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Reduction of by-catch and discards in the Algarve small-scale coastal fishery using a modified monofilament trammel net

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Declaração de autoria de trabalho

Declaro ser a autora deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam da listagem de referências incluída.

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Abstract

The purpose of this project is to reduce bycatch by modifying a monofilament trammel net commonly used in small scale fisheries along the southern European and Mediterranean coasts. The standard trammel net consists of three layers of netting: a small mesh inner panel and two large mesh outer panels. The modified net has a single layer of netting 3 meshes high between the trammel net and the footrope termed "greca", also known as a selvedge net. The main goal was to provide enough evidence of benefits that the modification poses, such as reduction in environmental deterioration, decrease in bycatch removal, and preventing a fisheries collapse, to local fishermen to convince them switch to the "greca" net. Fishing was conducted off the coast of Algarve with the boat departing from Quarteria from October 2016 to February 2017 with a total of 20 trips. Each fish and invertebrate was identified and measured, and recorded in which net type it was caught after a 24 hour soak time period. The time that it took to remove bycatch species was later analyzed using videos recorded onboard using GoPros and net damage assessment was conducted after the sampling period. Analysis using PRIMER and PERMANOVA showed that the factors depth and target catch affected commercial catch among the net types. This was also true for the combined catch data. Bycatch was also affected by the factor seasonality, however the separation between the two seasons was moderately distinct. When observing commercial catch, the greca net caught 53.9% of that of the standard trammel net regarding abundance and 64.3% of that of the standard trammel net in biomass. The economic value of the greca net catches was 61.8% of that of the standard net. The most significant decrease in commercial catch was seen among the sole species (or demersal commercial catch). Regarding discards, the greca trammel net caught 45.3% of that in the standard trammel net in commercial discards abundance and 57.7% of that in the standard net in bycatch abundance. The greca trammel net commercial discard biomass was 31.8% of that of the standard trammel net and 80.4% of the standard net bycatch biomass. For the three main bycatch species greca net catches for Longfin gurnards (*Chelidonichthys obscurus*) were 37.8% of those of the standard net caught, 128.4% of the standard net for Atlantic chub mackerel (*Scomber colias*) and 66.9% of those of the standard net for the Greater weever (*Trachinus draco*). The time it took to remove an individual from the net was timed and the six most abundant bycatch species' exhibited the importance of reducing bycatch. Some species will eventually take away many hours over the course of a year that could be spent on removing commercial catch or reducing labor in general. Less bycatch also reduces the damage that occurs in the net, relieving fishermen of additional costs in repairs. This also prevents loss in commercial catch, such as the observed decrease in catch rate of sole species in the modified trammel net. The results suggest that the greca modification, or selvedge net, did reduce bycatch abundance but, also reduced abundance and earnings in commercial catches. It is concluded that further research needs to be conducted on ways toreduce bycatch using trammel nets while maintaining similar if not increasing earnings.

Key Words: Bycatch Reduction; Discards; Trammel Nets; Catch Selectivity; Small Scale Fisheries

Resumo

O objetivo do presente estudo foi testar redes de tresmalho modificadas, utilizadas frequentemente na costa Sul da Europa e Mediterrâneo, com o objetivo de reduzir capturas acidentais. A captura acidental ocorre quando espécies não-comerciais ou de baixo valor comercial são capturadas pelas redes de pesca e, por isso, são rejeitadas e devolvidas ao mar após a captura. As rejeições são assim compostas por espécies que não possuem valor comercial para venda no mercado. Uma espécie comercial pode ser também rejeitada devido a reduzido tamanho, a danos provocados pelas artes de pesca ou por espécies necrófagos (e.g. anfípodes), ou ainda por imposição legislativa que protege a espécie. As redes de pesca, apesar de terem alguma seletividade, são responsáveis por altas taxas de pesca acidental e rejeições. As redes de tresmalho são constituidas de três camadas de rede: um painel interior de malha pequena e dois painéis exteriores de malha grande. As capturas geralmente passam através das redes exteriores, ficando presos em bolsos formados pela combinação das redes exteriores e interiores, processo este denominado de "trammeling". Na rede modificada testada foi adicionada uma camada extra de rede chamada "greca" ou "selvedge net", que possui três malhas de altura e se situa entre o tresmalho e a relinga inferior. Esta porção de rede difere das restantes também no material usado na sua construção.

O principal objetivo do presente estudo foi fornecer provas dos benefícios desta modificação, nomeadamente na redução de capturas acidentais, na redução do risco de colapso de stocks pesqueiros, e na motivação dos pescadores locais para a adopção do tresmalho modificado ("greca"). Este objetivo foi motivado pelas novas politicas da União Europeia 'A policy to reduce unwanted by-catches and eliminate discards in European fisheries (COM, 2007)', que encorajam a adoção de novas tecnologias, mesmo que estas impliquem uma diminuição temporária nas taxas de lucro, que possam beneficiar o

futuro da indústria pesqueira que, atualmente, sofre de más práticas de gestão, falta de fiscalização e resposta às atividades ilegais. Para este estudo, a amostragem decorreu a bordo de uma embarcação pesqueira comercial ao longo da costa do Algarve. A embarcação “Alfonsino” e a sua tripulação trabalharam em conjunto com a equipa de investigação e partilharam o tempo passado no mar entre as suas próprias redes e os tresmalhos a testar. Todas as saídas de amostragem aconteceram de manhã, a partir do porto de Quarteira. As redes foram caladas e deixadas dentro de água durante aproximadamente 24 horas. Posteriormente foram aladas através de um guincho metálico e limpas manualmente. Os peixes e invertebrados capturados foram identificados sempre que possível até à espécie e medidos ao centímetro. A rede em que cada indivíduo foi capturado, bem como a zona da rede e o destino de cada espécimen foi também registado. Em laboratório as imagens obtidas pelas câmaras colocadas a bordo (que filmaram todos os momentos das operações de pesca) foram cuidadosamente analisadas para temporizar a remoção de espécies importantes na captura acidental (determinadas *a priori* pela sua abundância). A abundância foi observada para capturas comerciais e rejeições (compostas por capturas comerciais e acidentais) de modo a comparar os dois tipos de redes. A relação peso-comprimento de cada espécie foi usada para calcular e comparar a biomassa das capturas em ambas as redes de tresmalho. Os valores de venda em lota por espécie e em cada tipo de rede foram calculados com os valores de biomassa das capturas e o preço médio por quilograma de venda. Danos infligidos aos dois tipos de redes foram também avaliados após a realização das amostragens, por inspeção visual da totalidade das redes. Categorizando a dimensão das aberturas encontradas nas redes com base no seu diâmetro, foi possivel fazer a comparação do nível de danos inflingidos aos dois tipos de redes utilizados. O *sofware* PRIMER / PERMANOVA + foi utilizado para avaliar semelhanças entre amostragens e os dois tipos de redes, designadamente através das técnicas MDS (Multi-dimensional scaling), ANOSIM, (*Analysis of similarities*), SIMPER (*Similarity Percentages*) e *one-way* ou *two-way* PERMANOVA s. Para isso foram usados três fatores para as capturas comerciais, capturas acidentais e ambas combinadas: profundidade, espécie alvo e estação do ano. O tipo de rede foi utilizado apenas como fator nos dados combinados, uma vez que não apresentou diferenças significativas, com clusters de similaridades formados com base nas viagens. Esta análise indicou que a profundidade afeta as capturas comerciais nos dois tipos de rede, bem como as capturas totais, que incluem capturas comercias, acidentais e rejeições. A profundidade afetou também as capturas acidentais, em conjunto com a estação do ano, com níveis de influência semelhantes. A separação entre clusters de similaridades por estação foi moderadamente forte. A espécie alvo foi o fator com um efeito mais significativo tanto

nas capturas totais como nas capturas comerciais. A "Greca" indicou uma abundância de capturas comerciais de 53.9% e biomassa de 64.3% comparativamente ao tresmalho standard. A "Greca" produziu 61.8% do valor comercial do tresmalho standard. A diminuição de capturas comerciais foi mais intensa para as espécies de linguados (espécies comerciais). Paralelamente, a "Greca" obteve igualmente uma redução de 45.3% na abundância de espécies comerciais rejeitadas, e de 57.7% na abundância de capturas acidentais. Relativamente à biomassa, a "Greca" obteve um valor de 31.8% de rejeições de espécies comerciais e 80.4% da biomassa de capturas acidentais, quando comparado com o tresmalho standard. As três principais espécies capturadas acidentalmente foram: ruivo (*Chelidonichthys obscurus*), com uma captura de 37.8% e peixe-aranha (*Trachinus draco*) com uma captura de 66.9% no tresmalho modificado, quando comparadas com as capturas no tresmalho standard. A terceira espécie mais capturada acidentalmente foi cavala (*Scomber colias*), com uma abundância 28.4% mais elevada no tresmalho standard.O tempo de remoção das seis espécies com mais capturas acidentais mostrou a importância de reduzir estas capturas, pois a sua remoção das redes consome tempo e aumenta os danos infligidos às redes. Estes danos são responsáveis por perdas monetárias através do custo dos reparos e diminuição de capturas comerciais, como observado com a catura de solhas no tresmalho modificado. Os resultados sugerem que o tresmalho modificado reduziu a abundância das capturas acidentais, mas também reduziu a abundância e lucro das capturas comerciais. O resultado indica que será necessária a realização de mais estudos de modo a otimizar a rede modificada e reduzir as capturas acidentais causadas por redes de tresmalho evitando efeitos negativos nas vendas em lota efectuadas pelas embarcações desta atividade.

Descritores: Redução da Captura Acessória; Rejeições; Redes Trammel; Selectividade de captura; Pequena Escala de Pesca

Table of Contents

Table Index

Figure Index

1.Introduction

1.1 What are discards?

The fishing industry has evolved as of a result of new onboard technologies spurring a growth in the market. This has also caused environmental disasters and even fisheries to collapse due to overexploitation and overfishing. A key issue that the world has taken notice of is bycatch and discarding practices. Bycatch is the term used when marine species of little or no commercial value are accidently caught. The reason for bycatch is often due to being caught alongside targeted species that live in the same environment and because some fishing gears lack selectivity. Due to their low economic value, bycatch species are often discarded, or thrown away. Commercial species are discarded as well but, for various reasons. Some of these include the organism has been scavenged on, the species is poisonous, it has the potential to spoil rapidly, there is lack of space onboard, the quotas for said species are reached, it is a prohibited species to catch or caught with prohibited gear, the organism has parasites, there are visible signs of damage from the gear, the organism is too small to catch or is considered a juvenile, it is the wrong sex, or it is incompatible with the rest of the catch (Hall et al., 2000). In recent years, the average of discards for commercial fisheries has been 27 million tons per year, varying from 17.9 million tons to as high as 39.5 million tons (Alverson et al., 1994). Although discarding and bycatch are believed to be problematic, there is no agreement upon an exact definition of these two terms regarding fisheries, the impact on both bycatch and commercial species' population, the impacts on the ecosystem, and the ethics of fishing (Borges et al., 2001). However, some researchers have noticed that certain bycatch species pose problems for fishermen due to reduction in net area, and an increase in labor time due to the need to disentangle species from the nets within their fisheries (Metin et al., 2009).

On a global scale, there is not enough research on understanding the effects of bycatch. According to ICCAT[1], IATTC[2], IOTC[3], and SPC[4] there are 37 fishing nations that use pelagic gillnets or driftnets of which only 5 have observer programs that gather data on bycatch. In comparison there are 14 nations that use trawls with 4 having observer programs, 40 nations using pelagic longlines of which only 15 have observer programs, and 62 nations that use purse seines of which only 10 nations have observer programs (Lewison et al., 2004). Prior to tackling the problems of bycatch and discards

[1] ICCAT- International Commission for the Conservation of Atlantic Tuna
[2] IATTC- Inter-American Tropical Tuna Commission
[3] IOTC- Indian Ocean Tuna Commission
[4] SPC- Secretariat of the Pacific Community

in these countries, research must be conducted in order to understand the magnitude of the problem. This is especially neccessary in countries with little or no legislation that controls fishing methods in order to prevent a collapse which would affect the economy and the people involved in the fishing industry.

1.2 The ban on discards in the E.U.

The European Union legislation established a policy to reduce unwanted by-catches and eliminate discards in European fisheries (COM, 2007). This policy discusses the issues being faced due to discarding, the measures required to prompt a discards ban, and how the ban will affect the economy. In the initial article, the legislation encourages new technology in an effort to avoid the necessity of discarding. The section highlights the importance of regulating what is caught rather than regulating landings, meaning all individuals of all species (commercial or bycatch) caught will be brought to port. The second article discusses the effects, causes, and extent of discards, highlighting the effect on biodiversity in terms of reproduction and sensitivity to damage by specific gear. The section continues by identifying specific areas in Europe and the comparison of bycatch rates based on the commonly used gears of each area. The third article deliberates how to move towards a discard ban and reduction of by-catch progressively, giving international examples and the terms that discarding would fall under along with the exceptions.

Additional instruments and supplements that can be useful are suggested such as fees on bycatch and obligatory switching of fishing grounds. Instead of specifications for the gears, there will be requirements for specific results. This would permit the fisheries to decide what is most practical and economic prompting a discussion between researchers, fishermen, and the auction officials. The fourth article focuses on monitoring and controlling the fisheries due to areas that have little or weak enforcement if a ban is put into effect. It references how to enforce the ban using an observer scheme which includes careful monitoring of landings, an electronic log book, monitoring and control of gear, and stakeholders involvements and cooperation. The fifth section considers the social impact of the policy and what the incentives to change will be. In the short-term this change in policy can result in cost increase and losses in income. However, in the long term this policy will result in larger and healthier stocks, which will result in increased fishing opportunities over the course of many years.

1.3 Small scale fisheries in Portugal

It is imperative to control the amount of fishing occurring in each country, especially those that rely on fishing as it pertains heavily to the nation's economy. Small scale fisheries are responsible for the majority of seafood sold in the market worldwide. In European waters, there are nearly 75,000 vessels that are less than 12 m and the majority are involved in small scale fisheries (Stergiou et al. 2006) or artisanal fishing. A significant amount of the Portuguese fleet is considered small scale fisheries with the majority of targeted stocks being demersal species, or species that dwell on or near the ocean floor (Table 1.3.1).

Table 1.3.1. Fleet size in continental Portugal per gear type based on stock type in 2015 (Source: DGRNSSM)

Stock	Gear	N
Demersal	Fixed gear <12m	6216
Demersal	Fixed gear >=12m	348
Demersal & Mackerel	Trawl	81
Small Pelagics	Seine pursing	181
Demersal and Pelagics	Multigear	32

In Portugal, nets, which include trammel and gill nets, have the second highest number of licenses right after longlines (Table 1.3.2), with trammel nets accounting for 18% of all small scale fisheries licenses in the Algarve (Stergiou et al., 2006). The only exception to this is North Portugal where trawls were second to nets in the amount of licenses issued in 2015.

Table 1.3.2. Fishing licenses issued by type of gear, including all vessel types, in continental Portugal by region in 2015. (Source: DGRM)

	Longline	Traps	Trawls	Purse seines	Nets	Other gear
North	1042	675	130	65	1476	74
Central	1971	446	476	44	1347	271
Metropolitian Lisbon	2793	599	72	14	1140	27
Alentejo	256	80	9	10	113	1
Algarve	2794	813	101	68	1412	35

These licenses (Table 1.3.2) represent an overview of gears in general terms grouped into categories. Traps most commonly used in areas such as the Algarve include: metal frames with hard plastic netting with a single entry of octopi, large traps with metal frames for both fish and cuttlefish, and wire traps for fish (Erzini, 2008). The trawls category include multiple gears such as bivalve dredges, “otter trawls”, and beam trawls. It is important to note that although there is a specific number of licenses for each of the categories, these numbers do not necessarily indicate the number of vessels using solely the specific gear as most vessels have licenses for more than one gear. More than 90% of fishing vessels in Portugal are licensed to use multiple types of gear (Baeta et al., 2009) as seen in Table 1.3.3 (Polyvalent fishing).

Table 1.3.3. Numbers of vessels for the three types of fishing fleets in Portugal by region and the total of vessel registered in 2014 (Source: INE)

	Trawl fishing	Seine fishing	Polyvalent fishing	Total vessels
Portugal	1241	2058	11864	8177
Continental	1241	1905	8748	6973
North	284	1012	2797	1362
Central	645	444	1843	1984
A.M. Lisbon	8	90	1377	1645
Alentejo	54	16	606	189
Algarve	250	343	2125	1793
R.A. Azores	0	0	2831	769
R.A. Madeira	0	153	285	435

1.4 Trammel nets and Bycatch

Bycatch and discarding heavily affects biodiversity in terms of reducing the populations of predator and prey species to unsustainable levels (Gilman et al., 2008). The fishing industry has had a great effect on trophic level interactions and the food web. Globally, due to fisheries landings, trophic levels have been declining at a rate of 0.1 per decade, even though landings have not significantly increased (Pauly et al., 1997). Static nets are destroying the environment, disturbing food web interactions among trophic levels, and affecting future catch rates. In a study regarding the effect of different gears on trophic levels, trammel nets were responsible for the catch of over 50% of omnivores that prefer other animals, over 25% of carnivores that prefer decapods, and about 20% of carnivores with a preference for fish and cephalopods (Stergiou et al., 2007).

Several types of fishing gears are used in the marine environment ranging from gears that require a crew such as static nets and trawlers, to gears that can be operated by a single fisherman such as fishing poles and pots. An important static gear in coastal waters worldwide is the trammel net

(Gonçalves et al. 2008). Similar to other gear, trammel nets differ in design depending on the target catch and the environment. In general, trammel nets have three panels of netting which are made up of either multifilament or monofilament. There is a loose small mesh inner panel (hanging ratio ranges from 0.3 to 0.5) between two larger mesh panels (hanging ratio are usually more than 0.5) and a vertical slack (the ratio of the height of the small-meshed inner panel to large-meshed outer panels) that usually ranges from 2.0 to 3.0 (Erzini et al. 2006). The bottom of the net is connected to a lead line and floats are attached to the top of the net. In comparison to gillnets that are designed to wedge, entangle, or gill a fish, trammel nets are also capable of catching fish and invertebrates by "pocketing" or trammeling which consists of the fish being pushed through one of the outer larger mesh panels into a pocket formed by the inner smaller mesh (Fabi et al., 2002). The selectivity of size is restricted with very little fish being caught that are more than 20% smaller or 20% larger than the optimum length of the mesh size (Aydin et al., 2015). There is also the semi-trammel net which differs in the fact that there is only one layer of outer webbing (Thomas 2002).

When a single gear targets a specific species during a particular time of year, this is called a métier. In the Algarve, there are four important métiers for trammel nets. *Sepia officinalis* and *Solea* species are caught year round by a variety of trammel nets while *Pagrus* species, which are usually caught in summer, and *Lophius piscatorius* both require larger vessels and specific trammel nets (Erzini et al. 2001).

Since some gear is static, such as trammel nets, initial catches becomes easy prey for predators. Often when nets are pulled up bycatch species have already been picked apart. Mortality is also inevitable for some individuals upon being hauled onboard. A schematic drawn by Gasper and Chicharo (2007) displays all these possibilities resulting in either direct or indirect mortality in Figure 1.4.1. Some are dropped on the deck and left to die as fishermen work quickly and have no concern for the species while other individuals are ripped apart or smashed out of the net for efficiency purposes. Certain species pose a danger to the fishermen and therefore are killed to prevent any onboard injuries. While some make it off board, seagulls trail the boats and are in close enough proximity to grab the organism before there is a chance for it to swim away. In some cases, juveniles and pre-spawning or sexually immature organisms are caught. In the circumstance where these individuals are disposed of immediately, there is still a risk of mortality prior to spawning if the species is sensitive and damage that the gear has done is considerable. Discarding can severely affect recruitment in fisheries resulting in a loss of reproduction rate when a large number of discards are commercial juveniles (Jensen et al., 1988).

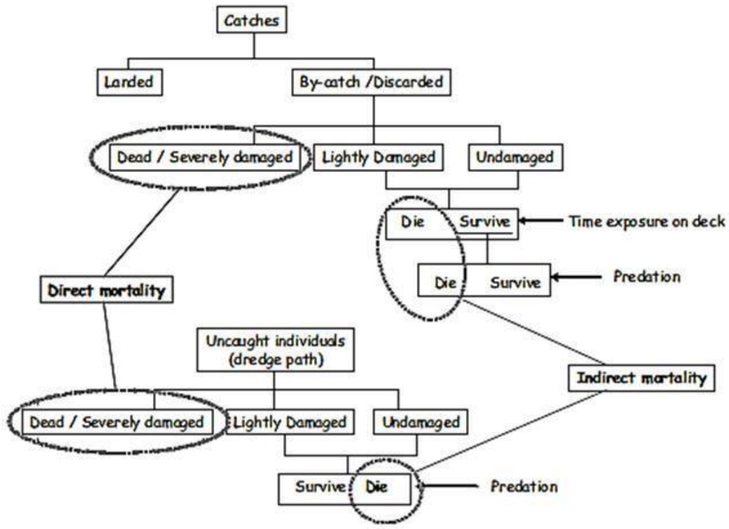

Figure 1.4.1. Schematic of indirect or direct mortality resulting from bycatch and discards (Source: Gaspar and Chicharo, 2007).

As mentioned before, some of these discards are supplying the food web with easy prey for predatory organisms such as seagulls and dolphins that trail the boat. Discards are believed to be dangerous for seabirds as this type of food is considered to be junk food for them (Österblom et al., 2008). However, some species of gulls (Audouin's gulls) receive a substancial part of their energy from fishery discards during the breeding season (Oro and Ruiz, 1997). In a study where reduction of discards for seabirds was conducted, researchers observed there was no attraction to the boat, resulting in decreased mortality rates due to a decline in seabird - gear interaction (Granadeiro et al., 2011). With mammals, dolphins are known to become entangled in trammel and gill nets, often being severely injured and possibly dying (Ross et al., 2010). Fishermen have reported dolphins that destroy their nets and would create competition between themselves and the fishermen resulting in deliberate killing of dolphins by angered fishermen (Gazo et al., 2007). Trammel nets have been reported as being responsible for a mortality rate of 60% ofsea turtles caught in the net, by incidental capture of the loggerhead sea turtles (*Caretta caretta*) in places such as Sardinia, Italy (Cambie, 2011). Attempts to reduce bycatch of these important species have been successful in some cases while in others they have affected commercial catch rates. In Mexico's Baja California peninsula, researchers attempted to use visual cues to reduce sea turtle bycatch in static gear by using shark shapes which did in fact reduce turtle bycatch by 54%, but also decreased target catch by 45%, while chemical light sticks did not affect the target catch and reduced sea turtle catch rates by 60% (Wang et al., 2010). Ultimately, important prey is being taken away from commercial species, resulting in increased competition and a decrease in population size as the species' food beings to disappear. Various gears have different results regarding the catch of fish; for trawls targeting haddock, discard related mortality can range from 9-35% versus haddock caught by seine nets which is less than 10%. In gear such as hook and lines, *Salmo* species have a post release mortality of 0% even with visible stress while the pacific salmon caught in static gear such as gillnets have a mortality rate of 80% due to stress (Chopin and Arimoto 1995). Some species are less sensitive than others to mortality after catch. For example, if caught as bycatch, sharks and rays have higher survival rates than most teleost's (Rodríguez-Cabello et al., 2005).

Bycatch has an impact on VMEs, or Vulnerable Marine Ecosystems. Passive gear, such as trammel nets, can result in entangling of branching corals (High, 1998) and upon hauling, coral will be broken and torn out of the sea floor. There is also the possibility of abrasions and crushing of benthic fauna (Lewis et al., 2009). Corals and marine plants serve as protection to many species and serve as nurseries while benthic fauna is often responsible for bottom up control in that these species serve an important part in the food web. VME's are defined by their uniqueness, which include rare species; critical feeding, spawning, or nursey habitats; fragility or easily degraded from human interactions; late maturations or slow growth; and low levels of natural disturbances (Donaldson et al., 2010). Upon interaction with static gear, these areas are highly susceptible to deterioration, resulting in a significant decrease in biodiversity.

1.5 Discards in the Algarve

The percentage and abundance of both bycatch and commercial catch depends on the type of gear as well as the environment it is fishing in. Longlining, has a set number of hooks and therefore only a set number of organisms can be caught while trawls are usually large and because they move along with the boat they are more likely to catch a larger variety of species. Static gear such as gill nets and trammel nets are more variable as their size selection is variable. In the Algarve, the mean discard rate for trammel nets was reported at 13% of total catch in comparison to other gear including demersal purse seines and fish trawls that had discard rates of 20% and 62% respectively (Borges et al., 2001). In another study based on multiple gears in Portugal, trawls and purse seiners were responsible for 90% of discards (mainly fish and cephalopods) and trammel nets followed with 81% in discards (Borges et al., 2001). According to Kelleher (2005) the highest global discard percentages are due to shrimp trawls, ranging from 0-96%; demersal finfish trawls, ranging 0.5-83%; and gillnets (including trammel nets), ranging from 0-66%.

Commercial catch and bycatch is also dependent on the season. In a trammel net study conducted in Setubal and Sesimbra, *Sepia officinalis* was caught in higher numbers during autumn and winter while *Solea senegalensis* was more prevalent during spring and summer but, was caught year round (Batista, 2009). The most widely discarded invertebrate species in winter and summer is *Phallusia mammillata* and during Autumn it is *Sphaerechinus granularis* (Gonçalves et al., 2008). In a study based on five different métiers in Algarve, Portugal, trammel nets were responsible for the discardg of 78 species (Erzini et al., 2002). Common commercial species in Portugal consist of cuttlefish (*Sepia officialis*), and soles *Solea senegalensis* which are discarded at 6% and 12.4%, respectively, while bycatch commonly consists of *Scomber japonicus*, *Sardina pilchardus*, and *Boops boops* (Gonçlaves et al., 2007).

1.6 Bycatch Problems and Solutions

Bycatch and discarding creates a problem both socioeconomically and environmentally. It is a nuisance for fishermen as their gear is affected negatively as mentioned previously. In some circumstances, a bycatch species has spines, scales, or teeth that are caught in the net and the only way to clean the net is by ripping these species out, leaving holes and ripped up mesh that will no longer be effective in catching the target species. Researchers have already begun attempting to resolve issues with top predator species such as dolphins, which destroy nets, by using pingers on trammel nets; while dolphins did not decrease in approaching the net, there was 87% less holes in the nets with pingers (Gazo et al., 2007). Cleaning the net of bycatch species forces the fishermen to lose time that would otherwise be used on cleaning the net of commercial fishes and arriving in the port earlier to the morning auction.

Currently, legislation is seeking to encourage the development of technologies that can result in elimination of discards. There have been several approaches to management of harvesting commercial catch while decreasing bycatch and discards and showing success. When conducting research on bycatch reduction using a trammel net rigged with a guarding net in the Northeastern Mediterranean, Gökçe et al. (2016) reported that the ‘ANet’ or the alternative net (modified net) exhibited 83% less bycatch than the 'CNet' (commercial net) and only 16% less commercial catch. Overall, the modification produced a 1.5% decrease in catches of the main target species, green tiger prawn, *Penaeus semisulcatus*, and 66-85% decrease in the three main bycatch species (invasive swimming crab, *Charybdes longicollis*; mantis shrimp, *Rissoides desmaresti*; and the blue crab, *Portunus pelagicus*). A study in the Eastern Mediterranean in Antalya Bay, found that a smaller mesh size for the inner panel (40mm or 44 mm) resulted in higher amount of commercial catch in both abundance and biomass for the species like *Pagellus acarne* in which 164 individuals (6.209 grams) were caught in the 44 mm net versus 774 individuals (31.219 kg) in the 40 mm net. There was also a decrease in bycatch, halving the abundance and biomass of individuals for species like *Citharus linguatula* where 70 individuals (2.079 kg) were caught in the 44 mm net versus 35 individuals (0.959 kg) in the 40 mm net (Olguner and Deval, 2013).

In Izmir Bay of the Aegean coast in Turkey, researchers added a guarding net to the common trammel net being used in the area to raise it from the muddy bottom focusing on the commercial fishery of the prawn *Melicertus kerathurus* (Metin et al., 2009). The alternative net went through two rounds of experiments because in the first there were too may floats resulting in a 17% decrease in commercial catch. However, in the second experiment there was only a 0.99% decrease in the prawn catch for significant reductions in the three main bycatch species: crabs (50.63%), mantis shrimp (17.33%), and purple dye murex (25.92%). The results thus show that a guarding net in this area can reduce bycatch and highlights the importance of height of the guarding net regarding bycatch reduction. Another project in Izmir Bay regarding trammel net discard reduction focused on *Mullus* spp in seagrass meadows (Aydin et al., 2013). Discard rates decreased 54.7% in the first experiment and 62.8% in the second experiment using a selvedge. The selvedge reduced the discard of three main bycatch species (*Hexaplex trunculus*, *Bolinus brandaris*, *Maja* spp) which ultimately avoided damage to the net caused by these species. In the Kerala state in India, researchers surveyed net usage along 16 districts and noticed trammel nets being used for soles, mackerel, and prawn during different periods of the year, signifying the awareness that switching gear is efficient and that it ensures targeting of specific species and avoidance of juveniles and bycatch (Thomas and Hridayanathan 2006).

1.7 The Greca net goals

There is still a significant amount of information that all fisheries require in order to make informative decisions regarding future management. In conclusion, scientific research is needed to gain the knowledge that will enable proper maintenance for a sustainable fishery for not only environmental purposes but, economic ones as well. The goal of this project is to produce enough evidence to convince fishermen to switch from the standard trammel net to the modified trammel net. The modified net's success will be proven if there is no reduction in commercial catch compared to the standard net while the bycatch is reduced significantly. The reduction of bycatch will be dependent on the greca's design (the selvedge). For the commercial catch to remain unaffected, the target species must be compatible with the new design. With less bycatch, the time to clean the net will also be reduced. This is important for fishermen as they can focus on commercial species, get to port before the morning auction, and less bycatch species in the net can result in more space in the net for commercial catch. A reduction in time for cleaning the net of bycatch species means less time on the boat and quicker setting time for the next day. Goals also include the reduction of bycatch in terms of the ecosystem. This ultimately can prevent severe population collapse in key species that either serve as food for others in the food web or serve as control for species that are their food source. With a decline in species that are important food sources for commercial species, there is a potential collapse of these fisheries which can be devastating to the economy. The specific objectives of this research were: 1) to compare a standard trammel net with a modified trammel net (greca) in terms of catch compostion, bycatch and discard species, 2) compare the economic yield of the standard net with that of the modified net, 3) compare the time needed to clean the different nets (removal of bycatch and discard species), and 4) compare net damage in the standard trammel net and the greca net.

2.Materials and Methods

2.1 Net Design

The standard trammel net consists of three layers of netting: a small mesh inner panel and two large mesh outer panels. The modified net has a single layer of netting 3 meshes high between the trammel net and the footrope termed "greca". The difference can be seen in Figure 2.1.1. The experimental nets consisted of fifteen 45-meter nets of each type tied together. There were three standard and three modified nets interchanging five times giving (SN1...SN5 & GN1..GN5), with two meters in between each section to reduce bias (guiding of fish), making up a total of approximately 1.5 kilometers of net. In the standard net (Figure 2.1.2), the inner panel has a stretched mesh size of 120 of 0.30 mm diameter (0.30 Ø) monofilament. The net is 40 meshes high, or 4.80 m stretched mesh, by 995 meshes long, or 119.4m stretched mesh. The floatline was 52 m long and made of PE with 7mm in diameter. The number of poach lines between the floats was 10. The leadline was 55.2m long and made of PE, or polyester, (braided line with lead) with 7mm in diameter. The upper hanging ratio and lower hanging ratio were 0.43 and 0.46, respectively and were calculated as follows:

$$E_{Upper} = \frac{L_{floatline}}{L_{stretched\ mesh}}$$

$$E_{Lower} = \frac{L_{leadline}}{Lstretched\ mesh}$$

The number of meshes per poach line for both upper and lower was five (five meshes on the bottom and five meshes at the top). The material for the floats were polyethylene and were 50 mm in length The outer panels have a stretched mesh size of 600mm of 0.60 mm diameter (0.60 Ø) monofilament. For the outer panel, the number of meshes high was 3, or 1.8 m stretched mesh, by 199 meshes long, or 119.4m. The hanging ratio for both upper and lower was identical to the inner panel. The vertical slack was 2.7 and was calculated by the following:

$$Vertical\ Slack = \frac{H_{inner\ panel}}{H_{outer\ netting}}$$

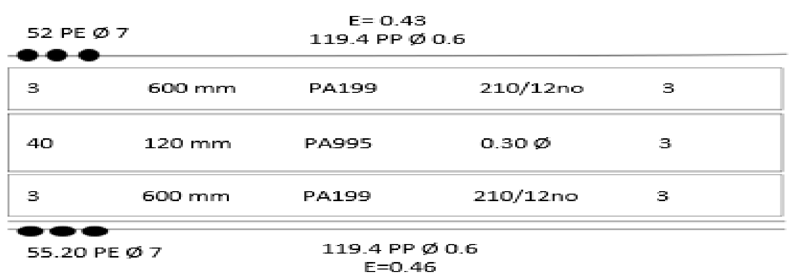

Figure 2.1.1. The technical plan for the standard net. (PA, Polyamide; PE, Polyester; PP, Polypropylene)

The modified net (Figure 2.1.2) had similar measurements for the outer and inner panels. The selvedge, or greca, (Figure 2.1.3) consisted of a single panel 3 meshes high, of 140 mm stretched mesh (210/12 PA).

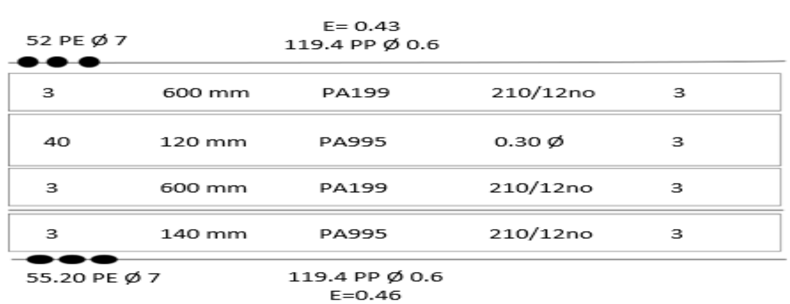

Figure 2.1.2. The technical plan for the modified net. (PA, Polyamide; PE, Polyester; PP, Polypropylene)

Figure 2.1.3. The greca part of the modified net.

The two métiers that this research focused on are *Solea* species and *Sepia officinalis*. *Solea* species was the initial métier during autumn and *S. officinalis* was caught in winter time when the water temperature decreased.

2.2 Experimental fishing trials

Fishing was conducted off the coast of Algarve with the fishing vessel (Alfonsinho) departing from the port of Quarteria, Portugal (Figure 2.2.1). Twenty sampling trips were conducted from October 2016 to February 2017. The nets were set at dawn and hauled in the next morning; this usually occurred before sunrise with the goal of keeping the soak time (the time the net is in the water) standard (approximately 24 hours). The two times that were crucial to record were the setting time the day before and the hauling time the day of sampling. It is important to note that sampling was not conducted under conditions of high biomasses of the algae *Cystoeria* in the water as it blocked the net and prevented any catch from occurring. Two GoPros were set up on board to use as references and to record possible overlook of species in the net. GoPro videos were used later to evaluate the time required to clean the two different nets. The net was pulled in using a hydraulic hauler. Each marine organism caught in the net was identified (to the species level) and measured, using either a ruler connected to a stable metal platform (ichthyometer) or if the species was too large with a measuring tape, and registered as bycatch or commercial. If the organism was considered "bycatch" or simply discard, as some commercial species can also be considered discard, then the reason was noted. Some reasons that are possible include too small to sell, scavenged, rotting, or contains parasites. For each species the net type was recorded. Futhermore, for species caught in the modified net, it was recorded whether it was caught in the upper trammel net part or the “greca” part.

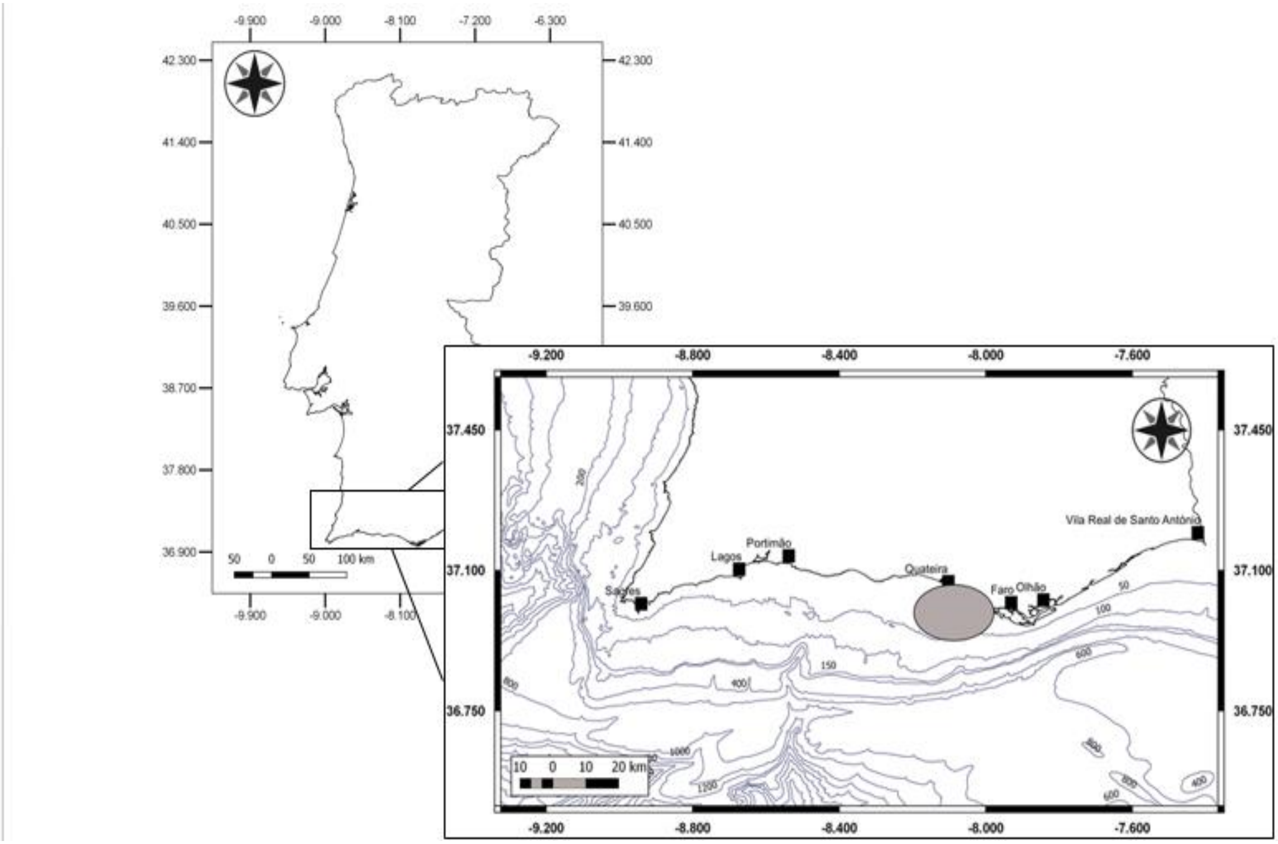

Figure 2.2.1. The location where experimental fishing trials took place. The shaded area, off the port of Quarteria, Portugal, is where the experimental fishing trials took place.

Each fish was removed from the net manually by the fishermen. Certain bycatch species were killed in order to clean the net and to continue hauling at a moderate pace. For instance, the sea urchin (*Sphaerochinus granularis*) was usually crushed by the fisherman, while the sea snail (*Cymbium olla*) was ripped out of its shell. *Trachinus draco* and the electric ray *Torpedo torpedo* had their heads crushed to avoid injuries. Special care is taken with species such as *Rhizomata pulmo*, the barrel jellyfish, which was carefully taken out to avoid stings as they are quite large organisms.

GPS tracking was used to note the waypoints (where each net is set). Wind conditions (recorded onboard), water conditions (including water temperatures, salinity, dissolved oxygen in both percentage and mg/L format, and total dissolved solids), sunrise and sunset time were also recorded in order to track external condition. This data was also used to compare the catch based on the differences in daily conditions.

2.3 Net Damage Assessment

The damage to the net was accounted for by counting every visible hole across the entire 1.5 km of net at the end of the experimental trials. As the net was pulled onto the deck and onto a black tarp for easy visualization, four observers checked the section of the net for holes and it was noted in which net type (modified or standard) the hole was in. Upon spotting a hole, a 20 cm ruler was placed on the hole to observe the width/diameter and a picture was taken for later analysis (Figure 2.3.1). Each hole was observed using three factors: 1) which layer the hole occurred (greca layer, inner layer, or outer layer), 2) where the net occurred (either the lower half of the net or the upper half of the net), and 3) size of the net (hole size < 20 cm was considered small and hole size > 20 cm was considered large). This information was used in accounting for the differences in catch between the modified greca net and the standard net.

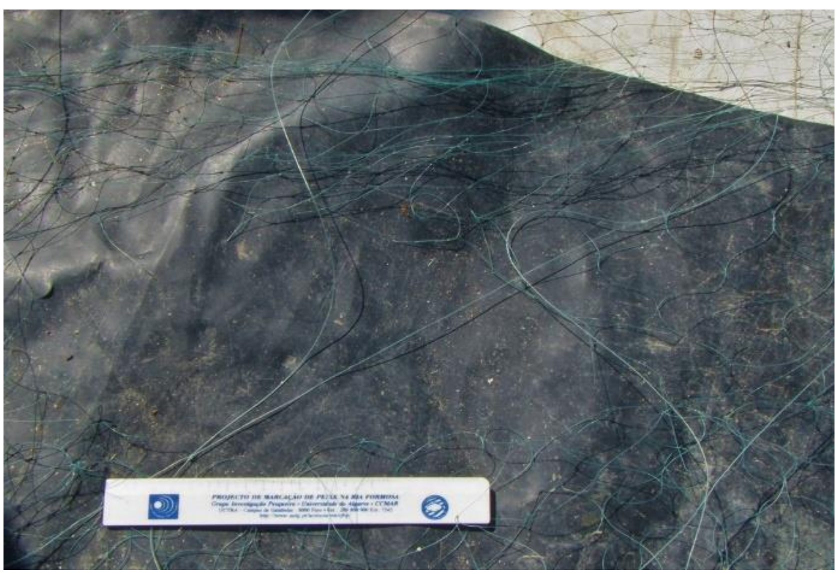

Figure 2.3.1. Net damage assessment with the 20 cm ruler on a hole on the upper layer and inner mesh.

2.4 Analysis

The weight of each fish was calculated using weight-length relationships, in order to estimate value of the catch based on average selling price for the day and the catch biomass. In order to do this, the equation below was used:

$$W = aL^b$$

Where a and b are parameters for the weight-length relationship and given based on country by fishbase.org for each individual species. For the purpose of this study, the Portuguese coefficients were used, Algarve if possible, otherwise Portugal in general or if neither was an option, a Mediterranean country. The weight of octopi (*Octopus vulgaris*) was estimated by the fishermen. The other commercial invertebrates such as the spider crab (*Maja brachydactyla*) and cuttlefish (*Sepia officialis*) were weighed on board measured to for weight to length relationships. The total catches (kg) of each species were converted to value in euros using the average price per kg obtained at the fish auction in Quarteria, Portugal (Doca Pesca). The weight of each bycatch species was also recorded to compare the two net types.

Analysis was conducted using PRIMER and PERMANOVA in order to evaluate differences between the catch compositions of the two different types of trammel net. The idea is to compare discards, commercial catch, and the combined cath data between the two net types. Data sheets were prepared in excel using pivot tables. Trip number and net type (e.g. T16: T -standard net, 16 - trip 16) were assigned as the samples samples and the species were assigned variables. There were a total of 6 excel files: 1) commercial catch abundance, 2) commercial catch biomass, 3) bycatch abundance, 4) bycatch biomass, 5) combined catch abundance, and 6) combined catch biomass. Each of these files were input into PRIMER and analyzed using one of three main factors: target catch (10 trips where sole species were target and 10 trips where cuttlefish were targeted), season (15 trips where sampling was conducted during fall and 5 trips where sampling was conducted during winter), and depth that was decided after sampling using bathmetric ranges (10-20 meters was the range for 12 trip and 20-30 m was the range for 8 trips). Net type was also used as a factor but, only for the combined catch data and for two-way PERMANOVA s, to observe the interaction effect, which included the following: net type against depth, net type against season, and net type against target catch. Cluster analysis, MDS (Multi-Demensional Scaling), Anisom (Analysis in Similarity), and SIMPER (Similarity Percentage Analsysis) were conducted with the PRIMER software both with and without square root transformation. It was later decided that analysis based on the square root transformation was more appropriate, giving lower positive stress levels and higher significance in PERMANOVA and ANOSIM. Two-way PERMANOVA s were used to compare the interaction effect between net type and the three main factors.

3. Results

3.1 Abundance

When comparing the abundance of commercial species that were landed and sold between the standard and the modified net (greca) it appears that 19 species were either caught in one net or the other, with 21 species caught by both nets (Table 3.1.1). The overall ratio (total number of commercial species caught) for greca to standard net was 0.539, showing that the standard net caught more than the greca net. At the species level this occurred 15 times, with the smallest ratios being less than 0.4 occurring for three sole species: *Microchirus azevia*, *Pegusa Lascaris*, and *Solea senegalensis*. If the ratio is more than one then the standard net caught less of the species than the greca net and this occured four times with the highest ratio being 1.5 for the species *Mullus surmuletus*, followed by a ratio of 1.4 for the species *Raja undulata*.

Table 3.1.1. Total catch in numbers of commercial species in the standard trammel net and in the modified net (Greca) and the standard : commercial net ratios.

Species	**Greca**	**Standard**	**Total**	**Greca : Standard**
Alosa fallax	2	3	5	0.67
Argyrosomus regius	1		1	
Balistes capriscus	10	9	19	1.11
Belone belone	1	1	2	1
Conger conger		1	1	
Dentex dentex	1		1	
Diplodus bellottii	3		3	
Diplodus sargus	2		2	
Diplodus vulgaris		4	4	
Halobatrachus didactylus		1	1	
Homarus gammarus	1	1	2	1
Loligo vulgaris	1		1	
Maja squinado	4	*6*	10	0.67
Merluccius merluccius	13	16	29	0.81
Microchirus azevia	64	177	241	0.36
Mullus surmuletus	3	2	5	1.5

Octopus vulgaris	5	7	12	0.71
Pagellus acarne	3	4	7	0.75
Pagellus bellottii		1	1	
Pagellus erythrinus	14	15	29	0.9
Pagrus auriga	3		3	
Pegusa Lascaris	10	28	38	0.36
Phycis phycis		6	6	
Plectorhinchus mediterraneus		4	4	
Pomatomus saltatrix	1	1	2	1
Raja undulata	7	5	12	1.4
Sarda sarda	1		1	
Sardina pilchardus	1		1	
Scophthalmus rhombus		2	2	
Sepia officinalis	19	26	45	0.73
Serranus cabrilla	2		2	
Solea senegalensis	11	32	43	0.34
Solea vulgaris	2	4	6	0.5
Spicara maena		1	1	
Spondyliosoma cantharus	1		1	
Synapturichthys kleinii	3	3	6	1
Torpedo marmorata		2	2	
Torpedo torpedo	1	1	2	1
Trachurus trachurus	4	3	7	1.33
Trisopterus luscus	10	12	22	0.83
Total	204	378	582	0.54

The abundance of discards was split into two sections: one for discarded commercial species, reasons for this include scavenged, parasites, decay, or identified as undersized or juvenile, (Table 3.1.2 and bycatch species (Table 3.1.3). If the ratio of greca to standard net is less than one, then the standard net caught more discarded individuals. If the ratio of greca to standard net is more than one, then the greca net caught more discarded individuals. The ratio of greca trammel net catches to standard trammel net catches in numbers for commercial discards was 0.432, while for bycatch it was 0.584, and the overall ratio was 0.557. The two most discarded commercial species were *Pagellus erythrinus* with a ratio of 0.457 and *Microchirus azevia* with a ratio of 0.382; both species were discarded in higher numbers in the standard net. Over 200 individuals were caught for three bycatch species. *Chelidonichthys obscurus*, with 288 individuals caught and a ratio of 0.378, was caught more often in the standard net than the greca net. *Scomber colias*, with 233 individuals caught and a ratio of 1.284, was caught more often in the greca net than the standard net. Lastly, for *Trachinus draco*, with 202 individuals caught and a ratio of 0.669, 40% were caught in the greca net and 60% in the standard net.

Table 3.1.2. Abundance of bycatch species in both the standard net and the modified net (greca) and the ratio between the greca and the standard net.

Species	**Greca**	**Standard**	**Total**	**Greca : Standard**
Alosa fallax	2	4	6	0.500
Argyrosomus regius		1	1	0.000
Balistes capriscus	1	3	4	0.333
Caranx rhonchus	1		1	0.000
Conger conger	3	1	4	3.000
Dicentrarchus labrax		1	1	0.000
Diplodus annularis	3	4	7	0.750
Diplodus bellottii	2	3	5	0.667
Diplodus vulgaris		2	2	0.000
Loligo vulgaris		1	1	0.000
Maja squinado	1	5	6	0.200
Merluccius merluccius	6	2	8	3.000
Microchirus azevia	13	34	47	0.382
Mullus surmuletus	1	1	2	1.000
Pagellus acarne	3	14	17	0.214
Pagellus bellottii		2	2	0.000
Pagellus erythrinus	16	35	51	0.457
Pegusa Lascaris	3	8	11	0.375
Phycis phycis		1	1	0.000
Raja undulata		6	6	0.000
Sarda sarda	1	1	2	1.000
Sardina pilchardus		1	1	0.000
Sepia officinalis	2	9	11	0.222
Serranus cabrilla		2	2	0.000
Solea senegalensis		8	8	0.000
Spondyliosoma cantharus	3	5	8	0.600
Synapturichthys kleinii	1	1	2	1.000
Trachurus trachurus	12	10	22	1.200
Trisopterus luscus	10	19	29	0.526
Total	84	184	268	0.457

Table 3.1.3. Abundance of bycatch species in both the standard net and the modified net (greca) and the ratio between the greca and the standard net.

Species	Greca	Standard	Total	Greca : Standard
Antedon mediterranea	1		1	0.000
Aplysia punctata		1	1	0.000
Astropecten aranciacus	5	7	12	0.714
Atrina pectinata	5	11	16	0.455
Boops boops	15	19	34	0.789
Calliactis parasitica	2	6	8	0.333
Callionymus lyra		1	1	0.000
Charonia Lampas	1	3	4	0.333
Chelidonichthys cuculus	5	8	13	0.625
Chelidonichthys lastoviza	1	4	5	0.250
Chelidonichthys lucerna		1	1	0.000
Chelidonichthys obscurus	79	209	288	0.378
Crangon crangon		1	1	0.000
Cymbium olla	14	39	53	0.359
Dardanus arrosor	1	1	2	1.000
Hippocampus hippocampus		3	3	0.000
Holothuria arguinensis		5	5	0.000
Lagocephalus lagocephalus	3		3	0.000
Leptogorgia lusitinia		1	1	0.000
Leptogorgia sarmentosa	2	1	3	2.000
Lithognathus mormyrus	2		2	0.000
Marthasterias glacialis	1	1	2	1.000
Murex brandaris		1	1	0.000
Myliobatis aquila	4	4	8	1.000
Ophidiaster ophidianus		3	3	0.000
Pagrus auriga	1		1	0.000
Pentapora foliacea		1	1	0.000
Phallusia mammillata	4	15	19	0.267
Polychaetae		1	1	0.000
Porifera	28	33	61	0.848
Prionace glauca	1		1	0.000
Rhizostoma pulmo	15	12	27	1.250
Sardinella aurita		1	1	0.000
Scomber colias	131	102	233	1.284
Scorpaena notata	2	5	7	0.400
Scorpaena porcus		1	1	0.000
Sphaerechinus granularis	7	77	84	0.091
Stichopus regalis	1	1	2	1.000

Trachinus draco	81	121	202	0.669
Trigla lyra		1	1	0.000
Uranoscopus scaber		2	2	0.000
Veretillum cynomorium		3	3	0.000
Total	413	707	1120	0.584

3.2 Biomass

The overall ratio between the greca net and the standard net is 0.643 for the biomass of commercial catch (Table 3.2.1). The most lucrative species in the greca net were *Homarus gammarus* (€121.72), *Microchirus azevia* (€87.48), and *Sepia officinalis* (€77.30). The most earnings per species for the standard net were for *Microchirus azevia* (€237.33), *Solea senegalensis* (€192.60) and *Homarus gammarus* (€146.26). The overall value of the catch of the greca net was €645.13 while that of the standard net was €1044.41 (ratio of 0.618).

Table 3.2.1. The biomass in kilograms (kg) per commercial species caught in each type of net and the value of the catch per net type in euros (€).

Species	Greca catch (kg)	€ per species	Standard net catch (kg)	Value of catch (€ per species)
Alosa fallax	0.720	0.06	1.128	0.09
Argyrosomus regius	0.994	9.05	0.000	0.00
Balistes capriscus	5.843	27.17	8.315	38.66
Belone belone	0.287	0.22	0.000	0.00
Conger conger	0.000	0.00	0.344	0.95
Dentex dentex	0.521	6.67	0.000	0.00
Diplodus belloti	0.000	0.00	0.093	1.19
Diplodus sargus	0.941	7.43	0.000	0.00
Diplodus vulgaris	0.000	0.00	0.576	1.16
Halobatrachus didactylus	0.000	0.00	0.692	1.23
Homarus gammarus	4.718	121.72	5.669	146.26
Loligo vulgaris	2.620	29.87	0.000	0.00
Maja squinado	1.206	6.99	2.697	15.64
Merluccius merluccius	3.990	11.57	4.009	11.63
Microchirus azevia	9.509	87.48	25.797	237.33
Mullus surmuletus	0.648	9.72	0.610	9.15
Octopus vulgaris	11.000	59.40	16.000	86.40
Pagrus auriga	2.607	31.28	0.000	0.00
Pagellus acarne	0.532	2.42	0.910	4.14
Pagellus bellottii	0.000	0.00	0.092	0.53
Pagellus erythrinus	1.802	9.91	1.746	9.60

Pegusa Lascaris	1.759	12.49	6.650	47.22
Phycis phycis	0.000	0.00	1.645	5.10
Plectorhinchus mediterraneus	0.000	0.00	2.484	8.69
Pomatomus saltatrix	0.478	4.21	0.407	3.58
Raja undulata	15.390	40.01	14.580	37.91
Sarda sarda	0.771	2.16	0.000	0.00
Sardina pilchardus	0.069	0.14	0.000	0.00
Scophthalmus rhombus	0.000	0.00	0.904	11.93
Sepia officinalis	14.866	77.30	19.496	101.38
Solea senegalensis	4.030	49.17	15.787	192.60
Solea vulgaris	0.681	10.08	1.161	17.18
Spicara maena	0.000	0.00	0.146	0.41
Spondyliosoma cantharus	0.196	0.43	0.000	0.00
Synapturichthys kleinii	1.805	22.02	3.376	41.19
Torpedo marmorata	0.000	0.00	2.143	6.00
Torpedo torpedo	0.746	2.09	1.010	2.83
Trachurus trachurus	0.223	0.51	0.266	0.61
Trisopterus luscus	0.921	3.55	0.989	3.81
Total	89.873	645.13	139.722	1044.41

The biomass of discarded species is separated into two tables: The abundance of discards was split into two sections: one for discarded commercial species (reasons for this includes scavenged, parasites, decay, or marked as juvenile, (Table 3.2.2) and bycatch species (Table 3.2.3). The discard ratio of the greca to standard net for commercial catch is 0.318, bycatch discard 0.804, and the overall ratio was 0.607. The species with the highest discarded weight in the greca net were *Balistes capriscus* (1.859 kg) and *Microchirus azevia* (1.465 kg). The species with the highest discarded weight in the standard net were *Raja undulata* (5.687 kg), *Sepia officinalis* (5.508 kg), and *Microchirus azevia* (3.601 kg). Regarding bycatch species, 14.483 kg of *Chelidonichthys obscurus* were discarded from the greca net and 33.253 kg were discarded from the standard net. 7.082 kg of the species *Trachinus draco* was discarded from the greca net and 11.187 kg from the standard net. Lastly, 6.470 kg of *Scomber colias* was discarded from the greca net and 5.858 kg discarded from the standard net.

Table 3.2.2. The biomass in kilograms (kg) per discarded commercial catch in each net type with the ratio being greca to standard net for all the species.

Species	Greca net (kg)	Standard net (kg)
Alosa fallax	0.396	0.978
Argyrosomus regius		0.446
Balistes capriscus	1.859	1.840
Caranx rhonchus	0.444	
Conger conger	0.184	0.704
Dicentrarchus labrax		1.766
Diplodus annularis	0.234	0.612
Diplodus bellottii	0.267	0.143
Diplodus vulgaris		0.192
Loligo vulgaris		0.914
Maja squinado	0.175	1.939
Merluccius merluccius	0.693	0.635
Microchirus azevia	1.465	3.601
Pagellus acarne	0.102	1.623
Pagellus bellottii		0.062
Pagellus erythrinus	0.880	2.507
Pegusa Lascaris	0.799	1.614
Phycis phycis		1.681
Raja undulata		5.687
Sarda sarda	0.851	0.783
Sardina pilchardus		0.040
Serranus cabrilla	0.139	
Sepia officinalis	0.191	5.508
Solea senegalensis		2.828
Spondyliosoma cantharus	0.677	0.879
Synapturichthys kleinii	1.055	0.419
Trachurus trachurus	1.062	0.406
Trisopterus luscus	0.803	0.793
Total	12.276	38.600

Table 3.2.3. The biomass in kilograms (kg) per bycatch in each net type with the ratio being greca to standard net for all the species.

Species	Greca net (kg)	Standard net (kg)
Boops boops	0.808	1.206
Callionymus lyra		0.084
Chelidonichthys lastoviza	0.247	0.520

Chelidonichthys lucerna		0.295
Chelidonichthys obscurus	14.483	33.253
Hippocampus hippocampus		0.015
Lagocephalus lagocephalus	6.535	
Lithognathus mormyrus	0.157	
Myliobatis aquila	0.592	1.040
Pagrus auriga		1.541
Prionace glauca	8.885	
Scomber colias	6.470	5.858
Scorpaena notata	0.147	0.251
Scorpaena porcus		0.282
Trachinus draco	7.082	11.187
Trigla lyra		0.257
Uranoscopus scaber		0.683
Total	45.406	56.472

3.3 Factor: Net Type

Similarities for combined catch (commercial catch, commercial discards, and bycatch) appear among trips when using net type as a factor. For abundance (Figure 3.3.1a), it is noted that trip 19's catch from both the greca and standard had a resemblance level of less than 30. It was later observed when focusing on discard and bycatch biomass and abundance that the two net types were outliers. This is due to the fact that more than 50% of the catch was commercial and therefore trip 19 as a whole is excluded from the data sets using strictly discards and bycatch. Trip 9's catch from the greca net was also considered an outlier with a resemblance level of less than 20. This is because the greca net did not catch any commercial individuals during that trip and was therefore excluded from the data sets using strictly commercial catch. Similar results can be seen in biomass (Figure 3.3.1b), with a resemblance level of around 40 for trip 19's greca and standard net catch . Although trip 9's catch in the greca net had a resemblance level less than 20, it has a similarity with trip 1's catch from the greca net and this is because only 9.8% of the catch was considered commercial.

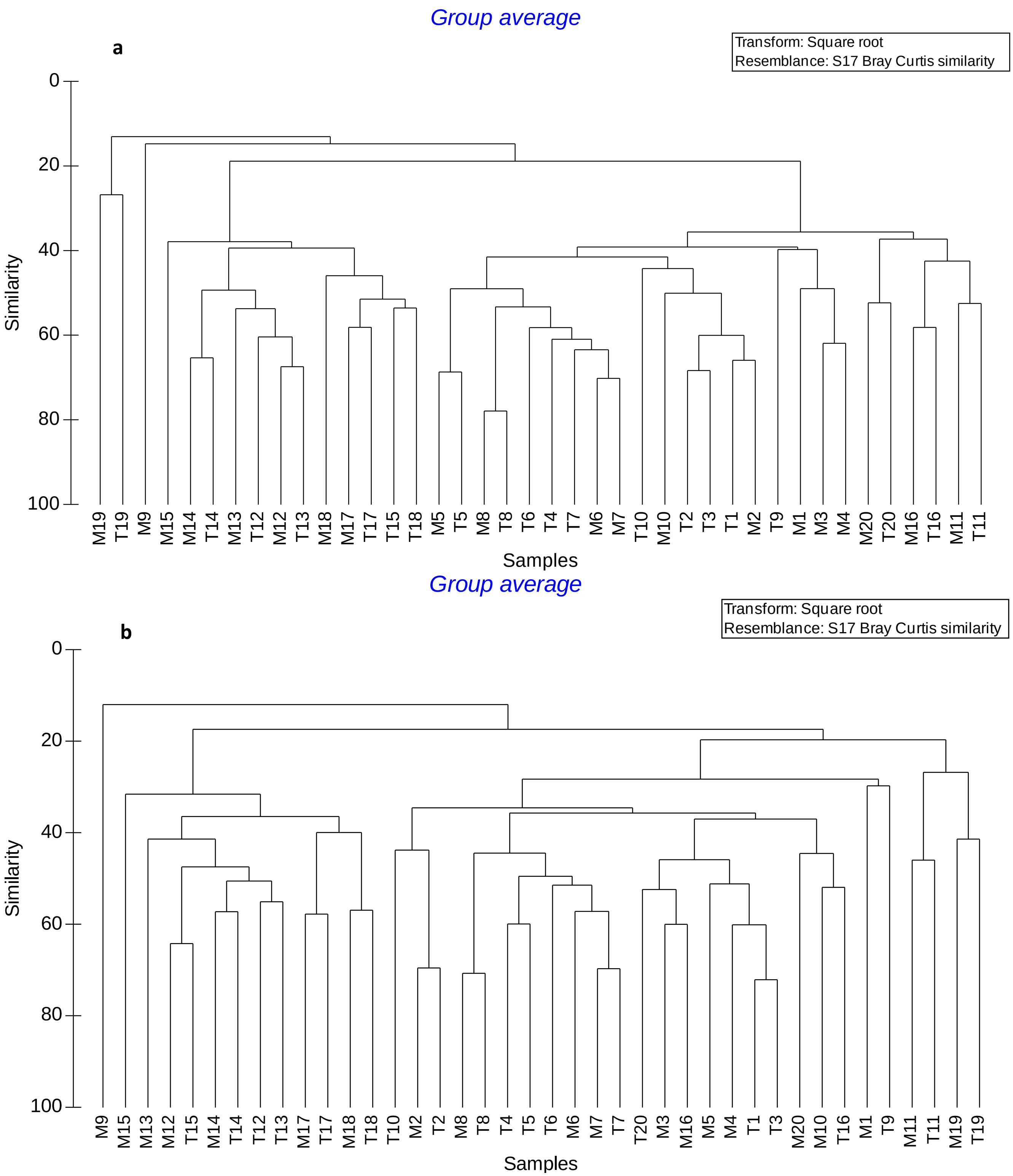

Figure 3.3.1a. Cluster plot, with a square root transformation, for the abundance and **b.** biomass of all species (commercial discards, commercial catch, and bycatch) caught within 20 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with net type as the factor (greca net or standard net).

3.4 Factor: Seasonality

Figures 3.4.1a and 3.4.1b are the MDS plots for the abundance and biomass of commercial catch. The stress factors are 0.16 and 0.17 for abundance and biomass, respectively, which is a fair goodness of fit. ANOSIM for commercial abundance and biomass with a square root transformation gave a global R values of 0.124 and 0.11 and significance levels of 2.2% and 1.9% meaning that that with seasonal variation the separation is significant. This is further supported by a p-value of 0.006 and 0.008 in PERMANOVA. In SIMPER (Figure II and Figure III), there is support for strong dissimilarity (83.29%) between fall and winter and with average similarity between the trips of 19.94% in fall and 26.49% in winter for abundance as well as a strong dissimilarity (83.54%) between fall and winter and with average similarity between the trips of 19.34% in fall and 24.99% in winter for biomass.

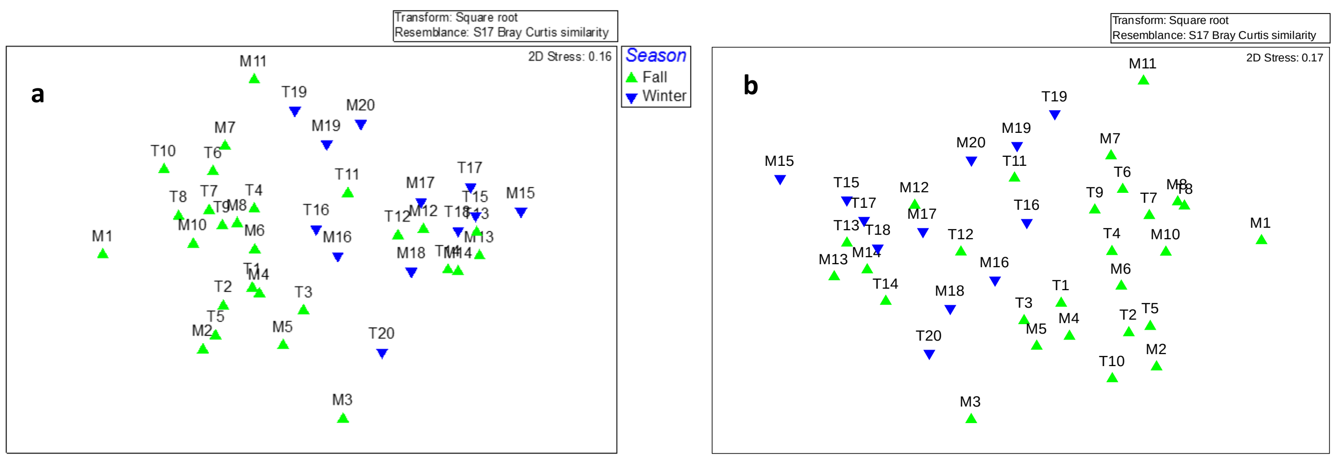

Figure 3.4.1a. MDS plot, with a square root transformation, for the abundance and **b.** biomass of commercial species caught within 20 trips in each type of net excluding the greca for trip 9 (M=Modified Trammel; T=Standard Trammel) with seasonal variation (either fall or winter).

Figures 3.4.2a and 3.4.2b are the MDS plots for the abundance and biomass of bycatch. The stress factors are 0.19 and 0.20 for abundance and biomass, respectively, which is a fair goodness of fit. ANOSIM for commercial abundance and biomass with a square root transformation have a global R of 0.438 and 0.308, respectively, signifying moderately strong seperations. Abundance and biomass have a significance level of 0.1% and 1.3% meaning that that with seasonal variation the separation is significant. This is further supported by a p-value of 0.002 and 0.016 in PERMANOVA . In SIMPER (Figure IV and Figure V), there is support for strong dissimilarity (75.87%) between fall and winter and with average similarity between the trips of 37.3% in fall and 24.84% in winter for abundance as well as a strong dissimilarity (73.89%) between fall and winter and with average similarity between the trips of 36.47% in fall and 21.39% in winter for biomass.

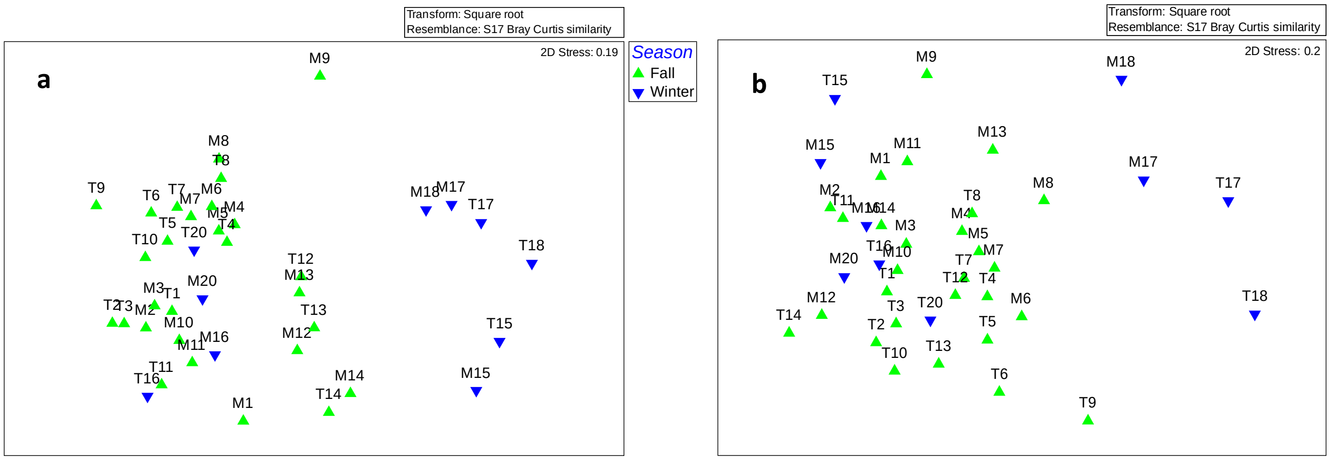

Figure 3.4.2a. MDS plot with a square root transformation for the abundance and **b.** biomass of discarded species caught within 19 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with seasonal variation (either fall or winter).

Figures 3.4.3a and 3.4.3b are the MDS plots for the abundance and biomass of combined catch data. The stress factors are 0.17 and 0.21 for abundance and biomass, respectively, which is a fair goodness of fit for abundance and a poor goodness of fit for biomass. ANOSIM for commercial abundance and biomass with a square root transformation have global Rs of 0.468 and 0.28 signifying seperations that are moderate in strength. Abundance and biomass both have a significance level of 0.1%, meaning that that with seasonal variation the separation is significant. This is further supported by a p-value of 0.002 and 0.016 in PERMANOVA. In SIMPER (Figure VI and Figure VII), there is support for strong dissimilarity (79.2%) between fall and winter and with average similarity between the trips of 34.52% in fall and 25.3% in winter for abundance as well as a strong dissimilarity (78.15%) between fall and winter and with average similarity between the trips of 30.12% in fall and 24.15% in winter for biomass.

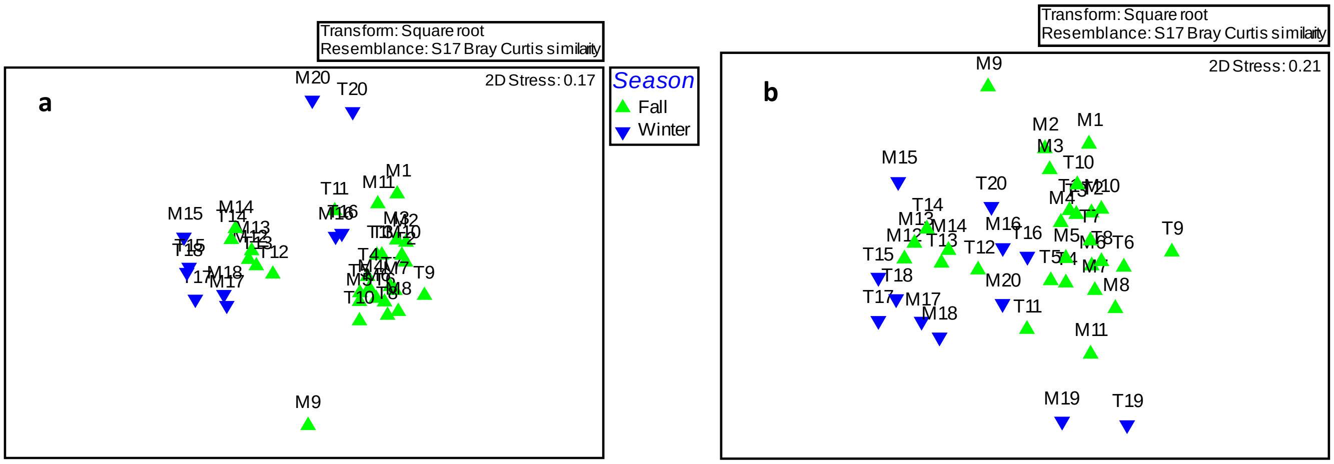

Figure 3.4.3a. MDSplot, with a square root transformation, for the abundance and **b.** biomass of the entire catch caught within 20 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with seasonal variation (either fall or winter).

3.5 Factor: Target Catch

Figures 3.5.1a and 3.5.1b are the MDS plots for the abundance and biomass of commercial catch with target catch as the factor. The stress factors are 0.16 and 0.17 for abundance and biomass, respectively, which is a fair goodness of fit for both. ANOSIM for commercial abundance and biomass with a square root transformation have global R values of 0.613 and 0.576, signifying a strong separation between the two target catch species. Abundance and biomass have a significance level of 0.1% and 0.1% meaning that that with a variation in target catch the separation is significant. This is further supported by a p-value of 0.001 and 0.001 in PERMANOVA. In SIMPER (Figure VIII and Figure IX), there is support for strong dissimilarity (90.97%) between sole species and cuttlefish and with average similarity between the trips of 28.95% for sole species and 31.41% for cuttlefish for abundance as well as a strong dissimilarity (90.97%) between cuttlefish and sole species and with average similarity between the trips of 27.31% for sole species and 29.31% for cuttlefish for biomass.

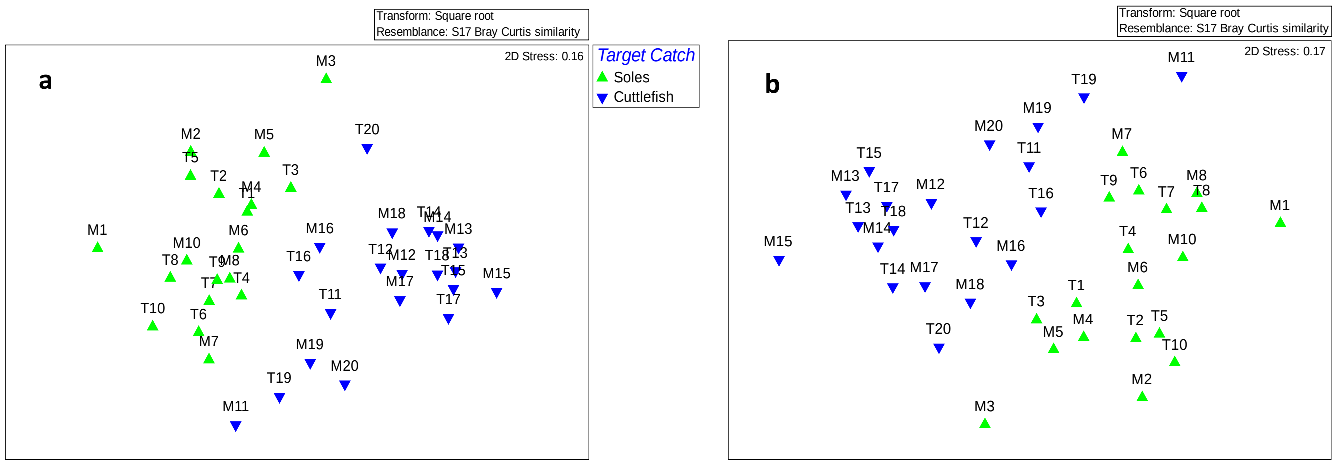

Figure 3.5.1a. MDSplot, based on square root transformation of abundance and **b.** of biomass of commercial species caught within 20 trips in each type of net excluding the greca for trip 9 (M=Modified Trammel; T=Standard Trammel) with variation in métier (sole species or cuttlefish).

Figures 3.5.2a and 3.5.2b are the MDS plots for the abundance and biomass of bycatch with target catch as the factor. The stress factors are 0.19 and 0.2 for abundance and biomass, respectively, which is a fair goodness of fit for both. ANOSIM for commercial abundance and biomass with a square root transformation have global R values of 0.368 and 0.154 respectively, signifying a moderate and weak strength in seperation between the two target catch species. Abundance and biomass have a significance level of 0.1% and 0.1% meaning that that with a variation in target catch the separation is significant. This is further supported by a p-value of 0.001 and 0.002 in PERMANOVA. In SIMPER (Figure X and Figure XI), there is support for strong dissimilarity (73.64%) between sole species and cuttlefish and with average similarity between the trips of 42.49% for sole species and 28.82% for cuttlefish for abundance as well as a strong dissimilarity (70.88%) between cuttlefish and sole species and with average similarity between the trips of 38.93% for sole species and 27.32% for cuttlefish for biomass.

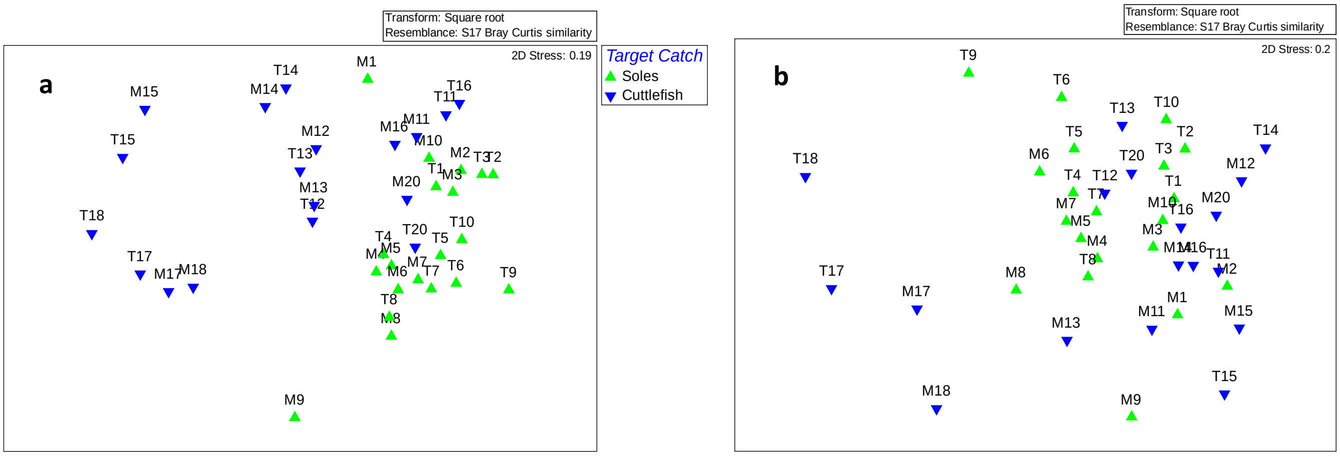

Figure 3.5.2a. MDSplot with a square root transformation for the abundance and **b.** biomass of discarded species caught within 19 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with variation in target catch (sole species or cuttlefish).

Figures 3.5.3a and 3.5.3b are the MDS plots for the abundance and biomass of combined catch data with target catch as the factor. The stress factors are 0.17 and 0.21 for abundance and biomass, respectively, which is a fair goodness of fit for abundance but, a poor goodness of fit for biomass. ANOSIM for commercial abundance and biomass with a square root transformation gave global R values of 0.591 and 0.511 respectively, signifying a strong separation between the two target catch species. Abundance and biomass have a significance level of 0.1% and 0.1% meaning that that with a variation in target catch the separation is significant. This is further supported by p-values of 0.001 in PERMANOVA. In SIMPER (Figure XII and Figure XIII), there is support for strong dissimilarity (79.57%) between sole species and cuttlefish and with average similarity between the trips of 41.79% for sole species and 30.83% for cuttlefish for abundance as well as a strong dissimilarity (80.64%) between cuttlefish and sole species and with average similarity between the trips of 37.02% for sole species and 28.81% for cuttlefish for biomass.

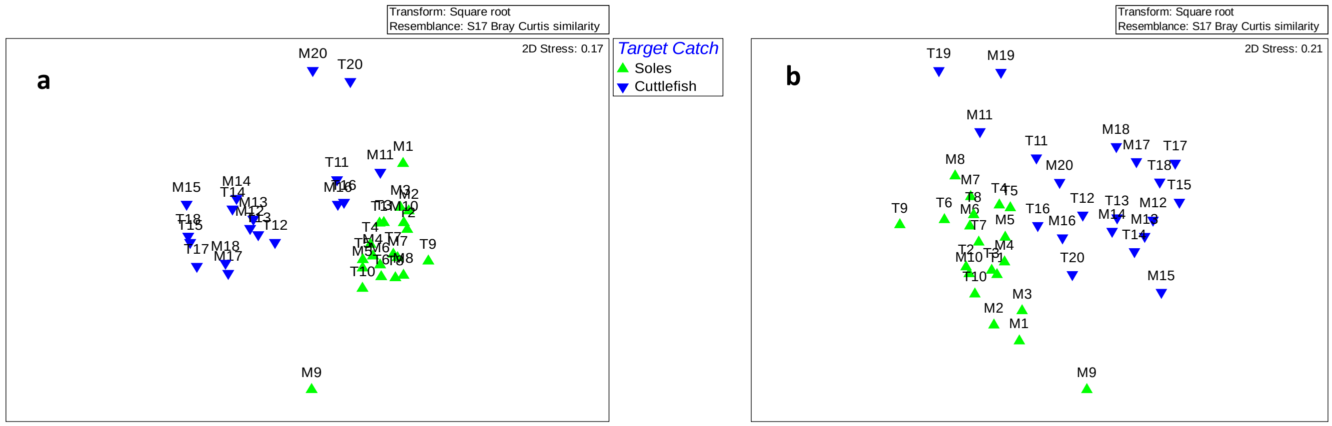

Figure 3.5.3a. MDSplot with a square root transformation for the abundance and **b.** biomass of all (commercial discards, commercial catch, and bycatch) species caught within 20 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with variation in target catch (sole species or cuttlefish).

3.6 Factor: Depth

Figures 3.6.1a and 3.6.1b are the MDS plots for the abundance and biomass of commercial catch with depth as the factor. The stress factors are 0.17 and 0.17 for abundance and biomass, respectively, which is a fair goodness of fit for both. ANOSIM for commercial abundance and biomass with a square root transformation gave global R values of 0.586 and 0.545 signifying a strong separation between the two depth ranges. Abundance and biomass have a significance level of 0.1% and 0.1% meaning that that with a variation in depth the separation is significant. This is further supported by a p-value of 0.001 and 0.001 in PERMANOVA. In SIMPER (Figure XIV and Figure XV), there is support for strong dissimilarity (93.72%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 22.74% for first depth range (10-20m) and 30.26% for the second depth range (20-30m) for abundance as well as a strong dissimilarity (92.24%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 20.33% for first depth range (10-20m) and 26.29% for the second depth range (20-30m).

For the abundance there is a resemblance level of 30 for most of the trips where the net was at a depth between 10 and 20 meters and a resemblance level of 55 among the majority of the trips where the net was at a depth between 20 and 30 meters in the standard (T) trammel net (Figure 16a). For biomass there a resemblance level of 30 for the majority of the trips where the net was at a depth between 10 and 20 meters (Figure 16b). A resemblance level of 50 was associated with standard nets and similar depth ranges. In both abundance and biomass, greca (M) trammel nets did not have a higher resemblance level with either greca nets in similar depth ranges nor with standard trammel nets.

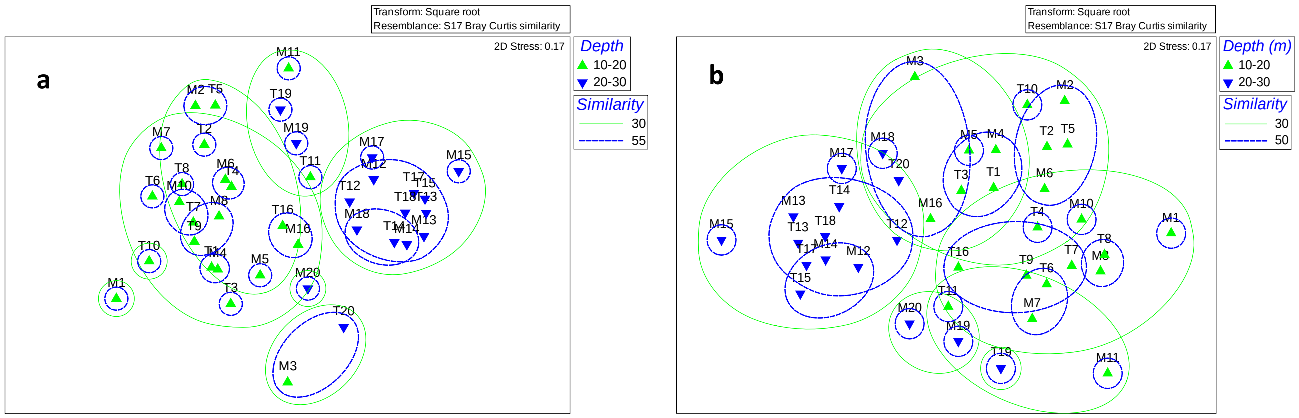

Figure 3.6.1a. MDSplot, with a square root transformation, for the abundance and **b.** biomass of commercial species caught within 20 trips in each type of net excluding the greca for trip 9 (M=Modified Trammel; T=Standard Trammel) with variation in depth with two ranges (10-20m and 20-30m) and a cluster overlay.

Figures 3.6.2a and 3.6.2b are the MDS plots for the abundance and biomass of bycatch with depth as the factor. The stress factors are 0.19 and 0.20 for abundance and biomass, respectively, which is a fair goodness of fit for both. ANOSIM for commercial abundance and biomass with a square root transformation have a global R of 0.547 and 0.286 signifying a strong separation between the two depth ranges for abundance while a weak strength in biomass. Abundance and biomass have a significance level of 0.1% and 0.1% meaning that that with a variation in depth the separation is significant. This is further supported by a p-value of 0.001 and 0.002 in PERMANOVA. In SIMPER (Figure XVI and Figure XVII), there is support for strong dissimilarity (80.33%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 32.14% for first depth range (10-20m) and 24.75% for the second depth range (20-30m) for abundance as well as a strong dissimilarity (78.51%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 30.56% for first depth range (10-20m) and 17.1% for the second depth range (20-30m).

For the abundance there is a resemblance level of 30 for most of the trips where the net was at a depth between 10 and 20 meters except the greca trammel net from trip 9 and a resemblance level of 55 between the trips where the net was in a similar depth range for the standard (T) trammel net and greca (M) trammel net in the same trip (Figure 17a). For biomass there a resemblance level of 20 for the majority of the trips where the net was at a depth between 10 and 20 meters except for trip nine's standard trammel net (Figure 17b). A resemblance level of 45 varied, however there are two main group with trips where the nets were at a depth range of 10 to 20 meters.

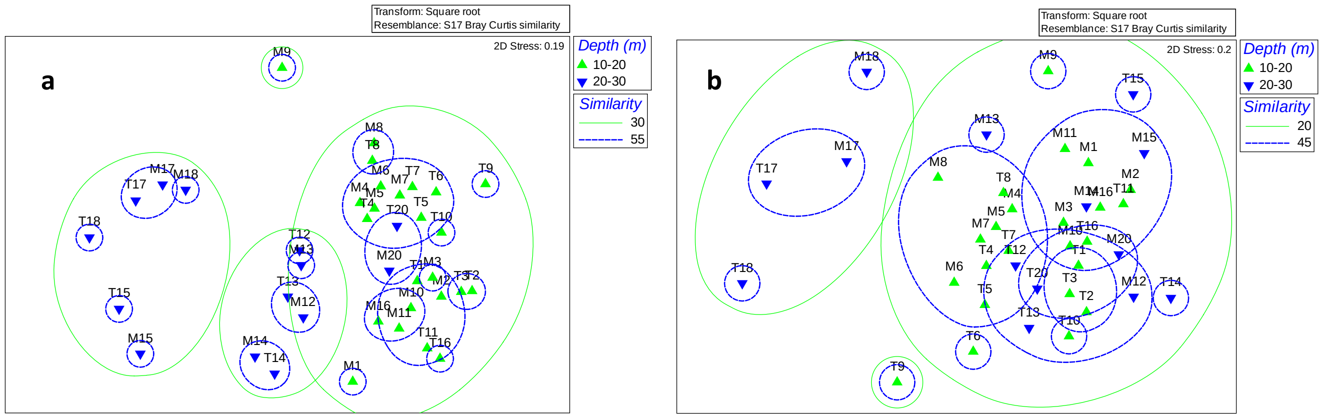

Figure 3.6.2a. MDSplot with a square root transformation for the abundance and **b.** biomass of discarded species caught within 19 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with variation in depth with two ranges (10-20m and 20-30m) and a cluster overlay.

Figures 3.6.3a and 3.6.3b are the MDS plots for the abundance and biomass of combined catch data with depth as the factor. The stress factors are 0.18 and 0.21 for abundance and biomass, respectively, which is a fair goodness of fit for abundance but, a poor goodness of fit for biomass. ANOSIM for commercial abundance and biomass with a square root transformation gave global R values of 0.66 and 0.683 respectively, signifying a strong separation between the two depth ranges. Abundance and biomass have significance levels of 0.1% and 0.1% meaning that that with a variation in depth the separation is significant. This is further supported by a p-value of 0.001 and 0.001 in PERMANOVA. In SIMPER (Figure XVIII and Figure XIX), there is support for strong dissimilarity (85.09%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 31.07% for first depth range (10-20m) and 26.62% for the second depth range (20-30m) for abundance as well as a strong dissimilarity (87.25%) between two depth ranges (10-20m and 20-30m) and with average similarity between the trips of 24.74% for first depth range (10-20m) and 23.11% for the second depth range (20-30m).

For the abundance there is a resemblance level of 35 for most of the trips where the net was at a depth between 10 and 20 meters except the greca trammel net from trip 9 as well as for the trips where the depth range was between 20 and 30 meters except for trip 19's standard and greca trammel net. A resemblance level of 55 between the trips where the net was in a similar depth range for the standard (T) trammel net and greca (M) trammel net in the same trip (Figure 18a). For biomass there a resemblance level of 30 for the majority of the trips where the net was at a depth between 10 and 20 meters, except for trip nine's standard and greca trammel net, and for the trips where the net was at a depth range between 20 and 30 meters with the except of trip 20's standard trammel net and trip 19's standard and greca trammel net (Figure 18b). A resemblance level of 45 varied, however there are two main group with trips where the nets were at a depth range of 10 to 20 meters.

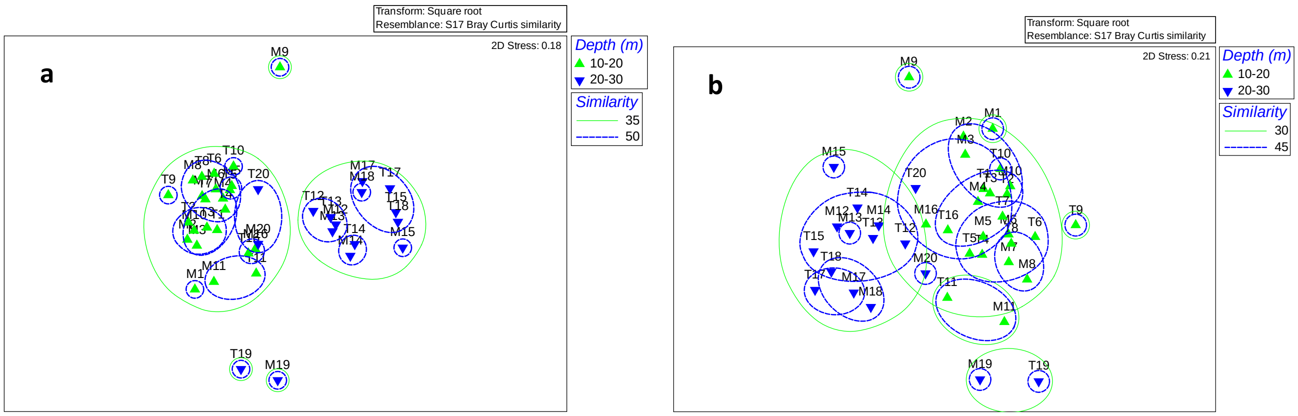

Figure 3.6.3. a. MDSplot with a square root transformation for the abundance and **b.** biomass of all (commercial discards, commercial catch, and bycatch) species caught within 20 trips in each type of net (M=Modified Trammel; T=Standard Trammel) with variation in depth with two ranges (10-20m and 20-30m) and a cluster overlay.

3.7 Two Way PERMANOVA

For abundance of all species using a two way PERMANOVA test, depth is significant with a p-value of 0.001 while net type is not significant with a p-value of 0.104 (Table 3.7.1). The interaction between these two factors is not significant with a p-value of 0.828. The factor season was significant with a p-value of 0.002 while net type was not significant with a p-value of 0.282 (Table 3.7.2). Again, the interaction between two factors (net type and season) was not significant (p = 0.944). The two way PERMANOVA was repeated with target catch, which was significant with a p-value of 0.001, and net type, which was insignificant with a p-value of 0.131 (Table 3.7.3). The interaction between two factors, net type and target catch, was not significant with a p-value 0.935.

Table 3.7.1. Two way PERMANOVA for abundance of all the species (commercial discards, commercial catch, and bycatch) with two factors: depth (De) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ne	1	3252.9	3252.9	1.5533	0.104	999
De	1	23236	23236	11.096	0.001	998
NexDe	1	1317.8	1317.8	0.62927	0.828	999
Res	36	75389	2094.1			
Total	39	1.04E+05				

Table 3.7.2. Two way PERMANOVA for abundance of all the species (commercial discards, commercial catch, and bycatch) with two factors: season (Se) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ne	1	2806.5	2806.5	1.1325	0.282	999
Se	1	10077	10077	4.0661	0.002	999
NexSe	1	650.25	650.25	0.26239	0.994	998
Res	36	89215	2478.2			
Total	39	1.04E+05				

Table 3.7.3. Two way PERMANOVA for abundance of all the species (commercial discards, commercial catch, and bycatch) with two factors: target catch (Ta) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ne	1	3455.5	3455.5	1.4542	0.131	997
Ta	1	21301	21301	8.964	0.001	999
NexTa	1	1088.8	1088.8	0.45821	0.935	999
Res	36	85546	2376.3			
Total	39	1.11E+05				

For biomass of all species using a two way PERMANOVA test, depth is significant with a p-value of 0.001 while net type is not significant with a p-value of 0.214 (Table 3.7.4). The interaction between these two factors is not significant with a p-value of 0.386. The two way PERMANOVA was done using the factors season and net type was significant with a p-value of 0.003 while net type was not significant with a p-value of 0.379 (Table 3.7.5). Again, the interaction between these two factors (net type and season) was not significant(p = 0.96). The two way PERMANOVA was repeated with target catch, which was significant with a p-value of 0.001, and net type, which was not significantwith a p-value of 0.131 (Table 3.7.6). The interactive effect between these two factors was not significant with a p-value 0.935

Table 3.7.4. Two way PERMANOVA for biomass of all the species (commercial discards, commercial catch, and bycatch) with two factors: depth (De) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
De	1	21617	21617	9.2783	0.001	999
Ne	1	3058.5	3058.5	1.3128	0.214	999
DexNe	1	2446.4	2446.4	1.0501	0.386	998
Res	36	83872	2329.8			
Total	39	1.11E+05				

Table 3.7.5. Two way PERMANOVA for biomass of all the species (commercial discards, commercial catch, and bycatch) with two factors: season (Se) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ne	1	2853.2	2853.2	1.0549	0.379	997
Se	1	9435.2	9435.2	3.4885	0.003	997
NexSe	1	1131.3	1131.3	0.41827	0.96	996
Res	36	97369	2704.7			
Total	39	1.11E+05				

Table 3.7.6. Two way PERMANOVA for biomass of all the species (commercial discards, commercial catch, and bycatch) with two factors: métier (Ta) and net type (Ne).

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ne	1	3455.5	3455.5	1.4542	0.131	997
Ta	1	21301	21301	8.964	0.001	999
NexTa	1	1088.8	1088.8	0.45821	0.935	999
Res	36	85546	2376.3			
Total	39	1.11E+05				

3.8 Bycatch Removal Time

23 individuals were used to observe the average time it took to remove each of the six most abundant bycatch species (Figure 3.8.1). The species that takes the longest to time to remove from the net is *Rhizostoma pulmo* with an average time of 18 seconds (SD 12.14 s) followed by *Trachinus draco* with an average removal time of 14 seconds (SD 5.5 s) as seen in Figure 3.4.1. The species with the largest standard deviation of 8.45 seconds after *R. pulmo*, is *Cymbium olla*. The last three species (*Chelidonichthys obscurus*, *Scomber colias*, and various Porifera species) had an average removal time between 9, 6.54, and 8.45 seconds respectively with standard deviations of less 6 seconds.

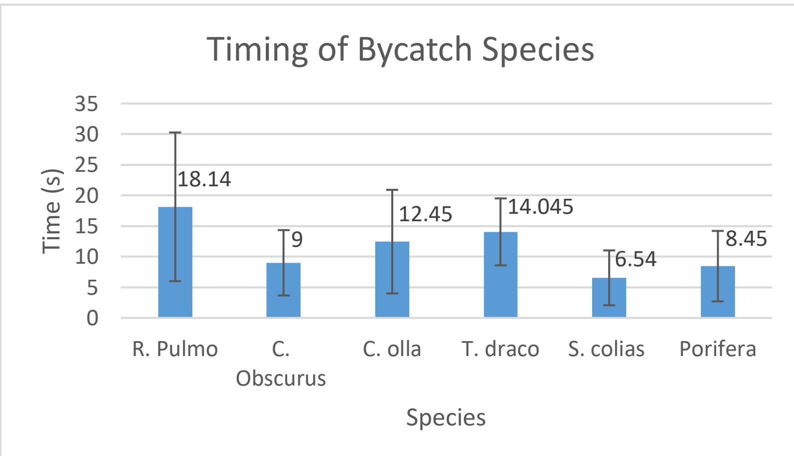

Figure 3.8.1. The average time (in seconds) with the standard deviation for the six most abundant bycatch species that it took for the fisherman to retrieve the individual out of the net over the course of 20 trips. (R. pulmo – *Rhizostoma pulmo*, C. obscurus - *Chelidonichthys obscurus*, C. olla - *Cymbium olla*, T. draco - *Trachinus draco*, S. colias - *Scomber colias*).

3.9 Net Damage Assessment

The entire 1.5 kilometers of net had 127 holes in total (Figure 3.9.1). 84, or 66% of the total, holes occurred in the greca (modified net). About 81% of the holes in the greca net occurred in the lower half of the net, about 60% were larger than 20 cm, and 62% of the holes were found in the greca layer. 43, or 34% of the total, holes occurred in the standard net where approximately 88% were in the upper part of the net, 58% were more than 20 cm in width/diameter, and 50% were in the inner layer and other 50% in the outer layer.

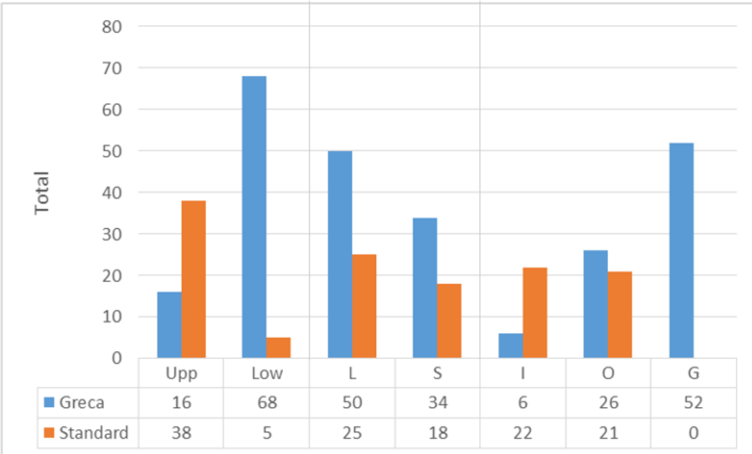

Figure 3.9.1. Comparison of 127 holes that occurred over 20 fishing trips in the two net types. There are three factors: placement - the upper (U) or lower (L) part of the net; width - large (L) > 20 cm or small (S) < 20 cm; and the layer – inner (I), outer (O), or greca (G).

4. Discussion

4.1 Commercial Catch: Greca vs Standard

In regards to the legislation 'A policy to reduce unwanted by-catches and eliminate discards in European fisheries (COM, 2007)', this modification to the trammel net resulted in a loss of earnings revenue, with the catches of the modified nets worth only 61.8% of those of the standard nets earnings. When observing commercial catch, the greca net caught 53.9% of that caught in the standard trammel net regarding abundance and 64.3% of that in the standard trammel net in biomass which is more important as it also indicates higher similarity in revenue. The most significant decrease in commercial catch was seen among the sole species: *Microchirus azevia* (64 individuals in greca trammel net and 177 individuals in the standard trammel net), *Solea senegalensis* (11 individuals in the greca versus 32 in the standard), and *Pegusa lascaris* (10 individuals in the greca and 28 individuals in the standard). When observing revenue, two of the three most valuable species for the standard net were two sole species: *Microchirus azevia* (€237.33) and *Solea senegalensis* (€192.60). *Microchirus azevia* that was caught in the greca trammel net produced a revenue 36.86% that of the standard net with €87.48, followed by the second target species *Sepia officinalis*, which was a less valuable species in the standard net in comparison to the soles, with €77.30. Compared to previous studies such as in Izmir Bay, the net was not considered successful as these studies were geared towards target catches that were pelagic species versus the initial target species which were demersal (soles species) for the first half of sampling. In Antalya

Bay, none of the commercial species are demersal; they were considered bycatch, and with teleosts as the commercial catch, the selvedge net was considered successful (Oluger & Deval 2013). However, the greca trammel net's second most valuable species was *Sepia officinalis* which was the second target species for the second half of sampling and the value of the catch was nearly as much as that of the standard net. This year was not a good year for this cuttlefish species as waters in the Algarve were considered warm until the end of fall and therefore the cuttlefish season was short and unproductive. However, the greca trammel net did catch the European squid (*Loligo vulgaris*) which is a high value, relatively rare species.

4.2 Discards: Greca vs Standard

Greca trammel net catches were 45.3% of those of the standard trammel net in commercial discards abundance and 57.7% in bycatch abundance. Bycatch is a problem in terms of taking up net area that can be used to catch commercial species especially if a certain bycatch is being caught in relatively large quantities. There were three main bycatch species. Longfin gurnards (*Chelidonichthys obscurus*) of which 288 individuals were caught and the greca net caught 37.8% of what the standard net caught. This species is possibly attracted to the net as its diet is rich in Amphipods (Serrano et al. 2003) and commercial species that were discarded generally were scavenged by amphipods. Since there was less commercial discard biomass in the greca net, it could possibly correlate to the significant reduction in this bycatch species in the greca net. This is an important reduction as the longfin gurnard has many spines that would be entangled in the net which could cause damage to the net, possibly explaining why in the standard net nearly all of the holes found were in the upper part of the net, many of which were in the inner layer where this species was often caught in. The second bycatch species with the highest individual count was the Atlantic chub mackerel (*Scomber colias*) with 233 individuals, of which the greca net caught 128.4% that of what the standard net caught. However, this species is sometimes considered a commercial catch and it did not pose a threat of physical damage to the net. Also, out of the six bycatch species that were timed, it was the species that took the least amount of time on average to be removed from the net. Lastly, the third bycatch species with the highest individual count was the Greater weever (*Trachinus draco*), with 202 individuals, of which the greca net caught 66.9% of what the standard net caught. The reduction of this species is important due to the danger it poses to the fishermen as it is venomous and it was the second most time consuming removal species as it took on average 14.045 seconds, for a total of nearly an hour of removal time for this species over the course of 20 trips.

Additional time is required to smash the head in to prevent onboard injuries which can result in population reductions and as this species is the prey of Brill, or *Scophthalmus rhombus* (Bagge, 2004) which is a one of the most expensive flatfish at €13.2 per kilogram, this can possibly disrupt the fishery for the species.

The discard ratio of the greca to standard net for commercial catch biomass is 0.318 and this was most likely due to the fact that less individuals of commercial were caught, although a decrease in discards is a positive step for the legislation to ban discards. The species with the highest discarded weight in the greca net were *Balistes capriscus* with 1.859 kg discarded or a loss of €8.65 and *Microchirus azevia* with 1.465 kg discarded, or a loss of €13.478. The species with the highest discarded weight in the standard net were *Raja undulata* with 5.687 kg , or a loss of €14.79, *Sepia officinalis* with 5.508 kg discarded, or a loss of €67.19, and *Microchirus azevia* with 3.601 kg discarded, or a loss of €33.10. The majority of discarding commercial species was due to scavenging and parasites. *Maja squinado* was the only species for which multiple individuals were released due to being undersized and considered juveniles. *Myliobatis aquila* was released because they are considered of little or no value and are highly vulnerable (Baeta et al., 2010). A blue shark (*Prionace glauca*), which is often caught in driftnets, was also released as it was considered bycatch and under protection due to its high vulnerability (Cavanagh and Gibson, 2007). With dolphins and seagulls trailing the boat, many of the species that came onboard alive, were predated on upon entering the water. The greca trammel net caught 80.4% of that in the standard net in bycatch biomass. The most significant different was in *C. obscurus* in which the greca net discarded 12.483 kg and the standard trammel net discarded 33.253 kg. The other two main bycatch species did not have a significant difference in biomass.

Theoretically, had the net been only used during cuttlefish season and the three main sole species were not targeted, the greca trammel net caught nearly the same amount with a ratio of 0.844 that of the standard net. The Atlantic chub mackerel, *Scomber colias*, although sold commonly in the market, was considered a bycatch species by the fishermen. Had the fishermen who use trammel nets sold the mackerel species, the ratio of discard abundance in the greca net would drop to 0.463 that of the standard net while increasing the commercial abundance in the greca trammel net from 0.539 to 0.698 that of the standard trammel net. Therefore, changing the net from standard net used in during the métier of sole species to the greca trammel net during cuttlefish season can possibly result in similar production in earnings and even more so if the fishermen using the net would consider selling Atlantic chub mackerel while reducing bycatch significantly.

4.3 Damage in the Net

Conducting net damage assessment gave some insight on the possibility as to why there was a significant reduction in sole species caught in the greca trammel net. There were twice as many holes in the greca modified net with the majority in the greca layer and about 60% of the holes had a width or diameter larger than 20 centimeters. The greatest difference among the three factors in the standard trammel net was placement in the net. Approximately 88% of the holes found in the standard net were in the upper half of the net, most likely due to teleost species occurring in higher numbers. In a previous study comparing standard trammel net to a modified trammel net, damage was also assessed but, only whether it was in the upper or lower halves of the inner net and disregarding size (Gökçe et al., 2016) while another study simply accounted for the size of the hole in the net but not where in the net the hole occurred (Maccarrone et al. 2014) which can result in missing information as to which commercial and bycatch species are being affected through modifications. The greca trammel net holes were most likely due to two reasons: the material was not strong enough against demersal species with spikes or the fishermen were less careful as they suspected they would not use the greca net after sampling was finished. If the standard net were to make more money but, have more holes which would require fixing that is taken away from earnings then the assessment could be a necessary in convincing fishermen to change nets. The cost of the greca trammel net (material and labour) was 105 euros per net while that of the standard trammel net was only 58 euros per net. Since there were twice as many holes in the greca net, twice as expensive as the standard net to construct, and the greca net produced less earnings than the standard trammel net, there was no benefit to calculating the loss in earnings for fixing the net.

4.4 Removing Bycatch: Time matters

Regarding the removal of different species from the nets, it was not possible to time all the removals as the videos were either not positioned in a way that would permit viewing of the species being removed from the net, not positioned on the fisherman working on a certain species (as it was noticed that each fishermen had a “specialty” and were given certain species every time), the GoPro moved during the trip, the battery died and therefore cut out. Therefore, there was a possibility of timing of 23 individuals for each of the six bycatch species. As previously stated, bycatch removal can be laborious and dangerous with no positive return, thus the reduction of these species would reduce overall time spent on species that are not earnings able. *Rhizostoma pulmo*, or the barrel jellyfish, was the most dangerous species being caught in the net as even pieces of the jellyfish left severe stings and was the most time consuming in releasing with an average time of 18.14 seconds. The main problem faced was having to stop hauling the net completely to release the jellyfish while it was still in the water. The second most time consuming species was *Trachinus draco*, as previously stated, due to its' dangerous venom and spines. The third most time consuming was *Cymbium olla* with an average time of 12.45 seconds, though it poses no threat the species must be ripped out of its' shell which can severally damage the animal directly while indirectly causing mortality as it is no longer protected and open to predation. The last three species *Chelidonichthys obscurus* (had their spines laid down), *Scomber colias* (generally small and easily removed), and *Porifera spp* (ripped apart) were removed at an average time between six and nine seconds. While the times seem insignificant when looked at in seconds, some of the species took nearly an hour over the course of only 20 trips to remove individuals and that time accumulates if fishermen are out on the water five days a week every week of the year. Furthermore, it is important to note that commercial trammel netters fish many kms of nets in a single set (more than 10km for the larger vessels), which means that considerable amounts of time and manpower are required to remove species such as the weeverfish from the nets if we extrapolate the estimates obtained in this study for only 1.5 km of trammel nets.

4.5 Factors influencing catch

Using PRIMER and PERMANOVA +, four factors were used to analyse the results and these were: net type (greca trammel net versus standard trammel net), seasonality (fall versus winter), target catch (sole species versus cuttlefish), and depth ranges (10-20 m versus 20-30 m). The reason for métier being separated into target catch and season was because there were 15 trips in fall while in winter there were only five trips conducted and sole species were targeted the first 10 trips while cuttlefish were targeted in the second half of the trips. Therefore season and target species did not coincide.

It is observed in the MDS plots that the strength of separation is more apparent in commercial catch when target species are the factor which is confirmed by ANOSIM and SIMPER which gave exceptionally high dissimilarities for both abundance and biomass. The results were similar for commercial catch when depth was a factor and when overlaying clusters on the MDS plot, there was a higher resemblance over the standard trammel nets. Seasonality as a factor for commercial catch produced the weakest separation among the two seasons for both abundance and biomass, although biomass had a slightly higher dissimilarity level.

For discard species, the factor target catch had the least effect with moderate separation strength for abundance and a weak separation strength for biomass with the weakest dissimilarity for both biomass and abundance across all three factors. The strongest separation strength was in abundance when the factor was depth. Our three main bycatch species vary in depth, *S.colias* can be found from 0 to 300 meters in depth (Vasconcelo et al. 2011), *C. obscurus* has a range of 0 to 170 meters according to Fishbase, and *T. draco* has a depth range of 0 to 200 meters (IUNC). Seasonality was important when observing what influences catch composition and discards in the Sothern Black Sea, Turkey, where it was observed that there was a significant difference in discard species between summer and spring with a significant difference in discard rates when the depth was greater than 30 meter and the highest discards rates with depth over 16 meter (Kalayci 2014). This is possibly the reason why discard rates were so high since 12 out of the 20 trips were in less than 16 meter depth. This is similar for the discard species when season was a factor. For both abundance and biomass the strength of separation was moderate with similar dissimilarity levels.

Overall, the combined species (commercial, commercial discards, and bycatch) displayed clusters formed among the trips. Examples included modified (M) and standard (T) trammel nets for trips 2,7, and 8 with the strongest similarities across biomass. Interestingly, for trip 7 the two net types were in the water the longest, approximately 47 hours due to unexpected bad weather the day it was supposed to be hauled in; therefore time did not affect the similarity between the net types. The combined data displayed a high dissimilarity and strong separation when target catch and depth were factors with biomass data having slightly higher dissimilarity. However, similar to commercial catch, seasonality as a factor resulted in moderate separation strength in abundance and weak separation in biomass and the weakest dissimilarity for both. Two groups were formed among the trips when overlaying the cluster for the data based on their depth ranges for both abundance and biomass, although the resemblance level was slightly higher regarding the abundance data. In general, a higher resemblance level meant greca trammel nets to be in their own group individually. Two-way PERMANOVA for combined catch data, for both biomass and abundance, was conducted comparing net type against depth, seasonality, and target catch. The results for abundance was that net type had a p-value 0.828, 0.994, and 0.935 respectively meaning that the interaction is not significant. For biomass the p-values were 0.386, 0.96, and 0.935 respectively also indicating that the interaction is not significant.

With a discard ban already becoming active across certain parts of Europe, the question is raised if this will in fact be positive for both the economy and the environment. According to legislating the ban would include all finfish and crustaceans. There are certain discards of commercial catch that are due to the species' being a juvenile or females are carrying eggs, which prevents the individual from being sold on the market. Certain species' juveniles and females can be free from any negative impact from interacting with the net. This being said, will the ban increase mortality of these individuals as they are brought into port or will there be a definition for which live discards are to be returned to the water and simply noted? The document claims that exception would be made if the species is known to have a high percentange in long-term survival. In order to establish this, researchers must conduct survivability tests and upon agreeing on the support of the results, the information must be given to all the fishermen involved in the specific fishery to avoid an increase in mortality of pre-spawn individuals.

5. Conclusions

The results suggest that the greca modification, or selvedge net, did not reduce bycatch in the trammel net in terms of biomass but, did reduce bycatch in terms of abundance There was, however, a significant difference between the greca trammel net and standard trammel net among commercial discard biomass which meant earnings revenue was lost in the modified net. Overall, the standard trammel produced nearly twice as much revenue as the modified net due to the significant difference in catches of sole species, especially *Microchirus azevia*, which is one the most expensive sole species that was caught. Although the removals of the most abundant and dangerous bycatch species were timed and there was a clear indication of the time fishermen wasted on removing them, to fully assess bycatch disrupting the valuable time that could be used for removal of commercial catch, the method must be expanded. In order to focus on timing bycatch species, researchers will have to either add hands on deck to do the timing while on board or consider adding more cameras to capture every fisherman working. It is equally vital to observe net damage assessment including monetary loss as this can play as a factor in convincing fishermen to change nets. It appears that depth had the most effect across the different data sets and therefore should be further studied with more depth ranges to see at what depth bycatch is more abundant in order to avoid those depths to reduce bycatch. Since this project was conducted on a commercial fishing boat and there was no language barrier between the fishermen and the researchers, it enabled a positive interaction in order to receive some perspective as well as observing a willingness to change. In conclusion, changing gear throughout the year per métier can be proven to be most effective in terms of economy and the environment. Further research must be conducted in this area with trammel net modifications.

6. References

Alverson D.L., Freeberg M.H., Murawski S.A., Pope J.G., 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper, pp.339.

Aydin, I., Gokce, G., Metin, C., 2013. Using guarding net to reduce regularly discarded invertebrates in trammel net fisheries operating on seagrass meadows (Posidonia oceanica) in İzmir Bay (Eastern Aegean Sea). Mediterranean Marine Science, 14(2), pp.282-291.

Aydın, E., Kahraman, A.E., Göktürk, D. and Ayaz, A., 2015. Trammel Net Selectivity for Four Barbel Scraper Capoeta baliki in the Sakarya River, Turkey. Turkish Journal of Fisheries and Aquatic Sicences, 15(3), pp.583-591.

Batista, M.I., Teixeira, C.M., Cabral, H.N., 2009. Catches of target species and bycatches of an artisanal fishery: The case study of a trammel net fishery in the Portuguese coast. Fisheries Research, 100(2), pp.167-177.

Baeta, F., Batista, M., Maia, A., Costa, M.J. and Cabral, H., 2010. Elasmobranch bycatch in a trammel net fishery in the Portuguese west coast. Fisheries Research, 102(1), pp.123-129.

Borges, T.C., Erzini, K., Bentes, L., Costa, M.E., Gonçalves, J.M.S., Lino, P.G., Pais, C., Ribeiro, J., 2001. By-catch and discarding practices in five Algarve (southern Portugal) metiers. J. Appl. ´ Ichthyol. 17, pp.104–114.

Cambiè, G., 2011. Incidental capture of Caretta caretta in trammel nets off the western coast of Sardinia (Italy): statistical models of capture abundance and immediate survival. Aquatic Conservation: Marine and Freshwater Ecosystems, 21(1), pp.28-36.

Cavanagh, R.D. and Gibson, C., 2007. Overview of the conservation status of cartilaginous fishes (Chrondrichthyans) in the Mediterranean Sea (No. 3). IUCN.

COM. 2007. Communication from the Commission to the Council and the European Parliament - A policy to reduce unwanted by-catches and eliminate discards in European fisheries {SEC(2007) 380} {SEC(2007) pp.381.

Chopin, F.S., Arimoto, T., 1995. The condition of fish escaping from fishing gears—a review. Fisheries research, 21(3), pp.315-327.

Donaldson, A., Gabriel, C., Harvey, B.J., Carolsfeld, J., 2010. Impacts of fishing gears other than bottom trawls, dredges, gillnets, and longlines on aquatic biodiversity and vulnerable marine ecosystems. DFO Canadian Science Advisory Secretariat Research Document 2010/011, pp.+84

Erzini, K., Costa, M.E., Bentes, L., Borges, T.C., 2002. A comparative study of the species composition of discards from five fisheries from the Algarve (southern Portugal). Fisheries Management and Ecology 9, pp.31–40.

Erzini, K., Bentes, L., Coelho, R., Lino, P. G., Monteiro, P., Ribeiro, J., & Gonçalves, J.,2008. Catches in ghost-fishing octopus and fish traps in the northeastern Atlantic Ocean (Algarve, Portugal). Fishery Bulletin, 106(3), pp.321-327.

Erzini, K., Gonçalves, J.M.S., Bentes, L., Moutopoulos, D.K., Casal, J.A.H., Soriguer, M.C., Puente, E., Errazkin, L.A., Stergiou, K.I., 2006. Size selectivity of trammel nets in southern European small-scale fisheries. Fish. Res. 79 (1–2), pp.183–201.

Erzini, K., Puente, E., Stergiou, K.I., Hernando, J.A. (Coordinators), 2001. Trammel net selectivity studies in the Algarve (Southern Portugal), gulf of Cadiz (Spain), Basque country (Spain) and Cyclades islands (Greece). Final Report UE-DG XIV-98/014, pp. 435 + annexes.

Fabi, G., Sbrana, M., Biagi, F., Grati, F., Leonori, I., & Sartor, P., 2002. Trammel net and gill net selectivity for Lithognathus mormyrus (L., 1758), Diplodus annularis (L., 1758) and Mullus barbatus (L., 1758) in the Adriatic and Ligurian seas. Fisheries research, 54(3), pp.375-388.

Gaspar, M. B. & Chicharo, L., 2007. Modifying dredges to reduce by-catch and impacts on the benthos. In: By-catch reduction in the world's fisheries. Springer Netherlands, pp.95-140.

Gazo, M., Gonzalvo, J., Aguilar, A., 2008. Pingers as deterrents of bottlenose dolphins interacting with trammel nets. Fisheries Research, 92, pp.70–75.

Gilman, E., Gearhart, J., Price, B., Eckert, S., Milliken, H., Wang, J., Swimmer, Y., Shiode, D., Abe, O., Peckham, S.H., Chaloupka, M., Hall, M., Mangel, J., AlfaroShigueto, J., Dalzell, P., Ishizaki, A., 2010. Mitigating sea turtle by-catch in coastal passive net fisheries. Fish and Fisheries, 11, pp.57–88.

Gökçe, G., Bozaoğlu, A.S.,Eryaşar, A.R., Özbilgin, H., 2016. Discard Reduction of Trammel Nets in the Northeastern Mediterranean Prawn Fishery. Journal of Applied Ichthyology, 32, pp427–431.

Gonçalves, J. M S, Bentes, L., Coelho, R., Monteiro, P., Ribeiro, J., Correia, C., 2008. Non-Commercial Invertebrate Discards in an Experimental Trammel Net Fishery. Fisheries Management and Ecology, 15, pp.199–210.

Gonçalves, J. M. S., Stergiou, K. I., Hernando, J. A., Puente, E., Moutopoulos, D. K., Arregi, L., ... Erzini, K., 2007. Discards from experimental trammel nets in southern European small-scale fisheries. Fisheries Research, 88(1), pp.5-14.

Granadeiro, J.P., Phillips, R.A., Brickle, P., Catry, P., 2011. Albatrosses Following Fishing Vessels: How Badly Hooked Are They on an Easy Meal?. PLoS ONE, 6, pp.1–7.

Hall, Martin A., Alverson, D.L., Metuzals, K.I., 2000. By-catch: problems and solutions. Marine Pollution Bulletin, 41(1), pp.204-219.

High, W.L. 1998. Observations of a scientist/diver on fishing technology and fisheries biology. NOAA, NMFS, AFSC Processed Report, 98 (1), pp.47.

Jensen, A. L., Reider, R. H., Kovalak, W. P., 1988. Estimation of production forgone. North American Journal of Fisheries Management, 8(2), pp.191-198.

Kalayci, F. and Yeşilçiçek, T., 2014. Influence of season, depth and mesh size on the trammel nets catch composition and discard in the Southern Black Sea, Turkey. Marine Biology Research, 10(8), pp.824-832.

Kelleher, K., 2005. Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper, 470, pp.131.

Lewis, C. F., Slade, S. L., Maxwell K. E., Matthews, T. R., 2009. Lobster trap impact on coral reefs: effects of wind-driven trap movement. New Zealand Journal of Marine and Freshwater Research, 43, pp.271-282.

Lewison, R. L., Crowder, L. B., Read, A. J., Freeman, S. A., 2004. Understanding impacts of fisheries bycatch on marine megafauna. Trends in Ecology & Evolution, 19(11), pp.598-604.

Maccarrone, V., Buffa, G., Di Stefano, V., Filiciotto, F., Mazzola, S. and Buscaino, G., 2014. Economic Assessment of Dolphin Depredation Damages and Pinger Use in Artisanal Fisheries in the Archipelago of Egadi Islands (Sicily). Turkish Journal of Fisheries and Aquatic Sciences, 14, pp.173-181.

Metin, C., Gökçe, G., Aydın, İ. and Bayramiç, İ., 2009. Bycatch reduction in trammel net fishery for prawn (Melicertus kerathurus) by using guarding net in Izmir Bay on Aegean Coast of Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 9(2), pp.133-136.

Olguner M.T., Deval M.C., 2013. Catch and selectivity of 40 and 44 mm trammel nets in small- scale fisheries in the Antalya Bay, Eastern Mediterranean. Ege Journal of Fisheries and Aquatic Sciences, 30(40), pp.167-173.

Oro, D. and Ruiz, X., 1997. Exploitation of trawler discards by breeding seabirds in the north-western Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. ICES Journal of Marine Science: Journal du Conseil, 54(4), pp.695-707.

Österblom, H., Olsson, O., Blenckner, T., Furness, R. W., 2008. Junk-food in marine ecosystems. Oikos, 117(7), pp.967-977.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., Torres, F., 1998. Fishing down marine food webs. Science, 279(5352), pp.860-863.

Rodríguez-Cabello, C., Fernández, A., Olaso, I., Sánchez, F., Gancedo, R., Punzón, A., Cendrero, O., 2005. Overview of continental shelf elasmobranch fisheries in the Cantabrian Sea. J. Northwest Atl. Fish. Sci, 35, pp.375-385.

Ross,P. S., Dungan, S.Z., Hung, S.K., Jefferson, T.A., Macfarquhar, C., Perrin, W.F., 2010. Averting the Baiji Syndrome: Conserving Habitat for Critically Endangered Dolphins in Eastern Taiwan Strait. Aquatic Conservation: Marine and Freshwater Ecosystems, 20, pp.685–694.

Stergiou, K.I., Moutopoulos, D.K., Soriguer, M.C., Puente, E., Lino, P.G., Zabala, C., 2006. Trammel Net Catch Species Composition, Catch Rates and Métiers in Southern European Waters: A Multivariate Approach. Fisheries Research, 79, pp.170–182.

Stergiou, K.I., Moutopoulos, D.K., Hernando, J.A.C., Erzini, K., 2007. Trophic Signatures of Small-Scale Fishing Gears: Implications for Conservation and Management. Marine Ecology Progress Series, 333, pp.117–128.

Thomas, S.N., 2002. Gill nets and their operation. Central Institute of Fisheries Technology.

Thomas, S.N. and Hridayanathan, C., 2006. Design and General Characteristics of. Fishery Technology, 43(1), pp.17-36.

Vasconcelos, J., M.A. Dias & G. Faria 2011. Age and growth of the Atlantic chub mackerel Scomber colias Gmelin, 1789 off Madeira Island. Arquipelago. Life and Marine Sciences, 28,pp.57-70.

Wang, J. H., Fisler, S., Swimmer, Y., 2010. Developing visual deterrents to reduce sea turtle bycatch in gill net fisheries. Marine Ecology Progress Series, 408, pp.241-250.

7. Annex

Taxonomy

Table I. Taxonomy of the 84 species caught over the course of 20 fishing trips taken.

Species	Family	Order	Class	Phylum	Kingdom
Alosa fallax	Clupeidae	Clupeiformes	Actinopterygii	Chordata	Animalia
Antedon mediterranea	Antedonidae	Comatulida	Crinoidea	Echinodermata	Animalia
Aplysia punctata	Aplysiidae	Anaspidea	Gastropoda	Mollusca	Animalia
Argyrosomus regius	Sciaenidae	Perciformes	Actinopterygii	Chordata	Animalia
Astropecten aranciacus	Astropectinidae	Paxillosida	Asteroidea	Echinodermata	Animalia
Atrina pectinata	Pinnidae	Ostreida	Bivalvia	Mollusca	Animalia
Balistes capriscus	Balistidae	Tetraodontiformes	Actinopterygii	Chordata	Animalia
Belone belone	Belonidae	Beloniformes	Actinopterygii	Chordata	Animalia
Boops boops	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Calliactis parasitica	Hormathiidae	Actiniaria	Anthozoa	Cnidaria	Animalia
Callionymus lyra	Callionymidae	Perciformes	Actinopterygii	Chordata	Animalia
Caranx rhonchus	Carangidae	Perciformes	Actinopterygii	Chordata	Animalia
Charonia Lampas	Ranellidae	Littorinimorpha	Gastropoda	Mollusca	Animalia
Chelidonichthys cuculus	Triglidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Chelidonichthys lastoviza	Triglidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Chelidonichthys lucerna	Triglidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Chelidonichthys obscurus	Triglidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Conger conger	Congridae	Anguilliformes	Actinopterygii	Chordata	Animalia
Crangon crangon	Crangonidae	Decapoda	Malacostraca	Arthropoda	Animalia
Cymbium olla	Volutidae	Neogastropoda	Gastropoda	Mollusca	Animalia
Dardanus arrosor	Diogenidae	Decapoda	Malacostraca	Arthropoda	Animalia
Dentex dentex	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Dicentrarchus labrax	Moronidae	Perciformes	Actinoptergii	Chordata	Animalia
Diplodus annularis	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Diplodus bellottii	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Diplodus sargus	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Diplodus vulgaris	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Halobatrachus didactylus	Batrachoididae	Batrachoidiformes	Actinoptergii	Chordata	Animalia
Hippocampus hippocampus	Syngnathidae	Syngnathiformes	Actinoptergii	Chordata	Animalia
Holothuria arguinensis	Holothuriidae	Aspidochirotida	Holothuroidea	Echinodermata	Animalia
Homarus gammarus	Nephropidae	Decapoda	Malacostraca	Arthropoda	Animalia
Lagocephalus lagocephalus	Tetraodontidae	Tetraodontiformes	Actinopterygii	Chordata	Animalia
Leptogorgia sarmentosa	Gorgoniidae	Alcyonacea	Anthozoa	Cnidaria	Animalia
Leptogorgia lusitanica	Gorgoniidae	Alcyonacea	Anthozoa	Cnidaria	Animalia
Lithognathus mormyrus	Sparidae	Perciformes	Actinoptergii	Chordata	Animalia
Loligo vulgaris	Loliginidae	Myopsida	Cephalopoda	Mollusca	Animalia

Maja squinado	Majidae	Decapoda	Malacostraca	Arthropoda	Animalia
Marthasterias glacialis	Asteriidae	Forcipulatida	Asteroidea	Echinodermata	Animalia
Merluccius merluccius	Merlucciidae	Gadiformes	Actinoptergii	Chordata	Animalia
Microchirus azevia	Soleidae	Pleuronectiformes	Actinoptergii	Chordata	Animalia
Mullus surmuletus	Mullidae	Perciformes	Actinoptergii	Chordata	Animalia
Murex brandaris	Muricidae	Neogastropoda	Gastropoda	Mollusca	Animalia
Myliobatis aquila	Myliobatidae	Myliobatiformes	Elasmobranchii	Chordata	Animalia
Octopus vulgaris	Octopodidae	Octopoda	Cephalopoda	Mollusca	Animalia
Ophidiaster ophidianus	Ophidiasteridae	Valvatida	Asteroidea	Echinodermata	Animalia
Pagellus acarne	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Pagellus bellottii	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Pagellus erythrinus	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Pagrus auriga	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Pegusa Lascaris	Soleidae	Pleuronectiformes	Actinopterygii	Chordata	Animalia
Pentapora foliacea	Bitectiporidae	Cheilostomatida	Gymnolaemata	Bryozoa	Animalia
Phallusia mammillata	Ascidiidae	Phlebobranchia	Ascidiacea	Chordata	Animalia
Phycis phycis	Phycidae	Gadiformes	Actinopterygii	Chordata	Animalia
Plectorhinchus mediterraneus	Haemulidae	Perciformes	Actinopterygii	Chordata	Animalia
Polychaete				Annelida	Animalia
Pomatomus saltatrix	Pomatomidae	Perciformes	Actinopterygii	Chordata	Animalia
Porifera					Animalia
Prionace glauca	Carcharhinidae	Carcharhiniformes	Elasmobranchii	Chordata	Animalia
Raja undulata	Rajidae	Rajiformes	Elasmobranchii	Chordata	Animalia
Rhizostoma pulmo	Rhizostomatidae	Rhizostomeae	Scyphozoa	Cnidaria	Animalia
Sarda sarda	Scombridae	Perciformes	Actinopterygii	Chordata	Animalia
Sardina pilchardus	Clupeidae	Clupeiformes	Actinopterygii	Chordata	Animalia
Sardinella aurita	Clupeidae	Clupeiformes	Actinopterygii	Chordata	Animalia
Scomber colias	Scombridae	Perciformes	Actinopterygii	Chordata	Animalia
Scophthalmus rhombus	Scophthalmidae	Pleuronectiformes	Actinopterygii	Chordata	Animalia
Scorpaena notata	Scorpaenidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Scorpaena porcus	Scorpaenidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Sepia officinalis	Sepiidae	Sepiida	Cephalopoda	Mollusca	Animalia
Serranus cabrilla	Serranidae	Perciformes	Actinopterygii	Chordata	Animalia
Solea senegalensis	Soleidae	Pleuronectiformes	Actinopterygii	Chordata	Animalia
Solea vulgaris	Soleidae	Pleuronectiformes	Actinopterygii	Chordata	Animalia
Sphaerechinus granularis	Toxopneustidae	Camarodonta	Echinoidea	Echinodermata	Animalia
Spicara maena	Centracanthidae	Perciformes	Actinopterygii	Chordata	Animalia
Spondyliosoma cantharus	Sparidae	Perciformes	Actinopterygii	Chordata	Animalia
Stichopus regalis	Stichopodidae	Aspidochirotida	Holothuroidea	Echinodermata	Animalia
Synapturichthys kleinii	Soleidae	Pleuronectiformes	Actinopterygii	Chordata	Animalia
Torpedo marmorata	Torpedinidae	Torpediniformes	Elasmobranchii	Chordata	Animalia
Torpedo torpedo	Torpedinidae	Torpediniformes	Elasmobranchii	Chordata	Animalia
Trachinus draco	Trachinidae	Perciformes	Actinopterygii	Chordata	Animalia
Trachurus trachurus	Carangidae	Perciformes	Actinopterygii	Chordata	Animalia

Trigla lyra	Triglidae	Scorpaeniformes	Actinopterygii	Chordata	Animalia
Trisopterus luscus	Gadidae	Gadiformes	Actinopterygii	Chordata	Animalia
Uranoscopus scaber	Uranoscopidae	Perciformes	Actinopterygii	Chordata	Animalia
Veretillum cynomorium	Veretillidae	Pennatulacea	Anthozoa	Cnidaria	Animalia

Seasonality

Table II. SIMPER analysis of the commercial species' abundance data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall
Average similarity: 19.94

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Solea senegalensis	0.82	5.3	0.54	26.56	26.56
Pegusa Lascaris	0.72	4.32	0.45	21.67	48.23
Pagellus erythrinus	0.55	1.78	0.35	8.92	57.15
Balistes capriscus	0.41	1.59	0.28	7.99	65.14
Raja undulata	0.34	1.42	0.28	7.12	72.26
Microchirus azevia	0.83	1.3	0.24	6.51	78.77
Octopus vulgaris	0.31	1.28	0.22	6.43	85.2
Sepia officinalis	0.5	0.89	0.24	4.47	89.67
Synapturichthys kleinii	0.22	0.82	0.2	4.12	93.8

Group Winter
Average similarity: 26.49

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	1.02	8.23	0.97	31.06	31.06
Microchirus azevia	2.31	6.62	0.5	25	56.06
Trisopterus luscus	0.8	3.65	0.65	13.8	69.85
Merluccius merluccius	0.73	2.54	0.51	9.6	79.46
Trachurus trachurus	0.42	1.84	0.42	6.94	86.39
Solea senegalensis	0.4	1.13	0.31	4.26	90.65

Groups Fall & Winter
Average dissimilarity = 83.29

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	0.83	2.31	14.24	0.99	17.1	17.1

Sepia officinalis	0.5	1.02	7.44	1.2	8.94	26.03
Solea senegalensis	0.82	0.4	5.75	0.96	6.9	32.93
Pegusa Lascaris	0.72	0.29	5.66	0.87	6.8	39.73
Trisopterus luscus	0.23	0.8	5.21	0.98	6.26	45.99
Merluccius merluccius	0.33	0.73	4.93	0.96	5.92	51.91
Pagellus erythrinus	0.55	0.12	3.64	0.68	4.38	56.29
Balistes capriscus	0.41	0.25	3.62	0.75	4.34	60.63
Trachurus trachurus	0.07	0.42	3.07	0.81	3.68	64.31
Octopus vulgaris	0.31	0.17	3.06	0.65	3.67	67.99
Raja undulata	0.34	0.08	2.74	0.62	3.29	71.28
Maja squinado	0.15	0.29	2.62	0.56	3.15	74.43
Pagellus acarne	0.04	0.35	1.98	0.58	2.38	76.81
Phycis phycis	0	0.35	1.93	0.53	2.31	79.12
Synapturichthys kleinii	0.22	0	1.66	0.5	1.99	81.11
Pagrus auriga	0	0.2	1.43	0.42	1.71	82.83
Alosa fallax	0.1	0.08	1.13	0.39	1.35	84.18
Solea vulgaris	0.11	0.08	1.1	0.39	1.32	85.49
Plectorhinchus mediterraneus	0	0.17	1.02	0.29	1.22	86.72
Mullus surmuletus	0.1	0.08	0.97	0.4	1.17	87.89
Diplodus sargus	0	0.12	0.89	0.29	1.07	88.96
Diplodus bellottii	0.05	0.08	0.79	0.35	0.95	89.9
Pomatomus saltatrix	0.04	0.08	0.75	0.35	0.9	90.8

Table III. SIMPER analysis of the commercial species' biomass data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall
Average similarity: 19.34

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Solea senegalensis	17.31	4.96	0.52	25.66	25.66
Pegusa Lascaris	10.88	3.54	0.42	18.32	43.98
Raja undulata	16.34	2.3	0.28	11.88	55.85
Octopus vulgaris	14.36	2.03	0.24	10.48	66.34
Balistes capriscus	10.91	1.86	0.28	9.62	75.95
Sepia officinalis	13.66	1.22	0.24	6.33	82.28
Pagellus erythrinus	6.16	1.04	0.35	5.36	87.64
Microchirus azevia	10.81	0.88	0.24	4.57	92.21

Group Winter
Average similarity: 24.99

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	27.84	11.13	0.97	44.53	44.53
Microchirus azevia	26.93	4.92	0.49	19.68	64.21
Merluccius merluccius	12.92	2.41	0.49	9.63	73.84
Trisopterus luscus	7.54	2.13	0.64	8.54	82.38
Solea senegalensis	9.2	1.26	0.31	5.05	87.43
Balistes capriscus	6.66	0.63	0.22	2.51	89.94
Octopus vulgaris	7.45	0.55	0.12	2.21	92.15

Groups Fall & Winter
Average dissimilarity = 83.54

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Sepia officinalis	13.66	27.84	9.91	1.33	11.87	11.87
Microchirus azevia	10.81	26.93	9.51	0.95	11.38	23.25
Octopus vulgaris	14.36	7.45	6.45	0.68	7.72	30.97
Solea senegalensis	17.31	9.2	6.4	0.97	7.67	38.63
Raja undulata	16.34	4.94	6.33	0.65	7.58	46.21
Balistes capriscus	10.91	6.66	4.71	0.78	5.64	51.85
Merluccius merluccius	4.86	12.92	4.56	0.93	5.46	57.31
Pegusa Lascaris	10.88	4.28	4.45	0.87	5.33	62.64
Trisopterus luscus	1.82	7.54	2.81	0.88	3.36	66
Homarus gammarus	2.54	6.27	2.34	0.35	2.8	68.8
Pagellus erythrinus	6.16	1.43	2.23	0.69	2.67	71.47
Synapturichthys kleinii	6.36	0	2.2	0.5	2.63	74.1
Maja squinado	2.46	5.22	2.11	0.54	2.52	76.62
Pagrus auriga	0	5.99	2.02	0.43	2.41	79.04
Pagellus acarne	0.27	5.16	1.61	0.57	1.92	80.96
Plectorhinchus mediterraneus	0	4.15	1.21	0.29	1.45	82.41
Trachurus trachurus	0.61	3.12	1.2	0.7	1.44	83.85
Phycis phycis	0	4.22	1.2	0.55	1.43	85.29
Alosa fallax	1.85	1.78	1.16	0.4	1.39	86.68
Torpedo marmorata	1.38	2.28	1.08	0.35	1.29	87.97
Loligo vulgaris	3.02	0	0.98	0.28	1.17	89.15
Solea vulgaris	2.11	1.06	0.98	0.4	1.17	90.32

Table IV. SIMPER analysis of the discarded species abundance data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall

Average similarity: 37.30

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	2.6	12.12	2.11	32.49	32.49
Trachinus draco	2.11	8.7	1.59	23.34	55.83
Scomber colias	1.76	3.97	0.64	10.64	66.46
Pagellus erythrinus	0.99	2.89	0.74	7.75	74.22
Sphaerechinus granularis	0.99	1.72	0.43	4.61	78.83
Boops boops	0.69	1.51	0.48	4.06	82.89
Cymbium olla	0.81	1.47	0.52	3.93	86.82
Trachurus trachurus	0.48	1.17	0.44	3.14	89.96
Rhizostoma pulmo	0.52	1.12	0.39	2.99	92.95

Group Winter
Average similarity: 24.84

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	1.77	7.14	0.88	28.75	28.75
Microchirus azevia	1.43	2.69	0.63	10.85	39.6
Trisopterus luscus	1.17	2.45	0.64	9.86	49.45
Porifera	0.97	2.41	0.66	9.71	59.16
Scomber colias	1.36	2.14	0.52	8.6	67.77
Trachinus draco	0.83	1.84	0.38	7.41	75.17
Trachurus trachurus	0.48	0.96	0.38	3.85	79.02
Calliactis parasitica	0.54	0.85	0.38	3.44	82.46
Chelidonichthys cuculus	0.66	0.82	0.33	3.32	85.78
Astropecten aranciacus	0.3	0.53	0.26	2.13	87.91
Scorpaena notata	0.46	0.49	0.26	1.96	89.87
Merluccius merluccius	0.49	0.48	0.26	1.91	91.78

Groups Fall & Winter
Average dissimilarity = 75.87

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Scomber colias	1.76	1.36	6.08	1.15	8.01	8.01
Chelidonichthys obscurus	2.6	1.77	5.6	1.35	7.38	15.39
Trachinus draco	2.11	0.83	5.37	1.35	7.08	22.47
Microchirus azevia	0.09	1.43	4.12	1	5.43	27.9
Porifera	0.5	0.97	3.71	1.03	4.89	32.8
Trisopterus luscus	0.05	1.17	3.42	1.04	4.51	37.31
Sphaerechinus granularis	0.99	0.1	3.25	0.74	4.28	41.59
Pagellus erythrinus	0.99	0.3	2.94	1.07	3.88	45.48
Cymbium olla	0.81	0.1	2.45	0.77	3.23	48.71
Boops boops	0.69	0.1	2.27	0.85	2.99	51.7
Rhizostoma pulmo	0.52	0.2	2.15	0.79	2.83	54.53
Chelidonichthys cuculus	0	0.66	2.1	0.64	2.77	57.3
Trachurus trachurus	0.48	0.48	2.09	0.95	2.75	60.05
Calliactis parasitica	0	0.54	1.77	0.73	2.33	62.38
Pagellus acarne	0.24	0.46	1.74	0.76	2.3	64.68
Atrina pectinata	0.15	0.44	1.49	0.65	1.96	66.63
Astropecten aranciacus	0.24	0.3	1.45	0.75	1.91	68.54
Merluccius merluccius	0	0.49	1.42	0.6	1.87	70.41
Scorpaena notata	0	0.46	1.38	0.62	1.81	72.23
Phallusia mammillata	0.37	0.1	1.3	0.6	1.71	73.94
Charonia Lampas	0	0.34	1.07	0.6	1.41	75.35
Sepia officinalis	0.23	0.1	1	0.54	1.32	76.68
Alosa fallax	0.06	0.24	0.94	0.51	1.24	77.92
Raja undulata	0.14	0.2	0.86	0.61	1.13	79.05
Spondyliosoma cantharus	0.26	0	0.84	0.54	1.11	80.16
Myliobatis aquila	0.19	0.1	0.79	0.52	1.05	81.2
Diplodus bellottii	0.11	0.14	0.77	0.45	1.01	82.21
Marthasterias glacialis	0	0.2	0.75	0.48	0.99	83.21
Pegusa Lascaris	0.21	0	0.69	0.45	0.91	84.12
Diplodus annularis	0.21	0	0.66	0.43	0.87	84.98
Conger conger	0.07	0.2	0.63	0.55	0.83	85.81
Chelidonichthys lastoviza	0.12	0.1	0.63	0.46	0.82	86.63
Dardanus arrosor	0	0.2	0.57	0.48	0.75	87.39
Veretillum cynomorium	0.04	0.14	0.56	0.38	0.74	88.13
Leptogorgia sarmentosa	0	0.2	0.56	0.48	0.74	88.87
Serranus cabrilla	0.04	0.1	0.53	0.37	0.7	89.57
Stichopus regalis	0.04	0.1	0.51	0.36	0.67	90.24

Table V. SIMPER analysis of the discarded species' biomass data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall
Average similarity: 36.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	34.21	20.38	1.93	55.88	55.88
Trachinus draco	18.64	7.77	1.24	21.3	77.18
Scomber colias	12.64	3.06	0.49	8.39	85.57
Pagellus erythrinus	6.52	1.49	0.46	4.07	89.64
Trachurus trachurus	3.92	1.06	0.36	2.9	92.54

Group Winter
Average similarity: 21.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	19.83	13.16	0.74	61.54	61.54
Scomber colias	9.08	1.98	0.48	9.27	70.81
Microchirus azevia	12.69	1.91	0.36	8.92	79.73
Trachinus draco	5.75	1.63	0.37	7.62	87.35
Pagellus acarne	5.8	0.65	0.25	3.04	90.39

Groups Fall & Winter
Average dissimilarity = 73.89

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Chelidonichthys obscurus	34.21	19.83	10.39	1.32	14.07	14.07
Trachinus draco	18.64	5.75	6.97	1.18	9.43	23.49
Scomber colias	12.64	9.08	6.47	0.99	8.76	32.26
Microchirus azevia	0.97	12.69	4.79	0.78	6.48	38.74
Raja undulata	3.5	5.68	3.35	0.49	4.53	43.26
Pagellus erythrinus	6.52	1.94	3.03	0.82	4.1	47.37
Pagellus acarne	1.4	5.8	2.9	0.62	3.93	51.3
Sepia officinalis	5.72	1.39	2.8	0.52	3.79	55.08
Trachurus trachurus	3.92	2.55	2.6	0.7	3.51	58.59
Merluccius merluccius	0	5.92	2.29	0.61	3.1	61.7
Boops boops	4.64	1.08	2.29	0.66	3.1	64.79
Trisopterus luscus	0	6.44	2.17	0.57	2.93	67.72
Alosa fallax	0.9	3.83	1.81	0.51	2.45	70.17

Pagrus auriga	0	3.89	1.66	0.32	2.25	72.42
Dicentrarchus labrax	0	4.2	1.63	0.32	2.2	74.62
Myliobatis aquila	2.96	0	1.38	0.38	1.86	76.48
Balistes capriscus	3.69	0	1.37	0.32	1.85	78.33
Pegusa Lascaris	3.05	0	1.33	0.42	1.8	80.14
Conger conger	0.17	3.93	1.33	0.49	1.8	81.94
Prionace glauca	3.37	0	1.26	0.19	1.7	83.64
Scorpaena notata	0	2.87	1.16	0.48	1.57	85.21
Phycis phycis	0	3.11	1.11	0.32	1.5	86.71
Synapturichthys kleinii	1.89	0	1.1	0.24	1.49	88.2
Spondyliosoma cantharus	2.52	0	0.93	0.35	1.25	89.46
Sarda sarda	2.04	0	0.86	0.27	1.16	90.62

Table VI . SIMPER analysis of the all (commercial, commercial discard, and bycatch) species abundance data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall
Average similarity: 34.52

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	2.6	8.94	2.2	25.91	25.91
Trachinus draco	2.11	6.5	1.58	18.82	44.73
Scomber colias	1.76	3	0.62	8.69	53.42
Pagellus erythrinus	1.25	2.88	0.87	8.33	61.75
Pegusa Lascaris	0.82	1.54	0.53	4.47	66.22
Solea senegalensis	0.83	1.43	0.53	4.14	70.36
Sphaerechinus granularis	0.99	1.35	0.43	3.9	74.26
Boops boops	0.69	1.2	0.48	3.48	77.74
Cymbium olla	0.81	1.2	0.51	3.46	81.2
Trachurus trachurus	0.51	0.92	0.44	2.66	83.87
Rhizostoma pulmo	0.52	0.9	0.39	2.61	86.48
Raja undulata	0.42	0.57	0.36	1.65	88.13
Sepia officinalis	0.61	0.52	0.3	1.52	89.65
Microchirus azevia	0.81	0.51	0.23	1.48	91.12

Group Winter
Average similarity: 25.30

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Microchirus azevia	3.15	4.67	0.65	18.46	18.46
Trisopterus luscus	1.6	3.32	0.85	13.11	31.57
Sepia officinalis	1.01	3.2	0.84	12.66	44.23
Chelidonichthys obscurus	1.19	2.15	0.58	8.49	52.72

Merluccius merluccius	1.07	1.82	0.64	7.18	59.9
Trachurus trachurus	0.76	1.81	0.68	7.14	67.04
Porifera	0.97	1.72	0.66	6.81	73.85
Calliactis parasitica	0.54	0.59	0.38	2.35	76.2
Chelidonichthys cuculus	0.66	0.59	0.34	2.33	78.52
Phycis phycis	0.51	0.54	0.37	2.15	80.68
Scomber colias	1.02	0.52	0.26	2.04	82.72
Solea senegalensis	0.38	0.49	0.26	1.95	84.67
Trachinus draco	0.41	0.47	0.26	1.87	86.54
Balistes capriscus	0.3	0.47	0.26	1.87	88.4
Pagellus acarne	0.62	0.44	0.39	1.74	90.15

Groups Fall & Winter
Average dissimilarity = 79.20

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	0.81	3.15	6.81	1.12	8.6	8.6
Chelidonichthys obscurus	2.6	1.19	4.87	1.52	6.15	14.75
Scomber colias	1.76	1.02	4.59	1.05	5.8	20.55
Trachinus draco	2.11	0.41	4.26	1.35	5.38	25.93
Trisopterus luscus	0.23	1.6	3.49	1.27	4.41	30.34
Pagellus erythrinus	1.25	0.34	2.74	1.11	3.46	33.8
Sepia officinalis	0.61	1.01	2.7	1.26	3.41	37.21
Porifera	0.5	0.97	2.69	1.04	3.39	40.6
Sphaerechinus granularis	0.99	0.1	2.49	0.72	3.14	43.74
Merluccius merluccius	0.31	1.07	2.48	1.06	3.13	46.87
Pegusa Lascaris	0.82	0.35	2.23	0.98	2.81	49.68
Solea senegalensis	0.83	0.38	2.11	1.01	2.66	52.34
Cymbium olla	0.81	0	1.91	0.74	2.41	54.75
Trachurus trachurus	0.51	0.76	1.82	1.07	2.3	57.05
Boops boops	0.69	0.1	1.74	0.85	2.2	59.24
Maja squinado	0.19	0.44	1.56	0.59	1.97	61.21
Chelidonichthys cuculus	0	0.66	1.51	0.65	1.91	63.12
Pagellus acarne	0.28	0.62	1.47	0.83	1.86	64.98
Rhizostoma pulmo	0.52	0.1	1.45	0.78	1.83	66.81
Balistes capriscus	0.46	0.3	1.45	0.87	1.83	68.63
Raja undulata	0.42	0.3	1.27	0.83	1.6	70.23
Calliactis parasitica	0	0.54	1.25	0.74	1.58	71.81
Phycis phycis	0	0.51	1.15	0.73	1.45	73.26
Atrina pectinata	0.15	0.44	1.07	0.66	1.36	74.61

Astropecten aranciacus	0.24	0.2	0.91	0.66	1.15	75.76
Phallusia mammillata	0.37	0.1	0.91	0.6	1.14	76.91
Octopus vulgaris	0.29	0.1	0.88	0.63	1.11	78.02
Charonia Lampas	0	0.34	0.77	0.61	0.97	78.99
Leptogorgia sarmentosa	0	0.3	0.76	0.59	0.96	79.95
Myliobatis aquila	0.19	0.2	0.74	0.63	0.94	80.89
Spondyliosoma cantharus	0.26	0.1	0.74	0.61	0.93	81.82
Mullus surmuletus	0.1	0.24	0.7	0.53	0.88	82.7
Diplodus bellottii	0.16	0.14	0.66	0.49	0.84	83.54
Synapturichthys kleinii	0.24	0	0.64	0.48	0.81	84.35
Serranus cabrilla	0.04	0.2	0.59	0.51	0.74	85.09
Conger conger	0.11	0.2	0.53	0.58	0.67	85.76
Marthasterias glacialis	0	0.2	0.52	0.47	0.66	86.42
Plectorhinchus mediterraneus	0	0.2	0.51	0.32	0.65	87.07
Diplodus annularis	0.21	0	0.51	0.43	0.64	87.71
Diplodus sargus	0	0.14	0.49	0.32	0.62	88.33
Pagrus auriga	0	0.14	0.49	0.32	0.62	88.95
Solea vulgaris	0.11	0.1	0.48	0.42	0.6	89.56
Holothuria arguinensis	0.1	0.1	0.45	0.41	0.57	90.13

Table VII. SIMPER analysis of the all (commercial, commercial discard, and bycatch) species biomass data with seasons (fall and winter) as a factor with a square root transformation.

Group Fall
Average similarity: 30.12

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	34.21	10.11	2.17	33.56	33.56
Trachinus draco	18.64	4.1	1.19	13.61	47.17
Solea senegalensis	17.1	2.42	0.51	8.04	55.21
Pegusa Lascaris	12.28	2.2	0.51	7.32	62.53
Pagellus erythrinus	10.95	1.9	0.79	6.32	68.85
Scomber colias	12.64	1.71	0.5	5.67	74.52
Raja undulata	17.74	1.54	0.33	5.12	79.64
Balistes capriscus	12.61	1.2	0.31	3.98	83.62
Octopus vulgaris	13.84	1.05	0.24	3.48	87.1
Sepia officinalis	16.07	1.03	0.29	3.4	90.51

Group Winter
Average similarity: 24.15

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	28.03	7.51	1.02	31.11	31.11

Microchirus azevia	29.73	3.67	0.5	15.2	46.31
Chelidonichthys obscurus	16.53	3.13	0.6	12.97	59.28
Merluccius merluccius	14.34	1.77	0.48	7.31	66.59
Trisopterus luscus	10.61	1.73	0.62	7.17	73.76
Solea senegalensis	9.2	1	0.31	4.16	77.92
Pagellus acarne	8.53	0.72	0.41	2.97	80.89
Scomber colias	7.56	0.69	0.39	2.84	83.73
Trachurus trachurus	4.76	0.61	0.4	2.53	86.26
Balistes capriscus	6.66	0.57	0.22	2.36	88.62
Phycis phycis	6.81	0.49	0.31	2.04	90.66

Groups Fall & Winter
Average dissimilarity = 78.35

	Group Fall	Group Winter				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	10.53	29.73	6.44	0.96	8.22	8.22
Sepia officinalis	16.07	28.03	6.22	1.41	7.94	16.16
Chelidonichthys obscurus	34.21	16.53	5.07	1.54	6.48	22.64
Raja undulata	17.74	9.67	4.69	0.75	5.98	28.62
Solea senegalensis	17.1	9.2	3.94	1.01	5.02	33.64
Octopus vulgaris	13.84	7.45	3.8	0.69	4.85	38.49
Trachinus draco	18.64	4.79	3.4	1.14	4.34	42.82
Balistes capriscus	12.61	6.66	3.27	0.83	4.17	46.99
Merluccius merluccius	4.68	14.34	3.13	0.91	4	50.99
Scomber colias	12.64	7.56	2.95	1.02	3.77	54.76
Pegusa Lascaris	12.28	4.28	2.92	0.97	3.72	58.48
Trisopterus luscus	1.76	10.61	2.31	0.92	2.95	61.43
Pagellus erythrinus	10.95	3.05	2.22	1.15	2.84	64.27
Maja squinado	3.63	6.11	1.86	0.54	2.37	66.64
Pagrus auriga	0	7.51	1.71	0.43	2.18	68.82
Homarus gammarus	2.45	6.27	1.69	0.34	2.15	70.98
Pagellus acarne	1.66	8.53	1.68	0.78	2.14	73.12
Synapturichthys kleinii	6.83	0	1.52	0.45	1.94	75.06
Trachurus trachurus	4.14	4.76	1.33	0.92	1.7	76.76
Phycis phycis	0	6.81	1.33	0.64	1.69	78.45
Alosa fallax	2.09	3.97	1.17	0.5	1.5	79.94
Boops boops	4.64	0.9	1.04	0.74	1.33	81.27
Plectorhinchus mediterraneus	0	4.15	0.92	0.29	1.18	82.45
Dicentrarchus labrax	0	3.5	0.78	0.29	0.99	83.44
Conger conger	0.83	3.27	0.69	0.49	0.88	84.32

Diplodus sargus	0	2.56	0.65	0.29	0.83	85.15
Spondyliosoma cantharus	2.52	1.17	0.64	0.47	0.82	85.97
Torpedo marmorata	1.33	2.28	0.64	0.35	0.82	86.79
Solea vulgaris	2.03	1.06	0.64	0.39	0.81	87.6
Loligo vulgaris	2.91	0	0.61	0.27	0.78	88.39
Torpedo torpedo	2.11	0	0.58	0.27	0.74	89.13
Myliobatis aquila	2.96	0	0.58	0.4	0.74	89.87
Prionace glauca	3.37	0	0.57	0.19	0.72	90.6

Target Catch

Table VIII. SIMPER analysis of the abundance of commercial species' data with target catch (sole species or cuttlefish) as a factor with a square root transformation.

Group Soles
Average similarity: 28.95

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pegusa Lascaris	1.02	8.87	0.72	30.64	30.64
Solea senegalensis	1.04	8.74	0.73	30.18	60.82
Raja undulata	0.48	2.91	0.41	10.06	70.88
Pagellus erythrinus	0.67	2.77	0.42	9.58	80.46
Balistes capriscus	0.47	1.83	0.29	6.33	86.79
Octopus vulgaris	0.31	1.83	0.24	6.32	93.11

Group Cuttlefish
Average similarity: 31.41

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Microchirus azevia	2.51	10.37	0.76	33.02	33.02
Sepia officinalis	1.28	9.25	1.14	29.46	62.48
Merluccius merluccius	0.88	3.82	0.68	12.17	74.65
Trisopterus luscus	0.79	3.73	0.69	11.87	86.52
Solea senegalensis	0.36	0.94	0.28	2.98	89.5
Balistes capriscus	0.25	0.77	0.23	2.45	91.95

Groups Soles & Cuttlefish
Average dissimilarity = 91.46

	Group Soles	Group Cuttlefish				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Microchirus azevia	0	2.51	15.6	1.14	17.05	17.05
Sepia officinalis	0	1.28	9.39	1.45	10.26	27.32
Pegusa Lascaris	1.02	0.17	7.21	1.09	7.88	35.2
Solea senegalensis	1.04	0.36	6.92	1.06	7.56	42.76
Merluccius merluccius	0	0.88	5.75	1.03	6.28	49.05
Trisopterus luscus	0	0.79	5.3	1.02	5.79	54.84
Pagellus erythrinus	0.67	0.17	4.57	0.77	4.99	59.83
Balistes capriscus	0.47	0.25	4.27	0.79	4.67	64.5
Raja undulata	0.48	0.05	3.58	0.74	3.92	68.42
Octopus vulgaris	0.31	0.22	3.44	0.68	3.76	72.17
Maja squinado	0.11	0.27	2.57	0.53	2.81	74.98
Synapturichthys kleinii	0.32	0	2.35	0.62	2.57	77.55
Trachurus trachurus	0.11	0.25	2.21	0.62	2.41	79.96
Pagellus acarne	0.05	0.21	1.43	0.46	1.56	81.52
Phycis phycis	0	0.21	1.23	0.39	1.34	82.86
Alosa fallax	0.14	0.05	1.22	0.39	1.33	84.2
Solea vulgaris	0	0.2	1.18	0.4	1.29	85.49
Torpedo torpedo	0	0.1	1.1	0.31	1.2	86.69
Mullus surmuletus	0.05	0.14	1.06	0.4	1.16	87.85
Pagrus auriga	0	0.12	0.92	0.31	1	88.86
Diplodus vulgaris	0	0.17	0.91	0.39	1	89.85
Loligo vulgaris	0.05	0.05	0.75	0.31	0.82	90.67

Table IX. SIMPER analysis of the biomass of commercial species' data with target catch (sole species or cuttlefish) as a factor with a square root transformation.

Group Soles
Average similarity: 27.90

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Solea senegalensis	21.7	8.02	0.69	28.75	28.75
Pegusa Lascaris	15.45	7.27	0.66	26.07	54.82
Raja undulata	23.22	4.71	0.41	16.9	71.72
Octopus vulgaris	14.66	2.47	0.24	8.87	80.58
Balistes capriscus	12.97	2.18	0.3	7.81	88.39
Synapturichthys kleinii	9.04	1.58	0.29	5.66	94.06

Group Cuttlefish
Average similarity: 29.31

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	35.14	12.63	1.14	43.09	43.09

Microchirus azevia	30.75	7.42	0.74	25.32	68.4
Merluccius merluccius	14.31	3.25	0.65	11.09	79.49
Trisopterus luscus	6.98	1.75	0.59	5.96	85.45
Solea senegalensis	8.27	1.05	0.28	3.57	89.02
Balistes capriscus	6.4	0.87	0.23	2.96	91.98

Groups Soles & Cuttlefish
Average dissimilarity = 90.97

	Group Soles	Group Cuttlefish				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Sepia officinalis	0	35.14	12.3	1.5	13.52	13.52
Microchirus azevia	0	30.75	10.27	1.08	11.29	24.81
Raja undulata	23.22	2.96	7.87	0.78	8.65	33.47
Solea senegalensis	21.7	8.27	7.48	1.06	8.22	41.68
Octopus vulgaris	14.66	9.93	7.11	0.71	7.81	49.5
Pegusa Lascaris	15.45	2.57	5.68	1.07	6.25	55.75
Balistes capriscus	12.97	6.4	5.41	0.83	5.95	61.69
Merluccius merluccius	0	14.31	4.86	0.96	5.34	67.03
Synapturichthys kleinii	9.04	0	3.07	0.62	3.37	70.4
Pagellus erythrinus	7.3	2.24	2.71	0.77	2.98	73.38
Trisopterus luscus	0	6.98	2.57	0.84	2.83	76.21
Homarus gammarus	0	7.2	2	0.32	2.2	78.41
Maja squinado	1.26	5.25	1.95	0.52	2.15	80.55
Torpedo torpedo	0	2.96	1.45	0.31	1.59	82.15
Loligo vulgaris	1.59	2.56	1.4	0.32	1.54	83.68
Pagrus auriga	0	3.59	1.28	0.32	1.41	85.09
Alosa fallax	2.63	1.07	1.2	0.39	1.32	86.41
Pagellus acarne	0.39	3.09	1.07	0.45	1.18	87.59
Solea vulgaris	0	3.48	1.05	0.4	1.16	88.75
Torpedo marmorata	0	3.24	1.04	0.33	1.15	89.9
Trachurus trachurus	0.87	1.87	0.87	0.56	0.96	90.85

Table X. SIMPER analysis of the abundance of discarded species' data with target catch (sole species or cuttlefish) as a factor with a square root transformation.

Group Soles
Average similarity: 42.49

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	2.53	10.87	1.87	25.59	25.59

Trachinus draco	2.41	9.54	1.71	22.46	48.05
Scomber colias	2.19	5.57	0.74	13.11	61.15
Pagellus erythrinus	1.26	4.71	1.12	11.1	72.25
Boops boops	0.97	3.01	0.77	7.09	79.34
Cymbium olla	1.13	2.92	0.85	6.87	86.2
Sphaerechinus granularis	1.08	1.58	0.41	3.72	89.92
Rhizostoma pulmo	0.63	1.37	0.46	3.21	93.14

Group Cuttlefish
Average similarity: 28.82

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	2.21	10.55	1.3	36.59	36.59
Trachinus draco	1.07	3.96	0.69	13.74	50.33
Porifera	1.31	3.27	0.64	11.33	61.66
Scomber colias	1.06	1.86	0.52	6.46	68.12
Microchirus azevia	0.93	1.35	0.44	4.69	72.8
Trachurus trachurus	0.46	1.1	0.38	3.82	76.62
Trisopterus luscus	0.73	0.94	0.37	3.28	79.9
Phallusia mammillata	0.58	0.9	0.38	3.11	83.01
Pagellus acarne	0.53	0.81	0.39	2.8	85.8
Sphaerechinus granularis	0.4	0.53	0.25	1.84	87.64
Astropecten aranciacus	0.28	0.47	0.26	1.65	89.29
Atrina pectinata	0.48	0.46	0.25	1.59	90.88

Groups Soles & Cuttlefish
Average dissimilarity = 73.64

	Group Soles	Group Cuttlefish				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Scomber colias	2.19	1.06	6.66	1.21	9.05	9.05
Trachinus draco	2.41	1.07	5.31	1.26	7.21	16.26
Chelidonichthys obscurus	2.53	2.21	5.2	1.28	7.06	23.33
Porifera	0	1.31	4.21	0.92	5.71	29.04
Sphaerechinus granularis	1.08	0.4	3.83	0.83	5.2	34.24
Pagellus erythrinus	1.26	0.3	3.65	1.28	4.96	39.2
Cymbium olla	1.13	0.06	3.37	1	4.58	43.78
Boops boops	0.97	0.06	3.11	1.13	4.23	48.01
Microchirus azevia	0	0.93	2.72	0.73	3.69	51.7
Rhizostoma pulmo	0.63	0.22	2.33	0.88	3.16	54.86
Trisopterus luscus	0	0.73	2.09	0.7	2.84	57.7

Trachurus trachurus	0.51	0.46	2.09	0.94	2.83	60.53
Phallusia mammillata	0.05	0.58	1.83	0.74	2.49	63.02
Pagellus acarne	0.1	0.53	1.73	0.78	2.35	65.36
Atrina pectinata	0	0.48	1.41	0.56	1.92	67.29
Astropecten aranciacus	0.24	0.28	1.36	0.72	1.85	69.14
Chelidonichthys cuculus	0	0.37	1.16	0.44	1.58	70.72
Sepia officinalis	0.1	0.31	1.14	0.6	1.54	72.26
Spondyliosoma cantharus	0.32	0.06	1.11	0.65	1.51	73.77
Myliobatis aquila	0.05	0.3	1.03	0.59	1.4	75.17
Calliactis parasitica	0	0.3	0.98	0.49	1.33	76.5
Pegusa Lascaris	0.3	0	0.97	0.55	1.32	77.82
Diplodus annularis	0.24	0.06	0.89	0.51	1.2	79.02
Raja undulata	0.2	0.11	0.83	0.58	1.13	80.16
Merluccius merluccius	0	0.27	0.78	0.41	1.06	81.22
Scorpaena notata	0	0.25	0.76	0.42	1.03	82.25
Chelidonichthys lastoviza	0	0.25	0.75	0.51	1.02	83.27
Diplodus bellottii	0.1	0.13	0.74	0.45	1.01	84.28
Alosa fallax	0.09	0.13	0.66	0.4	0.89	85.17
Charonia Lampas	0	0.19	0.59	0.42	0.81	85.98
Balistes capriscus	0.17	0	0.53	0.4	0.71	86.69
Conger conger	0.1	0.11	0.51	0.47	0.69	87.39
Veretillum cynomorium	0	0.13	0.46	0.34	0.63	88.01
Serranus cabrilla	0	0.11	0.45	0.34	0.61	88.62
Marthasterias glacialis	0	0.11	0.42	0.34	0.57	89.19
Holothuria arguinensis	0.14	0	0.41	0.3	0.56	89.74
Stichopus regalis	0	0.11	0.4	0.33	0.54	90.28

Table XI. SIMPER analysis of the biomass of discarded species' data with target catch (sole species or cuttlefish) as a factor with a square root transformation.

Group Soles
Average similarity: 38.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	33.93	18.43	1.87	47.35	47.35
Trachinus draco	21.55	9.35	1.5	24.02	71.37
Scomber colias	14.86	4.21	0.57	10.81	82.18
Pagellus erythrinus	8.42	2.44	0.6	6.27	88.45
Boops boops	6.5	1.79	0.49	4.6	93.05

Group Cuttlefish

Average similarity: 27.32

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	26.54	18.46	1.07	67.54	67.54
Trachinus draco	8.26	2.88	0.55	10.53	78.07
Scomber colias	8.19	1.55	0.42	5.66	83.72
Microchirus azevia	8.56	1.06	0.3	3.88	87.6
Pagellus acarne	4.98	0.76	0.3	2.79	90.39

Groups Soles & Cuttlefish

Average dissimilarity = 70.88

	Group Soles	Group Cuttlefish				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Chelidonichthys obscurus	33.93	26.54	9.28	1.26	13.09	13.09
Trachinus draco	21.55	8.26	7.2	1.22	10.16	23.24
Scomber colias	14.86	8.19	6.72	1	9.48	32.72
Pagellus erythrinus	8.42	1.86	3.59	0.96	5.06	37.79
Sepia officinalis	2.25	7.17	3.19	0.58	4.51	42.29
Microchirus azevia	0	8.56	3.11	0.61	4.39	46.68
Raja undulata	4.9	3.15	3.04	0.51	4.29	50.97
Boops boops	6.5	0.6	2.91	0.81	4.1	55.07
Trachurus trachurus	3.86	3.24	2.53	0.76	3.57	58.65
Pagellus acarne	0.37	4.98	2.19	0.58	3.09	61.74
Balistes capriscus	5.17	0	1.86	0.39	2.63	64.37
Myliobatis aquila	0.31	4.26	1.84	0.5	2.6	66.97
Pegusa Lascaris	4.28	0	1.8	0.51	2.53	69.5
Prionace glauca	0	5.24	1.79	0.24	2.52	72.03
Synapturichthys kleinii	2.65	0	1.48	0.28	2.08	74.11
Merluccius merluccius	0	3.29	1.26	0.42	1.78	75.89
Spondyliosoma cantharus	3.53	0	1.26	0.43	1.77	77.66
Alosa fallax	1.27	2.13	1.25	0.41	1.76	79.42
Trisopterus luscus	0	3.58	1.19	0.4	1.69	81.1
Lagocephalus lagocephalus	4.04	0	1.15	0.23	1.62	82.72
Sarda sarda	1.4	1.62	1.14	0.32	1.6	84.33
Diplodus annularis	1.87	0.53	1.04	0.38	1.47	85.8
Chelidonichthys	0	2.66	0.99	0.42	1.4	87.19

lastoviza						
Pagrus auriga	0	2.16	0.91	0.23	1.29	88.48
Dicentrarchus labrax	0	2.33	0.9	0.24	1.26	89.74
Conger conger	0.23	2.18	0.8	0.38	1.13	90.88

Table XII. SIMPER analysis of abundance of all species (commercial discards, commercial catch, and bycatch) data with target catch (sole species or cuttlefish) as a factor with a square root transformation.

Group Soles
Average similarity: 41.79

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	2.53	8.67	1.91	20.75	20.75
Trachinus draco	2.41	7.51	1.76	17.97	38.72
Scomber colias	2.19	4.42	0.73	10.58	49.3
Pagellus erythrinus	1.53	4.2	1.13	10.06	59.36
Pegusa Lascaris	1.14	3.07	0.89	7.35	66.7
Boops boops	0.97	2.39	0.77	5.71	72.42
Cymbium olla	1.13	2.38	0.84	5.69	78.11
Solea senegalensis	1.04	2.18	0.69	5.22	83.33
Sphaerechinus granularis	1.08	1.31	0.41	3.15	86.47
Rhizostoma pulmo	0.63	1.15	0.46	2.76	89.23
Raja undulata	0.59	1.14	0.54	2.72	91.95

Group Cuttlefish
Average similarity: 30.83

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Microchirus azevia	3.01	5.75	0.9	18.64	18.64
Chelidonichthys obscurus	1.88	4.85	0.97	15.72	34.36
Sepia officinalis	1.39	3.87	1.1	12.54	46.9
Trisopterus luscus	1.25	2.38	0.8	7.71	54.62
Porifera	1.31	2.24	0.64	7.25	61.87
Merluccius merluccius	1.08	2.12	0.79	6.87	68.74
Trachinus draco	0.84	1.88	0.59	6.09	74.82
Trachurus trachurus	0.61	1.34	0.53	4.34	79.16
Scomber colias	0.87	0.68	0.37	2.2	81.36
Pagellus acarne	0.61	0.66	0.47	2.15	83.51
Phallusia mammillata	0.58	0.57	0.39	1.85	85.36
Balistes capriscus	0.28	0.47	0.26	1.52	86.88
Pagellus erythrinus	0.43	0.45	0.39	1.46	88.34
Solea senegalensis	0.35	0.39	0.25	1.28	89.62
Myliobatis aquila	0.36	0.39	0.32	1.25	90.87

Groups Soles & Cuttlefish
Average dissimilarity = 79.57

Species	Group Soles Av.Abund	Group Cuttlefish Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	0	3.01	6.66	1.21	8.37	8.37
Scomber colias	2.19	0.87	5.04	1.14	6.33	14.7
Chelidonichthys obscurus	2.53	1.88	4.2	1.33	5.27	19.97
Trachinus draco	2.41	0.84	4.15	1.28	5.22	25.19
Sepia officinalis	0.1	1.39	3.3	1.42	4.15	29.33
Pagellus erythrinus	1.53	0.43	3.15	1.26	3.96	33.29
Porifera	0	1.31	3.07	0.94	3.86	37.15
Sphaerechinus granularis	1.08	0.4	2.89	0.81	3.63	40.78
Trisopterus luscus	0	1.25	2.85	1.11	3.58	44.36
Pegusa Lascaris	1.14	0.19	2.7	1.27	3.4	47.75
Cymbium olla	1.13	0	2.6	0.98	3.27	51.02
Merluccius merluccius	0	1.08	2.47	1.12	3.11	54.13
Solea senegalensis	1.04	0.35	2.37	1.11	2.98	57.11
Boops boops	0.97	0.06	2.31	1.12	2.9	60.01
Trachurus trachurus	0.55	0.61	1.74	0.99	2.19	62.2
Rhizostoma pulmo	0.63	0.17	1.66	0.88	2.08	64.28
Balistes capriscus	0.54	0.28	1.55	0.9	1.94	66.23
Raja undulata	0.59	0.17	1.45	0.91	1.83	68.05
Pagellus acarne	0.15	0.61	1.38	0.83	1.74	69.79
Phallusia mammillata	0.05	0.58	1.3	0.74	1.63	71.42
Maja squinado	0.17	0.36	1.24	0.54	1.56	72.98
Atrina pectinata	0	0.48	1.04	0.56	1.3	74.28
Octopus vulgaris	0.29	0.19	0.98	0.68	1.23	75.52
Astropecten aranciacus	0.24	0.22	0.92	0.67	1.15	76.67
Myliobatis aquila	0.05	0.36	0.87	0.67	1.1	77.77
Synapturichthys kleinii	0.34	0	0.87	0.6	1.1	78.87
Spondyliosoma cantharus	0.32	0.11	0.87	0.68	1.09	79.96
Chelidonichthys cuculus	0	0.37	0.86	0.45	1.08	81.04
Calliactis parasitica	0	0.3	0.71	0.49	0.9	81.94
Diplodus bellottii	0.17	0.13	0.68	0.5	0.85	82.79
Diplodus annularis	0.24	0.06	0.66	0.51	0.83	83.62
Phycis phycis	0	0.29	0.65	0.49	0.82	84.44
Mullus surmuletus	0.05	0.23	0.6	0.46	0.75	85.19
Solea vulgaris	0	0.22	0.51	0.43	0.64	85.83
Conger conger	0.15	0.11	0.48	0.53	0.6	86.43

Charonia Lampas	0	0.19	0.44	0.42	0.55	86.98
Diplodus vulgaris	0	0.23	0.44	0.43	0.55	87.53
Holothuria arguinensis	0.14	0.06	0.44	0.38	0.55	88.08
Serranus cabrilla	0	0.17	0.44	0.43	0.55	88.63
Leptogorgia sarmentosa	0	0.17	0.44	0.41	0.55	89.18
Alosa fallax	0.17	0	0.41	0.32	0.51	89.69
Chelidonichthys lastoviza	0	0.19	0.38	0.44	0.48	90.17

Table XIII. SIMPER analysis of biomass of all species (commercial discards, commercial catch, and bycatch) data with target catch (sole species or cuttlefish) as a factor with a square root transformation

Group Soles
Average similarity: 37.02

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	33.93	10.33	1.94	27.91	27.91
Trachinus draco	21.55	5.16	1.46	13.93	41.84
Pegusa Lascaris	17.19	4.39	0.84	11.85	53.68
Solea senegalensis	21.18	3.59	0.65	9.71	63.39
Raja undulata	24.84	3.07	0.49	8.29	71.68
Pagellus erythrinus	13.24	2.78	1	7.51	79.19
Scomber colias	14.86	2.46	0.58	6.64	85.84
Balistes capriscus	15.25	1.41	0.34	3.81	89.65
Octopus vulgaris	13.92	1.15	0.23	3.11	92.76

Group Cuttlefish
Average similarity: 28.81

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	37.07	8.39	1.2	29.11	29.11
Chelidonichthys obscurus	23.88	5.39	0.96	18.7	47.81
Microchirus azevia	32.58	5.08	0.75	17.63	65.44
Merluccius merluccius	15.16	2.17	0.64	7.52	72.96
Trisopterus luscus	8.82	1.3	0.58	4.52	77.48
Trachinus draco	7.43	1	0.49	3.46	80.94
Solea senegalensis	8.27	0.81	0.28	2.82	83.75
Balistes capriscus	6.4	0.72	0.23	2.5	86.26
Trachurus trachurus	4.49	0.64	0.38	2.22	88.48
Scomber colias	7.37	0.61	0.39	2.11	90.59

Groups Soles & Cuttlefish

Average dissimilarity = 80.64

Species	Group Soles Av.Abund	Group Cuttlefish Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Sepia officinalis	2.25	37.07	7.4	1.51	9.18	9.18
Microchirus azevia	0	32.58	6.51	1.06	8.08	17.26
Raja undulata	24.84	5.8	5.27	0.85	6.54	23.8
Chelidonichthys obscurus	33.93	23.88	4.63	1.39	5.74	29.54
Solea senegalensis	21.18	8.27	4.33	1.09	5.37	34.91
Octopus vulgaris	13.92	9.93	4.06	0.71	5.04	39.95
Pegusa Lascaris	17.19	2.57	3.62	1.25	4.49	44.44
Trachinus draco	21.55	7.43	3.61	1.18	4.48	48.92
Balistes capriscus	15.25	6.4	3.61	0.89	4.47	53.39
Scomber colias	14.86	7.37	3.2	1.06	3.97	57.36
Merluccius merluccius	0	15.16	3.05	0.94	3.78	61.14
Pagellus erythrinus	13.24	3.91	2.48	1.26	3.08	64.23
Synapturichthys kleinii	9.56	0	2.05	0.56	2.54	66.77
Trisopterus luscus	0	8.82	1.92	0.82	2.38	69.15
Maja squinado	2.97	5.79	1.62	0.53	2.01	71.16
Homarus gammarus	0	7.2	1.41	0.32	1.74	72.9
Trachurus trachurus	4.16	4.49	1.33	0.86	1.65	74.56
Boops boops	6.5	0.54	1.33	0.91	1.65	76.21
Pagellus acarne	0.74	6.7	1.3	0.69	1.62	77.82
Pagrus auriga	0	4.51	1.07	0.32	1.32	79.15
Alosa fallax	2.92	2.38	1.02	0.45	1.27	80.41
Torpedo torpedo	0	2.96	0.87	0.31	1.08	81.49
Phycis phycis	0	4.09	0.82	0.46	1.02	82.51
Myliobatis aquila	0.31	3.84	0.82	0.46	1.02	83.53
Loligo vulgaris	1.51	2.56	0.82	0.32	1.02	84.55
Prionace glauca	0	4.71	0.81	0.22	1.01	85.56
Spondyliosoma cantharus	3.53	0.7	0.73	0.5	0.9	86.46
Solea vulgaris	0	3.48	0.67	0.4	0.83	87.29
Lagocephalus lagocephalus	4.04	0	0.63	0.23	0.78	88.07
Sarda sarda	1.4	2.01	0.62	0.32	0.77	88.84
Torpedo marmorata	0	3.24	0.61	0.32	0.75	89.59
Plectorhinchus mediterraneus	0	2.49	0.57	0.22	0.71	90.3

Depth

Table XIV. SIMPER analysis of abundance of commercial catch data with depth (10-20m or 20-30m) as a factor with a square root transformation.

Group 10-20
Average similarity: 22.74

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pegusa Lascaris	1.78	7.7	0.64	33.87	33.87
Solea senegalensis	1.78	7.03	0.66	30.9	64.77
Balistes capriscus	0.74	2.25	0.36	9.89	74.66
Raja undulata	0.48	1.49	0.31	6.57	81.23
Pagellus erythrinus	1.09	1.4	0.31	6.16	87.39
Octopus vulgaris	0.35	1.23	0.23	5.43	92.82

Group 20-30
Average similarity: 30.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Microchirus azevia	14.88	17.65	0.85	58.34	58.34
Sepia officinalis	2.44	6.25	0.89	20.64	78.98
Merluccius merluccius	1.69	2.42	0.69	7.98	86.96
Trisopterus luscus	1.31	2.33	0.72	7.7	94.66

Groups 10-20 & 20-30
Average dissimilarity = 93.72

	Group 10-20	Group 20-30				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	0.13	14.88	33.11	1.3	35.33	35.33
Sepia officinalis	0.26	2.44	8.7	1.12	9.28	44.62
Pegusa Lascaris	1.78	0	6.42	0.84	6.85	51.47
Solea senegalensis	1.78	0.31	6.08	0.84	6.49	57.95
Merluccius merluccius	0.09	1.69	5.08	0.94	5.42	63.37
Trisopterus luscus	0.04	1.31	4.27	0.93	4.55	67.93
Pagellus erythrinus	1.09	0.25	3.6	0.53	3.84	71.77
Balistes capriscus	0.74	0.13	3.11	0.6	3.32	75.08
Maja squinado	0.13	0.44	2.46	0.46	2.63	77.71
Octopus vulgaris	0.35	0.25	2.2	0.59	2.35	80.06
Raja undulata	0.48	0.06	2.16	0.52	2.31	82.36
Trachurus trachurus	0.17	0.19	1.25	0.54	1.34	83.7

Pagellus acarne	0.04	0.38	1.17	0.4	1.25	84.95
Synapturichthys kleinii	0.26	0	1.16	0.47	1.24	86.18
Plectorhinchus mediterraneus	0	0.25	1.13	0.25	1.21	87.39
Phycis phycis	0	0.38	1.12	0.39	1.19	88.59
Pagrus auriga	0	0.19	1.09	0.34	1.17	89.75
Solea vulgaris	0	0.38	1.06	0.39	1.13	90.88

Table XV. SIMPER analysis of biomass of commercial catch data with depth (10-20m or 20-30m) as a factor with a square root transformation.

Group 10-20

Average similarity: 20.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Solea senegalensis	821.18	5.92	0.57	29.14	29.14
Pegusa Lascaris	401.36	4.42	0.56	21.75	50.89
Raja undulata	1150.51	3.47	0.3	17.05	67.95
Balistes capriscus	547.89	2.62	0.35	12.87	80.81
Octopus vulgaris	782.61	2.35	0.24	11.58	92.39

Group 20-30
Average similarity: 26.29

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	1909.62	11.85	0.99	45.06	45.06
Microchirus azevia	2182.87	9.67	0.83	36.78	81.84
Merluccius merluccius	453.13	1.81	0.62	6.88	88.72
Octopus vulgaris	500	0.68	0.16	2.6	91.32

Groups 10-20 & 20-30
Average dissimilarity = 92.24

	Group 10-20	Group 20-30				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	16.54	2182.87	15.98	1.01	17.32	17.32
Sepia officinalis	165.61	1909.62	14.7	1.22	15.94	33.26
Raja undulata	1150.51	219.29	9.76	0.64	10.59	43.85
Octopus vulgaris	782.61	500	8.75	0.69	9.48	53.33
Solea senegalensis	821.18	159.86	6.99	0.83	7.58	60.91
Balistes capriscus	547.89	97.33	4.77	0.7	5.17	66.08

Homarus gammarus	0	649.24	3.94	0.36	4.27	70.35
Merluccius merluccius	32.57	453.13	3.76	0.76	4.08	74.43
Pegusa Lascaris	401.36	0	3.71	0.9	4.03	78.45
Synapturichthys kleinii	225.32	0	1.86	0.51	2.01	80.47
Pagrus auriga	0	162.95	1.84	0.36	1.99	82.46
Maja squinado	28.95	189.74	1.81	0.49	1.97	84.43
Loligo vulgaris	39.77	163.81	1.56	0.32	1.7	86.12
Plectorhinchus mediterraneus	0	155.27	1.44	0.25	1.56	87.68
Pagellus erythrinus	124.91	42.25	1.27	0.55	1.37	89.05
Trisopterus luscus	4.17	113.44	1.15	0.62	1.25	90.3

Table XVI. SIMPER analysis of abundance of discarded species' data with depth (10-20m or 20-30m) as a factor with a square root transformation.

Group 10-20
Average similarity: 32.14

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	8.83	12.23	1.16	38.04	38.04
Trachinus draco	7.21	8.23	1.28	25.62	63.66
Scomber colias	7.42	4.03	0.47	12.53	76.19
Pagellus erythrinus	1.88	1.77	0.66	5.5	81.69
Sphaerechinus granularis	3.42	1.69	0.37	5.27	86.96
Boops boops	1.38	1.13	0.49	3.5	90.47

Group 20-30
Average similarity: 24.75

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	5.43	7.8	0.83	31.5	31.5
Porifera	4.36	5.11	0.69	20.64	52.14
Scomber colias	3.93	2.46	0.64	9.94	62.09
Microchirus azevia	3.36	1.78	0.44	7.21	69.3
Trachinus draco	2	1.64	0.43	6.64	75.93
Trisopterus luscus	2.14	1.19	0.4	4.82	80.75
Phallusia mammillata	1.29	0.9	0.48	3.63	84.38
Pagellus acarne	1	0.54	0.41	2.18	86.57
Atrina pectinata	1.14	0.52	0.31	2.09	88.66
Trachurus trachurus	0.5	0.36	0.33	1.44	90.1

Groups 10-20 & 20-30
Average dissimilarity = 80.33

Species	Group 10-20 Av.Abund	Group 20-30 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Chelidonichthys obscurus	8.83	5.43	11.26	1.18	14.01	14.01
Scomber colias	7.42	3.93	10.81	0.94	13.46	27.47
Trachinus draco	7.21	2	8.39	0.98	10.45	37.92
Porifera	0	4.36	7.04	0.83	8.76	46.68
Sphaerechinus granularis	3.42	0.14	4.71	0.58	5.87	52.55
Microchirus azevia	0	3.36	4.47	0.63	5.56	58.11
Trisopterus luscus	0	2.14	2.83	0.66	3.52	61.62
Pagellus erythrinus	1.88	0.43	2.45	0.95	3.05	64.67
Cymbium olla	2.17	0.07	2.44	0.57	3.04	67.71
Boops boops	1.38	0.07	1.93	0.77	2.4	70.11
Phallusia mammillata	0.04	1.29	1.88	0.7	2.34	72.45
Chelidonichthys cuculus	0	0.93	1.74	0.4	2.17	74.62
Rhizostoma pulmo	0.92	0.29	1.65	0.7	2.05	76.68
Atrina pectinata	0	1.14	1.61	0.58	2	78.68
Pagellus acarne	0.13	1	1.43	0.67	1.79	80.46
Trachurus trachurus	0.63	0.5	1.26	0.81	1.56	82.03
Calliactis parasitica	0	0.57	1.04	0.45	1.29	83.32
Merluccius merluccius	0	0.57	0.85	0.42	1.05	84.37
Sepia officinalis	0.13	0.5	0.82	0.59	1.02	85.4
Scorpaena notata	0	0.5	0.76	0.46	0.94	86.34
Astropecten aranciacus	0.29	0.29	0.73	0.71	0.9	87.24
Myliobatis aquila	0.04	0.43	0.7	0.58	0.87	88.11
Chelidonichthys lastoviza	0	0.36	0.56	0.54	0.7	88.81
Charonia Lampas	0	0.29	0.51	0.42	0.63	89.44
Alosa fallax	0.13	0.21	0.5	0.41	0.63	90.07

Table XVII. SIMPER analysis of biomass of discarded species' data with depth (10-20m or 20-30m) as a factor with a square root transformation.

Group 10-20
Average similarity: 30.56

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	1448.58	20.88	1.3	68.32	68.32
Trachinus draco	658.73	5.02	0.95	16.42	84.74
Scomber colias	369.54	2.24	0.38	7.34	92.08

Group 20-30

Average similarity: 17.10

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	926.56	11.28	0.84	65.97	65.97
Microchirus azevia	361.91	1.25	0.28	7.32	73.29
Scomber colias	247.13	1.25	0.44	7.32	80.61
Sepia officinalis	320.51	0.8	0.18	4.65	85.26
Trachinus draco	175.78	0.66	0.37	3.83	89.09
Pagellus acarne	119.24	0.49	0.36	2.88	91.97

Groups 10-20 & 20-30

Average dissimilarity = 78.51

	Group 10-20	Group 20-30				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Chelidonichthys obscurus	1448.58	926.56	18.05	1.16	22.99	22.99
Trachinus draco	658.73	175.78	7.22	0.86	9.19	32.18
Scomber colias	369.54	247.13	6.75	0.77	8.6	40.78
Sepia officinalis	50.55	320.51	4.68	0.51	5.96	46.74
Prionace glauca	0	634.71	4.57	0.27	5.82	52.55
Microchirus azevia	0	361.91	4.54	0.59	5.78	58.34
Raja undulata	102.77	230.09	3.9	0.4	4.96	63.3
Pagellus acarne	2.34	119.24	2.05	0.47	2.61	65.91
Myliobatis aquila	1.56	113.93	1.89	0.47	2.41	68.32
Dicentrarchus labrax	0	126.15	1.81	0.26	2.31	70.62
Pagrus auriga	0	108.19	1.79	0.26	2.28	72.9
Lagocephalus lagocephalus	272.32	0	1.7	0.21	2.16	75.06
Pagellus erythrinus	120.25	34.5	1.65	0.73	2.11	77.16
Balistes capriscus	154.17	0	1.62	0.33	2.06	79.23
Trisopterus luscus	0	114.09	1.44	0.41	1.84	81.07
Merluccius merluccius	0	94.97	1.37	0.46	1.75	82.81
Boops boops	77.51	8.29	1.26	0.5	1.61	84.43
Trachurus trachurus	43.94	33.28	1.24	0.48	1.58	86.01
Synapturichthys kleinii	61.45	0	1.23	0.22	1.57	87.58
Alosa fallax	26.75	52.34	1.02	0.43	1.3	88.88
Sarda sarda	32.65	60.83	0.94	0.3	1.19	90.07

Table XVIII. SIMPER analysis of abundance of all species (commercial catch, commercial discard, and bycatch) data with depth (10-20m or 20-30m) as a factor with a square root transformation.

Group 10-20
Average similarity: 31.07

Species	Av.Abund	Av.Sim	Sim/SD	Contrib %	Cum.%
Chelidonichthys obscurus	8.83	9.85	1.19	31.69	31.69
Trachinus draco	7.21	6.59	1.32	21.21	52.9
Scomber colias	7.42	3.39	0.46	10.92	63.82
Pagellus erythrinus	2.92	1.89	0.64	6.1	69.92
Pegusa Lascaris	2.04	1.86	0.68	5.99	75.91
Sphaerechinus granularis	3.42	1.42	0.36	4.56	80.47
Solea senegalensis	1.92	1.27	0.59	4.08	84.55
Boops boops	1.38	0.93	0.5	2.98	87.53
Cymbium olla	2.17	0.82	0.44	2.65	90.18

Group 20-30
Average similarity: 26.62

Species	Av.Abund	Av.Sim	Sim/SD	Contrib %	Cum.%
Microchirus azevia	17.81	9.32	0.81	35.01	35.01
Chelidonichthys obscurus	4.75	3.52	0.67	13.21	48.22
Sepia officinalis	2.94	2.86	1.03	10.76	58.98
Porifera	3.81	2.22	0.53	8.32	67.31
Trisopterus luscus	3.13	1.68	0.7	6.3	73.61
Merluccius merluccius	2.19	1.19	0.66	4.45	78.06
Scomber colias	3.44	1.12	0.5	4.21	82.27
Trachinus draco	1.81	0.94	0.42	3.52	85.79
Trachurus trachurus	0.69	0.44	0.43	1.66	87.45
Pagellus acarne	1.25	0.4	0.48	1.49	88.94
Phallusia mammillata	1.13	0.37	0.4	1.41	90.35

Groups 10-20 & 20-30
Average dissimilarity = 85.09

	Group 10-20	Group 20-30				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Microchirus azevia	0.13	17.81	14.92	1.01	17.53	17.53

Chelidonichthys obscurus	8.83	4.75	8.2	1.14	9.64	27.17
Scomber colias	7.42	3.44	7.9	0.85	9.29	36.46
Trachinus draco	7.21	1.81	6.22	0.93	7.31	43.77
Porifera	0	3.81	4.19	0.7	4.92	48.69
Sphaerechinus granularis	3.42	0.13	3.55	0.55	4.18	52.87
Sepia officinalis	0.38	2.94	3.05	1.16	3.59	56.46
Trisopterus luscus	0.04	3.13	2.85	0.9	3.35	59.8
Pagellus erythrinus	2.92	0.63	2.62	0.89	3.08	62.88
Merluccius merluccius	0.08	2.19	2.1	0.82	2.46	65.34
Pegusa Lascaris	2.04	0	2.09	0.96	2.45	67.79
Cymbium olla	2.17	0.06	1.92	0.54	2.26	70.05
Solea senegalensis	1.92	0.31	1.86	0.87	2.19	72.24
Boops boops	1.38	0.06	1.43	0.73	1.68	73.92
Maja squinado	0.21	0.69	1.32	0.4	1.55	75.47
Rhizostoma pulmo	0.92	0.31	1.22	0.71	1.43	76.9
Trachurus trachurus	0.75	0.69	1.11	0.82	1.3	78.21
Phallusia mammillata	0.04	1.13	1.07	0.65	1.26	79.47
Pagellus acarne	0.17	1.25	1.03	0.74	1.21	80.68
Chelidonichthys cuculus	0	0.81	0.96	0.39	1.13	81.82
Atrina pectinata	0	1	0.96	0.51	1.13	82.95
Balistes capriscus	0.88	0.13	0.94	0.73	1.1	84.05
Raja undulata	0.63	0.19	0.74	0.67	0.87	84.92
Alosa fallax	0.29	0.25	0.59	0.4	0.69	85.61
Octopus vulgaris	0.33	0.25	0.57	0.66	0.66	86.27
Astropecten aranciacus	0.29	0.31	0.56	0.72	0.66	86.93
Calliactis parasitica	0	0.5	0.53	0.45	0.62	87.56
Myliobatis aquila	0.04	0.44	0.53	0.58	0.62	88.18
Phycis phycis	0	0.44	0.5	0.44	0.58	88.76
Scorpaena notata	0	0.44	0.5	0.4	0.58	89.35
Mullus surmuletus	0.04	0.38	0.47	0.42	0.55	89.89
Pagrus auriga	0	0.25	0.45	0.33	0.52	90.42

Table XIX. SIMPER analysis of biomass of all species (commercial catch, commercial discard, and bycatch) data with depth (10-20m or 20-30m) as a factor with a square root transformation

Group 10-20
Average similarity: 24.74

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Chelidonichthys obscurus	1448.58	8.43	1.36	34.06	34.06
Solea senegalensis	837.04	2.96	0.54	11.96	46.02
Pegusa Lascaris	451.02	2.63	0.67	10.64	56.67

Raja undulata	1205.35	2.18	0.33	8.82	65.48
Trachinus draco	658.73	2.18	0.73	8.81	74.3
Balistes capriscus	679.23	1.78	0.39	7.21	81.51
Octopus vulgaris	750	1.55	0.23	6.27	87.78
Scomber colias	369.54	1.11	0.38	4.49	92.27

Group 20-30
Average similarity: 23.11

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sepia officinalis	2190.07	8.22	1.02	35.54	35.54
Microchirus azevia	2499.54	7.07	0.82	30.57	66.12
Chelidonichthys obscurus	810.74	2.71	0.67	11.73	77.85
Merluccius merluccius	536.23	1.27	0.58	5.5	83.35
Trisopterus luscus	213.27	0.56	0.54	2.44	85.79
Octopus vulgaris	500	0.44	0.16	1.89	87.68
Scomber colias	216.24	0.34	0.39	1.46	89.14
Maja squinado	235.24	0.32	0.15	1.39	90.53

Groups 10-20 & 20-30
Average dissimilarity = 87.25

	Group 10-20	Group 20-30				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Microchirus azevia	15.85	2499.54	11.84	0.95	13.57	13.57
Sepia officinalis	209.26	2190.07	10.4	1.17	11.92	25.48
Raja undulata	1205.35	420.62	7.19	0.66	8.24	33.73
Chelidonichthys obscurus	1448.58	810.74	6.49	1.2	7.44	41.16
Octopus vulgaris	750	500	5.65	0.67	6.47	47.63
Solea senegalensis	837.04	159.86	4.29	0.87	4.92	52.55
Balistes capriscus	679.23	97.33	3.6	0.72	4.13	56.69
Homarus gammarus	0	649.24	3.13	0.35	3.59	60.28
Trachinus draco	658.73	153.81	3.12	0.7	3.58	63.86
Merluccius merluccius	31.22	536.23	2.76	0.73	3.17	67.02
Pegusa Lascaris	451.02	0	2.46	0.99	2.82	69.84
Scomber colias	369.54	216.24	2.46	0.75	2.82	72.66
Prionace glauca	0	555.37	2	0.25	2.29	74.95
Pagrus auriga	0	257.62	1.94	0.35	2.22	77.17
Maja squinado	79.97	235.24	1.8	0.47	2.06	79.23
Synapturichthys kleinii	277.38	0	1.52	0.41	1.74	80.97
Trisopterus luscus	4	213.27	1.26	0.63	1.44	82.42

Pagellus erythrinus	239.96	72.44	1.18	0.83	1.35	83.77
Plectorhinchus mediterraneus	0	155.27	1.12	0.24	1.29	85.06
Lagocephalus lagocephalus	272.32	0	0.96	0.2	1.11	86.16
Loligo vulgaris	38.11	163.81	0.87	0.32	0.99	87.16
Pagellus acarne	4.59	191.11	0.85	0.52	0.97	88.13
Alosa fallax	84.92	74.45	0.85	0.41	0.97	89.1
Dicentrarchus labrax	0	110.38	0.77	0.24	0.88	89.98
Torpedo marmorata	0	133.97	0.65	0.35	0.75	90.73