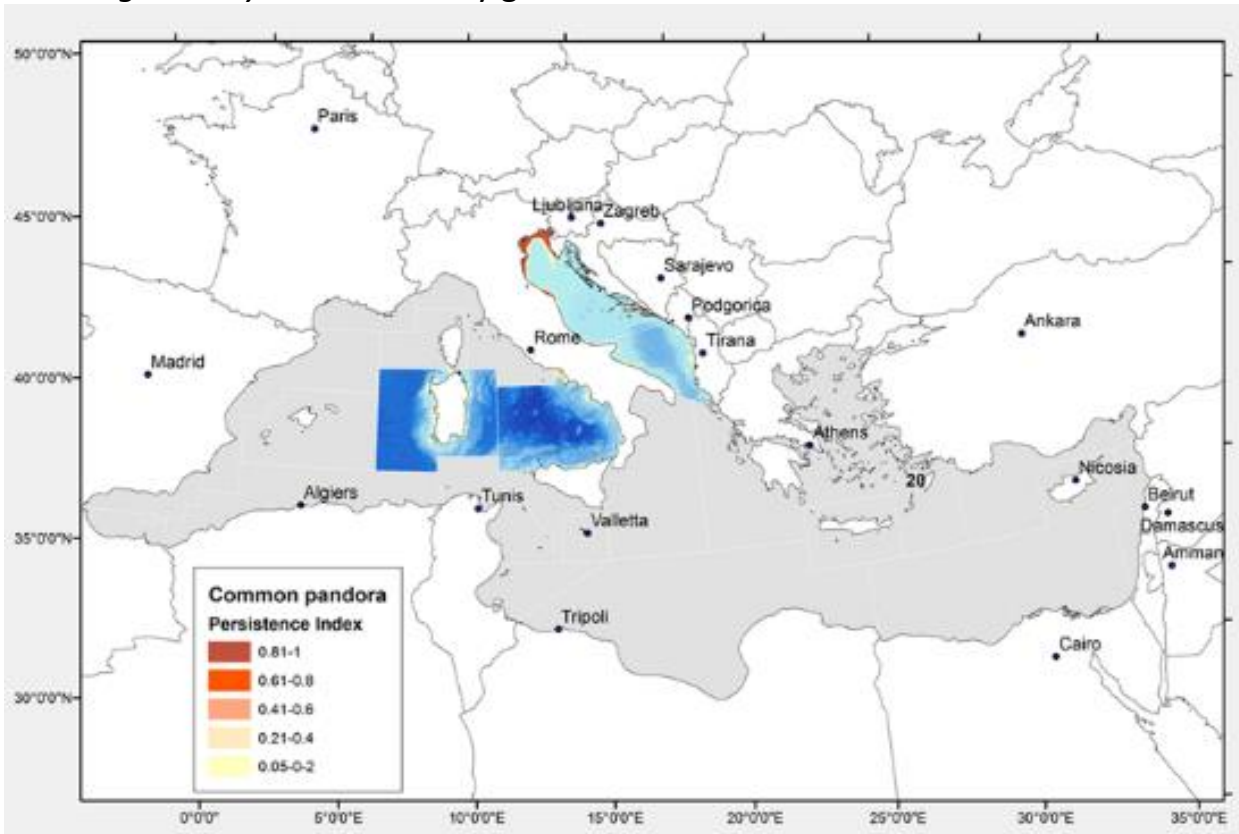


6.3 - *Parapenaeus longirostris* nursery grounds

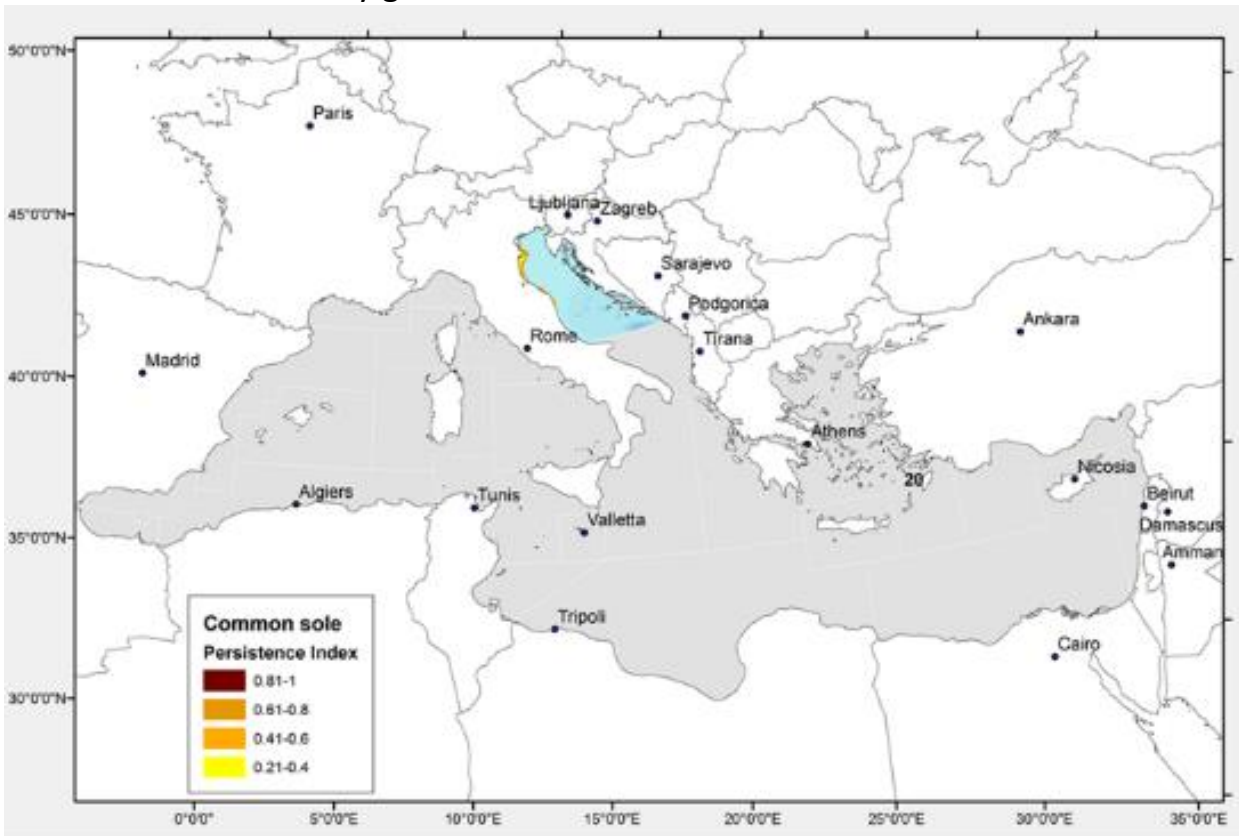


Other species – Demersals

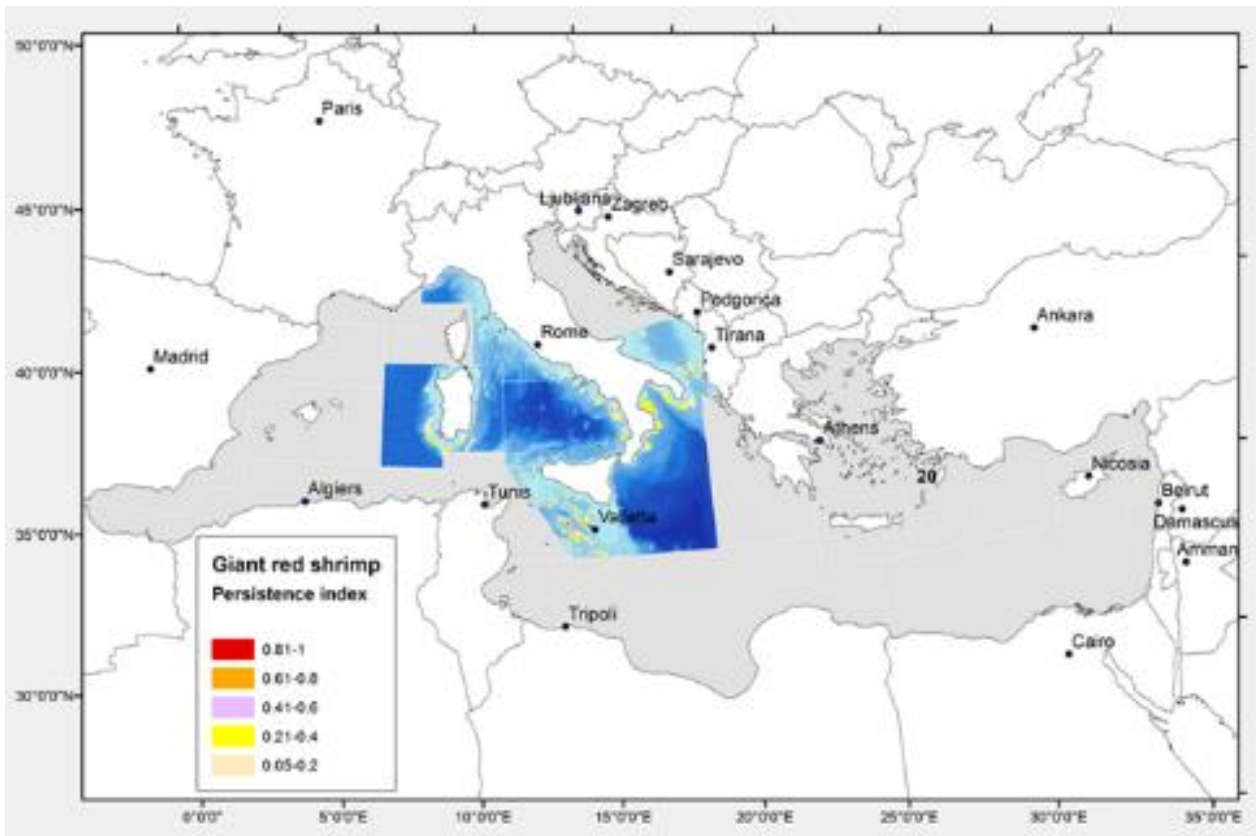
### 6.4 - *Pagellus erythrinus* nursery grounds



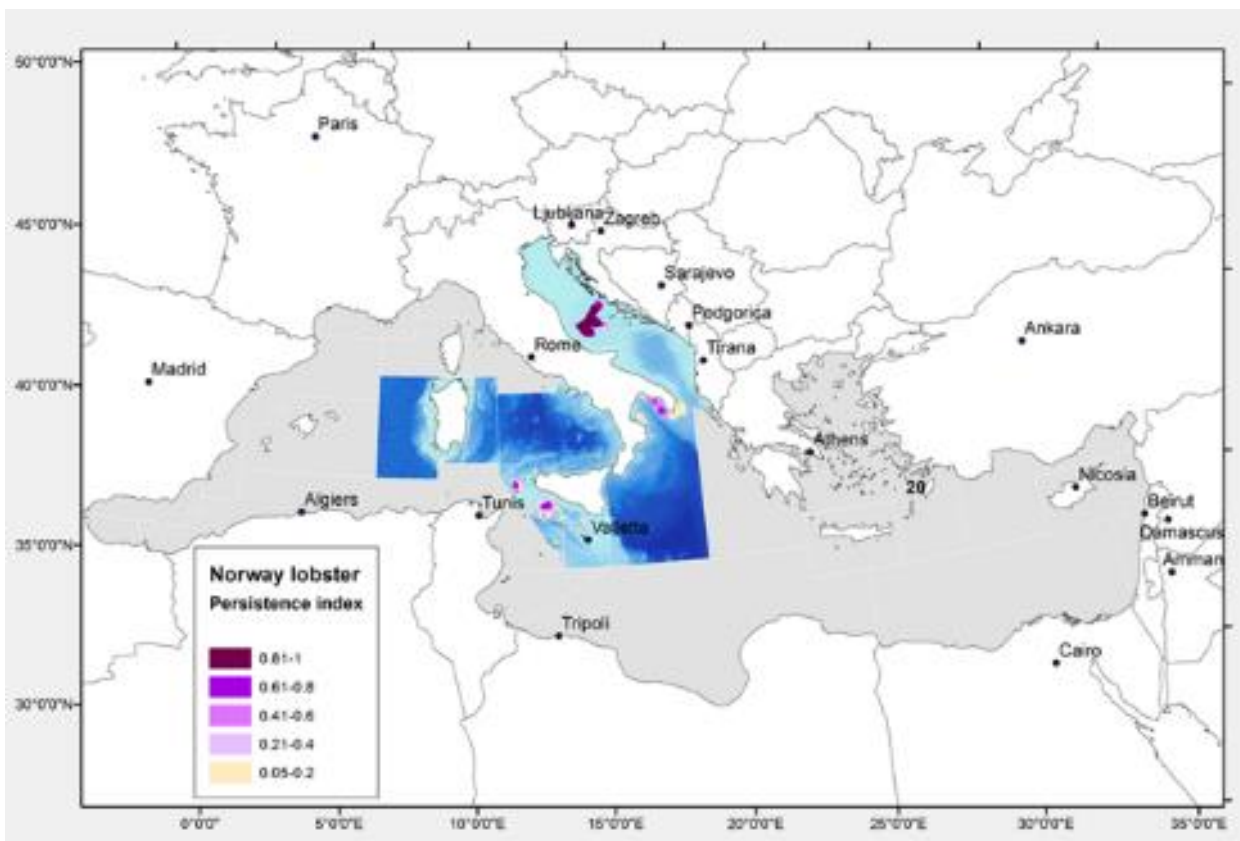
### 6.5 - *Solea solea* nursery grounds



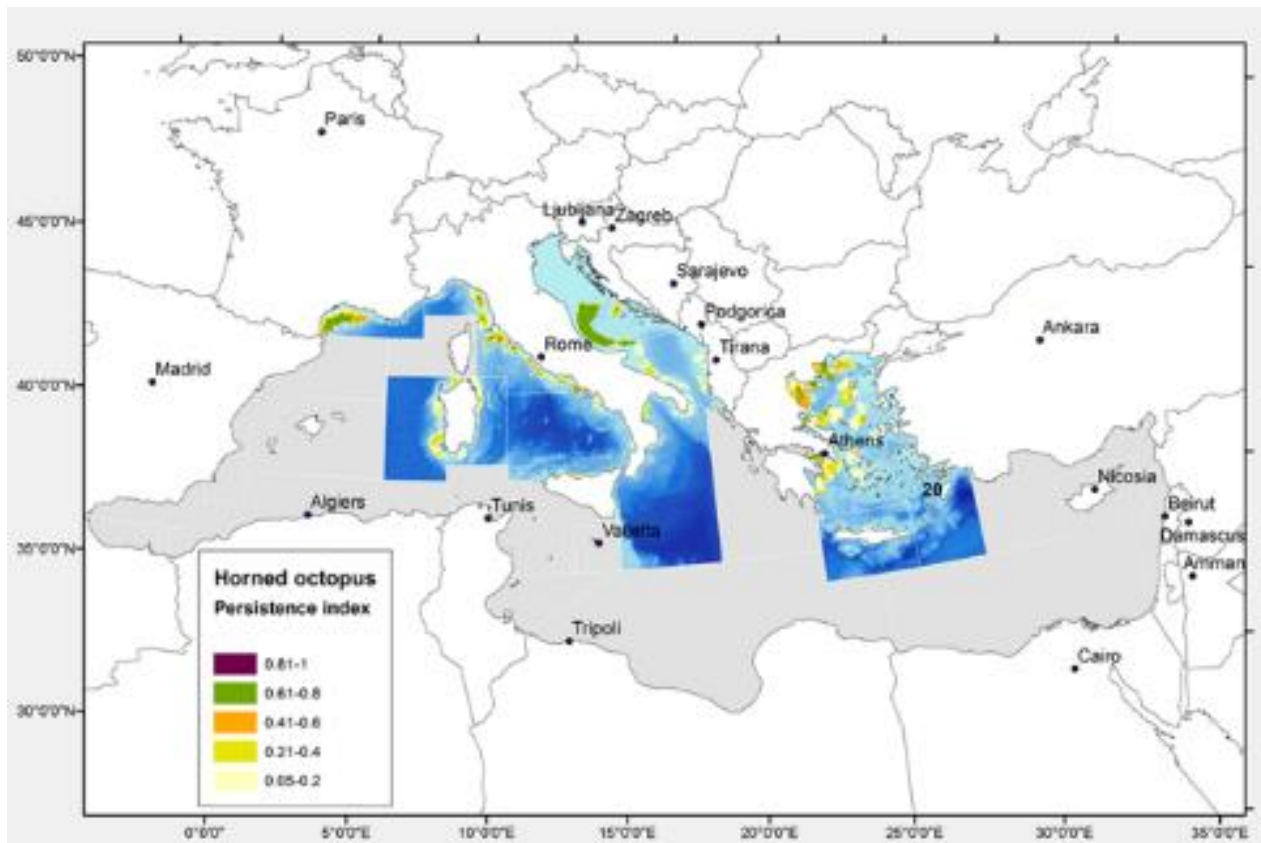
### 6.6 - *Aristaemorpha foliacea* nursery grounds



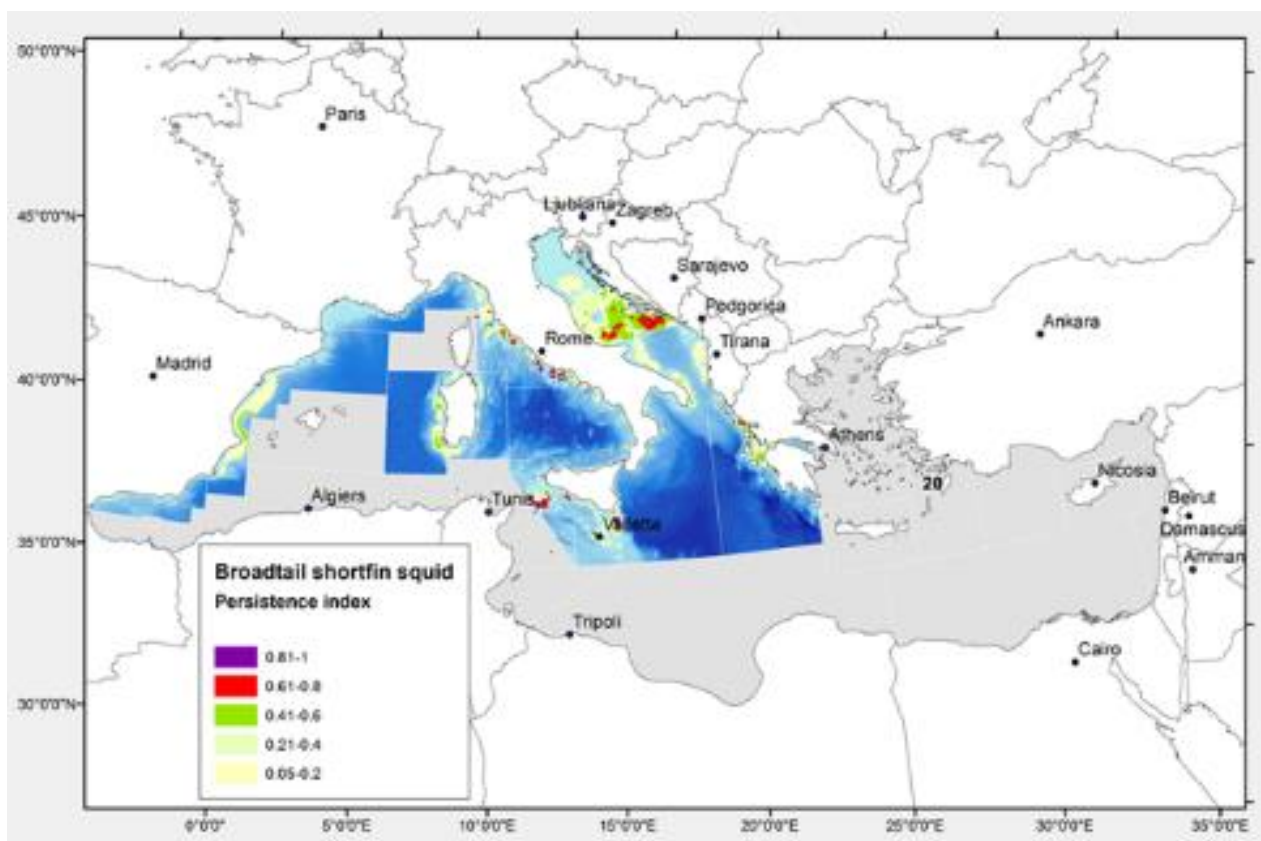
6.7 - *Nephrops norvegicus* nursery grounds



6.8 - *Eledone cirrhosa* nursery grounds



6.9 - *Illex coindetii* nursery grounds



## 7 - Information from Garofalo et al, 2010.

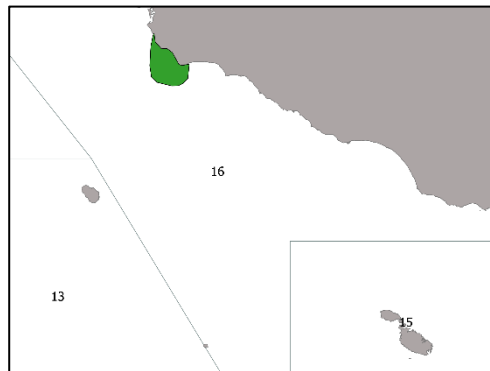
Study on the identification of nursery, spawning grounds and recruitment of *Octopus vulgaris* in the Strait of Sicily. The maps below show nursery areas with persistence indices > 60.

*Source:* Garofalo G., Ceriola L., Gristina M., Fiorentino F., Pace R., 2010. Nurseries, spawning grounds and recruitment of *Octopus vulgaris* in the Strait of Sicily, central Mediterranean Sea. ICES Journal of Marine Science, 67:1363-1371.

*Modelling method:* Inverse distance weighted interpolation of species density indices, annual hotspot analysis, time persistence index.

*Reference years:* 1994 – 2008

### 7.1 - *Octopus vulgaris* nursery grounds



### 7.2 - *Octopus vulgaris* spawning grounds

