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Unravelling the dynamics of a multi-gear fleet – Inputs for fisheries assessment and management under the Common Fisheries Policy

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ABSTRACT

Effective species management requires good knowledge on vessel dynamics, either at a stock basis or through the establishment of multiannual management plans as advisable under the new European Common Fisheries Policy (CFP). Achieving such knowledge on Portuguese multi-gear fisheries is challenging given the large number of species caught and the different management measures applied to potential target species. The latter ranges from no input or output controls to output controls based on individual vessel quotas (IVQ). To provide accurate regional knowledge to the CFP, the dynamics of vessels involved in the trammel net fishery targeting anglerfish (*Lophius* spp.) was characterised based on onboard sampling data and logbook reports. The selected vessels were very dynamic, and were found to target other species such as hake (*Merluccius merluccius*), John Dory (*Zeus faber*) and octopus (*Octopus vulgaris*). Anglerfish landing trends can be explained by changes in abundance, quota availability and shifts/changes in fishing effort. Overall, the dynamics of these vessels varied with area of exploitation, IVQ value and anglerfish total allowable catch (TAC). These results show the influence of different management systems in the dynamics of vessels and the advantage of an IVQ management system, where fishers can spatially and temporally allocate effort. Results also highlight a fishing effort shift towards unregulated species in face of IVQ or TAC restrictions.

1. Introduction

1.1. Fisheries dynamics: multi-gear and mixed-fisheries context

The need to understand and characterize fishing operations of multi-gear[1] fleets is common to many European and global fisheries [1,2]. Several studies have been developed to understand fleet dynamics of mixed-fisheries i.e., fisheries in which more than one species is present in the area being likely to be caught in the same fishing operation, and in which more than one gear can be used [3]. Most of these studies had the goal to identify and characterize groups of vessels or trips with similar exploitation patterns to better regulate and adjust fishing activity (e.g. [1,2,4–10]). These studies contributed to the identification of management units for further stock assessment (e.g. [1,6]) and to a deeper understanding of fishers' behaviour under a mixed-fisheries context (e.g. [2,7]).

However, in many cases fishers are able to easily diversify fishing activities (gear, fishing ground and target species), which precludes further monitoring or management based on fixed groups of fishing vessels [2]. These changes in target species, gear and areas of exploitation may be related to specific management measures, changes in species abundance, decreases in their commercial value or increases in fishing operation costs [5]. Such aspects should be evaluated both in a single-species fishery and in a mixed-fisheries management perspective, following the objectives defined by the European Common Fisheries Policy (CFP) for the conservation of marine biological resources and fisheries management. For example, under the new CFP a multiannual approach to fisheries management is advisable and should reflect the specificities of different fisheries. The design of multiannual plans that *shall cover either single species or in the case of mixed fisheries or where the dynamics of stocks relate to one another, fisheries exploiting several stocks in a relevant geographical area, taking into account knowledge about the interactions between fish stocks, fisheries and marine ecosystems* (EU Regulation No 1380/2013). Therefore, a good characterisation of the fleet dynamics and species catch composition is required to fully implement these new CFP guidelines. This further implies a continued improvement of scientific data.

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[1] Fleets that use a diversity of gears, being able to exploit different ecological communities [6].

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1.2. Portuguese multi-gear fisheries and the anglerfish fishery case study

The Portuguese multi-gear fisheries are difficult to characterize [4]. They involve a large group of vessels, with different sizes, with or without defined fishing grounds and that are usually licensed to operate with multiple fishing gears. The most common gears used are gill and trammel nets with different mesh sizes, longlines and traps. Different gears can be deployed on the same trip according to the target species, which in turn may have (or not) a seasonal character. In 2014, 2978 vessels were assigned to the multi-gear fleet (alongside with 61 trawlers and 148 purse seiners) being responsible for ~62% of the national fisheries revenue (Azores and Madeira Archipelagos excluded). These vessels ranged from 2.8 to 28 m in overall length (LOA) and operated from coastal to more offshore fishing grounds. Consequently, landing profiles are quite diverse within and among vessels since their activity is ruled by a multitude of factors that are measured in order to maximise fishers' profit [11].

To better understand the Portuguese multi-gear fleet dynamics, the trammel net fishery targeting anglerfish (*Lophius* spp.), particularly the white (*Lophius piscatorius* Linnaeus, 1758) and black-bellied (*Lophius budegassa* Spinola, 1807) anglerfish, was selected as a case study. This fishery started in the late 1970's [12] and gained a special interest in the 1980's due to the acceptance of anglerfish in the market trade [13]. Previously, this group of species was discarded by several fisheries or treated as an unimportant by-catch. The decrease in abundance of traditional demersal species rendered them profitable and highly valuable [14]. Anglerfish is also caught by the trawl segment but the majority of catches are attributed to the multi-gear fleet. This fleet is responsible for ~62–100% of the total landings of these species from 1978 to 2014 (Fig. 1). Within this fleet, trammel nets account for ~75–90% of the annual landings of anglerfish (logbook data).

Despite being an important revenue for the multi-gear fleet, it is recognised that most vessels targeting anglerfish are involved in many other fisheries. In 2014, 317 multi-gear vessels had landings of anglerfish (as target or by-catch species). Besides anglerfish, top ten landings (in weight and income) of these vessels included octopus (*Octopus vulgaris*), hake (*Merluccius merluccius*), soles (*Solea* spp.), John Dory (*Zeus faber*), skates (Rajidae) and horse mackerel (*Trachurus trachurus*) (Table 1). Landings of these species vary among vessels due to vessel size and autonomy, area of exploitation, species abundance and commercial value, and to regulations in place.

1.3. Management in place for Portuguese multi-gear fisheries

Management measures may regulate particular fisheries, mostly through technical measures such as gear restrictions and minimum landing sizes, but are mostly implemented for individual stocks. The Iberian anglerfish stocks (ICES Division VIIIc and IXa) are managed by a single annual total allowable catch (TAC), with quota allocation to Portugal, Spain and France, based on historical catches. These national quotas are often restrictive due to quota uptake (Table 2), leading fishers to reallocate their fishing effort. Other target species are managed differently, including management through an individual vessel quota (IVQ) system, as is the case of hake. The IVQ system for hake was implemented in 2006 with clear and defined objectives: to increase spawning biomass and decrease fishing mortality until 2016. The national quota established by the EU is shared by vessels taking part in the fishery, based on historical catches. Individual quotas may range from high to low quantities, leading fishers to individually manage their allocated catch and redistribute fishing effort to other target species to maximise profits. These IVQs are transferable between vessels, between May and early December, but require previous authorisation by the national authorities.

Despite efforts to assess and manage all species, there are some commercially important species lacking any management measure (or assessment). Others do not have input or output controls (i.e., intensity or landing quantity restrictions), relying only on technical management measures such as gear restrictions (e.g. mesh size) or minimum landing size. However, this group of unregulated species (here defined as species with no management measures or with technical measures only) may constitute an important fraction of the total income of the multi-gear fishery and would

Table 1
Ranking and proportion of the total landed (in € and in weight) of multi-gear vessels with landings of anglerfish in 2014 (as target or by-catch species; all vessels included: $n=317$). Multi-gear vessels include vessels that operate mostly with trammel nets, gillnets, longlines and traps.

Landed species	Landings in €		Landings in weight	
	Ranking €	Proportion	Ranking Kg	Proportion
Octopus	1	0.27	1	0.29
Hake	2	0.11	2	0.14
Soles	3	0.07	8	0.03
John dory	4	0.06	9	0.02
Anglerfish	5	0.05	6	0.04
European seabass	6	0.04	11	0.02
Skates	7	0.04	5	0.05
Pouting	8	0.03	4	0.07
Swordfish	9	0.03	10	0.02
Thickback sole	10	0.03	14	0.01
European conger	11	0.02	7	0.03
Horse mackerel	12	0.02	3	0.08
Wreckfish	13	0.02	21	0.00
Cuttlefish	14	0.02	12	0.02
Axillary seabream	15	0.02	13	0.01

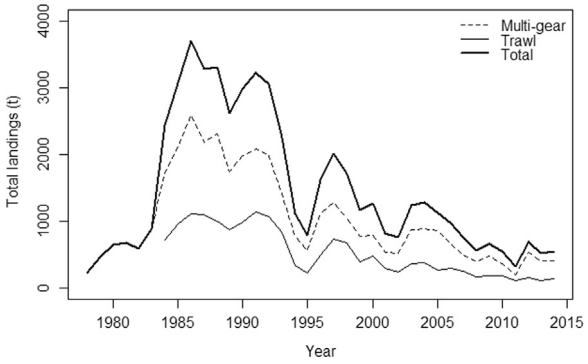

Fig. 1. Landings of anglerfish (*Lophius* spp.) in Portuguese landing ports from ICES Division IXa from 1978 to 2014. Data reported to ICES.

Table 2
Summary of anglerfish quota regulations in Portuguese continental waters (ICES Division IXa) from 2007 to 2014.

Year	Value (t)	70–80% quota (*)	Fisheries closure	Fisheries re-opening	Final closure
2007	324	17 Jun	27 Aug	8 Nov	
2008	324	16 May	4 Aug		
2009	292	18 May	22 Jul		
2010	248	16 Jul	6 Oct		
2011	260	27Apr	10 Jun		
2012	547	15 May			
2013	410	11 Oct		16 Oct	23 Dec
2014	436				

(*) from 2010 onwards the announcement is made when landings are 80% of the permitted quota.