Input-Output analysis of the economic impacts of the landing obligation: snap-shot from the trawler fleet in Northern Iberian waters (Spain).

Rodríguez-Rodríguez[1*], Gonzalo; Ballesteros V.Hugo.M[1]; Valeiras, Julio[2]; Bellido,Jose M[3].

[1]. Fisheries Economics and Natural Resources Research Unit, Dept of Applied Economics, Faculty of Economics and Business Administration, University of Santiago, Av. Burgo das Nacións s/n, 15782. Santiago de Compostela, A Coruña, Spain. gonzalo.rodriguez@usc.es, victorhugo.martinez@usc.es;

[2]. Instituto Español de Oceanografía, Centro Oceanográfico de Vigo (IEO), Subida Radio Faro 50. 36390 Vigo, Spain. julio.valeiras@ieo.es

[3]. Instituto Español de Oceanografía, Centro Oceanográfico de Murcia (IEO), C/Varadero 1, Apdo. 22, San Pedro del Pinatar, 30740 Murcia, Spain. josem.bellido@mu.ieo.es

[*] **Correspontding author**

Abstract:

The European Commission (EC) has recognised discards as one of the major challenges facing the Community fishing fleet. The obligation to land all regulated catches has been proposed as a mandatory and essential measure to minimise discarding practices. This paper analyses the economic consequences of enforcement of the Landing Obligation (L.O.) for the Spanish trawler fleet in Iberian Waters. A representative number of in-depth interviews were carried out with ship owners and skippers of the fleet in question, to identify the envisaged operational and logistic problems on board and in port arising from the L.O. Furthermore, the current economic performance of the target fishing companies was analysed using the Input-Output methodology to identify their most significant activity costs. The combination of both research techniques enabled the evaluation of the potential consequences of the new L.O., concluding that, although it will generate minor positive and negative economic impacts, the main issue stems from the loss of quota. Some recommendations, including complementary measures to improve the implementation of the new rule, will be made.

Keywords: discards, landing obligation, economic impact, trawlers, input/output analysis.

Highlights:

The LO implies monetary costs that are not actually compensated.
These added costs are reflected in three areas: on board, onshore and in loss of quota.
The main impact stems from the loss of quota.
An approach of pragmatic flexibility that allows progressive learning and adaptation is recommended.

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1. Introduction:

Discards are a common and pervasive practice in extractive fishing, representing one of the most significant challenges to the management of marine resources (Kelleher, 2005). In the European Union, unwanted catches represent a substantial part of the fishing biomass of the Community fleet (Feekings et al., 2012); they are a widespread phenomenon in all fisheries, although their amounts, patterns and composition vary according to fishing zone, target species, gear used, etc. (Tsagarakis et al., 2013; Uhlmann et al., 2013; Valeiras et al., 2014). Discarding is a feature of (possibly) most modern fisheries and is considered collateral damage of European fishing activities (Eliasen et al., 2014; European Commission, 2000; McArthur and Howick, 2010). In any case it represents a negative externality.

From an environmental point of view, discards constitute a serious disruption to ecological systems, causing uncertain consequences to marine ecosystems and threatening their sustainability (Bellido et al., 2011; Comisión Europea, 2013; Uhlmann et al., 2013).

Moreover, as an uncertain and unquantifiable source of mortality, discards represent a severe problem for management and stock assessment, since it is often difficult to obtain reliable data on real catches, discard rates, discarded biomass mortality, etc. (Damalas, 2015; European Union, 2013; Sigurdardóttir et al., 2015; Uhlmann et al., 2013; Vázquez-Rowe et al., 2011). Discarding is also a by-product of unsustainable fishing practices, which opens up ethical debates, such as the wasting of valuable natural resources or the use of unacceptable practices that threaten the conservation of resources used to feed the human population (Catchpole et al., 2005; Eliasen et al., 2014; Österblom et al., 2011; Stockhausen et al., 2012).

The European Union (EU) has addressed this challenging issue by updating the Common Fishery Policy (CFP) (European Union, 2013). Article 15 of this new CFP establishes a discard ban and the obligation to land certain regulated species within a progressive timetable as of January 1st, 2014. The Landing Obligation (LO) is one of the CFP's key pillars, the primary objective of which is to reduce unwanted catches (European Union, 2013) and at the same time promote sustainable fisheries by reducing the fishing mortality of species and sizes of low commercial value (Borges, 2015).

The rationale behind the European regulation is that environmental laws reduce social harm by internalising social and environmental costs (Bergkamp, 2001). Cost internalisation requires that the social costs of an activity (the externalities) be charged to that activity (internalised), so that the private costs reflect the costs imposed on society (Pigou, 1932). Nevertheless, cost internalization is difficult as it is necessary to determine what constitutes a cost, what it should be charged to and on whom the costs are to be imposed or distributed (Bergkamp, 2001; Lam, 2012) and by which means (Larach, 1998). Moreover, an implementation that impedes producers from exploiting resources should be avoided, as the aim here is to maintain the activity, but sustainably and responsibly (Larach, 1998). In this respect, Sardà et al. (2013) pointed out the risk of reducing income while costs increase. Therefore, it seems that the ultimate goal is to find a way to achieve a balance between environmental and economic sustainability.

Recognizing these difficulties, the CFP also allows some *de minimis* exemptions which help fishermen resolve the challenges brought about by an increase in catch selectivity or by the disproportionate costs of handling unwanted catches; nevertheless, it is necessary to assess if these measures are enough to obtain the aforementioned balance or if any others should be considered.

All of the above is key to the success of the LO, given that fishermen´s economic motivations and their compliance with fishing regulations have been highlighted as generic drivers for discarding (Catchpole et al., 2005; Damalas, 2015; Eliasen et al., 2014; Fernandes et al., 2015; Gullestad et al., 2015; Sigurdardóttir et al., 2015; Stockhausen et al., 2012). Reasons for discarding can be extremely varied and can occur under the influence of economic, sociological, environmental or biological factors (Bellido et al., 2014). As a human activity dependent on valuable natural resources, fishing is part and parcel of complex institutional systems (Ballesteros and Rodríguez-Rodríguez, 2018; Eliasen and Christensen, 2012; Johnsen and Eliasen, 2011; McGoodwin, 2002). In these systems, fishing, and therefore the practice of discarding, depends on the relationships established at an economic level with the market, at a social level with the community environment and at a regulatory level with the existing rules of the game (Scott, 2000). Consequently, the rationale behind discards is difficult to explain in a simple way (Valeiras et al., 2014).

Ultimately, the LO represents a major change in fisheries management in Europe which, among other issues, implies a move from landing quotas to catch quotas. With such a substantial change, identifying the real economic impact of the LO on fishing industries remains a key goal, not only for policy purposes but also for ecological (Borges, 2016) and economic modelling (Prellezo et al., 2015). The contribution of this research is therefore to verify the economic impact of the LO (considering a representative fleet, in an average year, with average quotas and average discards).

2. Materials and methods.

A proper assessment of the socio-economic impact of the discard ban requires not only detailed economic data about inputs, labour and demand, but also the contextualization of all those data within the specific operational practices, objectives, formal and informal rules, culture, environment, etc. of the studied fleet. Consequently, two different analysis were utilised to capture both quantitative and qualitative data, i.e. firstly, the input-output framework and, secondly, in-depth interviews to skippers and shipowners.

Input-Output (I-O) tables may be defined as a set of matrices that present the equilibrium between the supply and the use of goods and services. These matrices provide a detailed expression of the production process, the use of goods and services produced in a country (region or sector) or imported from the rest of the world and the income generated by the different economic activities (Schuschny, 2005). The standard input-output model may be represented compactly through the expression:

$$x = X_{e-} + f;\ x = Ax + f; x = (I - A)^{-1}f \quad (1)$$

where matrix X represents the transaction flows between sectors of activities and is the sum of gross outputs, matrix I is an identity matrix, vector x is the sum of gross outputs, vector f represents the part of gross output sold to final demand, and A is a matrix of input coefficients (technical coefficients) defined as

$$A = a_{ij} = \frac{z_{ij}}{x_j} \quad (2)$$

where zij is the intermediate demand for inputs between sector i and the supply sector j and xj is the final output for sector i. $(I - A)^{-1}$ (Eq. (1)) is known as Leontief's inverse matrix and represents the total direct and indirect outputs in sector i per unit of exogenous final demand, for sector j (Pérez-Labajos, 2001). In this scheme, the columns of the intermediate inputs matrix show each sector´s inputs (z_{ij}) and represent a function of production. Using this model it is possible to determine not only the structure of the production function, but also the impact of external shocks, policy measures, changes in demand, etc. (Venegas, 1994) and it thus constitutes an appropriate tool for assessing the economic impact of the landing obligation on the Galician trawler fleet.

Just like any other models, I-O includes certain assumptions and it is necessary to know these beforehand in order to interpret results correctly (Bess and Ambargis, 2011). The following are of particular importance for this research:

- *Fixed productions patterns*: I-O models typically assume that inputs are used in fixed patterns and without substitution between inputs. This applies both for intermediate and primary inputs, like labour, and means that if the output changes, inputs change in the same proportion.

- *Industry homogeneity*: This means that it is assumed that each input i is provided by only one sector of production and, subsequently, that each industry has only one production method (Leontief, 1986).
- *Fixed prices and no supply constraints*. It is assumed that there would be no price adjustments due to changes in supply or demand conditions and specifically that relative prices are invariable (Leontief, 1986; Schuschny, 2005). As for the second, supply shortages are not considered for typical modelling.

Certain limitations stem from these assumptions. Firstly, I-O analysis is not an adequate tool for modelling the transition to a new state and, secondly, and linked to the former, as no changes in the production function are allowed in the model, impacts are measured under current conditions (routines, technologies, equipment, etc) which tends to reflect the "worst case" cost scenario. Hence, this research focuses on present state or present conditions. In the long term, adaptive measures and new technologies or market driven solutions are likely to emerge. For a more detailed review of the I-O model assumptions and limitations see, for instance, Bess and Ambargis (2011) or Miller and Blair (2009).

Since Leontief's seminal contributions (1936), the use of the input-output framework has grown enormously and it is currently an essential component of many types of economic analysis: in fact, input–output analysis is one of the most widely applied methods in economics (Baumol, 2000).

While this framework is generally used at a national level, its application to individual sectors is also common. In the specific field of marine-based sectors, there are not yet many examples of its use, but representative examples include analyses of the Hawaiian fisheries sector (Cai et al., 2005; Coffman and Kim, 2009), the shipping sector in Germany (Van Der Linden, 2001), the role of the maritime sector in the South Korean economy (Kwak et al., 2005) or, similarly, an analysis of the maritime sector in Ireland (Morrissey and O'Donoghue, 2013). More recently, Surís-Regueiro and Santiago (2018) used this methodology to assess the economic impact of changes in physical production. Of particular importance for our research are The Input-Output tables for the Galician Fishing and Preserved Fish Sectors (García-Negro (Dir.), 2003, 1997; García-Negro et al., 2016), especially the first, as it is the basis for our analysis.

The Input-Output Tables for the Galician Fishing and Preserved Fish Sectors 2011 (TIO-2011) (García-Negro et al., 2016) provides information about the function of production of the whole Galician fleet in 2011 (intermediate inputs, wages, income, taxes, etc.) for all the different sub-sectors of the Galician fishing sector, including those coastal fishing vessels operating in Northern Iberian Waters. That´s to say, these are product-by-industry tables. This configuration is considered a better choice than a product-by-product or an industry-by-industry basis (Rueda-Cantuche, 2011) to address an impact analysis of the limitation of the production possibilities.

The questionnaires used for the TIO-2011 also provide information about the composition of the catches in tonnes. The values obtained from the questionnaires were used to recalculate the production when discards are counted against quota.

According to these data, the production function of the Galician coastal fleet was recalculated for this paper, from the average quotas in the period 2014-2016 and running the model through the technical coefficients of the TIO-2011 symmetric matrix. This represents de BAU (Business As Usual) scenario, i.e. no enforcement of the LO. Regarding LO scenarios, first of all, the production value was recalculated adding discard catches (of species subject to TACs and MLS) to the quota of that particular targeted species. The total quota consumption was simulated based on the following expression:

$q_i = n_i c_i + n_i u_i$ (3)

if the *de minimis* exemption is applied, then $n_i u_i > 0{,}05 q_i$

where q_i is the TAC (Total Allowable Catches, expressed in kg.) of species *i* allocated to a typical trawler, n_i is the number of hauls needed to fish the entire TAC, c_i are the catches per haul of the target species (in kg.) and u_i are the unwanted catches[1] (kg.) per haul of species *i*. If the *de minimis* exemption is applied, $n_i u_i$ will be 0 for every value lower than $0{,}05 q_i$.

At the same time, key inputs directly affected by the LO, such as fuel and labour, which represent almost 60% of the production costs of the typical boat, were recalculated taking into account the operational changes introduced by the new rules. The majority of the remaining inputs are variable costs, (services provided by public administration, naval repair services, transport services, wholesalers services, etc.) not directly affected by the LO, so the assumption of strict proportionality is coherent in this case.

To identify the potential impacts of the LO on the function of production of a standard vessel of the fleet, 13 in-depth interviews were carried out with ship-owners and skippers of the target fleet during the Life ISEAS project (http://lifeiseas.eu/es/). The in-depth interviewing technique used made it possible to establish flexible dialogues with the informants in long conversations lasting 81 minutes on average. Extensive qualitative information was gathered during the interviews and subsequently used to analyse the implications of the LO application. The interviews were semi-structured and conducted face-to-face in April and May 2015 at the fishing companies' offices in the Galician ports of Marin, Bueu and Ribeira. All the suggested impacts that would affect the function of production and economic performance of the fleet were checked and quantified.

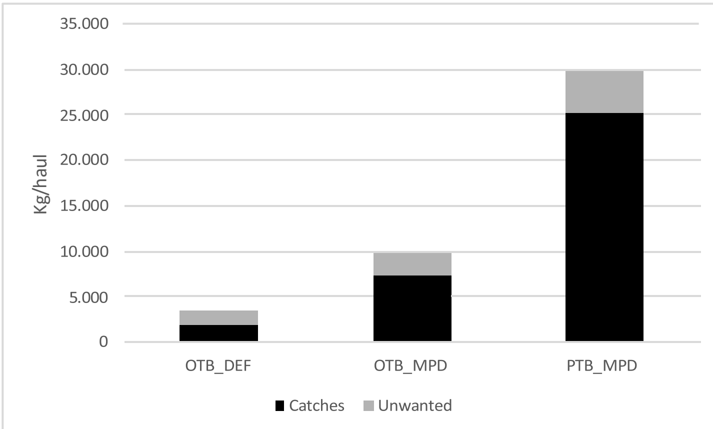
Data on catches were recorded by the Spanish Institute of Oceanography (IEO, Instituto Español de Oceanografía) within the framework of the Data Collection Regulation of the European Commission and collected by on-board observers for all the three trawling *métiers* in Northern Iberian Waters:

- OTB_DEF_>=55_0_0: Otter bottom trawl targeting demersal fish (at least 55 mm).
- OTB_MPD_>=55_0_0: Otter bottom trawl targeting mixed pelagic and demersal fish (at least 55 mm).
- PTB_MPD_>=55_0_0: Bottom otter trawl targeting mixed pelagic and demersal fish using "Baka" nets (at least 55 mm)

Observer records distinguish between retained catches, that are the part of the catches preserved on board and discarded catches, which are returned to the sea due to factors like regulatory issues (fish under MLS, lack of quota, etc.), no commercial value, damaged fish, lack of capacity in the holds, etc.

[1] Species under TAC or species which have a MLS (minimum landing size)

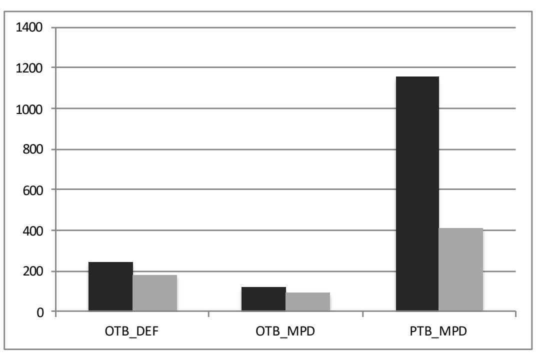
Figure 1. Total retained (black) and discarded (grey) catches by haul and *métier* in Iberian Waters. Trawling fleet. Average 2014-2016.



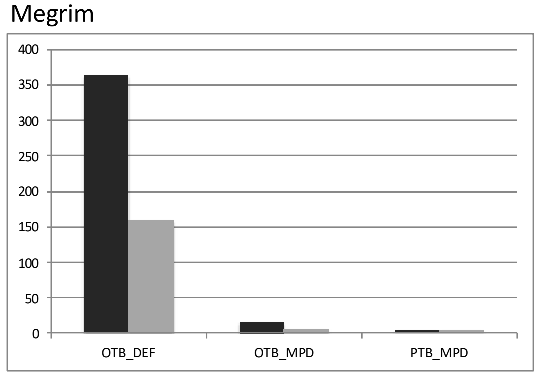
The bottom trawl mix fleet operating in the Cantabrian Sea and along the Iberian Atlantic Coast (ICES divisions VIIIc and IXa) was composed of 77 vessels in 2016, with an average length of 28.25 m., similar technology and fishing gear and even though it represents only 9.3% of the Spanish OTB fleet, it concentrates 29.4% of the tonnage. The main ports for this fleet are Vigo, Marin, Ribeira, A Coruña, Celeiro, Gijón, Ondárroa, Pasajes, etc. Several quota and fishing effort measures are currently being enforced in these areas.

Figure 2. Retained (black) and discarded (grey) catches (kg.) by haul, by species and by *métier* in Iberian Waters. Trawling fleet. Average 2014-2016.

Hake



Megrim



Angler Fish

Blue whiting

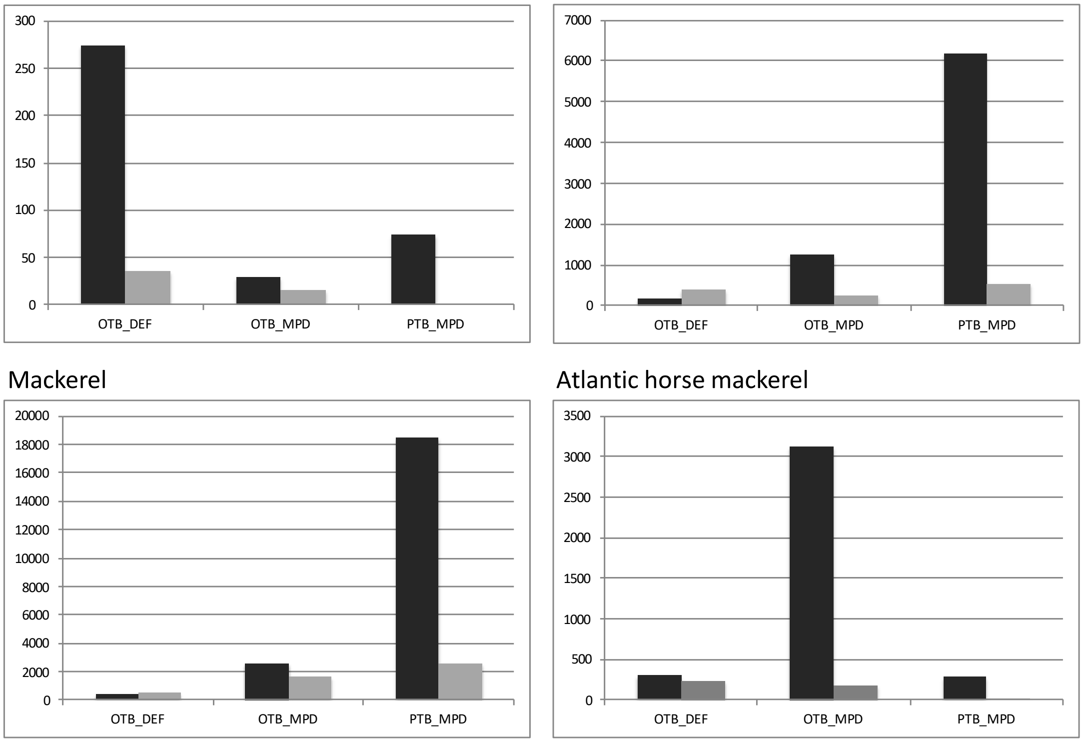


Figure 1 shows the composition of an average haul for the species subject to the LO, allowing us to model the impact using the input-output framework under the following four scenarios:

0. **Business as Usual (BAU):** Landing obligation not implemented, i.e. discards allowed.
1. **Landing obligation – no exemptions (LO):** Landing obligation fully implemented. Unwanted species (species subject to quotas or RMS) are sold at 0.05 EUR/kg for reduction.
2. **Landing obligation – de minimis:** As Sc-1 but with a 5% *de minimis* implemented.
3. **Landing obligation – increased costs:** As Sc-2, but with a 50% reduction in unwanted catches, either by improving efficiency, non-compliance or for any other reason.

Scenario 3 was introduced to get a snapshot of the economic impact under a threshold of increased selectivity.

3. Results.

3.1. Identification of the economic costs related with fishing.

The Input-Output analysis offers a detailed picture of the intermediate and primary inputs associated with the fishing activity, namely goods and services, other than fixed assets, used as inputs in the production process. The intermediate inputs of a typical trawler under the different scenarios are summarised in Table 1. It is worth noting that one of the inputs directly affected by the LO, namely fuel consumption, represents almost 33% of the intermediate inputs (19.7% of the production costs).

Table 1. Intermediate inputs of a single trawler. Euros.

	BAU	SCE 1	SCE 2	SCE 3
Oil refinery products, etc.	204.862,90	171.536,49	180.113,32	199.283,31
Services provided by the public administration	96.798,44	82.807,10	85.386,42	91.700,74
Boats and naval repair services	75.156,92	64.293,66	66.296,32	71.198,93
Other business services	43.099,02	36.869,45	38.017,88	40.829,30
Services provided by service stations and other mechanical repairs workshops	37.982,35	32.492,34	33.504,43	35.982,08
Transport services	17.866,33	15.283,91	15.759,98	16.925,43
Other foodstuffs	17.619,32	15.072,60	15.542,09	16.691,43
Other wholesale trade services	17.225,70	14.735,88	15.194,88	16.318,54
Ropes and nets	15.620,74	13.362,90	13.779,14	14.798,11
Legal fees and external consultants	15.235,52	13.033,36	13.439,33	14.433,17
Fisheries products: inshore fishing	13.999,32	11.975,85	12.348,88	13.262,08
Fisheries products: coastal fishing	10.220,96	8.743,61	9.015,96	9.682,69
Miscellaneous business services	9.957,72	8.518,42	8.783,76	9.433,32
Services provided by financial intermediaries	8.761,86	7.495,41	7.728,88	8.300,43
Miscellaneous metal goods	6.299,70	5.389,13	5.557,00	5.967,94
Machinery and electronic equipment	5.607,15	4.796,69	4.946,10	5.311,86
Tools and ironmongery items	5.242,89	4.485,08	4.624,78	4.966,78
Serv. provided by business & professional org.	4.086,62	3.495,94	3.604,83	3.871,41
Ice	3.582,75	3.064,90	3.160,36	3.394,07
Plastic containers and packaging	3.136,34	2.683,01	2.766,58	2.971,17
Machinery and mechanical equipment	3.012,11	2.576,74	2.657,00	2.853,49
Pulp, paper and cardboard items	1.070,52	915,79	944,31	1.014,14
Paint	965,22	825,71	851,43	914,39
Port services	773,87	662,01	682,63	733,12
Textile ship items	618,14	528,79	545,26	585,58
Salt	540,91	462,73	477,14	512,42
Postal and communications services	507,10	433,80	447,32	480,39
Electrical energy and gas	420,19	359,45	370,65	398,06
Tobacco	393,61	336,72	347,21	372,89
Other plastic and rubber articles	280,12	239,63	247,10	265,37
Other chemical products	196,25	167,88	173,11	185,91
Fresh water	195,44	167,19	172,40	185,14
Other retail sale services	83,86	71,74	73,97	79,44
Other textile goods	69,06	59,08	60,92	65,42
Basic chemical products, pesticides and agricultural chemical products	49,14	42,04	43,35	46,55
Clothes and leatherwear	25,32	21,66	22,33	23,99
Retail trade services	18,05	15,44	15,92	17,10
Processing & preserving fish, crustaceans, molluscs	11,69	10,00	10,31	11,07

TOTAL	621.593,13	528.032,12	547.713,27	594.067,27

Figure 3 shows the essential primary inputs (land, labour and capital) needed by the productive units analysed. In so far as the production cost of the fishing activity, *Compensation of employees* (*Gross Wages and Salaries + Social Contributions*), another critical input directly affected by the LO, accounts for 39.9% of the production cost. Therefore, fuel and labour costs represent almost 60% of the production costs of a typical vessel.

It is important to highlight that the *Gross Operating Surplus* (*GOS*) approximately represents the profits that the companies would obtain from their fishing activity. The average GOS in this case study is 71,131.60€ per boat. Considering that intermediate inputs plus employee remuneration average almost 1,000,000€ per trawler, the resulting GOS may be considered low. Note that this amount should remunerate the capital invested and contribute to financing new investments aimed at improving the performance of the companies. Therefore, the coastal trawlers analysed are quite vulnerable to changes in their cost structure, especially if these changes produce additional expenses with no economic return.

Table 2. Primary Inputs per trawler. (Euros)

	Primary Inputs	BAU	SCE 1	SCE 2	SCE 3
a	Intermediate consumption in basic prices	601.482,44	514.543,56	530.570,84	575.015,66
b	Net taxes per product	20.110,70	17.203,88	17.739,75	19.051,61
c=a+b	Intermediate consumption in purchaser's prices	621.593,13	528.032,12	547.713,27	594.067,27
d= e+f	Employee remuneration	415.175,69	361.336,39	370.969,74	395.156,10
e	Gross wages and salaries	350.730,03	304.922,25	313.135,71	333.720,61
f	Social contributions	64.445,67	56.414,14	57.834,03	61.435,49
g	Other net Production Taxes	3.724,54	3.186,19	3.285,44	3.528,39
h	Gross Operating Surplus (GOS)	71.131,60	59.401,22	59.738,58	61.712,48
i	Mixed Income	4.722,90	3.889,37	3.911,45	4.040,70
k=d+g+h+i	Gross Value Added in Basic Prices	495.754,74	427.813,16	437.905,20	464.437,67
l=c+k	Production in Basic Prices	1.117.347,87	955.845,28	985.618,47	1.058.504,94

3.2. Identification of expected contingencies related with enforcement of the LO.

When discard reduction measures are implemented in regulated fisheries, it is expected that the fishermen will have to assume an initial economic cost (Catchpole et al., 2006). However, because not every cost can be assumed, it is essential to determine precisely the different kinds of costs (in terms of time, money or fishing opportunities) entailed by the introduction of the LO. The research undertaken for this study has identified the three main areas in which these costs manifest themselves: on board, on shore and in terms of loss of quota.

3.2.1. Impacts on board.

During the in-depth interviews, fishermen pointed out that the application of the LO will force them to keep on board, select, handle, conserve, register, transport and land all unwanted catches, increasing not only the working time of the crew but also the economic costs of the activity. Thus, the main issues on board seem to be an increase in crew working hours as well as the reduction of the storage capacity and the additional supported costs.

Regarding the workload for the crew, the interviewees explained this increase in the work on board in relation to two specific problems that also have an economic implication:

i) An increase in the crew working hours. The LO will require the sorting and storing of additional quantities of fish, as well as the accounting, recording and transmission of catches, all of which must be carried out with the utmost accuracy to avoid possible sanctions. These extra tasks must be added to the workday or subtracted from other activities, including resting hours, possibly jeopardizing safety in the workplace.
ii) This new additional work has no reward. The wages system used by most crews of the studied fleet is based on the system known as "share payment", through which the wages of the fishermen are established according to the value of the catches. The higher the value of the landed fish, the higher the salaries of the crew will be. Under the new CFP, the crews will spend hours on processes linked to the extraction, treatment, storage, etc. of fish with almost no value.

This issue was then evaluated to quantify the economic impact and transfer it into the input-output model. The method to identify the required time to handle all the LO catches was to calculate how long it would take to handle a single box of fish and then extrapolate that value to the resulting amount of catches (Jaurlaritza et al., 2015).

Trawlers use plastic boxes of 15, 20 or 40 kg for storing the fish. As the 15kg box is the most common, it was used as a unit of measure.

An observer recorded all the handling times of the unwanted catches, clearly identifying every step:

- S1: Preliminary fish sorting and preparation of boxes.
- S2: Fish gutting and classification into boxes.
- S3: Storing of boxes and other tidying tasks.
- S4: Landing of boxes.

All this process resulted in an *Average Handling Time of a Box of Fish* (AHT)[2] of 3.75 minutes per box. Extrapolated results are shown in Figure 3.

[2] AHT= Total Handling Time (minutes) / Nº of 15 kg boxes.

Figure 3. Required annual time per vessel to handle unwanted catches. Scenario 1.

	Unwanted catches of target species (Kg)	Number of BOXES	Total Handle Time (Min.)
Hake	15.272,34	1.090,88	4.090,80
Megrim	3.372,91	281,08	1.054,03
Angler fish	1.516,47	108,32	406,20
Blue whiting	47.594,84	3.966,24	14.873,39
Mackerel	35.759,76	2.554,27	9.578,51
Atlantic H. mackerel	19.715,24	1.408,23	5.280,87
TOTAL	123.231,56	9.409,01	35.283,80

Figure 4. Required annual time per vessel to handle unwanted catches. Scenario 2.

	Unwanted catches of target species (Kg)	Number of BOXES	Total Handle Time (Min.)
Hake	13.705,51	978,96	3.671,12
Megrim	2.987,97	249,00	933,74
Angler fish	927,60	66,26	248,47
Blue whiting	35.355,36	2.946,28	11.048,55
Mackerel	28.031,32	2.002,24	7.508,39
Atlantic H. mackerel	13.810,82	986,49	3.699,33
TOTAL	94.818,58	7.229,22	27.109,59

Figure 5. Required annual time per vessel to handle unwanted catches. Scenario 3.

	Unwanted catches of target species (Kg)	Number of BOXES	Total Handle Time (Min.)
Hake	7.255,77	518,27	1.943,51
Megrim	1.544,38	128,70	482,62
Angler fish	182,30	13,02	48,83
Blue whiting	12.572,30	1.047,69	3.928,85
Mackerel	11.204,57	800,33	3.001,23
Atlantic H. mackerel	4.269,94	305,00	1.143,73
TOTAL	37.029,26	2.468,62	10.548,76

In short, the LO will imply 588 additional working hours under scenario 1, 452 additional hours under scenario 2 and 176 under scenario 3 (31%, 24% and 9% of the working capacity of one full-time employee, respectively). These hours were converted into euros and included in the function of production of each scenario.

The interviewees argued that the lack of room on board would be one of the main problems adapting to the new law, for several reasons:

i) Working areas on trawlers are small and adapted to selection processes which enable unwanted catches to be discarded. The fishermen consider that it will be difficult, and even dangerous, to work in limited spaces when having to select, process, conserve and store previously discarded fish that sometimes comes in massive quantities. Furthermore, it was pointed out that to comply with the mandatory landing of all regulated catches, several investments will probably be required to adapt not only the factory space on board, but also the storage hold capacity and to incorporate technology to improve the aforementioned processes.
ii) Storage limits. The sector is really concerned about storage limitations on fishing vessels. The landing obligation for all the biomass subjected to TACs will reduce the available space for the conservation of valuable catches. This lack of space might force ships to return to port with a full hold but without having accomplished their catch objectives for a given trip.

During the Life iSEAS project, 28 experimental LO trips were made. 4.3% of the experimental trips filled the vessels' storage capacity. The studied units were based in Galician ports and operated in two fishing grounds in ICES areas VIII-IX (Galicia-Cantabrian Sea and waters off the North of Portugal). The former usually make one-day fishing trips and therefore do not usually fill their holds, whereas those operating in Portuguese waters make longer trips of around 5-7 days, so they need to store several days´ catches. To simulate the state of the ships' holds under the full implementation of the LO, the number of catches identified as discards for reasons of small size (MLS) or lack of quota was added to that of the retained fish.

Discarding due to MLS, particularly for species such as blue whiting, hake, horse mackerel and Atlantic mackerel, which can even saturate nets, is common in the Northwest Cantabrian (Valeiras et al., 2014) and North of Portugal fishing grounds (García-Rivera et al., 2015). It is worth remembering that incidental fishing can be highly variable even within the same fisheries (Bellido et al., 2014; Uhlmann et al., 2013).

Hence, results suggest that for fleets fishing in more distant grounds, full storage may marginally increase fuel consumption due to additional trips and also the cost associated to it. This cost was added to the different scenarios calculated in this research.

Finally, ice and plastic boxes are the most relevant inputs in so far as handling, preserving and storing catches. Each productive unit consumes 3,582.70€ of ice on average (0.6% of the activity cost) and almost all the vessels in the fleet are equipped with ice-making machinery. As a result, direct costs linked to additional ice consumption do not represent a significant burden. Nevertheless, for the interviewees, an important concern is the room needed for storing ice. In fact, carrying a greater amount of ice will imply a reduction in load capacity and a (marginal) increase in the cost of fuel. These circumstances can cause problems because of the lack of space whenever there is a high volume of incidental fishing that must be landed.

As for plastic boxes, most of the trawlers use box rental services, registered under the items *Services for the Handling and Storage of Merchandise* and *Other Business Services* and a few of them buy their own boxes. In both situations, a specialised company collects, sanitises and replaces the boxes, which are the most valuable input in the storage and conservation of fish on board. The box company applies a fee depending on the type of service: either a comprehensive rental package or a maintenance service for companies with their own boxes.

The main concern of the industry about the use of boxes for storing discards is that, in many cases, the container will be more expensive than the content. There are two underlying ideas associated with the previous statement:

i) It is mandatory to store the fish in an appropriate container, implying that a storage cost will always be imposed on the industry. The value of a plastic box depends on its capacity and whether the trawlers buy or rent them. Boxes have a 15, 20 or 40 kg capacity, the first being the most commonly used, and cost 0.92 €/u, 1.05 €/u and 1.18 €/u, respectively. The fee for collection, sanitation and replacement when the boxes belong to the ship is lower, ranging from 0.20 to 0.50 €/u, depending on the type of box.
ii) The low price for the fish for reduction. The new CFP bans the commercialisation of fish under MLS (90% of total unwanted catches in this fleet) for direct human consumption, the main available market for this kind of fish being fishmeal production, which in Galicia offers an average price of 0.05 € per Kg.

A simple calculation shows that a company will pay 0.92 €/u to rent each 15 kg box, but receive 0.75 €/box of discards for fishmeal processing at the average price of 0.05 €/kg[3]. If discards are stored in 20 kg boxes, the rental price of 1.05 €/u will still be higher than the 1€ they receive from selling the fish to the fishmeal industry. If 40 kg boxes are used, the rental would be 1.18€ per unit and each box of discards would be sold for 2€; this is the only case in which fishermen would not lose money on the packaging alone. Owning the boxes does not dissipate the problem because even though the fishing companies would pay less for collection, cleaning and replacement services, they would have had to make a prior investment to acquire the packaging.

3.2.2. Impacts on shore.

The specific costs directly related to the activity on shore are identified in Table 4 as a total amount, as the percentage of the landing costs and as the percentage of each corresponding supply sector. Generally speaking, landing costs in the studied fleet represent 5.19% of the total cost structure, the primary on-shore input being the service offered by fish brokers, registered as *Other Wholesale Trade Services*, which represents 65.42% of landing expenses. This service includes tasks like the management of port fees, the selection of fish and the process of labelling and preparing for auction. These brokers operate for a percentage of the

[3] The three fishmeal processors located in Galicia were contacted for this research, informing that prices range from 30 €/t for the lowest quality to 70 €/t for the highest.

sale of the fish and, consequently, a reduction in valuable fish will mean a marginal reduction in the marketing cost for the fishing company.

Table 3. Landing Costs

	Intermediate Inputs	Value	% of each input on total landing costs	% of each supply sector
1	Other Wholesale Trade Services	28,473.8 €	65.42%	2.97%
2	Transport Services	7,222.8 €	16.59%	0.75%
3	Services for the Handling and Storage of Merchandise	5,204.6 €	11.96%	0.54%
4	Ice	2,588.1 €	5.95%	0.27%
5	Serv. Provided by Business & Professional Organizations	2,429.0 €	5.58%	0.25%
6	Fresh Water	196.43 €	0.45%	0.02%
	Total	43,526.6 €	100.00%	5.19%

The second input in order of importance is *Transport Services,* and it refers to the transport of fish between the port of landing and where the fish is sold. Although in general the fish is landed at the point of sale, during some weeks per year it can be done at other more distant landing sites for: i) operational reasons; and ii) when it means saving fuel and time spent sailing to the base port. This cost could eventually increase depending on the availability of alternatives for managing the unwanted catches at the landing port, the occupation of the trucks' holds, etc.

On the other hand, the intermediate input of *Services for the Handling and Storage of Merchandise* includes services such as the use of boxes in ports, transport inside the ports, storage, the use of trailers and other services that may be needed in the port area. These activities are expected to increase depending on the amount of fish managed on shore. But in most cases, the landing of incidental fish will still be the responsibility of the crew, who will have to invest more time and effort on this task. Nevertheless, on a global level, an increase in this type of landing costs would not be significant, as it would only be incurred by a few ships.

At an operational level, it is difficult to foresee how the LO will affect certain costs on shore because it is yet to be clarified how unwanted catches will be handled at the landing sites. It is worth mentioning that fishmeal companies collect discards at the landing ports and therefore assume the costs of transportation to their facilities. Nevertheless, they are not interested in collecting amounts under 500kg, so when small quantities are landed the fishing companies may incur in costs of storage, conservation or management. Similarly, in cases of damaged fish, not suitable for fishmeal, the cost of managing waste would increase.

3.2.3. Quota impact.

Finally, the third type of threat stemming from the new rules is the impact on quota. According to the new LO, unwanted catches must be counted against quota when applicable. This is a sensitive matter as any reduction in fishing possibilities can affect the final fishing production and, consequently, fishing companies' business results. After recognising the problem in Article 16, the 2013 CFP wants to adjust the TACs to the new scenario, taking into account the need to establish *"catch quotas"* that will replace the current *"landing quotas"* (European Union, 2013). The fundamental idea is to adapt the system of quotas to the biomass extracted. This proposal will imply a general increase in quotas; nevertheless, the application of the theory, in fact generates uncertainty among the fishermen. In fact, conflicts of interest may emerge with the assignation of additional quotas.

Anticipating such a risk, the CFP has introduced some exemptions to permit a certain degree of flexibility; these are the *de minimis* exemptions, survivability exemption, as well as inter-species and the inter-annual flexibility that will allow the allocation of a percentage of the catches to future and past quotas and to quotas of the main species (European Union, 2013). As a result, in order to check the potential losses stemming from the loss of quota, the opportunity cost scenario was calculated for 2017. Since discards are characterised by their high variability (Bellido et al., 2014), it was necessary to take several decisions to avoid extreme or unrepresentative scenarios:

a) First, the observed population was the fleet operating in Iberian Waters (ICES VIIIc and IXa). In 2016, 77 vessels made up this fleet, even though the average was 93 for the analysed period, representing 9.3% of the Spanish trawling fleet but concentrating 29.4% of the total tonnage (MAPAMA, 2018).

b) Data on wanted and unwanted catches differentiates the three trawling *métiers* in the area.

c) Data on wanted and unwanted catches is taken from the period 2014-2016 to avoid modelling based on particular circumstances.

d) Multispecies approach: Hake (Merluccius merluccius), Megrims (Lepidorhombus boscii and L. whiffiagonis), Anglerfish (Lophius piscatorius and L. budegassa), Blue whiting (Micromesistius poutassou), Horse mackerel, (Trachurus trachurus) and Mackerel (Scomber scombrus)

All these precautions have been adopted in order to represent the impact of the LO on the trawling fleet in Iberian waters in an average year under ordinary circumstances, assuming that in the absence of the LO the fishing companies would consume the totality of the quota. At the same time, the aim is to address not only the impact under different conditions but also the drivers behind those impacts.

The reduction in fuel consumption linked to effort reduction as well as the increase in working load and consequently in salaries (see above) were both specifically taken into account to recalculate the function of production of a typical boat. Also, it was considered that the cost of plastic boxes does not vary with changes in production, as the number of boxes needed is more or less the same, regardless of whether they are storing cheap or expensive fish. It is worth noting that the cost of fuel and the cost of labour represent about two thirds of the total production costs. Results of the input-output model are presented in Table 4.

Table 4. Economic impact per vessel of the LO for the trawling fleet in Northern Iberian Waters.

	BAU	SCE 1		SCE 2		SCE 3	
	Value	Value	Δ BAU	Value	Δ BAU	Value	Δ BAU
Quota (t)	693,71	693,71	0%	693,71	0%	693,71	0%
Catches of quota species (t.)	693,71	568,26	-18,08%	596,67	-13,99%	654,46	-5,66%
Discards (t.)	153,17	0,00	-100%	34,57	-77,43%	34,57	-77,43%
Unwanted catches (t)	0	123,23		94,82		37,03	
Catches of quota species (1000€)	791,54	623,88	-21,18%	655,07	-17,24%	730,85	-7,67%
Unwanted catches (1000€)	0	5,36		4,74		1,50	
Expected revenue from quota species (1000€)	791,54	791,54	0%	791,54	0%	791,54	0%
Revenue from quota species (1000€)	791,54	630,04	-20,40%	659,81	-16,64%	732,70	-7,43%
Income reduction (1000€)	0	161,50		131,73		58,84	
Opportunity cost per unit of unwanted catches	0	35,83		35,83		35,83	
GOS (1000€)	72,13	55,91	-17,65%	59,18	-17,18%	61,71	-14,44%
Total income (1000€)	1.117,35	955,85	-14,45%	985,62	-11,79%	1.058,50	-5,27%
Fleet (Average 2014-2016)	93	93		93		93	
Income reduction for the fleet	0	15.019,7		12.250,8		5.472,4	

*. Average prices for fish obtained from: www.pescadegalicia.com. Average price for fish for reduction in Galicia is 0,05€

Given the spatial and temporal scope, as well as the precautions adopted, the results can be considered representative of the magnitude of the impacts of the LO in Iberian Waters.

The results show that we should expect a significant impact of the LO in the short term in all the scenarios under full implementation, even though the intensity of the impact also varies from *soft* to *hard* scenarios. The change in income with respect to the BAU scenario goes from a 14.5% reduction in Scenario 3 to a 5.3% reduction in Scenario 1. The intermediate scenario, a 5% *de minimis* exemption, would contribute to reducing the impact but it is not enough to compensate it.

These results are brought about by the substitution of high-value marketable production for (almost) no value unwanted catches paid at 0.05€ for reduction. At this price, fishermen must sacrifice 35.8€ of valuable catches for every euro paid for unwanted catches. Species by species, this ranges from an opportunity cost of 12€ for blue whiting to 85.8€ for megrim. Therefore, the primary driver of the decrease in income is the low price of fish for reduction.

The impact on GOS goes from a 22.5% reduction in Scenario 1 to a 14.4% reduction in Scenario 3, with fuel costs contributing positively to profitability, labour costs contributing negatively and with most inputs changing proportionally with production value. To this regard, the reduction in the fleet income, that goes from 15M€ in Scenario 1 to almost 5.5M€ in Scenario 3, would mean an indirect impact on the coastal communities due to the reduction of inputs provided by ancillary industries and services.

4. Discussion

This research shows that the implementation of the LO may bring about a reduction in discards and the fishing effort, but it may also result in a reduction in the income and revenues of fishing companies.

The first significant change stems from how quotas are counted. Before the discard ban, fishermen could fish and discard until the TAC was reached exclusively with target species. Under the LO, since part of the unwanted catches are counted against the quota, fewer days fishing will be needed to consume identical quotas. The reduction of the fishing effort will vary depending on the characteristics of the fisheries. Specific problems are expected in mixed fisheries (Ulrich et al., 2011), where a variety of species are caught simultaneously and they cannot discriminate among the stocks they catch (García et al., 2017); in other words, in those mixed fisheries where increasing selectivity is more difficult, the expected impact of choke species on the fishing effort under LO will be higher (Hatcher, 2014). Research carried out in the Cantabrian Sea - Northwest Spain has shown that this is the case in these fishing grounds (Valeiras et al., 2014).

In fact, when considering the short-term economic impact, the estimations suggest that the income of the trawling fleet in Iberian waters will be reduced by 14.5% (15M€) with no *de minimis* and by 11.8% (12M€) with a 5% *de minimis*. The main drivers of this result are, on the one hand, the high rates of catches under MLS and, on the other, the loss of quota; that's to say, substituting valuable catches for fish for reduction at a meagre price; other adverse impacts, such as the increase of the working load and consequently of salaries, are limited. It is worth noting that a reduction in the fishing effort will mean less fuel consumption and benefit profitability (marginally).

It has been pointed out that inappropriate incentives that generate low incomes for fishermen also reduce management flexibility and increase the likelihood of environmentally damaging decisions (Sissenwine and Rosenberg, 1993). Since the LO implies significant additional costs for fishing companies, we would expect reluctance from ship owners to leave a BAU situation. Furthermore, not only ship owners but also fishermen have incentives for discarding, because of the "share payment" system, since the lower the value of the fish, the more their income will decrease. Alternatively, this loss may be compensated by fishing companies, but this would ultimately affect profitability.

If monitoring and control are implemented, this may create two-way incentives. Scenario 3 shows that even with a 50% increase in selectivity (and maintaining the *de minimis* exemption) the reduction in income will be 5.3% and the GOS will be 14.4% lower than in the BAU scenario. This means that, on the one hand, there will be an incentive to avoid discards to reduce the loss of quota and, on the other hand, as profits are going down, the incentives and financial resources for investing in fishing activity are lower.

It worth noting that the model assumed fixed prices, but variation in quantities should provoke changes in prices depending on the presence of substitutes in the market, the income of demand, bargaining power, etc. The available evidence suggests that variations in quantities provoke less than proportional variations in prices (Gómez and González, 1998; Jaffry et al., 1999). This is a consequence of the short term reduced flexibility of production, the perishable nature of the fish, the presence of substitutes (Jaffry et al., 2000) and the participation in an open market. Nevertheless, the specific delimitation of price reactions to reductions in quantities requires further research.

It is also worth mentioning that these results were obtained at a time when the LO had not yet been fully implemented. Hence, we can expect a better performance once there are (real) incentives created by full enforcement. In other words, when carrying out this study, there was no incentive in place to modify the fishing strategy to avoid discards, but with full implementation we expect skippers to change not only their fishing strategies, but also gear selection, timing, fishing grounds, etc. so as to avoid discards. Consequently, a probable reduction in discard rates should be expected when the LO is fully enforced.

It should also be taken into account that other authors have suggested that the abundance of target species will increase in the long-term as a consequence of the reduction of the fishing effort, so then quotas may increase in the long term as well as income (García et al., 2017)

Therefore, the problem seems to be how to go from the short to the long term. In this regard, when considering how to put into operation the LO, the experience of the early adopters of the discard ban (usually in combination with other management tools) such as New Zealand, Iceland and Norway has shown that it is indeed a feasible way of achieving a reduction in discard rates (Bellido et al., 2016), at least in some fisheries (Icelandic Directorate of Fisheries, 2012; Pálsson et al., 2003). Such experiences, according to Gullestad et al., (2015), have proved beneficial in changing fishermen’s attitudes and discouraging the practice of discarding when combined with appropriate regulations, and have not only exerted a positive influence on the research and development of more selective fishing gear but also yielded gains from improvements in exploitation patterns.

It is worth highlighting that the benefits of discard reduction are usually recognised by fishermen (Damalas et al., 2015), and therefore opposition to the LO should not be vaguely considered to be the result of uninformed behaviour but rather as a function of incentives. In fact, the main complaint from European fishermen regarding the new fishing law is that the LO will prompt changes that will negatively affect their business performance.

Furthermore, previous experiences suggest that the reduction of discard rates is, firstly, more closely associated with a combination of other measures than merely with prohibition *per se* (Bellido et al., 2016) and secondly that its success relies on how legitimate and rational fishermen perceive the system to be (Johnsen and Eliasen, 2011). As a result, a discard ban can work and even enjoy broad support among fishermen, but only if it is applied in a fair and pragmatic way (Kelleher, 2005). Such pragmatism is composed on the one hand of economic, environmental and cultural rationality and on the other by the necessary inclusion of fishermen in the management of resources and decision-making processes (Margeirsson et al., 2012). In economic terms, such rationality may be expressed as removing profit from landing discards, but at the same time covering fishing processing costs (Turner, 2016). In fact, experiences like that of the British Columbia rockfish trawl fishery (Rice, 2003) show that a balanced performance of the fleet is key to facilitating a quicker and more effective response to changes in fisheries management. Therefore, those measures that help to cover the cost of landing discards without creating benefits will help to achieve long-term economic sustainability.

In cases like this, where ecological services are threatened and are considered valuable enough to warrant intervention, investments made by fishermen to improve conservation or to undertake practices that mitigate adverse impacts, such as bycatch reduction devices, may deserve public support (Grafton et al., 2006). Complementary tools to be implemented may include promoting the improvement of fishing selectivity (Fauconnet and Rochet, 2016), effort reallocation (Hoff et al., 2018) and stimulating innovation to increase efficiency, the adoption of systems for sharing real-time information, an appropriate and adequate system of supervision and control is also needed, as is the inclusion of fishermen in the management of resources and decision-making processes (Margeirsson et al., 2012). It has also been suggested to combine general and specific management measures adapted to each particular fishery (Uhlmann et al., 2013); the regionalisation of the CFP has an underexploited potential to address at least part of those necessary adaptations, because although the rules are the same in all EU waters, the fisheries are not (Ulhmann et al., 2013). Further debate is probably necessary on the temporary easing of tools like interspecies flexibility. In fact, recent research (Simons et al., 2015) has found that the negative effects of the landing obligation could be reduced by allowing a quota increase for the most restrictive stock at the expense of the quota for the least restrictive stock. Finally, the creation of products (for non-direct human consumption (European Union, 2013)) with higher added value from unwanted catches would help to reduce the impact of quota loss.

Lastly, as previous experiences suggest, with the combination of a set of pragmatic tools and fishermen's participation, it will be possible not only to reduce discards, but also to foster stakeholders' acceptance of the policy (Gullestad et al., 2015), thereby paving the way for future improvements and global sustainability.

5. Conclusions

The reduction of discards is a social, economic, environmental and ethical imperative and citizens, policy makers and fishermen alike recognise its importance. The European Commission has sought to meet this challenge through the latest version of the CFP, the primary objective of which is to reduce unwanted catches and at the same time promote sustainable fisheries, that's to say, to keep on fishing but with a lower impact on unwanted species.

This paper shows that the LO is undoubtedly going to contribute to reducing discards but also to provoke (at least) a short-term reduction in fishing companies' income that goes from 14.5% in the worst scenario to 5.3% in the most favourable one. The new regulation will demand processes that involve higher conservation, storage tasks and, more importantly, the consumption of quota, the most valuable economic resource for the fleet. In fact, this is where the main impact stems from.

Even though there are certain factors that can mitigate this impact: alternative fishing strategies adopted by fishermen, market solutions, technological improvements and innovation or price increases due to a drop in supply, it is also true that in mixed fisheries, selectivity improvements are difficult and demand is elastic and, hence, prices will not compensate a fall in production. Under this scenario, given both the value of the ecological services and the (at least) short term income reduction, the efforts of fishermen to improve selectivity and efficiency and achieve long-term sustainability may deserve public support.

At the same time, previous measures are likely to foster the social legitimacy of the new rule and mitigate the foreseeable adverse economic effects associated with the LO. This will enhance general compliance, thereby discouraging the practice of discarding. In short, what is needed is a pragmatically flexible approach that enables a process of progressive learning and adaptation for both policy makers and the fishing sector. Without unnecessarily overburdening fishing companies and fishermen, this will make it possible not only to adopt the new practices required but also to create the organisational, technological and marketing innovations needed and complete the learning curve and the function of production adaptation.

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7. References

Ballesteros, H.M., Rodríguez-Rodríguez, G., 2018. How much in the clan are you? The community as an explanatory factor of the acceptance of poaching in small-scale fisheries. Mar. Policy. doi:10.1016/j.marpol.2018.06.014

Baumol, W.J., 2000. Leontief's great leap forward: Beyond Quesnay, Marx and von Bortkiewicz. Econ. Syst. Res. 12, 141–152.

Bellido, J.M., Carbonell Quetglas, A., Garcia Rodriguez, M., Garcia Jimenez, T., González

Aguilar, M., 2014. The Obligation to Land All Catches – Consequences For The Mediterranean – In-Depth Analysis. PE, IP/B/PECH/IC/2013-168. 529.055, 52pp.

Bellido, J.M., García-Rodriguez, M., García-Jiménez, T., González-Aguilar, M., Carbonell-Quetglas, A., 2016. Could the obligation to land undersized individuals increase the black market for juveniles: evidence from the Mediterranean? Fish Fish. doi:10.1111/faf.12166

Bellido, J.M., Santos, M.B., Pennino, M.G., Valeiras, X., Pierce, G.J., 2011. Fishery discards and bycatch: solutions for an ecosystem approach to fisheries management? Hydrobiologia 670, 317–333. doi:10.1007/s10750-011-0721-5

Bergkamp, L., 2001. Liability and Environment: Private and Public Law Aspects of Civil Liability for Environmental Harm Inan International Context. Martinus Nijhoff Publishers, Leiden, The Netherlands.

Bess, R., Ambargis, Z.O., 2011. Input-output models for impact analysis: Suggestions for practitioners using RIMS II multipliers, in: 50th Southern Regional Science Association Conference. Southern Regional Science Association Morgantown, WV, pp. 23–27.

Borges, L., 2016. One year on: the landing obligation in Europe. ICES Featur. Artic.

Borges, L., 2015. The evolution of a discard policy in Europe. Fish Fish. 16, 534–540. doi:10.1111/faf.12062

Cai, J., Leung, P., Pan, M., Pooley, S., 2005. Economic linkage impacts of Hawaii’s longline fishing regulations. Fish. Res. 74, 232–242.

Catchpole, T.L., Frid, C.L.J., Gray, T.S., 2006. Resolving the discard problem—A case study of the English Nephrops fishery. Mar. Policy 30, 821–831. doi:10.1016/j.marpol.2006.04.002

Catchpole, T.L., Frid, C.L.J., Gray, T.S., 2005. Discards in North Sea fisheries: causes, consequences and solutions. Mar. Policy 29, 421–430. doi:10.1016/j.marpol.2004.07.001

Coffman, M., Kim, K., 2009. The economic impacts of banning commercial bottomfish fishing in the Northwestern Hawaiian Islands. Ocean Coast. Manag. 52, 166–172.

Comisión Europea, D.O. de la U., 2013. REGLAMENTO (UE) N o 1380/2013 DEL PARLAMENTO EUROPEO Y DEL CONSEJO de de 11 de diciembre de 2013 sobre.

Damalas, D., 2015. Mission impossible: Discard management plans for the EU Mediterranean fisheries under the reformed Common Fisheries Policy. Fish. Res. 165, 96–99. doi:10.1016/j.fishres.2015.01.006

Damalas, D., Maravelias, C.D., Osio, G.C., Maynou, F., Sbrana, M., Sartor, P., Casey, J., 2015. Historical discarding in Mediterranean fisheries: a fishers’ perception. ICES J. Mar. Sci. J. du Cons. 72, 2600–2608. doi:10.1093/icesjms/fsv141

Eliasen, S., Christensen, A., 2012. The institutional basis for discard behaviour. Badmint. Proj. Rep. Badmint. Proj. … 1–15.

Eliasen, S.Q., Papadopoulou, K.N., Vassilopoulou, V., Catchpole, T.L., 2014. Socio-economic and institutional incentives influencing fishers’ behaviour in relation to fishing practices and discard. ICES J. Mar. Sci. 71, 1298–1307.

doi:10.1093/icesjms/fst120

European Commission, 2000. Report from the Commission on the regional meetings arranged by the Commission in 1998-1999 on the Common Fisheries Policy after 2002. doi:10.1017/CBO9781107415324.004

European Union, 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. European Union.

Fauconnet, L., Rochet, M.J., 2016. Fishing selectivity as an instrument to reach management objectives in an ecosystem approach to fisheries. Mar. Policy 64. doi:10.1016/j.marpol.2015.11.004

Feekings, J., Bartolino, V., Madsen, N., Catchpole, T.L., 2012. Fishery discards: factors affecting their variability within a demersal trawl fishery. PLoS One 7, e36409. doi:10.1371/journal.pone.0036409

Fernandes, A.C., Pérez, N., Prista, N., Santos, J., Azevedo, M., 2015. Discards composition from Iberian trawl fleets. Mar. Policy 53, 33–44. doi:10.1016/j.marpol.2014.10.012

García-Negro (Dir.), M.D.C., 2003. INPUT-OUTPUT TABLES FOR THE GALICIAN FISHING AND PRESERVED FISH SECTORS. Consellería de Pesca e Asuntos Marítimos, Santiago de Compostela.

García-Negro (Dir.), M.D.C., 1997. Táboa Input Output Pesca-Conserva Galega 1995. Conselleria de Pesca, Marisqueo e Acuicultura, Xunta de Galicia., Santiago de Compostela.

García-Negro, M. do C., Rodríguez-Rodríguez, G., Ballesteros, H., Sálamo Otero, P., 2016. Táboas Input-Output Pesca-Conservas Galegas 2011. Xunta de Galicia, Consellería do Mar, Santiago de Compostela.

García-Rivera, S., Sánchez Lizaso, J.L., Bellido, J.M., 2015. A quantitative and qualitative assessment of the discard ban in European Mediterranean waters. Mar. Policy 53, 149–158. doi:10.1016/j.marpol.2014.12.003

García, D., Prellezo, R., Sampedro, P., Da-Rocha, J.M., Castro, J., Cerviño, S., García-Cutrín, J., Gutiérrez, M.-J., Jardim, H. editor: E., 2017. Bioeconomic multistock reference points as a tool for overcoming the drawbacks of the landing obligation. ICES J. Mar. Sci. 74, 511–524.

Gómez, J.A.M., González, J.L., 1998. Un análisis dinámico de demanda inversa de carne y pescado en España. Rev. española Econ. Agrar. 105–129.

Grafton, R.Q., Arnason, R., Bjørndal, T., Campbell, D., Campbell, H.F., Clark, C.W., Connor, R., Dupont, D.P., Hannesson, R., Hilborn, R., Kirkley, J.E., Kompas, T., Lane, D.E., Munro, G.R., Pascoe, S., Squires, D., Steinshamn, S.I., Turris, B.R., Weninger, Q., 2006. Incentive-based approaches to sustainable fisheries. Can. J. Fish. Aquat. Sci. 710, 699–710. doi:10.1139/F05-247

Gullestad, P., Blom, G., Bakke, G., Bogstad, B., 2015. The “Discard Ban Package”: Experiences in efforts to improve the exploitation patterns in Norwegian fisheries. Mar. Policy 54, 1–9. doi:10.1016/j.marpol.2014.09.025

Hatcher, A., 2014. Implications of a Discard Ban in Multispecies Quota Fisheries. Environ. Resour. Econ. 58, 463–472. doi:10.1007/s10640-013-9716-1

Hoff, A., Frost, H., Andersen, P., Prellezo, R., Rueda, L., Triantaphyllidis, G., Argyrou, I., Tsikliras, A., Motova, A., Lehuta, S., Curtis, H., Rodríguez-Rodríguez, G., Ballesteros, H.M., Valeiras, J., Bellido, J.M., 2018. Potential economic consequences of the Landing Obligation, in: Uhlmann, S.S., Ulrich, C., Kennelly, S. (Eds.), The European Landing Obligation − Reducing Discards in Complex, Multi-Species and Multi-Jurisdictional Fisheries. Springer Nature, pp. 109–128.

Icelandic Directorate of Fisheries, 2012. No [WWW Document]. URL www.fiskistofa.is/english (accessed 1.15.17).

Jaffry, S., Pascoe, S., Taylor, G., Zabala, U., 2000. Price interactions between salmon and wild caught fish species on the Spanish market. Aquac. Econ. Manag. doi:10.1080/13657300009380267

Jaffry, S.A., Pascoe, S., Robinson, C., 1999. Long run price flexibilities for high valued UK fish species: a cointegration systems approach. Appl. Econ. 31, 473–481.

Jaurlaritza, E., Vasco, G., Garapen, E., Pereira, A., 2015. DESMAN – Estudio de posibilidades de manipulación de la captura no deseada (exdescartes) a bordo de las principales flotas de Euskadi (bajura , altura y artes menores).

Johnsen, J.P., Eliasen, S., 2011. Solving complex fisheries management problems: What the EU can learn from the Nordic experiences of reduction of discards. Mar. Policy 35, 130–139. doi:10.1016/j.marpol.2010.08.011

Kelleher, K., 2005. Discards in the World’s Marine Fisheries: An Update, FAO. ed. FAO Fisheries Technical Paper. No. 470.

Kwak, S.-J., Yoo, S.-H., Chang, J.-I., 2005. The role of the maritime industry in the Korean national economy: an input–output analysis. Mar. Policy 29, 371–383.

Lam, M.E., 2012. Of Fish and Fishermen : Shifting Societal Baselines to Reduce Environmental Harm in Fisheries. Ecol. Soc. 17.

Larach, M.A., 1998. Comercio y medio ambiente en la Organización Mundial del Comercio (LC/L. 1127). Santiago Chile, Com. Económica para América Lat. y el Caribe.

Leontief, W.W., 1986. Input-output Economics. Sci. Am. doi:10.1017/CBO9781107415324.004

Leontief, W.W., 1936. Quantitative input and output relations in the economic systems of the United States. Rev. Econ. Stat. 105–125.

MAPAMA, 2018. Estadística de la flota pesquera [WWW Document]. URL http://www.mapama.gob.es/es/estadistica/temas/estadisticas-pesqueras/pesca-maritima/estadistica-flota-pesquera/default.aspx (accessed 3.31.18).

Margeirsson, S., Sigurðardóttir, S., Stefánsdóttir, E.K., Viðarsson, J.R., 2012. BADMINTON: Bycatch and Discards: Management, Indicators, Trends And locatiON. Work Packag.

McArthur, A., Howick, M., 2010. Scoping study: actionable insight into discarding behaviours of trawlermen in the North East, The Social Marketing Gateway.

McGoodwin, J.R., 2002. COMPRENDER LAS CULTURAS DE LAS COMUNIDADES PESQUERAS. CLAVE PARA LA ORDENACION PESQUERA Y LA SEGUIRIDAD. FAO Documento Técnico de Pesca. No. 401. Roma, FAO. 2002. 301p.

Miller, R.E., Blair, P.D., 2009. Input-output analysis: foundations and extensions. Cambridge University Press.

Morrissey, K., O'Donoghue, C., 2013. The role of the marine sector in the Irish national economy: an input–output analysis. Mar. Policy 37, 230–238.

Österblom, H., Sissenwine, M., Symes, D., Kadin, M., Daw, T., Folke, C., 2011. Incentives, social–ecological feedbacks and European fisheries. Mar. Policy 35, 568–574. doi:10.1016/j.marpol.2011.01.018

Pálsson, Ó.K., Einarsson, H.A., Björnsson, H., 2003. Survival experiments of undersized cod in a hand-line fishery at Iceland. Fish. Res. 61, 73–86. doi:http://dx.doi.org/10.1016/S0165-7836(02)00248-5

Pérez-Labajos, C.A., 2001. Spending pattern of the recreational maritime sector and its impact on employment: the case of Cantabria, Spain. Mar. Policy 25, 187–196. doi:http://dx.doi.org/10.1016/S0308-597X(01)00009-4

Pigou, A.C., 1932. The economics of welfare,. Macmillan and Co., London.

Prellezo, R., Kraak, S., Ulrich, C., 2015. Overarching report, in: RESEARCH FOR PECH COMMITTEE - THE DISCARD BAN AND ITS IMPACT ON THE MAXIMUM SUSTAINABLE YIELD OBJECTIVE ON FISHERIES. Brussels.

Rice, J., 2003. The British Columbia rockfish trawl fishery, in: Swan, J., Gréboval, D. (Eds.), Report and Documentation of the International Workshop on Factors of Unsustainability and Overexploitation in Fisheries, Mauritius, 3–7 February 2003. FAO, Rome, Italy.

Rueda-Cantuche, J.M., 2011. The choice of type of input-output table revisited: Moving towards the use of supply-use tables in impact analysis. SORT 35, 21–38.

Sardà, F., Coll, M., Heymans, J.J., Stergiou, K.I., 2013. Overlooked impacts and challenges of the new European discard ban. Fish Fish. n/a-n/a. doi:10.1111/faf.12060

Schuschny, A.R., 2005. Tópicos sobre el modelo de insumo-producto: teoría y aplicaciones. United Nations Publications.

Scott, W.R., 2000. Institutions and Organizations (Foundations for Organizational Science). SAGE Publications.

Sigurdardóttir, S., Stefánsdóttir, E.K., Condie, H., Margeirsson, S., Catchpole, T.L., Bellido, J.M., Eliasen, S.Q., Goñi, R., Madsen, N., Palialexis, A., Uhlmann, S.S., Vassilopoulou, V., Feekings, J., Rochet, M.J., 2015. How can discards in European fisheries be mitigated? Strengths, weaknesses, opportunities and threats of potential mitigation methods. Mar. Policy 51, 366–374. doi:10.1016/j.marpol.2014.09.018

Simons, S.L., Döring, R., Temming, A., 2015. Modelling fishers' response to discard prevention strategies: the case of the North Sea saithe fishery. ICES J. Mar. Sci. 72, 1530–1544.

Sissenwine, M.P., Rosenberg, A.A., 1993. Marine Fisheries At a Critical Juncture. Fisheries.

doi:10.1577/1548-8446(1993)018<0006

Stockhausen, B., Officer, R. a., Scott, R., 2012. Discard mitigation – what we can learn from waste minimization practices in other natural resources. Mar. Policy 36, 90–95. doi:10.1016/j.marpol.2011.03.011

Surís-Regueiro, J.C., Santiago, J.L., 2018. Assessment of Socioeconomic Impacts Through Physical Multipliers: The Case of Fishing Activity in Galicia (Spain). Ecol. Econ. 147, 276–297. doi:https://doi.org/10.1016/j.ecolecon.2018.01.020

Tsagarakis, K., Palialexis, A., Vassilopoulou, V., 2013. Mediterranean fishery discards: review of the existing knowledge. ICES J. ….

Turner, D., 2016. Landing obligations under the New Zealand fisheries quota management system, in: IIFET 2016 Challenging New Frontiers in the Global Seafood Sector. A Northern Enlightenment. Aberdeen.

Uhlmann, S., Van Helmond, Aloysius, T.M., Stefánsdóttir, E.K., Sigurðardoótti, S., Haralabous, J., Bellido, J.M., Carbonell, A., Catchpole, T. l., Damalas, D., Fauconnet, L., Feekings, J., Garcia, T., Madsen, N., Mallold, S., Margeirsson, S., Palialexis, A., Readdy, L., Valeiras, J., Vassilopoulou, V., Rochet, M.-J., 2013. Discarded fish in European waters: general patterns and contrasts. ICES J. ….

Ulrich, C., Reeves, S.A., Vermard, Y., Holmes, S.J., Vanhee, W., 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. ICES J. Mar. Sci. J. du Cons. 68, 1535–1547. doi:10.1093/icesjms/fsr060

Valeiras, J., Pérez, N., Araujo, H., Salinas, I., Bellido, J.M., 2014. Atlas de los descartes de la flota de arrastre y enmalle en el Caladero Nacional Cantábrico-Noroeste. Instituto Español de Oceanografía.

Van Der Linden, J.A., 2001. The economic impact study of maritime policy issues: application to the German case. Marit. Policy Manag. 28, 33–54. doi:10.1080/03088830120336

Vázquez-Rowe, I., Moreira, M.T., Feijoo, G., 2011. Estimating global discards and their potential reduction for the Galician fishing fleet (NW Spain). Mar. Policy 35, 140–147. doi:10.1016/j.marpol.2010.08.012

Venegas, J., 1994. Una matriz insumo-producto inversa de la economía chilena 1986. Ser. Estud. Económicos NA 38.

8. APPENDIX I:

Sectors included in the Galician Input-Output Table of the Fishing and Preserved Seafood Sector 2011.

The TIO-2011 covers five different production sectors:

1. Extractive fishing
   1.1. Fishing 1 (Off-shore fishing 1): 0 – 5 GRT
   1.2. Fishing 2 (Off-shore fishing 2): 5.01- 40 GRT
   1.3. Fishing 3 (Coastal fishing): 40.01-100 GRT
   1.4. Fishing 4 (Deep-sea fishing): 100.01-250 GRT
   1.5. Fishing 5 (Long-distance fishing): +250 GRT
2. Mussel farming
3. Canned and preserved fish and new processed products
4. Shellfish collecting
5. Marine fish-farming