Bio-economic impact assessment of multiannual management plans (MAPs) for Iberian demersal mixed fisheries

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1. Introduction

Bio-economic impact assessment of multiannual management plans (MAPs) for Iberian demersal mixed fisheries have been carried out using FLBEIA. The case study involves two countries Spain and Portugal. The fishing activity of the fleets operating in the area has been divided in 7 fleets depending on the country and the main gear used along the year. In turn the activity of the fleets has been divided in metiers characterized by the gear used and the target stocks. Eight stocks have been included in the model, Southern stock of Hake, Monkfish, Megrim and Four Spot Megrim, Southern Horse Mackerel, Western Horse Mackerel, Blue Whiting and Mackerel. Three management scenarios have been combined with two fleet dynamics scenarios which produced a total of six scenarios. Management scenarios include a scenario with maximum sustainable yield (MSY) fishing mortalities as target and a restriction in TAC variation of 15% until 2020 and two scenarios with the limits of MSY fishing mortality ranges as targets and biomass reference levels as safeguards. Fleet dynamics have been modelled using two different approaches, one based on observed data and a second one based on maximization of profits. All the scenarios have been run from 2016 to 2025.

2. The Case Study

The Atlantic Iberian waters (ICES Divisions VIIIc and IXa) include three areas with different oceanographic characteristics: Gulf of Cadiz with Mediterranean influence, Atlantic front with high upwelling process, and Cantabrian Sea (south area of Bay of Biscay) with transition between subtropical and sub-polar areas. Politically, the Atlantic Iberian waters are compounded of the Spanish and Portuguese national waters. The case study of the Iberian waters is only considering the Atlantic front and the Cantabrian Sea.

However, from an ecological point of view, the narrowness of the Iberian continental shelf provides a common spatial dimension where different fleets share a variety of fishing resources.

As commented before vessels that operate in Atlantic Iberian waters belong to the national fleets of Spain and Portugal. Therefore, the vessels fishing Iberian stocks (ICES VIIIc and IXa) have to apply for a fishing licence to operate in the respective National waters. Both countries classify their national vessels in fleet categories depending of the gear type (trawl, purse seine, gillnet or longline), but both countries leave an independent group for the small-scale fleet.

These fleets operate on a narrow continental shelf where they exploit a variety of fishing resources by using different type of gears (trawl, gillnet, long lines…), forming a common demersal mixed-fisheries fleet. Although recent changes in fishing strategies and gears design have led some traditional demersal fleets to also exploit pelagic species, is not simple the combined management of demersal and pelagic stocks. On the one hand, most of the landings of pelagic stocks are made by fleets (purse seine, hand lines…) without any effect on demersal stocks. On the other hand, the populations of large pelagic species usually inhabit wide oceanic areas, so their life cycle is developed beyond the geographical limits of the case study.

3. The Conditioning

IW case study has been conditioned using different data sources. It implies that a big effort has been deployed to match these different sources and to cover the inconsistencies found between these data bases.

Fleets have been conditioned using data sources obtained through GEPETO project (http://gepetoproject.eu/) with a time series that goes from the year 2010 to the year 2012. The number of vessels by segment and Member State is presented in Table 1 with a description of the fishing gear used.

FLBEIA considers the fleet as the economic unit from the costs side. It implies that the fixed costs are at fleet level and variable costs at metier level. The costs have been obtained from the Annual Economic Report (AER, 2012). To adapt these values to the specific conditioning of the case study, the economic figures have been weighted by the proportion of vessels that each segment has and them converted into weighted averages of the fleets. Figures used in the simulation are presented in Table 1.

From the income side FLBEIA considers that the economic unit is the metier. The reason is that each metier is providing a different catch profile (including landings and discards) that differs in the total income and the composition of it. The diverse casuistic of the IW case study is wide. Table 3 presents the *metiers* considered for the simulation, providing the definition, a description of the fishing gear and the main stock or stocks targeted by each specific metier.

Nine stocks have been introduced in the biological operating model, Black anglerfish (*Lophius budegassa)*, Hake (*Merluccius merluccius*), Four-spot megrim (*Lepidorhombus boscii*), Megrim (*L. whiffiagonis)*, White anglerfish (*Lophius piscatorius)*, South and Western Horse mackerel (*Trachurus trachurus)*, Mackerel (*Scomber scombrus)* and Blue Whiting (*Micromesistius poutassou*). The first six stocks have been simulated using age structured dynamics and the data necessary to condition the model has been taken from ICES assessment working group reports. Western Horse mackerel, blue whiting and mackerel are widely distributed stocks exploited by several fleets apart from those considered here. Although the catch of these stocks is important for the fleets in the case study, the amount of catch harvested by them is small in comparison with the international catch. Hence, the catch of these fleets is supposed to have little impact on the dynamic of the three stocks. As it is practically impossible to include in the model all the fleets that catch these stocks, it has been assumed that the biomass of these stocks stays constant and equal to the average of the last three year biomass in the projection part of the simulation. In the historical period the conditioning has been done using data from working group reports. The MSY targets are those used by ICES to give advice and the Expert working group agreed on using a preliminary ranges based (partially) on ICES methodology. These MSY point estimates and the ranges are given in the table below:

Table 1. MSY point estimates and the ranges

Stock	**MSY**	**Flow**	**Fupp**
Hake (Sout)	0.24	0.17	0.36
Megrim (South)	0.17	0.08	0.19
4 Spot Megrim	0.17	0.11	0.24
Monkfish	0.19	0.13	0.26
Horse Mackerel (South)	0.13	0.09	0.18

Biomass safeguards has been set equal to Btrigger, when it has been defined by the assessment working group and equal to 1.4 times the lowest observed biomass, otherwise. The resulting biomasses are given in the table below:

Table 2. Biomass safeguards for the stocks concerned

Stock	**Biomass safeguard**

	(tonnes)
Hake (Sout)	12 600
Megrim (South)	910
4 Spot Megrim	4 600
Monkfish	2 700
Horse Mackerel (South)	301 800

The fleets in the case study harvest a great number of different stocks, and although big effort has been made to include as much stocks as possible not all the stocks captured by the different *metiers* have been considered (see Tables x , for the explicit stocks and average market price[1]).

The multi-species characteristic of the fisheries studied, makes it practically very difficult to incorporate into the model all the stocks explicitly (not all the stocks caught are assessed; the data is not available at fleet level or even at aggregated level…). To overcome this limitation, an “Others” (OTH) stock which accounts for all the catches of the species not explicitly considered, but that are economically relevant has been created. There are as many “others” stocks as metiers and an average price has been calculated for each of them. Finally catches of these “others” stocks are proportional to the effort deployed by each metier. But no stock dynamics are considered.

Additionally for the Portuguese fleets it has been impossible to obtain income coming from these “others” stocks at metier level. It implies that the two metiers of the DTS fleet segment of the Portuguese fleets have been merged into one.

4. The Model

FLBEIA is a simulation BEM coupled in all its dimensions (economic, biologic and social), it is developed in R using FLR libraries . FLBEIA follows the MSE approach, which is widely used in fisheries management to analyse the performance of management strategies against predefined management objectives, by means of simulation before they are put in place. It consists of simulating the fish stocks and the fleets that exploit them together with the management procedure. The goal is to analyse the performance of different management strategies and identify those strategies that are robust to the uncertainties considered. The simulation algorithm is divided into two blocks, the Operating Model (OM) and the Management Procedure Model (MPM). In FLBEIA the OM is made up of the fish stocks, the

[1] Source: INIAP, IEO and AZTI-Tecnalia.

fleets, the covariates and their interactions (see . The MPM describes the management process and is formed by the observation, assessment and management advice models. The stocks can be age structured or aggregated in biomass and there are no trophic interactions. Fleet activity is divided into *metiers* where *metiers* are defined as trips within a fleet that share the same characteristics in terms of gear used, fishing area and catch profiles.

The stocks can be age structured or aggregated in biomass. The interaction between fish population and catch is done in biomass and the relationship between catch and effort is based on a Cobb Douglas production model , at age level.

The stochasticity in the model is introduced using Monte Carlo simulation and can be introduced in any model parameter. In the simulations it has been introduced only in the biological side (in the stock recruitment relationship) and a Monte Carlo simulation has been performed with xx iterations. The coupled characteristic of FLBEIA implies that this uncertainty is spread through all the remaining dimensions of the model (economic and social).

4.1. Short term dynamics

Short term dynamic models how much effort is exerted and how it is distributed along metiers. There are two possibilities which define the two “extreme” situations.

The first possibility used to mimic mixed fisheries is based on the Fcube method and is used in FLBEIA to approximate mixed fisheries dynamics. The effort share along metiers is given as input data and only the total effort is estimated in each step. First, the effort corresponding to the TAC-share of each stock caught by the fleet is calculated, this returns one effort per stock. The final effort is selected based on the previously calculated efforts. The selection is done using different available options (min the minimum, max the maximum, mean the mean, previous the most similar to the previous year effort and stock-name the effort that produces a catch level equal to the quota share of the stock specified).

The second possibility used to simulate mixed fisheries dynamics calculates the total effort and the effort allocation among metiers that maximises profit. The total effort is constrained by the capacity of the fleet (capacity unit has to be converted in the same unit as effort) and by the catch quota of some of the stocks.

Results are provided using this second possibility in order to capture the reaction of the fleet to the different management scenarios.

4.2. Long term dynamics

This describes the long term dynamics of the fleet or strategic behaviour; the investment or disinvestment of fishermen in new vessels or technological improvements. In FLBEIA the capital dynamics could be modelled through changes in fleet's capacity or changes in fleet's catchability (technological improvements). However, at present, models that dynamically change catchability are not available in FLBEIA. Catchability can vary over time but only if time dependent catchability is provided through input data. Capital can vary according to the model described in . This model relates the investment and disinvestment in new vessels with the ratio between revenue and break even revenue, that is the amount of revenue needed to cover both fixed and variable costs. The annual investment for each fleet is determined by the possible maximum investment multiplied but the profit share that will go to the investment itself; however, investment in new vessels will only occur if the operational days of existing vessels are equal to maximum days.

Then the investment decision will follow the rule below

$$
If \begin{cases}
\frac{REV-BER}{REV} < 0 \;\; and \;\; \Pr ofshare \left| \frac{REV-BER}{REV} \right| < 0.2 \;\; Investment = \Pr ofshare \times \frac{REV-BER}{REV} \\
\frac{REV-BER}{REV} < 0 \;\; and \;\; \Pr ofshare \left| \frac{REV-BER}{REV} \right| > 0.2 \;\; Investment = -0.2 * Fleet_{t-1} \\
\frac{REV-BER}{REV} > 0 \;\; and \;\; \Pr ofshare \left| \frac{REV-BER}{REV} \right| < 0.1 \;\; Investment = \Pr ofshare \times \frac{REV-BER}{REV} \\
\frac{REV-BER}{REV} > 0 \;\; and \;\; \Pr ofshare \left| \frac{REV-BER}{REV} \right| > 0.1 \;\; Investment = 0.1 * Fleet_{t-1}
\end{cases}
$$

Where 0.1 stands for the limit on the increase of the fleet relative to the previous year and 0.2 stands for the limit on the decrease of the fleet relative to the previous year. The increase in number of vessels is then obtained dividing the final investment in new vessels, by the maximum number of days that a vessel operates in a year.

4.3. Inter Year flexibility

FLBEIA is able to simulate inter-year flexibility. Nevertheless this option has not been used in the simulations performed for the sake of the robustness of the final results.

4.4. Landing Obligation

FLBEIA is able to simulation the landing obligation as defined by the CFP by calculating the necessary effort to catch the quota of the more restrictive stock. In the simulations performed landing obligation has been simulated using this approach

FLBEIA it is able to simulate the exemptions anticipated in the CFP, specially the inter-species flexibility and de minimis. Nevertheless these two options have been not used in the final simulations due to different reasons.

The case of de minimis (as the inter year flexibility) results obtained create some effects that we have not been able to explain. For the sake of the robustness of the final results the group has decided to switch off this option.

The case of the inter-species flexibility the reason for not using it is the existing un-clarification in terms of how to implement it, in particular in terms of if the donor stocks and the receivers stocks are constrained for any reason. (beyond the “good” biological status of the receiver)

4.5. Scenarios

Six scenarios have been run, combining a management strategy with a fleet dynamic. The management strategy scheme is shown in the figure below.

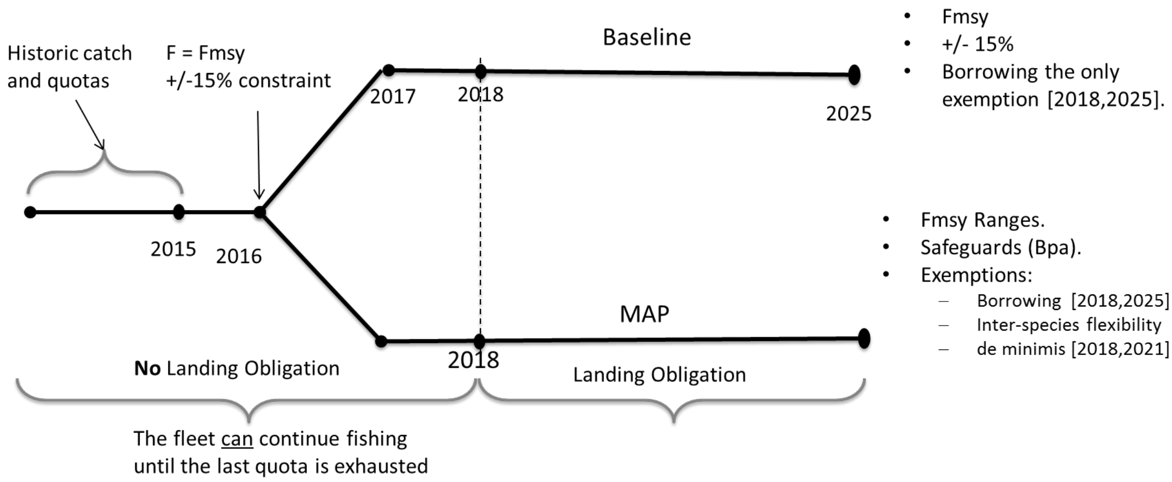

Figure 1. Management strategy scheme

The observed data ranges up to 2012 and the simulation started in 2013. From 2013 to 2016 all the scenarios share the same management strategy, namely:

- Historical TACs and quotas from 2013 to 2015.
- In 2016, TAC based on Fmsy with a +/-15% constraint in catch variation.

The management strategy was combined with the two fleet dynamics, traditional and profit maximization.

From 2017 the management strategy has been divided in three different strategies which produced the six scenarios described in the table below.

Management Strategies from 2017:

- CFP: TAC advice is generated based on Fmsy and until 2020 there is +/-15% TAC variation constraint. Since 2020 the advice is based on Fmsy whatever the resulting catch is.
- MAP – Upper: TAC advice is generated based on the upper limit of Fmsy range. There is a biomass safeguard so that if a stock is or falls below safeguard levels, the strategy is to rebuild it above such levels in 5 years.
- MAP – Lower: TAC advice is generated based on the lower limit of Fmsy range. There is a biomass safeguard so that if a stock is or falls below safeguard levels, the strategy is to rebuild it above such levels in 5 years.

Mathematically the harvest control rule associated to the safeguards can be written as:

$$F_{adv} = \begin{cases} F_{tg} & \text{if } SSB_y \geq B_{pa} \\ min(F, F_{tg}) : SSB_{y+1}[F] = SSB_y + \frac{(B_{pa} - SSB_y)}{K} & \text{if } SSB_y > B_{pa} \end{cases} \quad (1)$$

Where K is equal to:

- Five if y is the first consecutive year were SSB was forecasted to be below Bpa.
- Five minus the number of consecutive years that SSB has been forecasted to be below Bpa. If this number is equal or lower than zero K is equal one, i.e F_{adv} is such that Bpa is reached right after the TAC year.

All together the scenarios can be summarized as shown in the table below.

Table 3. Scenarios in the simulation

Scenario	Management Strategy	Fleet Dynamic
cfp_trad	CFP	Traditional
cfp_mpro	CFP	Profit

		Maximization
map_upp_trad	MAP – Upper Limit	Traditional
map_upp_trad	MAP – Upper Limit	Profit Maximization
map_low_trad	MAP – Lower Limit	Traditional
map_low_trad	MAP – Lower Limit	Profit Maximization

5. Results

5.1. Traditional Fleet Dynamics

The fishing mortalities for all the stocks in 2025 under the management scenario based on the CFP (cfp_trad scenario) were well below MSY targets (Figure 1). For those stocks other than hake fishing mortality was even below the lower limit. In the management plan scenario with Flow as target (mnf_lo_trad) all the fishing mortalities were below the lower fishing mortality limit Flow (Figure 1). In the scenario with Fup as target (mnf_up_trad) the fishing mortalities of Hake and of the two megrims were inside the fishing mortality ranges, on the contrary that of Horse Mackerel and Monkfish was below the lower limit. The fishing mortality of hake was the only one above the MSY target.

The fishing mortalities decreased in the initial years of the simulation where the historical TACs were applied (2013-215, Figure 2). However, they increased significantly in 2016 and 2017. For Hake and Four Spot megrim they were well above the upper limit in all the scenarios, especially in the case of Hake. With the introduction of landing obligation in 2018 the fishing mortalities decreased sharply for all the stocks and scenarios. Afterwards they situated below lower limit for all the stocks during some years and increased above the lower limit in the final years of the simulation. The median fishing mortalities were always the highest in the Upper limit scenario (mnf_up_trad) and lowest in the Lower limit scenario (mnf_lo_trad). In the Upper limit scenario the fishing mortalities decreased until zero in some of the scenarios because the SSB of Horse Mackerel was below the biomass safeguard during some years.

The SSB of the megrims and of monkfish was above the safeguard in all the iterations and years (Figure 3). Hake's SSB in the upper limit scenario was below the target in some iterations in 2018 but then it started increased and maintained above the safeguard in the whole projection and all the scenarios. Horse Mackerel's SSB in upper limit and CFP scenarios was below the safeguard in more than 5% of the iterations in most of the years since 2018. In median the highest SSB was obtained in the lower limit scenarios and the lowest in the upper limit scenario.

For all the fleets but Portuguese polyvalent gear fleet (PGP_PT), fishing effort increased in the initial part of the simulation (until 2017) in relation to historical efforts (2010-2012, Figure 4). Landing obligation produced a sharp decrease in effort and for all the fleets and scenarios it maintained below historical levels since 2018. The highest effort level was observed in the Upper limit scenario and the lowest in the Lower limit scenario.

The revenue in the initial years of the simulation fluctuated around the mean historical revenue for all the fleets but Portuguese polyvalent gear fleet (PGP_PT, Figure 5) and in 2016 and 2017 it increased above it in most of the cases. Landing obligation produced a high reduction in the revenue of all the fleets in all the scenarios. The revenue of Spanish fleets increased since 2020 and stabilized after 2022. The revenue of Spanish fixed nets (DFN_SP) exceeded the historical revenue in the upper limit scenario in all the scenarios, in the case of the other two Spanish fleets the historical level was only exceeded in some of the iterations. For all the fleets the highest revenue was obtained in the upper limit scenario and the lowest in the lower limit scenario.

The profits and the revenue followed similar trends (Figure 6). There were significant differences in 2017. In this year the profits in the Upper limit scenario were not the highest for all the fleets. In the case of Spanish longliners (HOK_SP) the lowest profits were obtained in the upper limit scenario, in the case of trawlers (DTS_PT and DTS_SP) the profits in upper limit and MSY scenarios were equal and in the case of Spanish fixed (DFN_SP) netters the profits in the upper limit scenario were between the profits in the other two scenarios. In the long term the obtained profits were closer than revenue to average historical level. In the case of Spanish Fixed nets and Trawlers the average historical profit level was reached in median even in the CFP scenario.

In 2016 and 2017 there were significant overquota catches for some stocks in all the scenarios. By definition until 2017 all the fleets stopped fishing when the quota of the specified stock was exhausted. In the case of Portuguese trawlers, the stock was Hake and as they have undersize discards for this stock the resulting catch before 2017 was above the quota. After LO, as flexibility and exemptions were not applied, the catches were always equal or lower than the quota. For Spanish Fixed netters and Longliners Hake was the stock that restricted the effort in the whole projection since the introduction of landing obligation (Figure 7 and Figure 10). The restrictor in the case of Portuguese trawlers was monkfish (Figure 8). Spanish trawlers were restricted by Hake Quota in the initial period of landing obligation and then they were restricted by Hake insome cases and by Horse Mackerel in other cases (Figure 9). Finally Portuguese trawlers were restricted by monkfish in the whole projection (Figure 11)

5.2. Maximum Profit dynamics

Fishing mortalities for all the stocks in 2025 under the management scenario based on the CFP and maximum profit fleet dynamics (cfp_mpro scenario) were well below MSY targets (Figure 12). For those stocks other than hake fishing mortality was even below the lower limit. In the management plan scenario with Flow as target (mnf_lo_mpro) all the fishing mortalities were below the lower fishing mortality limit Flow (Figure 1) expect that of hake that was just in the lower limit. In the scenario with Fupp as target (mnf_up_mpro) the fishing mortalities of Hake and of the two megrims were inside the fishing mortality ranges, on the contrary that of Horse Mackerel and Monkfish was below the lower limit. The fishing mortality of Four Spot Megrim was the only one above the MSY target.

All the fishing mortalities increased significantly after 2013 (Figure 13). For Hake and Four Spot megrim they were well above the upper limit in all the scenarios, especially in the case of Hake. With the introduction of landing obligation in 2018 the fishing mortalities decreased sharply for all the stocks and scenarios. Afterwards, in median, they situated below the specific targets in each scenario for all the stocks except of Four Spot Megrim. For this stocks the fishing mortality, in median, stabilized around the targets in the long term.

The SSBs of megrim and of monkfish were above the safeguard in all the iterations and years (Figure 14). Hake's SSB in all the scenarios was below the target in some iterations from 215 to 2018 but then it started increased and maintained above the safeguard in the whole projection and all the scenarios. Horse Mackerel's SSB in upper limit and CFP scenarios was below the safeguard in more than 5% of the iterations in most of the years since 2018. The SSB of Four Spot megrim was below the safeguard in 2018 in some of the iterations in upper limit scenario. In median the highest SSB was obtained in the lower limit scenarios and the lowest in the upper limit scenario.

For all the fleets but Portuguese polyvalent gear fleet (PGP_PT) the effort increased in the initial part of the simulation (until 2017) in relation to historical efforts (2010-2012, Figure 15). Landing obligation produced a sharp decreased in effort and for all the fleets and scenarios it maintained below historical levels since 2018. In the long term the highest effort level was observed in upper limit scenario and the lowest in the lower limit scenario. In the short term the CFP scenario produced higher or equal effort level in the case of trawlers.

The revenue in the initial years of the simulation fluctuated around the mean historical revenue for all the fleets but Portuguese polyvalent gear fleet (PGP_PT, Figure 16) and in 2016 and 2017 it increased above it in most of the cases. Landing obligation produced a high decreased in the revenue of all the fleets in all the scenarios. The revenue of Spanish non-trawlers fleets increased since 2020 and stabilized after 2022. That of Spanish trawlers reached a peak in 2022 an then decreased . The revenue of Spanish fixed nets (DFN_SP) exceeded the historical revenue in the upper limit scenario in some of the scenarios. For all the fleets the highest revenue was obtained in the upper limit scenario and the lowest in the lower limit scenario. In the short term the CFP scenario produced higher or equal revenue level in the case of trawlers and fixed nets.

The profits and the revenue followed similar trends (Figure 17). There were significant differences in 2017. In this year the profits in upper limit scenario were not the highest for all the fleets. In the case of Spanish longliners (HOK_SP) the lowest profits were obtained in the upper limit scenario, in the case of trawlers and fixed netters (DTS_PT, DTS_SP and DFN_SP) the CFP scenario produced the highest profits. In the long term the obtained profits were closer than revenue to average historical level. In the case of Spanish Fixed nets and Trawlers the average historical profit level was reached in median even in the CFP scenario.

In 2016 and 2017 there were significant overquota catches for some stocks in all the scenarios. By definition until 2017 all the fleets stopped fishing when the quota of the specified stock was exhausted. In the case of Portuguese trawlers, the stock was Hake and as they have undersize discards for this stock the resulting catch before 2017 was above the quota. After LO, as flexibility and exemptions were not applied, the catches were always equal or lower than the quota. For Spanish Fixed netters and Longliners Hake was the stock that restricted the effort in the whole projection since the introduction of landing obligation (Figure 18 and Figure 21). The restrictor in the case of Portuguese trawlers was monkfish (Figure 19). Spanish trawlers were restricted by different stock depending on the scenario and iteration, the unique stock that never restricted the effort was monkfish. Finally Portuguese trawlers were restricted by monkfish in the whole projection (Figure 11)

6. Tables

Table 1. Fleets in the fishery: average 2010-2012

Fleet	**Number of Vessels Spain**	**Number of Vessels Portugal**	**Description**
DFN0010	391	0	
DFN1012	136	0	
DFN1218	183	0	Gillnetters
DFN1824	29	0	
DFN2440	6	0	
DTS0010	0	6	Trawlers
DTS1218	2	9	
DTS1824	5	18	

DTS2440	103	46	
HOK0010	127	0	
HOK1012	64	0	
HOK1218	81	0	Longliners
HOK1824	38	0	
HOK2440	19	0	
PGP0010	0	992	
PGP1012	0	100	
PGP1218	0	178	Polyvalent
PGP1824	0	43	
PGP2440	0	4	
PSX0010	37	6	
PSX1012	18	12	
PSX1218	72	23	Purse Seiners
PSX1824	74	49	
PSX2440	90	16	

Source: IEO

Table 2. Economic conditioning of the fleets considered in the simulation

	Portugal			**Spain**				**Units**
Variable	**DTS**	**PS**	**PGP**	**DTS**	**DFN**	**HOK**	**PS**	**1000€**
Fuel Cost	790	457	23	561	46	46	401	€/days
Crew Cost	30%	46%	36%	24%	40%	21%	45%	% from the fishing income
Variable Cost	365	531	14	264	51	86	533	€/days
Fixed Cost	19.130	15.523	602	14.557	2.527	4.704	17.924	€/vessel/year
Capital Cost	357.306	68.973	15.904	57.762	4.519	10.848	49.586	€/vessel/year
Depreciation	113.440	12.757	3.883	57.762	4.519	10.848	49.586	€/vessel/year
Max days	250	220	220	297	220	220	220	days
FTE (direct)	7	12	1	5	2	2	8	FTE per vessel

Source: AER 2014

Table 3. Fleets and *Metiers* in the simulation

Fleet	Metier	Description	Stocks
DFN	GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Hake
	GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60-79 mm	Horse Mackerel
	GNS_DEF_80-99_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 80-99 mm	Mackerel
	GTR_DEF_60-79_0_0	Trammel net targeting demersal fish with mesh sizes within the range 60-79 mm	Monkfish
	LHM_DEF_0_0_0	Hand line targeting demersal fish	Others
	LLS_DEF_0_0_0	Set longline targeting demersal fish	
	PS_SPF_0_0_0	Purse seiner targeting pelagic species	
DTS	OTB_DEF_>=55_0_0	Bottom otter trawl targeting demersal fish using mesh sizes larger than 55 mm	Blue Whiting
	OTB_MPD_>=55_0_0	Bottom otter trawl targeting mixed crustaceans and demersal fish using mesh sizes larger than 55 mm	Hake
	PS_SPF_0_0_0	Purse seiner targeting pelagic species	Horse Mackerel
	PTB_MPD_>=55_0_0	Bottom pair trawl targeting mixed pelagic and demersal fish using mesh sizes larger than 55 mm	Mackerel
			Megrim
			Megrim (4 Spot)
			Monkfish
			Others
HOOK	GNS_DEF_>=100_0_0	Set gillnet targeting demersal fish with mesh sizes larger than 100 mm	Hake
	GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60-79 mm	Horse Mackerel
	GNS_DEF_80-99_0_0	Set gillnet targeting demersal fish with	Mackerel

		mesh sizes within the range 80-99 mm	
	GTR_DEF_60-79_0_0	Trammel net targeting demersal fish with mesh sizes within the range 60-79 mm	Monkfish
	LHM_DEF_0_0_0	Hand line targeting demersal fish	Others
	LLS_DEF_0_0_0	Set longline targeting demersal fish	
	PS_SPF_0_0_0	Purse seiner targeting pelagic species	
PS	GNS_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 60-79 mm	Horse Mackerel
	GTR_DEF_60-79_0_0	Set gillnet targeting demersal fish with mesh sizes within the range 80-99 mm	Mackerel
	PS_SPF_0_0_0	Purse seiner targeting pelagic species	Others

Source: IEO

Table 4. Stocks considered and first sale prices for Spanish and Portuguese fleets

Code	Common name	Scientific name	Stock	Average Price Spain	Average Price Portugal
ANK	Black anglerfish	*Lophius budegassa*	VIIIc-IXa	4.92€	4.56€
HKE	Hake	*Merluccius merluccius*	VIIIc-IXa	3.25€	2.63€
LDB	Four-spot megrim	*Lepidorhombus boscii*	VIIIc-IXa	4.17€	2.35€
MEG	Megrim	*L. whiffiagonis*	VIIIc-IXa	4.17€	2.35€
MON	White anglerfish	*Lophius piscatorius*	VIIIc-IXa	4.92€	4.56€
HOM	Horse mackerel	*Trachurus trachurus*		0.94€	1.62€
HOM	Horse mackerel	*Trachurus trachurus*	VIIIc	0.94€	1.62€
MAC	Mackerel	*Scomber scombrus*		0.98€	0.42€
WHG	Blue Whiting			0.99€	0.70
		Metiers			
OTH	Others	GNS_DEF_>100		6.40€	-
OTH	Others	GNS_DEF_60_79		4.15€	-
OTH	Others	GNS_DEF_80_99		3.41€	-
OTH	Others	GTR_DEF_60_79		5.86€	-
OTH	Others	LHM_DEF		5.99€	-
OTH	Others	LHM_SPF		1.26€	-
OTH	Others	LHM_DEF		4.03€	-

OTH	Others	OTB_DEF_>55	2.64€	-
OTH	Others	OTB_MPD_>55	1.13€	-
OTH	Others	PS_SPF	1.05€	-
OTH	Others	PTB_MPD_>55	1.29€	-
OTH	Others	PGP	-	0.55€
OTH	Others	DTS	-	4.91€

Source: AZTI, IEO and INIAP

7. Figures

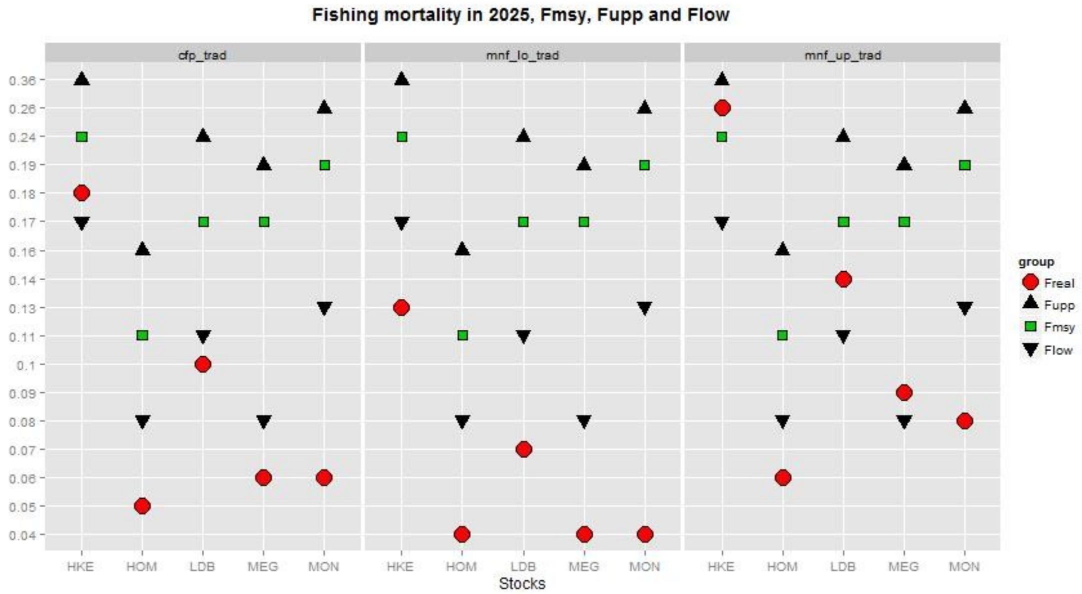

Figure 1. Reference fishing mortality in 2025 (red circles) in Traditional fleet dynamics scenarios. Fmsy (green square), Flow and Fupp (black triangles).

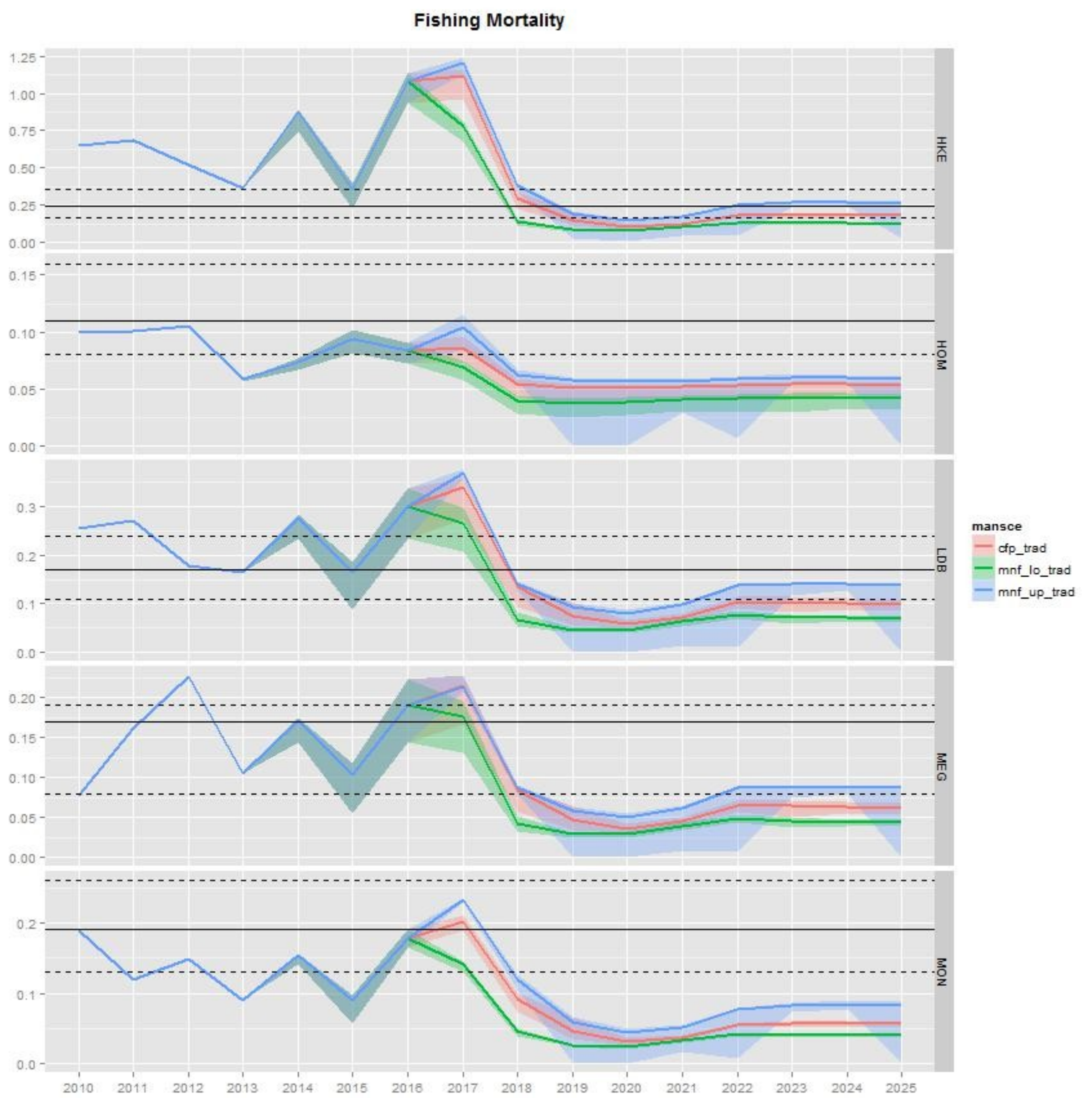

Figure 2. Reference fishing mortality time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The horizontal black lines correspond with Fmsy (solid lines) and upper and lower limits (dashed lines).

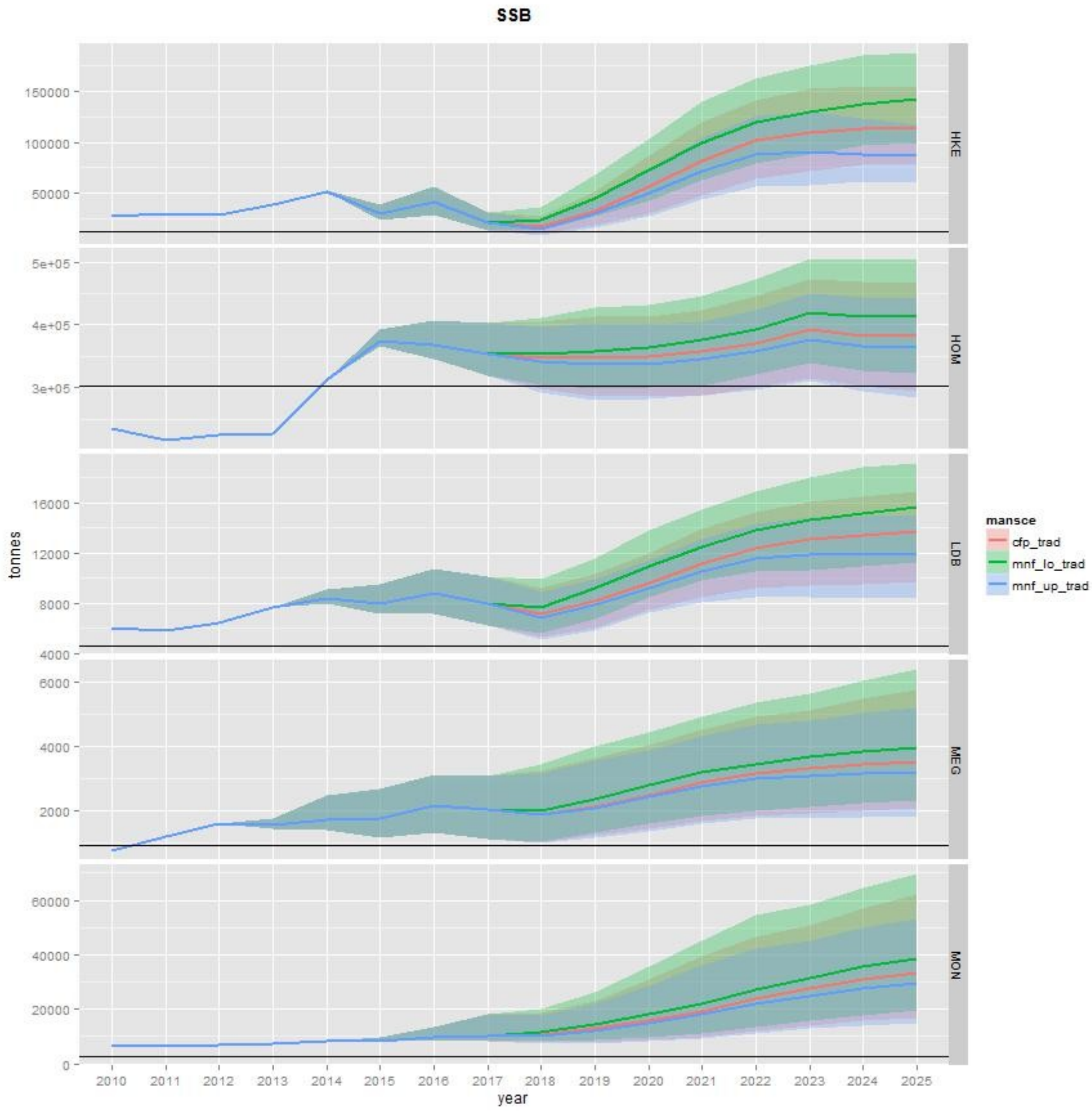

Figure 3. Spawning stock biomass (SSB) time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The horizontal black line corresponds with SSB safeguard.

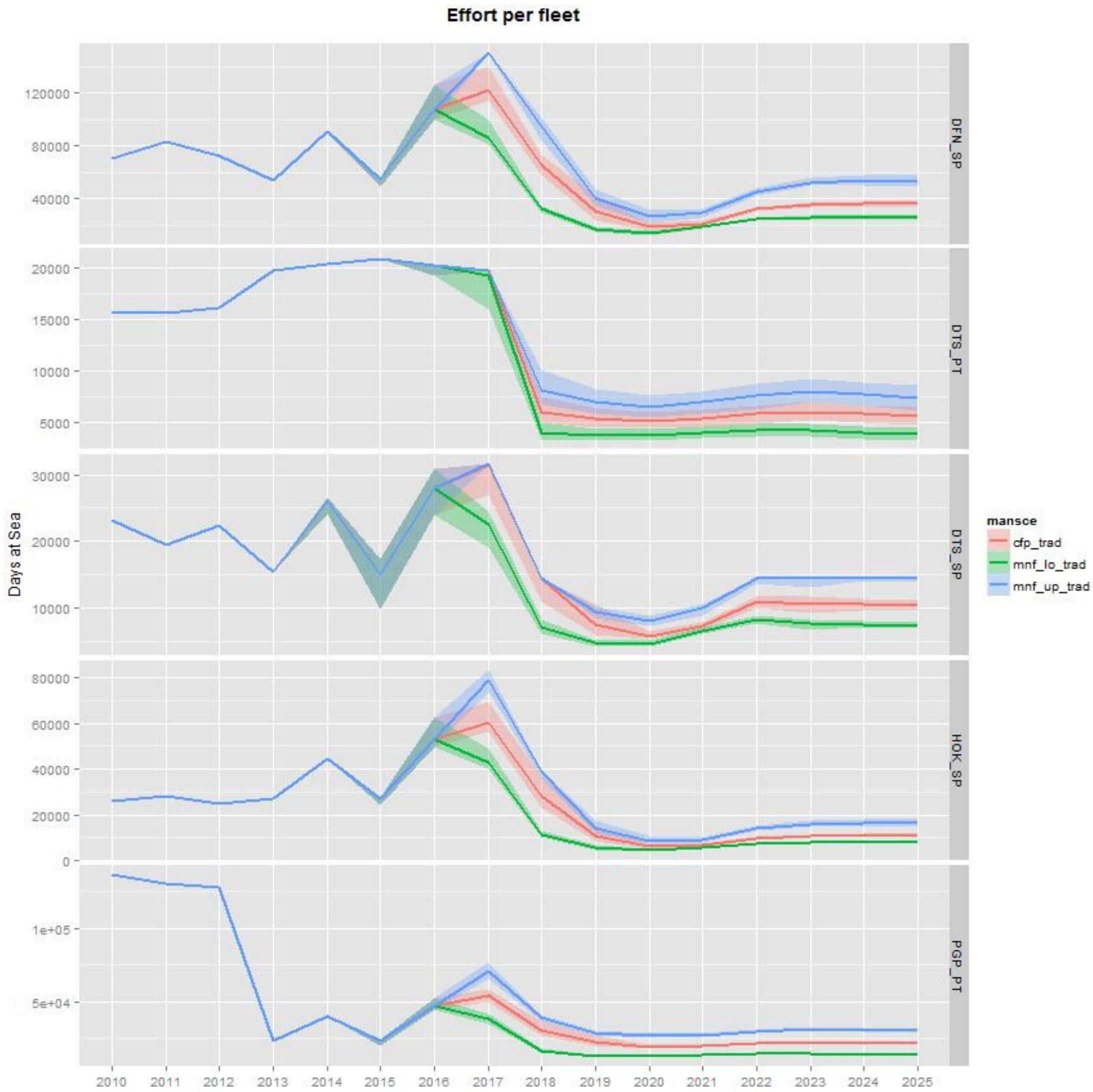

Figure 4. Effort time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

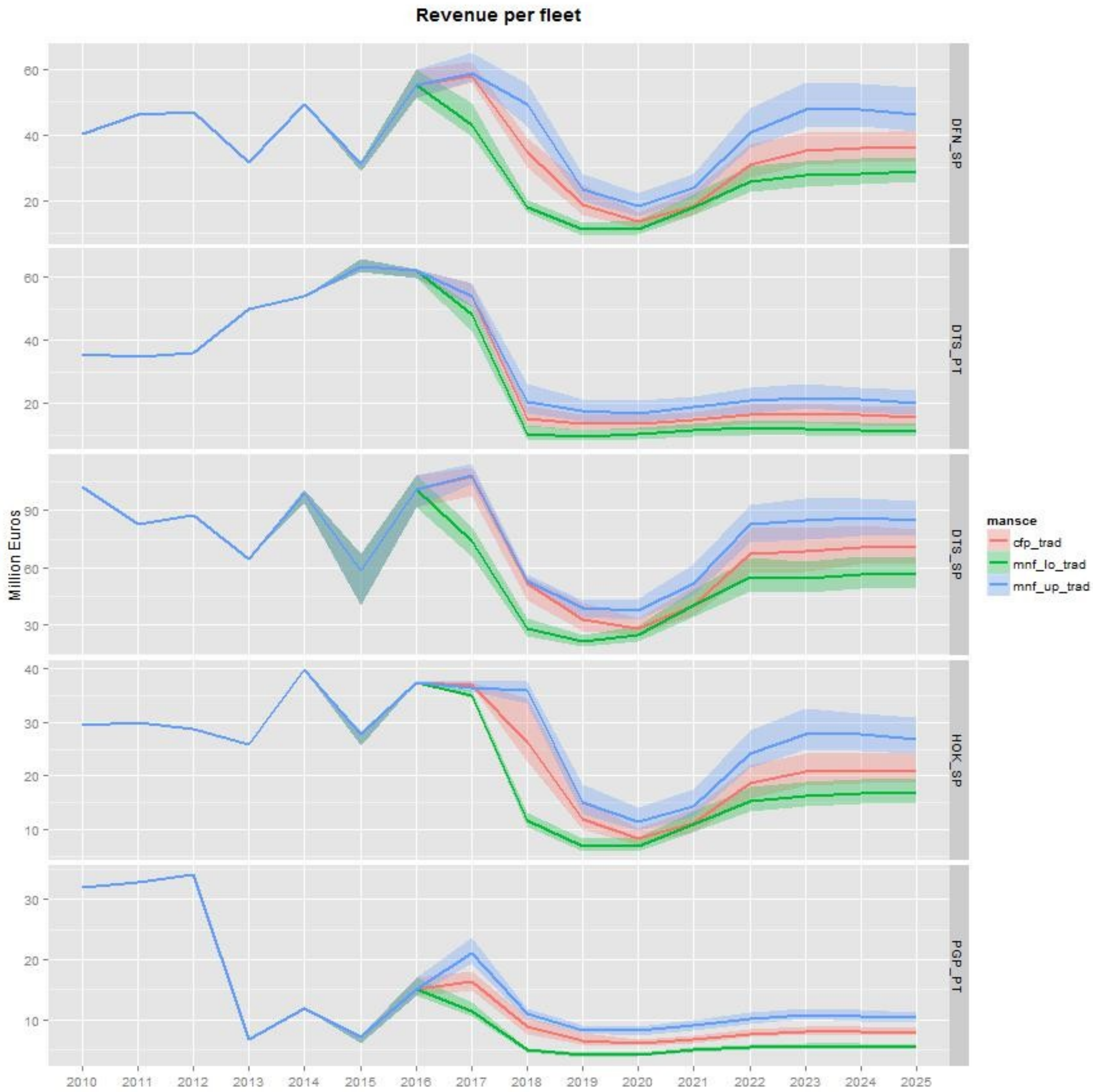

Figure 5. Revenue time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

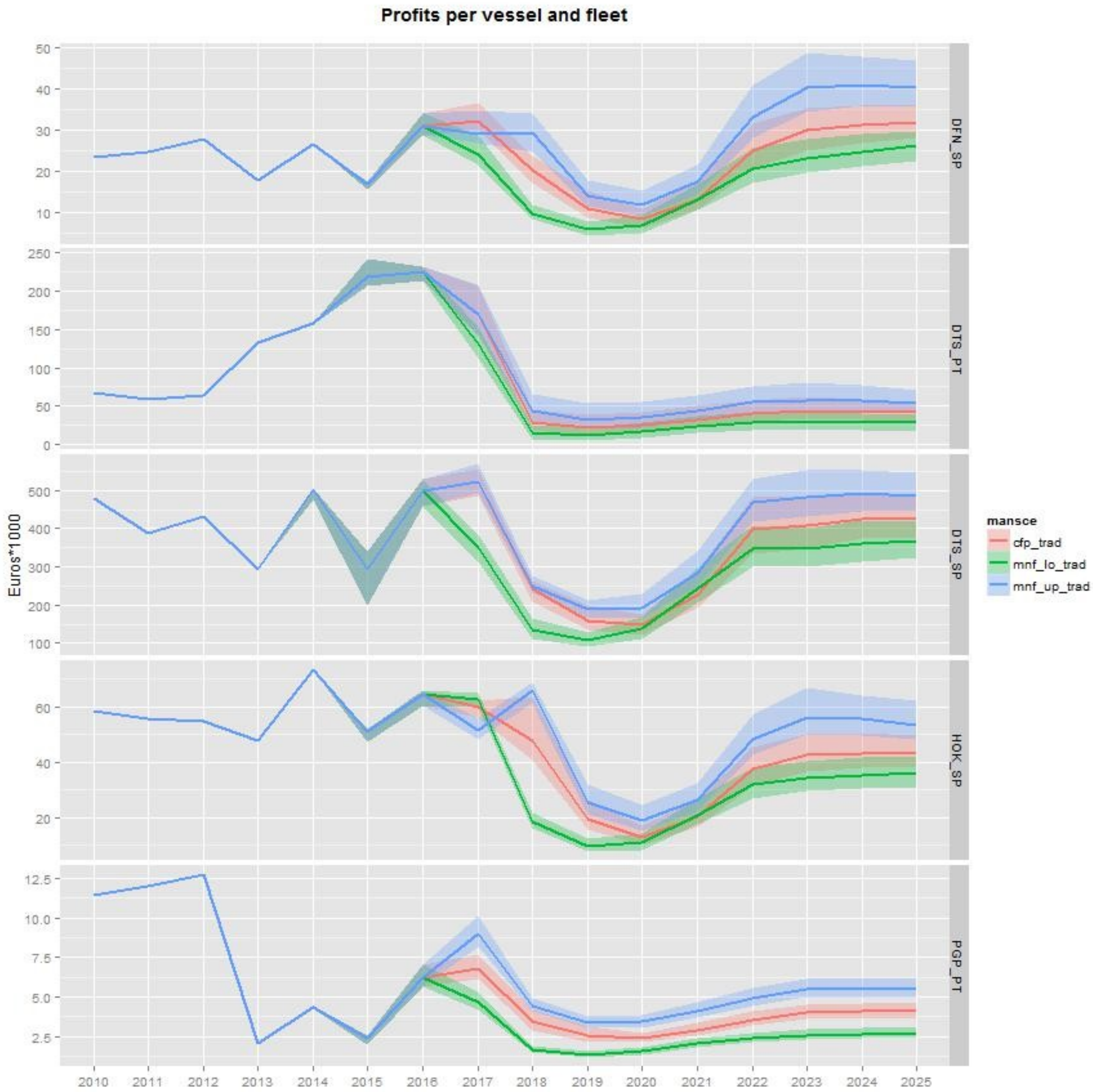

Figure 6. Profits per vessel time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

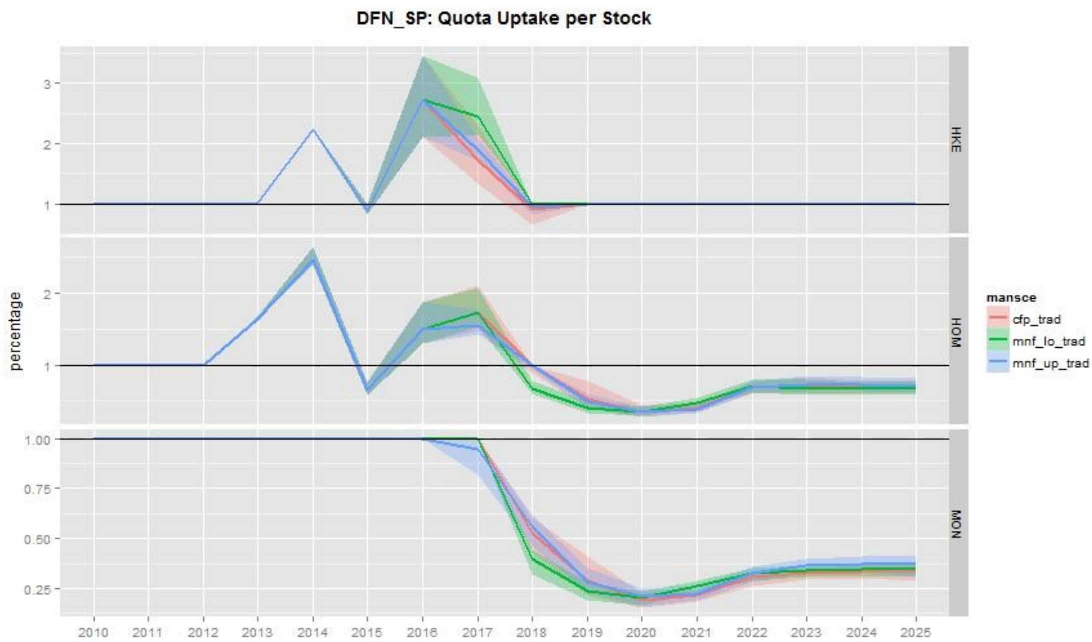

Figure 7. Quota uptake time series for DFN_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

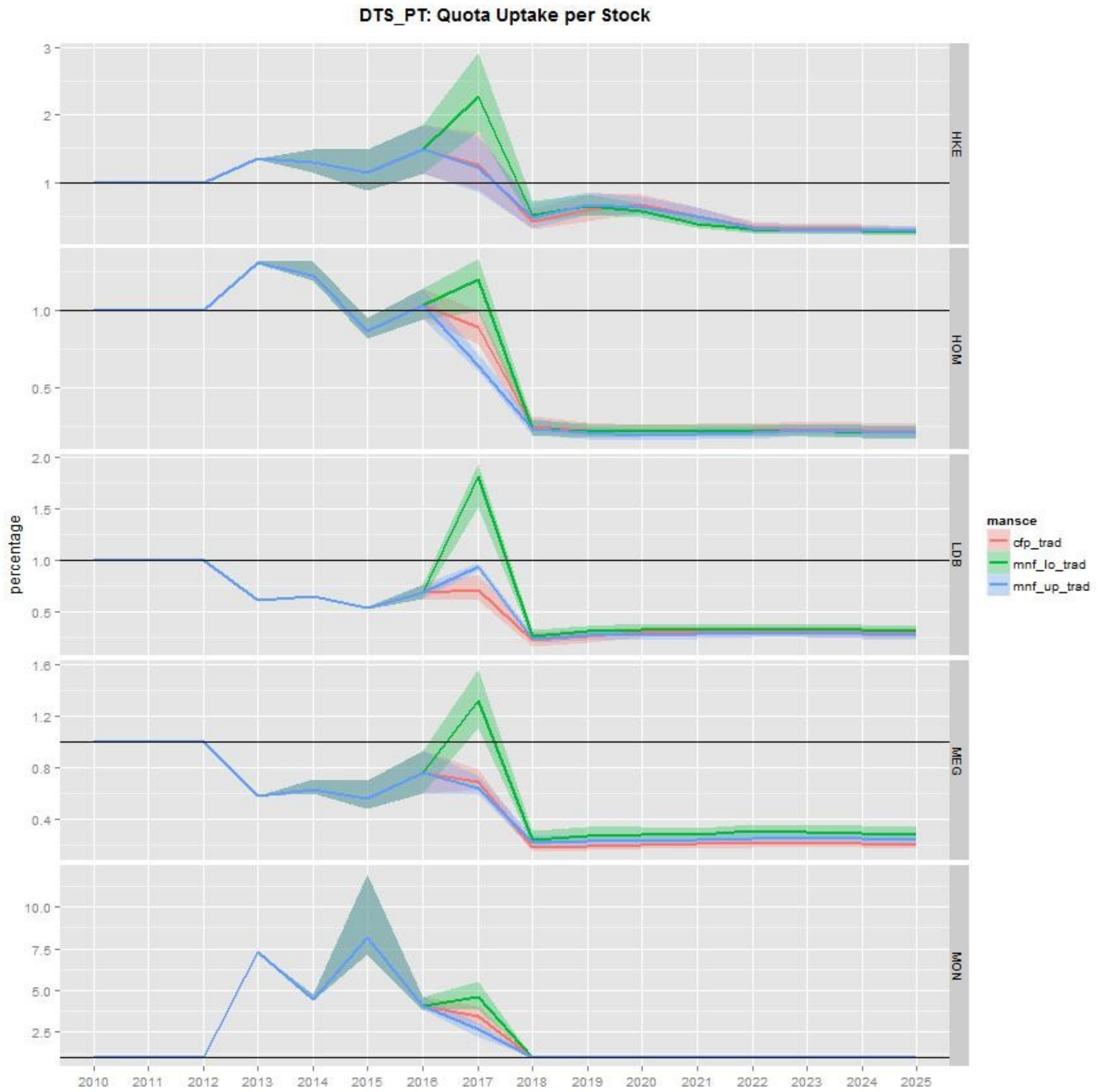

Figure 8. Quota uptake time series for DTS_PT fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

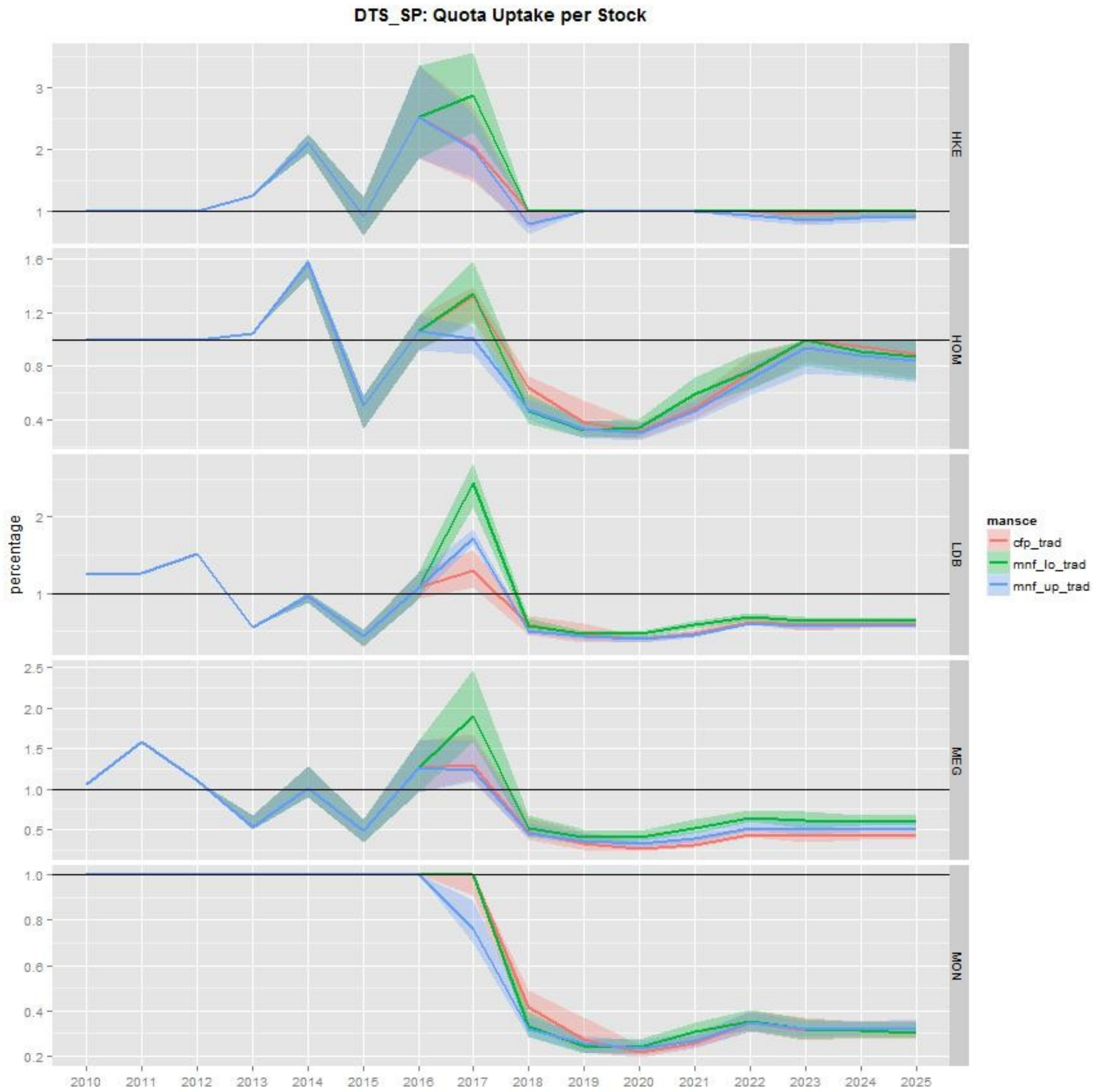

Figure 9. Quota uptake time series for DTS_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

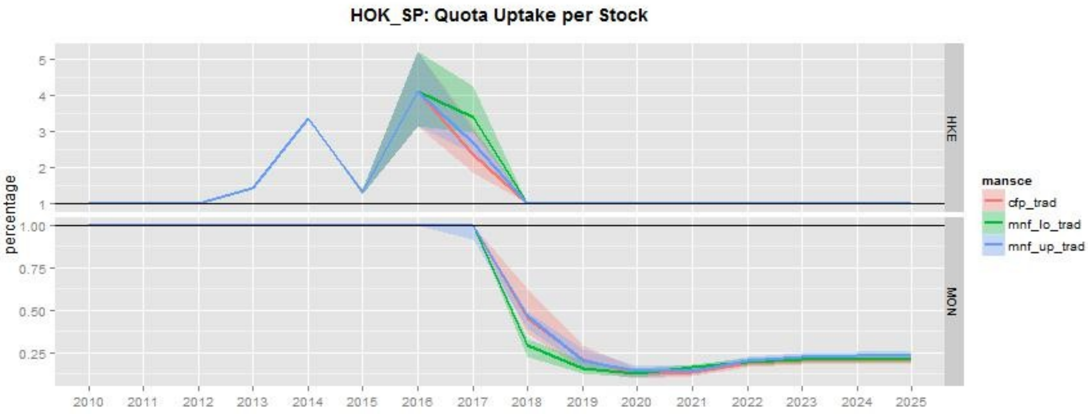

Figure 10. Quota uptake time series for HOK_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

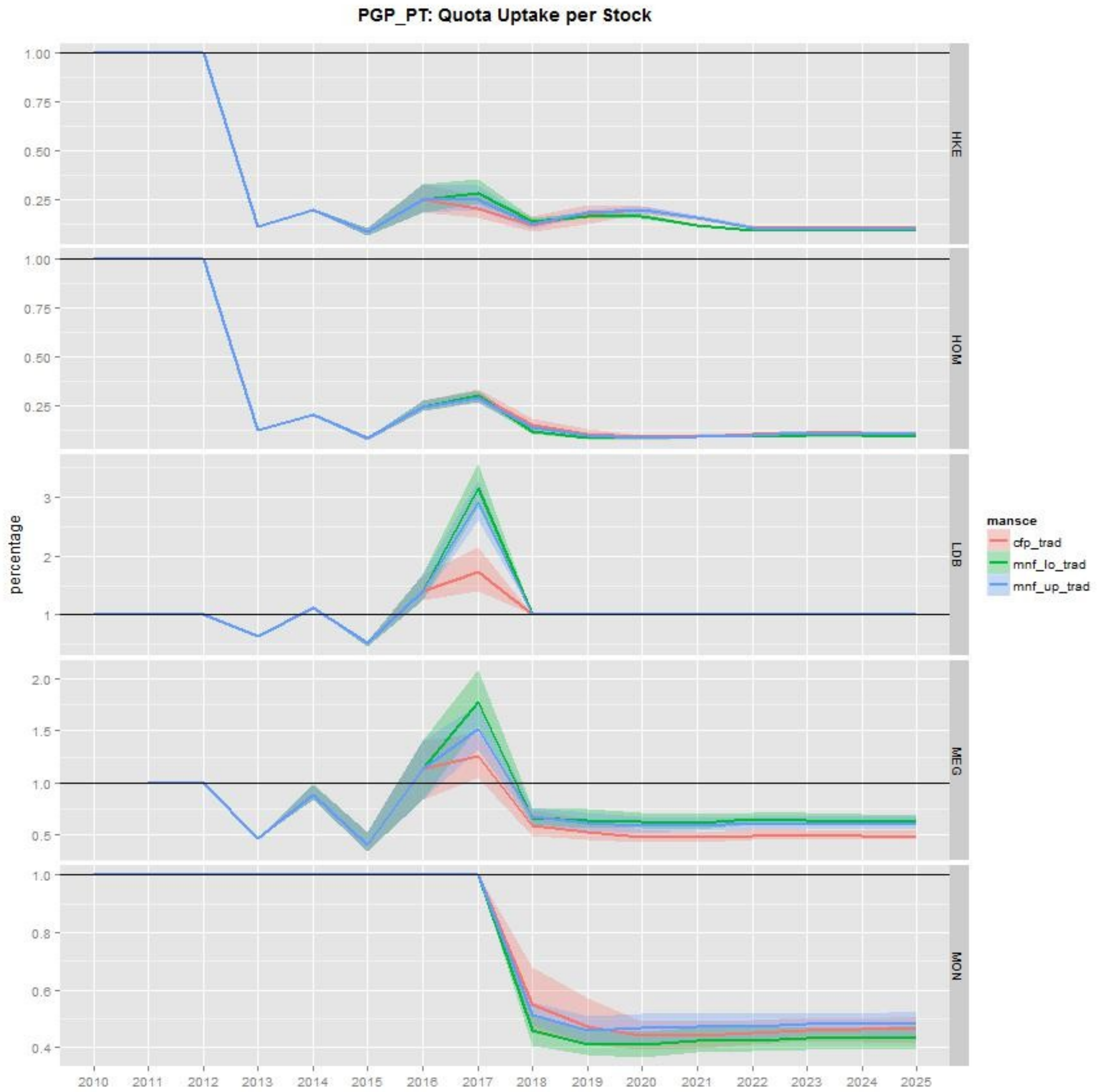

Figure 11. Quota uptake time series for PGP_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

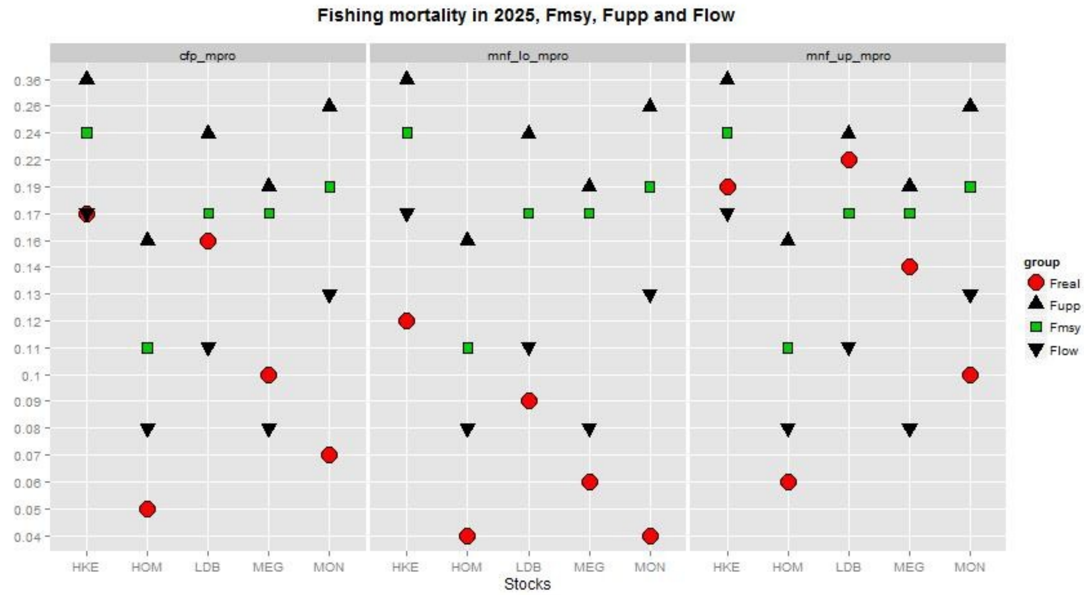

Figure 12. Reference fishing mortality in 2025 (red circles) in Traditional fleet dynamics scenarios. Fmsy (green square), Flow and Fupp (black triangles).

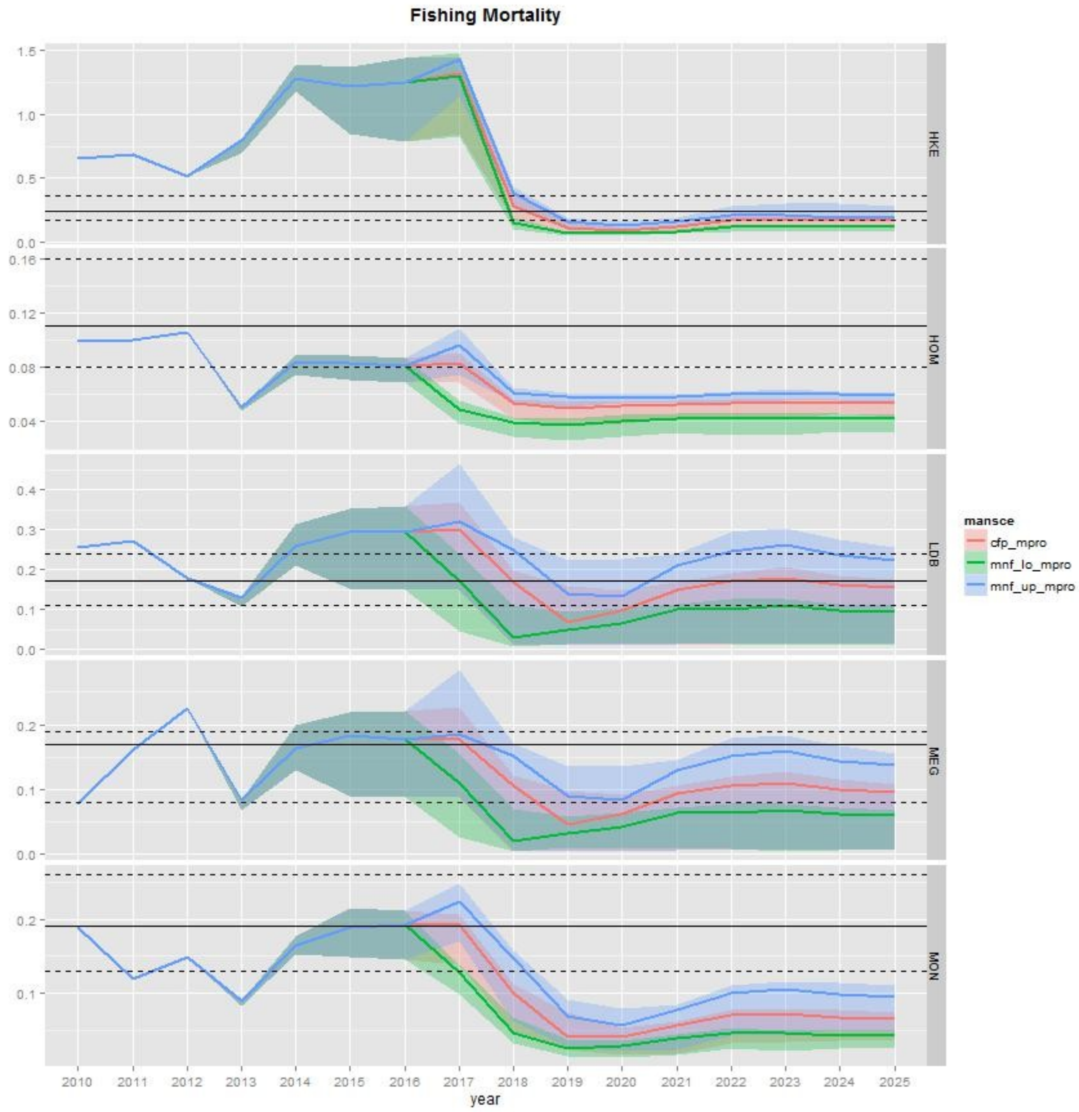

Figure 13. Reference fishing mortality time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The horizontal black lines correspond with Fmsy (solid lines) and upper and lower limits (dashed lines).

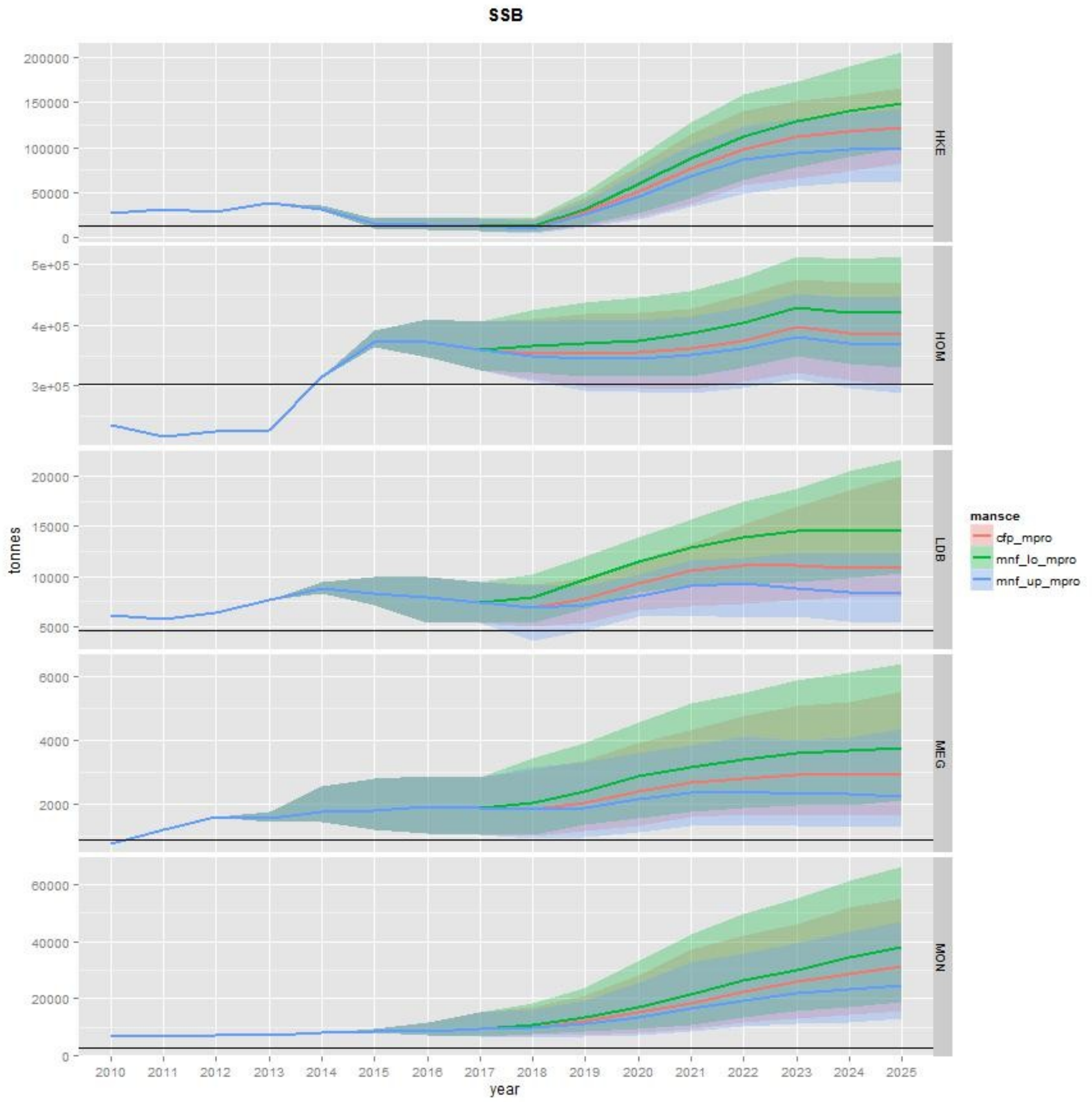

Figure 14. Spawning stock biomass (SSB) time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The horizontal black line corresponds with SSB safeguard.

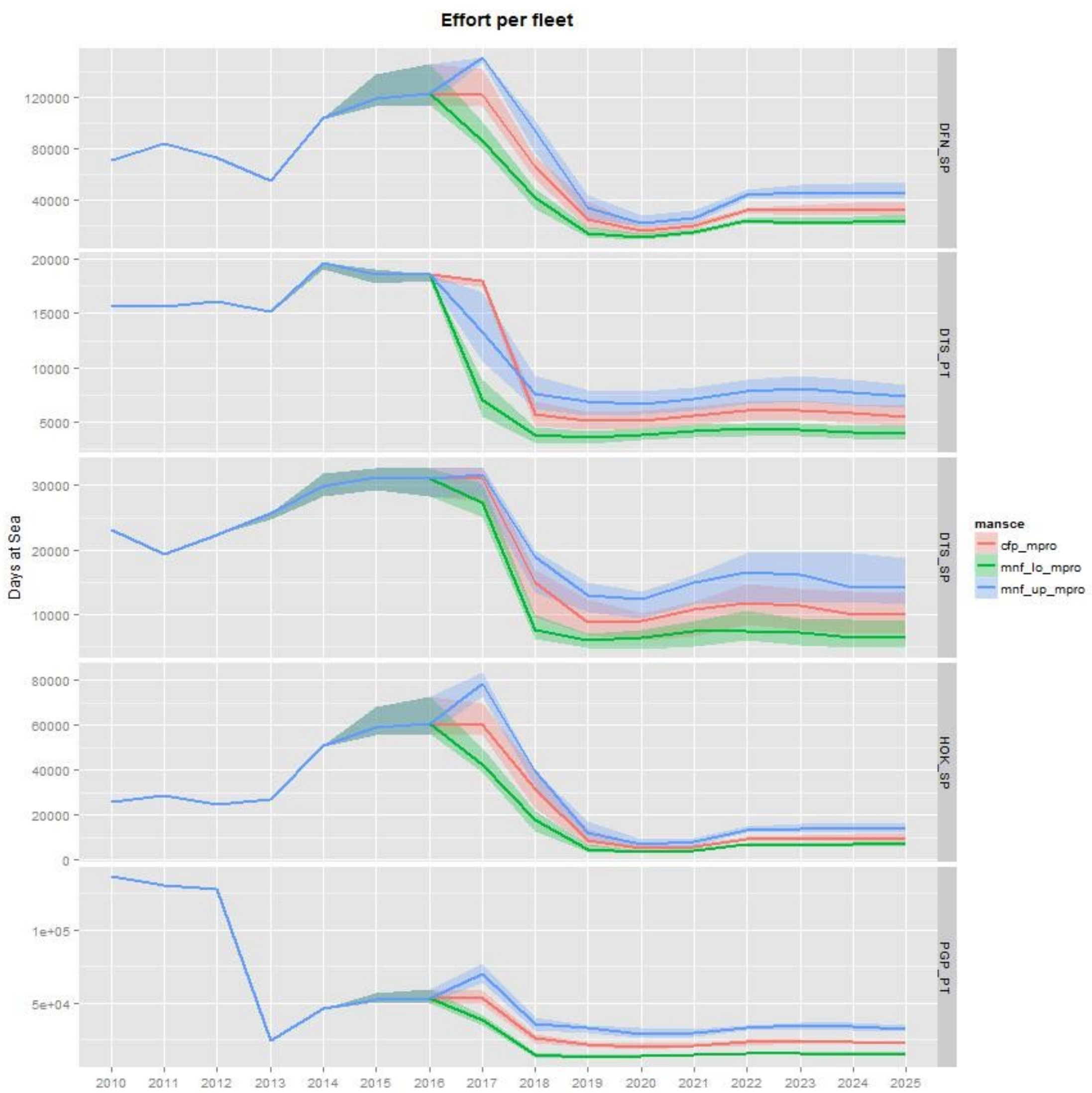

Figure 15. Effort time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

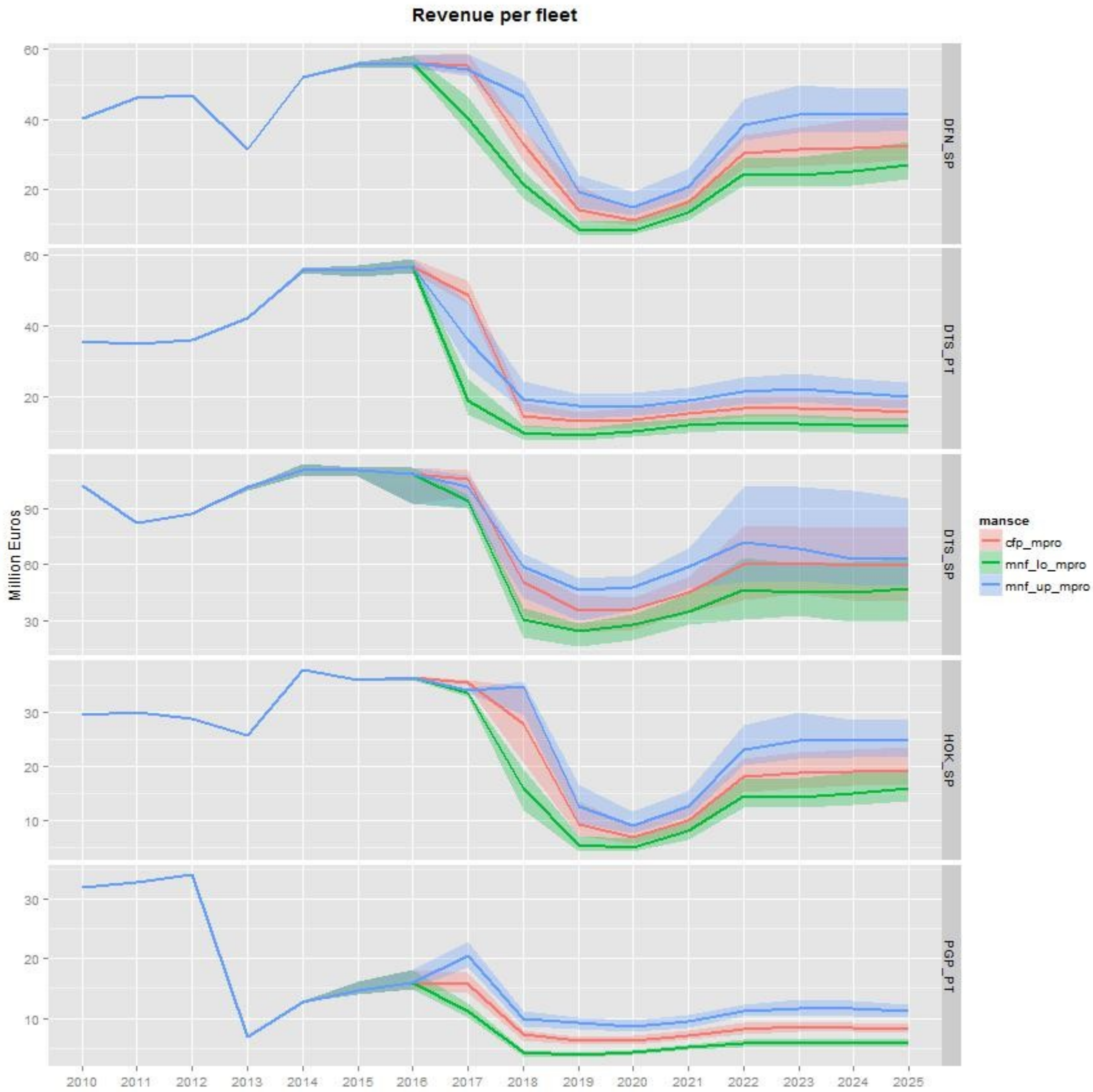

Figure 16. Revenue time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

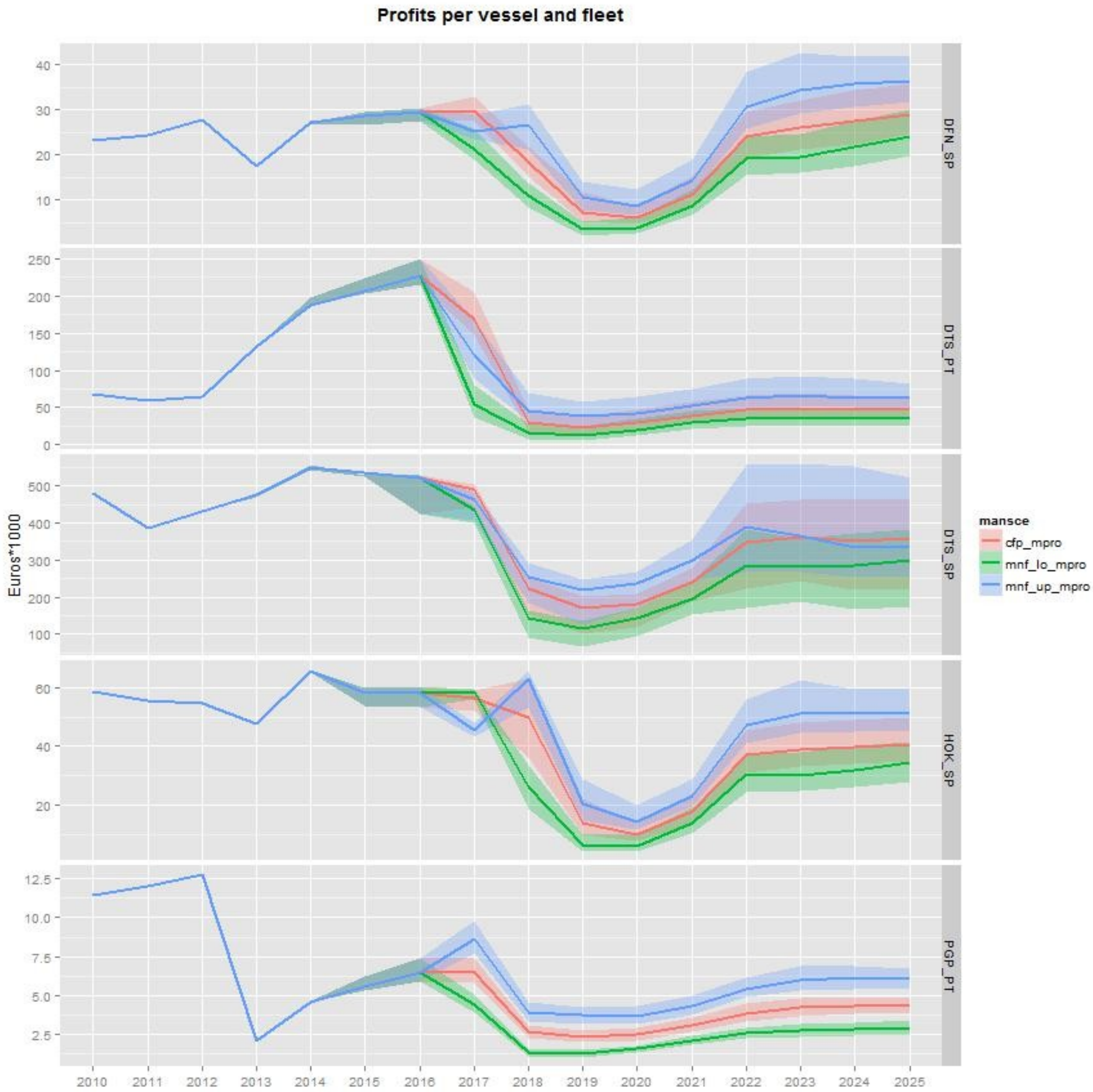

Figure 17. Profits per vessel time series in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles.

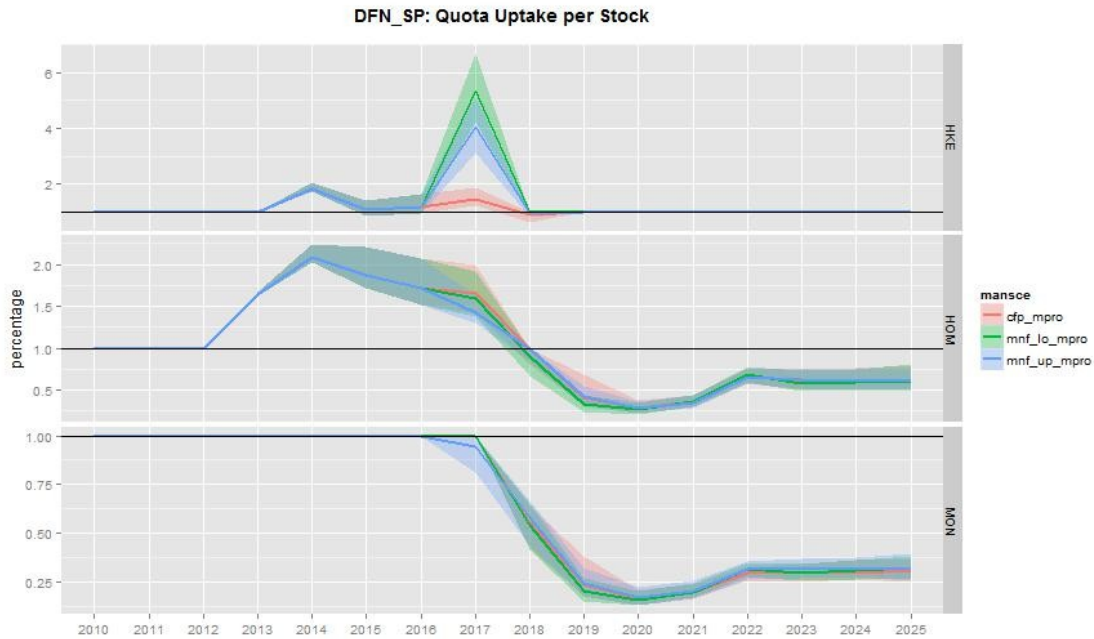

Figure 18. Quota uptake time series for DFN_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

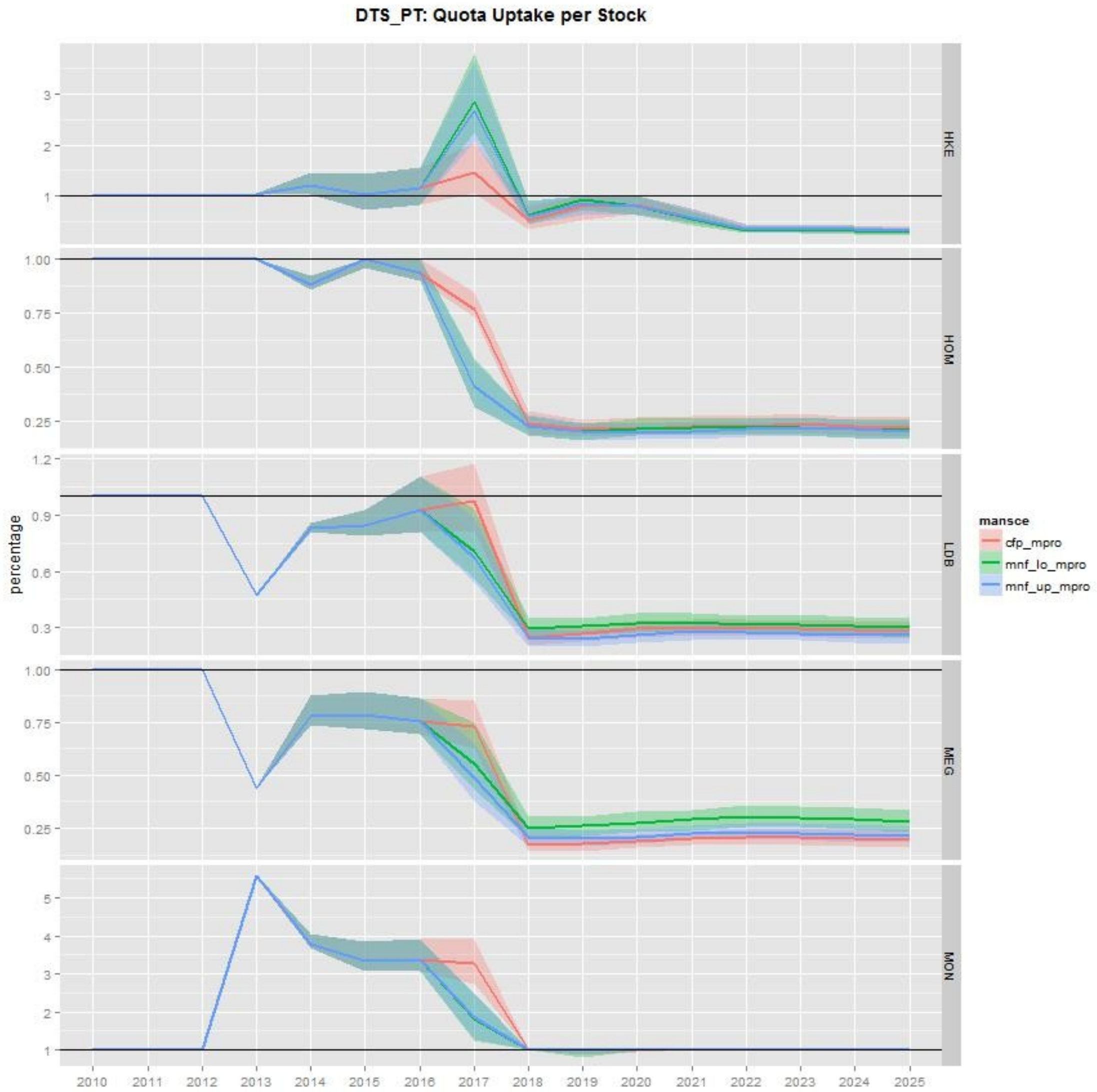

Figure 19. Quota uptake time series for DTS_PT fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

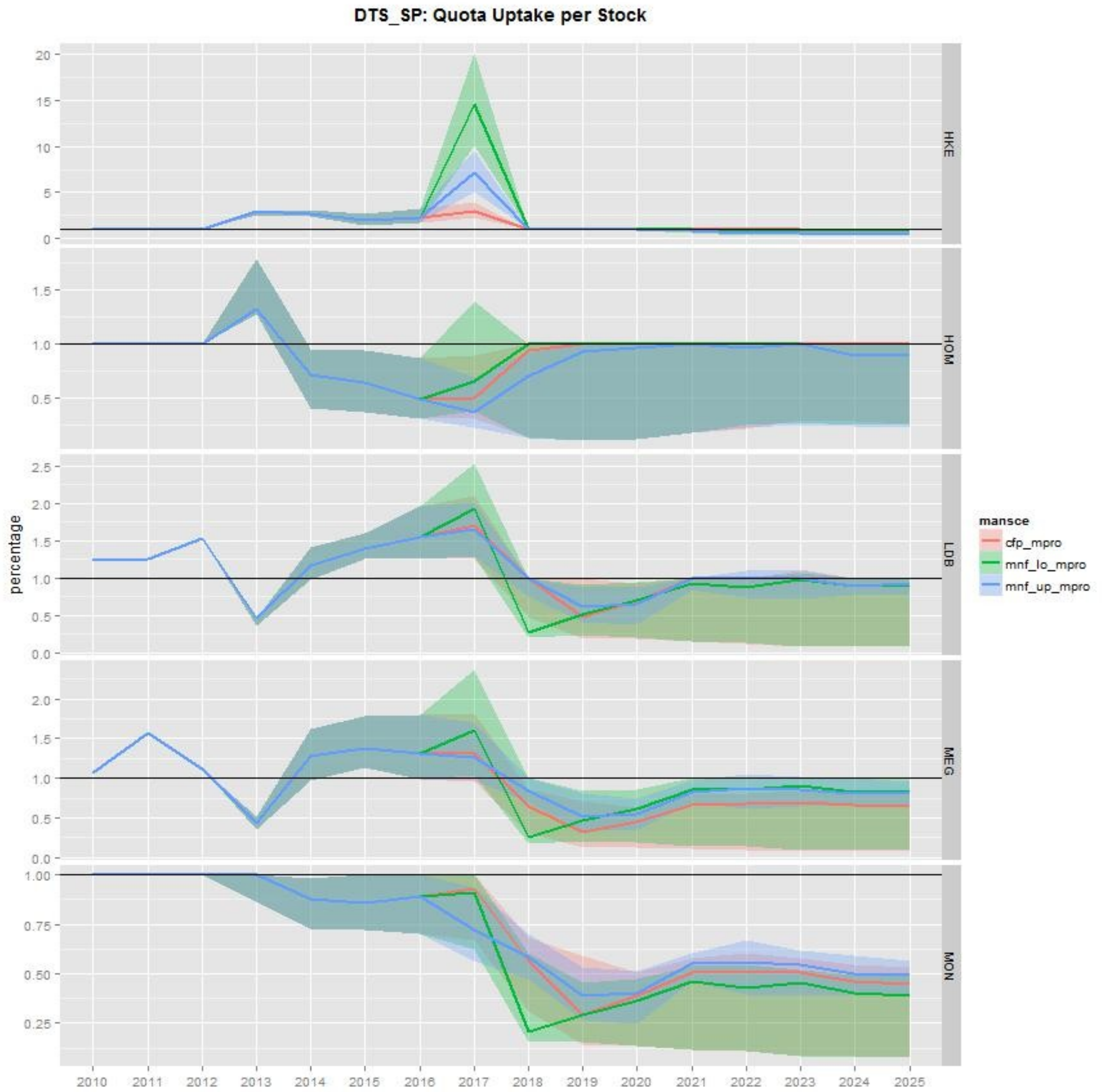

Figure 20. Quota uptake time series for DTS_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

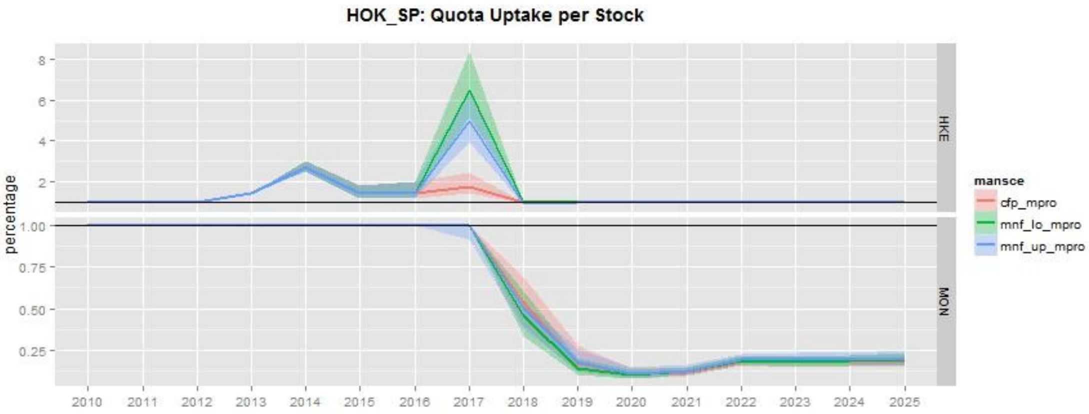

Figure 21. Quota uptake time series for HOK_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

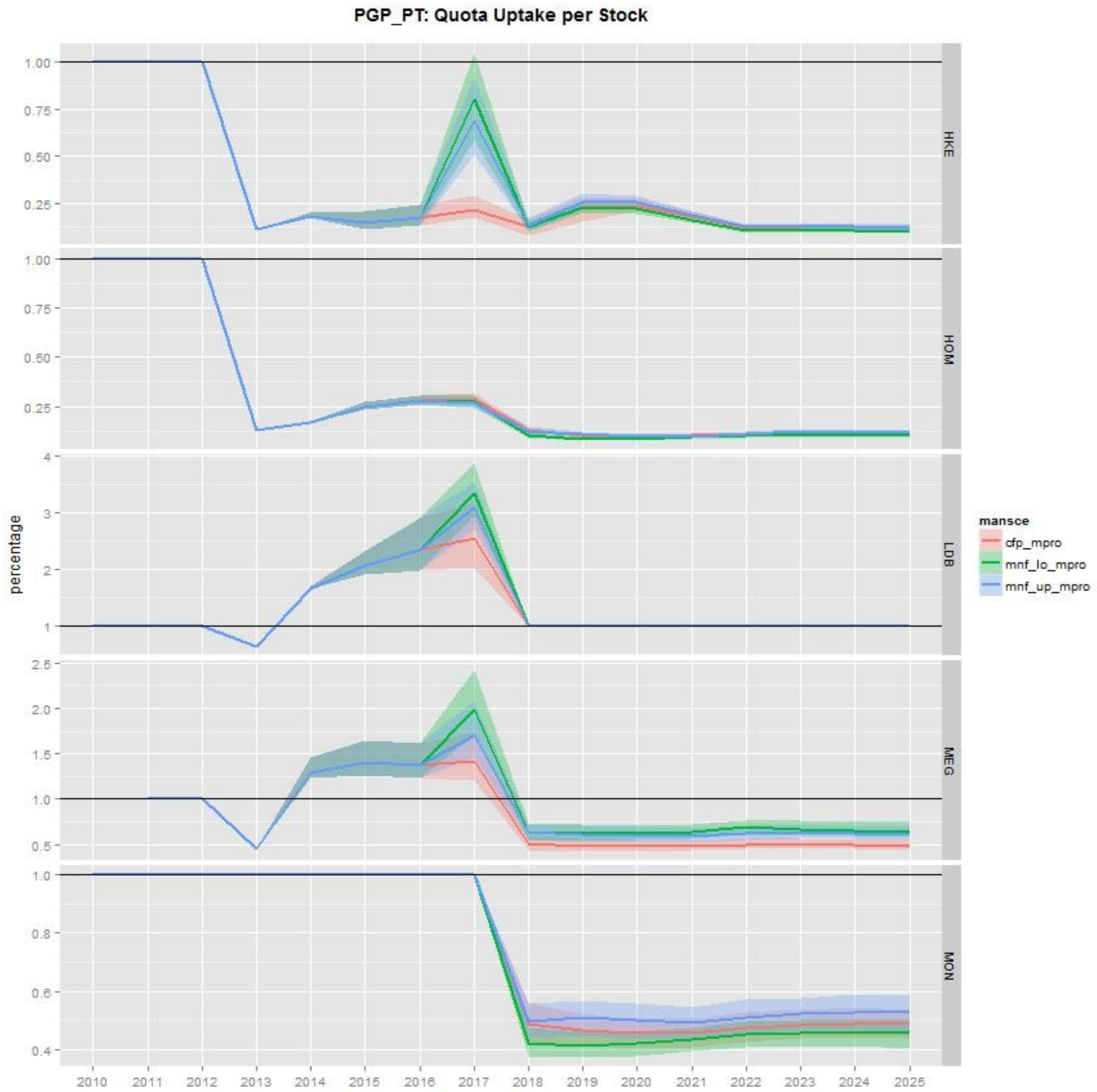

Figure 22. Quota uptake time series for PGP_SP fleet in Traditional fleet dynamics scenarios and the three management scenarios. The solid lines indicate the median and the shades delimit the 5% and the 95% quantiles. The solid black line corresponds with quota uptake equal to 1, i.e, the fleet has fully consumed its quota without exceeding it.

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