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Economic, Social, and Environmental Impact of a Sustainable Fisheries Model in Spain

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Received: 27 September 2019; Accepted: 7 November 2019; Published: 10 November 2019

Abstract: In recent decades, fishing sustainability has been subject to intense international debate. Overfishing and contamination of the marine environment are elements that contribute to a reduction in fish stock and catches, often leading to declining income and employment, especially in rural areas. We present a sustainable fisheries model that promotes artisanal fishing while incorporating replacement rates of fish stock and actions that benefit the fishing industry. First, the sustainable fisheries model defines the guidelines and actions that may apply either together or independently, sequentially, or simultaneously, according to a defined budget. These concrete actions are quantified and incorporated into an environmentally extended input-output model to evaluate the economic impact on the Spanish fishing industry. The impact is complemented with an assessment of social impact (employment) and environmental impact (estimated reduction of CO_2 emissions).

Keywords: economic impact; environmental impact; social impact; input-output model; sustainable fisheries

1. Introduction

Global fisheries may underperform due to overfishing, harmful subsidies, and over-capacity [1,2]. This condition is not sustainable either globally or at a regional level (Europe). Institutions, organizations, and governments are aware of the need to implement policies to ensure the sustainability of fisheries in the long term. In general, fishery policy has focused on large-scale fishing, resulting in a lack of knowledge on many biological, environmental, socioeconomic, management, and policy aspects of small-scale fisheries [3]. Small-scale fisheries could be an important source of income for some regions [2,4,5], and are critical for livelihoods and food supply [6], in addition to the employment of fishers and other workers in small-scale fisheries and related activities which provide vital supplements to livelihoods", especially in times of crisis [7].

According to the Millennium Ecosystem Assessment, depletion of fish stocks is one example of a potentially irreversible change to an ecosystem that results from present unsustainable practices. The Code of Conduct for Responsible Fisheries developed in 1995 by the Food and Agriculture Organization (FAO) of the United Nations includes a set of recommendations for reducing the negative impacts of fishing activities on marine ecosystems [8]. Voluntary Guidelines for Securing Small-Scale Sustainable Fisheries (SSF) were developed in 2015 as a complement to the 1995 FAO Code [7], and the SSF Guidelines are a fundamental tool to promote sustainable development in a strategic framework [7].

In Europe, the "Green Paper" on a reform of the Common Fisheries Policy (CFP)" was adopted in 2009 to define objectives for ecological, economic, and social sustainability. The goal was to provide guidance in the short term and to ensure the sustainability of fisheries in the long term [9]. The Common Fisheries Policy (CFP), in force since 1 January 2014, offers the possibility of eliminating overfishing while providing a viable and environmentally sustainable alternative for the industry. From 2014 to 2024, Member States are required to apply regulations to repopulate fish stock, reduce the capacity of fleets and overfishing, eliminate destructive fishing practices, and promote access to resources for sustainable fishing. Moreover, in a broader framework, numerous European governments "are encouraging the development of economic activity within the marine realm" or "Blue Growth" [10,11], and "small-scale fisheries could become part of a blue economy" [12].

As part of the CFP, some authors proposed compliance with maximum sustainable yield (MSY) by re-allocating quotas based on criteria linked to sustainable fishery management [13]. The authors note that re-allocation would increase revenue and create employment more efficiently compared with the current allocation based on historical quotas. The concept of MSY has a long tradition as a guide to fisheries management worldwide, however it does not take into consideration other economic and social variables. It is recognized that fisheries sustainability is a multidimensional human endeavor that has socio-economic, technological, ethical or institutional implications [9] and should incorporate an analysis of the full social-ecological system before proposing solutions [14]. Fisheries are complex social-ecological systems, and the human dimension is required within an interdisciplinary approach to include societal challenges in a broader context [15].

Managing fisheries is increasingly cast in terms of restoring high levels of sustainable fish stocks, catches, and revenue [16]. A key question is the identification and selection of possible paths that produce objective levels for restored fisheries. The authors developed a formal analysis of the recovery process for a fishery, from crisis to desired levels of sustainable exploitation, using a theoretical framework of viable control. They defined sustainability as a combination of biological, economic, and social constraints that need to be met for a viable fishery to exist. Factors that favor sustainability using Ostrom's framework for the analysis of socioecological systems were investigated [14]. Those factors have to do with the resource system, governance, the users and interactions, self-organization, and partnerships. Pauly lays out the five concerns surrounding fisheries: Primary Production Required, Fishing Down the Food Web, China and the World's Fisheries, Sustainability, and Future of Fisheries [17]. In view of these problems, the author proposes four different scenarios that correspond to various societal and policy choices and their implications upon the future of fisheries. One of these scenarios is "Sustainability First", in which environmental sustainability is valued over economic profit. A quantitative assessment of the outcomes of the sustainability schemes secondarily describes the economic outcomes of the models in terms of the economic, social, and environmental impact.

Environmental Impact Assessment [11] has been applied to projects in the marine environment at earlier stages of development in other areas [18]. Life cycle assessment (LCA) is another environmental tool for establishing alternative solutions aimed at reducing potential impacts and the search for sustainable development in fisheries and offshore fish farms [5,19,20]. Other tools developed to assess the sustainability of fisheries in Norway [21] include indicators and rubrics with categories that articulate levels of performance. Sustainability assessment can be defined as any process that directs decision-making towards sustainability [22], and in this context, our paper relates to an impact assessment that has sustainability as its primary goal for two reasons. First, the model under consideration is for the sustainability fisheries, and second, because it includes characteristics of sustainability assessment, it seeks to promote "multiple reinforcing gains" from decision-making, simultaneous economic, social, and environmental benefits (win-win-win approach).

This paper focuses on the Spanish fishing industry, one of the largest in Europe. The Spanish fleet represents 11.1% of the entire European Union (EU-28) fleet in terms of the number of vessels and 21.3% of average Gross Registered Tonnage (GRT) [23]. Spain is one of the EU countries with the highest volume of catches (17.5% in 2015), greatest contribution to aquaculture production (22.5% of volume in tons live weight in 2015) and almost a quarter of the EU total employment: 29,322 in fisheries during 2015, 5946 in aquaculture during 2014, and 17,693 in processing during 2016 [23]. However, the contribution of the fishing sector to the Gross Domestic Product (GDP) in the European Union Member States is, in the majority of cases, below 1%. In Spain, the extracted fishing contributed 0.11% of the Gross Value Added (GVA) and 0.18% to the employment in 2017 [24].

Spain's entry into the European Economic Community in 1986 marked a turning point in employment in the industry. One of the main directives of the Common Fisheries Policy was the on-going decrease of the European fishing fleet capacity, to reduce the pressure on fishing resources. The fishing fleet capacity in smaller vessels (0 to 25 Kw) has decreased, 24% in the European Union, and almost 50% in Spain, whereas the fishing fleet capacity in larger vessels (2000 Kw or over) shows different trajectories. In the European Union, it increased by 58% and in Spain, it has decreased by 15% (Figure 1).

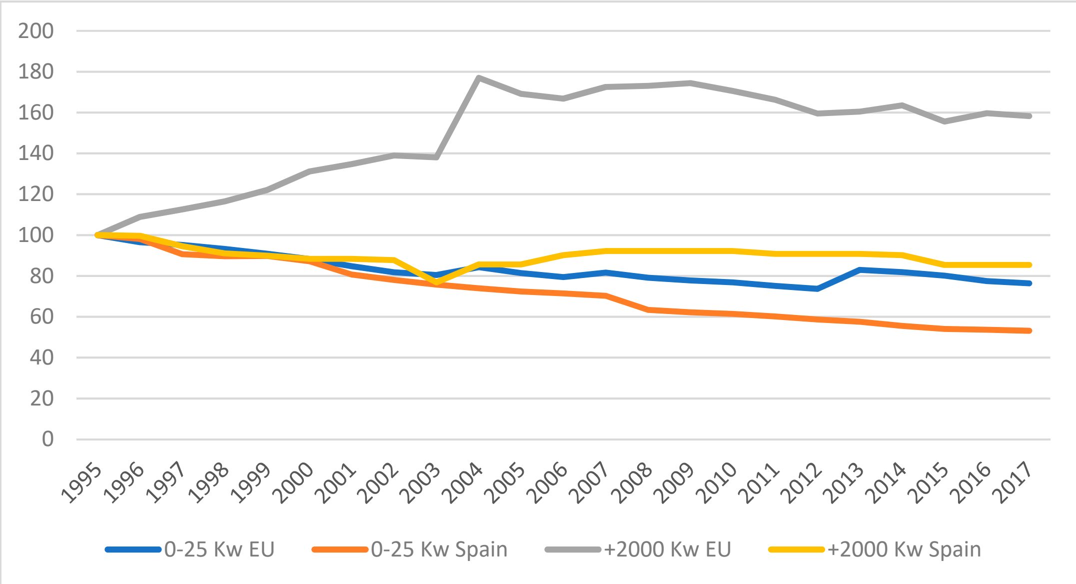

Figure 1. Evolution in fishing capacity (Gross Tonnage) of small and large vessels from 1995–2017. EU and Spain. Index numbers (1995 = 100). Source: Eurostat and own data.

The Spanish fishing industry has not only been significantly reduced, but there has also been a major transformation from smaller to larger vessels with a greater capacity. Both processes have resulted in the destruction of fishing employment, especially in artisanal fisheries.

At an international level, there is a lack of attention on small-scale fisheries that manifests itself in "potentially misleading statistics", which may omit or substantially underreport small-scale fisheries data, and it´s possible that artisanal catches "are partly masking the decline in industrial catches at the global level" [25].

The objectives of this study are, first, to design a sustainable fisheries model with different areas of action based on eight guidelines to be implemented during a ten years period (coinciding with the mandate of the Common Fisheries Policy); second, to quantify the actions and finally, assess the sustainability impact of this model. The methodology chosen is an impact analysis based on an extended input-output model that incorporates an environmental dimension by calculating the emissions eliminated, as well as meaningful details on the type of employment created and lost by the proposed action. This type of model is extensively used to analyze the impact in general. The research of [26] is an application to the fisheries sector in Galicia, a region in the north of Spain, using an input-output model to analyze the influence on the fishing industry and estimate the economic impact of a change in final demand in the industry, on the economy as a whole. This work performs a detailed analysis of the internal economic structure of the fishing industry, recording its interrelation with the rest of the Galician economy and the importance of overseas industries, and estimating the economic impact of an increase in final demand on the regional economy through exports.

The following section describes the actions proposed to move towards a sustainable fisheries model in line with the CFP and its strategic focus on traditional fishing and compliance with the rate of renewal of fish stock. We also estimate the investment required to implement the model during a period of ten years. Section 3 reviews traditional input-output methodology and describes three specific contributions of this study: differentiation between "traditional or artisanal" and "large-scale" fishing that enables identification of the different actions and effects on both subsectors, an extension of the economic impact model with an environmental vector that makes it possible to measure the changes in CO_2 emissions, and a distribution in employment that identifies the main features that would be contributed by the new employment model. The main results relating to the economic, environmental, and employment impact, resulting from the action proposed, are presented in Section 4. The final section presents the main conclusions.

2. Conceptualization and Identification of the Areas of Action of the Proposed Sustainable Fisheries Model

The conceptualization of fishing as "sustainable" commenced in an environmental context, but has since evolved and is now used in economic and social contexts. Sustainable fishing is often defined as fishing that can be maintained indefinitely without affecting the viability of the species caught or negatively affecting other species that form part of the ecosystem, or the fishing communities that depend on the industry. The general principles established by the Food and Agriculture Organization (FAO) Responsible Fishing Code of Conduct [27], and its Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the context of Food Security and Poverty Eradication' of the FAO, are central [7] to guarantee a sustainable fisheries model highlight the important contribution of traditional fishing to employment, revenue and a secure food supply and therefore encourage States to protect the rights of workers and fishers, especially those involved in traditional fishing, as well as to provide preferential access, if applicable, to traditional resources and fishing grounds in national waters. Some authors evaluate the ecological effects by comparing compliance with the code, and their results indicate that countries with higher levels of compliance with the FAO Code of Conduct in 2008 experienced an increase in fisheries sustainability from the 1990s to 2000s [8].

Along the same lines as the SSF Guidelines, we establish a series of criteria for sustainable fishing, based on eight different areas related to the ecosystem: protection of susceptible species and habitats, maintenance of all types of species at acceptable levels, use of selective fishing methods, maintenance of biodiversity, reduction of energy and chemical products used, social, and economic responsibility and justice and the awareness of the origin of catches at all times throughout the chain.

Therefore, the concept of sustainable fishing is not currently limited to an environmental context but refers to a triangle that includes environmental, economic, and social sustainability. Under this framework, the sustainable fisheries model proposed and evaluated in this study is guided by SSF Guidelines and based on the correct application of the criteria passed by the CFP, with certain additional measures.

The proposed fishing model is comprised of a set of eight fundamental areas of action to encourage the transition towards a sustainable fisheries model. The work analyzes the impact of each area of action and its overall effects, as well as the combined impact of all the areas.

The initiatives proposed for the implementation of a more sustainable fisheries model are grouped as follows, and broken down into different areas of action:

(1) Support for traditional fishing:

- Exclusive 12-mile reserve exclusively for traditional fishing.
- Support for a traditional fishing label.
- Support for the energy efficiency of fleets and improved communications systems (investment advice and subsidies).
- Support for fishing tourism. Potential strategic focus: business and entrepreneurial development, cultural tourism, development of human resources, environmental tourism, promotion, and development.

(2) Prohibition of trawling:

- Progressive prohibition of trawling until its disappearance.
- Prohibition of certain purse seine fishing practices.

(3) Extension of the Marine Resources Network:

- The proposed extension of the network to 35 new marine reserves covering a much larger area than at present. A viable and well-managed network of Protected Marine Areas covering at least 10% of the marine surface area.
- Development and promotion of different training, research, and tourism training activities that are compatible with the levels of protected reserves.

(4) The advance of deep-sea fishing towards sustainability:

- Commitment to sustainable fishing using sustainability certification systems.
- Restriction of the number of deep-sea and distant water fishing vessels (prohibition of new vessels).
- Prohibition of importing fish without information on its origin or legal certification.
- Improved measures to supervise and control illegal fishing.
- Promotion of Marine reserves in international waters (prior studies, analysis, and promotion).

(5) Prohibition of new aquaculture operations:

- Prohibition of new marine aquaculture operations of breeding as well as mussel farming.

(6) Demand measures:

- Awareness campaign on the sustainability of fish stock.
- Promotion of "responsible buying" (advertising, educational campaigns, trade fair activities).
- Implementation of a sustainable fishing identification logo (coastal, deep see, and distant fishing): design, retail trading regulations, and awareness campaigns.

(7) Compliance with biological optimums:

- Suitable evaluation of Maximum Sustainable Yields (MSY) for coastal fishing
- Studies on the causes of annual variations in certain coastal fishing species.
- Improved control of compliance with MSY at the port.

(8) Control of contamination of marine coastlines:

- Compliance with "framework" water policy regulations governing the correct treatment of wastewater (Directive 91/271/EC and Directive 2000/60/EC), especially in so-called sensitive areas. The lack of suitable treatment can cause substantial damage to the marine environment, as it facilitates the processes of eutrophication (excessive growth of algae that prevents the development of other living creatures).

The estimated investment in each area of activity was agreed upon with the different relevant stakeholders in the sector and based on previous equivalent public investment information from other sectors. The estimated budget to make the necessary investment in each area of action over a period of ten years, is shown in Table 1.

The group of actions proposed requires a budget of 2725 million euros, of which the 50.5% for the control of marine coastal contamination forms part of the Ministry of Agriculture, Food and the Environment policy (Directive 91/271/EC and Directive 2000/60/EC in the "National Plan for Water Quality, Sewerage, and Treatment"). Of the remaining 49.5%, 28.3% would be used to extend the network of marine reserves and 17.7% to support traditional fishing. The other measures require very limited or inexistent public expenditure.

Table 1. Estimated budget per area of activity of the proposed sustainable fisheries model.

	Estimated Budget	
	Millions of Euros	**%**
Support of traditional fishing	483	17.7
Prohibition of trawling	0	0.0
Extension of the marine reserve network	770	28.3
The advance of deep-sea fishing towards sustainability	49	1.8
Prohibition of new aquaculture operations	0	0.0
Demand measures	13	0.5
Compliance with biological optimums	34	1.2
Control of contamination of marine coastlines	1375	50.5
Total	**2725**	**100**

Source: own data.

3. Methodological Approach

The impact of the sustainable fisheries model was calculated using an input-output (IO) analysis methodology. This type of analysis enables the measurement of impact on the economy as a whole, associated with a change in demand for goods and services in a particular sector. The IO analysis is frequently used as a tool to measure the economic impact of certain sectors on others. Through the linear model presented here, we have provided a quantitative tool for carrying out analysis on the necessary measures for the implementation of a sustainable fisheries model, subject to data availability.

This methodology has been used at an international level. For the U.S. fishing grounds of Westport (Washington) and Newport (Oregon), [28] built Social Accounting Matrices (SAM) to analyze their degree of dependence on fish stock, by developing economic dependence indexes. These dependence indexes are obtained using SAM and represent the percentage of GRP (Gross Regional Product) and total employment in the community resulting from the exports of such industries. The dependence indexes are equivalent to the percentage of total economic activity (measured in terms of GRP or employment) generated by the economic activity (in this case, exports) of a particular sector. The aim was to determine the dependence of the communities on marine resources, both economically (gross regional product) as well as in terms of employment, by estimating the effect on the economic activity generated by the exports of the respective industries, as well as in terms of employment, by estimating the effects on economic activity generated by the exports.

Also in the United States, for the State of Alaska, [29] used a general equilibrium model (GEM) to analyze the economic effects of three exogenous shocks on fishing: a reduction in the number of catches; increase in price and fuel, and a reduction in demand for seafood products; to estimate the impact on production, employment, added value, and household income.

Under the SAM framework for fisheries in the south-eastern region of Alaska, Seung used a Structural Path Analysis (SPA) to show how the variation in a sector of the fishing industry generated effects in different ways on the regional economy and to what extent these effects were amplified [30]. Based on the total economic impact measured by the multipliers obtained from input-output models, the SPA decomposes the regional multipliers and provides information on the ways or channels through which management action or an exogenous change produces effects. The author creates models for two scenarios that show, firstly, the impact caused by a change in the level of captures of certain species and, secondly, the impact caused by a change in demand for processed seafood products.

At a worldwide level, Dyck and Sumaila apply an input-output methodology to estimate the direct and indirect impact of marine fishing on the global economy [31]. In order to do so, they use a large database of economic flows developed by the Global Trade Analysis Project (GTAP), which includes a collection of input-output tables, with economic flows for 57 sectors and 113 regions throughout the world. In addition to estimating the gross revenue from fishing, they conclude that the indirect and induced impact of the sector is almost three times greater than its economic value.

These models provide valuable information that helps to identify not only the sectors and groups of stakeholders affected by the fishing industry but also the magnitude of the impact of the action affecting the sector. This information can help the planners of policy designs to guarantee the biological sustainability of fishing resources.

As noted, the objective of this study, in addition to data on the economic impact on the production and the number of jobs created by applying the measures, included two main issues affecting the sector—a section that analyses the characteristics of the new jobs created and an environmental section that quantifies the increase and decrease of CO_2.

3.1. Database

The database was constructed according to the Input-Output Tables in Spain published by the National Institute of Statistics. One of the innovative contributions of this work is that fishing activity was divided into two subsectors—traditional fishing and large-scale fishing. To make this distinction, we used the Galician Input-Output Framework published by the Galician Institute of Statistics.

The only existing official data, those of the Galician fishing sector, have been taken as a reference. This aspect is assumable since Galicia is the first Spanish fishing region, and the Galician fishing sector represents more than half of the Spanish fishing sector. The distinction between traditional and large-scale fishing is based on the following:

Traditional fishing:

- Coastal fishing: carried out by companies involved in traditional daily fishing, featuring techniques, such gathering seafood at sea and the use of pots.
- Seafood: units of production are groups of seafood companies that manage, control and plan the production process (pre-fattening, fattening, farming, and collection).

Large-scale fishing includes:

- Coastal fishing: companies that perform their fishing operations with the aim of selling fresh products, comprised of catches from estuaries and along the coastline.
- Deep-sea fishing: industrial with a much larger radius of activity, even reaching fishing grounds such as the Gran Sol and Canary Islands-Sahara bank.
- Deep-sea fishing: companies that have a much higher average exceeding 500 GRT involved in deep-sea industrial fishing in waters such as the Falklands, the South West Atlantic and the Indian Ocean.
- Aquaculture: includes different activities involving the breeding of fish as well as mollusks, at installations on land, and using metallic structures placed at sea.

Based on the fishing industry breakdown, the sectors included for calculating impact are shown in Table 2. Santero et al show detailed information about differences between sustainability fisheries (traditional, small-scale, or artisanal) and large-scale fisheries in Spain [32].

Table 2. Areas of activity included in the impact analysis.

Agriculture and Forestry
Traditional fishing
Large-scale fishing
Extraction
Fuel and gas
Production and distribution of electrical energy
Collection, treatment, and distribution of water
Food products
Textiles, leather and wooden products
Chemical industry
Building materials
Metal industry and manufacture of metal products
Machinery
Manufacture of motor vehicles, trailers, and other transport material
Other manufactured goods
Construction
Trade, restaurants, and catering
Transport and communications
Other services (financial, insurance, research and development, …)
Services aimed at promoting sales
Services not aimed at promoting sales

Source: own data.

3.2. Input-Output Methodology

An input-output table (IOT) is a statistical basis that records the different sectors that make up the productive structure of a country or region. The data enables a detailed analysis of the dimensions of the economic sectors and, in our work, enabling us to breakdown the fishing sector into two subsectors, traditional, and large-scale fishing. It also enabled us to measure the impact in terms of production and employment of certain investment policies on different sectors. The main advantage of the methodology based on input-output tables is that it allows recording of the multiplier effect of the different inter-related sectors on a particular region.

Models using IOTs first appeared in work by [33]. They basically consist of a system of linear equations, each of which describes the distribution of the products of an industry in the entire economy [34,35]. Currently, European Commission proposes the use of environmentally extended input-output tables and models as tools to identify priorities [36], assess impacts and make strategic goals, such as eco-efficiency or decoupling environmental impact from operational growth.

The models are multi-sectorial linear models in which the productive sectors are expressed as linear functions of demand. Therefore, the total production of any sector could be expressed as the total transaction with the other sectors and the transactions carried out through final demand. This gives the following matrix equation:

$$X = AX + D \quad (1)$$

D being an order matrix $n \times 1$ (n is the number of productive sectors) that contains the final demand, X an order matrix $n \times 1$ comprised of the total output of the sectors and A an order matrix $n \times n$ comprised of the average propensity of the productive sectors to spend.

Resolving the equation:

$$X = (I - A)^{-1}D \quad (2)$$

where $(I - A)^{-1}$ is the Leontief matrix, in which each c_{ij} element shows the change in the output of sector i if sector j receives an additional monetary unit from the final demand. The resulting vector X is the matrix that indicates the degree at which an exogenous injection into the system affects the total revenue of the sectors.

The expression $(I-A)^{-1}$ includes all the impact on production when a change in final demand takes place. An increase in final demand in a sector will produce an increase in its production to cover the new level of demand which, in turn, will result in such sectors increasing its purchases from the other sectors and so on.

To obtain both the direct and indirect economic effects on the Spanish economy of the economic measures necessary to change the fishing model, the above expression is used and any variation in the revenue of the sectors (due to a change in final demand) is shown in a variation of the production vector, as described in the following equation:

$$\Delta X = (I-A)^{-1}\Delta D \tag{3}$$

Direct impact is considered as the impact on the areas of activity that directly receive the changes in final demand (which, in this case, we will quantify as the necessary investment to implement each of the eight areas of action comprising the proposed model) and indirect impact as the changes experimented by the other areas of activity that do not change their final demand (investment).

The input-output analysis also enables an estimate of the effects on employment of the changes in final demand, by constructing a diagonal matrix E that contains the employment generated in each sector per unit of its output,

$$Y_E = E(I-A)^{-1}D \rightarrow \Delta Y_E = E(I-A)^{-1}\Delta D \tag{4}$$

where ΔY_E shows the increase or decrease in employment due to a change in final demand.

The studies analyzing impact using an IOT traditionally express economic impact as GDP or GVA and the impact on employment. These results are normally presented per sector of activity. However, this study advances in the characterization of the employment generated by the investment in the proposed model. Based on the information available, taken from the Workforce Survey (National Institute of Statistics) and the Employment History Extract (Ministry of Labor and Social Security), on how the different areas of activity distribute employment according to the level of studies, gender, age ranges, and place of residence of the worker (urban or rural), the employment created or destroyed is broken down into each area of the characteristics identified. To do so, the following employment distribution matrices were constructed:

Two matrices, $EDU_{21\times4}$ and $AGE_{21\times4}$, to distribute the variation in employment in each of the 21 areas of activity into four areas of education (compulsory primary and secondary education, professional training, pre-university studies, and other medium qualifications, and university studies) and into four age ranges (over 25, from 26 to 45, from 46 to 55, and over 55).

Two matrices, $SEX_{21\times2}$ and $RU\_UR_{21\times2}$, to distribute the variation in employment in each of the 21 areas of activity between men and women and urban and rural employment.

By pre-multiplying the matrices by an $\Delta E_{21\times21}$ matrix, that contains the vector of the variation in the diagonalized employment, we obtain the breakdown of employment created or destroyed, in each of the 21 areas of activity, according to the four criteria considered:

$\Delta E{\cdot}EDU$ shows the distribution of employment into four areas of education,
$\Delta E{\cdot}AGE$ shows the distribution of employment into four age ranges,
$\Delta E{\cdot}SEX$ shows the distribution of employment into men and women,
$\Delta E{\cdot}RU\_UR$ shows the distribution of employment into urban and rural.

As mentioned above, in addition to economic impact and, as an innovation in this sector, we analyzed the environmental impact by calculating the direct and indirect impact of atmospheric emissions in each of the sectors analyzed. The CO_2 emissions data are taken from the Environmental Accounts of the National Statistics Institute, in particular, of the Air Emission Accounts by the branch of activity. For calculating the emissions associated with each subsector, traditional fishing and large-scale fishing, we took each subsector consumption on the sector, "Manufacture of coke, refined petroleum products, and nuclear fuel", assuming that the fishing sector emissions are mainly due to fuel consumption. This impact was obtained by pre-multiplying the Leontief inverse matrix by a the diagonalized vector of unitary coefficients of atmospheric emissions, *EM*, which shows the atmospheric emissions in a sector per unit of its output:

$$Y_{EM} = EM(I - A)^{-1}D \rightarrow \Delta Y_{EM} = EM(I - A)^{-1}\Delta D \quad (5)$$

This enables the calculation of the direct and indirect changes in atmospheric emissions ΔY_{EM} in each area of activity of the sustainable fisheries model proposed.

4. Main Results of the Implementation of a Sustainable Fisheries Model

The calculation of the economic impact of the different strategic areas of action proposed is based on the identification of a set of activities within each action and an estimate of the related budget needs over a defined period of time. We then determine the direct impact of the activity on the production fabric, the sectors affected by the investment in each activity identified, and the direct and indirect impact on production and employment using the IO methodology, as described above, in addition to the environmental impact.

The results of the overall impact of the sustainable fisheries model proposed are shown in Table 3. The economic impact throughout the period of ten years is specified as an increase in total production of approximately 4000 million euros, the net creation of more than 60,100 jobs, and a reduction in greenhouse gas emissions equivalent to 412,297 tons of CO_2.

Table 3. Principal figures representing the economic and environmental impact of the transition to a sustainable fisheries model.

	Production		Employment		CO_2 Emissions	
	Millions of Euros	**%**	**Jobs**	**%**	**Tons**	**%**
Support for traditional fishing	1364	0.06	24,137	0.12	66,061	0.03
Prohibition of trawling	−1179	−0.05	−9038	−0.04	−738,082	−0.28
Extension of the marine reserve network	1260	0.05	11,666	0.06	75,800	0.03
The advance of deep-sea fishing towards sustainability	78	0.003	544	0.003	3419	0.001
Prohibition of new aquaculture operations	0	0	0	0	0	0
Demand measures	21	0.001	143	0.001	892	0.0003
Compliance with biological optimums	53	0.002	384	0.002	2367	0.001
Control of marine coastline contamination	2368	0.10	32,325	0.16	172,196	0.07
Total	**3965**	**0.16**	**60,162**	**0.30**	**−418,457**	**−0.16**

Source: own data.

The area with the greatest economic impact is the control of contamination. The activities requiring investment in this area have an impact on the total production of approximately 2400 million euros and the creation of 32,300 new jobs in the 10-years period contemplated in the simulation. However, this is also in line with a negative result in terms of emissions, as it would produce an increase of more than 172,000 tons of CO_2. On the other hand, the prohibition of trawling would involve a decrease of almost 740,000 tons of CO_2.

The support for traditional fishing and the extension of the marine reserves are two other areas of action that also have highly positive effects in terms of total production (1364 and 1260 million euros, respectively) and employment (24,137 and 11,666 jobs, respectively).

The prohibition of trawling would imply a loss of 1179 million euros and approximately 9000 jobs, both in fishing as well as other related sectors during the decade studied.

4.1. Sectorial Impact of a Sustainable Fisheries Model

The overall results appearing above are shown in detail per sector of activity in Table 4. Traditional fishing—with an increase in sectorial production of 574 million euros and 20,478 new jobs—would be the sector most benefited by the transition towards a sustainable fisheries model. On the other hand, the prohibition of trawling has a negative impact on the large-scale fishing sector, due to its importance in large-scale Spanish fishing. Thus, the impact on large-scale fishing, according to the estimates carried out, is calculated as a loss of some 795 million euros in sectorial production and close to 7000 jobs. However, the reduction in industrial fishing will give rise to a decrease in greenhouse gases of 672,510 tons of CO_2.

Table 4. Sectorial impact of the sustainable fisheries model.

	Production (Millions of Euros)	Employment	CO_2 Emissions (Tn)
Agriculture, livestock, and forestry	11.7	203	2209
Traditional fishing	573.9	20,476	18,445
Large-scale fishing	−795.5	−6881	−672,510
Extraction	15.0	23	693
Fuel and gas	10.8	7	9019
Production and distribution of electrical energy	64.4	104	123,747
Collection, treatment, and distribution of water	6.5	41	402
Food products	23.8	102	1213
Textiles, leather, and wooden products	42.1	243	4480
Chemical industry	82.1	214	9945
Construction materials	15.0	86	18,349
Metal industry and manufacture of metal products	58.2	263	8028
Machinery	126.5	433	1043
Manufacture of motor vehicles, trailers, and other transport material	80.1	198	1336
Other manufactured goods	95.5	582	754
Construction	134.0	1020	2243
Trade, restaurant, and catering	164.0	2408	3494
Transport and communications	128.9	884	28,926
Other services	1092.3	7418	2595
Services aimed at promoting sales	333.9	3173	3887
Services not aimed at promoting sales	1702.1	29,160	13,245
Total	**3965.5**	**60,162**	**−418,457**

Source: own data.

Other than the fishing industry, the most affected sectors by the action proposed to move towards a sustainable fisheries model are the Services not aimed at promoting sales, which are basically public services—with an increase in production of approximately 1702 million euros and the creation of 29,160 jobs during the decade (Table 5), and the Other services sector (financial, corporate services to other companies, cultural, and leisure, etc.)—in which production would increase by 1092 million euros, and 7418 new jobs would be created. Services aimed at promoting sales and the tourism sector (trade, restaurants, and catering) are other sectors that would benefit significantly from the sustainable fisheries model, especially in terms of employment. SSF Guidelines shows than in many places, there is a high dependence between artisanal fisheries and other sectors like tourism, agriculture, industry, etc. [7]. In fact, "if fisheries have a long-term future, it will be as local activities, embedded in a blue economy, the complement of a green economy on land" [12].

With regard to environmental impact, considered as CO_2 emissions, the most significant variations are the heavy decreases in emissions resulting from reduced large-scale fishing and the increases from the energy, transport, and communications sectors (123,747 and 28,926 tons, respectively, over the decade subject to this study).

Table 5. Characterization of employment created with a sustainable fisheries model.

	All Sectors of The Economy		Fishing Sector	
	N of Workers	**%**	**N of Workers**	**%**
According to gender				
Men	31,724	52.7	8802	64.7
Women	28,438	47.3	4795	35.3
According to level of studies				
Compulsory primary and secondary education	24,305	40.4	12,886	94.8
Professional training	8670	14.4	331	2.4
University studies and medium qualifications	7415	12.3	419	3.1
University studies	19,772	32.9	−39	−0.3
According to age range				
Under 25	4714	7.8	1191	8.8
From 26 to 45	33,356	55.4	7037	51.8
From 46 to 55	14,130	23.5	2498	18.4
Over 55	7962	13.2	2871	21.1
According to place of residence				
Urban	29,191	48.5	1982	14.6
Rural	30,971	51.5	11,615	85.4
TOTAL	**60,162**	**100**	**13,597**	**100**

Source: own data.

4.2. Characterization of the Employment Created

The combined effect of support for traditional fishing, the prohibition of trawling, the extension of the marine reserves network, compliance with biological optimums, and the other activities proposed would clearly have a positive effect on the recovery of fish stock and the profitability of fishery activities, with the relevant increase in direct employment in the sector. Employment could reach 28.4% at the end of the period, which would mean the net creation of 13,597 jobs in the sector. In the fishing industry, just as important as the number of jobs is the type of jobs created or destroyed, given that it is the characteristics of employment where the contribution of fishing to social sustainability lies, especially in rural areas.

The results obtained indicate that the adoption of a sustainable fisheries model would also have highly positive effects in terms of social sustainability (Table 5):

- It would enable the net creation of some 12,886 jobs in the sector for workers with compulsory primary or secondary levels of education (18,395 in traditional fishing and −5508 in large-scale fishing).
- The number of young people under the age of 25 employed in the sector is 1,191 and for people between 26 and 45, over 7000, which would result in more young people working in the fishing industry and traditional fishing communities in rural areas.
- It is calculated that the number of women employed in the sector would increase by 4795, also with a highly positive effect on the demographic growth of rural areas that depend upon traditional fishing.
- Finally, the proposed fishing model would generate approximately 11,615 new jobs in the fishing industry for people that live in rural areas.

These results are in line with the considerations of the SSF Guidelines on the social development, employment, and decent work [7]. Considering the employment created in the overall economy and not only in the fishing industry, it can also be said that the transition towards a sustainable fisheries model would enable the creation of employment (Table 5):

- With a gender balance, given that it is estimated that 47.3% of the new jobs would be held by women.
- Highly polarized per level of studies, given that 40.4% would be held by workers with compulsory primary and secondary education and 32.9% by workers with university studies.
- Mainly focused on the intermediate age range, from 26 to 45 years of age (55.4% of the new jobs would be held by people in this age range).
- Balanced with regard to the place of residence of the workers, as it is calculated that 51.5% (almost 31,000) would reside in a rural area, whereas urban workers would represent 48.5%.

5. Discussion and Conclusions

The results obtained constitute an essential tool for decision-making, as they enable us to answer questions such as what would be the cost in terms of employment of gradually eliminating trawling? What type of employment would be created by supporting traditional fishing? How many jobs would be held by women and young people? How many would be held by people living in rural areas? What would be the extent of the CO_2 emissions linked to the construction of the necessary infrastructure to improve the quality of coastal waters?

The use of an input-output model has allowed estimating the economic, social, and environmental impact from Spanish fisheries. Based on the simulation, it has been shown the economic impact in terms of production and employment and environmental impact in terms of CO2 emissions throughout the period of ten years. Reducing the environmental impact by minimizing CO_2 emissions should be added as an aim [5]. The results reveal that comparatively more job opportunities would be created because of leisure and tourism to young people, women, and people with medium and high qualifications. This contribution gives a clear guideline for sustainable fishery management and for the development the country's economic status.

The combined action would make the Spanish fishing industry 100% sustainable and also increase economic production by 4000 million euros, as well as creating more than 60,100 jobs and also enabling better preservation of our seas and coastlines and greater reserves.

According to the technical estimate made in this project, the necessary budget to carry out the transition towards a sustainable fisheries model is 2725 million euros over the entire decade. The annual effort in advancing towards a sustainable fisheries model (around 135 million euros per annum) is practically the same as the amount allocated in the latest Operating Program to action 1, "Measures for the adaptation of the Community fishing fleet" (133 million euros per annum), which has basically been used to reduce the number of vessels, mainly in the traditional fishing sector.

The net creation of employment, especially in the traditional fishing sector, would enable a gradual incorporation throughout the decade of a substantial number of women into the job market (around 4800), as well as young people (around 1200) and workers in the intermediate age range (around 7000), increasing the diversity of employment in the sector and establishing these groups of workers in the area. In fact, it is expected that the majority of new jobs created in the sector will be held by people that live in rural environments (11,615). These new jobs´ characteristics are complying with the recommendations of SSF Guidelines [7]. In addition, some of the measures contemplated, such as the plan to promote fishing tourism or the training and leisure activities linked to marine reserves, will allow a significant diversification of local economies, especially in rural fishing areas. The diversification of the local production fabric will improve levels of competitiveness and the creation of jobs in areas other than fishing (around 19,400) and for people with medium and high qualifications. It will substantially strengthen demographic growth in coastal areas linked to fishing.

Therefore, it can be expected that the transition towards a sustainable fisheries model will improve the situation of vulnerability that currently exists in fishing communities, by contributing more employment to the fishing sector, more employment to other activities related to leisure and tourism services and more employment opportunities for young people, women, and people with medium and high qualifications.

The results of the impact analysis carried out show that the investment and expense required to move towards a sustainable fisheries model, as well as the new training, leisure, and tourism activities, will also have highly positive effects on the entire economy, not only in the area of fishing. Outside the fishing industry, this impact during the decade of reference is specifically calculated as an increase in sectorial production of around 4187 million euros, with the creation of more than 46,500 jobs. These results could be in population ecology and focus on the dynamics of organizational populations in terms of changes in the composition of employment, resources, and other aspects of organizational behavior [37].

The sector that would receive the majority of the benefits would be the public sector, as it would be required to make substantial investments and take charge of new functions relating to the different areas of action and, particularly, the control of coastline contamination and extension of the marine reserves network.

Other sectors that will benefit are the Other services sector, which includes consulting, technical assistance, and research services; the Services aimed at promoting sales (education, health, sewerage, management of natural environments in other activities performed by the private sector), as well as services relating to tourism (Trade, restaurants and catering).

The results of this impact analysis are clearly positive for both the fishing industry as a whole, as well as other areas of economic activity. They show that the proposed action would have a very limited cost and that in only one decade would be able to reverse a large part of the negative effects of the current fisheries model; retain people in rural coastal areas; benefit groups of people with difficulties in obtaining employment, such as young people and women; and open up new business opportunities, such as fishing tourism. Accordingly, the core objective of sustainability assessment of our proposal model would confirm delivering net gains with a positive contribution to global sustainability [22].

The primary limitation of these static models is their starting point, the reference year of the input-output table, which could invalidate them for predictions, in case of significant changes in technical-economic relations included in the table. However, given that the input-output tables are the result of solid statistical progress carried out by the different institutions to build such updated tables, we carry out medium-term analysis (<10 years), thus we can consider the assumption of structural permanence as valid. Recently, the integration of nonlinear dynamic modeling with an IO analysis has been suggested [38], especially if the interest of research is related to the longer-term (>10 years). These techniques would be interesting to extend this paper in the future.

Author Contributions: Conceptualization, R.S.-S.; methodology and software, A.C.; validation, A.C. and R.S.-S.; writing—original draft preparation, writing—review and editing, A.C. and R.S.-S.

Funding: This research received no external funding and the APC was funded by Rey Juan Carlos University.

Acknowledgments: A.C. is grateful for support from project ECO2016-75204-P (AEI/FEDER, UE). Authors are grateful to Abay Analistas Económicos and Greenpeace Spain for allowing us partial use of its results. Authors are deeply grateful for useful comments and suggestions from editor and referees.

Conflicts of Interest: The authors declare no conflict of interest.

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