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SONSERA FISHERY: BY-CATCH SPECIES

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ABSTRACT

Not only the species targeted are affected by the commercial fishing, there are several other species that are caught incidentally. This is known as “by-catch”. By-catch is one of the most pressing issue in the commercial fishing industry worldwide. “Sonsera” have a high selectivity when targeting sand eel. “Sonsera” known both, the gear and the boat have *Gymnammodytes cicerelus* and *Gymnammodytes semisquamatus* as target species. The study focused on the central-northern Catalan coast (NW Mediterranean). Specifically, 5 fishing ports were considered: Estartit, Palamós, Sant Feliu de Guíxols, Blanes and Arenys de Mar. From 2012 to 2018.

The aim of this study is to have knowledge of the biodiversity of the fish community associated with “sonso”, if the by-catch follows a pattern considering the factor year, season and geographical position of the fishing port, why some of these species are captured unintendedly and finally, if some species of seagrass meadows are affected by “sonsera”.

A total of 67 species where identified and the relative weight have been calculated with this, using PRIME, a multi-dimensional scaling analysis (MDS) have been done for all the samples first and then considering the factors said before. For the biodiversity study some ecological indexes have been used.

Results showed that no distribution pattern has been observed by the non-targeted species at the “sonsera” fishery per year, season and fishing port. However, the lack of seasonality it could be seen for the low by-catch rate observed. Therefore, all the “sonsera” boats are fishing on the same costal community. The community of sandy bottom and shallower waters species. “Sonsera” fishery have a considerably number of unwanted species capture. In addition, some of the captures of the species at the fishery are below the minimum catch size. The average percentage of by-catch is lower than 1%, the lowest rate compared with other typical fisheries of the Mediterranean. Some species are more dominant in abundancy than others for example *Bothus podas, Pagellus erythrinus, Xyrichthys novacula* and *Rhizostoma pulmo*. Finally, Posidonia meadows are not damage by “sonsera” fishery.

RESUM

No només les espècies diana són les afectades per la pesca comercial, sinó que n'hi ha moltes altres que en són capturades de manera fortuïta. Això, és conegut com a descartament. El descartament és un dels problemes amb més pressió de les grans indústries pesqueres a escala internacional. La sonsera té una gran capacitat de selecció de la seva espècie diana, el sonso format per dues espècies el *Gymnammodytes cicerelus* i el *Gymnammodytes semisquamatus*. L'estudi es va dur a terme a la zona central-nord de la costa catalana. Concretament en 5 ports pesquers: L'Estartit, Palamós, Sant Feliu de Guíxols, Blanes i Arenys de Mar. Estudi fet des del 2012 fins al 2018.

Els objectius d'aquest estudi són tenir coneixement sobre la biodiversitat de la comunitat associada al sonso, si el descartament segueix un patró de captura considerant també l'any de captura, l'estació i el port pesquer, per què algunes d'aquestes espècies són capturades de manera incidental i finalment, si algunes de les praderies de fanerògames marines es veuen afectades per la sonsera.

Un total de 67 espècies es va identificar i es va calcular el pes relatiu, amb l'ús del PRIMER, es va dur a terme una anàlisi d'escalament multidimensional (MDS) amb les mostres en general i després tenint en compte els factors mencionats anteriorment. Per l'estudi de la biodiversitat es van utilitzar alguns índexs de biodiversitat comunament emprats.

Els resultats van mostrar que les espècies del descartament no segueixen cap patró tant per l'any de captura, l'estació o el port pesquer. Tanmateix, la falta d'estacionalitat vista pot ser deguda a la baixa captura d'espècies no-diana. Per tant, tots els vaixells estan pescant en la mateixa comunitat. La comunitat d'espècies costaneres de fons sorrencs. La sonsera té un nombre considerable d'espècies no-diana capturades. A més, algunes d'aquestes captures són d'individus per sota la talla mínima establerta d'algunes espècies. La mitjana del percentatge dels descartaments de tots els anys és inferior a l'1%, el més petit comparat amb altres pesqueries del Mediterrani. Algunes espècies són més dominats que altres com per exemple, *Bothus podas, Pagellus erythrinus, Xyrichthys novacula* i *Rhizostoma pulmo*. Finalment, les praderies de Posidònia no es veuen afectades per la sonsera.

RESUMEN

No sólo las especies diana están afectadas por la pesca comercial, sino que hay muchas especies que son capturadas de manera fortuita. Esto, es conocido como descarte. El descarte es uno de los problemas con más presión a nivel mundial. La sonsera tiene una gran capacidad de selección de su especie diana, el sonso, formado por dos especies *Gymnammodytes cicerelus* i *Gymnammodytes semisquamatus*. El estudio se realizó en la zona centro-norte de la costa catalana. Concretamente en 5 puertos pesqueros: Estartit, Palamós, Sant Feliu de Guíxols, Blanes y Arenys de Mar. Estudio realizado entre 2012 y 2018.

Los objetivos de este estudio son tener conocimiento de la biodiversidad de la comunidad asociada al sonso, si el descarte sigue un patrón de captura considerando también el año de captura, la estación y el puerto pesquero, por qué algunas de las especies son capturadas de forma incidental i finalmente, si alguna pradería de fanerógama marina es afectada por la sonsera.

Un total de 67 especies fueron identificadas y se calculó es peso relativo de estas, usando PRIMER, se hizo un análisis d'escalamiento multidimensional (MDS) con las muestras en general y después teniendo en cuenta los factores año, estación y puerto pesquero. Para el estudio de la biodiversidad se usaron algunos índices de biodiversidad comúnmente utilizados.

Los resultados mostraron que las especies del descarte no siguen ningún patrón tanto para el año de captura, la estación o el puerto pesquero. Sin embargo, la falta de estacionalidad puede ser observada por las bajas capturas de especies no-diana. Por los tanto, todos los barcos están pescando en una misma comunidad. La comunidad de especies costeras de fondos arenosos. La sonsera tiene un número elevado de especies no-diana capturadas. Además, algunas capturas son de individuos por debajo de la talla mínima establecida de algunas especies. EL promedio del porcentaje de descarte para todos los años es inferior al 1%, el más pequeño comparado con otras pesquerías del Mediterráneo. Algunas especies son más dominantes que otras como por ejemplo *Bothus podas*, *Pagellus erythrinus*, *Xyrichthys novacula* y *Rhizostoma pulmo*. Finalmente, las praderas de Posidonia no son afectadas por la sonsera.

1. INTRODUCTION

Not only the species targeted are affected by the commercial fishing, there are several other species that are caught incidentally. This is known as “by-catch”. By-catch can be referred as the species of less commercial importance or non-commercial importance, along with some incidental catch of vulnerable species or individuals that are small (juveniles) or in bad conditions. This type of by-catch generally is dumped overboard into the sea during the fishing manoeuvre (FAO, 2018).

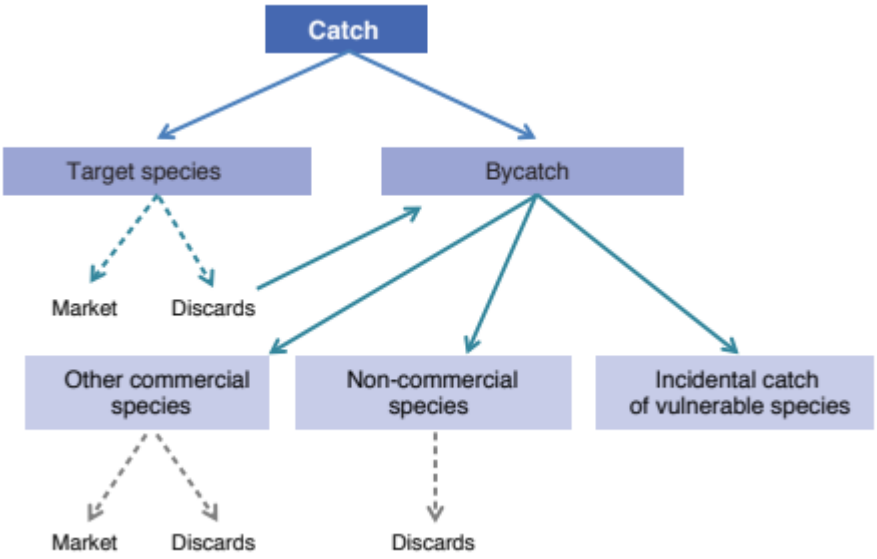

Figure 1.- Different components of a fishing catch. Source: FAO, 2018.

Most recent report of fisheries by-catch released by FAO estimated that 7,3 million tonnes of fish are discarded every year around the world. The weighted discard rate, which is the proportion of the discard in relation with the total catch, is estimated at 8%. In the Mediterranean this percentage increase up to 18% (approximately 230.000 tonnes) (FAO, 2018).

By-catch is one of the most pressing issue in the commercial fishing industry worldwide, after the sustainability of the population of the different fish species themselves (Hall & Mainprize, 2005). Also, there are the problem of catching endangered species which can create a conservation problem. By-catch can affect biodiversity and can disturb the ecosystem by water biomass transferring, causing accumulations of biomass that can affect the nutrients pathways, for example anoxia can be faced (Hall *et al,* 2000). In addition, discards can affect the food chain generating high levels of food through dead fish, modifying the relative prey-predator abundance (FAO, 2018).

Nowadays, both governmental and nongovernmental conservation bodies accept by-catch as a major concern (Hall & Mainprize, 2005). Therefore, minimizing by-catch is one of the most significant challenges facing fisheries these days. There are two main reasons that have created concern by conservation bodies. Firstly, the waste issue, the average discard during 2000-2010 has been 10,3 Mt per year. Secondly, the ecological impact, with the same importance on individual species and on the wider marine ecosystems (Miller *et al*, 2017).

On the other hand, some scientific reports show that discard is declining in comparison of the situation of the fisheries ten or twenty years ago. This reduction is associated to more selective gears and fishing practices, the disappearance of some fisheries which are particularly wasteful and for the fact that fish, which previously was discarded, now is being retained as feed for aquaculture in Southeast Asia and Europe, for instance (Zeller & Pauly, 2005).

Lleonart, *et al* (2014) pointed out that "sonsera" have a high selectivity when targeting sand eel. That is because the presence of by-catch species can be detected by the echo-sounder. Around 2% to 3% is the percentage in weight of by-catch species in relation to the total sand eel catch.

"Sonsera" is a type of boat seine which have the sand eel as the target species. "Sonsera" is known both, the gear and the boat. In Catalonia it can be found two species of sand eel, which are *Gymnammodytes cicerelus*, recognized as "sonso blau", and *Gymnammodytes semisquamatus*, known as "sonso ros" (Figure 2). Sand eel can receive other names such as "enfú", "trencavits" or "barrinaire". The present fishery it is address primarily for human consumption and a slight portion for bait (Lleonart *et al*, 2014).

Figure 2.- Left: *Gymnammodytes cicerelus* ("sonso blau"); Right: *Gymnammodytes semisquamatus* ("sonso ros").

Source: ICM.

There are 26 artisanal boats distributed around 6 fishing ports scattered about the central-northern Catalan coast (NW Mediterranean). These ports are from North to South: Estartit, Palamós, Sant Feliu de Guíxols, Blanes, Arenys de Mar and Barcelona. These indicated vessels operate five days per week during the morning when sand eel is easiest to capture. The selling of the catch is carried out when the boat arrives to port, that is, the same day it is captured (Sanchez *et al,* 2013; Martin *et al,* 2016). Sand eel prices in the period 2000/2012 varied between 1 and 5 euros per kilo. Thanks to the collaboration of the fishermen, in 1987 was created an agreement with the main objective of the implementation of a seasonal closure. Sand eel can not be fished from 15 December until the end of February. This interval of non-fishing coincides with the reproduction period of the target species (Lleonart *et al*, 2014).

For the "sonso's" capture only can be used this kind of fishery. The mentioned fishery gathers some specific characteristic such as the mesh size and fishing on a depth less than 50 m from the coast (Sanchez *et al,* 2013). Concretely, the boat characteristics are: length between perpendicular of 8,05 ± 1,75 m and power of 42,55 ± 20,60 kw. The number of fishermen working on board can be about two or three (Martin *et al,* 2016).

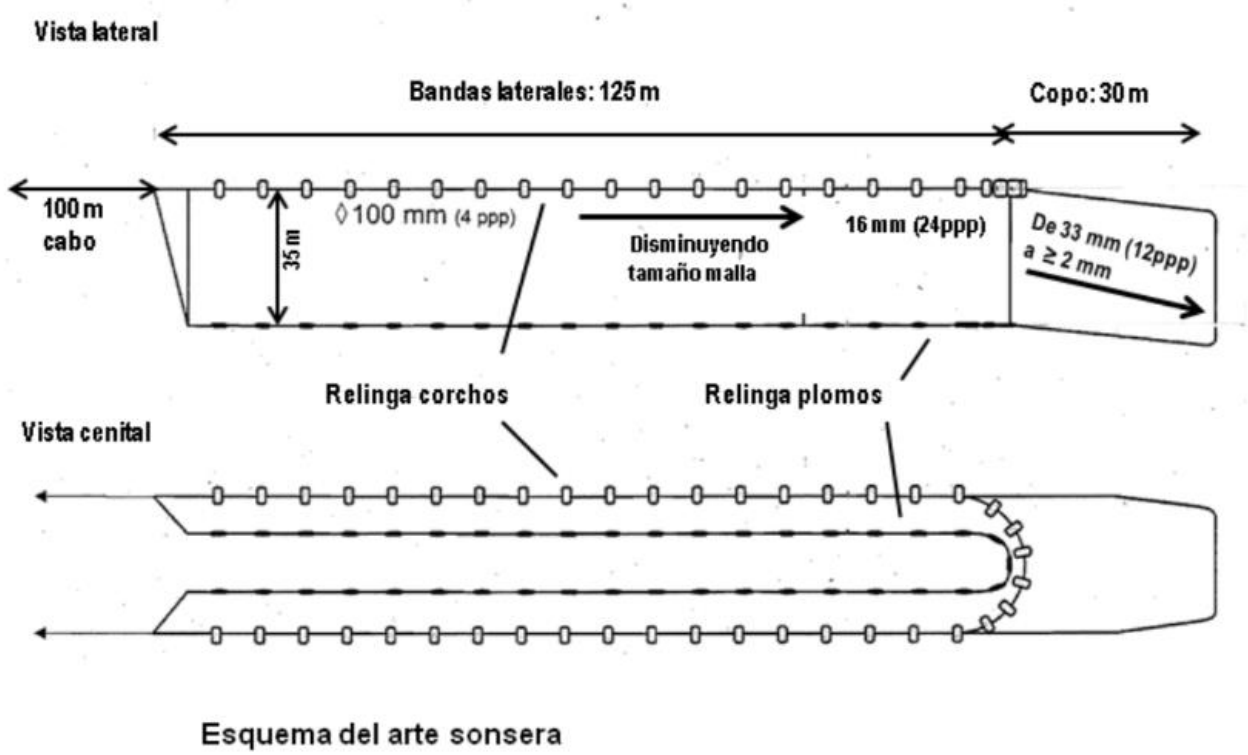

Figure 3.- "Sonsera" gear technique representation. Above: Lateral view; Below: Top view. Source: Sánchez *et al*, 2017.

The “sonsera” is based on two long lateral wings and a bag in between of those wings, including the codend, which retains the catch. The dimensions of the gear are: a maximum length of wings of 125 m, a maximum height of wings of 35 m and a maximum length of codend of 30 m. Moreover, a rope with a maximum of 100 m is attached at the end of each wing. The wings have a leadline with weights along the net bottom, no more than 6 weights can be use with a maximum of 250 g each one. At the end of the wing the mesh size is 100 mm (4Ppp) up to the net mouth that is 16 mm (24 Ppp). Thus, decreasing along the wings to the net mouth. The mesh size of the codend goes from 33 mm (12 Ppp) at the mouth to no less than 2 mm (200 Ppp) to its lower white portion of the mesh (Figure 3). The catch is removed from a cylindrical net extension found at one end of the codend (Sánchez *et al,* 2017).

In 2006 the European Council made some legislations which banned the fisheries with some specific characteristic of the mesh size and the depth and distance from the coast. Therefore, “sonsera” was automatically affected by this legislation. With the knowledge of the European legislation a scientific study was made focused in the sustainability of the “sonso” stock, the prevention of discard and the protection of seagrass meadow (Lleonart *et al*, 2014).

At the same time with the scientific research in 2012 was created the Sand Eel Co-Management Committee. This Committee consist of different parts: public administrations, fishermen’s associations, researchers and Non-Governmental Organizations (NGO’s) (Sanchez *et al,* 2013).

The objectives of the management plan are: Maintenance of historical small-scale fisheries and subsequent adoption of appropriate management measures. Monitoring the state of exploitation by determining the amount of each catch, fishing effort and the basic biological parameters. Identification the impact of the fishing gear on ecosystem. Identification of a set of indicators needed to verify both the state of exploitation and the effectiveness of the management measures taken (LLeonart *et al*, 2014; Sanchez *et al,* 2013).

Therefore, the Sand Eel Co-Management Committee was created with the specific mission of ensuring a sustainable fishery in accordance with the EU rules (Dimitriadis *et al,* 2015).

2. OBJECTIVES

This study is aimed to:

- Have knowledge of the biodiversity of the fish community associated with “sonso” by knowing the non-targeted species in the “sonsera’s” fishery.
- By-catch follows some model or distribution or seasonal patron. Know if there are some species that can be catch in a determinate moment for example per year, season or geographical position of the fishing port.
- Why some of these species are captured unintendedly. Have knowledge if there are some incidental/unwanted catch of endangered species or if some species of seagrass meadows are affected.

3. MATERIAL AND METHODS

3.1 Study area

The study focused on the central-northern Catalan coast (NW Mediterranean). Particularly, 5 fishing ports were considered: Estartit, Palamós, Sant Feliu de Guíxols, Blanes and Arenys de Mar. Barcelona's port has not been considered because there are just one sample from 2012 and the boat, is more specialized in the capture of gobids. The depth on the fishing points was with a maximum of 19 m and a minimum of 2 m, with an average of 7,7 m, with sandy bottoms.

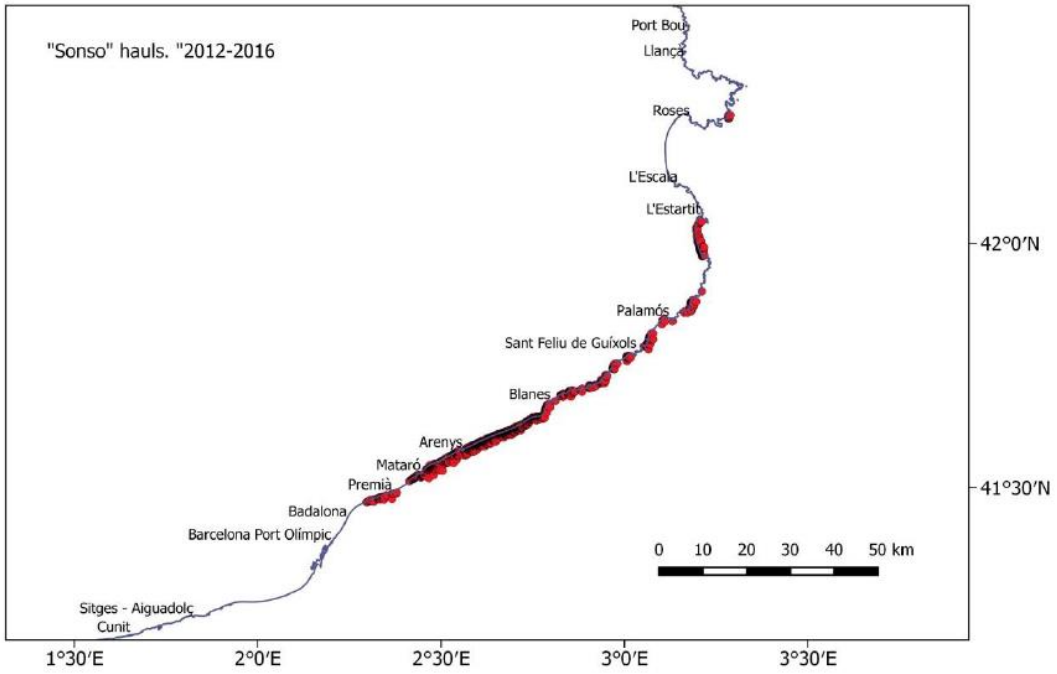

Figure 4.- General Map of the Mid-North Catalan coast showing the sand eel fishery position. Red dots: "sonsera" fishery position. Source: Sánchez et al, 2017.

3.2 Methodology

The study has been made with data provide by ICM (Institut de Ciències del Mar). Samplings on board "sonsera" boats from August 2012 to December 2018 was carried out from the five ports. It should be pointed out, that there is a gap between July 2013 and March 2014, due to the lack of funding.

One observer on board recorded the information on specific composition of the catches and by-catch, data on the fishing grounds where the boat seine operated. In the closed season (Mid-December to February) only one sampling per month in two ports (Arenys de Mar and Blanes) was carried out in order to obtain samples for the biological study by experimental or scientific fishing trips.

All the hauls were taken into consideration for the analysis, even the zero by-catch hauls.

All by-catch was examined at the laboratory, including species identification (up to the minimum taxonomical category possible), lengths and weights. Specimens were measured to the nearest half centimeter and weighed to the nearest 0,1 g (Sánchez *et al,* 2017).

Figure 5.- Left: "Sonsera" capture with some visible by-catch species. Right: Scientists of ICM during the identification process of the by-catch and compilation of biological parameters of "sonso". Source: ICM & Sánchez et al, 2017.

Table 1.- Number of hauls per year and total. Num: Number of hauls; Num.w/B: Number of hauls with by-catch; Num.w/oB: Number of hauls without by-catch.

Year	Num.	Num. w/B	Num. w/oB
2012	65	39	26
2013	48	22	26
2014	74	59	15
2015	32	15	17
2016	13	11	2
2017	20	9	11
2018	24	15	9
Total	276	170	106

The samples label consisted of three parts: the first three letters are the first letters of the month when the captured has been done, then, the last two numbers of the fishing year and lastly, the initial letter of the fishing port for every boat (Table 2). For example: "Jun16P" referred to June 2016, Palamós.

Table 2.- “Sonsera” boat names related to the fishing port.

Boat name	Fishing port
CRIS-U	Arenys de Mar
ESPARTA	
LLAMANTU U	
MARIA	
MARIA MAR QUATRE	
MONTSERRAT	
PAI I AINA	
NEUS II	
NOVA SANT JOAN	Blanes
PARE TRIAS	
REFI	
ROSA DOS	
SANT JOAN TERCERA	
HERMANOS CAYUELA DOS	
MARLU	
FERMA	L’Estartit
ELISA	
FOQUE UNO	Palamós
EL BOLERICO II	
AVI MARTINET	
AVI TONI	Sant Feliu de Guíxols
CONSTANT	
GERMANS REFI	

In order to describe the unwanted species per year, season and geographical position of the fishing port tables with the relative weight have been made.

Ratio of by-catch to the total capture has been done giving a percentage in order to be compared with some other fisheries of the Mediterranean.

$$\%\ bycatch = \frac{Bycatch\ weight}{\text{Total capture weight}} \times 100 \qquad (1)$$

Evaluate if there are a pattern of the discard in the “sonso’s” fishery, per year of catch, per season or geographical position of the fishing port. To fulfil this, it has been used the PRIMER package (Clarke & Warwick, 1994).

PRIMER is the acronym for “Plymouth Routines in Multivariate Ecological Research”. It is a spin-out Enterprise from Plymouth Marine Laboratory (PML) in the UK. PRIMER software and methodology are now established in research laboratories in over 132 countries worldwide (About Primer-e, 2017).

Plot analysis was applied to the unwanted species matrix using multidimensional scaling (MDS) techniques, and the double square root transformation. The percentage of the samples was calculated by means of Bray-Curtis index.

Some Biodiversity indices were calculated using the PRIMER routine DIVERSE, accessed with a data worksheet (Clarke & Warwick, 1994). The diversity indices used were:

Shannon-Wiener diversity index:

$$H' = -\sum_i p_i(log_2 p_i) \quad (2)$$

Where p_i is the proportion of the total count arising from the *i*th species (Clarke & Warwick, 1994).

Pielou’s evenness index:

$$J' = \frac{H'(observed)}{H'_{max}} \quad (3)$$

Where H'_{max} is the maximum possible diversity which would be achieved if all species were equally abundant (Clarke & Warwick, 1994).

Simpson diversity index:

$$1 - \lambda = 1 - \sum p_i^2 \quad (4)$$

Where p_i is the proportion of the total count arising from the *i*th species (Clarke & Warwick, 1994).

Search graphic documents in order to know the damage towards marine phanerogams species, specially toward *Posidonia oceanica* meadows.

4. RESULTS AND DISCUSSION

A total of 67 species were captured and identified from 2012 to 2018 in this study (Table 3). Most of the individuals were classified by Genus and Species. Some of the individuals were identified only by the Genus, for example *Sepiola spp*. or *Pagellus spp*. Other captures were such small or in bad condition that the identified process was difficult, therefore, these individuals were classified by the Family, for example *Gobidae* or *Sparidae*.

Table 3.- Unwanted species or families captured from 2012 to 2018.

Arnoglossus laterna	*Loligo vulgaris*	*Scomber colias*
Arnoglossus spp.	*Mactra stultorum*	*Scomber japonicus*
Atherina hepsetus	*Mullus barbatus*	*Scomber scombrus*
Belone belone	*Mullus spp.*	*Sepia officinalis*
Boops boops	*Mullus surmuletus*	*Sepietta oweniana*
Bothus podas	*Muraena helena*	*Sepiola spp.*
Callionymus maculatus	*Myliobatis aquila*	*Seriola dumerili*
Callionymus risso	*Octopus vulgaris*	*Sparidae*
Caranx rhonchus	*Pagellus acarne*	*Sparus aurata*
Chelidonichthys cuculus	*Pagellus bogaraveo*	*Spicara spp.*
Crystalogobius linearis	*Pagellus erythrinus*	*Synodus saurus*
Dactylopterus volitans	*Pagellus spp.*	*Trachinus araneus*
Dasyatis pastinaca	*Pagurus prideaux*	*Trachinus draco*
Diplodus annularis	*Pomatoschistus marmoratus*	*Trachinus evacuens*
Echiichthys vipera	*Pomatoschistus pictus*	*Trachinus radiatus*
Eledone cirrhosa	*Pontocaris cataphracta*	*Trachurus mediterraneus*
Engraulis encrasicolus	*Pseudaphia ferreri*	*Trachurus picturatus*
Gobidae	*Raja asterias*	*Trachurus spp.*
Gobius bucchichi	*Rhizostoma pulmo*	*Trachurus trachurus*
Holothuria foskalis	*Sarda sarda*	*Uranoscopus scaber*
Liocarcinus vernalis	*Sardina pilchardus*	*Xyrichthys novacula*
Lithognathus mormyrus	*Sardinella aurita*	
Liza aurata	*Sardinella spp.*	

It has been studied the number of individuals captured per haul (Figure 6). The results showed that the number of species captured per haul are mainly, between 0 and 3, being one species captured the most abundant option (37 hauls). It has been seen that from 8 species captured to 14 only happens one or zero times. Thus, the number of species captured at the “sonsera” fishery are very low. These results showed that the “sonsera” fishery is a very specific fishing gear, not so many unwanted species are captures per haul.

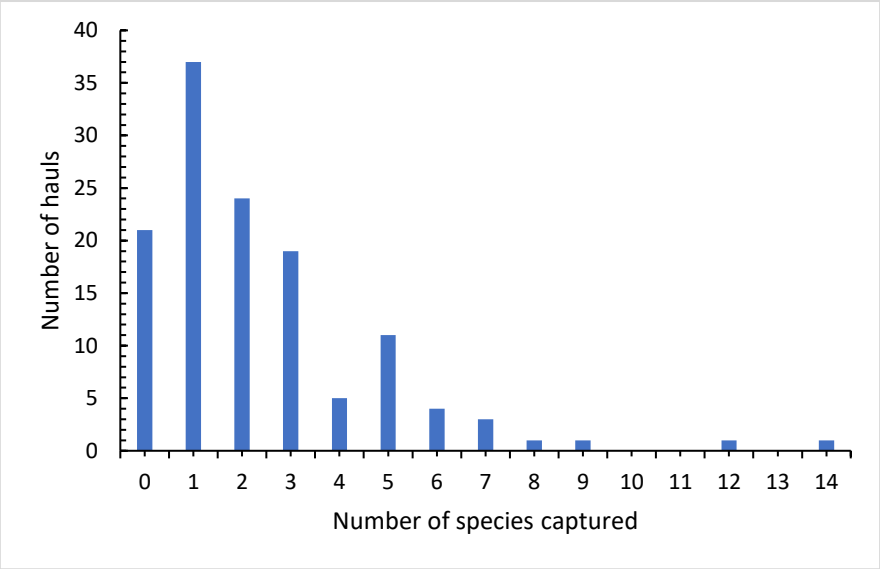

Figure 6.- Number of species captured per haul during 2012-2018.

Table 4.- By-catch relative weight (Kg species/kg "sonso") per year. Shaded number: Higher relative weights.

Species / Year	2012	2013	2014	2015	2016	2017	2018
Arnoglossus laterna	0	0	0	0	0	0,0000053	0
Arnoglossus spp.	8,8227E-07	0	0	0	0	0	0
Atherina hepsetus	0	0	0	0	0	0,01105833	0
Belone belone	2,8495E-05	0,00054872	0,00031524	0,003	4,6154E-05	0	0
Boops boops	0	2,8325E-05	8,7302E-06	0	0	0,00035	0
Bothus podas	0,00065088	0,00011362	0,0012794	0,00062143	0,00208923	0,00091667	0,00145098
Callionymus maculatus	0	0	4,6667E-07	0	0	0	0
Callionymus risso	0	0	0	0	2,5231E-06	0	0
Caranx rhonchus	0	3,4286E-05	0,00060159	0	0	0	0
Chelidonichthys cuculus	0	1,0667E-05	0	0	0	0	0
Crystalogobius linearis	0	0	0	0	0	0,00444	0
Dactylopterus volitans	0	0	7,4074E-06	0	0	0,00126667	0
Dasyatis pastinaca	0	0	0	0,00108444	0	0	0
Diplodus annularis	0	0	0	0	0	4,1667E-05	0
Echiichthys vipera	4,884E-07	1,6064E-06	0	0	3,2231E-06	0	0
Engraulis encrasicolus	2,9777E-08	1,0214E-05	0,00173567	0,00040707	0,00058195	0,0000754	2,0912E-05
Gobidae	8,7044E-08	0	0	0,00047	0	0	0,00016395
Gobius bucchichi	0	0	0	0	0,00046154	0	0
Holothuria foskalis	0	0	0	0	0	0	9,7222E-06
Liocarcinus vernalis	0	0	0	0	3,0462E-06	0	0
Lithognathus mormyrus	0	6,5512E-05	0	0	0	0	0
Liza aurata	0	0	0,00147778	0	0	0	0
Loligo vulgaris	9,1026E-06	6,6421E-05	0	0	0,00070253	0	1,413E-05
Mactra stultorum	0	0	0,00022833	0	0	0	0
Mullus barbatus	0	0	0	4,725E-06	0	0	0
Mullus spp.	2,0276E-07	0	0	0,00056028	0	0	0

Mullus surmuletus	2,0276E-07	0	0	0,00055556	0	0	0
Muraena helena	0	0	4,2708E-05	0	0	0	0
Myliobatis aquila	5,7774E-05	0	0	0	0	0	0
Octopus vulgaris	3,1235E-05	0	0,0015	0	0	0	0
Pagellus acarne	0	0	0	0,01907143	0	0	0
Pagellus bogaraveo	0	9,619E-07	0	0	0	0	0
Pagellus erythrinus	0,00076057	0,00257676	0,00170277	0,01551141	0,01320513	0,0014019	0,00068335
Pagellus spp.	0	0	0,00333333	0	0	0	0
Pagurus prideaux	1,221E-07	0	0	0	0	0	0
Pomatoschistus marmoratus	0	0	0	0	2,8846E-07	0	0
Pomatoschistus pictus	0	0	2,1167E-05	0	0	0	0
Pseudaphia ferreri	0	0	6,8333E-05	0	3,9974E-05	0,00000109	1,1932E-06
Raja asterias	0,00013462	0	0,00716667	0	0	0	0
Sarda sarda	8,2532E-05	0,0001239	0	0	0	0	0
Sardina pilchardus	0	0,00106814	0,00011183	0	3,1713E-05	0	0
Sardinella aurita	4,3262E-05	0	0	0	0	0	0
Sardinella spp.	0	7,3437E-06	0	0	0	0,0000382	0
Scomber colias	0	0,00010476	0,0005642	0	0	0	0
Scomber japonicus	0	0,00013049	0	0	0	0	0
Scomber scombrus	0	0	0,0001446	0	0	0	0
Sepia officinalis	3,616E-06	4,2254E-05	0	0	0	0	5,5556E-07
Sepietta oweniana	0	0	0	0	0	0	0,00010492
Sepiola spp.	0	0	0,0000035	0	0	4,8333E-06	0,00045889
Seriola dumerili	9,1779E-05	0	0	0	0	0	0
Sparidae	0	0	0,0000985	0	0	0	0,00075758
Sparus aurata	0	1,5605E-05	0	0	0	0	0
Spicara spp.	6,9849E-05	0,0003287	0,00016589	0	0	0,00370417	0
Synodus saurus	0,00229714	0,00304945	0,00033959	0,000143	0,02494745	0,0002289	0,00068403
Trachinus araneus	0	0	0	0	0	0	0,00088889
Trachinus draco	6,8304E-05	0,00044395	0,00040291	0	0	0	0
Trachinus evacuens	0	7,1952E-06	0	0	0	0	0
Trachinus radiatus	1,8725E-05	0	2,5758E-06	0	9,1385E-06	0	0
Trachurus mediterraneus	0	0,00036291	0,0000055	0	0	5,6667E-06	0
Trachurus picturatus	0	0	0,00088556	0	0	0	0
Trachurus spp.	3,7323E-06	0,00090469	0	0,00833333	7,3369E-05	0	0,00063134
Uranoscopus scaber	6,1728E-06	4,1469E-05	0	0	0	0	0
Xyrichthys novacula	0,0001762	3,2837E-05	0,00027754	0,00442856	0,00117809	0	0,00044566

The results of the relative weight of unwanted species per year (Table X) showed, which are the most abundant species depending on the total weight of the discard. Per year, the most abundant species by relative weight in percentage are: 2012 *Synodus saurus* (51%), *Pagellus erythrinus* (17%) and *Bothus podas* (14%); 2013 *Synodus saurus* (30%), *Pagellus erythrinus* (25%) and *Sardina pilchardus* (11%); 2014 *Raja asterias* (32%) and *Pagellus spp.* (15%); 2015 *Pagellus*

acarne (35%), *Pagellus erythrinus* (29%) and *Trachurus spp.* (15%); 2016 *Synodus saurus* (58%) and *Pagellus acarne* (30%); 2017 *Atherina hepsetus* (47%), *Crystalogobius linearis* (19%) and *Spicara spp.* (16%); 2018 *Bothus podas* (23%), *Trachinus araneus* (14%), *Sparidae* (12%), *Synodus saurus* (11%), *Pagellus erythrinus* (11%) and *Trachurus spp.* (10%).

There are some years that the most abundant species are just two but there are other that the most abundant species are three or even more, depending on the proportion. Therefore, some years the species of the discard are more evenly distributed than others. For example, in 2018 there are 6 species spread out on the most abundant fraction of the results.

There are some differences within the species which are the most abundant by abundance or by relative weight. This can be explained by the size of the fish captured. For example, *Engraulis encrasicolus* appears several times at the list of most abundant by abundance but, it does not appear at the most abundant by relative weight. Consequently, the fish captured were abundant by number of individuals but such small. Another example to point out is the case of *Raja asterias* in 2014, which is the most abundant species by relative weight, but for abundance is one of the lowest. This is because there is only one individual captured but it weighs more than 4 Kilograms in a haul that only were captured 20 kilograms of "sonso" therefore, the relative weight it is high. Additionally, not all the species in the hauls were weighted, for example *Rhizostoma pulmo*.

Moreover, it is notable the presence of so many species with a commercial value, such as *Engraulis encrasicolus*, *Pagellus erythrinus* or *Xyrichthys novacula*. It is also important to mention that, there are some unwanted species in the "sonsera" fishery that have a minimum catch size established. These species are: *Belone belone* (25cm)*, Boops boops* (11cm)*, Diplodus spp.* (15cm), *Engraulis encrasicolus* (9cm)*, Mullus spp.* (11cm), *Pagellus spp.* (12cm)*, Sardina pilchardus* (11cm), *Scomber japonicus* (18cm)*, Scomber scombrus* (18cm)*, Sparus aurata* (20cm) and *Trachurus spp.* (12cm) (RD 560/1995, of 7th April). With this, it can be said that some of the captures of these species at the "sonsera" fishery are below the minimum catch size. The number of juveniles captured in shallowest waters can be explained because of the sheltering behaviour from possible predators, because the accessibility of predators can be difficult. As well as for the availability of food (García-Rubies & Macpherson, 1995). Also, it has been seen that the temperature and the bottom type are important factors for the distribution pattern during the life cycle of some species (Demestre *et al,* 2000).

In addition, the results showed that some species captured are classified as Near Threatened (NT) by the IUCN Red List. These species are *Raja asterias* (Serena *et al*, 2016) and *Scomber colias*

the Mediterranean population (Di Natale *et al*, 2011). More importantly, *Dasyatis pastinaca* which is classified as Vulnerable (VU) (Serena *et al*, 2016). To be exact the number of species captured were 1 *Dasyatis pastinaca* in 2015, 2 *Raja asterias* in 2012 and 1 in 2014 and 2 *Scomber colias* in 2013 and 14 in 2014. Therefore, with not so much significance, because there are not many individuals of these species for the seven years that this project has been made.

With these results it has been seen that these species could follow a pattern. That is, various species are more abundant in some years than others or the same species are repeated every year or every other year. As an example, *Pagellus erythrinus* is the most abundant species in five of the seven years or *Synodus saurus* in four of the seven years. Some studies showed that *Pagellus erythrinus* is distributed in more shallower waters between 0-70 m (Somarakis & Machias, 2001), depths where the "sonsera" fishery captures sand eel. In addition, some studies showed that *G.cicerelus* juveniles and other species also found on the discards, such as *Pagellus acarne* or *Boops boops,* are an important part of the *Synodus saurus'* diet (Esposito *et al,* 2009). Therefore, some species have more probability to be a part of the by-catch at "sonsera" fishery.

Figure 7.- Multidimensional scaling diagram of the samples between 2012 and 2018. Example: (Jan18A) Jan = January; 18 = 2018; A = Arenys de Mar.

The result of MDS analysis (figure 7) showed that there is not any pattern on the unwanted species capture in general.

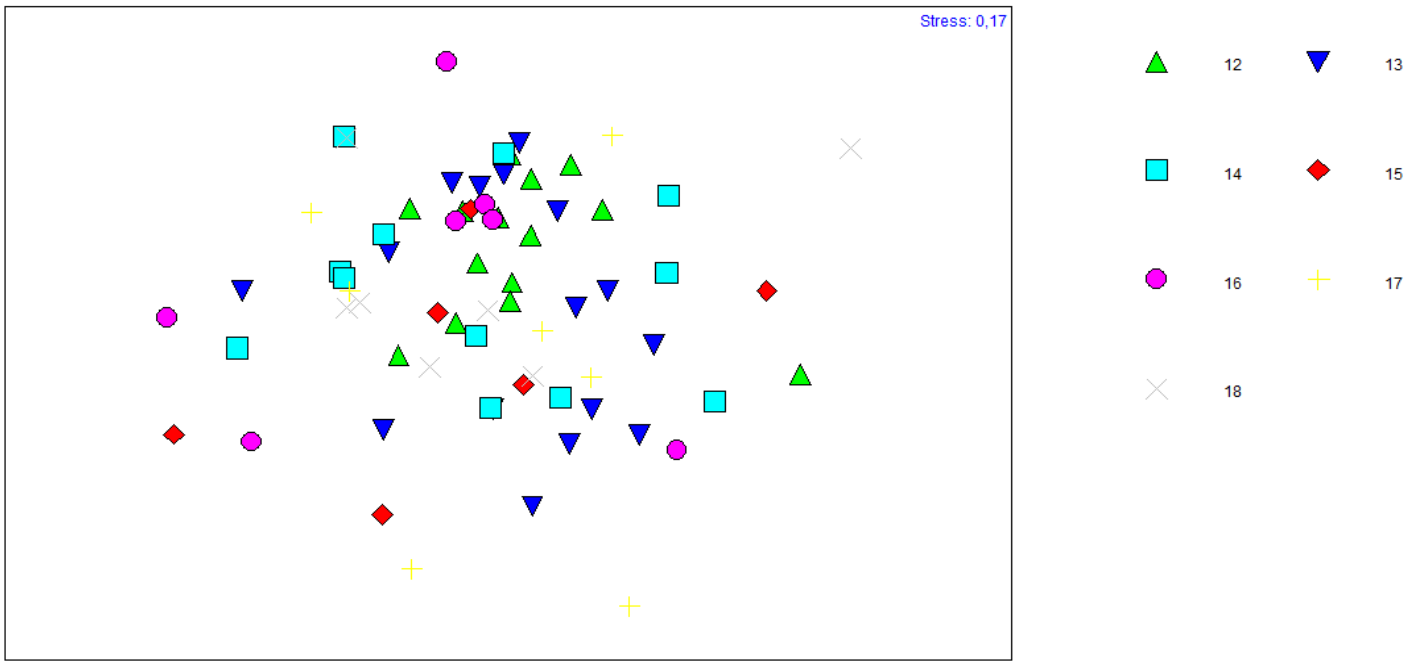

Figure 8.- Multidimensional scaling diagram of the samples between 2012 and 2018 per year.

The result of the MDS analysis with the factor year taken into consideration (Figure 8) reflected that the discard does not follow any pattern. So, the year is not a factor that influence in the species that are captured by the "sonsera" fishery. Which means that any species can be captured anytime regardless of the year.

Table 5.- By-catch relative weight (Kg species/kg "sonso") per season. Shaded number: Higher relative weights.

Species / Year	Winter	Spring	Summer	Autumn
Arnoglossus laterna	2,3043E-06	0	0	0
Arnoglossus spp.	0	0	0	7,1685E-07
Atherina hepsetus	0,00146014	0	0	0,00160417
Belone belone	0,00164593	0,00013333	0,00020282	5,961E-05
Boops boops	0,00156589	8,1845E-06	0	0
Bothus podas	0,0007501	0,00039721	0,00069664	0,00163282
Callionymus maculatus	0	0	3,6842E-07	0
Callionymus risso	0	1,025E-06	0	0
Caranx rhonchus	0,00067702	9,9881E-05	0	0
Chelidonichthys cuculus	0	0,000007	0	0
Crystalogobius linearis	0	0	0	0,000925
Dactylopterus volitans	0	0,00040278	0	0
Dasyatis pastinaca	0	0,00033889	0	0
Diplodus annularis	0	1,3021E-05	0	0
Echiichthys vipera	0	2,3636E-06	0	3,9683E-07
Engraulis encrasicolus	0,00018411	1,5828E-06	0	0,00126598
Gobidae	0,00012831	0	0,00012368	7,0723E-08
Gobius bucchichi	0,00026087	0	0	0
Holothuria foskalis	0	5,4688E-06	0	0
Liocarcinus vernalis	0	0	0	8,25E-07

Lithognathus mormyrus	5,9816E-05	0	0	0
Liza aurata	0	0	0,00116667	0
Loligo vulgaris	6,0645E-05	0	0	0,00020296
Mactra stultorum	0	0	0	0,00014271
Mullus barbatus	0	1,4766E-06	0	0
Mullus spp.	0	1,4766E-06	0	0,00011591
Mullus surmuletus	0	0	0	0,00011591
Muraena helena	0	4,0039E-05	0	0
Myliobatis aquila	0	0	4,9708E-05	7,5893E-06
Octopus vulgaris	0	0	0	0,00096288
Pagellus acarne	0,00829193	0	0	0
Pagellus bogaraveo	0	6,3125E-07	0	0
Pagellus erythrinus	0,01022631	0,00031429	0,00027026	0,00484219
Pagellus spp.	0	0	0,00263158	0
Pagurus prideaux	0	0	0	9,9206E-08
Pomatoschistus marmoratus	0	0	0	7,8125E-08
Pomatoschistus pictus	0	0	0	1,3229E-05
Pseudaphia ferreri	1,5583E-05	0	0	4,6743E-05
Raja asterias	0	0	0	0,00458854
Sarda sarda	0,00011313	0	0	6,7057E-05
Sardina pilchardus	0	0,00070097	0	7,8485E-05
Sardinella aurita	0	0	0	4,3109E-05
Sardinella spp.	6,7051E-06	0	0	0
Scomber colias	0	0,00059769	0	0
Scomber japonicus	9,3607E-05	1,8353E-05	0	0
Scomber scombrus	0	0,00013556	0	0
Sepia officinalis	3,8579E-05	0	0	3,1463E-06
Sepietta oweniana	8,211E-05	0	0	0
Sepiola spp.	0,00035913	0	2,7632E-06	1,0069E-06
Seriola dumerili	0	0	3,4386E-05	4,7348E-05
Sparidae	0	0	0,00035885	6,1563E-05
Sparus aurata	1,4248E-05	0	0	0
Spicara spp.	0,00190444	4,4444E-06	0	0,00016043
Synodus saurus	0,00018509	0,00227662	0,00054156	0,00846823
Trachinus araneus	0	0,0005	0	0
Trachinus draco	0,00033804	0,00024915	9,3997E-05	9,9054E-05
Trachinus evacuens	6,5696E-06	0	0	0
Trachinus radiatus	0	3,7125E-06	2,0335E-06	1,5214E-05
Trachurus mediterraneus	0,00029945	2,4702E-05	2,7632E-06	0,00000125
Trachurus picturatus	0	0	0	0,00055347
Trachurus spp.	0,00085998	0	3,6772E-06	0,00197659
Uranoscospus scaber	0	2,7214E-05	6,3353E-06	0
Xyrichthys novacula	0	0,00068592	0,00010181	0,00120192

The results of the relative weight of unwanted species per season (Table 5) showed, which are the most abundant species depending on the total weight of the discard. Per season, the most abundant species by relative weight in percentage are: Winter *Pagellus erythrinus* (35%) and *Pagellus acarne* (28%); Spring *Synodus saurus* (33%), *Sardina pilchardus* (10%) and *Xyrichthys novacula* (10%); Summer *Pagellus spp.* (42%), *Liza aurata* (19%) and *Bothus podas* (11%); Autumn *Synodus saurus* (29%), *Pagellus erythrinus* (17%) and *Raja asterias* (16%).

There are some seasons that have three most abundant species (Spring, Summer and Autumn) and Winter only have two. Autumn is the season with the highest number of by-catch species (36), followed by spring (29), winter (27) and finally summer (18). It is notable to say that autumn is the month with the most hauls considered (48). Therefore, there are more possibilities to captures different species compared, for example, with the winter that only have 23 hauls considered.

It is important to have in mind that the seasonal closure of "sonso" take place from 15 December until the end of February. Thus, hauls in winter are always less than any other season, and most of the winter hauls are done at experimental or scientific fishing trips.

As well as the results of the Table 4, there are some species that the relative weight is higher than other species because of the size of the fish captured. Therefore, the results for the abundancy are slightly different than the results for the relative weight.

Seasonal pattern can be a consequence of a biological behaviour: The recruitment to fishing grounds, some species tend to be more abundant at the coast because of the arrival and concentration of new recruits; and the seasonal trophic or spawning migrations, the abundancy of some species can be influenced by these migrations and the seasonal availability of resources (Aldebert, 1998).

With these results it has been seen that these species can follow a seasonal pattern. That is, various species are more abundant in some seasons than others or the same species are repeated every season.

The result of the MDS analysis with the factor season taken into consideration (Figure 9) reflect that the by-catch does not follow any seasonal pattern. So, the season is not a factor that influence in the species that are captured by the "sonsera" fishery. Which means that any species can be captured anytime no matter of the season.

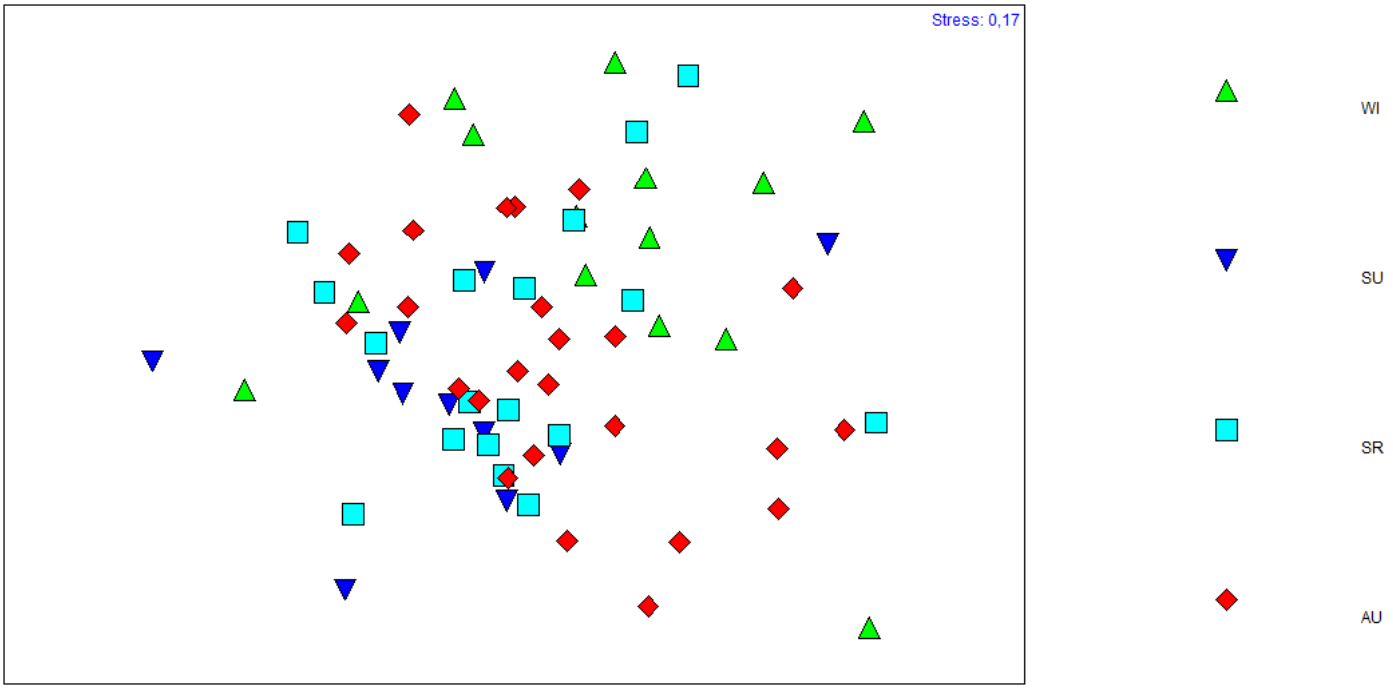

Figure 9.- Multidimensional scaling diagram of the samples between 2012 and 2018 per season. WI = Winter; SU = Summer; SR = Spring; AU = Autumn.

Table 6.- By-catch relative weight (Kg species/kg "sonso") per fishing port. Others = Palamós, Sant Feliu de Guíxols and Estartit fishing ports. Shaded number: Higher relative weights.

Species / Year	Blanes	Arenys	Others
Arnoglossus laterna	0	7,5714E-07	0
Arnoglossus spp.	0	0	1,3234E-06
Atherina hepsetus	0,00016296	0,001475	0
Belone belone	0,0008716	4,144E-05	0,00040648
Boops boops	8,3456E-06	5,3741E-05	8,4337E-06
Bothus podas	0,00073915	0,00127877	0,00046289
Callionymus maculatus	0	0	5,3846E-07
Callionymus risso	7,2889E-07	0	0
Caranx rhonchus	0,00034603	4,566E-05	0
Chelidonichthys cuculus	4,9778E-06	0	0
Crystalogobius linearis	0	0,00063429	0
Dactylopterus volitans	0	0,00018413	0
Dasyatis pastinaca	0	0	0,00041709
Diplodus annularis	9,2593E-06	0	0
Echiichthys vipera	9,3111E-07	7,5404E-07	0
Engraulis encrasicolus	0,00125212	0,00012337	2,737E-06
Gobidae	0	0,0001093	1,3057E-07
Gobius bucchichi	0	8,5714E-05	0
Holothuria foskalis	0	0	6,7308E-06
Liocarcinus vernalis	0,00000088	0	0
Lithognathus mormyrus	2,8148E-05	1,5584E-06	0

Liza aurata	0	0	0,00170513
Loligo vulgaris	1,037E-05	0,00015244	0
Mactra stultorum	0	9,7857E-05	0
Mullus barbatus	0	6,75E-07	0
Mullus spp.	0	8,004E-05	3,0414E-07
Mullus surmuletus	0	7,9365E-05	3,0414E-07
Muraena helena	2,8472E-05	0	0
Myliobatis aquila	8,0952E-06	0	7,265E-05
Octopus vulgaris	0	0	0,00177762
Pagellus acarne	0,0042381	0	0
Pagellus bogaraveo	4,4889E-07	0	0
Pagellus erythrinus	0,00170299	0,00580708	0,00018566
Pagellus spp.	0	0	0,00384615
Pagurus prideaux	0	6,8027E-08	0
Pomatoschistus marmoratus	8,3333E-08	0	0
Pomatoschistus pictus	0	9,0714E-06	0
Pseudaphia ferreri	2,3932E-08	7,871E-06	7,8846E-05
Raja asterias	0	0,000075	0,00826923
Sarda sarda	0,00011464	9,4567E-06	0
Sardina pilchardus	9,1614E-06	4,7929E-05	0,00086273
Sardinella aurita	3,4722E-07	2,1429E-05	6,6001E-06
Sardinella spp.	0	5,4571E-06	5,9314E-06
Scomber colias	8,7778E-05	0,00010969	0,00028837
Scomber japonicus	1,4444E-05	1,5231E-05	3,9388E-05
Scomber scombrus	9,6397E-05	0	0
Sepia officinalis	2,2222E-07	1,2676E-05	5,424E-06
Sepietta oweniana	0	2,6979E-05	0
Sepiola spp.	2,9037E-05	0,00011869	4,0385E-06
Seriola dumerili	0,00030303	0	8,7413E-05
Sparidae	0	0	0,00011365
Sparus aurata	0	0	1,2604E-05
Spicara spp.	0,00053994	0,00038883	5,0046E-06
Synodus saurus	0,0012421	0,00629376	0,00029636
Trachinus araneus	0	0	0,00061538
Trachinus draco	1,5179E-05	0,00024314	0,00024504
Trachinus evacuens	0	2,1586E-06	0
Trachinus radiatus	0,00000264	0	3,106E-05
Trachurus mediterraneus	0,00014579	4,3084E-06	3,7718E-05
Trachurus picturatus	0,00059037	0	0
Trachurus spp.	0,00022257	0,00149677	2,2415E-07
Uranoscospus scaber	3,5556E-06	1,0155E-05	9,2593E-06
Xyrichthys novacula	0,00052809	0,00073897	0,00030839

The results of the relative weight of unwanted species per fishing port (Table 6) showed, which are the most abundant species depending on the total weight of the discard. Per fishing port, the most abundant species by relative weight in percentage are: Blanes *Pagellus acarne* (32%) and *Pagellus erythrinus* (13%); Arenys *Synodus saurus* (32%), *Pagellus erythrinus* (29%); Others *Raja asterias* (41%) and *Pagellus spp.* (19%).

It is important to clarify that the high abundance of *Raja asterias,* with a 41% of the total of by-catch, it is a special case as it was said before.

In order to see if there are any pattern in the unwanted species by the fishing port, a multidimensional scaling analysis has been made (Figure 10).

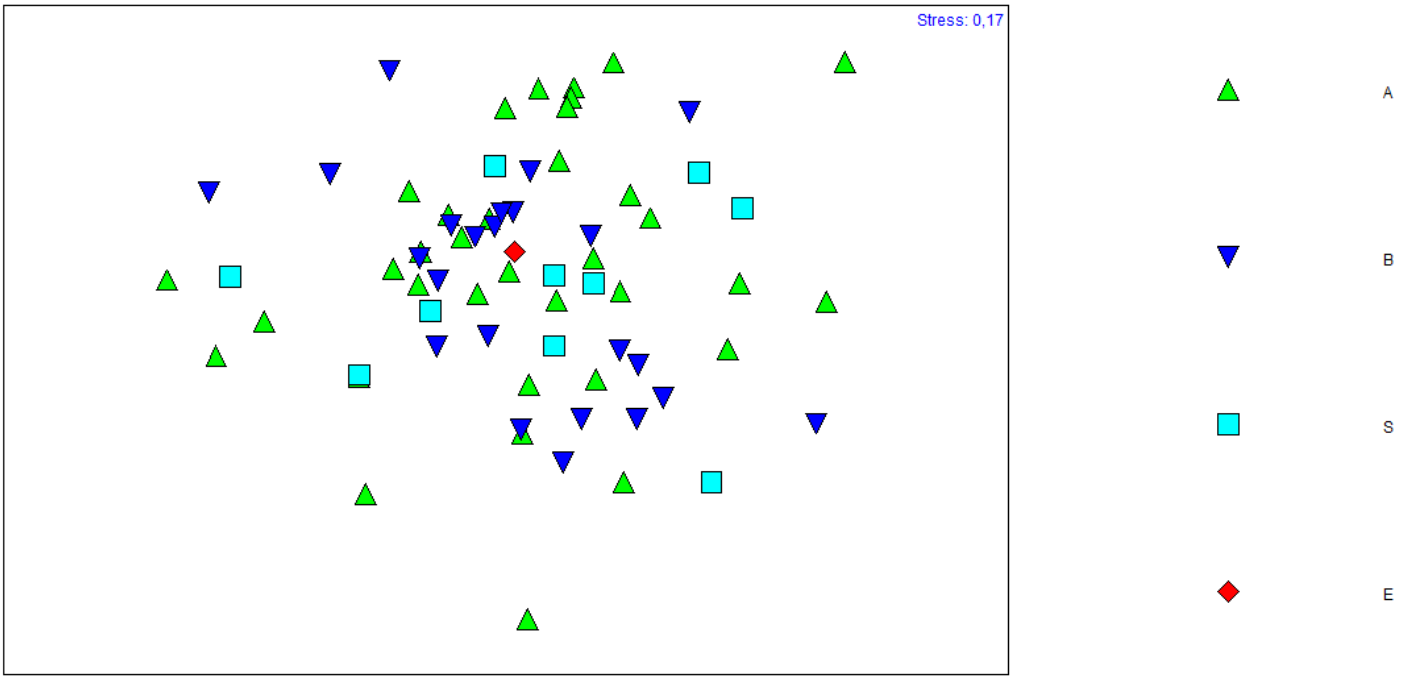

Figure 10.- Multidimensional scaling diagram of the samples between 2012 and 2018 per season. A = Arenys; B = Blanes; S = Sant Feliu de Guíxols; E = Estartit.

The result of the MDS analysis with the factor fishing port taken into consideration (Figure 10) reflect that the discard does not follow any pattern. Therefore, the fishing port is neither a factor that influence in the species that are captured by the "sonsera" fishery. Which means that any species can be captured anytime regardless of the fishing port.

The lack of differences with the Blanes and Arenys fishing ports can be because of the fishing points where so close in the two locations, both fish in the same fishing ground. Therefore, the proximity can be the key factor. The other ports have not showed any differences too. So, there

are not a proximity factor. The reason of the no differences between all the fishing ports it is because the fishing points are a part of the same community.

Generally, the most abundant species repeated in all the previous results are *Pagellus erythrinus* (9) and *Synodus saurus* (7). Which not means that these are the most by-catch captured species by "sonsera" because the most abundant species by abundance are *Rhizostoma pulmo* (554) and *Bothus podas* (526). With *Rhizostoma pulmo* only the abundance was considered, therefore, the relative weight can not be calculated.

Table 7. % by-catch calculated per year.

Year	% by-catch
2012	0,25
2013	0,61
2014	0,64
2015	0,98
2016	0,89
2017	0,95
2018	0,51
Average	0,69

The results of the calculations of the percentage of by-catch for the "sonsera" fishery (Table 7) showed, that the percentage is very low, with an average of 0,69%. This means that the captured of unwanted species by "sonsera" it is substantially small.

Here, it can be seen, that there are two years where the percentage it is slightly higher than the others. Which are 2015 (0,98%) and 2017 (0,95%). This can be justified because, first, 2015 was a bad year for the "sonsera" fisheries, the captures were so low, that much that even the fishery was closed during some months because the fisherman could not find "sonso". Therefore, this year most of the hauls considered where made in experimental fish trips. Secondly, 2017 also was year with low captures but, not as much as 2015. In 2017 the fishery was not closed, but not all the fishing boats were in operation. But it is important to say, even in these two situations the percentage of by-catch was very low.

In order to confirm that these results are substantially lower than any other type of fishery, a comparative table has been done (Table 8).

Table 8.- % by-catch from different fisheries including “sonsera”. Source: FAO, 2018.

Fisheries	% by-catch
Bottom trawl fisheries	40-50%
Beam trawl fisheries	>15%
Longline fisheries	<15%
Purse seine fisheries	<15%
Small-scale fisheries	<15%
Pelagic trawl fisheries	<15%
“Sonsera” fishery	<1%

It can be said that, the “sonsera” fishery is the type of fishery with the lowest ratio of weight of discard to weight of sand eel.

The obvious highest percentage it is from the bottom trawl fisheries. These fisheries, in the Mediterranean, are the responsible for the bulk of discards. Some studies report an oscillation from 40 to 50% and other articles confirmed this high percentage reporting a mean of 33% of discards (FAO,2018). This technique consists of a cone-shaped net ending in a codend and, bottom contact with the gear is essential for a successfully operation (FAO, 2001-2019).

Other fisheries responsible for more than a 15% of by-catch are the beam trawlers (FAO,2018). This technique consists of a cone shaped net ending in a codend, where the catch is retained. It is called beam, because the opening of the net is provided by a beam (FAO, 2001-2019).

Four other techniques have a by-catch lower than 15%. The first ones are the longline fisheries that are considered more environmentally friendly because of the species selectivity and the production of a minimal discard (FAO, 2018). Consists of a line with hooks where the fish is attracted by a natural or an artificial bait (FAO, 2001-2019). The second is the purse seine, where target species represent more than the 90 percent of the catch, which are small pelagic (FAO, 2018). Consisting by surrounding nets with large netting walls set for surrounding and capture aggregated fish (FAO, 2001-2019). The third is the small-scale fishery, which could be most fisheries in the Mediterranean in terms of employment and production. Such a variety of fishing gear are used, as gillnets, trammel nets, longliners, traps or pots, being multi-species fisheries (FAO, 2018). The fourth one is the pelagic trawl fishery, which *Engraulis encrasicolus* and *Sardina pilchardus* are the predominant target species (FAO. 2018). Consists of a cone-shaped net ending in a codend (FAO, 2001-2019).

The fishing gear used by “sonsera” is such specific for the sand eel that the by-catch, unlike all the fisheries mentioned, is below 1%. Therefore, the impact on the sandy bottom coastal environment is not significative. The structure of the food chain or the nutrients pathways are not altered, mainly because most of the individuals considered non-targeted or by-catch species are dumped back into the see alive.

The official total number of by- catch in the Mediterranean’s fisheries is 230.00 tonnes per year (FAO, 2018). Approximately 125 kilograms or 0,125 tonnes of by-catch is the weight by the “sonsera” fishery for seven years, average per year is 0,017 tonnes. Therefore, the impact of by-catch by “sonsera” is very low.

Here, it can be said that this low number of by-catch could be the cause for the non-seasonal pattern of the species, which was documented in several studies (Esposito *et al,* 2009; Demestre *et al*, 2000; Somarakis & Machias, 2001).

In order to know more about the sandy bottoms community some biodiversity indexes have been considered (Table 9). These indexes have been calculated by the total abundances of the species from 2012 to 2018. Because of the non-significant results of the MDS analysis therefore, the by-catch was not following any pattern. Thus, the index calculations per year, season or port are not necessary.

Table 9.- Biodiversity indexes of by-catch 2012-2018. S=Total species; N= Total individuals; J’= Pielou’s evenness; H’(log2) = Shannon’s index; H’max= Maximum diversity; 1-lambda= Simpson’s index.

	S	N	J'	H'(log2)	H'max	1-lambda
By-catch	67	3743	0,6473	3,9263	6,0661	0,9058

Of the 67 species the most abundant by abundance species are *Rhizostoma pulmo* (554 individuals), *Bothus podas* (526), *Pagellus erythrinus* (478) *Xyrichthys novacula* (476). It is important to say that any of the individuals of *Rhizostoma pulmo* was weighted, as it has been said before. So, the individuals of this species could have not been used for the relative weight results.

All the ecological indexes concluded that the sandy bottom community have a medium level of diversity, not the richest community bit still with diversity. The Pielou’s evenness index showed that not all the species are equally abundant. To confirm this, the Simpson’s index is high, therefore, some species are more abundant than others.

Other studies showed a variety of results for the biodiversity indexes to compare with the results of this report. One study showed Shannon's index higher than 20 in two trawls hauls in the Mediterranean (Coll *et al,* 2010). Other report showed a diversity index around 2 and a Pielou's index around 0,6 of some Italian and Greek fishing hauls (D'Onghia *et al,* 2003) similar values with this report.

Corbera and Garcia-Rubies (1999) made a schematic representation of a sandy bottom community (Figure 11). They divided the community in 6 spatial categories of fishes:

- The number 1 category is formed by pelagic species like *Engraulis encrasicolus*, *Sardina pilchardus*, *Sardinella aurita, Liza auratus* or *Spicara spp*.
- Number 2 formed by pelagic species but related somehow with the bottom like *Gymnammodytes cicerelus* and *Gymnammodytes semisquamatus,* which use the sandy bottoms as refuge.
- Category 3 integrated by basically species from Sparidae family such as *Pagellus erythrinus*, *Pagellus acarne, Diplodus annularis* or *Sparus aurata*.
- Number 4 formed by species always related with the bottom where they find food like *Dactylopterus volitans, Mullus barbatus* or *Mullus surmuletus*.
- The number 5 category integrated by species which make short displacements but always near the bottom such as *Xyrichthys novacula*.
- And finally, category 6 formed by typical benthonic fishes as *Dasyatis pastinaca, Raja asterias, Synodus saurus, Echiichthys vipera, Trachinus spp., Uranoscopus scaber, Gobius bucchichi, Pomatoschistus spp., Bothus podas* or *Arnoglossus spp*. (Corbera and Garcia-Rubies, 1999).

The results of this report compared with the results of the community explained by Corbera and Garcia-Rubies (1999) showed the high similarity. At least one species of every spatial category has been captured by the "sonsera" fishery. Thus, it can be said that the "sonsera" by-catch is clearly a part of the sandy bottom community.

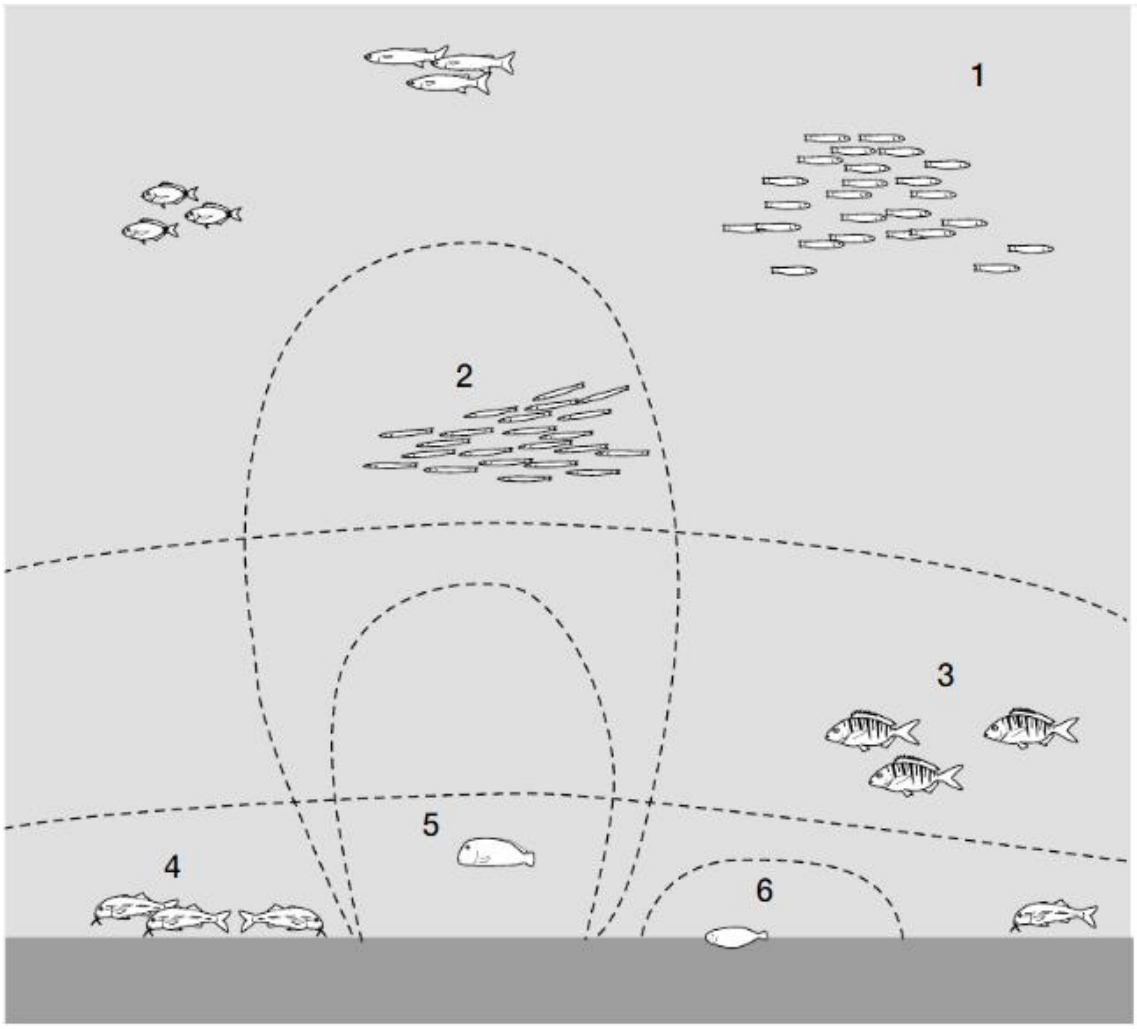

Figure 11.- Representation of the spatial categories of sandy bottom fishes. See the next above for the explication of the numbers. Source: Corbera and Garcia-Rubies, 1999.

Seagrass meadows are the most important ecosystems on Earth. However, seagrasses are declining at alarming rates in consequence to climate change, alien species and direct human activities near the coast, such fisheries (Telesca et al, 2015). In this study has been seen that the "sonsera" fishery do not alter the marine phanerogams, which the most important one being *Posidonia oceanica*.

As it shows in Figures 12, 13 and 14 the vessels' positions to capture sand eel are out of the zones where Posidonia meadows grows. Therefore, there are not any register of an accidental Posidonia mat catch with the fishery net. In addition, "sonso" is a species from the sandy bottom community. Using the sand as a refuge from predators or any danger. Therefore, it will never be found at the Posidonia meadows ecosystem.

Figure 12.- Map of Lloret de Mar coast (near Blanes) showing the sand eel fishing position and Posidonia meadows. Round and square dots: Fishing position from fishermen; Green spots: Posidonia meadows location. Source: Sánchez et al, 2013.

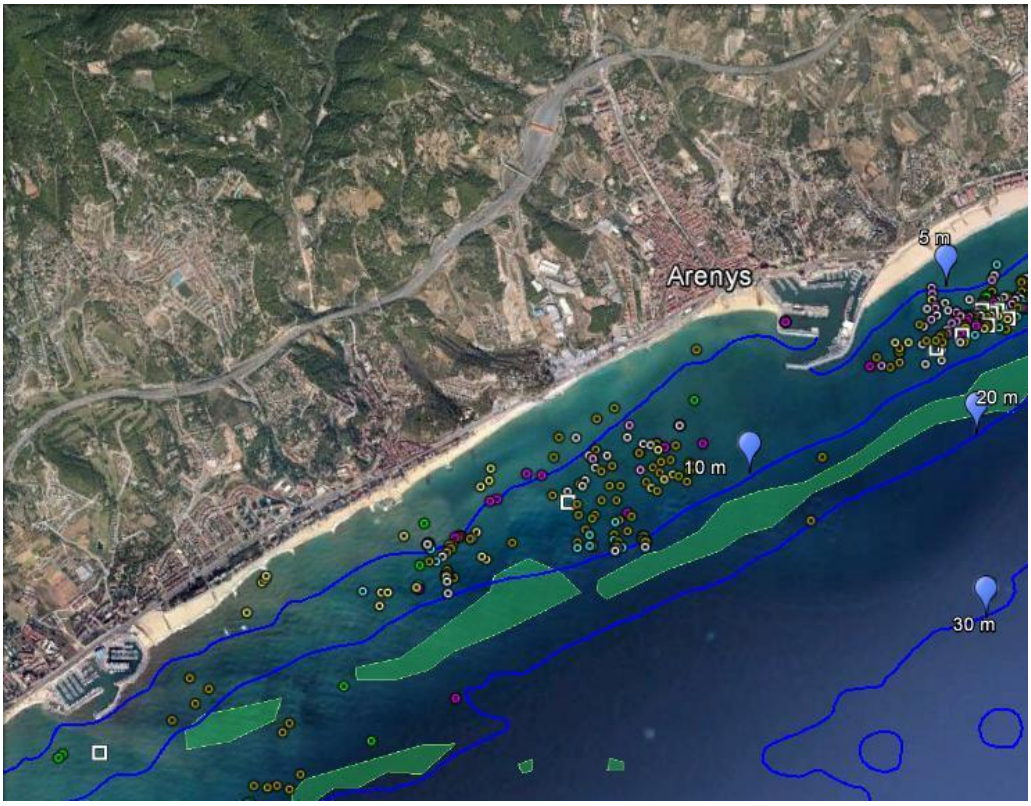

Figure 13.- Map of the Arenys de Mar coast showing the sand eel fishing position and Posidonia meadows. Round and square dots: Fishing position from fishermen; Green spots: Posidonia meadows location. Source: Sánchez et al, 2013.

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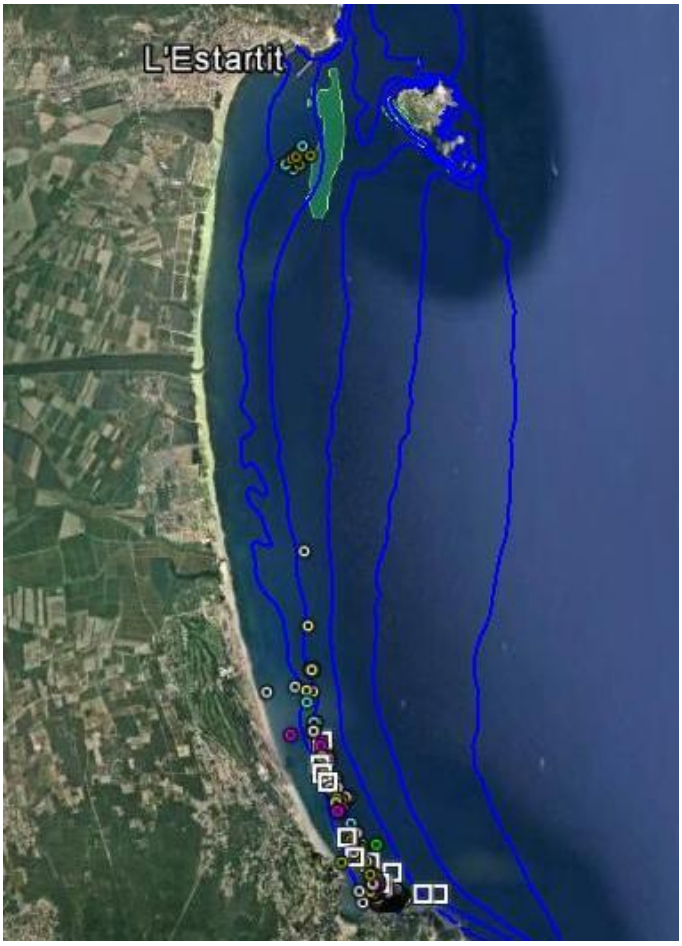

Figure 14.- Map of Estartit coast showing the sand eel fishing position and Posidonia meadows. Round and square dots: Fishing position from fishermen; Green spots: Posidonia meadows location. Source: Sánchez et al, 2013.

4.1 Ethics and sustainability

Ethical and sustainable criteria was considered on the totality of this study. Have not been created more by-catch than the already done at the different fishery vessels. During the closed season of "sonsera" fishery the experimental or scientific fishing trips capture the minimum amount of "sonso" and non-targeted species in order to have a continuing at the hauls' samples. "Sonsera" have a high percentage of alive discard that is returned immediately again to the sea, because of the technique of the fish gear is so quickly most capture remain alive. Therefore, the sandy bottom community has not been damage.

5. CONCLUSIONS

The main conclusions of this study are:

- All the “sonsera” boats are fishing on the same costal community. The community of sandy bottom and shallower waters species.
- No distribution pattern has been observed by the non-targeted species at the “sonsera” fishery. There are no differences between the samples.
- Year and fishing port are not a factor to consider having an influence for the by-catch samples. That is, there are no differences neither similitudes in the distribution of discard species because it is all one big community.
- Season is not a factor to consider having an influence for the by-catch samples. That is, there are no differences neither similitudes in the distribution of discard species per season. The low by-catch can not reflect the seasonal variability in the distribution of the species.
- The “sonsera” fishery have a considerably number of unwanted species capture. However, most part of these species the individual capture is low. Also, some of the captures of the species at the fishery are below the minimum catch size. Due to the proximity to the coast (García-Rubies & Macpherson, 1995).
- The average percentage of by-catch is lower than 1%. Compared with other typical fisheries of the Mediterranean it is a very low proportion, for example bottom trawl fisheries produce between 40-50% of by-catch (FAO, 2018).
- Sandy bottom community is diverse and rich but compared with other ecosystems these indexes are not very high (Coll *et al,* 2010). Some species are more dominant in abundancy than others for example *Bothus podas, Pagellus erythrinus, Xyrichthys novacula* and *Rhizostoma pulmo*.
- Posidonia meadows are not damage by “sonsera” fishery. In fact, they are avoided by the fishermen because “sonso” is not located in this ecosystem.

6. ACKNOWLEDGEMENTS

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Also, I will like to thank Josep Lloret for the liberty and trust that he had placed in my in this work.

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8. APPENDIX I

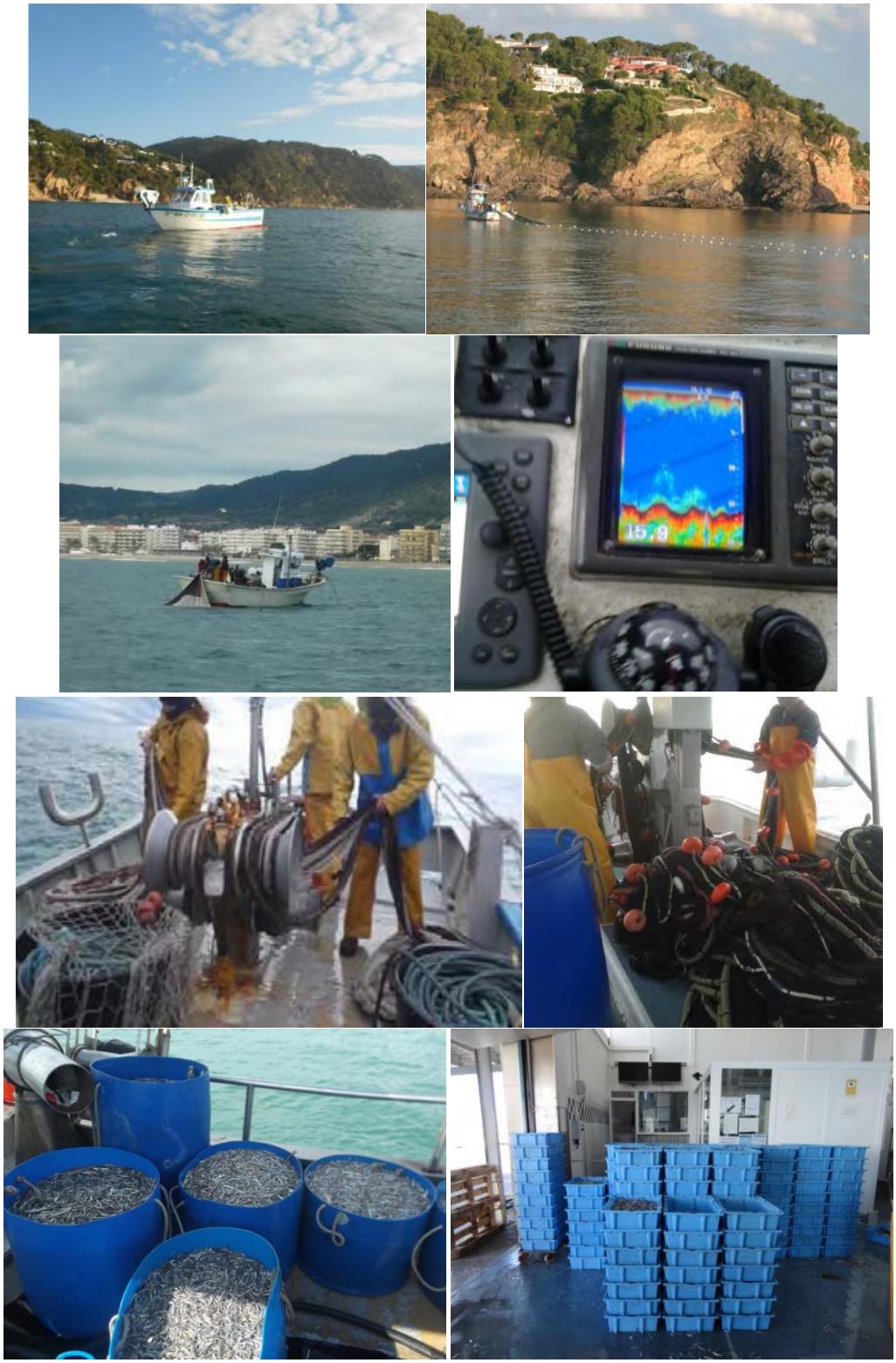

Figure 15.- Different sequences of the “sonsera” fishing operation. Source: Sánchez *et al*, 2013.

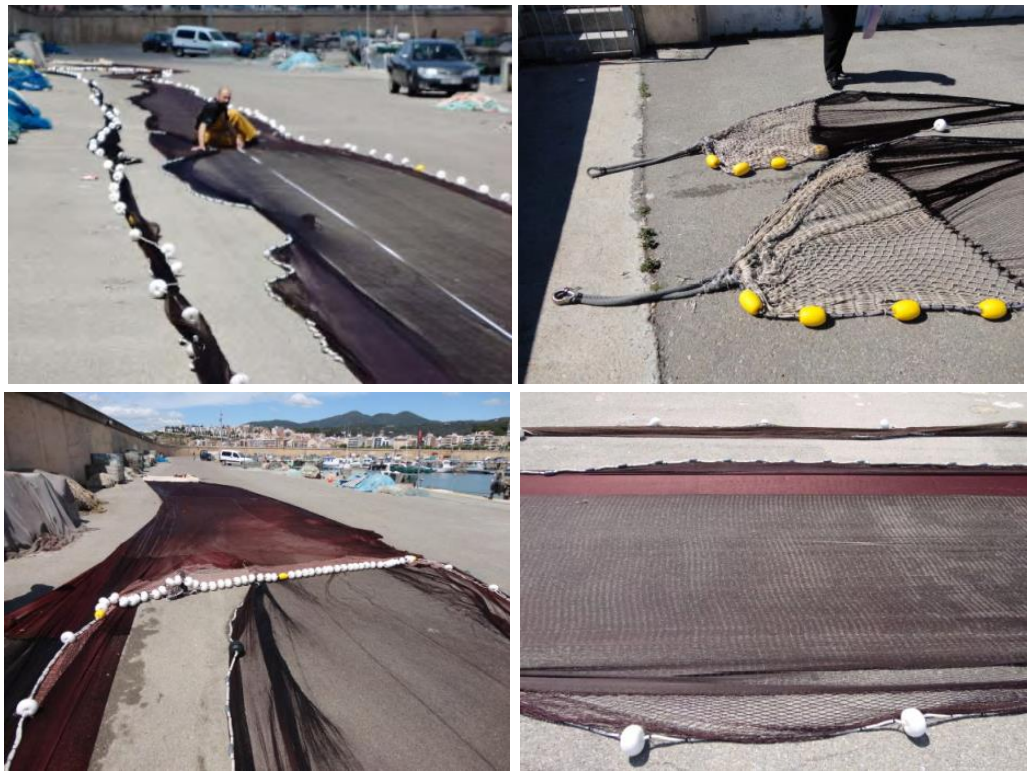

Figure 16.- Different images of “sonsera”: i) wings; ii) end of wings where rope is attached; iii) mouth; iv) leadline and floatline. Source: Sánchez *et al*, 2013.