MINOUW

SFS-09-2014

RIA •634495

Science, Technology, and Society Initiative to Minimize Unwanted Catches in European Fisheries

WP3. Impact assessment of minimizing unwanted catches and discarding.

Deliverable 3.2 Overlap of potential unwanted catch and fishing effort

Responsible beneficiary: 9 - HCMR

Contractual due date: month 24

Dissemination level: PUBLIC

Report Status: FINAL

Actual submission date: 27 April 2017 (month 26)

Authors: M. Giannoulaki, M.Myrto Pyrounaki, S. Despoti (HCMR); G. Milisenda, G. Garofalo, S. Vitale (CNR-IAMC); A. Ligas, M. Sbrana, C. Musumeci (CIBM); F. Maynou (CSIC); L. Bentes, J. Gonçalves, K. Erzini (CCMAR)

Contact person:

Dr. F. Maynou

maynouf@icm.csic.es

http://minouw-project.eu/

Co-funded by the Horizon 2020 Framework Programme of the European Union

European Commission

RESEARCH & INNOVATION

ID•634495

Table of Contents

Overlap of potential unwanted catch and fishing effort

1. Background

The catch of unwanted species or unwanted fractions of commercial species ("unwanted catches") has been recognized as an important problem in world fisheries (Kelleher 2005). Discarding is considered globally among the most important issues for fisheries management. The recent reform of the Common Fisheries Policy (Regulation (EC) No 1380/2013) establishes in its Art. 15 a landing obligation for the species which are subject to catch limits and, in the Mediterranean, for species which are subject to Minimum Conservation Reference Size (MCRS) as defined in Annex III to Regulation (EC) No 1967/2006. In the Mediterranean Sea, the unwanted catch fraction of commercial species varies from 13.3 and 26.8% (Tsagarakis et al. 2014) and bottom trawls produce among the highest unwanted catch rates (discards) in the Mediterranean (Tsagarakis et al. 2014).

The reasons behind discarding are several including market demand (species with low or no commercial value), regulations (TACs, quotas, species with minimum landing size), fishing strategies, environmental conditions (depth, productivity, etc.) and technical characteristics of the gears (Kelleher 2005, Catchpole et al. 2005, Sánchez et al. 2007, Tsagarakis et al. 2014, Gonçalves et al. 2007). The literature on discards has mainly been descriptive, with a focus on understanding discard rates of specific species or estimating the amount or proportion of total catch discarded from particular fisheries (Rochet et al., 2002).

The landing obligation raises several issues to stakeholders (examined in Deliverable D1.5 of the MINOUW project) and presents a wider concern, such as waste management, building port facilities, or adapting the existing ones, handling extra costs related to sorting and on board preservation of the unwanted catch, transportation to land facilities, creation of new markets and the challenge to avoid incentives to fish unwanted catches (Tsagarakis et al., 2017 and references therein, and D1.5).

However, the amounts of unwanted catches that need to be handled cannot always be estimated accurately (Uhlmann et al. 2014), especially since the ban applies to a certain number of species only and in addition, discards are dynamic in time and space. The spatial management of fisheries with special attention to identify locations that may produce unwanted catches has recently been proposed as a very useful tool for discard reduction strategies (Dunn et al., 2011; Viana et al., 2013, Pennino et al., 2014).

2. Objectives

Under the framework of Task 3.3 and the Objective 3.4 "The spatial dimension of discards reduction: Maps of high density patches of potential unwanted catch incorporating fishers' knowledge and fishing effort" the main goal of deliverable 3.2 was to estimate maps of potential unwanted catch from bottom trawlers in the different Case Studies (CS) using statistical modeling techniques and taking into account the spatial distribution of fishing effort. In a further step, we aimed to explore minimizing the production of unwanted catches by setting area closures. For this purpose, we assessed the overlapping between the resulting maps of potential areas with increased unwanted catch biomass related to species with Minimum Landing Size (MLS) or Minimum Conservation Reference Size (MCRS) with existing or proposed area closures per CS study. Specifically, we estimated the overlap between potential unwanted catch grounds of species with MCRS and a) nursery grounds of the main target species of the bottom trawl fishery per CS, b) existing area closures in a permanent basis, c) proposed area closures by national or international organizations or NGOs and d) proposed areas by fishermen organizations (depending on the CS).

The spatial information on discards is often largely ignored when it comes to marine spatial planning. Most important many marine fishing area closures decided in the past in the Mediterranean were not based on scientific knowledge. For example in Greek waters the majority of Fishing Restricted Areas were decided in the 60s or 70s (Papadopoulou et al., 2013). The resulting Tables presented in D3.2 give an idea of how effective existing or proposed marine fishing area closures can be in terms of discarding related to MCRS.

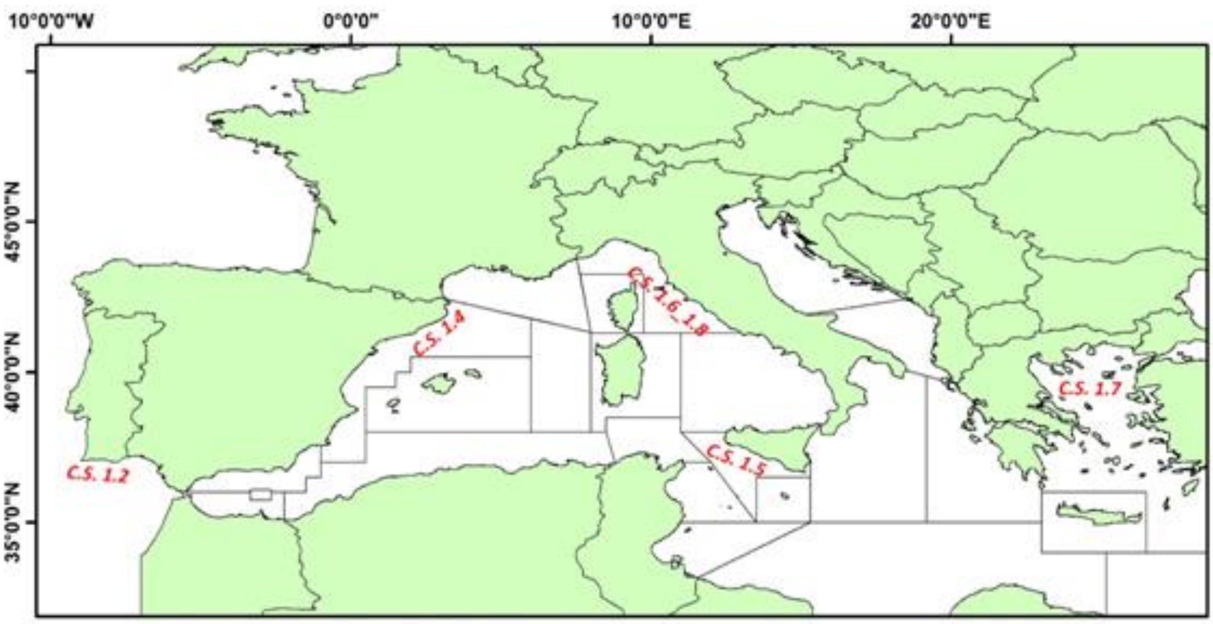


Fig. 1 Spatial location of the different Case Studies.

3. Datasets used:

Different main sources of data were identified to fulfil the project deliverables: i) national scientific bottom trawl surveys in Case Study 1.2, ii) the International scientific trawl surveys (MEDITS) in Case Studies 1.4, 1.5 and iii) the unwanted catch information from on board sampling in Case Studies 1.6-1.8 and 1.7.

For CS 1.2, the Portuguese International Bottom Trawl Survey (PT-IBTS) was used. Specifically, the Autumn groundfish survey was the one used in this report. This survey aims to monitor the abundance and distribution of hake in the spawning season. For CS 1.4 and 1.5 data from the Mediterranean International bottom trawl survey were used. 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 cod-end 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. For CS1.6-1.8 and CS1.7 data on discards and discarding practices from commercial fisheries and the national commercial sampling programs were used. Sampling activities for these two CS are carried out throughout the year, providing accurate information on the spatial and temporal dynamics of discards.

Fishing effort data were provided by the Vessel Monitoring System (VMS) for most case studies. VMS is the main geo-positioning device currently used to track the fishing activity of the European fleet (Regulation EC No 2371/2002).

4. Estimating Seasonal Potential Unwanted Catch Grounds based on habitat modeling techniques.

Below there are details on the estimation of potential unwanted catch grounds for CS1.7 Aegean Sea and CS 1.6-1.8 Ligurian and northern Tyrrhenian Sea. For these two CSs, "on board" recordings of discards at georeferenced commercial bottom trawlers were available and statistical modeling using satellite environmental data was applied.

Methodology used in each case study and results:

CS 1.7 - Aegean Sea (Greece)

In order to display the amount of potential total discard (PTD) for species with established minimum landing size as produced by fisheries in this CS, we used the discard amount coming from commercial data and on board sampling carried out within the framework of Data Collection Framework (DCF) in Greek waters. Data from this case study were elaborated directly by HCMR. The time series considered ranged from 2003 to 2008 and 2013 to 2014. In total 850 sampling stations were recorded covering most of the Greek part of Aegean Sea. Data have been analyzed considering three different seasons: spring, autumn and winter as summer period is closed for the bottom trawl fishery in territorial Greek waters.

For each sampling station several types of information such as date and time of sampling, longitude and latitude, swept area, depth, haul duration and species composition were recorded. Catch data were divided into **unwanted catch - discards (UWDI)** and landings per species at each sampling station. Subsequently the biomass of species with **minimum landings size (MLS)** or otherwise **established minimum conservation reference size (MCRS)** was standardized and summed as total kilograms per hour for the following groups:

- potential total discards (**PTD**),
- potential fish discards (**PFD**),
- potential Crustacean discards (**PCD**) and
- potential Cephalopod discards (**PCEPHD**).

Biomass of each group was modeled along with satellite environmental parameters (Sea Surface Chlorophyll concentration (CHL in mg/m^3), Particulate Organic Carbon concentration (POC in mg/m^3), Sea Surface Temperature (SST in ^oC), Sea Level Anomaly (SLA in cm), Sea Surface Salinity (SAL in psu), season and haul duration by means of Generalized Additive Models (GAMs). GAMs employ non-linear and non-parametric techniques for regression modeling (Hastie & Tibshirani, 1990). This allowed us to identify areas that are most likely to show high biomass of potential unwanted catch. Final model selection was made on a stepwise forward approach. Data were log or sqrt transformed and modeled using a Gaussian error distribution or a Gamma error distribution and an identity or log link function depending on the group analyzed and the inspection of the residual fit and the lack of trend in the residual vs predictor plots (i.e. residuals vs fitted values, QQ-plots, residual vs original explanatory variables). The minimization of the Restricted Maximum Likelihood (REML) and the level of Deviance Explained (DE) led to the selection of the model that fitted best the response variable (Wood 2006).

Because results revealed different selection pattern based on bathymetry, for each response variable (PTD, PFD, PCD except from PCEPHD) two models were applied:

a) one for observations at the shallow stratum (depth ≤ 150 m) and

b) one for observations at the deep stratum (depth > 150 m).

As data of Crustacea and Cephalopods were zero-inflated, a two stage modeling approach was followed (Brorchers et al., 1997, Gray 2005) involving a) a presence – absence model (data were divided into 1 for positive and 0 for non-positive hauls respectively and modeled using a binomial error distribution with logit link function), and b) a given presence model (only positive hauls, data were log transformed and modeled using a Gaussian error distribution with identity link function).

In order to avoid over-fitting and to simplify the interpretation of the results, the degree of smoothing was chosen based on the restricted maximum likelihood while the maximum degrees of freedom allowed to the smoothing functions were limited to the main effects at k = 5 and, for the first-order interaction effects, at k = 15. Only statistical significant parameters, with p-value < 0.05, were retained in the final models.

Based on the final model selected (Table 1) we obtained seasonal mean maps showing potential areas with increased discards biomass for the study period (Figs. 2-5).

Table 1. CS 1.7 Aegean Sea Final GAM models selected. Analysis of deviance for GAM covariates and their interactions of the final model fitted. Level of significance was set to 0.05. DE, deviance explained; AIC, Akaike information criterion value; REML, restricted maximum likelihood; CHL, sea surface chlorophyll concentration (log-transformed); SST, sea surface temperature; DEPTH, bathymetry (log transformed); SLA, sea level anomaly; DURATION, haul duration; SEASON; GSA, Geographical subarea.

Response variable	Depth categorization	Error distribution	Model	DE %	AIC	REML
Total discards	≤150 m depth	Gamma	te(CHL, SST) + s(DEPTH)	36.9%	2437.176	1266.6
	>150 m depth	Gamma	s(DEPTH) + s(CHL) + s(SST) + DURATION	31.4%	545.252	278.9
Fish discards	≤150 m depth	Gamma	te(CHL, DEPTH) + s(SST) + s(DURATION) + as.factor(GSA)	29.2%	2357.275	1195.8
	>150 m depth	Gaussian	s(CHL) + s(DEPTH) + s(DURATION)	27.2%	863.994	432.6
Crustacea discards	≤150 m depth	Binomial	te(CHL, DEPTH) + s(SLA) + as.factor(SEASON) + as.factor(GSA)	22.5%	1059.285	526.9
		Gaussian	s(CHL) + s(DEPTH) + s(SLA) + as.factor(SEASON) + as.factor(GSA)	37.4%	2534.299	1274.6
	>150 m depth	Binomial	te(CHL, DEPTH) + s(SST)	36.6%	235.142	107.1
		Gaussian	s(CHL) + s(DEPTH) + s(SST, SEASON) + as.factor(GSA)	30.8%	631.388	311.2
Cephalopod discards		Binomial	s(CHL) + s(DEPTH) + s(SLA) + s(SST, SEASON) + as.factor(GSA)	17.9%	1002.215	504.5
		Gaussian	s(CHL) + s(DEPTH) + s(SLA) + s(SST) + as.factor(GSA)	24.6%	3683.878	1851.3

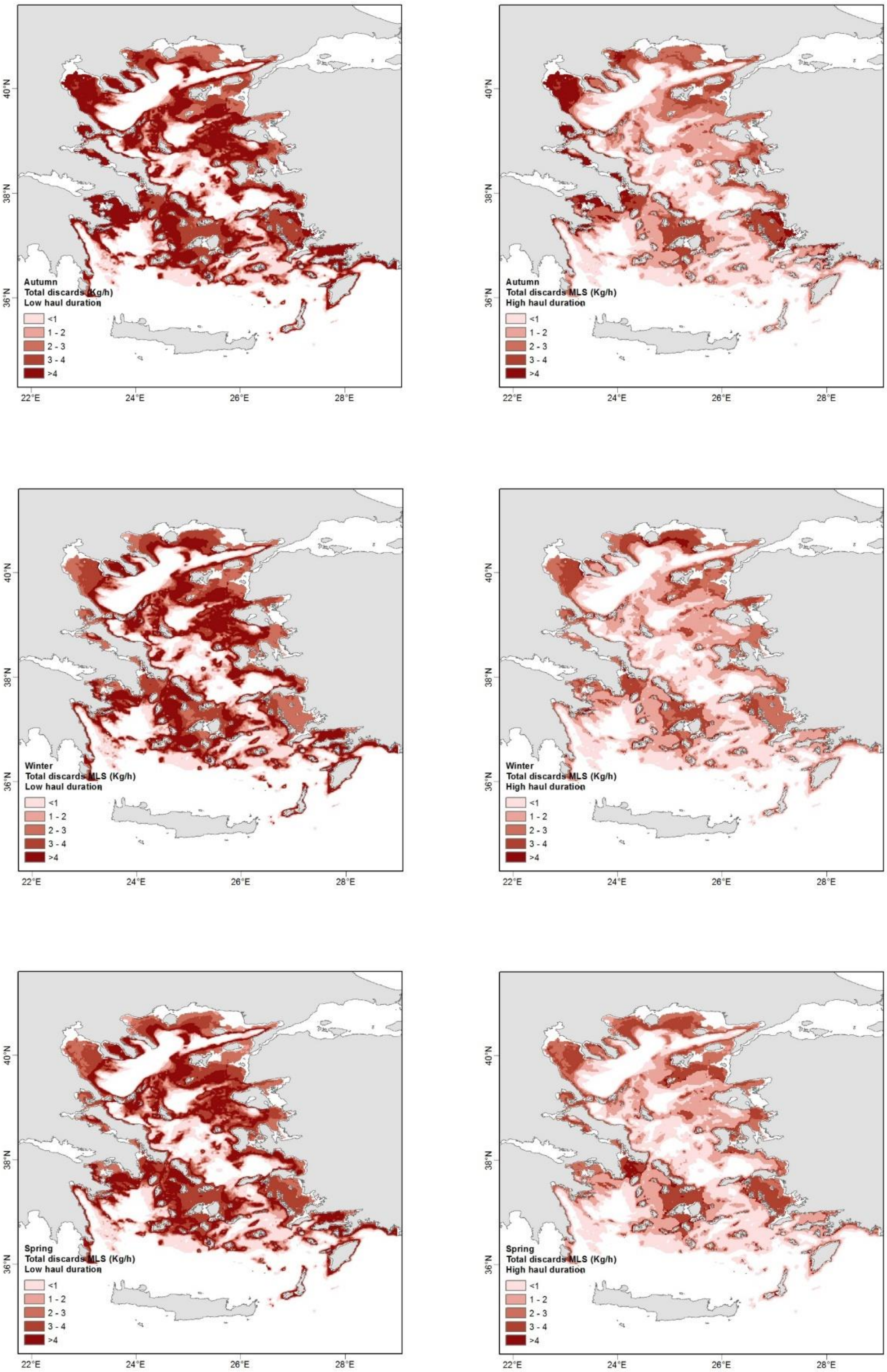


Fig. 2. CS 1.7 Aegean Sea Mean seasonal maps of potential total discards production for species with MLS. Low haul duration: 100 min; High haul duration: 400 min. (Shp files produced within D3.2).

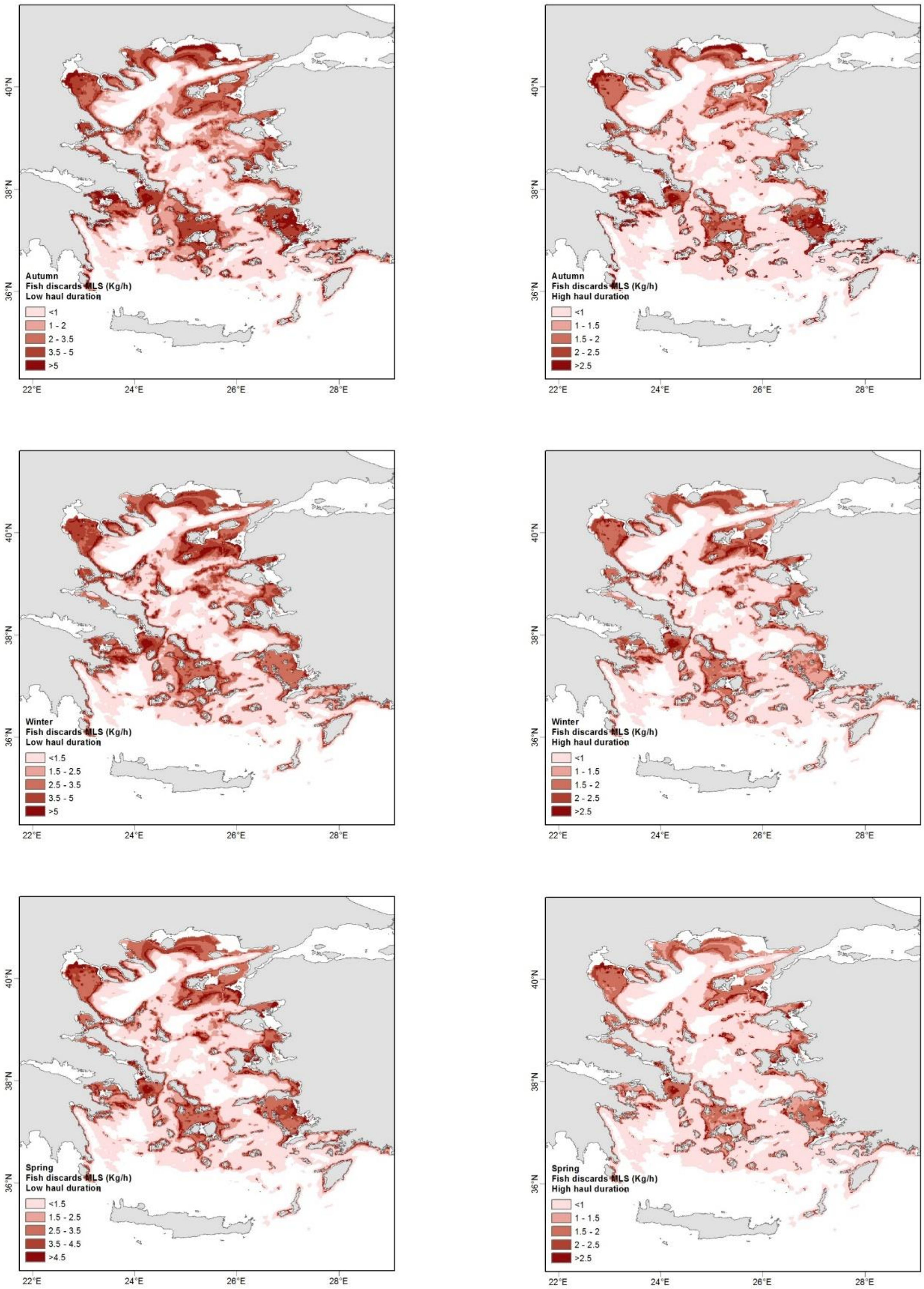


Fig. 3 CS 1.7 Aegean Sea Mean seasonal maps of potential fish discards production for species with MLS. Low haul duration: 100 min; High haul duration: 400 min. (Shp files produced within D3.2).

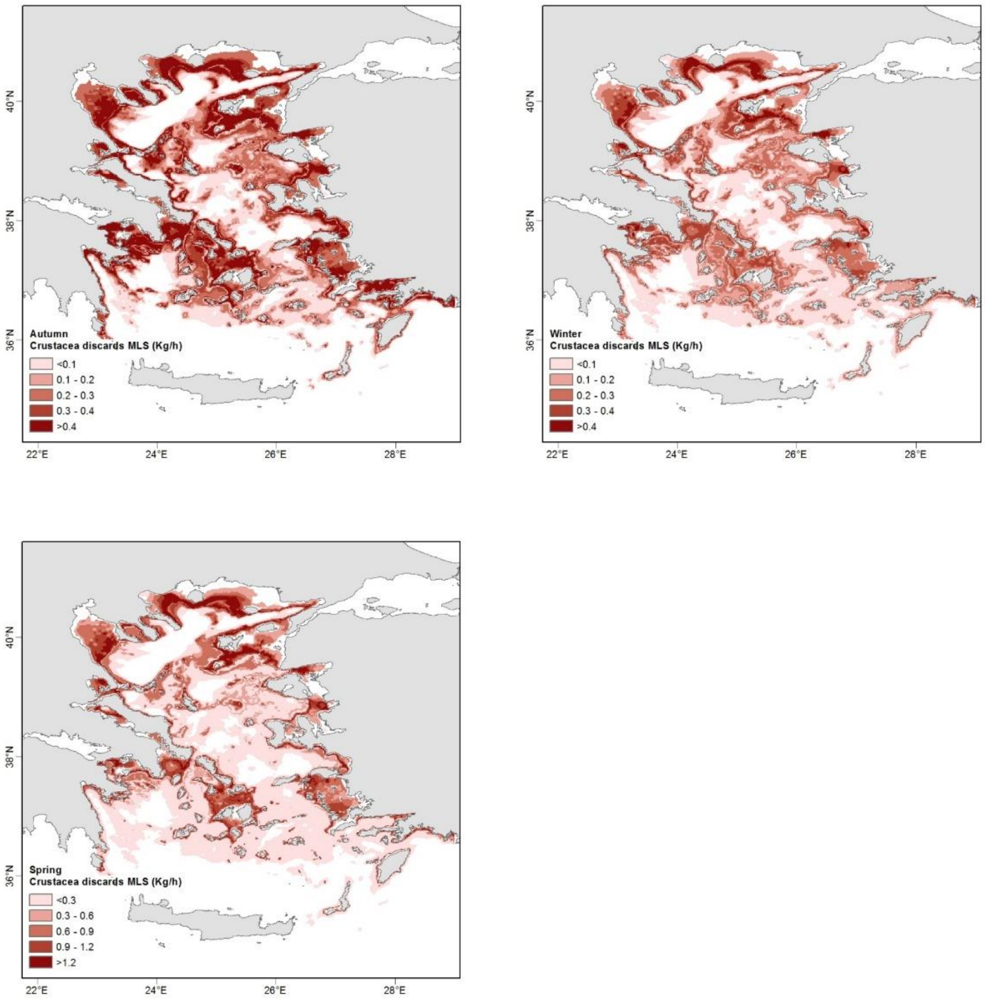


Fig. 4. CS 1.7 Aegean Sea Mean maps of potential Crustacea discards production for species with MLS. (Shp files produced within D3.2).

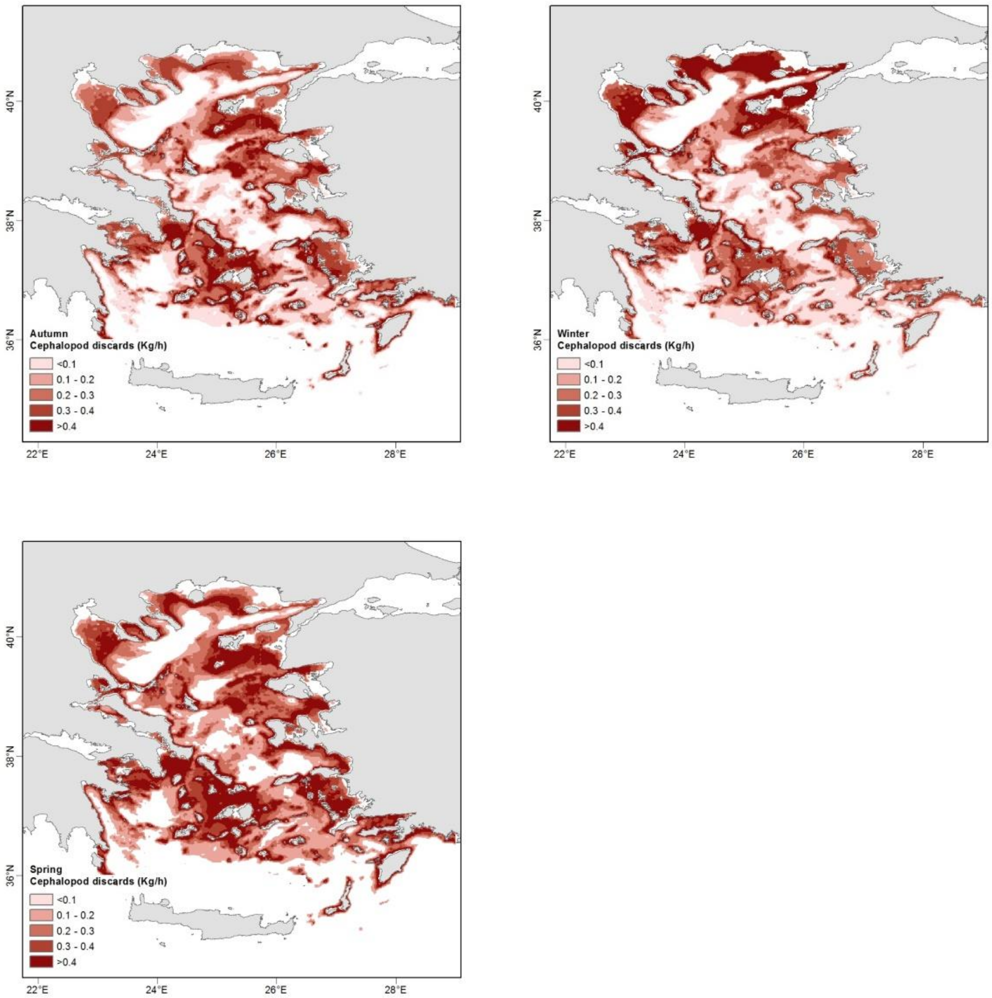


Fig. 5 CS 1.7 Aegean Sea Mean seasonal maps of potential cephalopod discards production for species with and without MLS. (Shp files produced within D3.2).

Weighting with Fishing Effort

Finally, for the year 2012 the seasonal maps were weighted at each grid point with the respective available fishing effort index as derived from VMS data (Maina et al., 2016):

Fishing Effort Index (FE_{index}) = FE/max(FE)

where Fishing Effort (FE) = Σ(hours/day) on an annual basis.

Weighted maps are shown in Figs. 6-9, in order to determine actual trawled areas of increased biomass of discards.

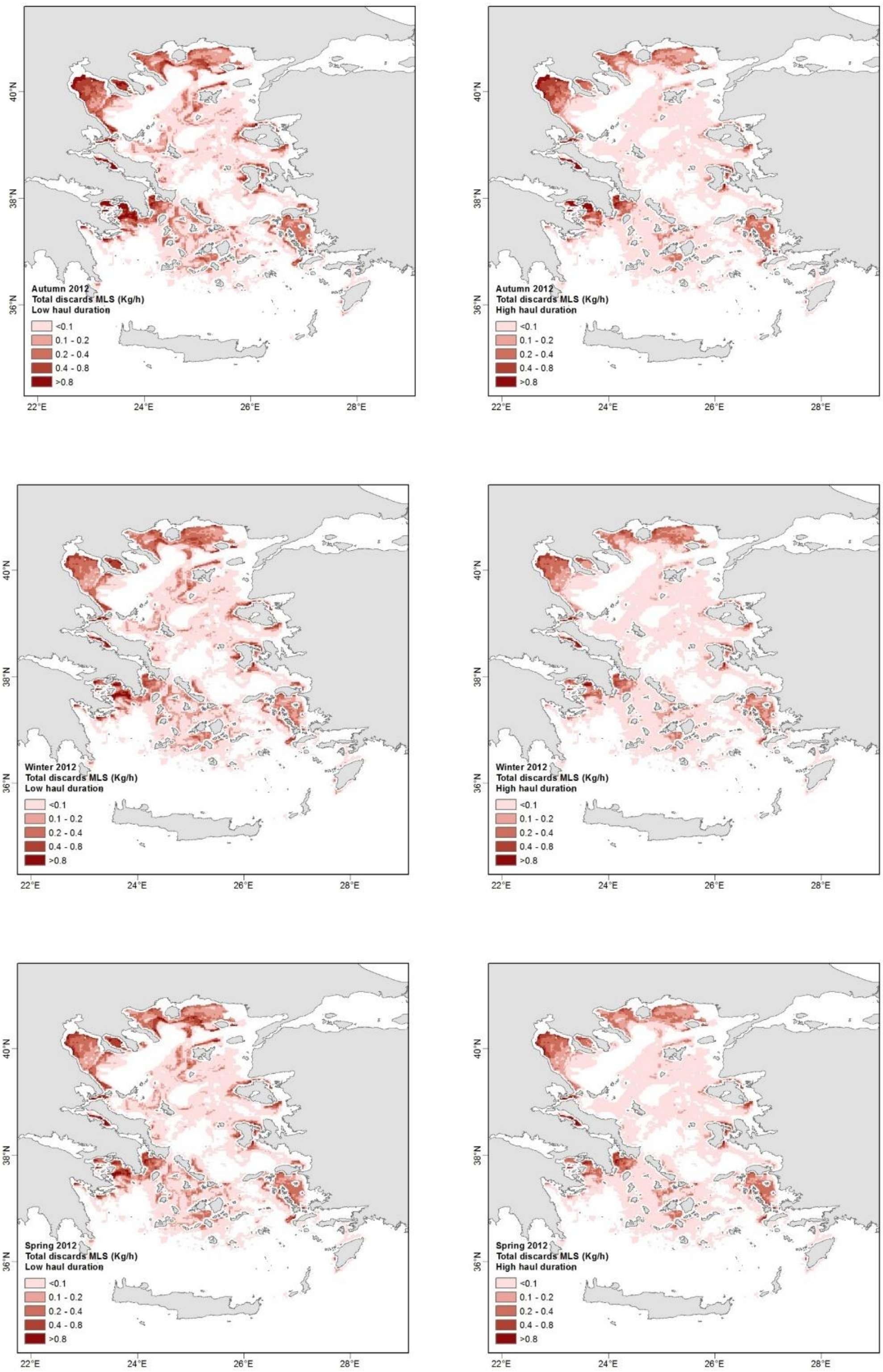


Fig. 6. CS 1.7 Aegean Sea Seasonal maps for the year 2012 of **potential total discards** production for species with MLS weighted by bottom trawlers fishing effort. (Shp files produced within D3.2).

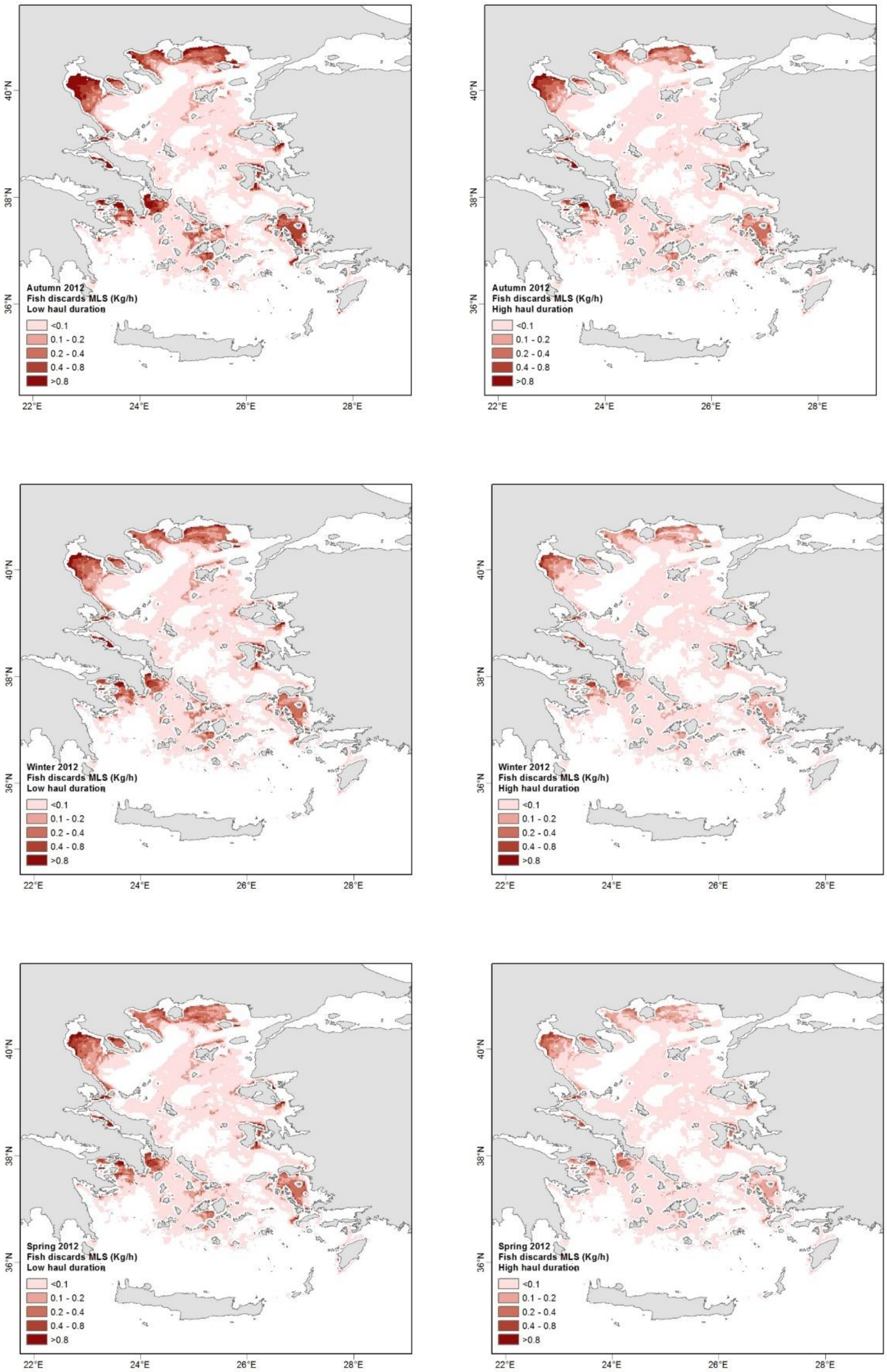


Fig. 7. CS 1.7 Aegean Sea Seasonal maps for the year 2012 of **potential fish discards** production for species with MLS weighted by bottom trawlers fishing effort. (Shp files produced within D3.2).

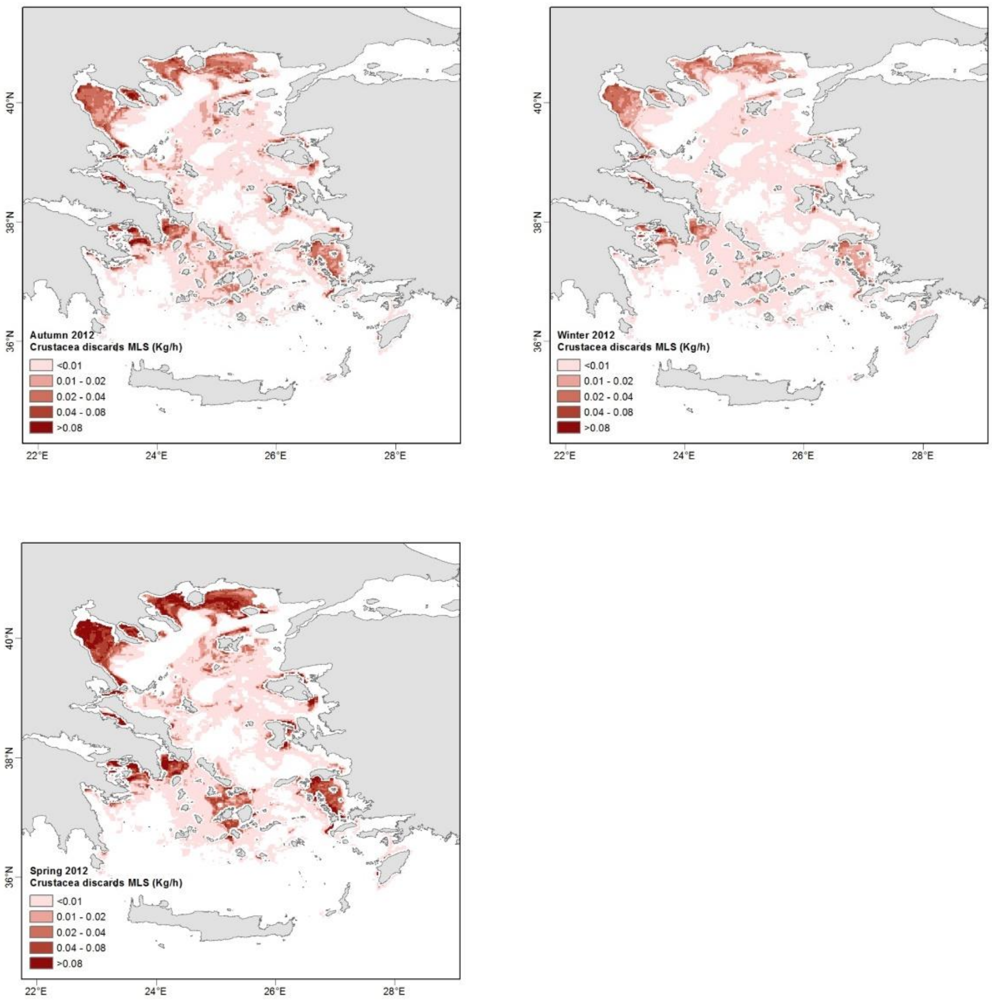
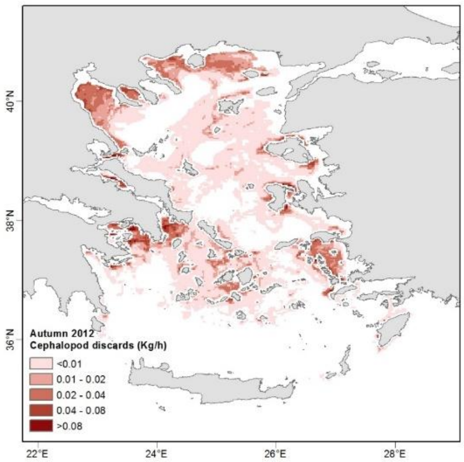
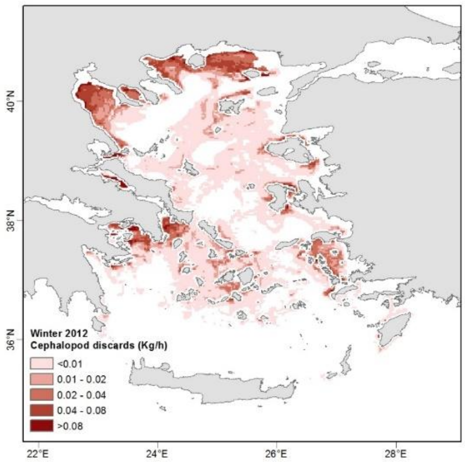


Fig. 8. CS 1.7 Aegean Sea Seasonal maps for the year 2012 of **potential Crustacea discards** production for species with MLS weighted by bottom trawlers fishing effort. (Shp files produced within D3.2).





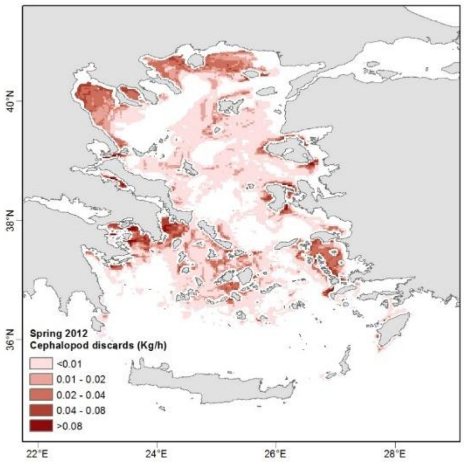


Fig. 9. CS 1.7 Aegean Sea Seasonal maps for the year 2012 of **potential cephalopod discards** production weight by bottom trawlers fishing effort. (Shp files produced within D3.2).

CS1.6-1.8 - Ligurian and northern Tyrrhenian Seas

In order to display the amount of potential total discard (PTD) for species with established minimum landing size as produced by fisheries in this case study, we used the discard amount coming from commercial data and on board sampling carried out under the framework of EU DCF in **Ligurian and northern Tyrrhenian Seas.** Data from this case study were analyzed directly by CIBM in collaboration with HCMR. The time series considered ranged from 2003 to 2015. In total 336 sampling stations were recorded. Data were analyzed considering four different seasons: summer, spring, autumn and winter.

For each sampling station several types of information such as date and time of sampling, longitude and latitude, swept area, depth, haul duration and species composition were recorded. Catch data were divided into **unwanted catch - discards (UWDI)** and landings per species at each sampling station. Subsequently the biomass of species with **minimum landings size (MLS)** or otherwise **established minimum**

conservation reference size (MCRS) was standardized and summed as total kilograms per hour for the **potential total fish discards (PTD) group**.

Biomass of **potential total discards** was modeled along with satellite environmental parameters (Sea Surface Chlorophyll concentration (CHL in mg/m^3), Particulate Organic Carbon concentration (POC in mg/m^3), Sea Surface Temperature (SST in ^{o}C), Sea Level Anomaly (SLA in cm), Sea Surface Salinity (SAL in psu), season and haul duration by means of Generalized Additive Models (GAMs). GAMs employ non-linear and non-parametric techniques for regression modeling (Hastie & Tibshirani, 1990). This allowed us to identify areas that are most likely to show high biomass of potential unwanted catch. Final model selection was based on a stepwise forward approach. Data were log transformed and modeled using a Gaussian error distribution with identity link function based on the inspection of the residual fit and the lack of trend in the residual vs predictor plots (i.e. residuals vs fitted values, QQ-plots, residual vs original explanatory variables). The minimization of the Restricted Maximum Likelihood (REML) and the level of Deviance Explained (DE) led to the selection of the model that fitted best the response variable.

In order to avoid over-fitting and to simplify the interpretation of the results, the degree of smoothing was chosen based on the restricted maximum likelihood while the maximum degrees of freedom allowed to the smoothing functions were limited to the main effects at k = 5. Only statistical significant parameters, with p-value < 0.05, were retained in the final models.

Based on the final model selected (Table 2) we obtained seasonal mean maps showing potential areas with increased total discard biomass for the study period (Fig 10).

Table 2. CS 1.6-1.8 Ligurian and northern Tyrrhenian Seas Final GAM models selected. Analysis of deviance for GAM covariates and their interactions of the final model fitted. Level of significance was set to 0.05. DE, deviance explained; AIC, Akaike information criterion value; REML, restricted maximum likelihood; DEPTH, bathymetry (log transformed); SAL, sea surface salinity (log transformed); SEASON.

Response variable	Depth categorization	Error distribution	Model	DE %	AIC	REML
Total discards	<600m depth	Gaussian	s(DEPTH) + s(SAL) + SEASON	57.5%	1262.2	634.5

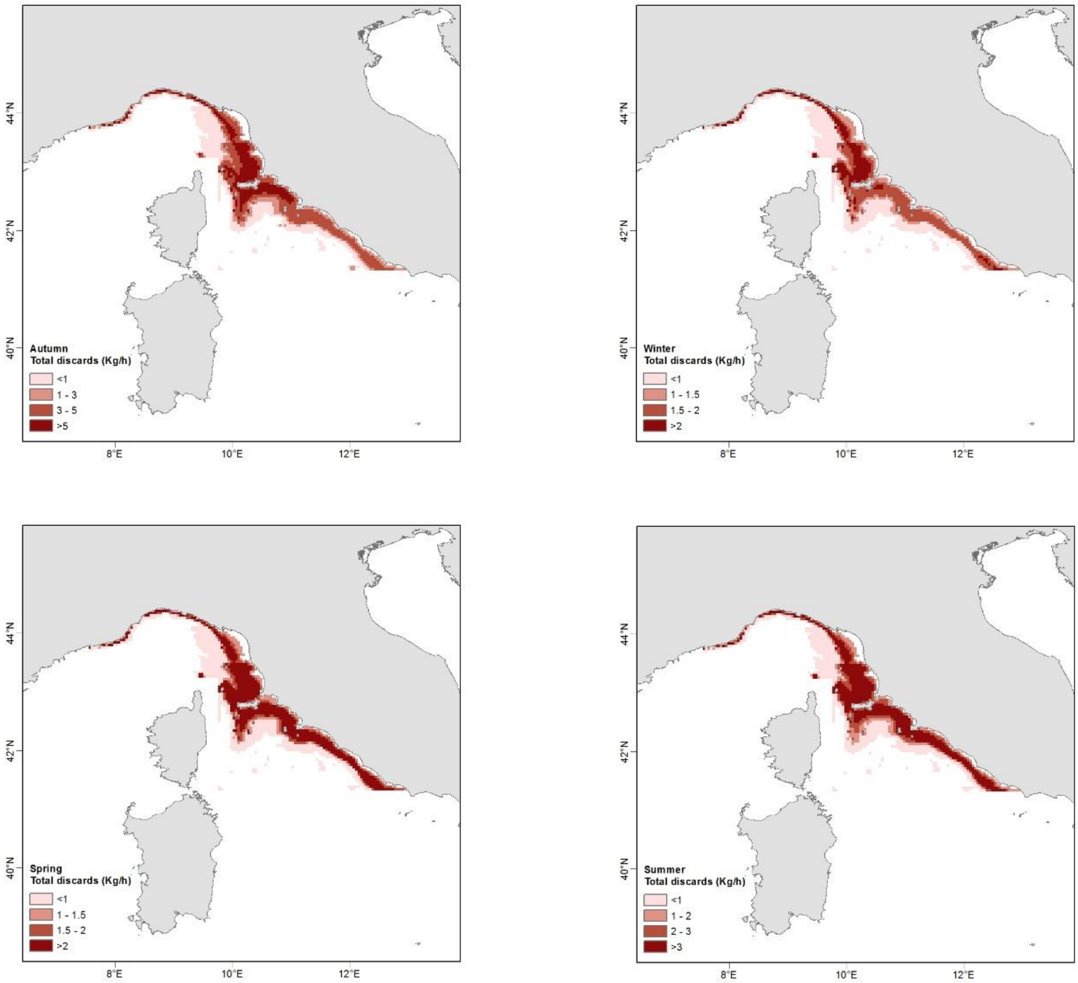


Fig. 10. CS 1.6-1.8 Ligurian and northern Tyrrhenian Seas Mean seasonal maps of potential total discards production. (Shp files produced within D3.2).

5. Estimating Potential Unwanted Catch Grounds based on bottom trawl surveys

For D3.2 no additional modeling was done concerning those Case Studies that were based on bottom trawl survey as the estimation of potential unwanted catch grounds was already done within D1.9.

CS1.2 – Algarve (SW Portugal)

Within D1.9 (Milisenda et al, 2016a), the amount of potential total discard (PTD) for CS 1.2 the raster file of unwanted catches (computed from International Bottom Trawl Survey (IBTS) data was combined and multiplied with the raster file of VMS data from crustaceans trawlers representing the fisheries effort in the same zone. The two-raster files were obtained using the same temporal range (2009, 2010 and 2011). Subsequently, the spatial analysis of PTD was performed using geostatistical methods (variogram analysis and kriging).

Density hot spots were outlined on the kriging maps using a threshold calculated on the basis of the cumulative distribution of the PTD and the Hot Spot Analysis (Getis-Ord Gi*) tool of ArcMap. The Getis' G statistic with a 0.95 significance level was selected among the local methods for spatial hot-spot identification in order to identify and locate spatial clusters of PTD with significantly higher production.

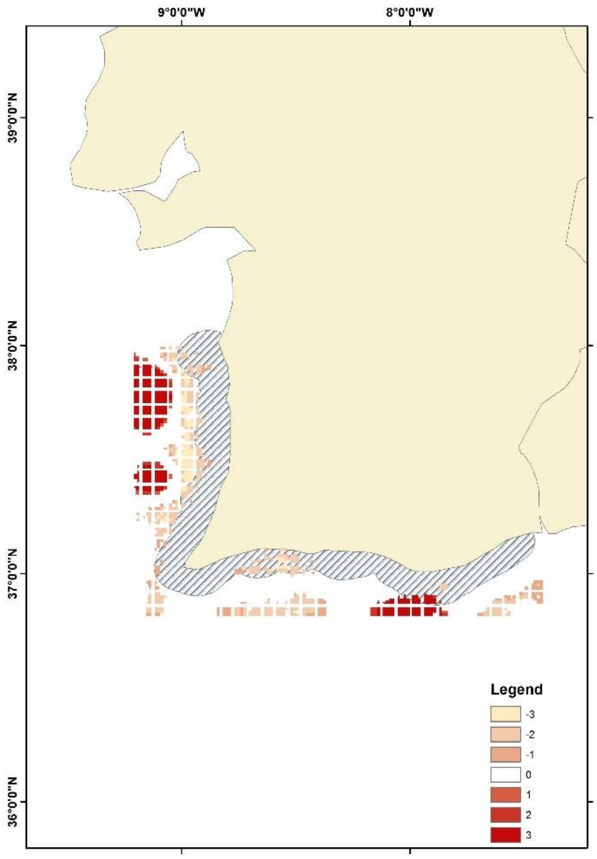


Fig. 11. CS 1.2 Algarve (SW Portugal) HotSpot maps showing the zones with the highest level of potential total discard production. (Shp files produced within D1.9).

CS1.4 – Catalan sea

Within D1.9 (Milisenda et al, 2016a), the amount of potential total discard (PTD) for CS 1.4 the raster file of unwanted catches (computed from the Mediterranean International bottom trawl survey (MEDITS) data was combined and multiplied with the raster file of VMS data from bottom trawlers representing the fisheries effort in the same zone. The two-raster files were obtained using the same temporal range (2013 and 2014). Subsequently, the spatial analysis of PTD was performed using geostatistical methods (variogram analysis and kriging).

Density hot spots were outlined on the kriging maps using a threshold calculated on the basis of the cumulative distribution of the PTD and the Hot Spot Analysis (Getis-

Ord Gi*) tool of ArcMap. The Getis' G statistic with a 0.95 significance level was selected among the local methods for spatial hot-spot identification in order to identify and locate spatial clusters of PTD with significantly higher production.

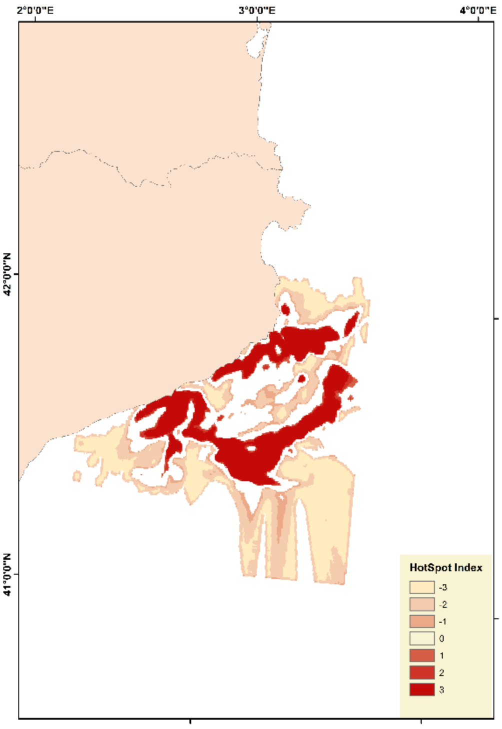


Fig. 12. CS 1.4 Catalan Sea HotSpot maps showing the zones with the highest level of potential total discard production. (Shp files produced within D1.9).

CS1.5 –Strait of Sicily

Within D1.9 (Milisenda et al, 2016a), the amount of potential total discard (PTD) for CS 1.5 the raster file of unwanted catches (computed from the Mediterranean International bottom trawl survey (MEDITS) data was combined and multiplied with the raster file of VMS data from bottom trawlers representing the fisheries effort in the same zone. The two raster files were obtained using the same temporal range (2009, 2010, 2011, 2012 and 2013). Subsequently, the spatial analysis of PTD was performed using geostatistical methods (variogram analysis and kriging).

Density hot spots were outlined on the kriging maps using a threshold calculated on the basis of the cumulative distribution of the PTD and the Hot Spot Analysis (Getis-Ord Gi*) tool of ArcMap. The Getis' G statistic with a 0.95 significance level was selected among the local methods for spatial hot-spot identification in order to identify and locate spatial clusters of PTD with significantly higher production.

For this CS, a persistent zone of undersized organisms was defined as an area consistently occupied by the highest density of PTD, 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:

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

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.

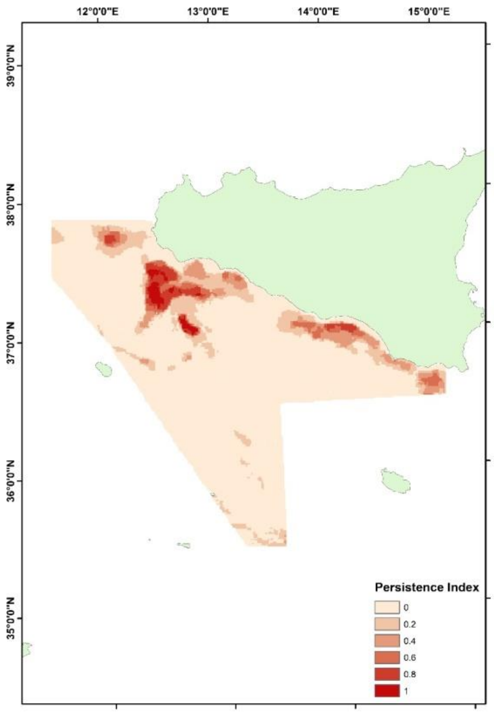


Fig. 13. CS 1.5 Strait of Sicily Persistence index maps showing the zones with the highest level of persistence of total discard production. (Shp files produced within D1.9).

6. Examining the spatial dimension of discards reduction in terms of nursery grounds and area closures for bottom trawlers

Under the framework of D3.2 we estimated the overlap between potential unwanted catch grounds of species with MCRS and a) nursery grounds of the main target species of the bottom trawl fishery per CS, b) existing area closures in a permanent basis, c) proposed area closures by national or international organizations or NGOs and d) proposed areas by fishermen organizations (depending on the CS).

6.1. Overlapping of PTD grounds with the nursery grounds of the target species

For the purposes of D3.2, we estimated the overlap between the potential unwanted catch grounds of species with MCRS and the nursery grounds of the main target species of the bottom trawl fishery per CS. The .shp files produced under D1.2 and D1.3 (Milisenda et al., 2016b) were used for this purpose, and overlapping was estimated by means of GIS techniques and the "tabulate area" tool of the ArcGIS software.

Depending on the analysis done per CS and the shp files available, we made the following choices:

a) limited the work to the main target species for the bottom trawl fishery in all CSs, Merluccius merluccius, Mullus spp. (M. barbatus for the Mediterranean CSs, and M. surmuletus for CS1.2 in Portuguese waters), Trachurus trachurus, Parapenaeus longirostris.
b) Defined a threshold to represent areas with high probability to be nursery grounds. For standardization purposes, this was selected to be >0.4 in all cases besides M. barbatus in CS1.7 where the estimated probability was generally low.
c) Determined a threshold to define areas of increased biomass of total discards (iBPTD). This choice was quite complicated as potential discard grounds were not estimated based on the same methodology. Thus for the two CSs (1.7 and 1.6-1.8) where GAMs and habitat modeling techniques were applied, areas exceeding 75% of the maximum estimated total discard catch were selected. For those CSs (1.4 and 1.2) where hot spot analysis was applied, areas exceeding a threshold of 1 were selected (hotspot -3 to 3). For CS 1.5 where persistence analysis was also applied, area exceeding a threshold of 2 was selected (persistence index 0-5).
d) Estimated the overlap between b) and c)

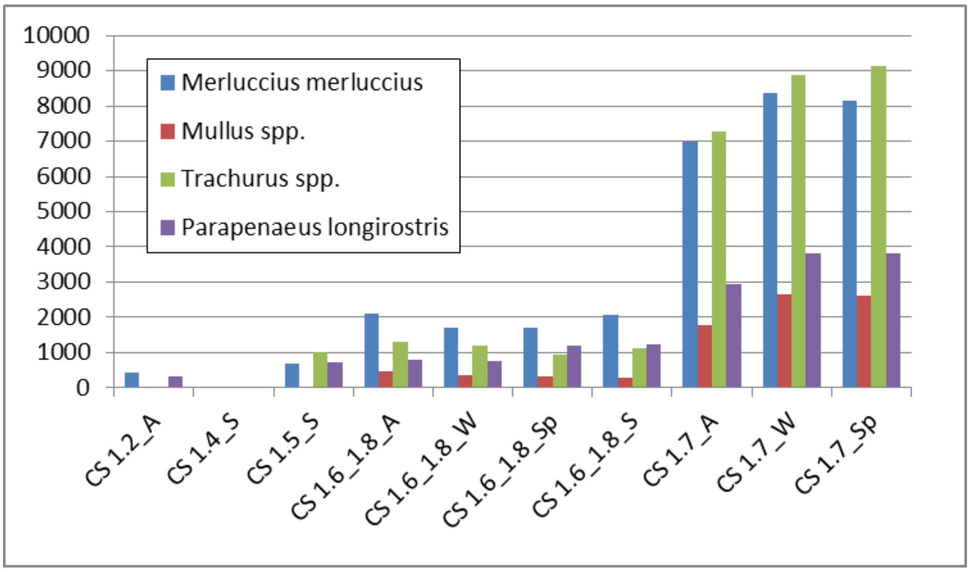
Results are presented in Table 3 and Fig. 14 for each CS. Seasonal overlapping was available only for CS 1.7 and CS 1.6-1.8.

Table 3. Results of overlapping between a) areas of increased biomass of total discards iPTD and b) the potential nursery grounds of the main four target species per CS. Seasonal overlapping was estimated depending on CS.

	iPTD in Km^2	*Merluccius merluccius*		*Mullus* spp.**		*Trachurus* spp.*		*Parapenaeus longirostris*	
		In km^2	%	In km^2	%	In km^2	%	In km^2	%
CS 1.2 (Autumn)	625.7	440.5	70.4%	14.1	2.2%	0.0	0.0%	322.3	51.5%
CS 1.4 (Summer)	1672.1	36.2	2.1%	25.2	1.5%	0.0	0.0%	-	-
CS 1.5 (Summer)	1791.7	689.7	38.5%	7.9	0.4%	1032.9	57.6%	712.9	39.8%
CS 1.6-1.8 (Autumn)	5927.4	2112.6	35.6%	462.1	7.8%	1314.8	22.2%	814.5	13.7%
CS 1.6-1.8 (Winter)	5826.7	1703.0	29.2%	360.9	6.2%	1196.5	20.5%	746.4	12.8%
CS 1.6-1.8 (Spring)	5984.8	1715.2	28.6%	337.1	5.6%	942.2	15.7%	1185.6	19.8%
CS 1.6-1.8 (Summer)	5949.0	2059.6	34.2%	304.3	5.1%	1127.2	18.9%	1233.4	20.7%
CS 1.7 (Autumn)	12885.0	6986.2	54.2%	1791.0	13.9%	7278.1	56.5%	2955.6	22.9%
CS 1.7 (Winter)	15894.9	8376.9	52.7%	2655.4	16.7%	8893.6	55.9%	3815.8	24.0%
CS 1.7 (Spring)	16650.2	8148.3	48.9%	2608.5	15. 7%	9134.6	54.8%	3819.5	22.9%

*: Refers to *Trachurus trachurus* and *T. mediterraneus.*

**: Consider *Mullus barbatus* for the Mediterranean case studies and *Mullus surmuletus* for CS 1.2 in Portuguese waters.



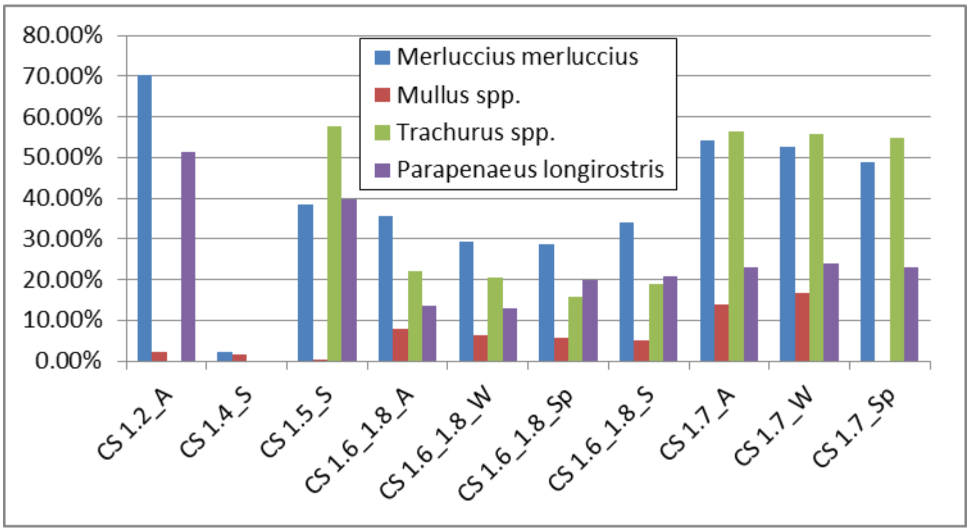


Fig. 14. (Top) Area overlap (in km^2) between areas of iBPTD and nursery grounds of the target species per case study. (Bottom) Area overlap (%) between areas of iBPTD and nursery grounds of the target species per case study. W: Winter, S: Summer, Sp: Spring, A: Autumn.

Results per Case Study showed that in terms of area overlap in km^2, the CS1.7 Aegean Sea showed the highest overlap between PTD and the nurseries of *M. merluccius* and *Trachurus* spp. However, the analysis of percentages showed more uniform results among the different case studies. The highest percentage in terms of PTD overlap was estimated for the nurseries of *M. merluccius* (for all case studies), *Trachurus* spp. (besides CS1.2) followed for *P. longirostris* (for all case studies).

6.2. Overlapping of PTD grounds with area closures for bottom trawlers

The spatial information on discards is largely ignored when it comes to marine spatial planning. Most important, a large number of existing marine area closures for the bottom trawl fishery that was decided in the past in the Mediterranean was not based on scientific knowledge and criteria involving the protection of nursery or spawning grounds or the minimization of discards. Thus towards an effort to evaluate area closures in terms of the amount of discards, for the purposes of D3.2 we estimated the overlap between the potential unwanted catch grounds of species with MCRS and different types of area closures were retrieved from MEDISEH database (Papadopoulou et al., 2013) and supplemented by partner's knowledge per CS. Finally, we organized area closures as a) existing area closures in a permanent basis, b) suggested area closures by national or international organizations or NGOs and c) suggested area closures by local authorities or fishermen organizations (depending on the CS). Overlapping was estimated by means of GIS techniques and tools available in ArcGIS software.

Tables 4 to 6 give an idea of how effective existing or suggested marine area closures can be in terms of discarding related to MCRS.

6.2.1. Existing Fishing Restricted Areas

For the purposes of D3.2, we estimated the overlapping between area of increased biomass of total discards (iBPTD) concerning species with MCRS with the currently existing Fishing Restricted Areas (FRAs) for bottom trawlers (where prohibition occurs in 12-month basis) per CS. The 1.5 nm distance from the coast prohibition for bottom trawlers based on the Mediterranean Regulation (Reg. EC n. 1967/2006) with the exception along the coasts of Liguria where trawlers can fish 0.7 nm off the coast, if the depth is > 50m was also included in the analysis. In addition the 6 nm prohibition for the Portuguese waters was included in the analysis.

Shape files were retrieved from MEDISEH database for the Mediterranean (Papadopoulou et al., 2013, see Fig. 15). This database was completed for CS1.4 with a FRA in Roses region located in the northern part of GSA 6 (F. Maynou personal communication). The two FRAs in Portuguese waters, CS1.2 (L. Bentes personal communication) results from the Regulation Council 850/98 and 2166/2005 protecting Hake and Norwegian lobster, however since theses FRAs are only temporal enclosures (prohibition is less than 12 months) they were excluded from the analysis. Results are shown as overlapped area (in km^2) as well as % percentage in Table 4 and Fig. 16.

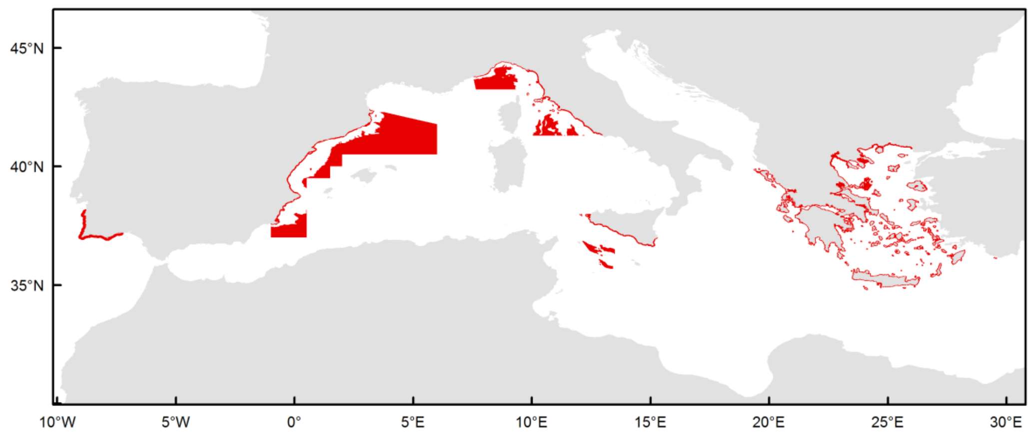
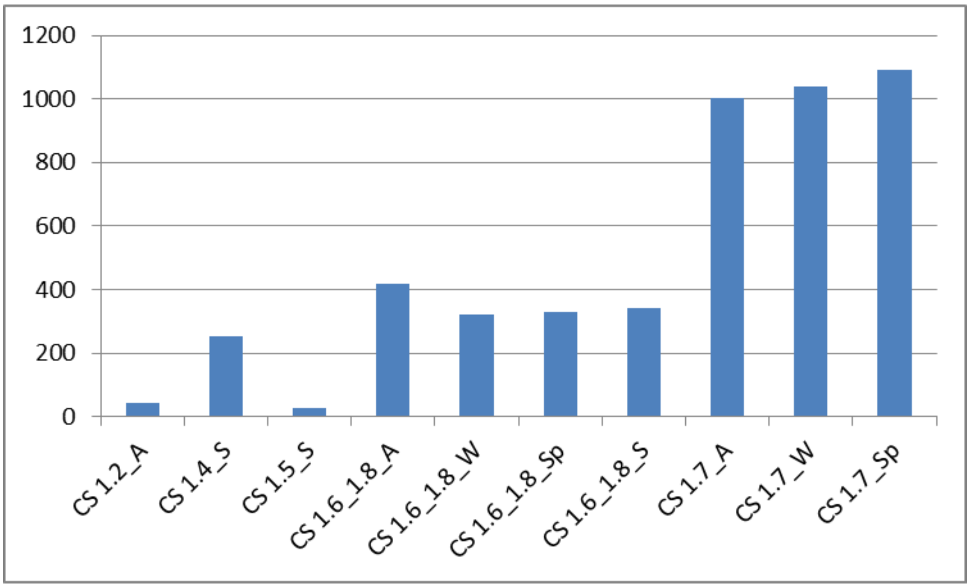


Fig. 15. Existing FRAs for bottom trawlers per CS. The 1.5 nm distance from the coast prohibition for bottom trawlers based on the Mediterranean Regulation (Reg. EC n. 1967/2006) is also shown. Trawling is not allowed in the Mediterranean for waters deeper than 1000 m (Reg. EC n. 1343/2011 (Art. 16), and

Recommendation GFCM/2005/1). For Portuguese waters, there is a 6 nm distance from coast prohibition.

Table 4. Area overlap (in km^2 and %) between areas of iBPTD and existing FRAs / fishing prohibitions per CS. Seasonal overlapping was estimated depending on CS.

Case Study (CS)	Overlapping area (km^2)	iBPTD area (km^2)	%
CS 1.2 (Autumn)	42.15	625.72	6.74%
CS 1.4 (Summer)	252.02	1672.16	15.07%
CS 1.5 (Summer)	26.26	1791.69	1.47%
CS 1.6-1.8 (Autumn)	418.54	5927.44	7.06%
CS 1.6-1.8 (Winter)	322.82	5826.67	5.54%
CS 1.6-1.8 (Spring)	328.45	5984.83	5.49%
CS 1.6-1.8 (Summer)	341.59	5949.01	5.74%
CS 1.7 (Autumn)	1004.59	12885.06	7.80%
CS 1.7 (Winter)	1039.38	15894.93	6.54%
CS 1.7 (Spring)	1090.62	16650.19	6.55%



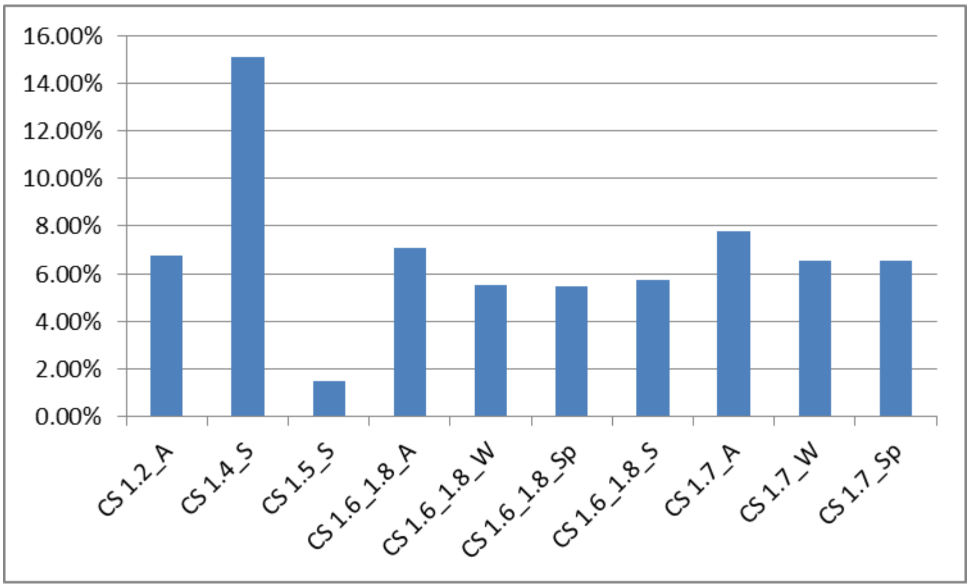


Fig. 16. Area overlap in km^2 (top) and % (bottom) between areas of iBPTD and existing FRAs per CS. Seasonal overlapping was estimated depending on CS.

Results per Case Study showed that in terms of area overlap in km^2, the CS1.7 Aegean Sea showed the highest overlap between iBPTD and existing FRAs for bottom trawlers. The analysis of percentages showed more uniform results among the different Mediterranean case studies (ranging from 5% to 15%) with the exception of CS1.5 (Strait of Sicily) where the overlapping was less than 2%. CS1.2 (Portuguese waters) showed a percentage reaching almost 50% of overlap.

6.2.2. Proposed MPAS by national or international organizations or NGOs

Concerning proposed Marine Protected Areas (MPAs), we selected the ones proposed by CIESM (2010), OCEANA (2011), De Juan and Lleonart (2010) and Greenpeace (2011). Note that the specific proposed MPAs were selected because their “protection target” is (mainly or partly) fisheries oriented rather than cetacean protection oriented [i.e. ACCOBAMS: Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (http://www.accobams.org) or Hoytt, 2011].

Shp files were retrieved from MEDISEH database for the Mediterranean (Papadopoulou et al., 2013, see Fig. 17). Results are shown as overlapped area (in km^2) as well as percentage (%) in Table 5 and Fig. 18 Regarding CS1.2 there is a proposed MPA which is situated well outside the area where the bottom trawl fishery operates and subsequently was not considered for analysis.

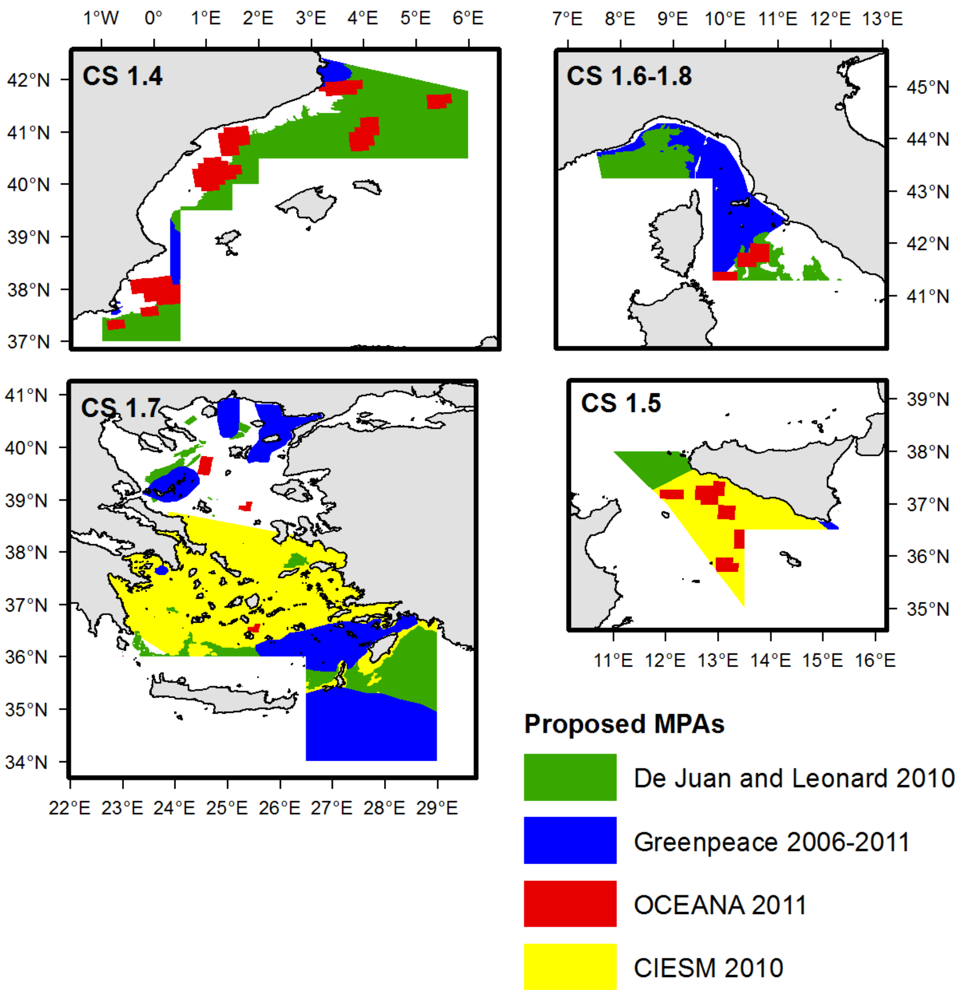
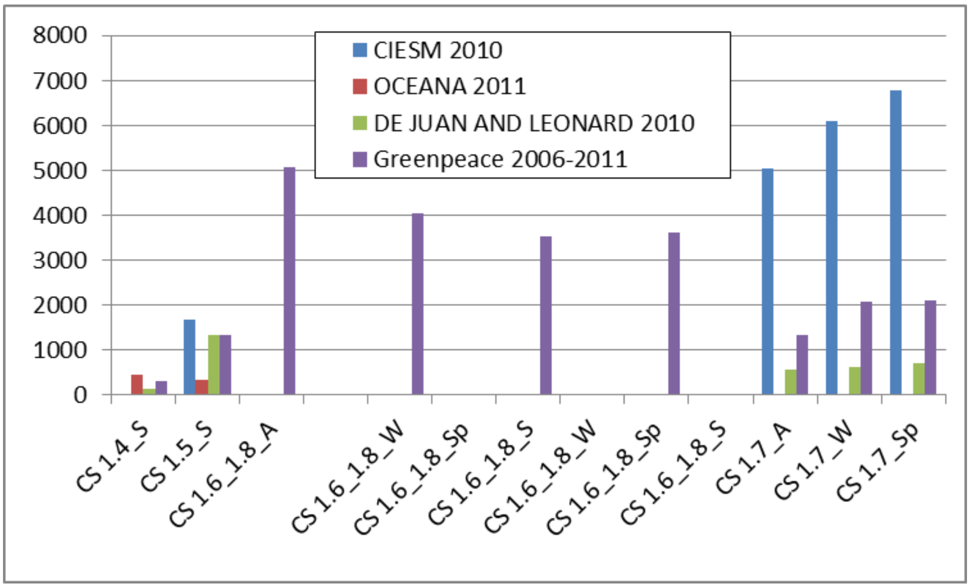


Fig. 17. Maps showing proposed MPAs by various national or international organizations or NGOs per CS.

Table 5. Area overlap (in km^2 and %) between areas of iBPTD and proposed MPAs per CS. Seasonal overlapping was estimated depending on CS.

	iBPTD **in km^2**	**CIESM 2010**		**OCEANA 2011**		**DE JUAN AND LLEONART 2010**		**Greenpeace 2011**	
		km^2	**%**	**km^2**	**%**	**km^2**	**%**	**km^2**	**%**
CS 1.4 (Summer)	1672.16	-	-	458.82	27.44%	125.58	7.51%	295.22	17.66%
CS 1.5 (Summer)	1791.69	1686.10	94.11%	336.56	18.78%	1333.15	74.41%	1346.26	75.14%
CS 1.6-1.8 (Autumn)	5927.44	-	-	0.00	0.00%	0.00	0.00%	5056.28	85.30%
CS 1.6-1.8 (Winter)	5826.67	-	-	0.00	0.00%	0.00	0.00%	4027.75	69.13%
CS 1.6-1.8 (Spring)	5984.83	-	-	0.00	0.00%	0.00	0.00%	3530.39	58.99%
CS 1.6-1.8 (Summer)	5949.01	-	-	0.00	0.00%	0.00	0.00%	3624.23	60.92%
CS 1.7 (Autumn)	12885.06	5043.45	39.14%	0.00	0.00%	574.05	4.46%	1322.37	10.26%
CS 1.7 (Winter)	15894.93	6092.90	38.33%	0.00	0.00%	614.41	3.87%	2068.51	13.01%
CS 1.7 (Spring)	16650.19	6779.25	40.72%	0.00	0.00%	706.60	4.24%	2099.31	12.61%



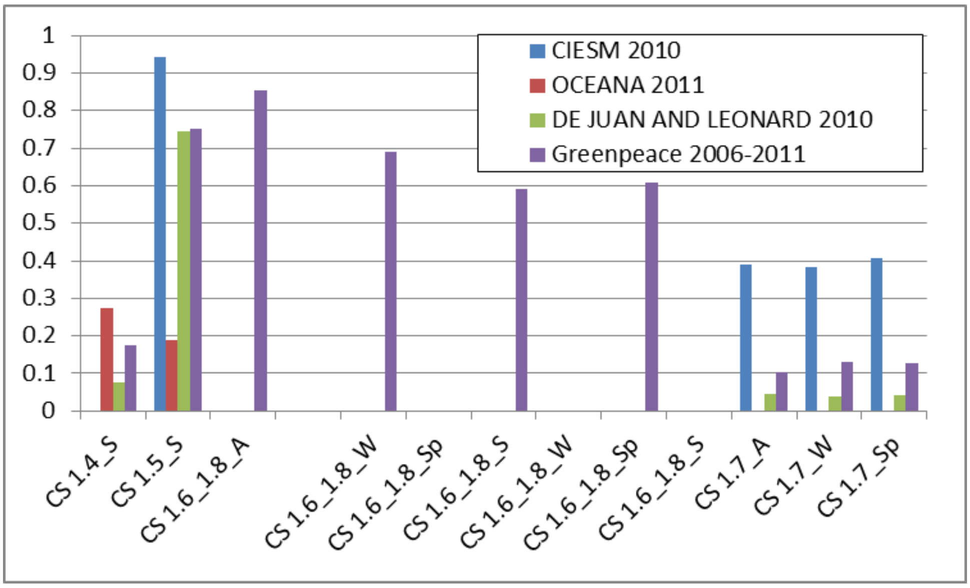


Fig. 18. (Top) Area overlap (in km^2) between areas of iBPTD and proposed MPAs per case study. (Bottom) Area overlap (%) between iBPTD and proposed MPAs per case study. W: Winter, S: Summer, Sp: Spring, A: Autumn.

Results showed that MPAs suggested by Greenpeace (2011) showed various degrees of overlap with iBPTD varying from 10% (CS1.7) up to 85% (CS1.6-1.8). CIESM (2010) suggested a very large area closure in CS1.5 (up to 90% overlap with iBPTD) and to a lesser extent in CS1.7 (40% overlap with iBPTD). OCEANA (2011) suggested area closures showed less than 30% overlap with iBPTD only in CS1.4 and CS1.5.

6.2.3. Proposed MPAs by Local Authorities or Fishers Associations

For the purposes of D3.2, we estimated the overlapping between areas of increased biomass of potential total discard (iBPTD) of species with MCRS with proposed FRAs for bottom trawlers suggested or agreed by local authorities (CS 1.6-1.8) or by trawl fishermen (CS1.4) (See Fig. 19).

In CS1.6-1.8, the proposed area closure involves five areas proposed as new FRAs under the Italian national management plan for GSA9 (AA.VV., 2008).

In CS1.4, the proposed area closure refers to the Vol de Terra area (GSA6, F. Maynou personal communication) with a rationale to protect a hake nursery ground. It was a mutual agreement between the fishermen from the harbors of Blanes and Palamos and should be enforced by fishers at the beginning 2018).

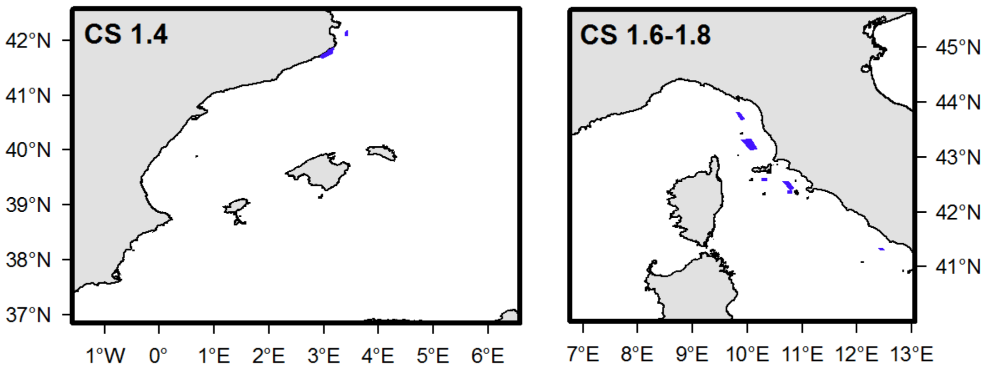
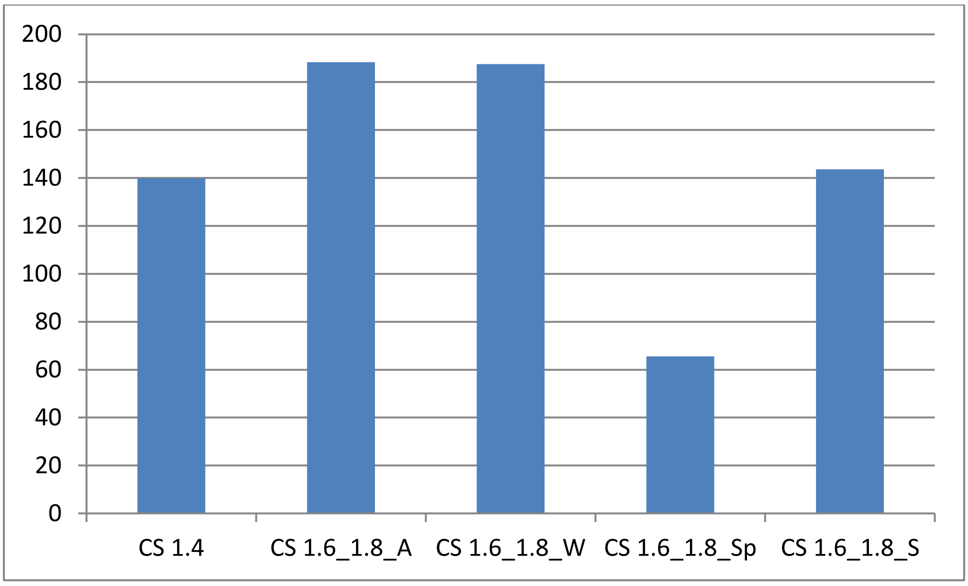


Fig. 19. Map showing proposed MPAs by local authorities or fishers association per CS.

Table 6. Area overlap (in km^2 and %) between areas of iBPTD and proposed MPAs by local authorities or fishermen association per CS. Seasonal overlapping was estimated depending on CS.

Case Study (CS)	Overlapping area (km^2)	Total discards area (km^2)	%
CS 1.4 (Summer)	139.93	1672.16	8.37%
CS 1.6-1.8 (Autumn)	188.38	5927.44	3.18%
CS 1.6-1.8 (Winter)	187.55	5826.67	3.22%
CS 1.6-1.8 (Spring)	65.56	5984.83	1.10%
CS 1.6-1.8 (Summer)	143.57	5949.01	2.41%



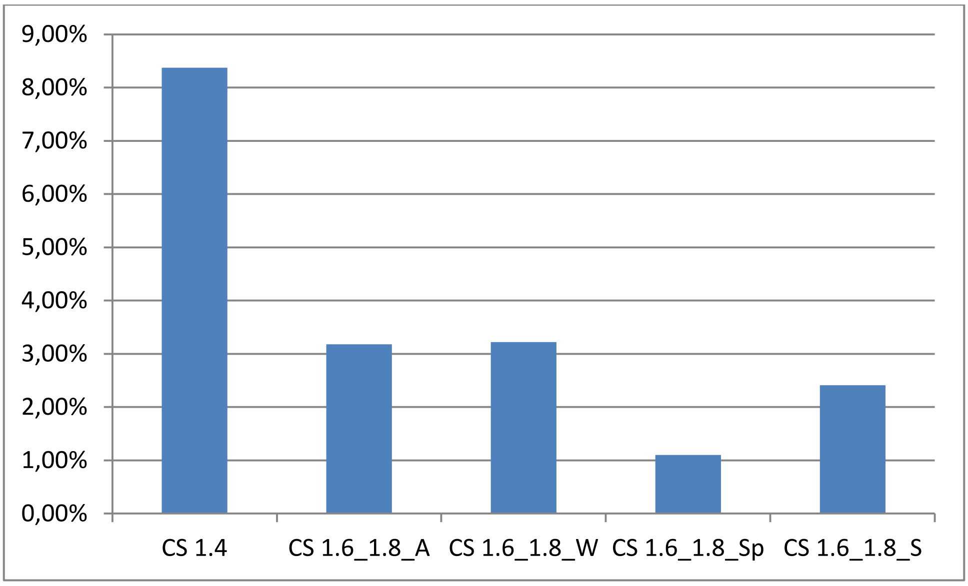


Fig. 20. Area overlap in km^2 (top) and % (bottom) between areas of iBPTD and proposed MPAs by local authorities or fishermen association per CS. Seasonal overlapping was estimated depending on CS.

Proposed area closures by local authorities in CS 1.6-1.8 showed 1% to 3% overlap with iBPTD depending on season. In CS1.4, proposed area closures by fishers associations showed 8% overlap with iBPTD.

7. Overall comments and Conclusions

Habitat modeling techniques applied in D3.2 for the estimation of potential unwanted catch grounds due to MCRS for CS1.7 (Aegean Sea) and CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) using "on board" recordings of discards at georeferenced commercial bottom trawlers and satellite environmental data revealed that:

- Bathymetry and season were the most important variables affecting total discards due to MCRS. This is in agreement with other studies in the Mediterranean Sea (Gucu, 2012, Tsagarakis et al., 2014, Pennino et al., 2014, Tsagarakis et al., 2017).
- Differences also evoked between the two models. In Aegean Sea, Chl and SST were important whereas Sal was important in Ligurian and northern Tyrrhenian Sea, probably denoting ecosystem differences. Discarding due to MCRS is largely related to the juvenile grounds of the main commercial species i.e. M. merluccius, P. longirostris, T. trachurus. In the oligotrophic Aegean Sea, which lacks big river input, Chl is a proxy of the more productive waters that coincide with the juvenile grounds whereas in the Ligurian and northern Tyrrhenian Sea Sal is a proxy of river input which is a major source of nutrients characterizing local juvenile grounds.

Advantages of the habitat modeling approach that uses environmental information and georeferenced "on board" data allow:

- Assessing spatial info in seasonal basis
- Assessing spatial info over a wider area beyond the sampled one,
- Covering the juvenile grounds of more than one species as we include info from more than one season.
- Surveys usually cover a single season and they are not designed to determine the nurseries of all species with MCRS. However, they can be a good proxy in case when "on board sampling" does not provide georeferenced information.

The spatial information on discards is largely ignored when it comes to marine spatial planning published studies (e.g. Katsanevakis et al., 2011; Micheli et al., 2013; Stelzenmuller et al., 2013). Most important, in the Mediterranean many marine fishing area closures decided in the past were not based on scientific knowledge. For example in Greek waters the majority of Fishing Restricted Areas were decided in the 60s or 70s (Papadopoulou et al., 2013) based on district decision and mostly as the outcome of conflicts between small scale fishermen and bottom trawlers. Thus in a further step, we aimed to explore how effective existing area closures or proposed fishing restricted areas are in terms of minimizing the production of unwanted catches due to Minimum Conservation Reference Size (MCRS). Specifically, we estimated the overlap between potential unwanted catch grounds of species with MCRS and a) nursery grounds of the main target species of the bottom trawl fishery per CS, b) existing area closures in permanent basis, c) proposed area closures by national or international organizations or NGOs and d) proposed areas by fishermen organizations (depending on the CS).

Spatial analysis results showed that "the area presenting increased biomass of total discards (iBPTD) concerning species with MCRS or otherwise "the discards-producing area due to MCRS" highly varies among case studies and also the overlapping with the nurseries of the main commercial species.

Specifically:

The estimated iBPTD area values per case study are presented below in decreasing order:

- ✓ CS1.7 (Aegean Sea) ranging from 12800 to 16600 km2 depending on season
- ✓ CS1.6-1.8 (Ligurian and northern Tyrrhenian Sea) being more seasonally stable around 5900 km2
- ✓ CS1.5 (Strait of Sicily) around 1790 km2
- ✓ CS1.4 (Catalan Sea) 1600 km2
- ✓ The smallest iPTD area was observed in CS1.2 (Portugal) being around 440 km2

In general "the discards-producing area due to MCRS" highly overlaps with *M. merluccius* nurseries independently of case study and the percentage of overlapping varies from ~70% (CS 1.2), >50% (CS 1.7, CS1.5), >30% (CS 1.6-1.8) limited to only 2% in CS 1.4. Moreover, "the discards-producing area due to MCRS" mainly overlaps in:

- CS 1.2 (Portugal) with the nurseries of M. merluccius and P. longirostris.
- CS 1.7 (Aegean Sea) with the nurseries of M. merluccius and T. trachurus.
- CS 1.5 (Strait of Sicily) with the nurseries of T. trachurus followed by M. merluccius and P. longirostris.
- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) with the nurseries of M. merluccius followed by T. trachurus, and P. longirostris.
- CS 1.4 (Catalan Sea) with the nurseries of M. merluccius but to a significantly lower percentage (~2%)

Subsequently, the degree of overlapping between "the discards-producing area due to MCRS" with existing Fishing Restricted Areas (FRAs) for bottom trawlers (prohibition in 12 month basis) or proposed fishing spatial restrictions for bottom trawls largely varies among case studies.

Specifically, for existing FRAs large differences are observed in terms of overlapping or otherwise the degree of protection in terms of discards due to MCRS:

- CS 1.4 (Catalan Sea) being around 15% during summer.
- CS 1.7 (Aegean Sea) 6.5 to 7.8 % depending on season.
- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) 5.5 to 7% depending on season.
- CS 1.2 (Portugal) being around 6% during autumn.
- CS 1.5 (Strait of Sicily) limited to 1.5% during summer.

For proposed MPAs by Greenpeace (2010, which addresses all CS) overlapping varies as shown below:

- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) is ~60 to 85 % depending on season.

- CS 1.5 (Strait of Sicily) is 75% during summer.
- CS 1.4 (Catalan Sea) is 17% during summer.
- CS 1.7 (Aegean Sea) is 10 to 13% depending on season.

For proposed MPAs by OCEANA (2011, which addresses all case studies), overlapping varies as shown below:

- CS 1.4 (Catalan Sea) is 27% during summer.
- CS 1.5 (Strait of Sicily) is 18% during summer.
- CS 1.7 (Aegean Sea) is less than ~1%.
- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) is less than 1%.

For proposed MPAs by De Juan and Lleonart (2010, which addresses all case studies) overlapping varies as shown below:

- CS 1.5 (Strait of Sicily) is 74% during summer.
- CS 1.4 (Catalan Sea) is 7.5% during sumnmer.
- CS 1.7 (Aegean Sea) is ~3.8 to 4.51% depending on season.
- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) is less than 1%.

For proposed MPAs by CIESM (2010, which addresses only CS 1.5 and 1.7) overlapping varies as shown below:

- CS 1.5 (Strait of Sicily) is ~94% during summer.
- CS 1.7 (Aegean Sea) is ~40% independently of season.

For proposed MPAs by local authorities or fishers (which addresses only CS 1.4 and 1.6-1.8) overlapping varies as shown below:

- CS 1.4 (Catalan Sea) is 8% during summer.
- CS 1.6-1.8 (Ligurian and northern Tyrrhenian Sea) is less than 1-3% depending on season.

Summarizing, potential unwanted catch grounds due to MCRS seem that they largely reflect the juvenile grounds of *M. merluccius* (>70% in Portuguese waters and ~40% in Mediterranean case studies besides C1.4, Catalan Sea where the overlapping was only 2%), followed by *Trachurus* spp. and *P. longirostris*. The highest protection over “the discards-producing area due to MCRS” due to existing fishing spatial closures seems to occur in the Catalan Sea at ~15%. The “discards-producing area due to MCRS” are being protected at around 5 to 8% in CS1.7 (Aegean Sea), CS1.2 (Portugal) and CS1.6-1.8 (Ligurian and northern Tyrrhenian Sea). The lowest level of protection was observed in the Strait of Sicily (~1.5%). Moreover, the protection of the “discards-producing area due to MCRS” offered by the different proposed MPAs varies greatly depending on the proposal and the case study. The most effective ones seem to be the MPAs proposed by Greenpeace (up to 85% in Ligurian and northern Tyrrhenian Sea, 75% in the Strait of Sicily, 17% in Catalan Sea and up to 13% in Aegean Sea).

8. References

AA.VV. 2008. Management Plan (ex art.24 Reg. (EC) n.1198/2006 and art.19 Reg. (EC) n.1967/2006), GSA 9 – Ligurian and northern and central Tyrrhenian Seas (in Italian).

Borchers D.L., S.T. Buckland, I.G. Priede and S. Ahmadi 1997. Improving the precision of the daily egg production method using generalized additive models. Canadian Journal of Fisheries and Aquatic Science, 54, 2727-2742.

Catchpole T. L., J. P. Feekings, N. Madsen, A. Palialexis, V. Vassilopoulou, J. Valeiras, T. Garcia, N. Nikolic, and M.-J. Rochet. 2013. Using inferred drivers of discarding behaviour to evaluate discard mitigation measures. ICES J. Mar. Sci., doi:10.1093/icesjms/fst170.

CIESM, 2010. Marine Peace Parks in the Mediterranean – a CIESM proposal. Siracusa (Italy) 18 - 20 November 2010, 128 p.

Colloca F, Bartolino V, Jona Lasinio G, Maiorano L, Sartor P, et al. 2009. Identifying fish nurseries using density and persistence measures. Mar Ecol Prog Ser.; 381: 287–296.

Condie H., Catchpole T. L., Grant A. 2013. The short term impact of implementing catch quotas and a discard ban on English North Sea otter trawlers. ICES Journal of Marine Science. doi:10.1093/icesjms/fst187.

DeJuan & Lleonart, 2010. A conceptual framework for the protection of vulnerable habitats impacted by fishing activities in the Mediterranean high seas. Ocean & Coastal Management 53:717-723 Abdulla, A, Gomei, M, Maison, E and Piante, C, 2008. Status of Marine Protected Areas in the Mediterranean Sea. IUCN, Malaga and WWF, France. 152 pages

Dunn, D.C., Boustany, A.M., Halpin, P.N., 2011. Spatio-temporal management of fisheries to reduce by-catch and increase fishing selectivity. Fish Fish. 12 (1), 110–119. http://dx.doi.org/10.1111/j.1467-2979.2010.00388.x

EU, 2006. Council regulation 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean sea, amending regulation (EEC) no. 2847/93 and repealing regulation (EC) No. 1626/94. Off. J. Eur. Union L 409, 11–85.

EU, 2013. Regulation No. 1380/2013 of the European Parliament and of the Council on the Common Fisheries Policy, amending Council Regulations (EC) No. 1954/2003 and (EC) No. 1224/2009 and repealing Council Regulations (EC) No. 2371/2002 and (EC) No. 639/2004 and Council Decision 2004/585/EC. Off. J. Eur. Union L 354, 22–61

Fiorentino F, Garofalo G, De Santi A, Bono, Giusto GB, et al. 2003.Spatio-temporal distribution of recruits (0 group) of Merluccius merluccius and Phycis blennoides (Pisces, Gadiformes) in the Strait of Sicily (Central Mediterranean). Hydrobiologia. 2003; 503: 223–236.

Giannoulaki M., A. Belluscio, F. Colloca, S. Fraschetti, 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.

Gonçalves J. M. S., Stergiou K. I. , Hernando J. A., Puente E., Moutopoulos D. K., Arregi L., Soriguer M. C., et al. 2007. Discards from experimental trammel nets in southern European small-scale fisheries, Fisheries Research, vol. 88. 5-14.)

Gray, B. 2005. Selecting a distributional assumption for modelling relative densities of benthic macroinvertebrates. Ecological Modelling 185: 1-12, doi:10.1016/j.ecolmodel.2004.11.006

Greenpeace 2011. Proposal, Marine reserve information, and google earth spatial data, http://maps.google.com/maps/ms?ie=UTF8&hl=en&t=k&msa=0&msid=105457831053982336422.00044eb47880f9121ed64&source=embed&ll=38.134557,15.996094&spn=24.124822,52.734375&z=4

Greenpeace International, 2006. Marine Reserves for the Mediterranean Sea. Proposal. 58pp. Retrieved from: http://www.greenpeace.org/france/PageFiles/266559/marine-reserves-med.pdf.

Hastie, T. and Tibshirani, R. 1990. Generalized Additive Models. London: Chapman and Hall, 335 pp

Hoyt, E. 2011. Marine Protected Areas for Whales, Dolphins and Porpoises: A World Handbook for Cetacean Habitat Conservation and Planning. 2nd Edition, revised. Earthscan, London and New York. 477pp. ISBN: 978-1-84407-762-5 and 978-1-84407-763-2.; www.erichhoyt.com/eh/MPA_files/MPAs4Whales_WorldMap_Poster_2011.pdf

Katsanevakis S, Stelzenmüller V, South A, Sørensen TK, Jones PJS, et al. 2011. Ecosystem-based marine spatial management: review of concepts, policies, tools, and critical issues. Ocean Coast Management, 54:807–20.

Kelleher K. 2005. Discards in the World's Marine Fisheries: An update. FAO Fisheries Technical Paper, 470. 131 pp

Lleonart J., Maynou F. (2003). Fish stock assessments in the Mediterranean: state of the art. Scientia Marina; 67(Suppl. 1):37-49.

Maina, I., Kavadas, S., Katsanevakis, S., Somarakis, S., Tserpes, G., Georgakarakos, S., 2016. A methodological approach to identify fishing grounds: A case study on Greek trawlers. Fish. Res. 183, 326–339, http://dx.doi.org/10.1016/j.fishres.2016.06.021

Micheli F, Levin N, Giakoumi S, Katsanevakis S, Abdulla A, Coll M, Fraschetti S, Kark S, Koutsoubas D, Mackelworth P, Maiorano L, Possingham HP. 2013. Setting Priorities for Regional Conservation Planning in the Mediterranean. Sea. PLoS ONE **8(4):** e59038. doi:10.1371/journal.pone.0059038

Milisenda G., Garofalo G., Tserpes G., Giannoulaki M., Ligas A., Bentes L., Maynou F., Vitale S. 2016a Science, Technology, and Society Initiative to Minimize

Unwanted Catches in European Fisheries - WP1. Ecological, socioeconomic and technical characteristics of discarding fisheries Deliverable 1.9 GIS maps (by-catch) Responsible beneficiary: 2 – CNR Contractual due date: month 18 Dissemination level: PUBLIC Report Status: IN PRESS (ID•634495 - SFS-09-2014 - RIA •634495).

Milisenda G., Garofalo G., Tserpes G., Giannoulaki M., Ligas A., Bentes L., Maynou F., Vitale S.. 2016b Science, Technology, and Society Initiative to Minimize Unwanted Catches in European Fisheries - WP1. Ecological, socioeconomic and technical characteristics of discarding fisheries Deliverable 1.3 GIS maps (by-catch) Responsible beneficiary: 2 – CNR Contractual due date: month 12 Dissemination level: PUBLIC Report Status: FINAL (ID•634495 - SFS-09-2014 - RIA •634495).

Oceana 2011. Oceana MedNet 2011. MPA Network Proposal for the Mediterranean Sea. Report. 96pages. Retrieved from: http://oceana.org/sites/default/files/reports/OCEANA_MEDNet_ING_16012012_0.pdf

Papadopoulou, K., Smith C., M. Gristina, A. Belluscio, S. Fraschetti, A. Santelli, M. L. Pace, V. Markantonatou, M. Nikolopoulou, V. Valavanis, M. Giannoulaki, E. Palikara, C. Martin, M. Scardi, L. Telesco, Fabi G., Barro J., Grati F., Scarcella G., Punzo E., Knittweis L., Guarnieri G., D'Anna G., Pipitone C.,Spedicato M. 2013. T. Reviewing and mapping of all types of existing marine protected areas in different GSAs in the Mediterranean basin. Mediterranean Sensitive Habitats (MEDISEH) Final Report, DG MARE Specific Contract SI2.600741

Pennino, M.G., Muñoz, F., Conesa, D., López-Quílez, A., Bellido, J.M., 2014. Bayesian spatio-temporal discard model in a demersal trawl fishery. J. Sea Res. 90, 44–53

Rochet, M. J., Peronnet, I., Trenkel M.V., 2002. An analysis of discards from the French trawler fleet in the Celtic Sea. ICES J. Mar. Sci. 59(3), 538–552. http://dx.doi.org/10.1006/jmsc.2002.1182

Sanchez, P., Demestre, M., Martin, P., 2004. Characterization of the discards generated by bottom trawling in the Northwestern Mediterranean. Fisheries Research, 67, 71-80.

STECF (2006). Discard from community vessels. Report of the Subgroup on Research Needs (SGRN) of the Scientific, Technical and Economic Committee for Fisheries (STECF), SGRN- 06-06, 46 pp.

STECF/SGMOS (2008). Scientific, Technical and Economic Committee for Fisheries. Evaluation of the STECF/SGMOS 07-04 Working Group on Discards. 14–18 April 2008, Hamburg. 2008. p. 156 pp.

Stelzenmüller V., Breen P., Stamford T., Thomsen F., Badalamenti F., Borja A., Bulh-Mortensen I., et al., 2013. Monitoring and evaluation of spatially managed areas: A generic framework for implementation of ecosystem based marine management and its application. Marine Policy, 37, 149-164.

Tsagarakis K., Palialexis A., Vassilopoulou V. (2014). Mediterranean fishery discards: review of the existing knowledge. ICES Journal of Marine Science; 71(5):1219-1234. doi:10.1093/icesjms/fst074.

Tsagarakis K, Carbonell A, Brcic J, Bellido JM, Carbonara P, Casciaro L, Edridge A, García T, González M, Krstulovic Šifner S, Machias A, Notti E, Papantoniou G, Sala A, Škeljo F, Vitale S and Vassilopoulou V (2017) Old Info for a New Fisheries Policy: Discard Ratios and Lengths at Discarding in EU Mediterranean Bottom Trawl Fisheries. Front. Mar. Sci. 4:99. doi: 10.3389/fmars.2017.00099

Uhlmann, S.S., A.T.M. van Helmond, E. Kemp Stefánsdóttir, S. Sigurðardóttir, J. Haralabous, J.M. Bellido Millán, A. Carbonell, T. Catchpole, D. Damalas, L. Fauconnet, J. Feekings, T. Garcia, N. Madsen, S. Mallol, S. Margeirsson, A. Palialexis, L. Readdy, J. Valeiras, V. Vassilipoulou, M.-J. Rochet. 2014. Discarded fish in European waters: general patterns and contrasts. ICES J. Mar. Sci. 71(5): 1235-1245.

Viana, M., Jackson, A.L., Graham, N., Parnell, A.C., 2013. Disentangling spatio-temporal processes in a hierarchical system: a case study in fisheries discards. Ecography 36(5), 569–578. http://dx.doi.org/10.1111/j.1600-0587.2012.07853.x

Wood , S.N., 2006. Generalized Additive Models: An Introduction with R. Chapman & Hall/CRC, UK.

The MINOUW Consortium

Co-funded by the Horizon 2020
Framework Programme of the European Union

Beneficiaries:

Linked parties: