

The effect of restrictive policy instruments on fishing fleet dynamics.

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ABSTRACT

Although fisheries management has changed its scope from a purely biological, over a more bioeconomic, to finally a political bioregnumomics approach, fisheries management is still mainly based on restrictive policy instruments founded in the biological and the bioeconomic approach. Since many studies have proven that such management techniques are economically inefficient, our paper examines the possible future effects of these policy instruments on Belgian fleet dynamics.

These effects are tested through scenarios in a microeconomic simulation model, including sensitivity analysis. This study opts for a dynamic simulation model based on a microeconomic approach of fleet dynamics using system dynamics as a modelling technique (operational base: Vensim®DSS).

The results indicate that changes in maximum fishing days and quota result in higher fluctuations in fleet performance and dynamics compared to changes in the number of licences. Furthermore, changes in maximum fishing days and quota have a direct impact on fleet performance, though not always as expected. Licences, on the other hand, only affect fleet performance indirectly

since they limit the entry of new vessels to the fleet and they often block the growth of successful sub fleets.

The outcomes of this study are translated into practical recommendations for improving fisheries management. Firstly, policy makers need to be more aware of misperceptions of feedback. Secondly, this paper opens the discussion for rethinking the use of restrictive policy instruments in the rapidly changing, complex and uncertain fisheries environment.

KEY WORDS: Fisheries management, restrictive policy instruments, sensitivity simulation, system dynamics.

INTRODUCTION

The rapid changes in the level of complexity (Healey and Hennessey 1998; Lane and Stephenson 1999) and the uncertainty (Charles 1998; Cochrane 1999) of the environment in which sea fisheries operate, caused fisheries management to change its scope from a purely biological (1930's), over a more bioeconomic (1950's), to finally a political bioregonomics approach (late 1980's). The biological approach (Russell 1931; Graham 1935) was primarily followed by fisheries biologists, hence the centre of their attention was the fish stocks, their total size and cohort structure, and how they changed over time. The main policy instruments following from the biological approach were total quotas, effort restrictions, gear regulations, closed seasons and closed areas. The bioeconomic approach (Gordon 1953, 1954; Scott 1955; Crutchfield 1956, 1959) are generally credited with expanding the fisheries management paradigm to include the interactions between the fish stocks and the industry. Additional policy instruments following from the bioeconomical approach were limited entry programs, transferable individual quotas and taxes. The political bioregonomics approach (Walters 1980; Anderson 1987) improved the scientific study of fisheries management by thinking of regulation as an endogenous variable. It looks at the three-way interaction between fish stocks, industry, and government entities.

In spite of this evolution, fisheries management in Belgium is still mainly based on restrictive policy instruments (often imposed by the European Union) founded in the biological and the bioeconomic approach, respectively quota- and effort restrictions (maximum days at sea) and limited entry programs (licenses for a vessel). Since implementing these kinds of policy instruments is not evident (Boude et al. 2001; Danielsson 2002; Polet et al. 2006) and often questioned by the literature (Barber 1988; Larkin 1996; Ruseski 1998; Boude et al. 2001), this study evaluates the effects of changes in these restrictive policy instruments on the future performance and dynamics of the Belgian fleet. The paper consists of four sections. Section one discusses materials and methods used to unveil these effects. Section two gives an overview of the obtained results. Section three discusses the results and finally, conclusions are drawn.

MATERIALS AND METHODS

The study uses the Belgian fleet as a case study. Scenarios in a simulation model are used to evaluate the performance (measured in gross operating profit) and dynamics of the Belgian fleet

under restrictive policy instruments. This study opts for a dynamic simulation model based on a microeconomic approach of fleet dynamics (Helu et al. 1999) using system dynamics as a modelling technique (operational base: Vensim®DSS) (Moxnes 1998a, 1998b, 1999, 2003; Dudley 2003, 2003). The simulation model has a time horizon of 18 years (936 weeks, from January 1, 1997 till December 31, 2014) with a time step (dt) of a week. The first nine years try to visualize the fit between the simulated data and the historical data (reference mode). Afterwards, the simulation gives insights in the future behaviour of the fleet performance and dynamics till the year 2015.

Insights for the creation of the simulation model are gained from the literature on the one hand and from expert group meetings involving scientist on the other. Additionally, informal contacts with the fishing industry and policy makers have further improved our global understanding of fisheries and its management system in specific. Based on these insights, decisions were made concerning the model approach and the scope of the simulation model. Table 1 enumerates and structures these decisions into two clusters: 1) conceptual decisions (approach) and 2) decisions related to the size of the arrays. Additionally, figure 1 gives a simplified representation of the simulation model visualising its basic dynamics, not taking into account the arrays.

Table 1: Structured overview of the decisions made regarding the scope of the simulation model.

	Decision	Justification
Conceptual	Comprehensibility above comprehensiveness	The aim of this study is not to exactly predict the impact of restrictive policy instruments on Belgian fishing fleet performance and dynamics. The aim is to learn what the effect can be when restrictive policy instruments are altered.
	Microeconomic approach	This approach enables evaluating the performance of individual companies and vessels as a result of the impact of policy instruments on their individual management decisions (tactical and investment decisions). As a result, the decisions of individual boat owners determine the general dynamics of the fleet (Helu et al. 1999).
	Investment loop as the dominant reinforcing loop	As a result of the microeconomic approach, the simulation model is built around an investment loop. Furthermore, this dominant reinforcing loop is only balanced by the restrictive policy-loops under research, clearly unveiling their effects.
	Fishermen react like a “homo economicus”	Since this study’s does not focus on social and emotional behaviour of fishermen under restrictive policies, the choice of the “homo economicus” as agents in our simulation model can be justified. Additionally, many bioeconomic models concerning fisheries management use this “homo economicus”-principle (Opaluch and Bockstael 1984).
	Combining tactical and investment decisions in one simulation model	Combining tactical and investment decisions is a result of the microeconomic approach of the simulation model.
	Profit generated by the fleet does not mix with “other” money	Profit generated by the fleet can only be invested in a new vessel and there is no external investment in the fleet. This principle contributes to the aim of delivering a comprehensible simulation model.
Size of arrays	Three restrictive policy instruments	Only three policy instruments (i.e. maximum fishing days, quota size and licences) are the focus of this paper, therefore only these three are taken into account. Effects of other policy instruments are set to zero.
	Four vessel types	This study distinguishes four vessel types in the Belgian fleet based on vessel length, fishing method and target species: 1) eurocutters, 2) large beam trawlers, 3) set netters and 4) shrimp trawlers. Consequently, our simulation model contains four companies, each operating a different homogeneous sub fleet of a vessel type.

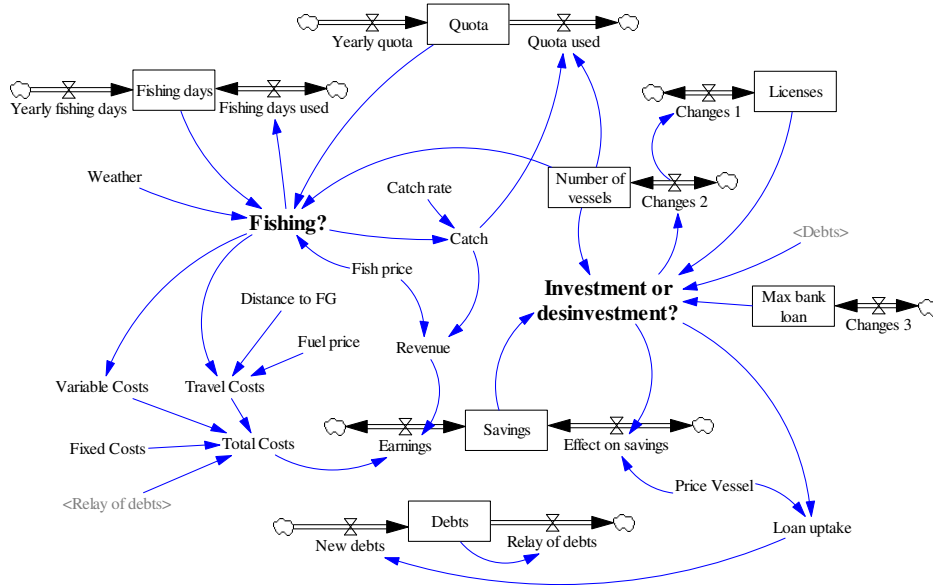
Three fishing grounds

This simulation model aggregates the six fishing grounds (ICES areas) that contain most of the Belgian quota into three fishing grounds: 1) IVbc, 2) VIIde, and 3) VIIfg. As a result, this simulation model underestimates the total amount of Belgian quota.

One theoretical average species

As a result of choosing comprehensibility above comprehensiveness, the simulation model runs with one theoretical average species.

Fig. 1: A simplified representation of the system dynamics simulation model (where: “□” = stock, “○” = converter, “=>” = in- or outflow, and “**bold**” = decision algorithms)



The scenarios (table 2) used to test the effect of restrictive policy instruments on the performance and dynamics of the Belgian fleet are based either on univariate or multivariate sensitivity simulations (Monte Carlo simulation).

Table 2: Overview of the scenarios used to test the effect of restrictive policy instruments on fleet performance and dynamics.

	Type of sensitivity simulation	Number of runs in the sensitivity simulation	Variable under sensitivity simulation	Array of the variable	Type of variable	Strength of the sensitivity simulation	Initial value of the variable	Minimum value for the sensitivity simulation	Maximum value for the sensitivity simulation	Distribution function for the sensitivity simulation
Scenario 1	Multivariate	1000	Maximum fishing days	Eurocutter	Constant	10%	200	180	200	Random uniform
				Large Beam trawler	Constant	10%	250	225	250	Random uniform
				Set netter	Constant	10%	140	126	140	Random uniform
				Shrimp trawler	Constant	10%	200	180	200	Random uniform
Scenario 2	Multivariate	1000	Maximum fishing days	Eurocutter	Constant	10%	200	200	220	Random uniform
				Large Beam trawler	Constant	10%	250	250	275	Random uniform
				Set netter	Constant	10%	140	140	154	Random uniform
Scenario 3	Multivariate	1000	Quota	IV bc	Constant	10%	14'156'674	12'741'007	14'156'674	Random uniform
				VII de	Constant	10%	3'555'241	3'199'717	3'555'241	Random uniform
				VII fg	Constant	10%	2'350'407	2'115'367	2'350'407	Random uniform
Scenario 4	Multivariate	1000	Quota	IV bc	Constant	10%	14'156'674	14'156'674	15'572'342	Random uniform
				VII de	Constant	10%	3'555'241	3'555'241	3'910'765	Random uniform
				VII fg	Constant	10%	2'350'407	2'350'407	2'585'448	Random uniform
Scenario 5	Univariate	1000	Licences	(None)	Constant	10%	110	99	110	Random uniform
Scenario 6	Univariate	1000	Licences	(None)	Constant	10%	110	110	121	Random uniform

To run the simulation model with its sensitivity simulations, data was collected from individual vessels on catch composition, effort allocation and financial situation for the years 1997 till 2005. These data were compiled from two institutes. There is a very useful database called 'Belsamp' hosted at the biological section of the Institute for Agriculture and Fisheries Research containing detailed data per individual vessel on catch composition and effort allocation. For financial data on individual vessel level, the Belgian Sea Fishery Service of the Flemish government was addressed. They collect financial data of the Belgian sea fisheries fleet through a survey (on a voluntary yearly basis, sample of approximately 65 vessels). This study uses the data between the year 1997 and 2005 to form a reference mode for the simulation model. From 2005 onwards, all input data were kept constant at the level of 2005.

RESULTS

In evaluating the explanatory power of a simulation model, the fit between the simulated data and the historical data (serving as a reference mode) needs to be investigated. Figure 2 and 3 show the two parameters for which the fit is crucial given our research objective of evaluating fleet performance and dynamics, respectively the average gross operating profit per vessel (Average GOP/vessel) and numbers of vessels in the fleet. Although the average GOP/vessel generated by the simulation model is systematically located below the historical data (Ref GOP/vessel), their behaviour is similar. This systematic underestimation is mainly due to the limited number of fishing grounds (and quota) taken into account in the simulation model. In reality, the amount of quota is significantly higher allowing more fish to be caught, resulting in potentially more revenues per vessel. Additionally, average GOP/vessel is a subtraction of revenues per vessel and operational costs per vessel which are in Belgian fisheries often both large figures. Such calculation results in a small outcome easily subject to systematic under- or overestimations.

Initially, the fit between the output-data of the simulation generated for 'vessels in the fleet' and its historical data is very good (figure 3). Nevertheless, further inquiry into the individual dynamics of the sub fleets indicates a rapid conversion of the fleet not at all observed in reality (figure 4). This rapid conversion is caused by the systematically underestimation of average GOP/vessel by the simulation model (as explained earlier). As a result, non-profitable fisheries will go bankrupt faster and "zero-profit fisheries" (Salz 2006) will become non-profitable fisheries going bankrupt as well. Consequently, these bankrupt vessels exit the fleet leaving fewer vessels with the residual amount of quota. The remaining vessels will have a better opportunity for increasing their revenues and therefore increase their future investment potential. However, this explanation only contains an explanatory power when quota are common pool resources and under the "ceteris paribus"-clause. In conclusion, the simulation output is plausible, taking into account the focus on comprehensibility of the simulation model.

Fig 2.: The average gross operating profit per vessel (Average GOP/vessel) in euro (Baseline = simulation data, Ref GOPvessel = historical data 1997-2005).

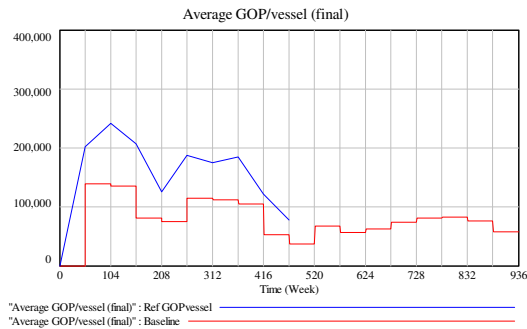


Fig. 3: Number of vessels in the Belgian fleet (Baseline = simulation data, Ref GOPvessel = historical data 1997-2005).

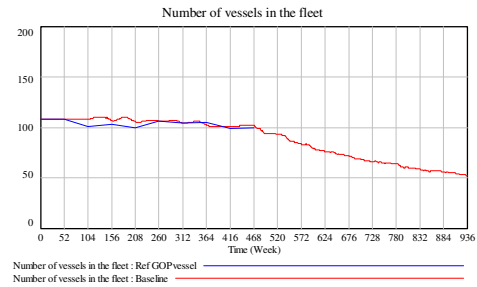
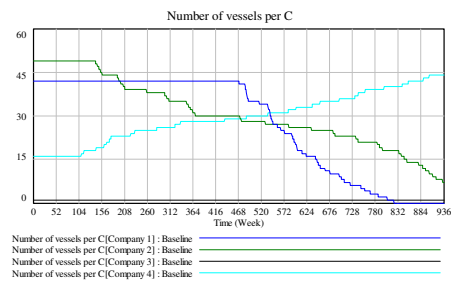


Fig. 4: Number of vessels per sub fleet (Baseline = simulation data, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



Sensitivity simulation on the number of maximum fishing days: scenario 1 and 2

The restrictive policy instrument of maximum fishing days is founded in the biological approach on fisheries management. It affects the amount of time fishermen can spend at sea trying to catch fish and as a result affects the fishing tactics of fishermen (Mathiesen 2003). Two multivariate sensitivity analyses (each containing 1000 runs) were run to unveil the effect of changes (maximum 10%) in maximum fishing days for each vessel type on fleet performance and dynamics (under the “ceteris paribus”-clause). The output figures gained from these two sensitivity simulations illustrate the confidence bounds for all the output values generated by the simulation model when the four parameters under sensitivity (the array of maximum fishing days per vessel type) were simultaneously and randomly varied between their maximum and minimum values (table 2).

Figure 5 illustrates the impact of decreasing the number of maximum fishing days with a maximum of 10% (giving fishermen less days to fish) on average gross operating profit per vessel (Average GOP/vessel). Such decrease will almost certainly lower the GOP/vessel, though not dramatically. Additionally, the outer bounds of uncertainty (100%, and thus taking in account all the runs) also indicate the chance of a positive impact on GOP/vessel. An explanation for this phenomenon lies in the mechanism of a smaller fleet (figure 6) left with the same amount of quota which can result in a growing average GOP/vessel (as earlier explained). Figure 7 illustrates that the large beam trawlers go bankrupt and exit the fleet. However, this explanation is only valid when quota are common pool resources and given the “ceteris paribus”-clause.

Fig. 5: The effect of a sensitivity simulation implying a maximum 10% decrease in maximum fishing days per vessel type on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 1 = original output, Ref GOPvessel = historical data 1997-2005).

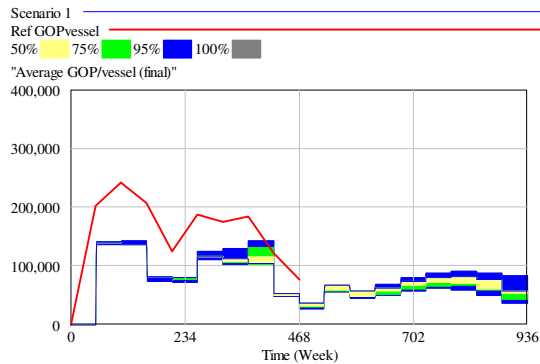


Fig. 6: The effect of a sensitivity simulation implying a maximum 10% decrease in maximum fishing days per vessel type on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 1 = original output, Ref GOPvessel = historical data 1997-2005).

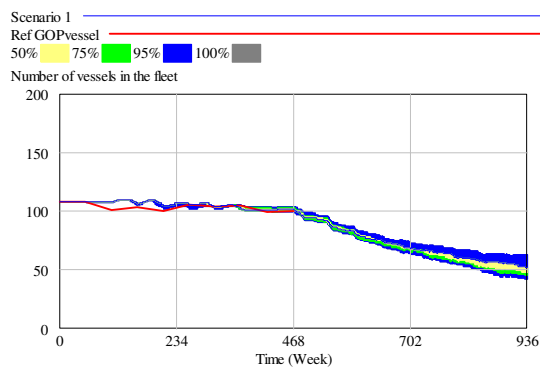
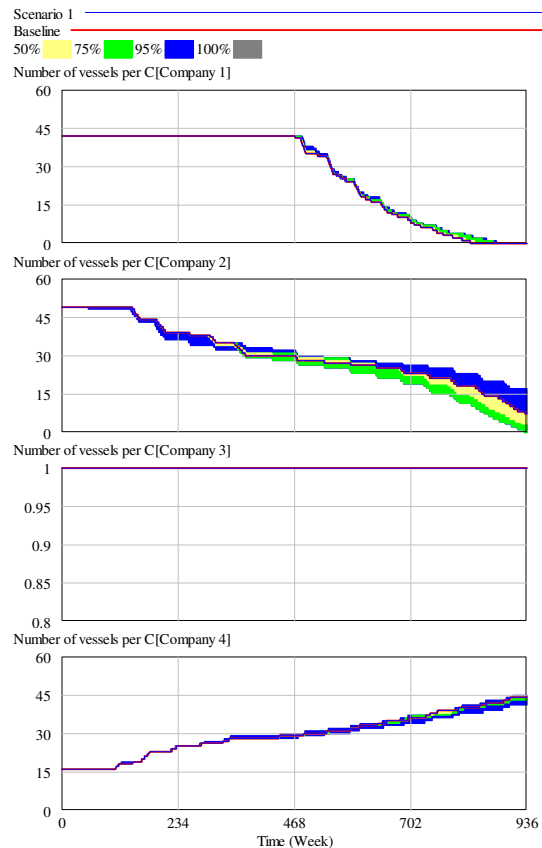


Fig. 7: The effect of a sensitivity simulation implying a maximum 10% decrease in maximum fishing days per vessel type on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 1 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



If the number of maximum fishing days per vessel type increases (with maximum 10%), both average GOP/vessel (figure 8) and total Belgian fleet size (figure 9) slightly decreases. Further inquiry on sub fleet level indicates that no sub fleet significantly increases due to the additional maximum fishing days (figure 10). This counterintuitive behaviour is mainly due to the decision algorithm for fishing tactics in the simulation model. The algorithm sends the fishermen fishing where the most fish per trip can be caught (fishing ground with highest catch per unit of effort), not taking into account the amount of fuel necessary to steam towards this “best” fishing ground. With the current high fuel prices, this behaviour can lead to financial losses on trip level resulting in declining average GOP/vessel. If fishermen are given more fishing days, this decision algorithm sends fishermen more often to these further located fishing grounds. However, these extra trips can result in financial losses on trip level leading to a decrease in average GOP.

Although this decision algorithm is artificial, many fishermen act alike. Giving them extra fishing days will result in more time spent at sea without performing a decent cost-benefit-analysis.

Fig. 8: The effect of a sensitivity simulation implying a maximum 10% increase in maximum fishing days per vessel type on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 2 = original output, Ref GOPvessel = historical data 1997-2005).

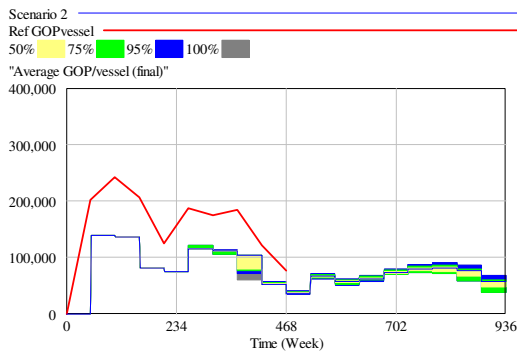


Fig. 9: The effect of a sensitivity simulation implying a maximum 10% increase in maximum fishing days per vessel type on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 2 = original output, Ref GOPvessel = historical data 1997-2005).

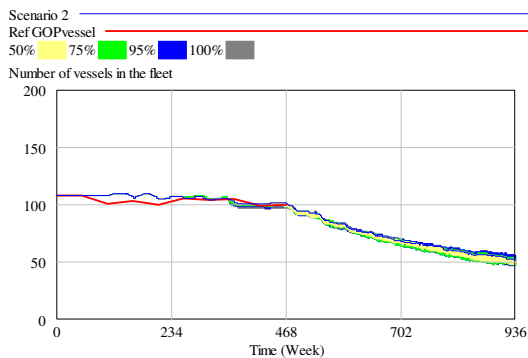
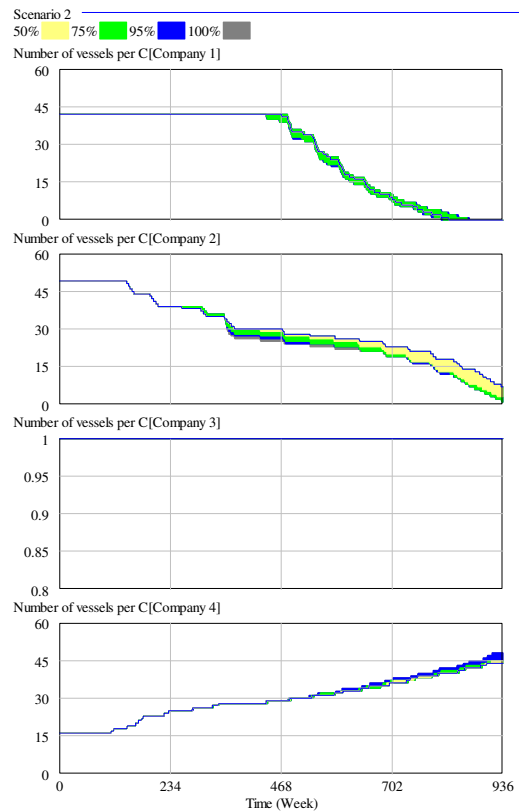


Fig. 10: The effect of a sensitivity simulation implying a maximum 10% increase in maximum fishing days per vessel type on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 2 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



In summary, fleet performance and dynamics are sensitive to positive and negative changes in maximum fishing days. Decreasing the number of maximum fishing days will cause the average GOP/vessel to decline, leading to a smaller less profitable fleet. The vessel type suffering the most from this policy instrument is the large beam trawlers. When the number of maximum fishing days increases, both average GOP/vessel and total fleet size almost certainly decrease. As a result, only changing the maximum fishing days has a negative effect on fleet dynamics and average fleet performance.

Sensitivity simulation on the amount of quota: scenario 3 and 4

A second group of restrictive policy instruments which is founded in the biological approach on fisheries management are quota-regulations. They restrict the amount of fish fishermen are allowed to land. Thus, changing these amounts affects the fishing tactical decisions of fishermen (Mathiesen 2003). Through two scenarios, each containing a multivariate sensitivity simulation (each 1000 runs), the effect of changing the size of the quota on fleet performance and dynamics is investigated (under the “ceteris paribus”-clause). These sensitivity simulations have three parameters under sensitivity, the three fishing grounds with their quota (table 2).

When decreasing the quota per fishing ground (with maximum 10%), the chance that average GOP/vessel will grow becomes higher, which is counterintuitive (figure 11). This behaviour is mainly caused by two mechanisms. Firstly, there is the early decrease in total fleet size (figure 12) due to large beam trawlers leaving the business (figure 13). Thus, the same amount of quota is left for fewer vessels resulting in higher GOP/vessel (as earlier explained). Secondly, if the quota on the fishing grounds which are far out of shore are being lowered, less trips are needed to catch these fish. Since some of these trips result in losses for the fishermen due to high fuel prices, fewer trips result in a limited negative impact on GOP/vessel.

The fleet dynamics on sub fleet level (figure 13) indicate the fast decline in the number of large beam trawlers due to a decrease in quota. However, this decline can be beneficial for the number of eurocutters (figure 13) since both vessel types are competing for the same fishing grounds.

Fig. 11: The effect of a sensitivity simulation implying a maximum 10% decrease in quota per fishing ground on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 3 = original output, Ref GOPvessel = historical data 1997-2005).

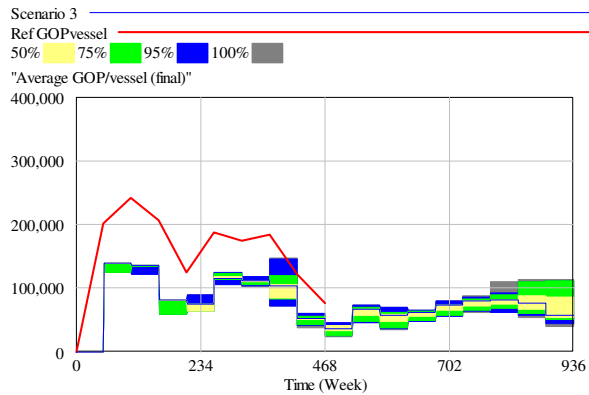


Fig. 12: The effect of a sensitivity simulation implying a maximum 10% decrease in quota per fishing ground on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 3 = original output, Ref GOPvessel = historical data 1997-2005).

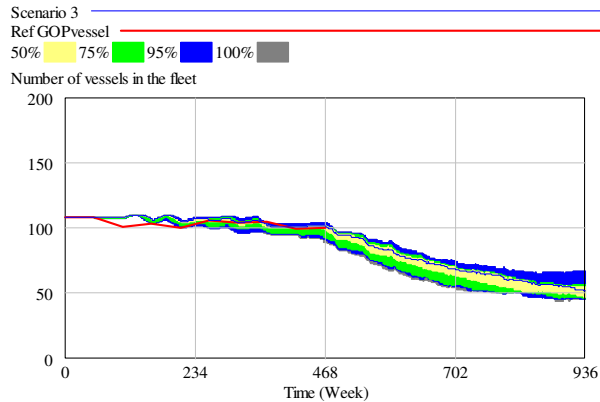
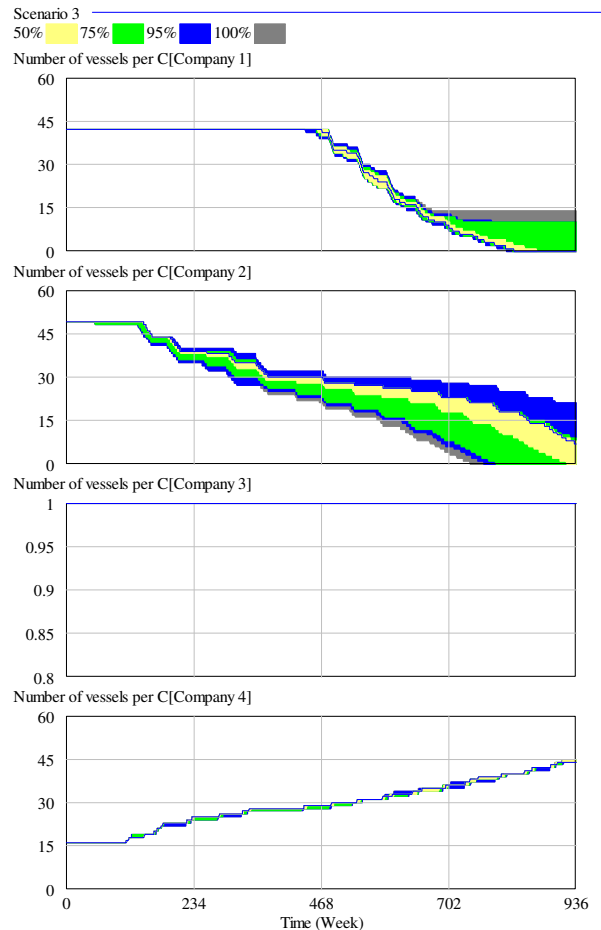


Fig. 13: The effect of a sensitivity simulation implying a maximum 10% decrease in quota per fishing ground on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 3 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



When the amount of quota increases (maximum 10%), the average GOP/vessel almost certainly increases (figure 14). This is translated into a slower decrease in total fleet size, even leaving room for a possible fleet-recovery in the long run (figure 15). This effect is especially visible for the sub fleet of large beam trawlers (figure 16), and to a lesser extent for eurocutters.

Fig. 14: The effect of a sensitivity simulation implying a maximum 10% increase in quota per fishing ground on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 4 = original output, Ref GOPvessel = historical data 1997-2005).

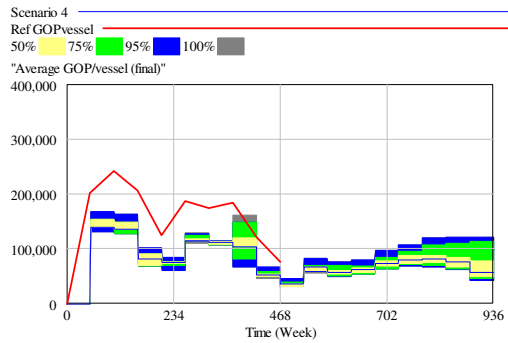


Fig. 15: The effect of a sensitivity simulation implying a maximum 10% increase in quota per fishing ground on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 4 = original output, Ref GOPvessel = historical data 1997-2005).

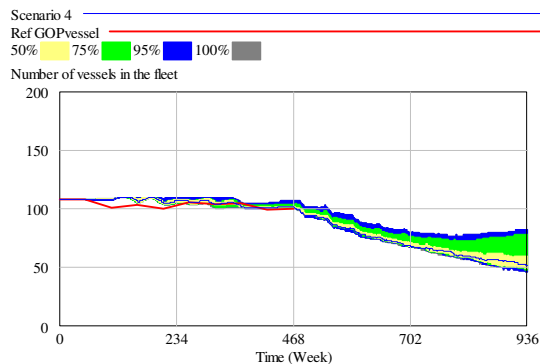
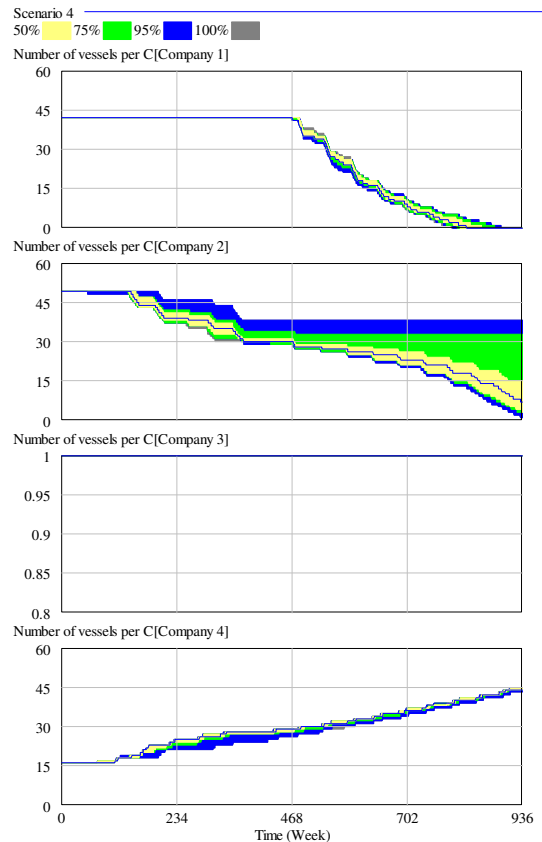


Fig. 16: The effect of a sensitivity simulation implying a maximum 10% increase in quota per fishing ground on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 4 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



In summary, the scenarios concerning quota show that both a decrease and increase in quota result in higher average GOP/ vessel. However, their impact on the fleet size is different. A decrease in quota results in a much smaller Belgian fleet compared to an increase in quota.

Sensitivity simulation on the amount of licences: scenario 5 and 6

This restrictive policy instrument belongs to the limited entry programs founded in the bioeconomic approach on fisheries management. They also provide a limitation on the fleet size. Contrary to the previous scenarios, the effect of changes (maximum 10%) in this restrictive policy instruments on fleet performance and dynamics is tested by univariate sensitivity analyses, since the only parameter under sensitivity is the number of licences (table 2). However, like the previous scenarios, they also consist of 1000 runs and call upon the “ceteris paribus”-clause.

The effect of decreasing the number of licences on both average GOP/vessel (figure 17) and total fleet size (figure 18) is small, though the small change in total fleet size houses an interesting finding at the sub fleet level. The decline in the number of licences delays the growth of the shrimp trawler fleet. Or more generally speaking, if a sub fleet is profitable, its fleet size can only grow as long as licences are available. As a result, the protective power of licences also blocks the growth of successful sub fleets.

Fig. 17: The effect of a sensitivity simulation implying a maximum 10% decrease in licences on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 5 = original output, Ref GOPvessel = historical data 1997-2005).

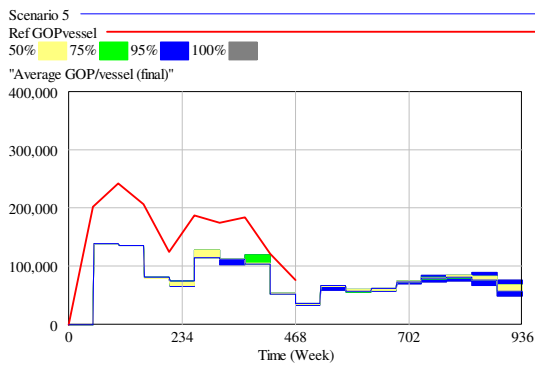


Fig. 18: The effect of a sensitivity simulation implying a maximum 10% decrease in licences on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 5 = original output, Ref GOPvessel = historical data 1997-2005).

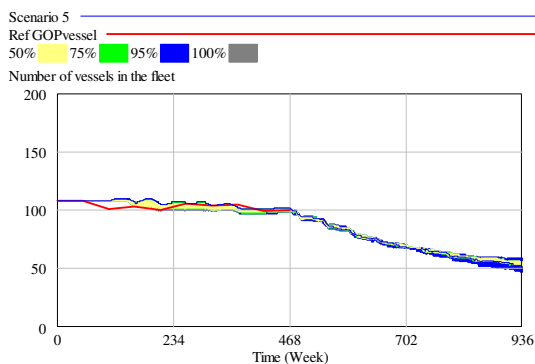


Fig. 19: The effect of a sensitivity simulation implying a maximum 10% decrease in licences on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 5 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).

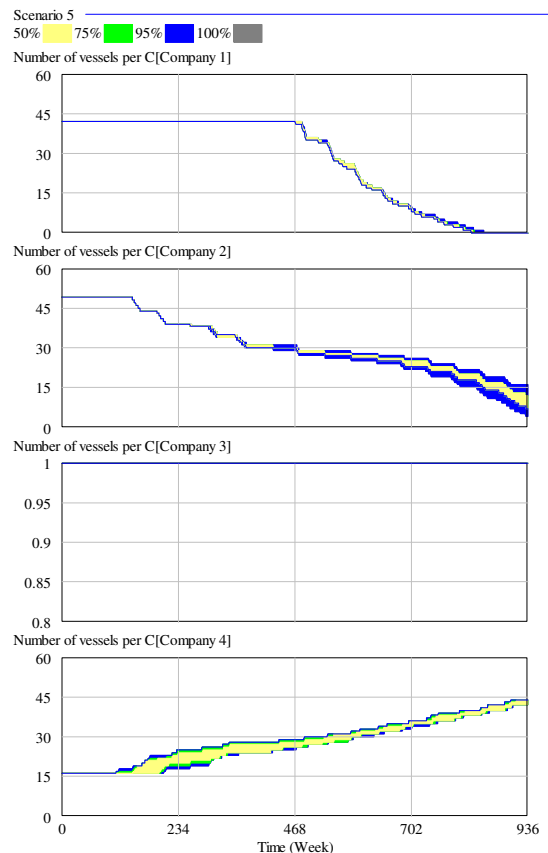


Figure 20 tells us that expanding the number of licences with maximum 10% does not at all affect the average GOP/vessel. Similarly, neither the fleet size (figure 21) nor the sub fleets (figure 22) are affected by the increase in licences. This can easily be explained because the number of licences has no direct impact on GOP. Additionally, if the total fleet size declines, increasing the total number of licences will not result in an increase in total fleet size given the scope of the simulation model. Consequently, increasing the number of licenses when the total fleet size is continuously decreasing has obviously no impact on future fleet performance and dynamics.

Fig. 20: The effect of a sensitivity simulation implying a maximum 10% increase in licences on the average gross operation profit per vessel (in euro) between 1997 and 2015 (Scenario 6 = original output, Ref GOPvessel = historical data 1997-2005).

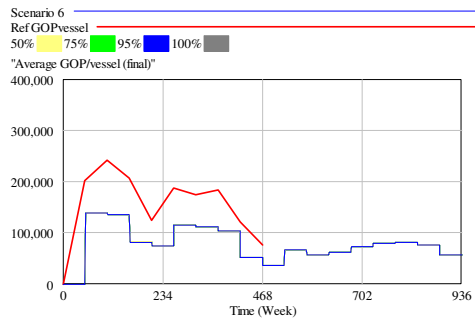


Fig. 21: The effect of a sensitivity simulation implying a maximum 10% increase in licences on the number of vessels in the Belgian fleet between 1997 and 2015 (Scenario 6 = original output, Ref GOPvessel = historical data 1997-2005).

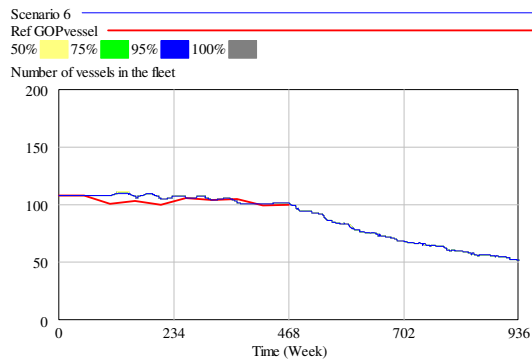
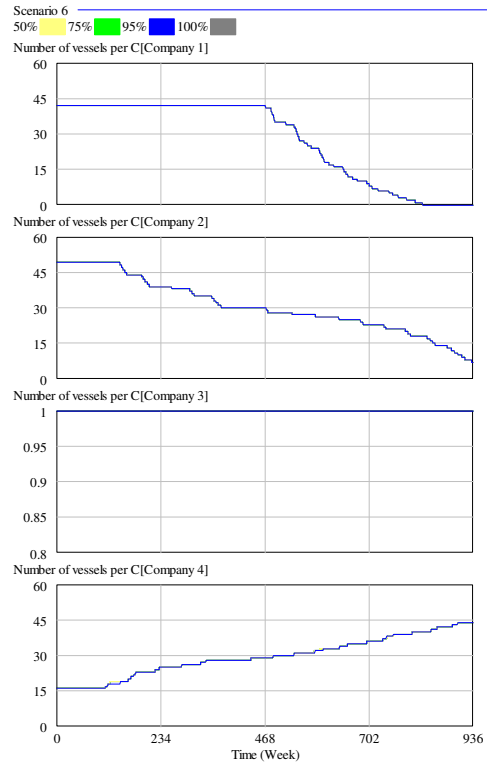


Fig. 22: The effect of a sensitivity simulation implying a maximum 10% increase in licences on the number of vessels per Belgian sub fleets between 1997 and 2015 (Scenario 6 = original output, and company 1 = eurocutters, company 2 = large beam trawlers, company 3 = set netter and company 4 = shrimp trawlers).



Given the above, fleet performance and dynamics are not too sensitive to changes in the number of available licences. Decreasing the number of licences has a rather small effect on both average GOP/vessel (figure 17) and total fleet size (figure 18). Increasing the number of licences does not affect the average GOP/vessel.

DISCUSSION

Over the last decades, the concept of fisheries management science has made progress “resulting in fisheries management which is now far more holistic, self-critical and intensive”. (Caddy and Cochrane 2001: 653) However, despite this apparent progress, fisheries management (restricted by EU-regulations) still consists mainly of traditional restrictive policy instruments founded in the biological and bioeconomic approach of the fisheries management paradigm. Since many studies have proven that “traditional management techniques such as closed seasons, closed

areas, gear restrictions, and total quotas are economically inefficient” (Anderson 1985: 409), the present study wonders about the future effect of these policy instruments (with their possible changes) on fleet performance and dynamics.

Although, the effect of restrictive policy instruments on fishing fleet dynamics is not uniform, a constantly returning observation was counterintuitive behaviour of fleet performance due to certain policy changes (e.g. the large beam trawler fleet cannot be saved by raising the maximum fishing days for all vessels. In doing so, the chance the beam trawler fleet declines faster is even higher). This counterintuitive behaviour is partly caused by misperception of feedback (Sterman 1989; Diehl and Sterman 1995). Misperception of feedback occurs when a system shows “dynamic complexity” (Senge 1990). The “system” of managing fisheries consists of many interactions between reinforcing and balancing feedback loops allowing such dynamic complex behaviour. Consequently, changing the strength of restrictive policy instruments can result in a counterintuitive outcome. Thus, misperception of feedback does occur when dealing with restrictive policy instruments. Moreover, it is observed in managing natural resources in general (Moxnes 1998a, 1998b).

When further examining the results, the distinction between the restrictive policy instruments affecting the fishing tactical decisions and those affecting the investment decisions become visible. For the Belgian case, changes in maximum fishing days and quota result in higher fluctuations in fleet performance and dynamics compared to changes in licences. Furthermore, changes in the first category have a direct impact on fleet performance, though not always as expected. Whereas licences only affect fleet performance indirectly since they limit the entry of new vessel to the fleet on the one hand and they often block the growth of successful sub fleets on the other.

Finally, the outcomes from this study need to be translated into practical suggestions for improving fisheries management. First of all, policy makers need to be more aware of misperceptions of feedback. Therefore, further research will try to introduce our simulation model in the group of Belgian policy makers making them more aware of the often counterintuitive effects of policies on fleet performance and dynamics. Secondly, the results show that altering only one (restrictive) policy instruments will not often result in the desired output, or will simply be inappropriate (e.g. increasing the amount of quota when stocks are depleting). Therefore, policy makers need to find a balance in combining policy instruments. Thirdly, the Belgian fleet has historically evolved towards a beam trawling fleet. For decades, this fishing method was highly profitable. However, with the recent and rapid changes in the fisheries environment (e.g. stock decline, changing catch per unit of effort and rising fuel prices), policies were put into place protecting these fisheries (e.g. investment subsidies, more quota for bigger vessels). Nevertheless, reality has shown that these policies cannot protect the beam trawler fleet any longer. Therefore, the time is right to shift policies and stimulate a conversion of the fleet towards a more diverse fleet consisting of different fishing methods and different vessel scales. Restrictive policy instruments can certainly contribute to this conversion; however they will need to be reengineered.

CONCLUSION

This study evaluated the effect of changes in three restrictive policy instruments, respectively maximum fishing days, quota-restrictions and licences on future fleet performance and dynamics. The used methodology of sensitivity simulation has proven to be very efficient in unveiling these effects.

The results indicated that changes in maximum fishing days and quota resulted in higher fluctuations in fleet performance and dynamics compared to changes in licences. Additionally, changes in the first category had a direct impact on fleet performance, though not always as expected, whereas licences only affected fleet performance indirectly.

Although, the effect of restrictive policy instruments on fishing fleet dynamics was not uniform, a constantly returning observation was counterintuitive behaviour partly caused by misperception of feedback. Being aware of this phenomenon is perhaps the most important recommendation for policy makers resulting from this paper. Finally, this paper opened the discussion for rethinking the use of restrictive policy instruments in our rapidly changing, complex and uncertain fisheries environment. Currently these policy instruments are aimed at “preserving the status quo”. In future, they should be used as a driving factor in “stimulating fleet dynamics”. This opens a lot of further research opportunities.

Our further research will focus on two dimensions. Firstly, research needs to be done to determine what kind of conversion is beneficial for the Belgian fleet and on how to get there given certain policy tools? Secondly, how can our simulation model change the thoughts of Belgian policy makers to fully back such a conversion?

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