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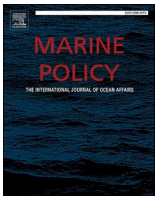

# Assessing the economic effects of the European landing obligation on the Spanish fishery in the Celtic Sea

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ABSTRACT

European Union has agreed to implement the landing obligation for all species subject to quota in order to ensure long term harvest in a healthy marine environment, implying a prohibition on discarding species subject to quota that can legally be caught and landed under Community fisheries legislation. Landing obligation has been progressively implemented since 2014 and entered fully into force in January 2019. This work analyses the potential economic effects of the landing obligation on the Spanish fleet fishing in the Celtic Sea. The profitability of the fleet is evaluated in the years preceding the entry into force of the European regulation and compared with the profitability obtained since its implementation. The results show a significant economic impact of the landing obligation on small and micro-enterprises. The first years of partial application of the regulations coincide with a drop in diesel prices that helps smaller companies maintain a high profitability. However, once diesel prices recover, the profitability of micro-enterprises falls to negative values when the application of the discards ban is complete, leading to the closure of many companies. This scenario of effort reduction and control of over-exploitation of the fishing grounds, positive from an environmental point of view, nevertheless suggests the need for some kind of institutional support to mitigate the socio-economic damage generated by the landing obligation and to improve the gear selectivity of the fleets concerned, allowing them to adapt to the new management scenario.

## 1. Introduction

Discards are the part of the total organic matter of animal origin in the catches, dead or alive, which is removed or returned to the sea for various reasons. It is important to note that plant materials or post-fishing residues, such as offal, are not included in this definition. The main reasons why fishing vessels discard part of their catches are multiple and FAO divides them into five groups: biological causes, legislative restrictions, market demands, fishing gear and ship characteristics [1]. Discards not only pose an environmental problem due to the decline of natural resources, but also lead to a loss in the reliability of the scientific information available to calibrate fishing mortality and maximum sustainable yield (MSY) in fish stock valuations. The European Council of Fisheries Ministers and the European Parliament have agreed to implement the landing obligation for all species subject to catch limits [2]. The aim of this regulation is to ensure long term harvest in a healthy marine environment. This obligation constitutes a ban on discarding, a ban that has been implemented gradually since 2014 and entered into full force in January 2019.

In the last decade, several papers have addressed the discard problem. Batsleer et al. [3] model the potential effects of a discard ban in a North Sea trawl fishery managed by individual quotas, showing that the ban creates an incentive to implement more selective gear. Vazquez-Fernandes et al. [4] study the composition of discards in the Spanish and Portuguese trawl fleets and analyze possible measures to reduce them. Guillen et al. [5] address maximum sustainable yield (MSY) targets and conclude that this level may change for certain stocks when discards are accounted for. Vázquez-Rowe et al. [6] estimate discards in the Galician fleet and their species composition. Villasante et al. [7] study the perception of stakeholders on the effects of the landing obligation in European small-scale fisheries.

The economic dimension of this problem has deserved special attention from academy. Frost and Hoff [8] propose a bioeconomic model to analyze the effects of discard bans under different management regimes and show that the landing obligation has a higher economic effect in the case of management with non-transferable quota shares. Prellezo et al. [9] use a bioeconomic simulation tool to anticipate the effects of the landing obligation on the Basque trawl fleet in the Bay of

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Biscay and find that there is a negative short-term economic effect and, therefore, incentives to improve selectivity and reduce discard levels. Villasante et al. [10] analyze the economic effects of the discard ban on artisanal fisheries in Galicia.

In line with the above research perspective on landing obligation, this paper analyzes the possible economic effects on the Spanish fleet fishing in the Celtic Sea in the face of the progressive implementation process of the landing obligation regulation that, in 2019, has been extended to all species (Table 1). The empirical review carried out in this study will analyze how the economic performance of the Spanish fleet has varied and, for this purpose, an analysis of the main financial variables before and after the entry into force of the Directive will be carried out. The paper is structured as follows: Section 2 describes the fishery under study; Section 3 presents the methods and data used in the empirical analysis; Section 4 analyzes the evolution of the profitability of the Spanish Celtic Sea fleet between 2010 and 2019; Section 5 discusses the relative importance of the landing obligation policy in the economic performance of the companies analyzed; and Section 6 presents the main conclusions reached through the research results of this paper.

## 2. The fishery

The Spanish fleet fishing in Grand Sole (a fishing ground located in the North-Western waters of the European Union, between the 48º and 60º parallels) amounts to 97 vessels in 2020 (Table 2). The main fishing area for this fleet is the Celtic Sea (FAO fishing area 27, Divisions VIIg -Celtic Sea North- and VIIh -Celtic Sea South-) (Fig. 1). In 2020, 86.5% of the Spanish communitarian fleet operated in the Celtic Sea [16]. Most of the Celtic Sea fleet has a home port in the region of Galicia, followed by the Basque Country, Cantabria and Asturias (Table 2). Furthermore, in 2020, of the total catches made by Spanish vessels, 34.7% of the tons and 38.2% of the value corresponded to the Celtic Sea fishery [17]. This shows the great importance of this fishing ground for Spanish fishing. In fact, the large number of Spanish vessels fishing in the Celtic Sea has made the Spanish fleet one of the most important in the European Union [18].

Spanish vessels in this area mainly catch hake (*Merlucius merlucius,* Merlucciidae), megrim (*Lepidorhombus whiffiagonis,* Scophthalmidae), anglerfish (*Lophius piscatorius* and *L. budegassa,* Lophiidae) and Norway lobster (*Nephrops norvegicus,* Nephropidae). Other species of wider distribution, like blue whiting (*Micromesistius poutassou,* Gadidae), horse mackerel (*Trachurus trachurus,* Carangidae) and ling (*Molva molva,* Lotidae), are also caught in this area in large quantities (Table 3). Depending on the type of gear used, a mixed catch (with variable quantities of hake, anglerfish, megrim, and Norway lobster) is caught on each fishing trip. Hake is caught throughout the year, with peak landings in the spring and summer months. The three main gear types used by the vessels that target hake are long lines, fixed gillnets, and trawls. For vessels seeking anglerfish, a trawl fishery was developed in the Celtic Sea in the 1970 s—on the shelf edge around the 200-mile contour to the south and west of Ireland and the Bay of Biscay—and expanded until about 1990. Megrim is caught predominantly by Spanish and French vessels. The Norway lobster fisheries were developed in the 1970 s and 1980 s, and they remain a crucial component of fleet activity in this area.

The state of these targeted stocks has changed markedly over the last decades. The MSY approach, widely accepted as an objective for fisheries management, searchs for a stable population biomass ($B_{MSY}$) able to support a fishing mortality ($F_{MSY}$) that generates the highest possible annual catch that can be sustained over time. This criterion is used to define the status of each fish stock on an annual basis. With respect to hake, the International Council for the Exploration of the Sea (ICES) classifies the species as being at full reproductive capacity and being harvested sustainably. However, the spawning stock biomass (SSB) declined severely in the early 2000 s and these circumstances led EU to establish measures for assisting the recovery of northern hake stock [21]. As a result, mortality due to fishing has been significantly reduced

**Table 1**
Species included in the landing obligation throughout the period of gradual application of the regulations in the North-Western waters of the European Union (ICES areas V, VI and VII).

| | | | 2014 | 2015 | 2016 | 2018 | |
|---|---|---|---|---|---|---|---|
| REGULATION (EU) Nº | | | 1393 | 2438 | 2375 | 46 | 190# |
| Area | | | NWW | | | | |
| ICES area | | | V, VI, VII | | | | |
| Species | **Family** | **Scientific name** | | | | | |
| Mackerel | Scombridae | Scomber scombrus | X | | | | |
| Herring | Clupeidae | Clupea harengus | X | | | | |
| Horse Mackerel | Carangidae | Trachurus trachurus | X | | | | |
| Blue Whiting | Gadidae | Micromesistius poutassou | X | | | | |
| Boarfish | Caproidae | Capros aper | X | | | | |
| Greater Silver Smelt | Argentinidae | Argentina silus | X | | | | |
| Albacore Tuna | Scombridae | Thunnus alalunga | X | | | | |
| Sprat | Clupeidae | Sprattus sprattus | X | | | | |
| Cod | Gadidae | Gadus morhua | | X | | | |
| Plaice | Pleuronectidae | Pleuronectes platessa | | X | | | |
| Haddock | Gadidae | Melanogrammus aeglefinus | | X | | | |
| Whiting | Gadidae | Merlangius merlangus | | X | | | |
| Saithe | Gadidae | Pollachius virens | | X | | | |
| Norway Lobster | Nephropidae | Nephrops norvegicus | | X | | | |
| Common Sole | Soleidae | Solea solea | | X | | | |
| Hake | Merlucciidae | Merluccius merluccius | | X | | | |
| Pollack | Gadidae | Pollachius pollachius | | | X | | |
| Black Scabbardfish | Trichiuridae | Aphanopus carbo | | | | X | |
| Megrim | Scophthalmidae | Lepidorhombus whiffiagonis | | | | X | |
| Blue Ling | Lotidae | Molva dypterygia | | | | X | |
| Grenadiers | Macroudidae | | | | | X | |
| Argentine | Argentinidae | Argentina sphyraena | | | | | X |

*Source*:Source: Own elaboration based on European Union [11–15].

**Table 2**
Characteristics of the Spanish Grand Sole fleet (2015–2019).

| | | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|
| Vigo zone | No. vessel | 15 | 16 | 15 | 15 | 15 |
| (Galicia) | GT | 4904 | 5296 | 4965 | 4965 | 4965 |
| | Power (kW) | 6767 | 7413 | 7016 | 7463 | 7463 |
| Pontevedra zone | No. vessel | 1 | 1 | 1 | 1 | 1 |
| (Galicia) | GT | 258 | 258 | 258 | 258 | 258 |
| | Power (kW) | 360 | 360 | 360 | 360 | 360 |
| Arousa zone | No. vessel | 5 | 5 | 4 | 4 | 4 |
| (Galicia) | GT | 1671 | 1671 | 1345 | 1345 | 1345 |
| | Power (kW) | 2465 | 2467 | 2016 | 2016 | 2016 |
| Muros zone | Número de barcos | 1 | 1 | 1 | 0 | 0 |
| (Galicia) | GT | 163 | 163 | 163 | – | – |
| | Power (kW) | 325 | 325 | 325 | – | – |
| A Coruña-Ferrol zone | No. vessel | 5 | 4 | 2 | 3 | 3 |
| (Galicia) | GT | 1738 | 1346 | 669 | 966 | 966 |
| | Power (kW) | 2477 | 1833 | 790 | 1328 | 1328 |
| Cedeira zone | No. vessel | 2 | 2 | 1 | 1 | 2 |
| (Galicia) | GT | 218 | 281 | 123 | 123 | 344 |
| | Power (kW) | 627 | 566 | 331 | 331 | 777 |
| A Mariña zone | No. vessel | 50 | 43 | 44 | 48 | 50 |
| (Galicia) | GT | 13035 | 11274 | 11548 | 12253 | 12614 |
| | Power (kW) | 21430 | 16340 | 16613 | 18351 | 18428 |
| Avilés zone | No. vessel | 2 | 2 | 2 | 2 | 2 |
| (Asturias) | GT | 370 | 370 | 370 | 370 | 370 |
| | Power (kW) | 712 | 712 | 712 | 712 | 712 |
| Santander zone | No. vessel | 6 | 6 | 6 | 4 | 4 |
| (Cantabria) | GT | 919 | 919 | 919 | 660 | 660 |
| | Power (kW) | 2014 | 2014 | 2014 | 1325 | 1325 |
| Ondarroa zone | No. vessel | 18 | 18 | 18 | 17 | 17 |
| (Basque Country) | GT | 6724 | 6724 | 6724 | 6248 | 6248 |
| | Power (kW) | 8773 | 8773 | 8773 | 8069 | 8069 |
| Total | No. vessel | 105 | 98 | 94 | 95 | 98 |
| | GT | 30000 | 28302 | 27084 | 27188 | 27770 |
| | Power (kW) | 45950 | 40803 | 38950 | 39955 | 40478 |

*Source*:Source: [20].

and so this species is currently above its MSY levels. The SSB has increased appreciably since 2006 and is above recent historical estimates; moreover, recruitment in 2012 and 2013 was among the highest in the time series [22]. Even so, quota restrictions in this fishery since early 2001 have required that the Spanish fleet not fish there for several months of each year.

For anglerfish and ling, the most recent estimates of SSB and fishing mortality are such that the ICES has classified these stocks as "undefined". Even though landings have been stable for the last five years, ICES [23] continue to advise a precautionary approach. The ICES estimates for megrim are that fishing mortality has been below MSY levels for almost the full time series and has exhibited a declining trend since the late 1990 s. Because the biomass of this species has been consistently above MSY levels and has also increased steadily since 2005, the ICES [24] advise maintain s an MSY approach. The blue whiting stock in these waters is classified as being at full reproductive capacity; despite high levels of exploitation, recent years have seen a large increase in its occurrence [25]. Absent defined reference points and a full analytical assessment, the viability of horse mackerel is unknown [26]; however, there are data indicating that its SSB has declined since the late 1980 s. Finally, the available information on Norway lobster stocks is considered inadequate to support any advice beyond observing precautionary limits [25]. In recent years, though, landings have declined.

## 3. Empirical study: methods and data

### 3.1. Data

With the purpose to define the population sample composed of Spanish companies whose vessels operate in the Celtic Sea fishery, a methodological procedure consisting of different steps has been followed. The first step has been to access the annual census of fleets operating in the Celtic Sea from 2010 to 2019, the study period of this paper. The Spanish Ministry of Fisheries publishes in the Official Spanish Gazette (BOE), between December and February of each year, the list of vessels that are granted the right to fish in the Celtic Sea during the following 12 months [27].

Once the vessels operating in Celtic Sea waters each year have been determined, the next step is to identify the owner company of each vessel. To do this, we have consulted the reports called Official List of Vessels from 2010 to 2019, published by the Spanish General Directorate of the Merchant Marine [28]. The official list of vessels has an annual periodicity and collects all the technical information related to each vessel registered under the Spanish flag, including the owner company to which the vessel belongs. In this way, the companies owning the vessels operating in the Celtic Sea have been identified.

Knowing the list of ship owning companies, the next step was to access their financial statements using the ORBIS database. ORBIS [29] contains the financial data of more than 370 million companies worldwide, including those of the fishing sector. Once the vessel-owning companies operating in the Celtic Sea were identified in the database, the result is a population sample of 122 companies, all based in four Spanish regions: Asturias, Cantabria, Galicia, and the Basque Country.

The classification of the companies in this analysis is based on their size. The criteria set out in Directive 2013/34/EU have been followed in order to classify the companies in the population sample into micro-companies, small companies, medium-sized companies and large companies (Table 4).

### 3.2. Methodology

The variables to be studied in the economic and financial analysis of the Spanish ship owning companies operating in the Celtic Sea, are the following: *turnover, total assets, n° of employees, economic profitability, financial profitability, EBIT* (*Earnings Before Interest and Taxes*) *margin* and *solvency ratio.*

*Turnover* corresponds to market sales of goods or services supplied to third parties [19]. *Total assets* are the sum of all cash, investments, equipment, receivables, intangibles, and any other items of value owned by a company. The *number of employees* is defined as those persons who work for an employer and who have a contract of employment and receive compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind [19].

*Economic profitability* or *Return on Assets* (ROA) measures the ratio between the net income of a company and the total value of the investment. It represents the profitability provided by each asset invested in the company. Economic profitability is calculated as the quotient between the net income and the total assets. Higher ROA indicates more asset efficiency.

*Financial profitability* or *Return on Equity* (ROE) measures the ratio between the net income of a company and the equity of the shareholders (assets minus liabilities). It represents the ability of a company to generate profits from its shareholders investments. Financial profitability is calculated as the quotient between the company's net income and the shareholders' equity. Higher ROE indicates better utilization of equity capital to generate profit.

The *EBIT margin* or *operating margin* measures the profitability of a company without considering the effect of interest and taxes. It reflects the profit generated by a company's economic activity alone, ignoring the way in which it is financed and the intervention of the State. EBIT margin is calculated as the quotient between the EBIT and the total revenue. Higher EBIT margin indicates more efficiency in turning sales into profits.

The *Solvency ratio* measures the capacity of a company to meet its long-term debt obligations. It reflects how financially stable the

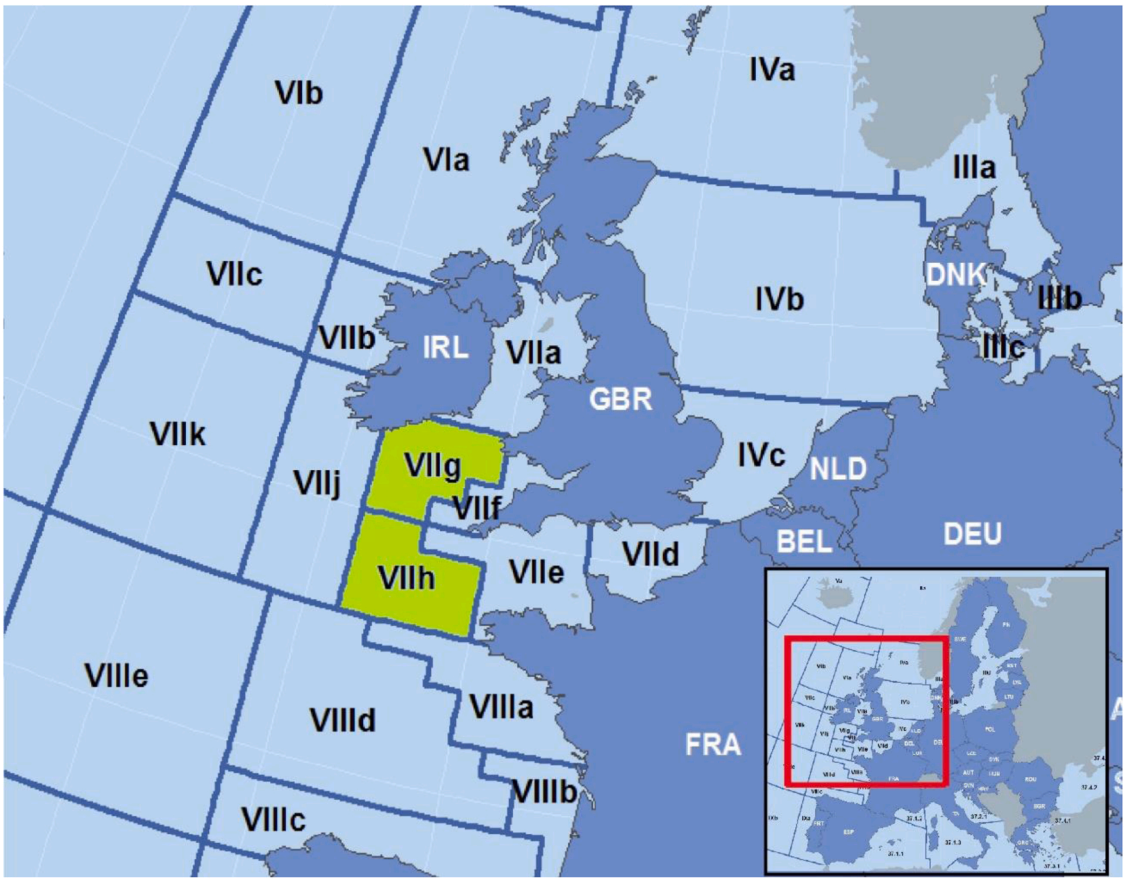


**Fig. 1.** Location of the Celtic Sea in the North-Western waters of the European Union (ICES areas VIIg and VIIh).
Source: Own elaboration based on [19].

company may be in the long run. It is calculated as the quotient between the total shareholders' equity and the total assets. Higher solvency ratio indicates higher number of assets financed by the shareholders.

## 4. Results

### 4.1. Economic and financial analysis

Regarding the structure of the sector during the study period it can be seen, firstly, that the total number of companies has decreased by − 29.4% (Table 5). The subsectors of large and medium-sized companies are completely stable throughout the period in terms of the number of companies, which remains constant in both cases. However, the small and micro-companies subsectors experience a net decrease in the number of companies throughout the study period, much greater in the case of micro-enterprises (−36.1%). The balance between creation and dissolution of companies is negative during all years of the study period for the small and micro-companies segments. The rate of disappearance of companies intensifies during the period of partial application of the discard regulations, and especially when the ban is fully applied. Regarding the age of the closed companies, it is generally high, as it is a consolidated sector. Although some young companies that were less than a decade old have been extinguished, the average number of years of activity is 32 for small companies and 22 for micro-companies.

Considered as a whole, the Spanish Celtic Sea fleet sector shows an unstable trend in relation to turnover throughout the period studied (Table 6). In the first years, an increasing trend in turnover is evident in all types of companies, highlighting the more pronounced growth in medium and small companies. In 2011, the subsector composed of medium-sized companies even presented a growth of 16.71%, demonstrating the good financial health of the subsector at the beginning of the period studied, when the discard regulations had not yet been approved. However, in contrast to the previous period, between 2013 and 2017, a decreasing trend in turnover is mostly observed. The subsector of medium-sized companies is once again the most volatile of those analyzed and, in 2014, first year of partial implementation of the landing obligation, presents its largest decline (−19.76%). In 2018 and 2019, the downward trend in turnover is observed in almost all subsectors, highlighting the decline of − 16.31% in medium-sized companies and − 10.20% in large companies. The downward trend in the turnover of the sector, which has become progressively more pronounced during the study period, could be due to the ban on discarding low-value species. These ones become "choke species", which saturate the storage capacity of the vessels, forcing them to finish the fishing trip with a much lower income than they would have obtained if they had caught their target species.

Considering the performance of the variation of the total assets of the companies, no atypical variation is observed in any of the years of the period for the values of the total of the companies. In more detail, according to the size of the company, the fluctuations that occur are slight. Only the 18.05% increase in assets in 2014 in medium-sized companies stands out, preceded by a rise in the previous year of 10.85%. Moreover, in the case of small companies, there is an increase of 11.29% in 2015. Regarding the number of employees, there is a negative trend for the period under study. During the period of gradual implementation of the landing obligation the number of employees decreased in all subsectors, except for small companies. It is necessary to note the sharp decrease in the number of employees in the subsector of micro-enterprises, which is consistent with the high number of this type of companies dropping out of the market.

**Table 3**
Catches of the Spanish Gran Sol fleet (2015–2019).

| Species | Scientific name | Year | Kg | € | €/kg |
|---|---|---|---|---|---|
| Cusk | *Brosme brosme* | 2015 | 146.50 | 219.75 | 0.67 |
| | | 2016 | 13,673.17 | 13,456.13 | 0.98 |
| | | 2017 | 101.00 | 101.00 | 1.00 |
| | | 2018 | – | – | |
| | | 2019 | 146.00 | 191.80 | 1.31 |
| Megrim | *Lepidorhombus whiffiagonis* | 2015 | 7297,280.35 | 30,547,561.69 | 4.19 |
| | | 2016 | 7227,927.56 | 30,565,093.10 | 4.23 |
| | | 2017 | 7250,543.16 | 31,574,654.11 | 4.35 |
| | | 2018 | 6559,978.35 | 27,970,989.83 | 4.26 |
| | | 2019 | 6256,546.60 | 25,423,372.54 | 4.06 |
| Blackbellied angler | *Lophius budegassa* | 2015 | 7654,441.33 | 42,939,794.18 | 5.61 |
| | | 2016 | 8368,290.88 | 45,307,781.30 | 5.41 |
| | | 2017 | 7919,734.08 | 43,915,700.31 | 5.55 |
| | | 2018 | 7424,725.30 | 43,436,115.02 | 5.85 |
| | | 2019 | 7283,402.29 | 41,450,662.22 | 5.69 |
| European hake | *Merluccius merluccius* | 2015 | 32,098,924.01 | 129,730,177.00 | 4.04 |
| | | 2016 | 35,102,479.24 | 138,660,387.44 | 3.95 |
| | | 2017 | 31,967,812.70 | 140,638,496.03 | 4.40 |
| | | 2018 | 27,354,862.86 | 122,496,005.95 | 4.48 |
| | | 2019 | 26,995,494.79 | 110,722,484.25 | 4.10 |
| Blue whiting | *Micromesistius poutassou* | 2015 | 20,974,723.21 | 16,732,679.27 | 0.80 |
| | | 2016 | 20,015,212.62 | 16,145,118.60 | 0.81 |
| | | 2017 | 23,744,841.35 | 15,729,112.73 | 0.66 |
| | | 2018 | 18,442,662.51 | 15,406,495.37 | 0.84 |
| | | 2019 | 18,708,860.92 | 13,158,202.78 | 0.70 |
| Common ling | *Molva molva* | 2015 | 368,891.41 | 659,911.12 | 1.79 |
| | | 2016 | 336,381.40 | 593,370.93 | 1.76 |
| | | 2017 | 290,529.31 | 521,032.67 | 1.79 |
| | | 2018 | 250,019.92 | 494,641.47 | 1.98 |
| | | 2019 | 193,349.73 | 346,420.98 | 1.79 |
| European pollock | *Pollachius pollachius* | 2015 | 208,721.12 | 1139,256.07 | 5.46 |
| | | 2016 | 223,614.88 | 1219,388.50 | 5.45 |
| | | 2017 | 180,859.95 | 1173,683.39 | 6.49 |
| | | 2018 | 200,834.54 | 1412,733.59 | 7.03 |
| | | 2019 | 239,926.76 | 1658,025.35 | 6.91 |
| Thornback ray | *Raja clavata* | 2015 | 616,551.40 | 1407,847.00 | 2.28 |
| | | 2016 | 675,900.10 | 1623,654.63 | 2.40 |
| | | 2017 | 699,334.33 | 1732,419.56 | 2.48 |
| | | 2018 | 801,079.53 | 2212,491.24 | 2.76 |
| | | 2019 | 539,643.65 | 1383,267.86 | 2.56 |
| Atlantic mackerel | *Scomber scombrus* | 2015 | 9675,653.82 | 6576,188.30 | 0.68 |
| | | 2016 | 6823,300.45 | 7160,742.58 | 1.05 |
| | | 2017 | 7244,125.89 | 6798,942.09 | 0.94 |
| | | 2018 | 9761,162.24 | 10,569,127.80 | 1.08 |
| | | 2019 | 5590,213.66 | 8774,586.03 | 1.57 |
| Spiny dogfish | *Squalus acanthias* | 2015 | 1.00 | 0.25 | 0.25 |
| | | 2016 | 5.00 | 10.00 | 2.00 |
| | | 2017 | 45.50 | 227.50 | 5.00 |
| | | 2018 | 440.20 | 939.95 | 2.14 |
| | | 2019 | 507.85 | 1266.50 | 2.49 |
| Atlantic horse mackerel | *Trachurus trachurus* | 2015 | 15,710,333.76 | 13,806,218.61 | 0.88 |
| | | 2016 | 19,930,520.26 | 14,389,530.15 | 0.72 |
| | | 2017 | 19,538,405.64 | 16,077,483.32 | 0.82 |
| | | 2018 | 22,590,976.49 | 17,502,063.25 | 0.77 |
| | | 2019 | 28,294,920.17 | 20,213,750.38 | 0.71 |
| Norway lobster | *Nephrops norvegicus* | 2015 | 108,822.61 | 1568,594.32 | 14.41 |
| | | 2016 | 112,173.76 | 1785,208.46 | 15.91 |
| | | 2017 | 107,593.56 | 1600,485.08 | 14.88 |
| | | 2018 | 175,122.37 | 2044,007.49 | 11.67 |
| | | 2019 | 157,578.85 | 1825,860.67 | 11.59 |

*Source*:Source: [20].

**Table 4**
Criteria for classifying company size, based on Directive 2013/34/EU.

| | Turnover (€) | Total Assets (€) | Nº of employees |
|---|---|---|---|
| Large company | $\geq$ 22,800,000 | $\geq$ 11,400,000 | $\geq$ 250 |
| Medium-sized company | $\geq$ 5700,000 $<$ 22,800,000 | $\geq$ 2850,000 $<$ 11,400,000 | $\geq$ 50 $<$ 250 |
| Small company | $\geq$ 2000,000 $<$ 5700,000 | $\geq$ 1000,000 $<$ 2850,000 | $\geq$ 10 $<$ 50 |
| Micro-company | $<$ 2000,000 | $<$ 1000,000 | $<$ 10 |

*Source*:Source: Own elaboration based on [2].

**Table 5**
Company creation and dissolution by company size and year.

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Large companies | Closures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | New companies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Net variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Balance | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Medium-sized companies | Closures | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | New companies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Net variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Balance | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Small companies | Closures | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| | New companies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Net variation | -2 | 0 | -1 | 0 | 0 | -1 | 0 | -1 | 0 | -2 |
| | Balance | 31 | 31 | 30 | 30 | 30 | 29 | 29 | 28 | 28 | 26 |
| Micro-companies | Closures | 3 | 2 | 2 | 3 | 5 | 2 | 2 | 4 | 2 | 10 |
| | New companies | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Net variation | -2 | -2 | -1 | -3 | -5 | -2 | -1 | -4 | -2 | -10 |
| | Balance | 83 | 81 | 80 | 77 | 72 | 70 | 69 | 65 | 63 | 53 |
| Total companies | Closures | 5 | 2 | 3 | 3 | 5 | 3 | 2 | 5 | 2 | 12 |
| | New companies | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Net variation | -4 | -2 | -2 | -3 | -5 | -3 | -1 | -5 | -2 | -12 |
| | Balance | 119 | 117 | 115 | 112 | 107 | 104 | 103 | 98 | 96 | 84 |

*Source*:Source: Own elaboration based on data from [29].

**Table 6**
Structure indicators (companies' average) for the 122 companies at aggregated, size and country level.

| | | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Large companies | Turnover (th €) | 232,941 | 271,048 | 290,486 | 286,548 | 289,348 | 259,960 | 303,095 | 301,261 | 290,725 | 261,063 |
| | Total assets (th €) | 139,855 | 138,850 | 143,989 | 140,257 | 143,560 | 149,105 | 147,804 | 153,229 | 141,815 | 141,176 |
| | Nº of employees | 92 | 97 | 100 | 109 | 107 | 108 | 103 | 103 | 102 | 100 |
| Medium-sized companies | Turnover (th €) | 45,114 | 52,652 | 56,723 | 67,731 | 54,348 | 46,136 | 47,140 | 56,122 | 59,252 | 49,589 |
| | Total assets (th €) | 99,015 | 97,830 | 99,840 | 110,674 | 130,647 | 126,392 | 123,621 | 127,067 | 127,683 | 137,820 |
| | Nº of employees | 164 | 160 | 168 | 193 | 210 | 222 | 200 | 186 | 184 | 180 |
| Small companies | Turnover (th €) | 109,465 | 121,728 | 126,806 | 124,359 | 122,308 | 141,541 | 145,241 | 146,347 | 127,047 | 114,862 |
| | Total assets (th €) | 181,761 | 177,938 | 173,979 | 171,159 | 173,911 | 193,550 | 206,753 | 229,213 | 218,126 | 212,905 |
| | Nº of employees | 1057 | 1062 | 999 | 944 | 922 | 932 | 1005 | 941 | 948 | 941 |
| Micro-companies | Turnover (th €) | 84,008 | 85,925 | 75,838 | 64,989 | 56,633 | 47,295 | 45,934 | 42,818 | 37,130 | 37,501 |
| | Total assets (th €) | 124,425 | 114,012 | 98,304 | 93,404 | 94,866 | 91,534 | 94,073 | 96,435 | 86,872 | 83,585 |
| | Nº of employees | 929 | 843 | 724 | 675 | 609 | 481 | 421 | 438 | 442 | 426 |
| Total companies | Turnover (th €) | 943,056 | 1062,707 | 1099,706 | 1087,255 | 1045,274 | 989,864 | 1082,820 | 1093,096 | 1028,308 | 926,030 |
| | Total assets (th €) | 1090,112 | 1057,260 | 1032,224 | 1030,988 | 1085,968 | 1121,162 | 1144,503 | 1211,888 | 1148,992 | 1150,972 |
| | Nº of employees | 4484 | 4324 | 3982 | 3842 | 3696 | 3486 | 3458 | 3336 | 3352 | 3294 |

*Source*:Source: Own elaboration based on data from [29].

Concerning economic profitability, the results show that, except for micro-companies in 2018 and 2019, during the whole study period a positive economic profitability is found, which means that business assets are generating profits (Figs. 2–5).

The analysis by subsectors shows us that large companies present a stable trend in the values obtained, reaching its maximum value (12.17%) in 2017. This is due to the increase in net income before tax, preceded by the increase in sales. In contrast, medium-sized companies have a very volatile evolution of economic profitability. Notably, there was a significant drop in the value of profitability in 2014 due to a sharp fall in ordinary profit before tax, from €9623,000 in 2013 to €612,000 in 2014. Regarding small companies, this group presents attractive economic profitability ratios. From 2015–2017 the value of the ratios exceeds 12%, which are rates never obtained by medium and large companies. In these years there is an upward trend in the net income before taxes, which causes this rise. The sharp drop in fishing diesel prices explains this increase in net income. For their part, micro-companies are the ones that have had the worst evolution of economic profitability. While in 2014 and 2015 the value of this variable is high, given that the ordinary result before taxes doubles, since 2016 there is a downward trend in profitability, reaching negative values in 2018 and 2019. This circumstance is derived of a negative net income before taxes, due to a drop in sales revenue because of the full application of the landing obligation. As long as diesel prices were low, economic profitability was high for micro-companies, but when they rose, profitability fell sharply.

The analysis of the financial profitability variable shows that, in general terms, the sector is interesting for investors in terms of profitability, especially regarding large and small companies (Figs. 2 and 4).

In the case of large companies, financial profitability shows high values during all the considered years. In line with economic profitability, the highest result was obtained in 2017 (20.97%), a circumstance that derives from the increase in ordinary profit before taxes. For their part, the medium-sized companies show two very different phases of evolution. From 2010–2013, the financial values are satisfactory and even show an upward trend. However, from 2014 onwards, this variable has a much more loss-making behavior because of the decrease in ordinary profit before tax and the stabilization of equity. As far as small

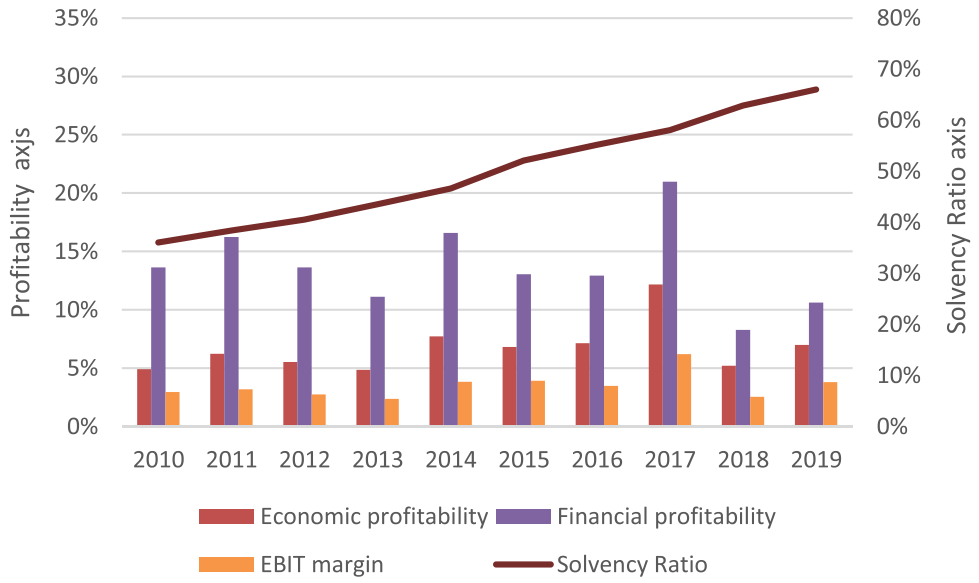


**Fig. 2.** Financial analysis of the large companies in the Spanish Celtic Sea fishing sector.
Source: Own elaboration based on data from [29].

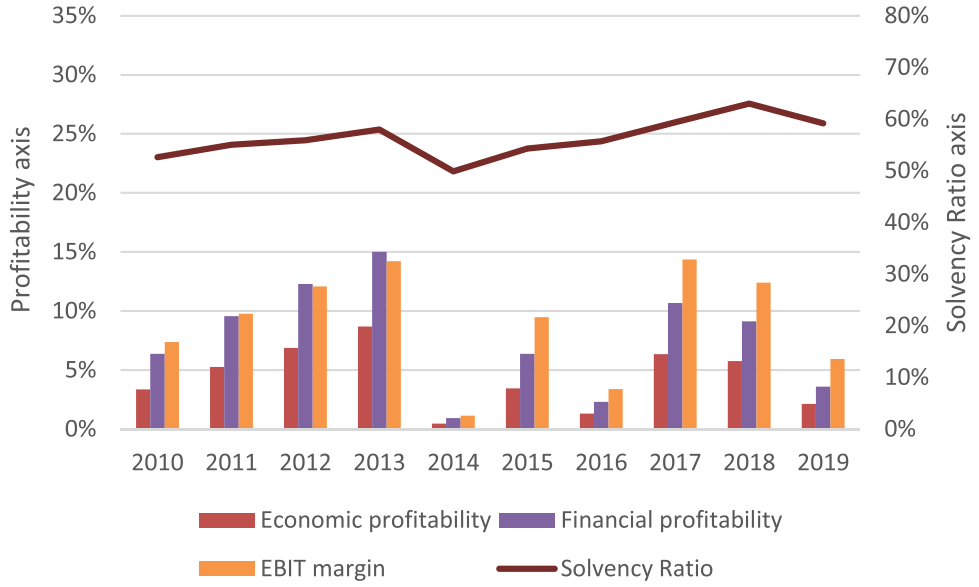


**Fig. 3.** Financial analysis of the medium-sized companies in the Spanish Celtic Sea fishing sector.
Source: Own elaboration based on data from [29].

companies are concerned, this group presents a high financial profitability during the ten years analyzed. It is remarkable the increase in the value of the variable between the years 2015–2017 which, despite the increase in equity, is driven by the strong rise in ordinary profit before tax. In the case of micro-companies, there is a volatility of results that is not observed in the rest of the companies. In the years 2010 and 2015 is when the ordinary profit before tax presents higher values (28.85% and 29.37%, respectively). No other group of companies analyzed obtained similar values of financial profitability. On the contrary, micro-companies also show the lowest profitability values of the sample, in 2018 and 2019, due to the negative ordinary result obtained.

The value of the EBIT margin has two differentiated stages. The first period lasts until 2014, when the different groups of analysis show values closer to each other. The second stage extends from 2015 to the present, in which the discordance between the average EBIT margin for each group is evident (Fig. 4).

In the case of large companies, a certain stability of this ratio is observed, obtaining a maximum value in 2017 since sales revenues are stable, but ordinary income before taxes increases. Regarding medium-sized companies, the attractiveness of investing in them is observed as they present stable values in almost all years. As far as small companies are concerned, the trend is the same as in the previous analysis on economic and financial profitability. In this case, the highest values are obtained in the years 2015–2017 due to the increase in ordinary income before taxes. For its part, the group of micro-enterprises again shows an unstable trend, showing the most extreme values of the study. In 2015, the EBIT margin value reaches the high percentage (31.96%) because of the increase in net income, while in 2018 and 2019 it presents negative values. This trend can be explained by the evolution of fishing diesel prices. While between 2015 and 2017 the low price of fuel oil compensated the decrease in sales due to the landing obligation, the increase in the cost of a liter of fuel from 2018, together with the

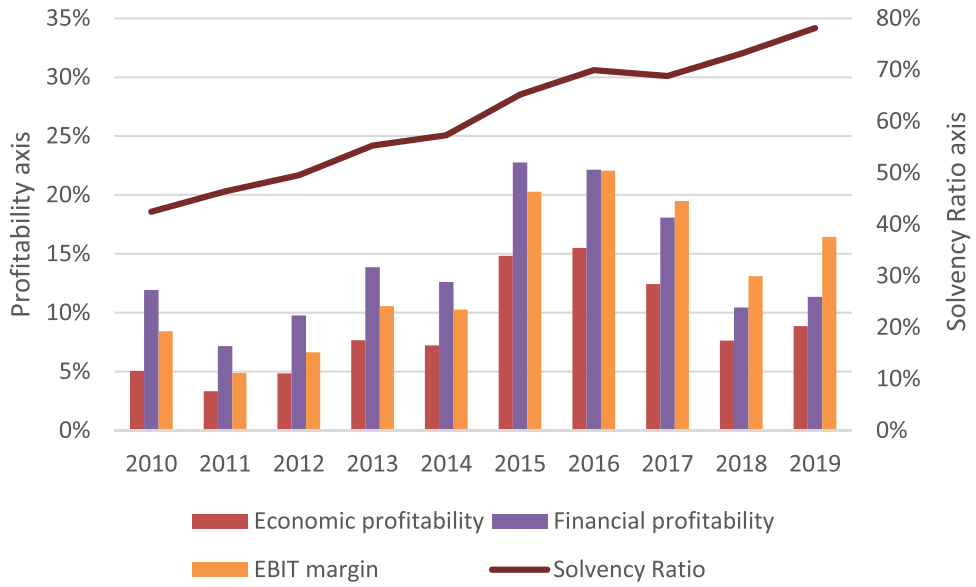


**Fig. 4.** Financial analysis of the small companies in the Spanish Celtic Sea fishing sector.
Source: Own elaboration based on data from [29].

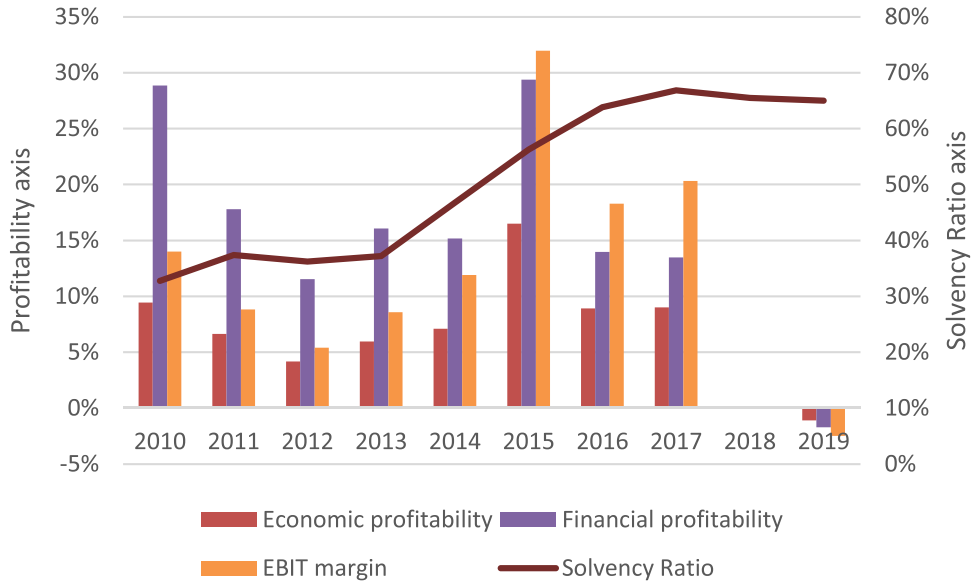


**Fig. 5.** Financial analysis of the micro-companies in the Spanish Celtic Sea fishing sector.
Source: Own elaboration based on data from [29].

progressive increase in species with landing obligations, has decreased the values of EBIT margin. The effects of the variation in the price of diesel have a greater impact on the smaller the size of the company; therefore, small and micro-companies present more pronounced variations than large and medium-sized companies.

All the groups of companies analyzed show a stable evolution for the solvency ratio, with a slight upward trend (Fig. 5). In fact, all four types of companies exceed the optimum of this ratio. It can therefore be concluded that the companies in the sample are solvent in terms of a possible repayment of debts. The results of this variable show the low indebtedness of the Celtic Sea fishing sector.

## 5. Discussion

The current situation of the fishing sector in the Celtic Sea contrasts with that of the 1980 s and 1990 s, when the Spanish fleet in the Grand Sole reached more than 300 vessels. Following Spain's entry into the EU in 1986, however, the Common Fisheries Policy entailed a resizing of this fleet to adapt it to the fishing possibilities available. Since then, there has been a gradual decrease in the number of companies (35 of them have disappeared throughout the study period of this work). However, it is noteworthy that no large or medium-sized company has disappeared from the market during this period. These companies have financial resources that allow them to face both decreases in income, such as those related to the obligation to comply with discard regulations, and increases in costs, such as those due to the increase in the cost of fuel. However, for small and micro-companies, compliance with the landing obligation implies economic losses that affect them to a greater degree than larger companies, to the point of causing many of them to cease operations. On the other hand, fuel costs represent a very high percentage of total costs of micro-companies, so an increase in fuel prices seriously affects their profitability.

Results show that, during the first half of the study period, there is a certain stability of economic profitability, apart from medium-sized companies in 2014. Their profitability reaches the minimum of the whole period coinciding with the entry into force of the discard regulations. Regarding the second half of the study period, in 2015 there is a significant increase in the economic profitability for small and micro-companies. Small ones remain at relatively high levels until the end of the period, but micro-enterprises reduce their profitability to zero in 2018 and to negative values in 2019. The strong increase in profitability in 2015 cannot be attributed to an increase in catches, given that, although the total quota available to the Grand Sole Spanish fleet increased compared to the previous year, it only rised by 6.4%. In fact, as the Table 7 shows, from 2014 onwards there are always increases in the total quota of the main target species for the Celtic Sea fleet, but such increases do not justify such a steep rise in the profitability of this fleet segment. It is the decrease in fixed costs that explains why the profitability of the small and micro-companies soars in the middle of the study period. This decrease is probably due to the fall in fishing diesel prices.

Fishing activity includes a series of operational costs, of which the cost of fuel is one of the most important (Table 8). Thus, variations in the price of fuel can significantly affect the fishing industry [31], particularly smaller companies. Throughout the study period of this article, fuel costs represented on average 18.8% of the total operational costs of the Spanish fishing fleet, sometimes exceeding 43% in the case of trawlers and longliners. The fuel used by the fishing fleet is type B diesel, which has a lower price than type A automotive diesel, due to the lower taxes applied to it. The price of this type of diesel, like the rest of the fuels, has been altered over the past decade by the behavior of oil prices.

In the mid-2010 s, the fall in demand in commodity markets due to the slowdown of the Chinese economy and the oversupply of shale oil from the United States and Canada, generated one of the most important drops in oil prices in recent decades, from around €97 in June 2014 to €39 in January 2015 [33]. Therefore, annual average prices of fishing diesel in Spain fell from 0.59 €/liter in 2014–0.34 €/liter in 2016 (Fig. 6). However, in parallel with the evolution of oil prices, fishing diesel prices have been recovering to reach 0.49 €/liter in 2019 [32].

During the second half of the study period, the price of fishing diesel rose again, but to lower levels than in the first half of the period. Smaller companies coped with the price increase by reducing fishing effort (days of fishing). In this way, the profitability of small companies remained high. However, the profitability of micro-enterprises no longer recovers from the 2015 peak, and even falls to negative levels by the end of the period. This low profitability can no longer be attributed to the cost of fuel (as firms were profitable at higher fuel prices in 2010–2014), nor can it be accredited to lower quota availability (which has increased throughout the period). The worsening economic performance of micro-enterprises can only be attributed to the compliance of the landing obligation, with which it coincides in time. In 2018, the last year of the gradual application by species and areas of the landing obligation, the profitability of micro-enterprises was equal to zero, and in 2019, the first year of full application of the regulation to all species and areas, profitability was negative. In addition, in 2019 there were more than a third of the business closures recorded during the study period, with a total of 12, of which 10 corresponded to micro-enterprises. The lower financial strength of these companies prevented many of them from overcoming the economic difficulties generated by the application of this regulation, difficulties that larger companies were able to face.

## 6. Conclusions

The landing obligation promoted by the Common Fisheries Policy is a necessary step in controlling the overexploitation of European fish stocks, since discards represent a serious problem in the fisheries. However, the implementation of this measure should not ignore the socio-economic consequences for the fishing communities affected, which are subject to a regulation that, in many cases, generates a significant economic damage that would require some type of compensation. It would be desirable that policymakers were able to foresee such effects and to incorporate mechanisms to mitigate them in the design of regulations. In the medium term, institutional support will also be necessary to develop projects to improve the fishing gear selectivity, which is the main objective of the landing obligation. In this way, the negative socio-economic consequences would not even occur.

The profitability of fishing companies is the result of a complex balance between multiple factors that either directly affect revenues, such as quota availability, or costs, such as fuel prices. This changing complexity is clearly reflected when performing a financial analysis, in particular for smaller companies, that are much more sensitive to factors that disrupt equilibrium. In the case of the Spanish Celtic Sea fleet, during the period of partial and full implementation of the landing obligation it has been observed a significant impact on its economic performance, particularly on small and micro-enterprises, which make up 94% of the total number of companies in the sector. The profitability of these companies is highly vulnerable to exogenous factors, as was clearly seen during the diesel price swings. In thinly capitalized companies, variations in costs and revenues, which hardly affect larger companies, can even cause them to go out of business. In the case of the landing obligation, companies are forced to land bycatch to the detriment of catches of target species that generate a higher profit, and this loss of revenue can be crucial for the company's future. During the 5 years of gradual implementation of the regulations and the first year of full implementation, 24 micro-enterprises have disappeared, three times as many as during the previous four years. In a sector as sparsely concentrated as this one, with few medium-sized and large companies, the short-term consequences of this dynamic may be serious. For the small companies that remain in the market, the negative expectations generated by the obligation to comply with discard regulations could discourage investment, which would be detrimental to their productivity and competitiveness. In the medium and long term, the solution envisaged for this sector could be a process of business concentration from which companies with greater financial strength would emerge, but in the short term, some type of institutional help is needed.

Moreover, the primary objective of the landing obligation, which is the adoption by the sector of more selective fishing methods, is difficult to achieve in the short term for an important part of the Spanish Celtic Sea fleet, which uses demersal or bottom trawling. Technological developments to increase the selectivity of this gear type will probably take years to be implemented, a period during which the current problems will continue. In the meantime, institutional support may be key to the future of this sector. Examples of programmes and projects aiming to

**Table 7**
Spanish fishing quotas for the main species caught in the Celtic Sea (tons).

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hake | 9109 | 9109 | 9109 | 9109 | 13,529 | 15,017 | 18,248 | 19,944 | 18,434 | 23,512 |
| Megrim | 5840 | 5875 | 5601 | 5601 | 5679 | 5685 | 6168 | 4752 | 4310 | 6097 |
| Anglerfish | 1400 | 1396 | 1325 | 1259 | 1401 | 1435 | 1476 | 1525 | 1584 | 1652 |
| Norway lobster | 1379 | 1711 | 1715 | 1961 | 1847 | 1884 | 1959 | 2456 | 2595 | 2016 |
| Total | 19,738 | 20,102 | 19,762 | 19,943 | 24,470 | 26,036 | 29,867 | 30,694 | 28,941 | 35,296 |

*Source*:Source: Own elaboration based on [30].

**Table 8**
Operational costs of trawlers and longliners of the Spanish fishing fleet (% over the total).

| | | Bait, salt, ice, containers and packages | Supplies | Fishing gears | Spare parts, repair and maintenance | Fuel and lubricants | Other services | Port charges | Other vessel expenses | Other non-fishing expenses |
|---|---|---|---|---|---|---|---|---|---|---|
| 2019 | Trawlers | 6.64% | 1.67% | 6.26% | 14.64% | 43.66% | 8.27% | 9.13% | 2.39% | 7.34% |
| | Longliners | 13.96% | 7.69% | 3.04% | 21.29% | 31.82% | 9.00% | 4.42% | 5.66% | 3.11% |
| | Average | 10.30% | 4.68% | 4.65% | 17.96% | 37.74% | 8.63% | 6.78% | 4.03% | 5.23% |
| 2018 | Trawlers | 6.21% | 1.72% | 5.28% | 14.20% | 42.05% | 8.03% | 8.78% | 5.22% | 8.50% |
| | Longliners | 18.57% | 6.41% | 5.27% | 13.79% | 31.31% | 9.36% | 3.52% | 7.06% | 4.72% |
| | Average | 12.39% | 4.06% | 5.28% | 13.99% | 36.68% | 8.70% | 6.15% | 6.14% | 6.61% |
| 2017 | Trawlers | 8.47% | 2.28% | 7.96% | 12.57% | 42.20% | 8.61% | 6.69% | 1.94% | 9.29% |
| | Longliners | 18.90% | 6.09% | 6.23% | 14.75% | 29.22% | 10.17% | 4.97% | 7.35% | 2.32% |
| | Average | 13.69% | 4.18% | 7.09% | 13.66% | 35.71% | 9.39% | 5.83% | 4.64% | 5.81% |
| 2016 | Trawlers | 6.24% | 2.15% | 7.21% | 17.89% | 39.30% | 9.04% | 4.14% | 2.89% | 11.13% |
| | Longliners | 16.76% | 7.12% | 6.18% | 17.48% | 26.92% | 10.78% | 3.05% | 9.89% | 1.83% |
| | Average | 11.50% | 4.63% | 6.69% | 17.69% | 33.11% | 9.91% | 3.59% | 6.39% | 6.48% |
| 2015 | Trawlers | 6.78% | 2.76% | 5.12% | 17.43% | 37.88% | 7.58% | 9.24% | 4.77% | 8.44% |
| | Longliners | 13.50% | 7.21% | 7.03% | 18.11% | 33.65% | 11.38% | 2.11% | 4.76% | 2.25% |
| | Average | 10.14% | 4.98% | 6.07% | 17.77% | 35.76% | 9.48% | 5.68% | 4.76% | 5.35% |
| 2014 | Trawlers | 11.06% | 1.95% | 5.07% | 12.27% | 42.81% | 5.38% | 6.98% | 5.63% | 8.85% |
| | Longliners | 12.28% | 6.17% | 4.89% | 17.13% | 39.96% | 7.95% | 1.59% | 8.30% | 1.73% |
| | Average | 8.67% | 4.06% | 4.98% | 14.70% | 41.38% | 6.66% | 4.28% | 6.97% | 5.29% |
| 2013 | Trawlers | 12.44% | 3.84% | 3.47% | 16.19% | 38.19% | 13.79% | 9.29% | 0.74% | 2.04% |
| | Longliners | 9.93% | 3.95% | 3.03% | 8.24% | 43.22% | 12.77% | 4.69% | 11.91% | 2.25% |
| | Average | 11.19% | 3.90% | 3.25% | 12.22% | 40.71% | 13.28% | 6.99% | 6.33% | 2.15% |
| 2012 | Trawlers | 5.01% | 2.22% | 1.61% | 13.92% | 42.88% | 8.45% | 10.29% | 0.86% | 14.76% |
| | Longliners | 13.88% | 4.48% | 2.59% | 11.50% | 35.65% | 11.94% | 6.36% | 12.12% | 1.48% |
| | Average | 9.45% | 3.85% | 2.60% | 12.71% | 39.27% | 10.69% | 8.32% | 6.49% | 10.12% |
| 2011 | Trawlers | 4.86% | 1.92% | 1.51% | 16.38% | 50.67% | 8.75% | 10.51% | 2.40% | 3.00% |
| | Longliners | 17.06% | 4.23% | 5.73% | 13.20% | 31.09% | 12.41% | 1.95% | 13.23% | 1.10% |
| | Average | 10.96% | 3.08% | 3.62% | 14.79% | 40.88% | 10.58% | 6.23% | 7.82% | 2.05% |
| 2010 | Trawlers | 2.71% | 2.46% | 3.03% | 9.49% | 37.78% | 9.85% | 7.20% | 17.56% | 9.92% |
| | Longliners | 13.21% | 4.83% | 9.10% | 9.87% | 30.67% | 14.15% | 4.13% | 12.84% | 1.20% |
| | Average | 7.96% | 3.65% | 6.07% | 9.68% | 34.22% | 12.00% | 5.66% | 15.20% | 5.56% |

*Source*:Source: Own elaboration based on data from [32].

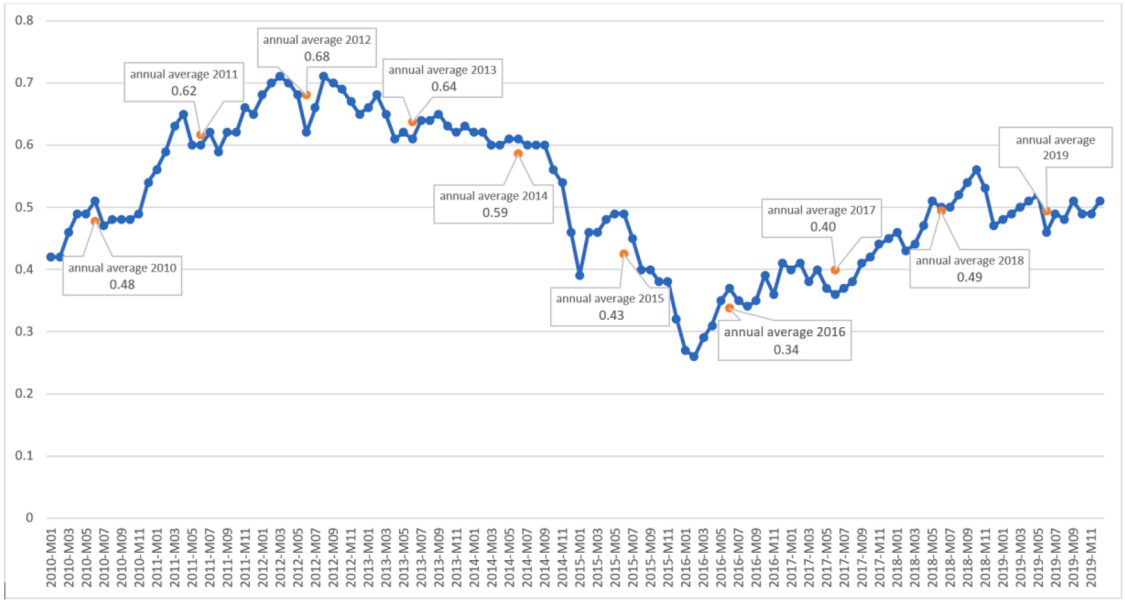


**Fig. 6.** Evolution of fishing diesel prices in Spain. 2010–2019.
Source: Own elaboration based on data from [32].

improve the selectivity of fishing gear, avoiding economic losses for the fishermen concerned, can be found in several European countries. For example, in Sweden, the Selective Fisheries Secretariat established a programme, whose participants are provided with income security, to develop gear changes and other ideas that help fishers to comply the landing obligation [34]. In the case of Spain, such institutional support could take the form of either this type of programmes to improve gear selectivity, or direct financial compensation to fishermen affected by the landing obligation, in pursuit of a balance between the objectives of sustainable exploitation of resources and maintenance of socio-economic variables of the fishing activity.

## CRediT authorship contribution statement

**Raquel Fernández-González**: Conceptualization, Validation, Formal analysis, Investigation, Writing – original draft preparation, Writing – review & editing, Visualization. **Marcos I. érez-P é rez**: Methodology, Validation, Resources, Writing – review & editing, Visualization. **M[a] Dolores Garza-Gil:** Validation, Formal analysis, Data curation, Writing – review & editing, Visualization.

## Data availability

Data will be made available on request.

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