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Evaluating the economic performance of fishing systems using fuzzy multicriteria analysis in a Fishery Local Action Group in South Italy

Abstract

The EU programming cycle 2007–2013 marks the introduction of the concept of local development in fisheries policies. This new vision implies the need to develop sustainable development processes according to a place-based perspective. Knowledge, understood as a learning process, becomes the focal point of the territorial development process. The aim of this study is to bridge the cognitive gap at the local level about the socio-economic aspects of the fisheries' sector, affecting the fleets involved in the definition of the Local Development Plan of the "Stretto" Coast Fishery Local Action Group (FLAG) in South Italy. The work aims to assess the economic performance of the fisheries' vessels operating in the FLAG area to deepen the knowledge about the costs and revenues of fishing activity that are critical variables for fishermen's choices. To this end, we carried out a budgetary analysis, from which seven performance indicators were derived. Moreover, a multicriteria analysis, performed through the Fuzzy VIKOR technique, allowed us to elaborate a composite indicator. The decision to operate in the fuzzy environment arises from the need to better manage the vagueness and imprecision of the data collected during the interviews. The framework is useful to both acquire and interpret in a synthetic manner the salient aspects needed to identify ideas and suggestions for the planning of development strategies, whose effectiveness is closely linked to the real conditions of the territory. The results show that the best economic performance was shown by vessels that adopt the surrounding as the main fishing system. However, at the local level, there is a general lack of interest shown by young people in undertaking fishing activities and carrying on the family business.

Keywords: Fisheries Local Action Group, Bottom-up approach, Fishing system, Budgetary Analysis, Multicriteria Analysis, Fuzzy VIKOR.

1. Introduction

Fishing activity plays an ever greater role in providing a high degree of economic and social stability for coastal communities. This strong link between fishing and territory is also testified by the EU 2007–2013 programming period, which marks the start of an important process of revision of the Common Fisheries Policy, assuming the canonical features of the Leader approach of participation and bottom-up planning strategies for the development of the territory. Based on this experience, a specific priority axis has been inserted in the European Fisheries Fund (EFF) established by reg. EC 1198/2006 (EC, 2006). Through the application of the approach "area-based" (Budzich-Tabor, 2014), the IV Axis provides a wide range of actions to help fishing communities to plan and implement sustainable local development strategies in their fishing areas.

This change involves the abandonment of the consolidated top-down process to move towards development processes that involve multiple stakeholders (Linke and Bruckmeier, 2015) and implies a decentralized decision-making process. The same Article 45 of the EFF describes the need to promote local development through a process of stakeholders' consultation and participation in the bottom-up planning process, in order to better understand the real needs of local communities and implement development policies that meet the needs and characteristics of the territory.

As regards to the fisheries' sector, this change involves the introduction of new organizational and institutional procedures able to promote shared strategies and bottom-up local development. For this purpose, the Fisheries Local Action Groups (FLAGs) represent the instrument of territorial governance for the development of the fishing communities through the promotion of diversification activities, which involve a greater diversity of local actors from the public, private, and non-profit sectors. The FLAGs, as an expression of the partnership, are called to promote networking activities between public components and private and social groups present in the territory to define and implement their development process. The instrument available to FLAGs to enable the realization of this synergy is the local development plan (LDP), whose objective is to ensure sustainable development of the fisheries' sector in economic, environmental and social terms. This objective is achieved mainly by strengthening the competitiveness of the fishing areas (Measure 4.1), improving the quality of life, diversification (Measure 4.2) and management of coastal areas (Measure 4.3) (Marcianò and Romeo., 2016).

In this context, to promote sustainable development of fishing communities, it is necessary to carry out analyses that can provide useful basic knowledge to define development strategies from a perspective of path-dependence, and which take into account both the inertia and the dynamics of the sector in relation to actual capabilities (Signorello, 2004). The bottom-up approach policies push strongly toward this direction and, therefore, the need grows for an information framework whose input data are as close as possible to the real local conditions and not, as sometimes happens, data deriving from larger scales that derive from realities derived from much larger or analyses conducted in completely different contexts. However, there is a particular shortage, in terms of local fisheries, of technical and economic information about the activities of fishermen. This creates serious shortcomings in the estimates used in the planning of the fishing activities on a small scale.

In this sense, the present work aims to evaluate the economic performance of the vessels operating in port areas falling within the area identified by the LDP "Stretto" Coast Flag in Calabria, South Italy. A previous study has been conducted in the same area, with the classic budgetary analysis approach (Romeo et al., 2016). The traditional economic analysis using single-valued estimates is subject to a greater error in estimating data (Lee et al., 2003). The crisp value may prove inadequate to model certain aspects of real conditions (Chen, 2000) that are important for decision making processes. To mitigate the distortive effects of these estimates the economic data could be designated as fuzzy numbers, successfully employed in engineering economics (Kahraman, 2008). In literature there are few applications of fuzzy logic in the field of fisheries economics while many applications can be found in the evaluation of the ecological sustainability's performance of the marine environment.

In this study, the methodology is structured in three phases: in the first one, a statistical analysis of both the socio-demographic situation of the interviewees and the techno-structural characteristics of the vessels was conducted. The survey sample was then been segmented on the basis of the main fishing system. In the second step, enterprise budgetary analysis was carried out, and the values obtained allowed description of the costs and incomes for each group, with a distinction between variable cost and fixed cost. From this analysis, seven financial indicators were developed to evaluate the level of economic performance. Although these financial indicators could have been examined individually, it is difficult to formulate a global solution. Therefore, in the third phase, a multi-criteria analysis was applied to reduce the level of complexity and to aggregate scores of indicators in a single measurement (Spronk, 1981; Chesson et al., 1999; Wu et al., 2009) that reflects the economic performance of the main fishing gear types adopted in the area. The socio-demographic aspects were not incorporated because costs and revenues were considered to be key variables influencing the choices of fishermen's investments (Romeo et al., 2016).

To take account of the strong subjectivity and imprecise data representative of the real-life situations, multiple criteria analysis was developed in fuzzy environment (Glicoric et al., 2010; Amini, 2015) through triangular numbers.

This has enabled us to consider each indicator over the mean, maximum, and minimum values. The fuzzy model shows a very simple interpretability, and the fuzzy number helps in capturing and managing the vagueness and imprecision of the data (Appadoo et al., 2008). Therefore, in the third phase, we implemented the multicriteria technique *Fuzzy-Vlse Kriterijumska Optimizacija Kompromisno Resenje* known as FVIKOR (Opricovic, 2011). This method takes into account simultaneously conflicting indicators and has allowed us to build a composite performance index to define a ranking among the fishing gear types examined. The composite/synthetic index has received substantial attention in the last twenty years and, starting from 2014, has been used increasingly in the field of MCDM techniques (El Gibari et. al, 2019). The diffusion of these indices was favored by their easy interpretation and by the high communicative effectiveness, because they are able to combine multiple indicators into single score (Saisana and Tarantola, 2002). These elements make the synthetic index a useful tool for both political analysis and public communication. For the decision making they are much easier to interpret not being forced to identify a common trend among the individual indicators.

2. Area of study and data collection

The fish production structure of the "Stretto" Coast FLAG, displaced along a coastline of approximately 55 Km, falls within the province of Reggio Calabria and includes the coastal municipalities of Villa san Giovanni, Scilla, Bagnara Calabra, Palmi, Seminara, Gioia Tauro and San Ferdinando (Fig.1).
The fishing fleet, registered in the Archives of Fishing Licenses in March 2015, consists of 141 vessels, and has a fishing capacity, expressed in terms of Gross Tonnage (GT) and engine power (kW) of 1,794 GT and 12,691.38 Kw, respectively. In comparative terms, the numerical consistence of the FLAG fleet represents 58.02% of the vessels in the province of Reggio Calabria and 16.79% and 1.13%, respectively, of the vessels in the regional and national segments. As regards fishing capacity, the analyzed fleet has a weight of 71.90% in terms of tonnage and 73.47% in terms of engine power at the provincial level while the corresponding values at the regional level are 25.12% and 25.84%, respectively. However, analyzing the average capacity of the fleet FLAG it is found a ratio GT/Vessels, equal to 12.72, lower than the national average (13.16), but higher than the provincial (10.27) and regional (8.50) average. The average power of the fleet FLAG is equal to 91.92 kW, considerably higher than the corresponding values identified at the provincial (72.6), regional (59.72) and national (80.96) level.

Figure 1

The analytical report of the division of fleets by the number of types of authorised fishing gear in a license distinguishes vessels with either a monovalent or a polyvalent license. In the former case, the vessels are authorized to use only one fishing system, while those in the latter group can employ more systems related to different capture modes, whose use depends mostly on periods of the fishing season, seasonal conditions, and the demands of the market. Official data reveal that, in 2015, 91.94% of the vessels of the FLAG area had polyvalent licenses.

In June–September 2015, a techno-economic survey was conducted that interviewed, through a structured questionnaire, vessel owners and members of the crew face-to-face. The questionnaire was structured in two parts. The first part dealt with the interviewee's basic information (age, marital status, education level, the year and reason for the beginning of activity, legal form of enterprise, fishing category, authorized fishing gear types in license, the most adopted fishing system, and number of crew members). This part included the characteristics of the vessel (Gross Tonnage, Engine Power, auxiliary deck equipment, on-board electronic instrumentation, and gear used for fishing). The second part referred to the *income statement* related to the costs, earnings, and fishing days to quantify specific economic indicators. The analysis was determined for an ordinary fishing year to avoid considering distorted data from particular climatic or market contingencies. Respondents were asked to refer to daily catches, the uses of the factors, and the fishing operations of an ordinary year.

Fishermen interviewed were randomly identified, depending on their willingness to cooperate, and 34 questionnaires, representing 24.11% of total active vessels, were collected. As found in other studies (Brinson et al., 2006) fishermen operating in the area examined showed a low rate of participation in that they refused to cooperate because of lack of time on the one hand and, on the other hand, lack of will to reveal information about their operations. These difficulties were encountered specifically in two fleets: Scilla and Bagnara. Moreover, in our view, the lack of trust in cooperating with us was partly due to the fact that, for many fishermen, part of their revenues derived from fish species fished with fishing gear that was not authorized. Despite the prohibition of the use of the *spadara*, imposed by the EC from 1998, some fishermen continue to use it for swordfish fishing (Palladino et al., 2019a). Informally several fishermen stated that without fishing for tuna and swordfish they have enormous difficulties in covering their costs. The *spadara* has been replaced mainly by longline and harpoon and the fishermen complain that, due to their high operating costs, they have suffered a significant reduction in profit (Palladino et al., 2019a).

In other cases, however, they refused to participate in the survey because, from their point of view, it did not have any immediate economic return. Moreover, during the survey, we found the presence of vessels that are registered in the Community Fishing Fleet Register of the FLAG area but operate mainly in different port localities. The survey sample was subsequently segmented on the basis of the main fishing system adopted by vessels, considering the number of fishing days. The vessels were identified by the six main fishing gear types that characterize the area (Tab. 1).

Table 1

3. Methodology

3.1 Budgetary analysis

To describe the structure of the key costs as well as and the revenues and profits for the main fishing systems, the technique of partial budgeting has been implemented. The model is specified by the following equation:

$$\pi = TR - TC$$

where,

π = Profit

TR = Total revenues

TC = Total costs

Total Costs (TC) are the sum of total fixed cost (TFC) and total variable costs (TVC). The TFC includes *fixed costs* (FC) and *capital costs* (CC). The former contain administrative costs (AC)—e.g., cooperative membership fee, accounting for expenses, license renewal—and extraordinary maintenance of vessels (EM). The latter include the opportunity cost of investment capital (OCC), defined as the value of the best alternative of investment available (Brinson et al., 2009). The opportunity cost is estimated by multiplying the initial value of the purchase of the new vessel (α), fishing gear (β), and equipment (γ) by a factor that represents the interest rate (r):

$$OCC = \Sigma (\alpha, \beta, \gamma) * r$$

In this study the interest rate is calculated using the average of the short-term Italy's Treasury bills (BOTs) returns, over the 2012–2014 period, and is equal to 2.18%.

Capital costs include also the depreciation of vessel (D), which, due to the limited availability of data, was estimated using the linear formula on the basis of initial values for acquisition and the years of useful life (y) as estimated by respondents relative to the fixed assets: vessel (α), engine (ε), equipment (γ), and fishing gear (β).

$$D = \Sigma (\alpha, \beta, \gamma, \varepsilon)/y$$

Total Variable Costs include *running costs* (RC), *labor costs* (LC), and *taxes and charges* (T). Running costs include expenses for fuel, lubricant, bait, ice, gas refrigerator, meals and ordinary repairs. The labor cost corresponds to the wages of the members of the crew, net of contributions. In general, the contract provides a shared remuneration system proportional to revenues minus operational costs. However, the determination of the parties can vary according to the uses and local customs. In this area, the contract provides that the sum of running costs, taxes and charges and fixed costs is subtracted from the total revenues. The resulting value is divided into two equal parts: (a) vessel owners' share (owner profit) and (b) crew members' share (including the owner). Therefore, in all vessels, the owners earn more than 50% because they receive a further share as crew members.

The voice taxes and charges comprise the Italian Regional Production Tax (IRAP), estimated at 1.9% of total revenues, social charges relating to the employment of labor and expenses of the Chamber of Commerce. Finally, revenues (R) are generally determined by multiplying the amount of fish caught by its sales' prices. However, due to the strong fishermen's reluctance to disseminate information on the type of fish, and particularly the quantities, revenues were estimated indirectly by multiplying the average economic value of the catches declared by respondents by the number of fishing days. As reported in other studies (Withmarsh et al., 2002) it was necessary to revise the economic data with the local fishermen's leaders. Table 2 presents a summary of the costs and revenues calculated in this analysis.

Table 2

3.2 *Financial and economic performance indicators*

Cost data and the revenues obtained from the economic analysis were utilized to develop key indicators that were used to assess the current status of the level of profitability and management efficiency of fishing gear types adopted in the FLAG area. Seven indicators were used in this study: Gross Profit, Net Profit, RoFTA, Value Added, Efficiency Level, Operating Ratio, and Daily Running Cost.

Gross Profit (GP) is calculated as the total amount of revenues generated from the sale of the catch *minus* the sum of running costs, taxes and charges, labor costs, and fixed costs (STEFC, 2015). This indicator provides an indication of net income for the owners of the vessel. Positive values indicate that revenues exceed the financial investment made by the owner.

$$GP = R - \Sigma\,(RC + T + LC + FC)$$

Net profit (NP) provides a measure of the richness and efficiency of a producer in society's view, and it is equal to the total of revenues *minus* all expenses (STEFC, 2015) . Among the expenses they are included the capital costs, for which there was not a real monetary payment.

$$NP = R - \Sigma\,(RC + T + LC) - \Sigma\,(CC + FC)$$

These indicators can be considered as the equivalent of the financial profit and the economic profit, respectively, according to the definitions of Whitmarsh et al. (2000) and Brinson et al. (2009). Therefore, positive values of GP indicate that fishing activity is profitable for the owner. Positive values of NP demonstrate that the activity is efficient and is also profitable for the society.

RoFTA is an indicator used as a proxy of the ROI, and it allows measurement of the profits in relation to the capital invested by providing an indication of how the fishing activity can be profitable respect to its total assets (STEFC, 2015; Mannini and Sabatella, 2015).

$$RoFTA = (NP + OCC) / D * 100$$

According to Gasalla et al. (2010), the value of the capital investment is estimated through considering the value of the initial costs of purchasing the vessel, the equipment, and gear needed to carry out fishing activities.

Value added (VA) is defined as the amount of money that remains after accounting for all costs except for the labor cost. It expresses a measure of the contribution to the Gross Domestic Product produced by either an individual producer or a production sector (STEFC, 2015; Mannini and Sabatella, 2015) and is calculated as:

$$VA = R - (TVC - LC) - TFC$$

Efficiency Level (EL) is calculated as the ratio of net profit to total costs. It reflects the percentage of income that an activity generates as profit after all expenses, including capital expenses, have been accounted. In other words, this indicator considers the economic efficiency by quantifying the amount of profit for each euro spent in realizing the production process.

$$EL = NP/TC$$

Operating Ratio (OR) is the result of the ratio of total variable costs and revenues generated by the sale of fish. This indicator points out the share of revenues needed to cover all operating expenses incurred during the fishing season.

$$OR = TVC/R * 100$$

Daily Running Cost (DRC) is given by the ratio of operating costs necessary to carry out fishing activities to the number of fishing days. This indicator allows us to highlight the degree of efficiency in the management of production factors.

$$DRC = RC/FD$$

3.3 Fuzzy Multicriteria Analysis

The use of Multicriteria Analysis (MCA) has been growing significantly in the last decade. It offers decision-makers the advantage of being able to determine the best solution according to the criteria established, which may also have different effects. Since the criteria can be conflicting, the search for an optimal solution is not easy, so, within the MCA, the concept of a compromise solution plays a significant role (Ashtiani and Azgomi, 2014).

Several techniques have been developed to address complex decision problems. In this study, the analytical approach FVIKOR was used.

The FVIKOR method was developed to solve problems in an environment in which the criteria and/or weights may be fuzzy sets. FVIKOR is based on the aggregative function $L_{p\text{-}metric}$ representing the distance of an alternative with respect to the ideal solution (Opricovic, 2011; Ashtiani and Azgomi, 2014), allowing the construction of composite indices. The composite indicators are a mathematical combination that allows to simultaneously aggregate conflicting indicators and/or with different measurement units of one or more dimensions. FVIKOR introduces a ranking performance index built with conflicting indicators considering distances from the ideal point (Zeleny, 1982). The development of FVIKOR adopts the following $L_{p\text{-}metric}$:

$$L_{P,K} = \left\{ \sum_{J=1}^{n} \left[\widetilde{W}_J \quad (|\tilde{f}_J^* - \tilde{f}_{K,J}|) \quad / \quad (|\tilde{f}_J^* - \tilde{f}_J^{\circ}|) \right]^P \right\}^{1/P}$$

where:

k = 1, 2, …, q represent the alternative $A_1, A_2, \ldots, S_k, \ldots, S_q$;

j = 1, 2, …, n represent the criterion $C_1, C_2, \ldots, C_j, \ldots, C_n$;

$\tilde{f}_{k,j}$ represents the triplet fuzzy of the value performance of A_k with respect to C_j;

$\widetilde{W}_j$ is the weight of C_j;

$\widetilde{f_J^*}$ and $\widetilde{f_J^{\circ}}$, respectively, represent the fuzzy value best and worst of the ideal point for each criterion C_j.

P = represents the characteristic parameter of the family of distance functions and is between 1 and ∞

The FVIKOR algorithm is summarized as follows:

I. *Construction of the fuzzy decision matrix*

Quantitative values of performance indicators are briefly expressed in the decision matrix fuzzy $\widetilde{\boldsymbol{D}} = [\tilde{x}_{k,j}]_{q*n}$:

$$C_1 \quad C_2 \quad \ldots \quad C_n$$

$$\widetilde{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_q \end{matrix} \begin{bmatrix} \widetilde{x}_{11} & \widetilde{x}_{12} & \cdots & \widetilde{x}_{1n} \\ \widetilde{x}_{21} & \widetilde{x}_{22} & \ldots & \widetilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \widetilde{x}_{q1} & \widetilde{x}_{q2} & \cdots & \widetilde{x}_{qn} \end{bmatrix}$$

where, $\tilde{x}_{i,j}$ represents the triplet of original values assumed by the indicators of the K_{th} alternatives with respect to J_{th} criterion. The triangular fuzzy numbers (TFNs) are defined as $\tilde{x}_{k,j} = (l_{kj}, m_{kj}, r_{kj})$ and are given by the following equation:

$$l = min_j \ \{l_j\}_j \ ; \quad m = \frac{1}{j}\sum_{j=1}^{j} m_j \ ; \ r = max_j \ \{r_j\}_j$$

II. Determination better and worse fuzzy values

For all criterion functions j= 1,2,…, n, the values best $\widetilde{f_j^*} = (l_{kj}^*, m_{kj}^*, r_{kj}^*)$ and worst $\widetilde{f_j^\circ} = (l_{kj}^\circ, m_{kj}^\circ, r_{kj}^\circ)$ were determined using the following expressions:

$$\tilde{f}_j^* = \begin{Bmatrix} max_k & \tilde{x}_{kj} & se & j_{th} & \text{represents a benefit} \\ min_k & \tilde{x}_{kj} & se & j_{th} & \text{represent a cost} \end{Bmatrix}, K = 1,2,\ldots,q$$

$$\tilde{f}_j^\circ = \begin{Bmatrix} min_k & \tilde{x}_{kj} & se & j_{th} & \text{represent a benefit} \\ max_k & \tilde{x}_{kj} & se & j_{th} & \text{represent a cost} \end{Bmatrix}, K = 1,2,\ldots,q$$

III. Weight determination

The weights represent the relative importance of each criterion J_{th}, which were given equal importance in this study; therefore $\widetilde{W}_j = (1,1,1)$

IV. Normalization

The normalized fuzzy difference $\tilde{d}_{kj}$ k = 1,…, q, j= 1,…,n is determined as follows:

$$\tilde{d}_{kj} = (\tilde{f}_j^* \ominus \tilde{x}_{kj}) / (r_j^* - l_j^\circ) \quad \text{for benefit criterion}$$

$$\tilde{d}_{kj} = (\tilde{x}_{kj} \ominus \tilde{f}_j^*) / (r_j^\circ - l_j^*) \quad \text{for cost criterion}$$

V. Distance calculation

At this stage, $\tilde{S}_k = (S_k^l; S_k^m; S_k^r)$ *e* $\tilde{R}_k = (R_k^l; R_k^m; R_k^r)$ are determined. $\tilde{S}_k$, given by the sum of the attributes, represents the distance of the J_{th} criterion with respect to the ideal positive solution (p = 1). $\tilde{R}_k$ considers the maximum distance from the anti-ideal solution of each alternative, and it is equal to the maximum distance existing between attributes (p = ∞). For K= 1,2,…,q $\tilde{S}_k$ e $\tilde{R}_k$ are identified with the following relationships:

$$\tilde{S}_k = \sum_{j=1}^{n} (\widetilde{w}_j \otimes \tilde{d}_{kj})$$

$$\tilde{R}_k = MAX_j (\widetilde{w}_j \otimes \tilde{d}_{kj})$$

VI. Calculating the value $\tilde{Q}_k$

Values $\tilde{Q}_k = (Q_k^l \quad Q_k^m \quad Q_k^r)$ for k= 1,2,…,q are obtained using the following equation:

$$\tilde{Q}_k = v \frac{(\tilde{S}_k \ominus \tilde{S}^*)}{(S^{or} - S^{*l})} \oplus (1 - v) \frac{(\tilde{R}_k \ominus \tilde{R}^*)}{(R^{or} - R^{*l})}$$

where,

$$\tilde{S}^* = MIN \left[\tilde{S}_k \middle| k = 1,2, \dots, q \right] \qquad S^{or} = max \left[S_k^r | k = 1,2, \dots, q \right]$$

$$\tilde{R}^* = MIN \left[\tilde{R}_k \middle| k = 1,2, \dots, q \right] \qquad R^{or} = max \left[R_k^r | k = 1,2, \dots, q \right]$$

The coefficient of strategy v is determined by the relationship v = (n+1)/2n, since the criterion relating to R is included in S. This coefficient represents the weight of the maximum utility strategy, while the coefficient 1-v is the relative weight to the anti-ideal individual solution. The coefficient v always belongs to the interval [0, 1] (Opricovic, 2011).

VII. Defuzzification

Fuzzy values of $\tilde{S}_k$, $\tilde{R}_k$, and $\tilde{Q}_k$ are converted into crisp numbers through the "2nd weighted mean method " (Opricovic, 2011):

$$\text{Crisp}\left(\tilde{N}\right) = \frac{2m+l+r}{4}$$

The best alternative is the one with the lowest value of Q_k, because it represents the minimum distance to the ideal level.

4. Results and discussion

4.1. Socio-demographic and technical and structural characteristics

The synthesis of the socio-demographic characteristics of fishermen surveyed is shown in Table 3. From descriptive analysis, total male dominance for each fishing segment considered in the study area emerges. The results show that the employed are predominantly over 50 years old, the youth component is poorly represented so there is a limited generational replacement. In particular, the older fishing segments appear to employ trawl and gillnets and entangling nets. The table also reveals that most fishermen are married and fishing is the only source of income for 82.4% of the respondents, particularly those involved in surrounding and trawl segments.
The remaining sample's part is forced to integrate their income mainly through maritime activities. As regards the level of education, data indicate that 47.1% have junior high school level education, while none of the fishermen owns an academic degree. This highlights that the fisheries' sector shows little or no propensity for investment in human capital. The percentage of fishermen with a primary education level is also significant. This low rate of schooling is likely due, on the one hand, to the exhausting rhythms of this profession, which requires many hours of work at sea and on land, and, on the other hand, to the fishermen's strong belief that learning to be good fishermen necessitates gaining experience from the sea, rather than from books. Therefore, in the fishing sector, it is important that ancient knowledge is handed

down from generation to generation. However, the low level of education may act as a barrier to the introduction of new knowledge and innovations.

In relation to years of work experience, the study shows that 88.2% of respondents are concentrated in the upper range, to 20 years' experience, emphasizing the long tradition that this activity has on the territory examined. In fact, several fishermen fall into the range of 50 years' experience, especially those who inherited the activity and started to work with their parents at the age of 8–10 years. This phenomenon does not happen today, because young people show a lack of interest both in undertaking the activity of being a fisherman and in carrying on the family business, and, thus, there is little generational replacement.

The analysis show low levels of education among fishermen and a poor generational turnover; the structure of employment is rather old, linked to traditions and to the figure of a fisherman poorly dynamic and creative. These aspects significantly restrict the propensity towards the implementation of policies aimed at the innovation and diversification of the fisheries sector as well as the general improvement of the competitiveness of fishermen and the territory.

Finally, the analysis reveals that 61.8% of respondents are members of a cooperative. In most cases, the choice to belong to a cooperative is dictated mainly by economic advantages, since fishermen gain financial and fiscal advantages by such membership. Furthermore, they receive technical assistance in bureaucratic and administrative practices. In general, other potential positive aspects of cooperation are exploited either little or not at all by fishermen. In fact, fishermen, although members of cooperatives, tend to assume an atomistic behavior that prevents them from taking further advantage, such as being able to make economies of scale on the purchase of bait, the cost of which weighs heavily on the budget. Another aspect that emerges is the high prevalence of trawl segment operators who prefer the individual corporate form.

Table 3

The technical and structural characteristics of the vessels surveyed are presented in Table 4, and it is possible to highlight them as they vary considerably among the six segments of fishing analyzed. Fishing capacity, measured in terms of GT and engine power, is particularly high within the trawling segment, with vessels averaging 36 GT and 261.91 kW motor power. Trawling vessels make up 55.38% of the GT and 41.64% of the motor power. This follows longline and harpoon vessels, while the level is lower for vessels using gillnets and entangling nets.

The vessels with the highest average age are those using gillnets and entangling nets and harpoon while driftnets and longline are relatively young segments. This is a consequence of the conversion process that was implemented in the late 1990s following the UN and EU ban on the use of the '*spadara*' pelagic driftnet system, which is considered to be too unselective. In particular, the longline was employed as the main system for replace driftnets with a mesh size of 430 mm, historically used for fishing for swordfish. The number of days of activity of the gillnets and entangling nets segment, with a sample value of 1,989 days, represents 31.91% of the total fishing effort of the overall sample. However, when considering the average values, such superiority becomes less evident, and the highest number of days is recorded for the trawling segment, with an average of 216.7 days, against 198.90 days' activity by the gillnets and entangling nets segment. Much lower values are found for other fishing systems, in particular the harpoon system, which is practiced almost exclusively during the summer.
The overall sample has 93 employees, with an average value of 2.74 employees per vessel. Higher average numbers of crew members were recorded for the vessels that practice the surrounding system, with 5.33 employees; this was followed by trawl, with an average of 2.71 employees. Such data, however, appear to be a poor representation of the truth, because of a strong presence of undeclared work reported for some fishing systems.

Table 4

4.2. Analysis of the economic budget

The results of the analysis of the economic budget are provided in Table 5, which shows that revenues were significantly higher for the surrounding and trawl segments, traditionally identified as the most rewarding in terms of revenues, with estimated mean values of 243.367€ and 218.396€, respectively. This was far greater than the economic productivity of gillnets and entangling nets or artisanal fishing, whose annual revenues amounted to only one-seventh of those of surrounding.
As regards aspects related to the total production costs, these can be used as a proxy for assessing the efficiency of the production process (Signorello, 2004). The results show that artisanal fishing is the most efficient fishing segment, with total production costs of 31,203€, while longline is the most inefficient, with average total annual costs of 176,683 €. A high incidence is shown by the variable costs, in particular, the running costs, which amounted to an average of 85,600€, equal to 48.65% of the total cost. The cause of this considerable

expenditure is the purchase of fuel and bait. In artisanal fishing, however, running costs are irrelevant, due both to the lower incidence of operating costs and to the usual habit of performing the ordinary repairs to fishing gear and engines in an artisanal way. However, there is a high incidence of variable costs in all fishing segments, with a range comprised between 79% (harpoon) and 93.35% (surrounding). For both types of fishing systems, the most relevant voice is the one related to work, due to the size of the crew.

In relation to the fixed costs, it can be seen that their weights vary between 6.65% for the surrounding and 21% for the harpoon systems. The preponderance of the cost of depreciation is found for all fishing segments. In absolute terms, the highest values are observed for the vessels armed with longline and trawl. These vessels, being equipped with diesel engines of considerable power, are susceptible to wear due to the high annual number hours-engine. Also, in the longline system, the gear has an average useful life of one year, mainly due to accidental loss. Finally, from the same table, it is possible to observe that the administration costs are higher for the trawl segment, although, in relative terms, they account only for 1.98% of the total costs. This is mainly due to the fact that trawls' owners are usually individual enterprises and do not belong to cooperatives.

Table 5

4.3. FVIKOR analysis

The seven criteria are expressed with different measurement units, and the respective values are obtained from budgetary economic analysis (Tab. 6). Multicriteria analysis maximizes all criteria except OR and DRC, which are minimized. The results obtained from implementing the algorithm FVIKOR are shown in Table 7. The best economic performance was exhibited by vessels that adopt surrounding as their main fishing system. In fact, the findings highlight the excellent performance in terms of GP and NP. The former shows that the profit of fish entrepreneur varies between 80,859€ and 105,639€, while the net profit values range between 73.699€ and 95.307€, showing this segment to be the most competitive. Also the RoFTA, which represents the profitability of capital invested, shows the best values in this fishing system. It follows that the surrounding is very profitable and allows an efficient use of its asset capital. Excellent results are shown also in the value added (VA) expression of social economicity. Surrounding is a fishing gear able to create a significant richness that is distributed among all the subjects that took part in the productive activity. Values vary between a minimum of 156,915€ and a maximum of 202,711€.
Follows the trawl fishing system, with a performance index of 0.34. It is distinguished by the same indicators of the surrounding. The high economic performance recorded by the surrounding and trawl do not stimulate the fishermen to participate in policies promoting investments for possible income diversification activities, such as the integration of fishing and tourism. This is a particularly critical aspect for the trawl, which is responsible for damaging the marine ecosystem and sea rejection of many fish species.
In third and fourth place are the harpoon and driftnets. Vessels like the harpoon are suitable for the activity of pesca-tourism and practise a system of fishing highly selective and with little environmental impact and a null bycatch. This traditional vessel called "*passerella*" or "*feluca*" is used for fishing swordfish and represents an important element of uniqueness and social, cultural identity of this territory. The seasonality of the fishing and the low profitability are leading to the disposal of these vessels that, thanks to their particular structural characteristics, they enhance the coastal landscape (Palladino et al., 2019a).
In the area study, the activity of pesca-tourism takes an occasional value (Nicolosi et al., 2016) and fishermen believe that it is not profitable because they complain a low tourist flow (Romeo et al., 2016), due to the lack of adequate activities of promotion and marketing. Moreover, they show little inclination to diversification because tourist activities deviate from their traditional vision of fishing (Nicolosi et al., 2016). It follows that these

diversification policies and interventions are struggling to intercept and involve fishermen whose fishing gears are significantly profitable.

In penultimate position, with $Q_k = 0.56$, lies the longline, which, in addition to low profitability, also shows high daily running costs, with a DRC ranging between 208.15€ and 681.72€. Such a high incidence is due to the technical and productive characteristics of the vessels as high dimensions and long time spent in the sea due to longer days' bordates. The expense items that weigh heavily are fuel and bait. This is an important point of weakness as it erodes the income of fishermen and causes a state of financial suffering.

Finally, the system with lowest performance levels is the gillnets and entangling nets segment. It represents a segment with a strong artisanal character and with prevalent family labor. Low performance values are registered for the indicators of VA, EL, and OR. The latter present a range that varies between 59.77 % and 109.63%, highlighting very low operational efficiency and indicating the presence of vessels that cannot cover all the costs incurred during the production phase. In contrast, this segment registers the best performance in terms of the DRC, because it is a system that does not require the use of vessels with large engines and is generally practiced within six miles of the coast, making fuel consumption lower. In addition, there are no bait costs, except when bait is used for the pots. The number of crew members is much more limited and, in some cases, there are vessels with only one fisherman.

Future strategies should be aimed at protecting and enhancing the traditional fishing activities of coastal communities, helping to ensure the socio-economic sustainability of less profitable fishing systems. In particular, they should be designed to give greater support to artisanal and seasonal fishing (Harpoon). A possible diversification activity for artisanal fishing could be the activity of sea scavengers. The protection of the sea could be an element of great importance in order to stimulate profitable diversification actions. Other useful interventions for all fishermen could be those aimed at the innovation of the techniques, the generational change and the completion of the phases of the supply chain, with particular regard to the policies of valorization of the catch. Such interventions have been inserted in the new development plan of the Flag. Finally, greater effort should be done in communicating the opportunities of diversification offered by bottom-up policies such as the Flag to the communities of fishermen since there is evidence that such information do not circulate effectively among them although there is a general awareness of the necessity to reduce the fishing effort and diversify their activities (Palladino et al., 2016, 2019b).

Table 6

Table 7

5. Conclusions

With the process of change of fisheries' policies gradually adopting a more localized approach, there is a growing need of microeconomic analyses at the local level. Good local development planning must start from a good knowledge of the context to avoid the definition of development strategies that have limited impact on the fisheries' communities. Planning is the heart of effective implementation, but knowledge is the lung of good planning.

The study describes the economic structure and performance of the fishing fleet operating in the "Stretto" Coast FLAG area, bridging the gap of the limited availability of official statistical information, at the local scale, via direct surveys conducted among the fishery communities. In view of the potential inaccuracies and subjectivity of the estimates provided by the respondents, the proposed method has proved useful. In fact, the integration of the economic budget analysis with Fuzzy Multicriteria has contributed to improve the economic knowledge of various fishing gear types, in a different way from the classic deterministic and monocriterial approach.

The use of fuzzy triangular numbers has allowed us to widen the picture of real situations, thereby allowing a better grasp the actual conditions found in the territory. Moreover, they are much more practical in applications, since they show greater simplicity for calculations, are more intuitive and have a more efficient computational representation.

The use of the FVIKOR technique has allowed us to aggregate the seven indicators in a single composite index, facilitating the interpretation of the results, so that they can convey useful information to not only the fisheries' managers but also policymakers and the general public. The composite indicator made it possible to analyze the economic performance not limited to profitability alone but also considering simultaneously efficiency and capital profitability. This information can be particularly useful for those local governances involved in the identification of possible development strategies respecting the place-based approach. The fuzzy composite indicator can be used as a knowledge-based decision support tool because it is able to summarise the information in a logical and transparent way and to mitigate the distortive effects of individual data. The comparison of the performance between the different fishing gear types can also be particularly useful in tackling the policy issues in the field of fisheries' management. The information gathered in this study, together with the other studies conducted in the area, have been used for the definition of the development plan of the Flag for the period 2014-2020, currently in the implementation phase. A future line of study could be to deepen with the different stakeholders the weights of the criteria. This phase should be done also with the FLAG partnership, to highlight the different perspectives of the private and public decision makers.

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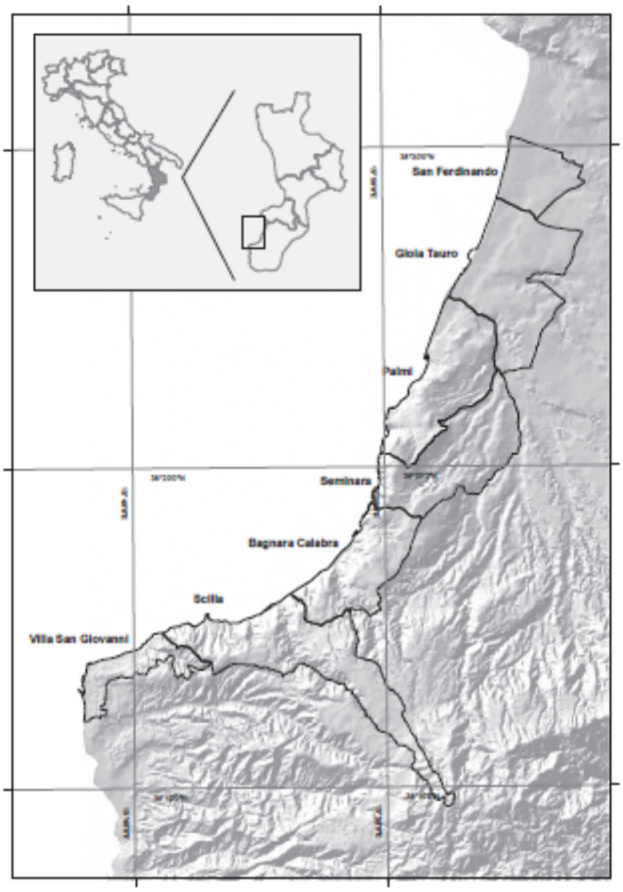

Figure 1 – The area of study

Table 1. Sample breakdown for main fishing system

Fishing System	Observations	
	N.	%
Harpoon	3	8,82
Gillnets and entangling	10	29,41
Surrounding	3	8,82
Drifnets	4	11,76
Longline	7	20,59
Trawl	7	20,59
Total Sample	**34**	**100**

Table 2. Headings of the economic budget

<table>
<tr><th></th><th>Typology</th><th>Sub-Typology</th><th>Description</th><th>Equation</th></tr>
<tr><td rowspan="5">Total Cost (TC)</td><td rowspan="2">Total Fixed Cost (TFC)</td><td>Capital Costs (CC)</td><td>Depreciation (D); Opportunity Cost of Capital (OCC)</td><td rowspan="2">CC+FC</td></tr>
<tr><td>Fixed Costs (FC)</td><td>Administrative Costs (AC); Extraordinary Maintenance (EM)</td></tr>
<tr><td rowspan="3">Total Variable Cost (TVC)</td><td>Running Costs (RC)</td><td>Ordinary Repairs (OR), Ice (I), Fuel (F), Bait (B), Gas refrigerator (G), Meals (M), Oil (O)</td><td rowspan="3">RC+LC+T</td></tr>
<tr><td>Labor Cost (LC)</td><td>Wages (W)</td></tr>
<tr><td>Taxes and charges (T)</td><td>Chamber of Commerce,IRAP, Social Charges</td></tr>
<tr><td rowspan="2">Total Revenues (TR)</td><td>Revenues</td><td>Revenues (R)</td><td>Fishing Days (FD), Average Value of the Fish (AVF)</td><td rowspan="2">R+S</td></tr>
<tr><td>Subsidies</td><td>Subsidies (S)</td><td>Fishing ban</td></tr>
</table>

Source: Cambiè 2012 (modified)

Table 3 . Socio-demographic characteristics of the sample

	Harpoon		Gillnets and entangling		Surrounding		Drifnets		Longline		Trawl		Fleet	
	a.v	%	a.v	%	a.v	%	a.v	%	a.v	%	a.v	%	a.v	%
Gender														
Male	3	8,82	10	29,41	3	8,82	4	11,76	7	20,59	7	20,59	**34**	**100**
Female	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**-**
Age														
20-29	1	25,00	1	25,00	-	-	-	-	2	50,00	-	-	**4**	**11,76**
30-39	-	-	-	-	1	50,00	1	50,00	-	-	-	-	**2**	**5,88**
40-49	1	11,11	3	33,33	-	-	1	11,11	3	33,33	1	11,11	**9**	**26,47**
≥ 50	1	5,26	6	31,58	2	10,53	2	10,53	2	10,53	6	31,58	**19**	**55,88**
Marital Status														
Single	1	16,67	3	50,00	-	-	-	-	2	33,33	-	-	**6**	**17,6**
Married	2	7,14	7	25,00	3	10,71	4	14,29	5	17,86	7	25,00	**28**	**82,4**
Divorced	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**0,0**
Widowed	-	-	-		-	-	-	-	-	-	-	-	**0**	**0,0**
Household Size														
1-3 members	1	14,29	4	57,14	-	-	-	-	2	28,57	-	-	**7**	**20,6**
4-6 members	2	7,41	6	22,22	3	11,11	4	14,81	5	18,52	7	25,93	**27**	**79,4**
7-9 members	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**0,0**
Education														
Primary education	-	-	2	40,00	1	20,00	1	20,00	-	-	1	20,00	**5**	**14,7**
High School	1	6,25	5	31,25	1	6,25	2	12,50	3	18,75	4	25,00	**16**	**47,1**
Junior High School	2	15,38	3	23,08	1	7,69	1	7,69	4	30,77	2	15,38	**13**	**38,2**
Accademic Degree	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**0,0**
Major Occupation														
Fisherman	1	3,57	8	28,57	3	10,71	3	10,71	6	21,43	7	25,00	**28**	**82,4**
Private practice	-	-	-	-	-	-	-	-	-	-	-	-	-	**0,0**
Public servant	-	-	-	-	-	-	-	-	-	-	-	-	**-**	**0,0**
Trader	-	-	-	-	-	-	-	-	-	-	-	-	**-**	**0,0**
Another	2	33,33	2	33,33	-	-	1	16,67	1	16,67	-	-	**6**	**17,6**
Years of experience														
1-5	-	-	-	-	-	-	-	-	-	-	-	-	-	**0,0**
6-10	-	-	-	-	1	100,00	-	-	-	-	-	-	**1**	**2,9**
11-15	1	33,33	1	33,33	-	-	-	-	1	33,33	-	-	**3**	**8,8**
16-20	-	-	-	-	-	-	-	-	-	-	-	-	**0**	**0,0**
≥ 20	2	6,67	9	30,00	2	6,67	4	13,33	6	20,00	7	23,33	**30**	**88,2**
Member of cooperative														

Yes	2	9,52	7	33,33	2	9,52	3	14,29	6	28,57	1	4,76	**21**	**61,8**
No	1	7,69	3	23,08	1	7,69	1	7,69	1	7,69	6	46,15	**13**	**38,2**

Table 4. Technical and structural characteristics of sampled vessels

Fishing System	Gross Tonnage			Motor Power			Fishing Days			Age of fleet	Crew members
	a.v	%	average	a.v	%	average	a.v	%	average	average	average
Harpoon	41,00	9,01	13,67	426,14	9,68	142,05	304,00	4,88	101,33	33,00	2,67
Gillnets and entangling	23,00	5,05	2,30	478,77	10,87	47,88	1.989,00	31,91	198,90	36,30	2,30
Surrounding	25,00	5,49	8,33	276,00	6,27	92,00	588,00	9,43	196,00	17,33	5,33
Drifnets	15,00	3,30	3,75	273,66	6,22	68,42	559,00	8,97	139,75	11,00	2,25
Longline	99,00	21,76	14,40	1.115,05	25,32	159,29	1.277,00	20,48	182,43	12,86	2,57
Trawl	252,00	55,38	36,00	1.833,38	41,64	261,91	1.517,00	24,33	216,71	19,71	2,71
Total Sample	**455,00**	**100,00**	**13,38**	**4.403,00**	**100,00**	**129,50**	**6.234,00**	**100,00**	**183,85**	**23,11**	**2,74**

Table 5. Costs and revenues of sampled vessels

Parameters	Harpoon			Gillnets and entangling			Surrounding			Drifnets			Longline			Trawl		
	average	S.D	%	average	S.D	%	average	S.D	%	average	S.D	%	average	S.D	%	average	S.D	%
Total Revenues	**91.850**	**21.091**	**100,00**	**33.182**	**12.389**	**100,00**	**243.367**	**31.380**	**100,00**	**53.885**	**18.393**	**100,00**	**194.392**	**64.237**	**100,00**	**218.396**	**40.615**	**100,00**
Total Variable Cost	**59.566**	**14.699**	**79,00**	**25.017**	**9.007**	**80,18**	**149.300**	**19.831**	**93,35**	**35.972**	**9.699**	**80,34**	**156.213**	**48.700**	**88,41**	**146.823**	**27.896**	**84,10**
Running costs	13.100	2.946	17,37	9.593	5.229	30,74	27.711	6.555	17,33	8.468	3.481	18,91	85.600	37.100	48,45	62.679	21.511	35,90
Labor cost	31.418	6.627	41,67	8.099	5.660	25,95	95.858	12.131	59,93	17.225	9.146	38,47	56.564	43.698	32,01	65.427	17.012	37,47
Taxes and charges	15.048	5.782	19,96	7.326	5.085	23,48	25.731	9.951	16,09	10.278	2.884	22,96	14.049	6.308	7,95	18.717	3.869	10,72
Total Fixed Cost	**15.832**	**2.508**	**21,00**	**6.186**	**5.189**	**19,82**	**10.637**	**1.701**	**6,65**	**8.802**	**4.508**	**19,66**	**20.470**	**8.115**	**11,59**	**27.768**	**16.655**	**15,90**
Depreciation	6.402	1.041	8,49	2.639	2.185	8,46	3.854	2.051	2,41	4.143	2.182	9,25	10.082	5.122	5,71	11.725	7.338	6,72
Capital Opportunity Cost	5.377	1.201	7,13	1.439	1.293	4,61	4.538	1.051	2,84	2.712	1.421	6,06	6.874	3.067	3,89	10.277	6.444	5,89
Administrative cost	2.407	436	3,19	1.055	612	3,38	1.256	578	0,79	1.244	613	2,78	2.132	939	1,21	3.462	2.342	1,98
Extraordinary Maintenance	1.647	605	2,18	1.054	2.271	3,38	990	668	0,62	703	389	1,57	1.381	442	0,78	2.304	1.245	1,32
Total Cost	**75.398**	**12.686**		**31.203**	**12.499**		**159.937**	**21.388**		**44.774**	**14.126**		**176.683**	**49.771**		**174.590**	**37.268**	

Table 6. Fuzzy values of economic performance indicators

Fishing system		Criteria						
		GP	NP	VA	RoFTA	EL	DRC	OR
		€	€	€	a.v	a.v	€	%
Harpoon	*l*	20.102	6.036	30.284,20	4,19	0,09	113,86	62,39
	m	28.231	16.452	47.869,72	9,45	0,21	128,53	64,74
	r	34.712	23.792	61.110,23	12,46	0,27	152,78	66,56
Gillnets and entangling	*l*	-2.351	-7.367,21	-6.594,05	-6,23	-0,40	6,34	59,77
	m	6.056,75	1.979,21	10.077,83	13,54	0,10	51,06	77,12
	r	13.816	9.097,79	24.588,36	56,67	0,51	96,27	109,63
Surrounding	*l*	80.859	73.699	156.914,95	31,25	0,49	116,49	60,01
	m	91.821	83.429	179.287,70	43,95	0,52	142,58	61,34
	r	105.639	95.307	202.710,80	53,79	0,56	159,82	62,48
Drifnets	*l*	15.967	2.703	7.380,05	6,04	0,11	38,86	59,22
	m	4.460	9.111	26.336,46	10,25	0,20	62,17	68,91
	r	25.245	18.259	44.776,25	17,65	0,38	86,52	80,75
Longline	*l*	-6.088	-11.813	35.787	-8,90	-0,11	208,15	67,75
	m	34.884	17.709	74.273	6,84	0,09	483,36	81,96
	r	59.286	40.834	192.982	14,28	0,19	681,72	104,24
Trawl	*l*	39.841	7.178,27	63.694,63	2,82	0,03	165,15	63,38
	m	61.169,14	39.166,81	104.594,07	13,48	0,23	283,62	68,73
	r	88.577	73.644,44	164.994,44	25,82	0,42	384,70	74,42

GP = Gross Profit; NP = Net Profit; VA= Value Added; RoFTA; EL = Efficiency Level; DRC = Daily Running Cost; OR = Operating Ratio.

Table 7. Fvikor Results

Alternative	$\tilde{S}$				$\tilde{R}$				$\tilde{Q}$			
	S^l	S^m	S^r	*Crisp S*	R^l	R^m	R^r	*Crisp R*	Q^l	Q^m	Q^r	*Crisp Q*
Harpoon	4,74	2,86	4,08	*3,63*	0,47	0,63	0,83	*0,64*	0,29	0,43	0,75	*0,48*
Gillnets and entangling	4,81	3,55	6,02	*4,48*	0,63	0,81	1,00	*0,81*	0,37	0,57	0,97	*0,62*
Surrounding	-0,93	0,14	1,40	*0,18*	0,04	0,14	0,39	*0,18*	-0,34	0,00	0,34	*0,00*
Drifnets	4,86	3,13	4,49	*3,90*	0,54	0,73	0,93	*0,73*	0,33	0,50	0,82	*0,54*
Longline	4,88	3,70	6,39	*4,66*	0,31	0,64	1,00	*0,65*	0,23	0,50	1,00	*0,56*
Trawl	2,49	2,30	4,31	*2,85*	0,12	0,46	0,82	*0,47*	-0,04	0,32	0,76	*0,34*