MINOUW

SFS-09-2014
RIA •634495

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
Actual submission date: 08 June 2016 (month 16)

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

European Commission RESEARCH & INNOVATION

ID•634495

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1. Background

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

The discard level produced by bottom trawlers in European Atlantic regions is about 60% of total catch, reaching levels as high as 90% in some areas (STECF 2006). Indeed, high amount of catches subject to quotas results in discarding smaller individuals, even when they are above the minimum legal size (Catchpole et al. 2005).

Discard rates in the Mediterranean seem to be lower than in the Atlantic because a wider size range of fish is routinely marketed and no quota system is in place (STECF/SGMOS 2008; Lleonart and Maynou 2003; Condie et al. 2013). In the Mediterranean, estimates of annual discards rates range between 13.3 and 26.8% of total catches (Tsagarakis et al., 2014). According to Sanchez et al. (2004), estimated discards in bottom trawl fisheries in the north western Mediterranean is around 1/3 of total catch in biomass.

Under the current trawl net selectivity pattern, undersized individuals predominate in the catches of some species such as European hake and red mullet in the Mediterranean, especially during the recruitment period (Sala and Lucchetti 2011).

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

The spatial distribution of potentially unwanted catches is an important source of information to contribute to lower production of discards. In this report (Demonstration) we summarize the characteristics of a spatial database elaborating raw data from different types of fishing surveys regarding unwanted bycatch of taxa (fish; invertebrates) with low or no commercial value. The exact spatial analysis methodology used varied in each case study, but the overall goal was to produce high-resolution maps of potentially problematic fishing areas vis-a-vis the generation of discards. The spatial objects created by the analyses described here will be accessible through a GEONODE portal and be used throughout the lifetime of the MINOUW project as input data for other Tasks, especially Task 3.3 in Workpackage 3. This report is complemented by Deliverable D1.2.

2. Objectives

Under the framework of Task 1.3 "Characterization of habitats where case-study fisheries producing unwanted catches take place", the main goal of Deliverable 1.3 is to produce GIS maps showing the density distribution of unwanted catches of species without MCRS regulation in each case study areas. Figure 1 shows the location of each case study involved in the present analyses.
The databases and results were intended to serve as preparatory knowledge for the development of GIS and modelling tools under WP3.

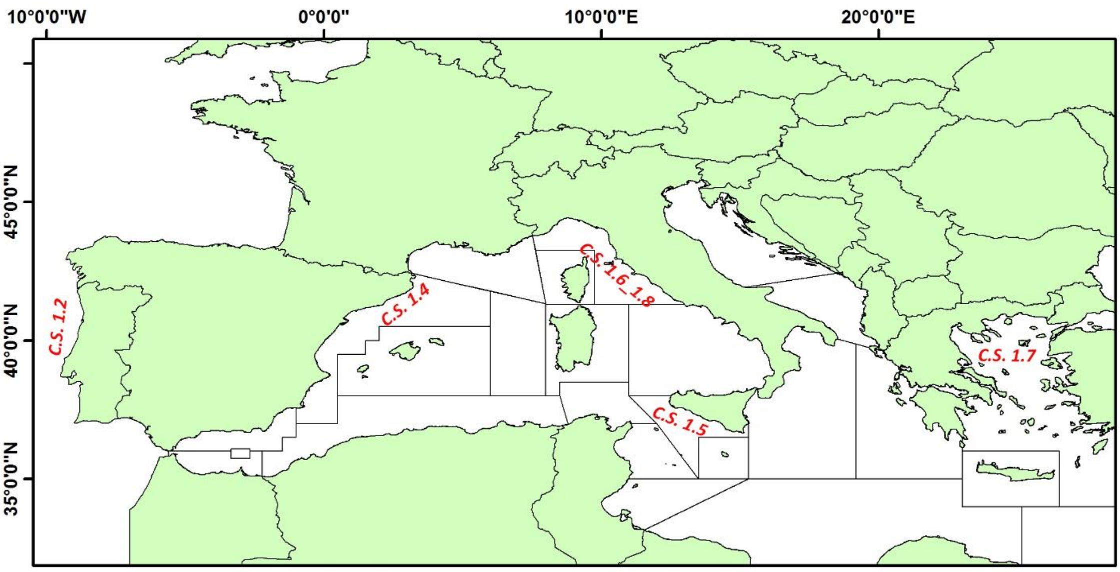


Figure 1 Spatial location of the Case Studies.

3. Description of the datasets available

In order to fulfil the project milestones and deliverables, an exploratory survey of the data available for each case study was performed. Different sources of data were identified: i) international scientific bottom trawl surveys in Case Study 1.2 (IBTS) and Case Studies 1.4, 1.5, 1.6 and 1.8 (MEDITS) and ii) acoustic survey in Case 1.7.
Between 1996 and 2001 four relevant European scientific projects (DISCARDS, FATE, DISCALG and BYDISCARDS) where carried out along the Portuguese coast, mainly off the Algarve (south Portugal), with the main objectives of characterize abundance, composition and distribution of catches and discards from the trawl fleet. Based on commercial vessels, the sampling covered year round fishing activity by on board observers which along with the biological data also recorded data on date, time, position and haul duration. The 387 validated hauls provide accurate information in spatial and temporal patterns to describe the discards dynamic.
The spatial information gathered from these projects covered the fishing grounds typically used by the trawl fleet using the common fishing procedures of commercial vessels which allowed the mapping of areas of potential unwanted catches.
The Mediterranean International bottom trawl survey (MEDITS) is routinely carried out in the Mediterranean with the primary aim of monitoring and assessing fisheries resources status. Data from MEDITS surveys provide an accurate picture of the population structure and spatial distribution of species. The main drawback is that the surveys cover a single season during the year, which is mostly during summertime, and use a codend net with a smaller mesh size than the commercial mesh size permitted. These two aspects make the MEDITS data not entirely comparable to the mapping that would be obtained from using high-resolution discards data from the commercial fishery (which is not available). However, it permits to produce density index maps of unwanted catches species without MCRS.
National commercial sampling programmes are aimed at collecting data on discards and discarding practices from commercial fisheries. Usually, sampling activities are carried out throughout the year, providing accurate information on the spatial and temporal dynamics of discards. However, national discards sampling programmes are not standardized at the European level (Uhlmann et al., 2013) and exhibit differences in the methodology of discards sampling and the level of detail of biological data (e.g. taxonomic identification, recording of abundance and biomass, etc.).

4. Material and methods

Figure 2 shows the template used to store the information needed for performing the distribution analysis of non-commercial species (non-commercial by catch: D).

GFCM/ICES Fishing Area	Data source	Sampling gear	Year	Haul n.	Lat (Decimal degrees)	Long (Decimal degrees)	Species	Commercial category*	by-catch n/km2	by-catch Kg/km2
GSA 16	Medits	Trawl	2009	1	37:25.23	12:30.28	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	2	37:22.15	12:32.47	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	3	37:25.22	12:26.89	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	4	37:26.01	12:26.37	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	5	37:21.34	12:17.87	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	6	37:22.89	12:18.65	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	7	37:22.80	12:11.32	*Aristeus antennatus*	C	0	0.000
GSA 16	Medits	Trawl	2009	81	37:42.97	11:36.28	*Capros aper*	D	117	0.235
GSA 16	Medits	Trawl	2009	82	37:39.91	11:39.06	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	83	37:36.35	11:32.87	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	84	37:06.68	13:16.79	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	85	37:02.81	13:23.44	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	86	37:03.44	13:23.24	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	87	37:04.75	13:29.13	*Capros aper*	D	1432	19.888
GSA 16	Medits	Trawl	2009	88	37:00.80	13:27.85	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	89	36:53.83	13:43.12	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	90	36:54.05	13:40.12	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	91	36:53.84	13:52.93	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	92	36:53.53	13:51.42	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	93	36:49.37	13:53.92	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	94	36:44.66	13:45.25	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	95	36:41.58	13:45.18	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	96	36:41.56	13:39.52	*Capros aper*	D	2465	32.867
GSA 16	Medits	Trawl	2009	97	36:33.74	13:56.03	*Capros aper*	D	0	0.000
GSA 16	Medits	Trawl	2009	98	36:34.50	13:57.03	*Capros aper*	D	0	0.000

Figure 2 Template used to collect biomass and abundance data for the unwanted catches of species without MCRS in different case studies (commercial by-catch: C; non-commercial by catch: D).

Data were received from the partners involved in the Task 1.3 according to the format required (Fig.2) with the exception of data from case study 1.2 which were elaborated directly by CCMAR and data from case study 1.7 which were elaborated directly by HCMR.

For each haul, the species were aggregated at high taxon level (Crustacean, Fish and Cephalopod, Table 3). The number of individuals was standardized to the area (N/km2) assuming a catchability coefficient equal to 1. This resulted in an unwanted catch density index (UWDI) by haul, which represents the input of the subsequent spatial analysis.

Table 3. List of taxa used to perform deliverable 1.3.

CASE STUDY	**TAXA**	**MADE BY:**
1.2	Crustacean	CCMAR
	Fish	CCMAR
	Cephalopod	CCMAR
	Total	CCMAR
1.4	Fish	CSIC
	Cephalopod	CSIC
	Total	CSIC
1.5	Crustacean	CNR
	Fish	CNR
	Cephalopod	CNR
	Total	CNR
1.6 – 1.8	Crustacean	CIBM
	Fish	CIBM
	Cephalopod	CIBM
	Total	CIBM

1.7	Crustacean	HCMR
	Fish	HCMR
	Cephalopod	HCMR
	Total	HCMR

Methodology used in case studies:
1.4 – Catalan sea
1.5 – Strait of Sicily
1.6 – 1.8 - Ligurian and North Tyrrhenian sea

The total number of hauls, the number of positive hauls and their percentages were calculated for each year. It was evident that the number of positive hauls per year was too low to produce maps of UWDI per year, consequently the spatial analysis of UWDI distribution, for each taxa, as well as for total UWDI, was performed pooling all the available years.
For each taxa, the spatial analysis of UWDI was performed using geostatistical methods (variogram analysis and kriging) whose fundamentals may be found in Goovaerts (1997) and Petitgas (1996).
Different exploratory plots (contour plots, scatter plots of density indices versus geographical components, normal q-q plots) were examined to check for significant deviations from stationarity and normality (the basic assumptions of linear geostatistics). The logarithm transformation of UWDIs values was applied in order to improve normality.
The successive step was to characterize the spatial structure of UWDIs data through variogram analysis. The experimental variograms were computed and fitted using asymptotic models such as spherical, exponential or Gaussian models. Anisotropy was not analysed because data were insufficient to characterize the possible directionality in spatial correlation. Following estimation of variogram parameters (range, nugget, sill), ordinary kriging was applied for estimating undersized specimens densities at not sampled locations and mapping their distribution. Grids were constructed using 1×1 km cells. Cross-validation procedures were applied to check the goodness of fit of selected variogram models and the choice of kriging parameters.

Methodology used in case studies:
1.7 – Aegean Sea

The unwanted catch UWDI was collected from on board observers on commercial bottom trawlers in a seasonal basis (i.e. autumn, winter, spring) for the period 2003 to 2008 and 2014 in Aegean Sea (Case Study 1.7) carried out within the framework of the Data Collection Framework. For each sampling station several types of information such as date and time of sampling, longitude and latitude, swept area, haul duration and species composition were recorded. In total over 1300 sampling stations were recorded covering most of the Greek part of Aegean Sea. The raw biomass data were divided by species into UWDI and landings at each sampling station and subsequently the biomass was standardized and estimated as total kilograms per hour for total UWDI, Crustacea, Fish and Cephalopods. In order to address the spatial dimension of UWDI reduction over the wider Aegean Sea we modeled the spatial distribution of each group along with satellite environmental parameters, season and haul duration by means of Generalized Additive Models (GAMs) which 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 transformed and modeled using a Gaussian error distribution or a Gamma error distribution and an identity link function depending on the group analyzed and the inspection of the residual plots. The Akaike Information Criterion (AIC), the level of Deviance Explained (DE), and the lack of trend in the residual plots led to the selection of the model that fitted best the response data. This allowed us to avoid any collinearity problems in the environmental variables. 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 $k = 4$ and, for the first-order interaction effects, at $k = 15$. Results revealed different selection pattern based on bathymetry. Moreover, haul duration and the effect of sea surface temperature by season were found significant in most cases. Finally, distribution maps were constructed assessing potential areas with high risk of unwanted catches.

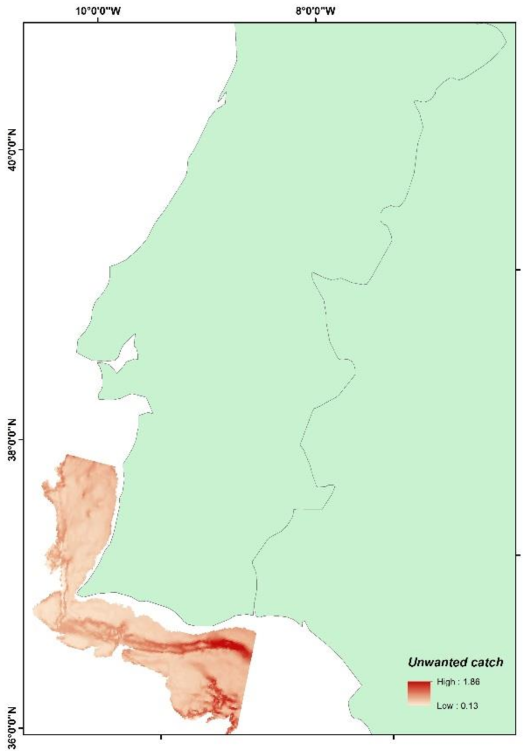
1.2 – Gulf of Algarve

Unwanted catches from commercial vessels were collected all year round between 1996 and 2001 in the south coast of Portugal, Algarve, in the context of European scientific projects. In each of the 387 hauls sampled, apart from position and haul duration, biomass data were categorized in UWDI and landings. With the aim of estimate the area of potential unwanted catches, raw biomass data was georeferenced and then sub divided in main groups, Fish, Crustaceans and Cephalopods following standardization in kilograms per hour towed.

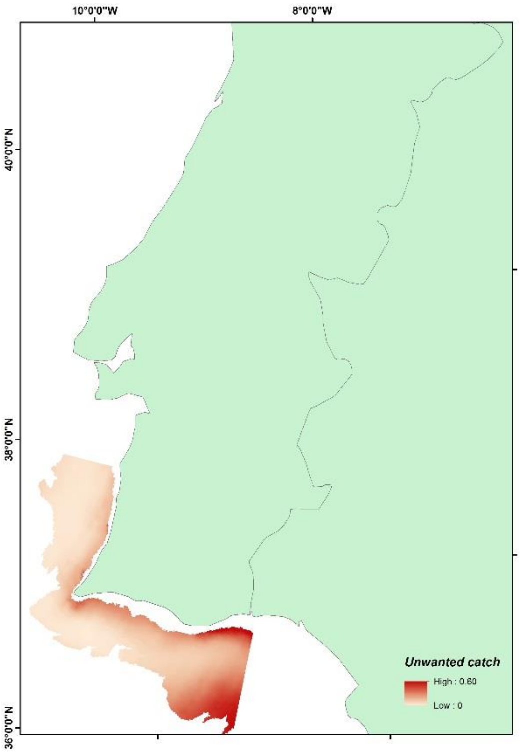
As for the Aegean Sea, generalized additive models (GAMs) were used to model the spatial component of the UWDI along with satellite environmental and geomorphologic variables using the same methodology. Potential areas of unwanted catch for the three main groups, fish, crustacean and cephalops and all UWDI were estimated with haul duration, slope, distance to coast and mean annual surface salinity being the most significant variables.

5. Results

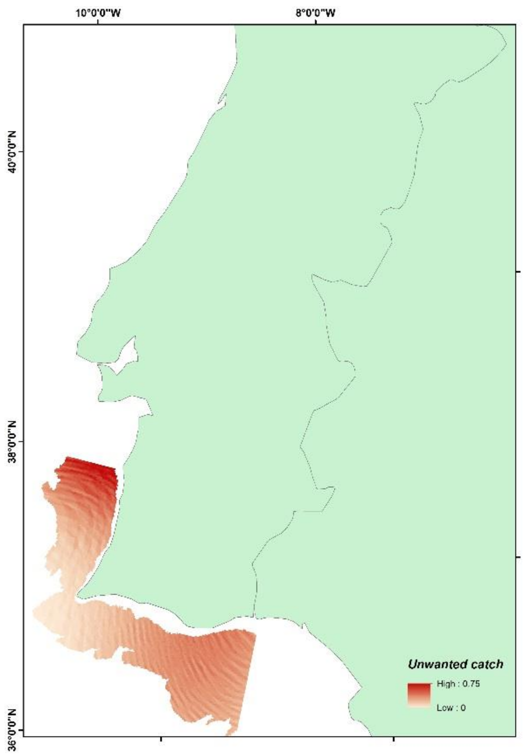
Distribution maps of unwanted catch in the case study 1.2



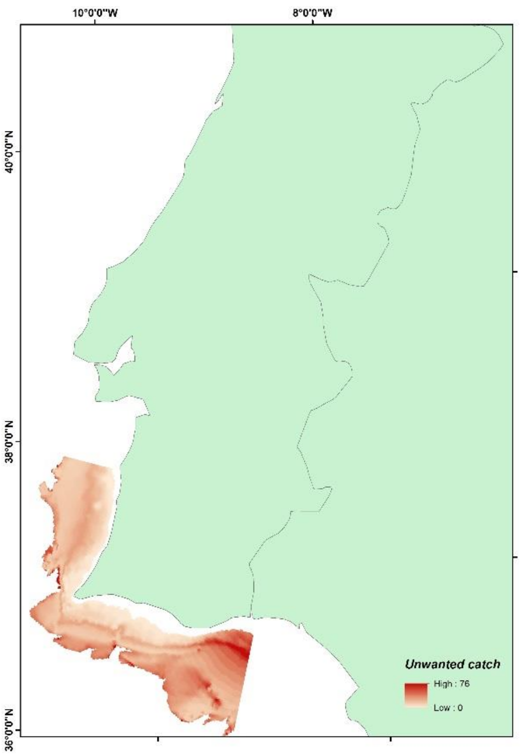
Crustacean



Fish

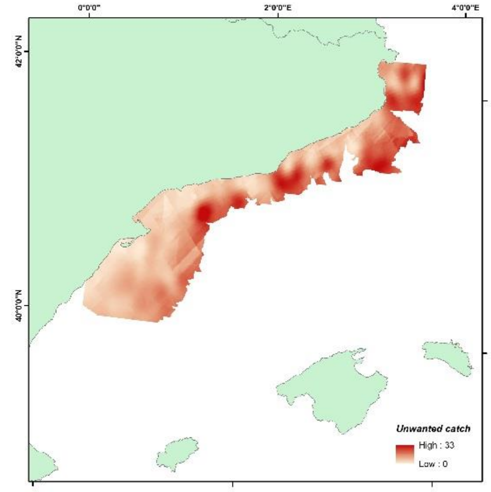


Cephalopod

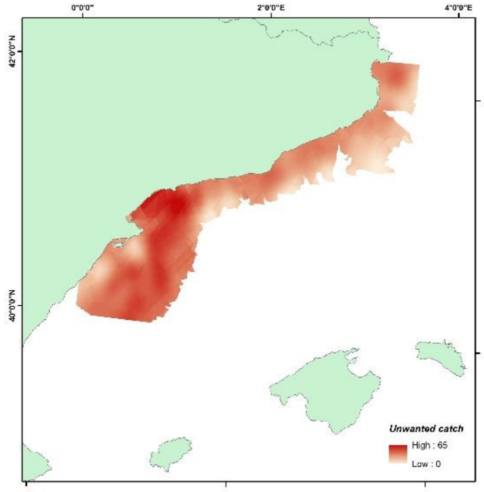


Total

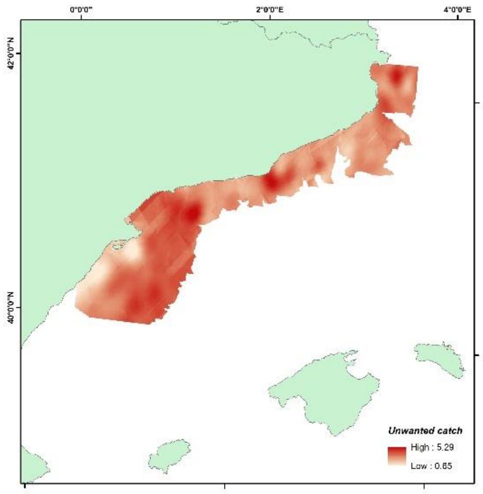
Distribution maps of unwanted catch in the case study 1.4



Fish

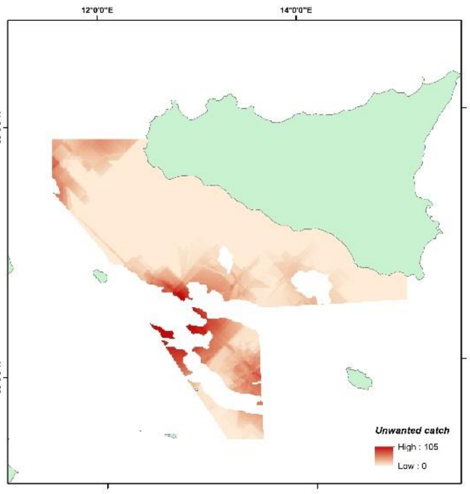


Cephalopod

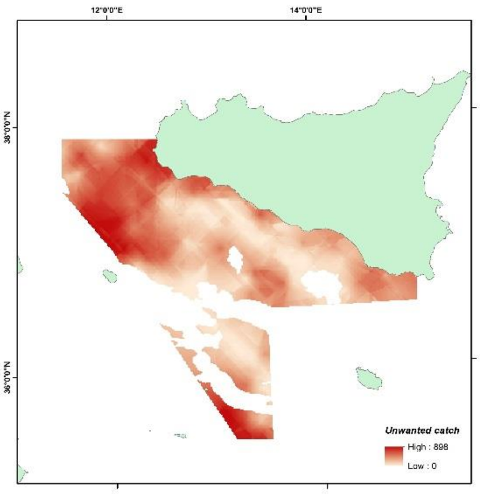


Total

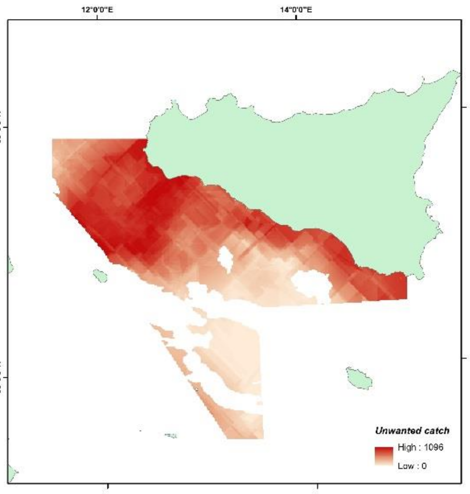
Distribution maps of unwanted catch in the case study 1.5



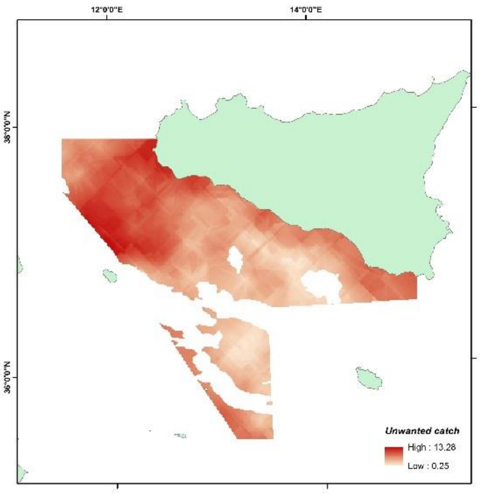
Crustacean



Fish

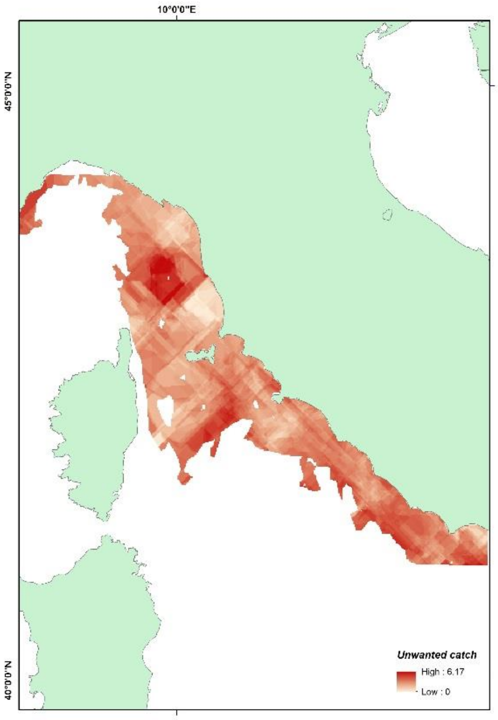


Cephalopod

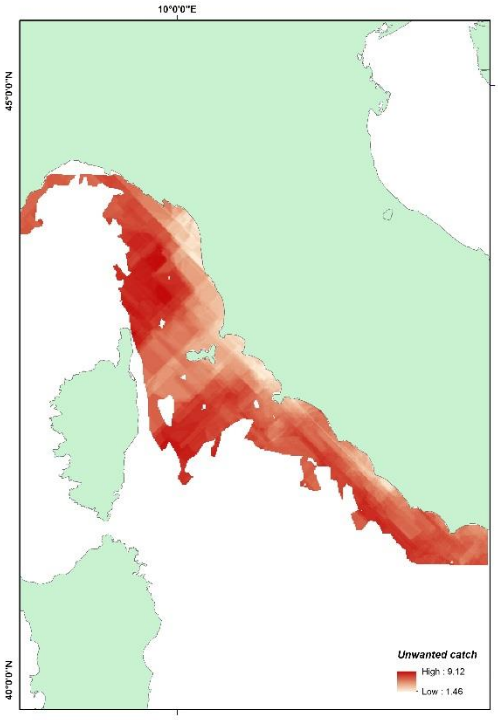


Total

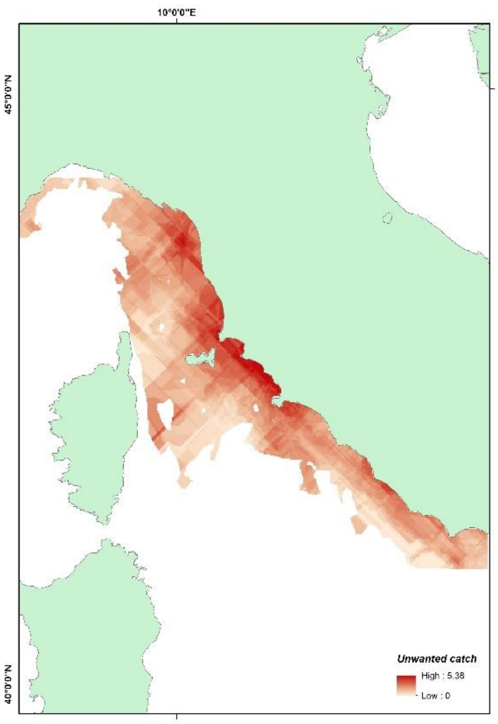
Distribution maps of unwanted catch in the case study 1.6_1.8



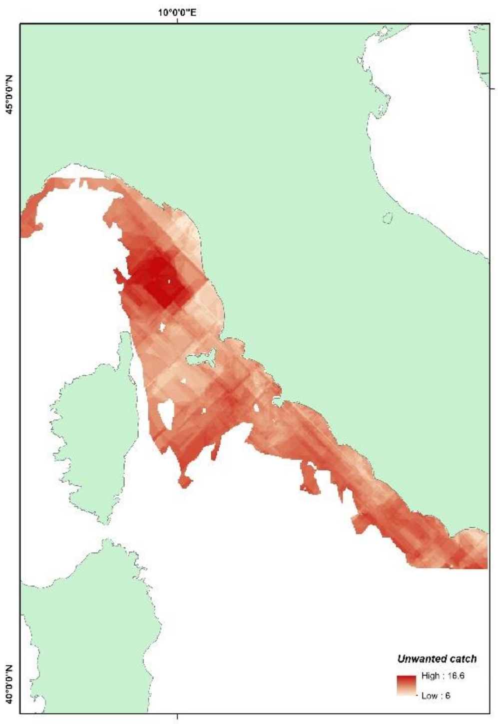
Crustacean



Fish

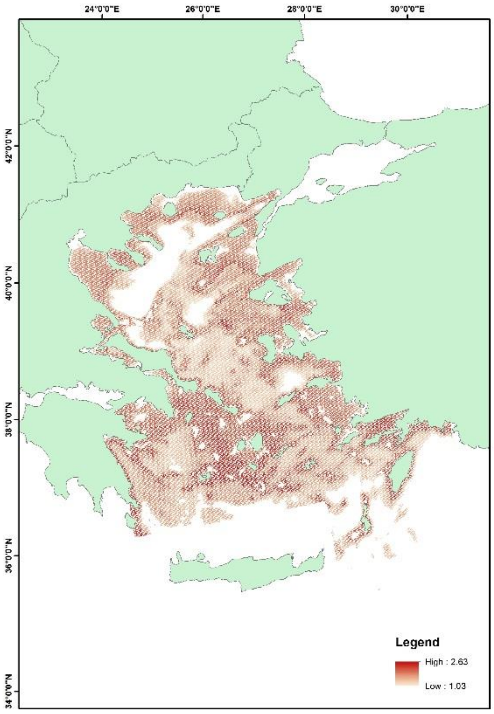


Cephalopod

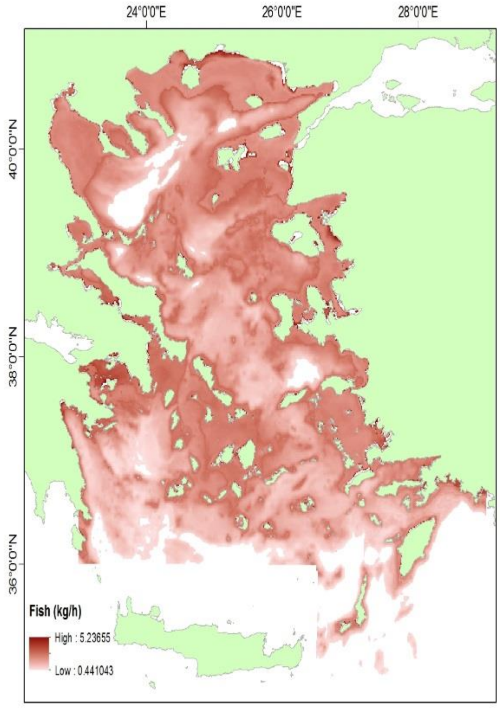


Total

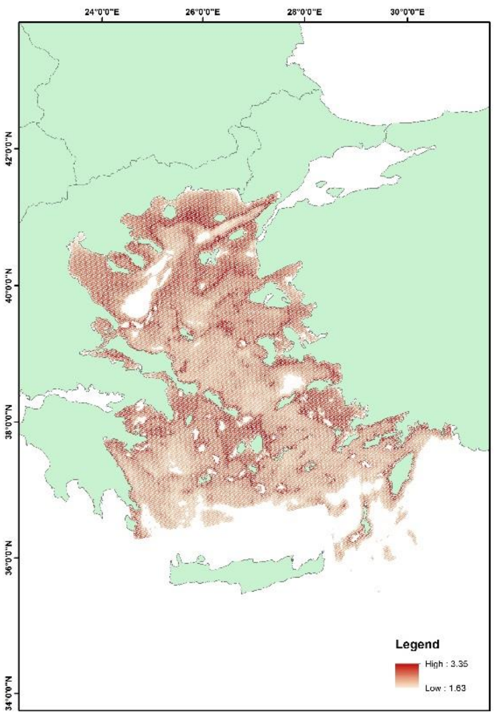
Distribution maps of unwanted catch in the case study 1.7



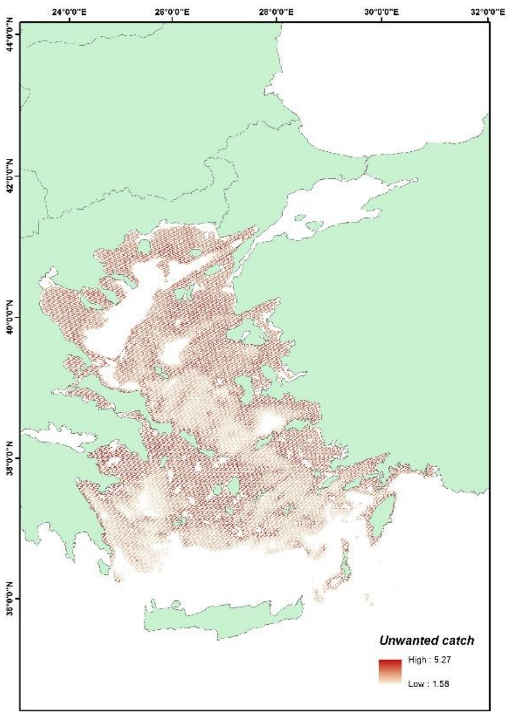
Crustacean



Fish



Cephalopod



Total

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

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