Economic consequences of the de minimis exemption on megrim on the Spanish trawl fleet operating in the ICES sub area VII

Produced by AZTI (Raúl Prellezo y Marina Santurtún)

Date: 25th May 2016

Abstract:

In this work the likely impacts of the de minimis exemption to the landing obligation for the catches of megrim made by the Spanish trawl fleet operating in the ICES subarea VII are calculated.

For doing so a bio-economic simulation model has been conditioned in where the main settings of the ICES working groups providing with biological advice for the stocks concerned have been used.

Results show how the landing obligation would produce a high economic impact for the fleet while a de minimis would only slightly reduce this impact.

Keywords: Landing obligation; Trawl fleet; de minimis.

Palabrasclave: Obligación de desembarco; Flota de arrastre; *de minimis*.

1. Introduction.

The Ministry of Agriculture, Food and Environment, through the Secretary for Fisheries, requested AZTI a study to analyze the economic impact of landing obligation in the trawl fleet targeting megrim.

Landing obligation (LO) is part of the Common Fisheries Policy (CFP) (EU, 2013).The aim of this discard ban is to reduce the waste of the sea-protein that discardscreate or at least the waste created in terms of human consumption (direct or not).Landing obligation has also the intention of boosting changes to end up with moreselective fisheries.

The Article 15 of this regulation foresee de minimis exemptions up to 7%-5%(depending on the year) of the total annual catches of the species subjected tolanding obligation. Such exemption can be applied if scientific evidence indicatesthat increases in selectivity are very difficult to achieve or to avoid disproportionatecosts of handling unwanted catches. It can be applied for those fishing gears whereunwanted catches per fishing gear do not represent more than a certain percentage,to be established in a plan, of total annual catch of that gear.

This study is focused on a Spanish trawl fleet that operates in the ICES sub area VIIand in particular on one of its metier targeting megrim. There are not specific worksin terms of the possible selectivity improvements that can be undertaken in order toreduce the discards of this fleet. However, in adjacent areas such as the Bay ofBiscay, there are scientific works for similar trawl fleets that expose the difficultiesof doing so (Alzorriz et al., 2016). Given that, the de minimis exemption for megrims based on the fact that improvements in selectivity in this fishery (trawlers in subarea VII) and for this species (megrim) are very difficult to achieve for this fleet (Spanish trawlers). Nevertheless it is important to consider the likely ecological andeconomic implications of this exemption, before putting them it into force.

In that sense, the objective of this work is to present the economic and biologicalresults that would be obtained from the application of a de minimis exemption for megrim on the OTB_DEF_70_100 metier of the Spanish trawl fleet operating inICES subareas VII.

For doing, so a full feedback bioeconomic model (FLBEIA) has been conditioned using the available data in order to anticipate the consequences of the application of a de minimis for megrim by the mean of simulations. That is, the objective is not toprovide the exact amount that is to be lost-gained through the application of the de minimis, but to compare the performance of the fishery under different scenarios.

2. Material y methods

2.1 Area and fleets studied

The fleet studied is the Spanish trawl fleet operating in the whole ICES sub area VII(Figure 1):

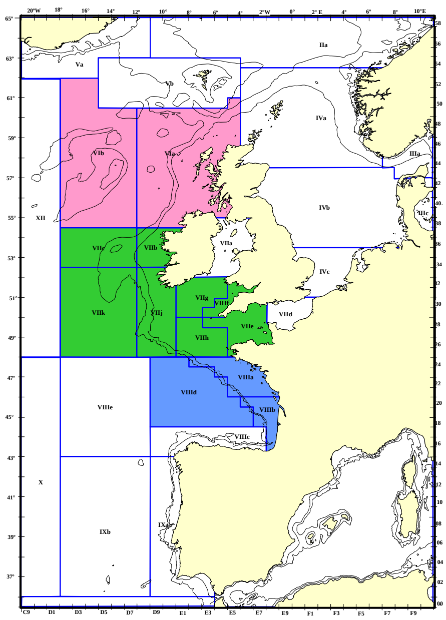

Figure 1. Fishing fleet studied (in Green)

This fleet uses otter trawl as the main gear. Its operation can be more easilyexplained using the main métiers defined for it, according to the Data CollectionFramework (EC, 2008). In that sense a métier can be defined as the group ofoperations target to the same species, or group of species, in the same area and/ortime of the year following the same exploitation pattern. The two métiers in which the activity of this fleet can be divided are:

OTB_DEF_110_119. The predominant gear for this métier is an otter trawl with a codend mesh size between 110 and 120 mm. This is a métier facing a mixed fishery taking predominantly gadoid species such as haddock and saithe and groundfish species such as anglerfish and megrim. Historically, cod was more important but the depleted nature of the stock has reduced fishing opportunities. In recent years, hakehas become increasingly important. In the deeper water on the shelf slope, speciessuch as blue ling are also caught.

OTB_DEF_70_100. The predominant gear for this métier is an otter trawl with a codend mesh size between 70 and 100 mm. This is a métier facing a mixed fisherytargeting flatfish, principally megrims and anglerfish, with hake as one of the main by catches. This last métier, OTB_DEF_70_100, is the one studied from now on.

Figure 2 can be used as a reference of the mixed composition of the landings of this métier. As it can be seen more than 80 species are landed and are part of therevenue composition of the fleet (Figure 3).

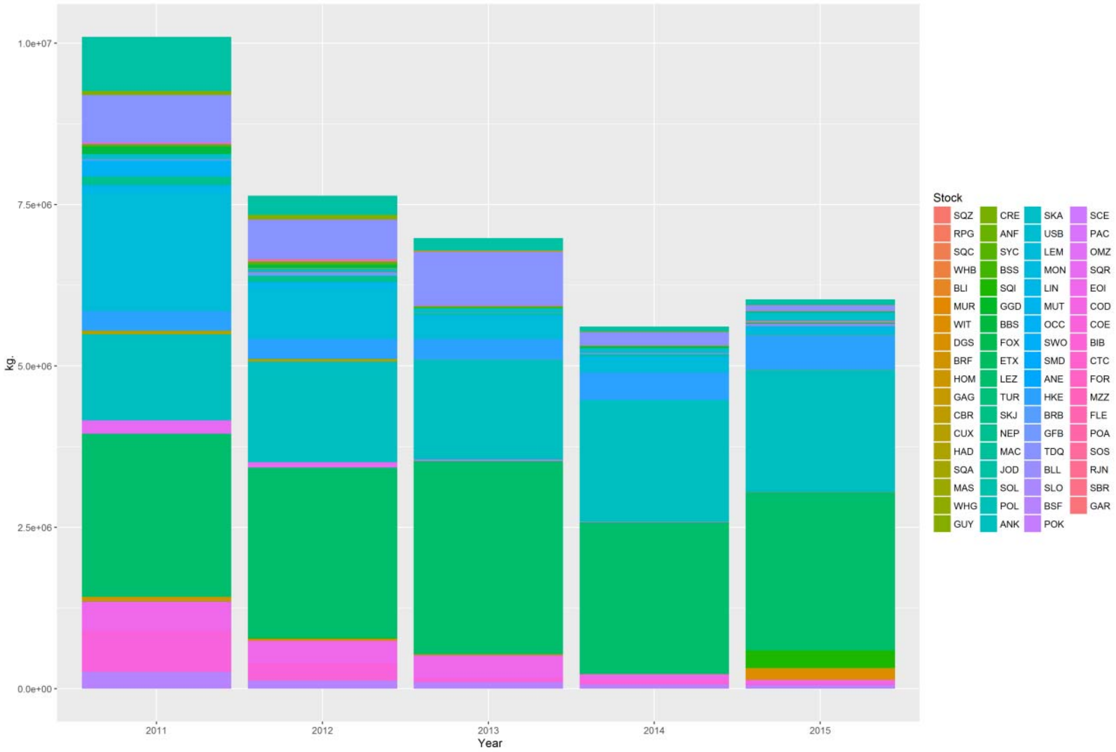

Figure 2. Landings composition (in kg.) by species for the OTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub-areas VII. Source: IEO.

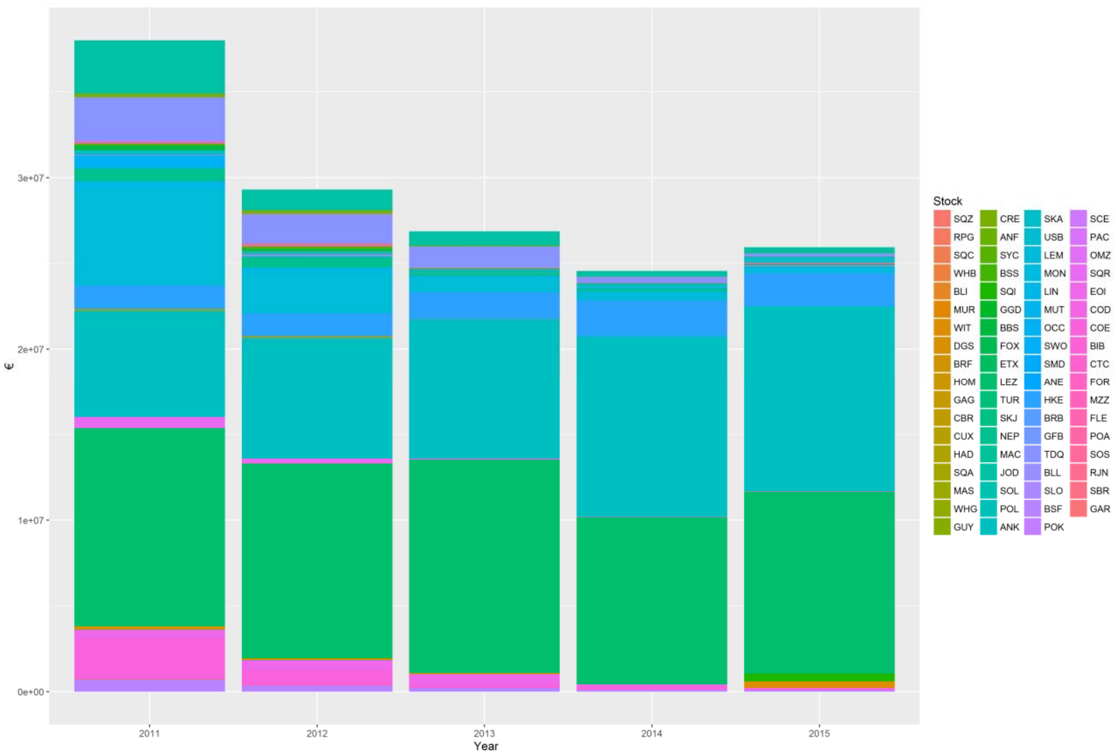

Figure 3. Landings value (in €) by species for the OTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub-areas VII.Even if there are more

than 80 species taking part of the landing composition, six ofthem account for approximately the 80% of the value (Figure 4) and quantity (Figure5).

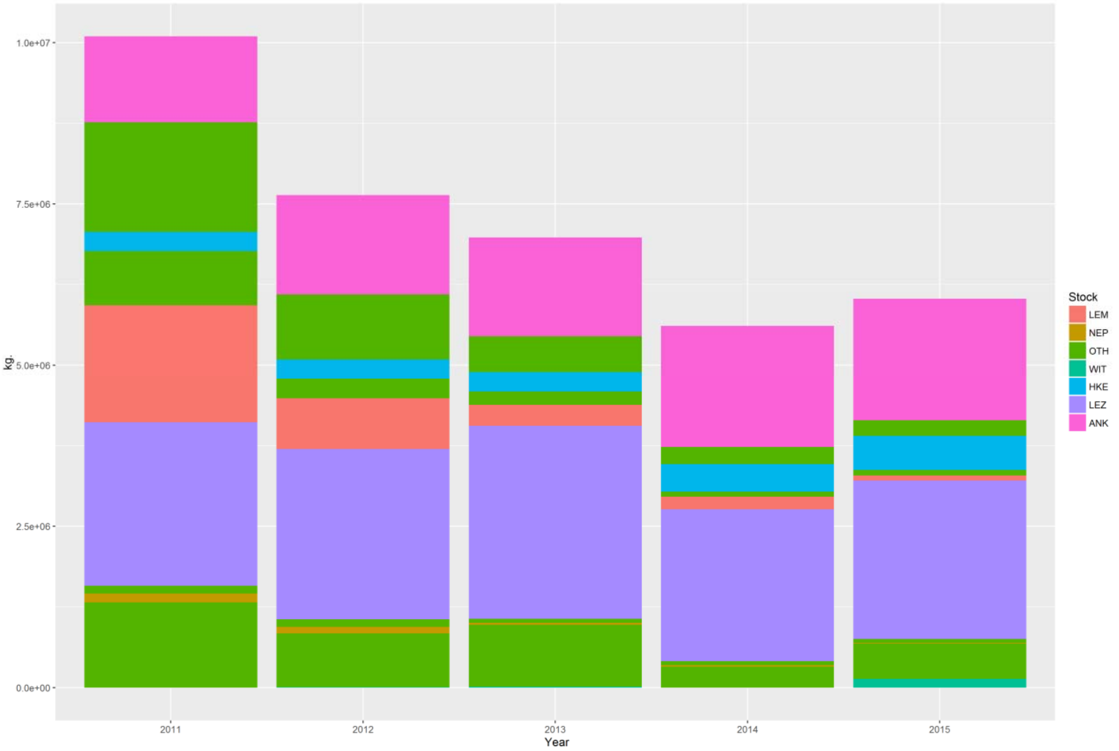

Figure 4. Landings composition (in kg) of the 6 main species for theOTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub-area VII.

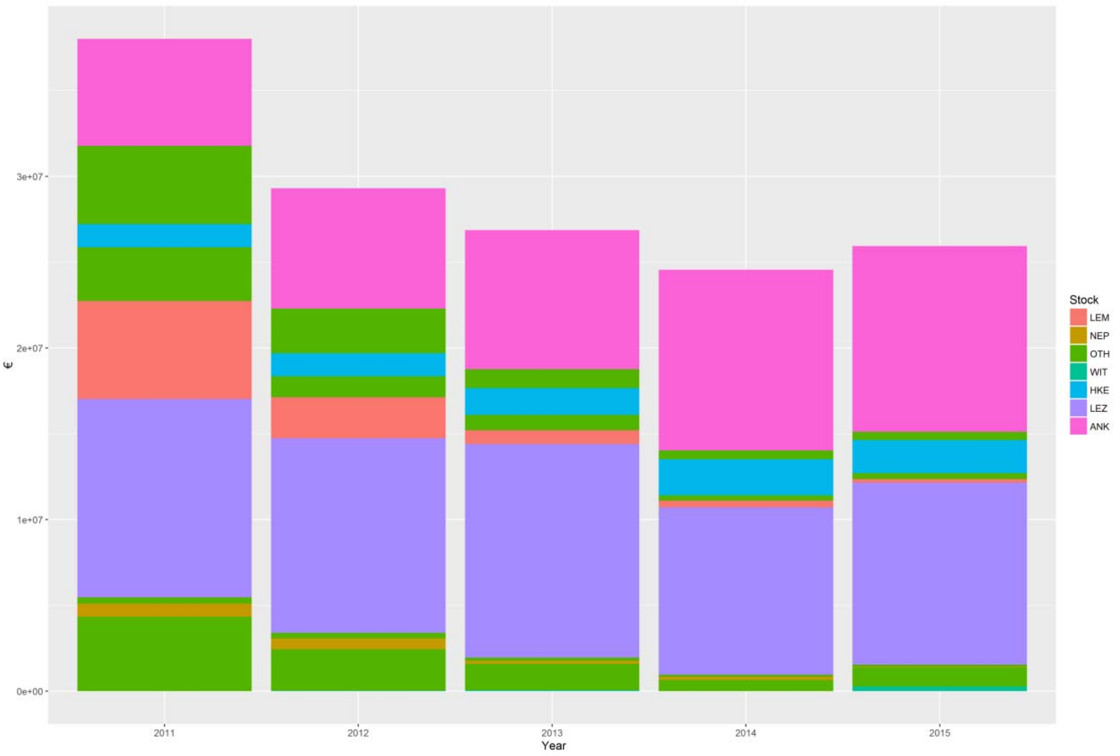

Figure 5. Landings value (in €) of the 6 main species for the OTB_DEF_70_100

métier of the Spanish trawl fleet operating in ICES sub-areas VII.These six main species are: Megrim (36% of the catches and 38% of the value), Anglerfish (22% of the catches and 30% of the value).

In terms of the discards rate of this fleet and according to Anon. (2014) the mainspecies discarded and their discard rate is presented in Table 1.

Table 1. Discard rate (average 2010-2012) for the OTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub-areas VII. Source: Anon. (2014).

Stock	Tasa de descarte
HKE	7 %
LEZ	35 %
ANF	18 %
WIT	12 %
HAD	92 %
NEP	42 %

2.2. Description of the simulation model used.

Simulations have been performed using FLBEIA (Garcia et al., 2013) (Jardim et al.,2013; García et al., 2016; Prellezo et al., 2016). This is a simulation bioeconomic model coupled in all its dimensions (economic, biologic and social). It has beendeveloped in R (R-Core, 2014) using FLR libraries (Kell et al., 2007).

2.3 Fleets conditioning

The analysis is centred on the Spanish fleet operating in sub area VII, however thisis not the only fleet considered in the simulation. Fleets included are those used inICES (2014a), that is, those included in the ICES working group assessing thenorthern stock of hake and megrim. It includes trawlers, gillnetters and longlinersoperating in the ICES sub-areas VIII and VII, from UK, Ireland, France and Spain.There is a group of “others” that accounts for the fishing mortality of hake andmegrim that is not covered by the fleets explained above. It implies that all thefishing mortality of hake and megrim stocks has been included, although divided byfleets.

Not all these fleets are equally conditioned. The fleets for which costs and prices areincluded explicitly is the Spanish fleet operating in ICES Divisions VIII a,b,d (see Figure 1) and the Spanish fleet operating in the ICES sub area VII. These two fleetsare composed of different vessels.

Costs of fishing of the Spanish trawl fleets has been obtained from the AnnualEconomic Report (AER) of the EU fishing fleet (STECF, 2015). The specific fleetsegment considered has been the demersal trawlers between 24 and 40 meters oflength. The particular values obtained for this fleet are presented in Table 2.

Table 2. Costs data of the fleet considered in the simulation

Variable	Spanish trawler fleet (VII)	Units
Fuel cost	1595	€/day
Crew cost	31%	% incomes from fishing
Other variable costs	630	1000 €/day
Fixed costs	161608	€/vessel/year
Capital costs	318859	€/vessel/year
Depretiation	79026	€/vessel/year

Source: AER 2015

Three types of cost dynamics have been considered in the study. Variable costs andfuel costs change with the fishing effort, crew costs change with the revenueobtained from the landings and, finally, capital, depreciation and fixed costs changewith the number of vessels. The average unit value of these costs (e.g., fuel cost perfishing day or fixed costs per vessel) is kept constant along all the years of thesimulation.

2.4. Population dynamics

The conditioning of the population dynamics is the same as in Prellezo et al.(2016). Twelve stocks have been introduced in the biological operating model:

Megrim (Lepidorhombus whiffiagonis), Hake (Merluccius merluccius), black anglerfish (Lophius budegassa), White anglerfish (Lophius piscatorius), Western Horse mackerel (Trachurus trachurus), Mackerel (Scomber scombrus), Blue whiting (Micromesistius poutassou), Rays (Leucoraja naevus), Inshore squids (Loliginidae), Seabass (Dicentrarchus labrax), Cuttlefishes and bobtail squids (Sepiida, Sepiolidae) and Red mullet (Mullus surmuletus).

Hake has been simulated using an age structured dynamic and the data necessaryto condition the model has been taken from ICES assessment working group reports(ICES, 2014a). The stock recruitment relationship (S-R) used is a Bayesiansegmented regression (Butterworth and Bergh, 1993) (Barrowman and Myers, 2000)which is consistent with the methodology used by ICES on estimating the referencepoints of this stock (ICES, 2014a). The population has been projected combining thisS-R relationship with the exponential survival equation provided in Quinn and Deriso (1989). The reference target point used is the MSY fishing mortality (FMSY).

The value for hake is 0.27 and has been calculated by ICES (ICES, 2014a). The TACadvice is generated using the Harvest Control Rule (HCR) provided by ICES in theframework of the Maximum Sustainable Yield (MSY) (ICES, 2012). This HCRimplies that FMSY for hake is advised unless the biomass falls below a triggerbiomass (46200 tonnes (ICES, 2014a)). If this happens a linear reduction of thisbiomass is advised in order to recover the biomass. There is also a third referencepoint, the limit biomass (33000 tonnes (ICES, 2014a)). If the biomass falls below thislast limit, the F advised should be zero (TAC=0).

Megrim has been simulated using an age structured dynamic. The conditioning hasbeen based on the stock assessment model used by ICES to give advice. Currently,this is used by ICES only as trends (ICES, 2014a). The S-R relationship used is adeterministic segmented regression. The population has been projected combinedthis S-R relationship with the exponential survival equation provided in Quinn and Deriso (1989). Megrim has not a defined FMSY, however, TAC advice is providedusing the ICES annex IV decision rule (ICES, 2012). The TAC advice is obtainedusing a biomass index of the previous 5 years. If the index of the last two years is a20% higher than the index of the first three years (of this 5 years period) the TACadvised is increased in a 15%. If the index of the first three years is a 20% higherthan the index of the last two years the TAC advised is reduced in a 15%. In anyother case in between these two cases, TAC is not changed.

Western horse mackerel, blue whiting and mackerel are widely distributed stocksexploited by several fleets apart from those considered here. Although the catch ofthese stocks is relatively important for the Spanish trawl fleet, the amount of catchharvested by it is small in comparison with the international catch of these stocks.Hence, the catch of this fleet is supposed to have little impact on the dynamics ofthem. For the historical period, the conditioning has been done using data fromworking group reports (ICES, 2014b). However, as it is practically impossible toinclude in the model all the fleets that catch these stocks, in the projection part ofthe simulation it has been assumed that the biomasses of these stocks stay constantand equal to the average of the last three years biomasses (2011-2013).

For, rays, inshore squids, seabass, cuttlefishes, bobtail squids and red mullet thereis no assessment. However, it has been important to consider that their catches arerelated to the effort deployed by the fleets. Given that, an arbitrary biomass hasbeen set with the only condition that this has to be consistent with the catches at allthe levels of fishing effort observed in the past.

In the historical period discards data for hake and megrim the discard data used inthe ICES assessment group has been included in the model, and the fleet share usedby it, included.

2.5. Uncertainty

Stochasticity in the model is introduced using Monte Carlo simulation and has beenincorporated only in the biological side (in the S-R relationship). For hake andmegrim a lognormal multiplicative error around the S-R curve (with a variationcoefficient equal to the one observed in the historical period) has been used. 250iterations have been run. For the case of hake there is another source of uncertaintyderived from the Bayesian stock recruitment model fit. At each iteration of thesimulation, parameters are drawn from the joint posterior distribution of theBayesian model fit. For the sake of simplicity results are provided in medians.

2.6. Fishing Effort

The interaction between fish population and catch is done in biomass and therelationship between catch and effort is based on a Cobb Douglas production model (Cobb and Douglas, 1928) at age level with constant return to scale (i.e. elasticity ofeffort and biomass equal to 1). Historical catchability is calculated using historicalbiomass and effort data in the Cobb-Douglas function, i.e. catchability is equal tocatch divided by the product of biomass and effort. In the projection, catchability isassumed to be constant and equal to the 2011–2013 average. This procedure hasbeen used for all the metiers and all the explicit stocks, individually.

The historical part of the evolution of the fishing effort is presented in Figure 6 (left).It shows the number of fishing days has been decreasing along the last 5 years.

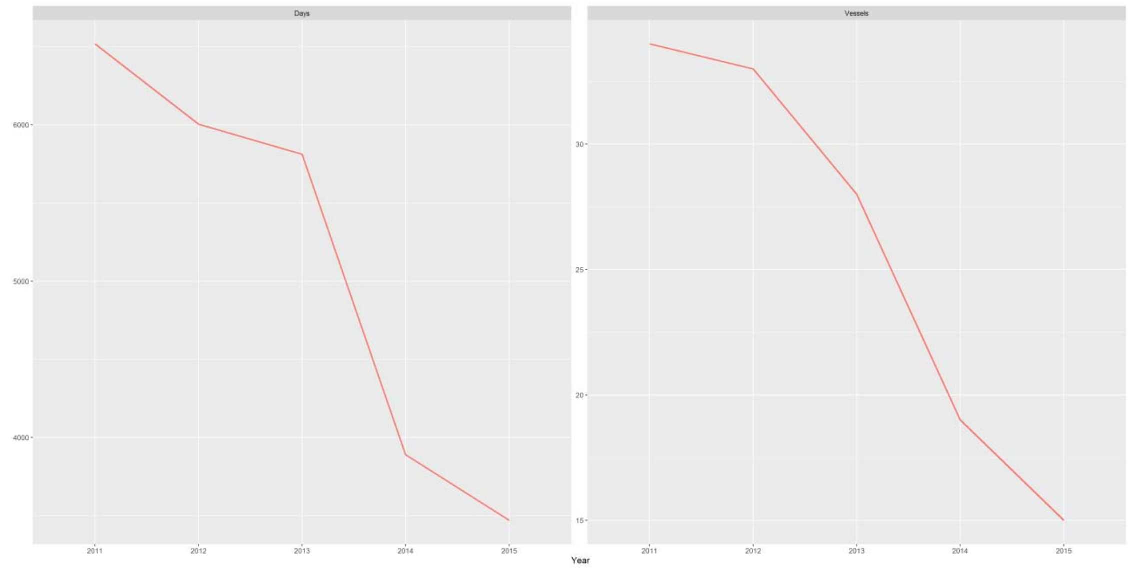

Figure 6. Evolution of the fishing effort (left) and number of vessels (right) for the

OTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub area VIIin the period 2011-2015. Source: IEO.

For the projection of this effort in the simulations performed the approach taken is based on the Fcube method (Ulrich et al., 2011). The effort corresponding to theTAC-share of each stock caught by the fleet is calculated. It has been assumed thatthe effort share along metiers is fixed and that the selection of the effort level is donein each step.

2.7. Capital: Number of vessels

In the historical part the evolution of the fishing fleet is presented in Figure 6(right). The recent evolution (2011-2015) shows how the number of vessels has beendecreasing along these 5 years.For the projection of the number of vessels, the investment or disinvestment in newvessels (capital changes) has also been simulated following the model described in Salz et al. (2011). This model relates the investment and disinvestment in newvessels with the ratio between revenue and break even revenue. The break-evenrevenue stands for the amount of revenue needed to cover both, fixed (in Table 2) itincludes repairs, maintenance, insurance premium and administration costs) andvariable costs. Variable costs are those changing with the value of landings, such asthe crew remuneration, and those changing with the fishing effort, such as fuel costand other variable costs (Table 2).

The annual investment for each fleet is determined by the possible maximuminvestment multiplied by the profit share (ps in Eq. 1). Profit share stands for thepercentage of the profits that are re-invested in the fishery;

however, investment innew vessels will only occur if the operational days of existing vessels are equal tomaximum days (Table 1). If they aren't, the algorithm increases the effort of thecurrent fleet. If they are equal to the maximum days, the investment decisionfollows the rule below:

$$Si\begin{cases} \psi < 0 \;\; y \;\; ps\psi < 0.2 \;\; Inversión = ps \times \psi \\ \psi < 0 \;\; y \;\; ps\psi > 0.2 \;\; Inversión - 0.2 * Flota_{t-1} \\ \psi > 0 \;\; y \;\; ps\psi < 0.1 \;\; Inversión = ps \times \psi \\ \psi > 0 \;\; y \;\; ps\psi > 0.1 \;\; Inversión = 0.1 * Flota_{t-1} \end{cases} \quad (1)$$

I n Equation 1 ψ is equal to the ratio between (REV-BER) and REV. REV stands forthe revenues obtained by the fleet and BER stands for the break-even revenue (thelevel where the fleet expects to generate neither profits nor losses from the totalnumber of landings). There is not an estimation of profit-share (ps) available to the authors for this fleet. In that sense it has been decided to use this obtained in(Prellezo et al., 2016). This implies that is has been assumed that 30% of the profitsare re-invested in the fishery. However, this value can be quite variable and inreality depends on external (e.g. overall economy situation) and/or particular (e.g.expected future revenues, expected retirement date) factors.

0.1 stands for the limit on the increase of the fleet relative to the previous year and0.2 stands for the limit on the decrease of the fleet relative to the previous year.Again, in these two cases, there are no estimations and they have been obtainedfrom the same source as the ps.

2.8. Prices of fish

Prices of fish (Table 3) have been assumed to be constant. For the stocks for whichtheir dynamics have been explicitly model, prices at age group are used. For theother (OTH) group, an average price has been calculated.

Table 3. Species considered and first sale prices. Source: AZTI.

Code	Age	Average price
ANK	all	5.53€
HKE	<3	2.27€
HKE	3	2.16€
HKE	4	2.07€
HKE	>4	2.89€
MEG	<7	4.02€
MEG	7	4.11€
MEG	>7	5.14€
MON	all	4.38€
OTH	all	3.24€

2.9. Scenarios analyzed

The scenarios do reflect only the management alternatives in the Spanish trawlfishing fleet operating in sub-area VII. However, there are other factors that affectthe conditioning of the model. The most important thing is that the results includethe inclusion of the landing obligation on hake (with a de minimis for years 2016-2019) for the fleets targeting them (mainly trawlers operating in Divisions VIIIabde). This is important given that hake which is not subject to the landingobligation for the metier studied due to their condition of non-directed species, is asingle management stock that is distributed, among others, in areas VIII and VII.Three scenarios have been compared in relative terms to a baseline scenario. Themain characteristics of each one are:

Statu quo: This scenario will be based on the no application of landing obligation tothis fleet and reflects an extrapolation of the fishing pattern of the historical periodconditioned in the simulation model

Landing obligation scenario: This scenario responds to the application of the landingobligation of megrim in area VII, from 2017 onwards. The implementation of thisscenario is based on considering that the effort of this metier cannot be increasedonce the quota share of the first species is reached. In this scenario an uplift of theTAC of megrim has been simulated in the advisory process. That is, when landingobligation is in place, the TAC advice is given in terms of catches instead oflandings.

De minimis for megrim: This scenario is based on the Landing obligation scenario inwhere on top of it a de minimis exemption is granted for megrim. This de minimis is of 7% in 2017 and 2018 and of 6% in year 2019.

3. Results

Results in terms of the evolution of several transversal and economic indicators arepresented in Figure 7. The specific indicators used are:

- Fishing effort: Days at sea.
- Revenue: Value of all the landings in €.
- Gross Value Added (GVA): The sum of the remuneration to the crew and theremuneration to the capital (profit) in €.

- Profits: It stands for the remuneration to the capital and is calculatedsubtracting all the costs from the landings value (revenue).

For the case of fishing effort (Figure 7 top-left) there is a decrease in the effort thatcan be applied when the landing obligation is introduced compared with the statu quo (no landing obligation) scenario. This decrease is lower, when a de minimis is granted where this extra effort is used to catch the extra catch allowed for themegrim through. The average (2017-2019) reduction of effort when landingobligation is introduced is of 4.1%, and when de minimis is applied of 3.7%.

In terms of revenue and gross value added and profits (Figure 7), the difference between the statu quo scenario and the other two are also negative. For the case ofrevenues the application of the landing obligation will reduce them in a 5.8%, while the de minimis will only change this reduction to 5.4%. However, this higherrevenues provided by the de minimis are created at the expense of a slightly highereffort (there is more to catch for the same quantity landed) which implies that theGVA, which has been reduced by the application of the landing obligation in a 7.3%,with the introduction of de minimis would be reduced (compared with the statu quo)in a 6.9%. The same effect is being created in terms of profits. The application of thelanding obligation will reduce them in an 8.4% without de minimis and in a 7.9%with de minimis.

Figure 7. Evolution of transversal and economic indicators for the different scenariosin relative terms to the statu quo:

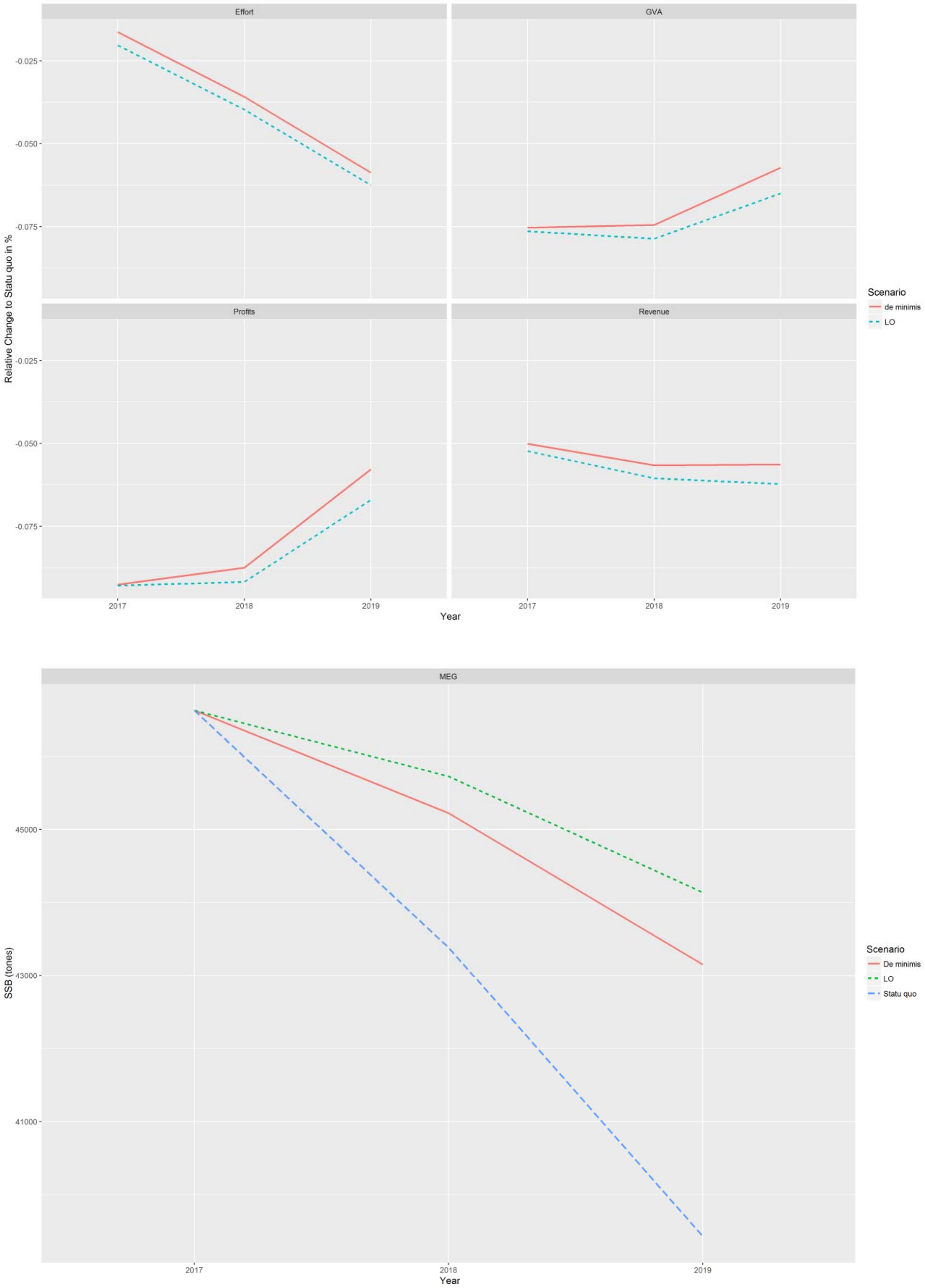

Figure 8. Evolution of Spawning Stock Biomass (SSB) for megrim under differentscenariosFigure 8 shows the evolution of the Spawning Stock Biomass (SSB) for the stock ofmegrim decreases slightly. However in terms of the differences between the differentscenarios the reduction is of around a 5% comparing the landing obligation with the statu quo. The change if a de minimis for megrim is applied is of around 1%. Overallit can be affirmed that de minimis does not change the overall evolution of the SSB.

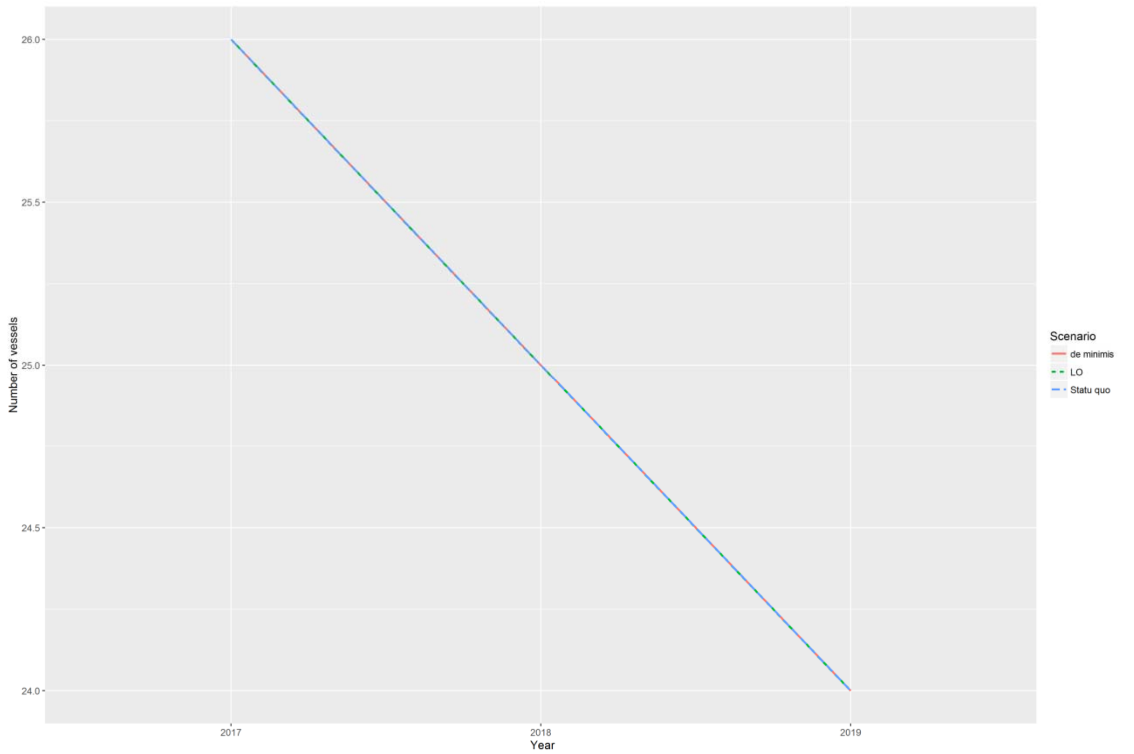

Figure 9. Evolution of the number of vessels for the OTB_DEF_70_100 métier of the Spanish trawl fleet operating in ICES sub area VII under different scenariosFinally, in terms of the evolution of vessels and the subsequent evolution ofcrewmembers, the application of equation 1 (capital changes) in projection part ispresented in Figure 9. The first result is that there are no differences between thescenarios simulated. The main reason for this result is that the profitability of eachof the scenarios is close enough to not change the results derived from theinvestment-disinvestment decisions.The second result from Figure 9 is obtained the trend obtained with what has beenobserved in the

historical evolution of the fleet (Figure 6). The result is that thereare no changes in the trend and that the evolution in terms of total number ofvessels is likely to follow the decreasing trend observed in the recent past.

4. Conclusions

The application of the landing obligation on this fleet is likely to change theeconomic performance of it in a significate way. Revenues are reduced in a 5.8% andprofits will be reduced in an 8.4%. It implies that the impact is high from theeconomic side. In absolute terms and in average the reduction in revenues by theapplication of the landing obligation will be of around 4 million Euros, and in termsof profits of around 2.5 million Euros.This impact is not likely to change the decreasing evolution of the overall number ofvessels, which is likely to continue to decrease in the following years.

The application of the landing obligation has straightforward benefits from the SSBpoint of view. These benefits come from the reduction in the fishing mortality ofmegrim (due to a lower fishing effort) and from the change in the catch profile ofmegrim. However even if the biomass is higher, it is not enough to compensate thereduction in fishing effort required. That is, the result of a lower effort applied to ahigher biomass is, in this case, negative.

The application of the de minimis is likely to slightly alleviate the economicperformance negative effects of the landing obligation; however, this reduction is, bynature, small. The reason for this is that there is a big difference between thecurrent discards levels of the fleet (35% -see Table 1) and the size of the de minimis simulated (7%, 7% and 6% for the years 2017, 2018 and 2019, respectively). Inabsolute terms the de minimis will increase the overall revenues in comparison withthe landing obligation scenario (without exemptions) in 0.3 million Euros while interms of profits this increase is of around 0.15 million Euros.

Annex: List of species

ANE Engraulis encrasicolus	**EOI** Eledone cirrhosa	**MON** Lophius piscatorius	**SLI** Molva macrophthalma
ANF Lophiidae	**ETX** Etmopterus spinax	**MUR** Mullus surmuletus	**SLO** Palinurus elephas
ANK Lophius budegassa	**FLE** Platichthys flesus	**MUT** Mullus barbatus	**SMA** Isurus oxyrinchus
BAS Serranus spp	**FOR** Phycis phycis	**MZZ** Osteichthyes	**SMD** Mustelus mustelus
BBS Scorpaena porcus	**FOX** Phycis spp	**NEP** Nephrops norvegicus	**SOL** Solea solea
BIB Trisopterus luscus	**GAG** Galeorhinus galeus	**OCC** Octopus vulgaris	**SOS** Solea lascaris
BLI Molva dypterygia	**GAR** Belone belone	**OMZ** Ommastrephidae	**SQA** Illex argentinus
BLL Scophthalmus rhombus	**GFB** Phycis blennoides	**PAC** Pagellus erythrinus	**SQC** Loligo spp
BRB Spondyliosoma cantharus	**GGD** Gaidropsarus mediterraneus	**POA** Brama brama	**SQI** Illex illecebrosus
BRF Helicolenus dactylopterus	**GUY** Trigla spp	**POK** Pollachius virens	**SQR** Loligo vulgaris
BSF Aphanopus carbo	**HAD** Melanogrammus aeglefinus	**POL** Pollachius pollachius	**SQZ** Loliginidae
BSS Dicentrarchus labrax	**HAL** Hippoglossus hippoglossus	**RED** Sebastes spp	**SWO** Xiphias gladius
BXD Beryx decadactylus	**HKE** Merluccius merluccius	**RJC** Raja clavata	**SYC** Scyliorhinus canicula
BYS Beryx splendens	**HOM** Trachurus trachurus	**RJN** Raja naevus	**TDQ** Todaropsis eblanae
CBR Serranus	**JAX** Trachurus spp	**RPG** Pagrus pagrus	**TUR** Psetta maxima

cabrilla

COD Gadus morhua	**JOD** Zeus faber	**SBA** Pagellus acarne	**USB** Labrus bergylta
COE Conger conger	**LEM** Microstomus kitt	**SBG** Sparus aurata	**WHB** Micromesistius poutassou
CRE Cancer pagurus	**LEZ** Lepidorhombus spp	**SBR** Pagellus bogaraveo	**WHG** Merlangius merlangus
CTC Sepia officinalis	**LHT** Trichiurus lepturus	**SCE** Pecten maximus	**WIT** Glyptocephalus cynoglossus
CUX Holothuroidea	**LIN** Molva molva	**SIL** Atherinidae	
DEL Dentex macrophthalmus	**MAC** Scomber scombrus	**SKA** Raja spp	
DGS Squalus acanthias	**MAS** Scomber japonicus	**SKJ** Katsuwonus pelamis	

Referencias

Alzorriz, N., Arregi, L., Herrmann, B., Sistiaga, M., Casey, J., and Poos, J. J. 2016. Questioning the effectiveness of technical measures implemented by the Basque bottom otter trawl fleet: Implications under the EU landing obligation. Fisheries Research, 175: 116-126.

Anon. 2014. Discard Atlas of the North Western Waters Demersal Fisheries. Prepared by Cefas, Lowestoft, UK.117pp.

Barrowman, N. J., and Myers, R. A. 2000. Still more spawner-recruitment curves: the hockey stick and its generalizations. Canadian Journal of Fisheries and Aquatic Sciences, 57: 665-676.

Butterworth, D., and Bergh, M. 1993. The development of a management procedure for the South African anchovy resource. Canadian Special Publication of Fisheries and Aquatic Sciences: 83-100.

Cobb, C. W., and Douglas, P. H. 1928. A Theory of Production. American Economic Review, 18: 139-165.

EC 2008. Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

EU 2013. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC Official Journal of the European Union, Brussels.

García, D., Prellezo, R., Sampedro, P., Da-Rocha, J. M., Castro, J., Cerviño, S., García-Cutrín, J., and Gutiérrez, M.-J. 2016. Bioeconomic multistock reference points as a tool for overcoming the drawbacks of the landing obligation. ICES Journal of Marine Science: Journal du Conseil. DOI: 10.1093/icesjms/fsw030.

Garcia, D., Urtizberea, A., Diez, G., Gil, J., and Marchal, P. 2013. Bio-economic management strategy evaluation of deepwater stocks using the FLBEIA model. Aquatic Living Resources, 26: 365-379.

ICES 2012. WKFRAME-3. Report of the Workshop on Implementing the ICES Fmsy Framework. Copenhaguen, Denmark.

ICES 2014a. Report of the Working Group for the Bay of Biscay and the Iberian waters Ecoregion (WGBIE), 7–13 May 2014, Lisbon, Portugal. ICES CM 2014/ACOM:11. 714 pp.

ICES 2014b. Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS)

Jardim, E., Urtizberea, A., Motova, A., C., O., Ulrich, C., Millar, C., Mosqueira, I., Poos, J. J., Virtanen, J., Hamon, K., Carvalho, N., Prellezo, R., and Holmes,

S. 2013. Bioeconomic Modelling Applied to Fisheries with R/FLR/FLBEIA. JRC Scientific and Policy Report EUR 25823 EN.

Kell, L., Mosqueira, I., Grosjean, P., J-M., F., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M., Poos, J., Scott, F., and Scott, R. 2007. FLR: an opensource framework for the evaluation and development of management strategies. ICES Journal of Marine Science, 64: 640-646.

Prellezo, R., Carmona, I., and Garcia, D. 2016. The bad, the good and the very good of the landing obligation implementation in the Bay of Biscay: A case study of Basque trawlers. Fisheries Research, 181: 172–185.

Quinn, R. B., and Deriso, T. J. I. 1989. Quantitative fish dynamics, Oxford University Press.

R-Core 2014. R: A Language and Environment for Statistical Computing. In R Foundation for Statistical Computing. Austria. Vienna.

Salz, P., Buisnman, E., Frost, H., Accadia, P., Prellezo, R., and Soma, K. 2011. FISHRENT; Bio-Economic simulation and optimisation model for fisheries. LEI Report 2011-024. 74 pp.

STECF 2015. Scientific, Technical and Economic Committee for Fisheries (STECF) – The 2015 Annual Economic Report on the EU Fishing Fleet (STECF-15-07). 2015. Publications Office of the European Union, Luxembourg, EUR 27428 EN, JRC 97371, 434 pp.

Ulrich, C., Reeves, S. A., Vermard, Y., Holmes, S. J., and Vanhee, W. 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. ICES Journal of Marine Science, 68: 1535-1547.