Using input–output methods to assess the effects of fishing and aquaculture on a regional economy: The case of Galicia, Spain

Mª Dolores Garza-Gil

Juan C. Surís-Regueiro

Manuel M. Varela-Lafuente

Department of Applied Economics, ERENEA-ECOBAS, University of Vigo

Corresponding author: M. Dolores Garza-Gil

Phone: 34-986-812515 Fax: 34-986-812401

e-mail: dgarza@uvigo.es

Address: Faculty of Economic and Business Sciences

Campus de Lagoas-Marcosende s/n

36310 Vigo, Galicia, Spain

Abstract

This paper uses an input–output model to quantify the socioeconomic impact of fishing and aquaculture on Galicia, one of Spain's most important maritime regions. Results indicate that the carryover effects of these production activities are important for Galicia's economy because they contribute not only to job creation but also to possibilities for obtaining income in other economic sectors. These sectors' combined production in 2013 was almost a million euros, and that production was estimated to account for nearly 2% of the regional economy's value added and for more than 17,000 full-time jobs. Together these contributions amounted to some €1.7 billion in production and €975 million in value added to other Galician economic activities. At the same time, fishing and aquaculture were responsible for creating the equivalent of more than 14,000 full-time jobs in other economic activities.

Keywords: fishing, aquaculture, input–output model, socioeconomic effects

1. Introduction

As primary activities, aquaculture and fishing are more typical of developing than developed economies; hence those activities are of little economic relevance in countries with higher income levels driven by industrial and/or urban economies [1]. Even so, fishing and aquaculture are affected by a significant share of the European community's governmental actions, among which are instituting measures to support these activities [2-7]. Within the jurisdiction of the Common Fishing Policy (CFP), such "structural" fishing aid is relevant [8-12] because it is widely acknowledged that this aid helps preserve the socioeconomic relevance of communities that depend on fishing and aquaculture yet for which there exist few other sectors offering realistic opportunities for an alternative economic activity [13-15].

When assessing the effects of institutional measures from a socioeconomic point of view, it is common practice to use methodologies based on input–output analyses or so-called social accounting matrices [16-18]. These tools have been applied to analyse the economic impact of the fish stock or of the marine environment more generally, to evaluate the economic effects of fishery policy measures, and to analyse economic outcomes at the regional or local level [19-36].

No matter how urbanized Galicia becomes it depends on fisheries and is one of the most important maritime regions in Spain [1]. The Galician fisheries sector has experienced significant changes over recent decades in response to developments in the world economy: the quantities fished have increased considerably, so resource sustainability is an issue of growing concern; there have been shifts in the relative importance of particular countries in the worldwide fishing sector, which reflect the increasing participation of developing countries; notable advances have been made in fishing techniques, detection systems, and vessel characteristics; changes in international laws have affected fishing activity; the field of aquaculture has seen increased knowledge about genetics, nutrition, and pathology along with improved stock monitoring; and both seafood consumption and the international trade in these products have undergone major changes [37]. Together these trends have affected Galician fishing and aquaculture activities as well as the region's economy as a whole.

The aim of this study is to assess—using a methodology based on input–output analysis—the economic and social effects (in employment and production terms) of fishing and aquaculture in Galicia. To do so, Section 2 presents the input–output approach adopted for quantifying the socioeconomic impacts; Section 3 describes fishing and aquaculture activities; the results are shown in section 4 and, finally, Section 5 summarizes the study's main findings and implications.

2. Methodology: Input–output approach applied to fisheries activities

Socioeconomic effects of the fishing and aquaculture activities just described are not limited to their own contribution to Galicia's economy. In addition, these economic agents can carry out their activities only by spending on goods and services from other economic sectors. Part of the labour income generated by fishing and aquaculture is, in turn, spent on satisfying the everyday consumption needs of households. These connections and ramifications result in increased output, income, and employment in other sectors. These effects can be estimated through to the input-output multipliers from the classic model of demand (multipliers derived from the supply model based on the contribution of Gosh [38] could also be used, but the validity and interpretation of the results of these analyses is still very questionable; [39-41]). This type of analysis undertakes a counterfactual exercise—in other words, it aims to evaluate socioeconomic outcomes in the *absence* of fishing and aquaculture activities due to the null domestic final demand or because this demand is attends with goods imported from other economies.

Three classes of effects are relevant in this context; the first includes direct effects, and the second consists of indirect effects, and the third includes induced effects [35, 42-43]. The direct includes the impact of the activities themselves (level of output, contribution to GDP and employment). Indirect refers to outcomes in the sectors that provide inputs for fishing and aquaculture and to the subsequent, related outcomes for their respective supplier sectors. In contrast, by induced effects we refer to the effect of income on household expenditures and on gross capital formation.

The basic structure of a symmetric input–output table (SIOT) can be represented algebraically, so we can derive the respective supply and demand models. Suppose that, in a given economy, we can distinguish n homogenous branches of activity. Then the total value of the domestic output of activity i (x_i) can be devoted either to the intermediate consumption of that economy's other activity (z_{ij}) or to satisfying final demand (f_i):

$$\mathrm{x_i} = \mathrm{z_{i1}} + \mathrm{z_{i2}} + \cdots + \mathrm{z_{ij}} + \cdots + \mathrm{z_{in}} + \mathrm{f_i} \quad ; \quad 1 \leq \mathrm{i}, \mathrm{j} \leq \mathrm{n} \qquad (1)$$

Generalizing over the n activities and using matrix algebra (see [35]), expression (1) can be written as $(\mathbf{I} - \mathbf{A})\ \mathbf{x} = \mathbf{f}$; here **f** is the matrix column for final demand, **x** is the matrix column of total outputs, **I** is a diagonal unit matrix with n-rows and n-columns, and **A** is the matrix that reflects the technical coefficients ($a_{ij} = z_{ij}/X_j$). Based on that, we get the following expression:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\ \mathbf{f} = \mathbf{L}\,\mathbf{f} \qquad (2)$$

Expression two is known as Leontief demand model and where the matrix **L** is the inverse Leontief matrix [44]. This inverse matrix consists of the so-called total requirements (l_{ij}), which represent the total value of the input from sector i that is needed (directly and indirectly) to produce a unit from sector j destined for satisfying final demand. By adding the elements in column j of the inverse Leontief matrix, we can see how much production is necessary from all an economy's sectors in order to serve a unit increase in the final demand of products (goods or services) generated by sector j. We refer to this sum of elements as the simple output multiplier (MO_j):

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \tag{3}$$

This term reflects the direct and indirect effect of variation in the final demand of a sector (here, fishing and aquaculture) on the economic system's overall output.

In order to estimate the induced effects, this basic model is often extending with household final consumption expenditure made endogenous; this aggregate generates capacity that is used as input of the productive sectors [45]. In this model input-output closed with respect to households, an expanded matrix of technical coefficients($\bar{\mathbf{A}}$) and an extended Leontief inverse matrix ($\bar{\mathbf{L}}$) will be generated, both with n+1 rows and n+1 columns. The elements of $\bar{\mathbf{L}}$ ($\bar{l}_{ij}$) incorporate the impacts total (direct, indirect and induced). The sum of the n-first elements of each columns of $\bar{\mathbf{L}}$ will represent the effects total multipliers of the output on each one of the productive n-sectors, and referred to truncated total output multipliers ($\bar{m}[o(t)]_j$)

$$\bar{m}\,[o(t)]_j = \sum_{i=1}^{n} \bar{l}_{ij} \tag{4}$$

We can similarly estimate the simple and truncated added value or income multipliers, $m(r)_j$ y $\bar{m}[r(t)]_j$. The simple multiplier accounts for the direct and indirect effects on income due to variation in the final demand of sector j, and the total truncated multiplier accounts for the total effects:

$$m(r)_j = \sum_{i=1}^{n} v_{c\,i}\, l_{ij} \tag{5}$$

$$\bar{m}\,[r(t)]_j = \sum_{i=1}^{n} v_{c\,i}\, \bar{l}_{ij} \tag{6}$$

where $v_{c\,i}$ represents the capacity to generate value added (v_i) per unit of product from sector i ($v_{ci} = v_i/x_i$).

Likewise, the inverse Leontief matrix can be used in order to obtain the employment requirements by activity to estimate the employment multipliers, $m(e)_j$ and $\overline{m}[e(t)]_j$. This multipliers reflect the direct and indirect effects and total effects, respectively, on employment stemming from increases in the final demand of sector j:

$$m(e)_j = \sum_{i=1}^{n} e_{c\,i}\, l_{ij} \tag{7}$$

$$\overline{m}\,[e(t)]_j = \sum_{i=1}^{n} e_{c\,i}\, \overline{l_{ij}} \tag{8}$$

Here e_{ci} is the employment technical coefficient, which represents the number of sector-i employees (e_i) needed to generate a unit of output in that sector i ($e_{ci} = e/x_i$). The sum of all the employment requirements then indicates the total employment generated in the economy due to production increases in sector j.

Because the technical coefficients of an economy to which the input-output models apply are presumably stable in the medium term, algebraic approach lends itself well to simple estimation exercises.

3. Fishing and aquaculture activities in Galicia

Galicia is a region located in the Northwest of the Iberian Peninsula and just above Portugal. It is flanked to the north by the Bay of Biscay and to the west by the Atlantic Ocean, which jointly account for more than a 1,490 km of coastline. The Galician economy is steeped in a long-standing fishing tradition, which began with the exploitation of nearby coastal waters but spread to fishing grounds further afield throughout the 20th century. As a result, Galicia developed thriving aquaculture and fishing sectors. The sea—and the productive activity its resources enable—is a hallmark of Galicia's economic identity, and it figures largely in scenarios whereby the region develops *international* economic and trade relations. Fishing is Galicia's forte and best-known activity, around which has developed a complex yet mostly regional-based network of processing, marketing, and R&D activity.

Different types of activities linked to marine aquaculture and fishing can be found along the Galician coastline. In spite of the evident synergies among fishing/aquaculture activities and fish processing/trade, this study is limited to the only sectors for which we can obtain disaggregated statistical data—namely, the marine fishery and aquaculture sectors. Their primary activity (extraction and farming) is closely linked to the maritime coastline and so should be the determining factor in evaluations of any area's dependence on fishing. Galicia's regional government distinguishes among three groups of fishing activities: aquaculture, shellfishing "on foot", and fishing.

Marine aquaculture and shellfishing at sea rely on (respectively) land-based coastal facilities and marine zones classified as inland waters (or *rías*) and three segments may be distinguished for this activity: rafts, aquaculture farms, and fish farms. The rafts are floating structures, placed in the middle of inland waters, and are used to produce mussels and oysters. They need auxiliary vessels with special equipment to carry out this operation, and their business structure is midway between a family enterprise and an industrialized company. Aquaculture farms are public land concessions—at intertidal, shallow areas in the rías—that are used to farm bivalve molluscs (mainly clams). Most of these farms are operated by artisanal companies with a family business model. Finally, the fish farm (and nursery) segment consists of enterprises that feature a high level of industrial development and whose onshore facilities engage mainly in the breeding and fattening of turbot, sole, and bream.

The second main group of fishing activity is shellfishing on foot. Such extraction, performed mainly by women, is an artisanal and traditional activity that seldom requires the use of a vessel. This type of marine aquaculture comprises two segments: goose barnacle harvesting; and shellfishing for bivalve molluscs (clams and cockles). These activities lie halfway between harvesting and extensive aquaculture. Such fishing usually takes place on rocky coasts (for the goose barnacle) or on the sandbanks of intertidal zones (for bivalve shellfish). Production methods are crude, and most of the employment is part-time.

Within the third activity group, fishing proper, four segments may be distinguished: small-scale, coastal fleet, offshore fleet, and long-distance fleet. The *small-scale* segment consists mostly of family-owned companies, and its fleet's vessels—none of which exceed 12 meters in length—are of the smallest size. The average length is 6 meters, and each boat has (on average) two crewmen; the longer boats can have as many as six crew members. These vessels are able to catch a mixture of species and change their fishing gear in accordance with the season. Small-scale fishers operate on inland waters and seek high-value species (mainly crustaceans, molluscs, octopus, and ground fish). The *coastal fleet* segment includes larger and more complex firms than the artisanal ones, although some family ownership is typically involved. These vessels have an average length of about 20 meters, usually operate in the fishing grounds off the Galician coastline, and have an average crew size of eight—although that number depends on the type of fishing gear used (i.e., hooks, trawl nets, purse seine gear, or gill nets). The main target stocks are hake, sardine, horse mackerel, mackerel, Norway lobster, and blue whiting. Catch is sold fresh through the numerous first-sale facilities located along the Galician coastline. Industrial-size companies make up the *offshore fleet* segment, which engages in trawling and long-line fishing. These vessels average 33 meters in length, have an average crew of ten, and operate over wider areas. Their main fishing grounds are in European Union (EU) waters, but they usually land their catches at Galicia's port facilities. Finally, the largest and most industrialized fishing companies are included in the *long-distance fleet* segment. The average vessel length in this fleet is 35 meters for long-line fishing boats, 60 meters for freezer trawlers, and 90 meters for freezer seiners. The average number of crewmen ranges from 9 for long-liner fishers to 16 for freezer trawlers and seiners. This fleet usually operates far from shore, both in international and third-country (non-EU) waters. Most of its catch is processed and frozen on board and then landed in different countries. Often these products are later transported (in refrigerated containers) by merchant vessels that land them in Galicia—mainly at the port of Vigo.

[INSERT Table 1 about Here]

Table 1 shows the evolution of socioeconomic data for these three fishing activity groups in 2005, 2010, and 2013 (the last year for which data are available). As shown, the value of production is decreasing for all of these activities but that the drop is greater for aquaculture (4%) than for fishing (about 2%). These declines are due mainly to reduced mussel and cockle production (stemming from ecological problems) and to lower catch quotas for the main target species of the respective fleet segments—reductions that nonetheless did *not* lead to increased prices [48].

[INSERT Table 2 about Here]

With regard to employment, Table 1 shows that it decreases significantly (4%) in fishing because of the declining fleet size over the period (see also Table 2); marine aquaculture suffers a slight (2%) reduction in employment—despite the increased concentration of fish farming companies—because of the lower number of mussel rafts and decreasing number of licences for shellfishing [48] With regard to the fishing fleet, in Galicia the number of ships drops by about 2.5% from 2005 to 2013. This decrease is observed across all four fleet segments, both in Galicia and in Spain as a whole (although fleet data are available only since 2010), but it is especially significant in the coastal fleet (a decrease of some 4%); the small-scale and long-distance segments exhibit a less severe decline. Table 2 reveals that, in fact, these latter two segments become more prominent among the total Spanish fleet: the Galician small-scale fleet accounts for 57% (up from 55%) of the total while the long-distance segment increases its share to 57% (up from 52%).

4. Estimating socioeconomic effects

Given the last SIOT for Galicia's economy, which was published by the Galician Institute of Statistics [46] based on 2011 data (a specific IOT for fishing and canning industry have just been published also by the regional government with data for 2011, however it is not yet freely available), we can estimate the effect of fishing and aquaculture activities on the production, gross value added (GVA), and employment in the entire Galician domestic economy for 2013. One must bear in mind that the estimation of these effects is restricted to the economy of Galicia and does not account for the obvious repercussions that such activity has on the rest of the Spanish economy (or abroad). In short, we will estimate the effects on fishing and aquaculture on the domestic economy of Galicia.

[INSERT Table 3 about Here]

Yet because for year 2013 we know only the productive "structure" (production, intermediate consumption, and GVA) of fishing and aquaculture, it is necessary first to estimate the final demand for both sectors during that year. For that purpose we assume that the final demand in 2013 affects production, at basic prices, much as it did in 2011 (the last year for which we have data). Table 3 reports the main economic aggregates for fishing and aquaculture during the three years evaluated. (Both the on-foot gathering of shellfish and the rest of marine aquaculture are included in the latter sector because the IGE provides that information jointly.) The table reveals that, in the case of fishing, 60% of this production becomes GVA, although this share declines slightly throughout the period. Most of the GVA from *fishing* is destined for gross operating surplus and mixed income, which also shows a negative trend; less than half goes to employee salaries, although they increase in 2013. Most of the production value from *aquaculture* comes from intermediate consumption (the main branches provider of inputs are highlighted below), which trends upward from 2005 to 2013. This GVA represents less than half of the aquaculture production, and it is devoted mainly to paying salaries. The contribution of both sectors to the creation of GVA in Galicia's economy decreased slightly during this period, declining to 1.2% in 2013 from 1.5% in 2005; the drop was slightly greater in the case of fishing. Hence there is also a downward trend observed for final demand during the period evaluated.

[INSERT Table 4 about Here]

The current input–output matrix of Galicia's economy considers 71 branches of activity. Table 4 shows the ten main ones that, in 2011, provided inputs for the fishing sector and the aquaculture sector. As shown in the table, 80% (resp. 62%) of intermediate consumption by the fishing (resp. aquaculture) sector is due to those ten main activities. Noteworthy factors with respect to fishing include fuel consumption, storage and services in the proximity of transportation hubs, and service related to the installation and repair of machinery and equipment. For aquaculture, the leading inputs are production and energy distribution services, animal feed, coking, and oil refinement.

[INSERT Table 5 about Here]

The domestic inverse Leontief matrix of the IGE's symmetric input–output table generates the simple multipliers for output, GVA, and employment, as reported in Table 5, for fishing and aquaculture. The total for all activities that exhibit an interrelation with fishing and aquaculture are included in the estimations (i.e., not only for the ten main ones listed in Table 4). Table 5 shows that the output and employment simple multipliers are higher for aquaculture than fishing but that the simple GVA multiplier is higher for fishing. The implication is that, in the Galician economy, aquaculture (resp., fishing) shows a greater degree of interrelation sectoral demanding intermediate inputs from of the rest of the branches of activity and, then, has a relatively greater carryover effect on production and employment. On other hand, fishing shows greater capacity relative of generate value added by unit of output and then greater carryover effect on the creation of GVA in Galicia.

If, in addition to above direct and indirect effects, the induced effects are also considered (truncated multipliers), fishing shows a greater total impact on output and value added and almost equals to the aquaculture in the impact total on the employment. By each additional unit of demand for fishing products, Galician production and value added would increase by 2.7 and 1.6 units, respectively. For a unit increase in final demand for aquaculture, these figures would be 2.6 and 1.3 units, respectively. Respect to employment and for both activities taken together, each additional millions of € of final demand could generate almost 32 FTE jobs in Galician economy.

Applying expressions (3)–(8), the total impacts on Galician economy can be estimated (results are shown in Table 6). These values have been obtained assuming that the intermediate demand of fishery and aquaculture products would have similar carryover effect that their products destined to the final demand. In addition, this type of analysis assumes that those intermediate outputs of fishing and aquaculture can be perfectly substituted by imports from other economies. I.e., not there will be impacts derived of downstream linkages of both sectors with the rest of branches of activity in the Galician economy.

[INSERT Table 6 about Here]

The socioeconomic impact of fishing and aquaculture on Galicia's economy is clearly significant. In this counterfactual analysis, the total impacts would represent a decrease of some €2.7 billion and € 1.5 billion on output and GVA, respectively, of Galician economy, and over 31,000 FTE jobs. In particular, the joint activity of both sectors in 2013 (€985 million) generates an estimated carryover (indirect and induced) effect of some €1.7 billion and €975 million on (respectively) the production and GVA in Galicia's economy. The effect is greater in the case of fishing because of its greater volume of economic activity as compared with aquaculture: fishing account for about 85% of the indirect and induced effects of both activities on the production and value added of Galicia's economy. With regard to generating employment, fishing is involved in the creation of slightly more than 12,000 full-time jobs in other sectors' productive activities while aquaculture contributed to the creation of approximately 1,800 jobs.

5. Conclusion

Although fishing and aquaculture are associated more with developing than developed countries, there exist maritime regions in some European economies (including Spain's) that are strongly dependent on both activities. The socioeconomic importance of fishing and aquaculture is not limited to within-sector income and employment. It is therefore necessary to consider also the economic transactions of both activities that occur with other productive sectors —that is, the carryover effect of this economic activity on the rest of the economy. The aim of this paper has been to quantify the importance that fishing and aquaculture have on Galicia's economy by way of an input–output model that carefully accounts for these inter-sectoral transactions.

The results obtained from the application of the input-output model show that the socioeconomic impact of fishing and aquaculture is significant in Galicia's economy. In 2013, these sectors' combined production was nearly a million euros and accounted for almost 2% of the regional economy's GVA. The total impact on Galician output would represent a decrease of almost €2.7 billion, of which by 37% is linked to the discontinuation of production activity in fishing and aquaculture, while the remaining 63% is accounted for by impacts caused in the rest of branches. The repercussion on the generation of GVA is estimated to be about €1.5 billion, of which 64% would be linked to the impacts on the Galician remaining economic activities. Likewise, these contributions amounted to an estimated 31,000 jobs in Galicia's economy, and fishing and aquaculture were responsible for creating the equivalent of nearly 14,000 full-time jobs in other economic sectors that supply inputs to these activities—or to their own respective suppliers.

Finally, it must remain cognizant that these simple models assume sectoral activities to be homogeneous even though the technological structure in which agents are embedded is known to vary both within and across activities. Another limitation of our approach is that linear Leontief production functions do not accommodate the inter-sectoral substitution of intermediate inputs (e.g., replacing one raw material with another) or of primary inputs (e.g., substituting labour for capital); neither do these functions allow for increasing or decreasing returns or for the existence of externalities. That being said, the absence (in our context) of abrupt technological changes and of widely varying coefficients means that such input–output models can serve as useful instruments for policy makers seeking to quantify the socioeconomic importance of fishing and aquaculture or to analyse the repercussions—on a region's economy—of enacted (or proposed) marine policy measures.

Acknowledgments

The authors acknowledge financial support from FEDER and Xunta de Galicia (GRC2014/022 and AGRUP2015/08) and from the Ministry of Economy and Competitiveness (ECO2014-52412-R and ECO2013-44436-R).

References

[1] Surís-Regueiro J.C.; Garza-Gil MD; Varela-Lafuente M. Marine economy: A proposal for its definition in the European Union. Marine Policy 2013; 42: 111-124.

[2] Gray T, Hatchard J. The 2002 reform of the Common Fisheries Policy's system of governance- rhetoric or reality? Marine Policy 2003; 27: 545-554.

[3] Daw T, Gray T. Fisheries science and sustainability in international policy: a study of failure in the European Union's Common Fisheries Policy. Marine Policy 2005; 29: 189-197.

[4] van Hoof L, van Tatenhove J. EU marine policy on the move: The tension between fisheries and maritime policy. Marine Policy 2009; 33: 726-732.

[5] Hadjimichael M, Edwards-Jones G, Kaiser MJ. Distribution of the burden of fisheries regulations in Europe: The north/south divide. Marine Policy 2010; 34: 795-802.

[6] Khalilian S, Froese R, Proelss A, Requate T. Designed for failure: A critique of the Common Fisheries Policy of the European Union. Marine Policy 2010; 27: 1178-1182.

[7] Da Rocha JM, Cerviño S, Villasante S. The Common Fisheries Policy: An enforcement problem. Marine Policy 2012; 36: 1309-1314.

[8] Hatcher A. Subsidies for European fishing fleets: the European Community's structural policy for fisheries 1971-1999. Marine Policy 2000; 24: 129-140.

[9] Surís-Regueiro JC, Varela Lafuente MM, Iglesias-Malvido C. Effectiveness of the structural fisheries policy in the European Union. Marine Policy 2003; 27: 535-544.

[10] González Laxe F. Dysfunctions in common fishing regulations. Marine Policy 2010; 34: 182-188.

[11] Markus T. Towards sustainable fisheries subsidies: Entering a new round of reform under the Common Fisheries Policy. Marine Policy 2010; 34: 1117-1124.

[12] Surís-Regueiro JC, Varela Lafuente MM, Garza-Gil MD. Evolution and perspectives of the Fisheries Structural Policy in the European Union. Ocean & Coastal Management 2011; 54: 593-600.

[13] Symes D. Fisheries dependent regions: scoping the problem. In: Symes D. editor. Fisheries dependent regions. Oxford: Blackwell Science; 2000. p. 3-14.

[14] Brookfield K, Gray T, Hatchard J. The concept of fisheries-dependent communities. A comparative analysis of four UK case studies: Shetland, Peterhead, North Shields and Lowestoft. Fisheries Research 2005; 72: 55-69.

[15] Ross N. Exploring concepts of fisheries 'dependency' and 'community' in Scotland. Marine Policy 2013; 37: 55-61.

[16] Berck P, Hoffmann S. Assessing the employment impacts of environmental and natural resource policy. Environmental and Resource Economics 2002; 22: 133-156.

[17] Pérez-Pérez L., Barreiro-Hurlé J. Assessing the socio-economic impacts of drought in the Ebro River Basin. Spanish Journal of Agricultural Research 2009; 7(2): 269-280.

[18] Jacobsen K.I, Lester S.E, Halpern B.S. A global synthesis of the economic multiplier effects of marine sectors. Marine Policy 2014; 44: 273-278.

[19] Leung P, Pooley S. Regional economic impacts of reductions in fisheries production: A supply-driven approach. Marine Resource Economics 2001; 16(4): 251-262.

[20] Jin D, Hoagland P, Dalton TM. Linking economic and ecological models for a marine ecosystem. Ecological Economics 2003; 46: 367-385.

[21] Hoagland P, Jin D, Thunberg E, Steinback S. Economic activity associated with the northeast shelf large marine ecosystem: Application of an input-output approach. In Sustaining large marine ecosystems: The human dimension. Amsterdam; Elsevier 2005: 159-181.

[22] Bhat MG, Bhatta R. Regional economic impacts of limited entry fishery management: an application of dynamic input-output model. Environment and Development Economics 2006; 11: 709-728.

[23] Goktolga ZG, Karkacier O. Structural analysis of animal husbandry and fishery in Turkey: an input-output analysis. Journal of Applied Sciences 2006; 6(6): 1317-1321.

[24] Fernández-Macho J, Gallastegui C, González P. Economic impacts of TAC regulation: A supply-driven SAM approach. Fisheries Research 2008; 90: 225-234.

[25] Kobayashi S, Saito K, Tanji H, Huang W, Tada M. Economic structure of Cambodia and strategies for pro-poor growth: Results from a computable

general equilibrium analysis. Studies in Regional Sciences 2008; 38(1): 137-154.

[26] Steinback SR, Allen RB, Thunberg E. The benefits of rationalization: The case of the American lobster fishery. Marine Resource Economics 2008; 23: 37-63.

[27] Roy N, Arnason R, Schrank WE. The identification of economic base industries, with an application to the Newfoundland fishing industry. Land Economics 2009; 85(4): 675-691.

[28] Seung CK, Waters EC. Measuring the economic linkage os Alaska fisheries: A supply-driven social accounting matrix (SDSAM) approach. Fisheries Research 2009; 97: 17-23.

[29] Carvalho N, Rege S, Fortuna M, Isidro E, Edward-Jones G. Estimating the impacts of eliminating fisheries subsidies on the small island economy of the Azores. Ecological Economics 2011; 70: 1822-1830.

[30] Norman-López A, Pascoe S. Net economic effects of achieving maximum economic yield in fisheries. Marine Policy 2011; 35: 489-495.

[31] Kaplan IC, Leonard J. From krill to convenience stores: Forecasting the economic and ecological effects of fisheries management on the US West Coast. Marine Policy 2012; 36: 947-954.

[32] Seung CK, Waters EC. Calculating impacts of exogenous output changes: application of a social accounting matrix (SAM) model to Alaska fisheries. The Annals of Regional Science 2012: 1-21.

[33] Morrissey K, O'Donoghue C. The role of the marine sector in the Irish national economy: An input-output analysis. Marine Policy 2013; 37: 230-238.

[34] Patrick WS, Benaka LR. Estimating the economic impacts of bycatch in U.S. comercial fisheries. Marine Policy 2013; 38: 470-475.

[35] Surís-Regueiro JC, Garza-Gil MD, Varela-Lafuente MM. Socio-economic quantification of fishing in a European urban area: the case of Vigo. Marine Policy 2014; 43:347–58.

[36] García de la Fuente L, Fernández-Vázquez E, Ramos-Carvajal C. A methodology for analyzing the impact of the artisanal fishing fleets on regional economies: An application for the case of Asturias (Spain). Marine Policy 2016; 74: 165-176.

[37] Caballero-Miguez G.; Garza-Gil MD; Varela-Lafuente M. Institutions and management of fishing resources: The governance of the Galician model. Ocean & Coastal Management 2008; 1: 625-631.

[38] Ghosh A. Input-output approach to an allocation system. Economica 1958; 25: 58-64.

[39] Oosterhaven J. On the plausibility of the supply-driven input-output model. Journal of Regional Science 1988; 28, 203–217. doi:10.1111/j.1467-9787.1988.tb01208.x

[40] Oosterhaven J. The supply-driven input-output model: a new interpretation but still implausible. Journal of Regional Science 1989; 29, 459–465. doi:10.1111/j.1467-9787.1989.tb01391.x

[41] Oosterhaven J. Adding supply-driven consumption makes the ghosh model even more implausible. Economic Systems Research 2012; 24, 101-111. doi:10.1080/09535314.2011.635137

[42] Cardenete M.A., Sancho F. Evaluación de multiplicadores contables en el marco de una matriz de contabilidad social regional. Investigaciones Regionales 2003; 2: 121-139.

[43] Schuschny A.R. Tópicos sobre el Modelo de Insumo-Producto: teoría y aplicaciones. Serie de Estudios Estadísticos y prospectivos 37. Naciones Unidas. Santiago de Chile: CEPAL; 2005.

[44] Leontief W. The Structure of the American Economy: 1919-1929. New York. Oxford University Press. 1941.

[45] Miller E.D. and Blair P.D. Input-Output Analysis. Foundations and Extensions. 2nd Edition. Cambridge University Press, 2009.

[46] IGE. Marco Input-Output de Galicia 2011. Instituto Gallego de Estatística 2015. www.ige.eu

[47] MAGRAMA. Estadísticas pesqueras. 2015. www.magrama.gob.es

[48] Xunta de Galicia. Anuario de pesca y acuicultura. 2015. www.pescadegalicia.com

[49] APROMAR. La acuicultura en España. 2014. www.apromar.es

Table 1. Main socioeconomic data from Galician fishing and marine aquaculture, 2005–2013

	2005	2010	2013
Fleet (number of vessels)	5,382	5,106	4,739
Production value at basic prices (10^3 €$_{2013}$)	1,172,413	1,149,896	984,445
Fishing	970,945	970,455	835,343
Aquaculture			
Shellfishing on foot	20,709	16,512	13,887
Other aquaculture	180,760	162,928	135,215
Employment (FTE)	24,816	21,086	20,427
Fishing [a]	19,598	15,210	14,492
Aquaculture			
Shellfishing on foot [b]	509	482	474
Other aquaculture	2,798	2,494	2,452

[a] This figure includes land-based fishing-related employment.
[b] This estimate is based on the number of shellfishers and the number of work hours reported by the Galician Association of Guilds.
Note: FTE = full-time equivalent.
Source: Authors' compilation from [46-48].

Table 2. Evolution of Galician and Spanish fleet, 2010–2015 (number of vessels)

	Length of vessel				
	< 12 m	**12–23 m**	**24–39 m**	**> 40 m**	**Total**
2010					
Galician fleet	4,290	321	427	68	5,106
Spanish fleet	7,855	1,259	1,603	130	10,847
2013					
Galician fleet	4,001	284	390	64	4,739
Spanish fleet	7,160	1,168	1,425	118	9,871
2015					
Galician fleet	3,897	260	345	60	4,562
Spanish fleet	6,888	1,113	1,303	105	9,409

Source: Authors' compilation from [47].

Table 3. Economic aggregates for fishing and marine aquaculture in Galicia, 2005–2013 (10^3 €$_{2013}$)

	Galician gross value added					
	2005 51,667,968		**2010** [a] 55,634,515		**2013** [b] 49,678,159	
	Fishing	**Aquaculture**	**Fishing**	**Aquaculture**	**Fishing**	**Aquaculture**
Production at basic prices	970,945	201,469	970,455	179,440	835,343	149,102
Intermediate consumption	393,994	90,630	393,346	101,438	355,152	81,357
Gross value added (GVA)	576,951	110,839	577,109	78,002	480,191	67,745
Employee remuneration	250,075	60,337	233,497	53,668	238,094	43,143
GOS / mixed income	351,547	51,501	382,088	25,280	272,958	25,357
Other net taxes on production	–24,671	–999	–38,476	–946	–30,861	–755
Final demand [c]	358,254	99,109	358,073	88,272	308,220	73,348

[a] Marine aquaculture is estimated based on the productive structure for total aquaculture in Galicia from the Galician National Account (continental aquaculture accounts for only 3% of Galician total aquaculture; figure estimated from [49]).
[b] Provisional data for 2013.
[c] This figure is estimated based on a similar percentage of production at basic prices for 2011.
Note: GOS = gross operating surplus.
Source: Authors' compilation from www.ige.eu.

Table 4. Main branches of economic activity for the providers of inputs to fishing and marine aquaculture in Galicia, 2011

Fishing			Aquaculture		
Code	**Branch of activity**	**%**	**Code**	**Branch of activity**	**%**
R19	Oil and fossil fuels	30.4	R35A	Services of production, transport, and distribution of energy	10.2
R52	Storage and services annexed to transport	11.2	R10D	Products for animal feed	9.1
R33	Services of installation and repair of machinery/equipment	11.0	R19	Coke and refined petroleum products	7.1
R03A	Extractive fishing	7.3	R33	Services of installation and repair of machinery/equipment	6.9
R46	Retail trade	5.8	R03A	Extractive fishing	6.5
R49B	Land transport	4.6	R46	Retail trade	6.3
R65	Insurance	4.1	R49B	Land transport	6.2
R32	Manufactured products	1.9	R77B	Rental of machinery and equipment	3.5
R69-70	Legal and accounting services	1.9	R35B	Services of production, transport, and distribution of gas, steam, and air conditioning	3.3
R77B	Rental of machinery and equipment	1.9	R69-70	Legal and accounting services	3.2
	Other	19.9		Other	37.7
	TOTAL	100.0		TOTAL	100.0

Source: Authors' compilation from [46].

Table 5. Total output, income (Value Added), and employment multipliers for fishing and aquaculture

	Fishing	**Aquaculture**
Simple Output multiplier (m(o))	1,48099214	1,652981219
Simple GVA multiplier (m(r))	0,92962355	0,7392047
Simple Employment multiplier (m(e))	0,01916720	0,02181496
Truncated Total Output multiplier ($\bar{m}$ [o(t)])	2,69614497	2,61922899
Truncated Total GVA multiplier ($\bar{m}$ [r(t)])	1,59689083	1,26979271
Truncated Total Employment multiplier ($\bar{m}$ [e(t)])	0,03191062	0,03194809

Source: Authors' compilation from [46] for Simple multipliers. For Truncated Total multipliers own estimations.

Table 6. Socioeconomic impact of fishing and aquaculture on Galicia's economy

		Productive activity (direct effects)	**Indirect impacts**	**Induce impacts**	**Total impact**
Fishing	Production	835343	401793	1015069	2252206
	Gross value added	480191	296364	557397	1333952
	Employment (FTE)	14492	1519	10645	26656
Aquaculture	Production	149102	97361	144069	390532
	Gross value added	67745	42472	79112	189329
	Employment (FTE)	2926	327	1511	4764
Fishing and aquaculture	Production	984445	499154	1159139	**2642738**
	Gross value added	547936	338835	636509	**1523280**
	Employment (FTE)	17418	1846	12156	**31420**

Notes: Reported values for production and gross value added are in thousands of 2013 euros.
FTE = full-time equivalent.