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COLLISION OF FISHING VESSELS: LORENZ CURVES AND GINI INDICES

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Abstract

Fishing vessel collisions are accidents which, in most cases, give rise to other accidents such as explosions, water on board and even sinking. These are accidents which often have fatal consequences for the crews and in many cases signify the loss of the vessel. Such losses can be avoided or reduced if the fishing vessels are equipped with the appropriate technological means and their crews proceed correctly and promptly. Thus, national governments should include in their regulation of the fishing sector control mechanisms that guarantee that the vessels are endowed with the adequate resources and with crews well-trained in safety. These resources and their distribution must be assigned in accordance with the needs of the fleet, which requires an in-depth knowledge of the degree of concentration of accidentality by collision of the fishing sector of a country.

In this context, the aim of this work is twofold: first, to formalise a methodology for the fishing sector of a country which allows the inequalities in the concentration of collisions to be analysed; and second, to apply this methodology to the Spanish fishing fleet for the period 1994-2002. Thus, indices are constructed by region and by fishing types for two variables: fishermen and fishing vessels. In these areas, results are then obtained both for the concentration of collisions and for their associated Lorenz curves. An increase in the inequalities in the spatial and functional distribution of these accidents is observed.

Key words: Fishing vessel collisions, Concentration of fishing vessel collisions, fishing vessel collision accidents.

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1. INTRODUCTION

Fishing vessel collisions are accidents which can be avoided or reduced if the fishing vessels are equipped with the appropriate technological means and their crews proceed correctly and promptly. The planning and regulation of a fishing fleet must incorporate control mechanisms that guarantee that the vessels are endowed with the adequate resources and with crews well-trained in safety. If they do not fulfil these conditions, the consequences may be fatal. Thus, the improvement in safety at sea has, for several decades, been one of the main concerns of various supranational institutions, national governments and non-government organisations. However, the statistics indicate that fishing, in comparison with other sectors, has been and continues to be one of the most dangerous of human activities (ILO 1999).

The present work focuses on fishing vessel collisions. This is a type of accident which usually gives rise to other accidents such as explosions, water on board and even sinking, with fatal consequences for the crews and the service life of the vessel. There is little specific research on fishing vessel collisions and usually addresses such questions as: aspects of the international regulation on collisions such as those concerning reach (Carver 1992a) sailing in narrow waters (Carver 1992c), lights (Du, Yao 1992) and speed (Carver 1992b); causes of fishing vessel collisions (Deng 2000, Hou 2004); development and implementation of anti-collision measures such as integral control systems on the bridge (Cox, Puckett & Gowen 1977), systems base don hearing and sight (Lodge 1987, Noble 1980), vessel identification systems (Kao, Lee & Ko 2003) and those of crew operation controls (Ren, Yao 2004); structural measures of protection of fishing vessels such as the use of reinforcement in the structure (Evans, Boufounos 1977) and of more protective light elements (Pike 1978); and reports on actions of fishing vessels in collisions (Puthran 1978, Siler 1978); (National Transp. Safety Board 1985).

This work addresses the phenomenon of fishing vessel accidentality by collision from a perspective which is somewhat different from those developed in the above references. The aim is to analyse fishing vessel collisions from the point of view of their spatial and functional distribution. To this end, a twofold objective is set: first, to formalise a methodology for the fishing sector of a country which allows the inequalities in the concentration of collisions to be analysed; and second, to apply this methodology to the Spanish fishing fleet for the period 1994-2002.

The sections below present the formalisation of this methodology, the data used, the results obtained and the main conclusions drawn from the research.

2. METHODOLOGY

Inequality measurements are intended to underline the greater or lesser degree of proximity in the total distribution of the values of a variable in a population. They are thus indicators of the degree of distribution/concentration of the variable. In the field of health science, the research on accidentality makes widespread use of inequality analysis (concentration).

There are several studies on the methodological aspects of measuring inequalities in health. Among the most classical studies are those which analyse and examine the different indices of inequality in health and some others which propose a classification of the indices according to their level of complexity, possible use and the appropriacy of different measurements for the study of inequalities in health (Kunst, Mackenbach 1994, Pamuk, Lenzner & Brackbill 1993, Brown 1994/5, Wagstaff, Paci & van Doorslaer 1991). In more recent works, new indices have been incorporated for measuring health inequalities based on the notion of entropy (Bacallao et al. 2002).

Similarly and in keeping with the spatial analysis of this work, the differences in the health conditions of different geographical zones of one same country have been described (Cook 1990, Csaszi 1990, Kirchgässler 1990, Lahelma, Valkonen 1990).

From all of the inequality measures used concerning health, the Gini coefficient is selected for this work. This coefficient will be used to formalise the general equation which will allow us to determine the collision concentration indices for the fishing sector, for different population variables (fishermen, fishing vessels etc.) and different groups of these (regions, fishing types, etc.).

As an application of the Gini coefficient to the present analysis, equation (1) is the starting point

$$CII = \left(\sum_{i=1}^{k-1} (p_i - q_i) \right) \Big/ \left(\sum_{i=1}^{k-1} p_i \right) \qquad (1)$$

where:

FIC = Gini Coefficient of inequality (concentration) of collisions.

p_i is the accumulated percentage of the at-risk population variable analysed, (X), which has k individuals, and is determined by means of equation (2)

$$p_i = \sum_{i=1}^{i} \left(X_i \Big/ \sum_{i=1}^{k} X_i \right) = \sum_{i=1}^{i} X_i \Big/ \sum_{i=1}^{k} X_i \qquad 2)$$

q_i es el porcentaje acumulado de la variable poblacional accidentada en la colisión (CX) para un grupo que dispone de k individuos, que se determina mediante la ecuación (3).

$$q_i = \sum_{i=1}^{i}\left(CX_i \Big/ \sum_{i=1}^{k} CX_i \right) = \sum_{i=1}^{i} CX_i \Big/ \sum_{i=1}^{k} CX_i \tag{3}$$

Substituting in (1), we get the general equation (4) by jeans of which the inequality in the concentration of collisions in the fishing sector can be determined for a specific group and period t.

$$CII/X(t) = \left(\sum_{i=1}^{k-1}\left[\left(\sum_{i=1}^{i} X_i \Big/ \sum_{i=1}^{k} X_i \right) - \left(\sum_{i=1}^{i} CX_i \Big/ \sum_{i=1}^{k} CX_i \right) \right] \right) \Big/ \left(\sum_{i=1}^{k-1}\left(\sum_{i=1}^{i} X_i \Big/ \sum_{i=1}^{k} X_i \right) \right) \tag{4}$$

The variables to be used in the construction of the collision concentration indices are shown in Table 1. These are the at-risk population and the injured population variables.

G^a	At-risk Population Variable (X)		Injured Population Variable (CX)	
	Crew Members	Fishing Vessels	Crew Members	Fishing Vessels
1	$CM_1(t)$	$FV_1(t)$	$CCM_1(t)$	$CFV_1(t)$
...	...	...	...	...
I	$CM_i(t)$	$FV_i(t)$	$CCM_i(t)$	$CFV_i(t)$
...	...	...	...	...
K	$CM_k(t)$	$FV_k(t)$	$CCM_k(t)$	$CFV_k(t)$
Total	$\sum_{i=1}^{k} CM_i(t)$	$\sum_{i=1}^{k} FV_i(t)$	$\sum_{i=1}^{k} CCM_i(t)$	$\sum_{i=1}^{k} CFV_i(t)$

Table 1. Variables used in the construction of collision concentration indices

Two different groupings of variables are made in the present work, one corresponding to fishing regions and the other to typ es of fishing. The values of At-risk Population Variable and Injured Population Variable will change depending on the variable selected (Crew Members and Fishing Vessel) the variable groupings and the period (t).

The Gini coefficient is based on the Lorenz curve, which is a function of the accumulated frequency which compares the empirical distribution of a variable with a uniform (of equality) distribution. This uniform distribution is represented by the diagonal y=x. The greater the distance, or more precisely, the area between the Lorenz curve and this diagonal, the greater the inequality.

In its application to the analysis of accidents through collision in the fishing sector, the "p" axis represents the accumulated value of the at-risk population variable (censuses of fishermen and vessels) and the "q" axis the accumulated value of the injured population variable (fishermen injured and vessels collided.

3. DATA

The methodology described above will be applied to the Spanish fishing sector for the years 1994, 2002 and 2004 in order to determine the concentration of sinking accidentality and its evolution, per region and types of fishing. In Spain, the fishing fleet is distributed by base ports through 9 coastal Autonomous Communities (The Basque Country, Cantabria, Asturias, Galicia, Andalusia, Murcia, Valencia, Catalonia, Balearic Islands, Canary Islands) and two Autonomous Cities (Ceuta and Melilla).

In Spain, the sea accident statistics are drawn up by the Merchant Navy Council of The Ministry of Industrial Development. The data available is structured according to types of vessel (merchant, fishing, recreational), accident (collision, list, structural failure, technical failure, sinking , fire-explosion, grounding, flooding and others), cause of accident (human failure, material failure, bad weather and unknown), denotation of damage (total loss, man over board, hull damage, machine damage and others), and aspects of personal and material damage. As for the technical characteristics of the damaged vessel, the statistics only incorporate the general characteristics and a vessel identification code. Thus, any indicator of accidentality in the Spanish fishing sector is drawn up from these sources.

Since we intend to develop our analysis in the regional context and for types of fishing, the above data is insufficient as it does not incorporate these references. Thus, we have turned to the fishing censuses drawn up by the Secretary General of Fishing of the Ministry of Agriculture, Fishing and Food. As well as technical data on the fishing boats, these censuses incorporate the type of fishing (demersal trawl, gillnet, purse seine, long line and complementary activities) and the base port. From these two sources, a data base has been created with Microsoft Access with two tables linked by the common register of the vessel identification code

4. RESULTS

The concentration indices for collision accidents for the Spanish fishing sector for the period (1994-2002) are shown in Table 2. These have been structured by region (Autonomous Communities) and type of fishing, for the at-risk variables analysed: fishermen (crews) and fishing vessels.

The indices refer to crew members injured in collisions and collisioned Vessels.

4.1. Fishermen Accidentality Concentration

By Autonomous Community for the period analysed (1994-2002), the concentration of injured crews of Spanish fishing vessels increased by 74.57%, as can be

Year	Indices by Regions		Indices by Fishing Types	
	Fishermen	Fishing Vessels	Fishermen	Fishing Vessels
1994	0,346	0,352	0,587	0,681
1998	0,389	0,460	0,449	0,326
2002	0,604	0,597	0,616	0,493

Table 2. GINI collisions concentration indices for Spanish fishing sector for the period (1994-2002) by region and type of fishing.

observed from the variations in the fishermen affected by regions indices (Table 2). The associated Lorenz curves in Figure 1 show the distribution of accidentality by regions. These have been ordered from higher to lower accidentality. For the last year analysed, the regions of Murcia, Valencia, Cantabria and Galicia with a number of crews that make up 48.82% of the total census of Spanish fishermen, suffered 94.78% of the total number of accidents by collision of Spanish fishing vessels.

By fishing types, the degree of concentration of crew accidents varied for the years analysed, but for the whole period (1994-2002) it increased by 4.94%, as shown by the changes in the indices of fishermen affected by fishing types indices (see Table 2). The Lorenz curves in Figure 2 show the distribution of accidentality by fishing type for the Spanish fleet. As for the regions, the fishing types have been ordered from higher to lower accidentality. In the last year, fishermen working in the dermesal trawl and purse seine fishing types, which make up 42.63% of the country's fisherman population, suffered 84.35% of the total crew accidents by collision of the Spanish fleet.

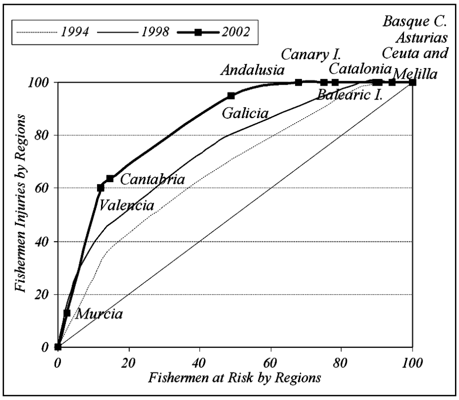

Fig. 1. Lorenz curves for Spanish fishermen injured in collisions, by region. The values in the two axes represent the accumulated % of the variables.

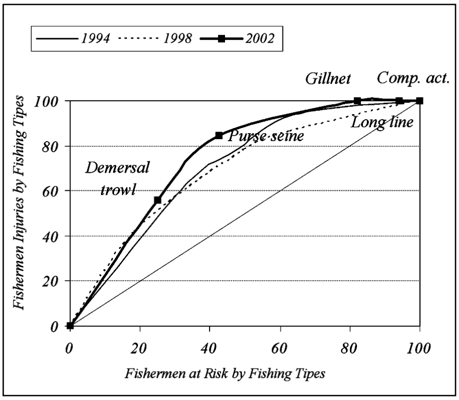

Fig. 2. Lorenz curves for Spanish fishermen injured in collisions, by fishing type. The values in the two axes represent the accumulated % of the variables.

4.2. Concentration of fishing vessel accidentality

By Autonomous Communities, the number of Spanish fishing vessels suffering collisions in the period analysed (1994-2002) increased its concentration by 69.60%, as shown by the variations in the indices for collisioned vessels by Regions (see Table 2). The distribution of accidentality by collisions shown by the Lorenz curve for the final period analysed (see Fig.3), indicates that 27.43% of the Spanish fishing fleet accounted for 75% of the collisions. The regions bearing the brunt of this accidentality were Valencia, Cantabria, Murcia and Andalusia.

By fishing types, the degree of concentration of collisions in the fleet varied greatly for the period analysed (1994-2002), although overall there was a reduction of 27.6%, as shown by the variations in the indices for vessels collisioned by Fishing Types (see Table 2). The Lorenz curve for the last period shows the distribution of fishing vessel collisions by fishing types for the Spanish fleet (Fig. 4). The fishing vessels working in dermesal trawl and purse seine fishing types, which make up 20.34% of the overall census for the country, accounted for 66.67% of the collisioned vessels.

This is due to the fact that the number of vessels dedicated to Gillnet and Purse Seine fishing make up 77.49% of the total Spanish fishing fleet. The use of a measurement of fleet size or capacity would probably eliminate this disparity since these vessels are smaller than the average of the fleet.

CONCLUSIONS

The indices of accidentality concentration by collision and their associated Lorenz curves prove to be a useful instrument in the analysis of the accidentality concentration of a country's fishing sector. Moreover, these tools could be applied to

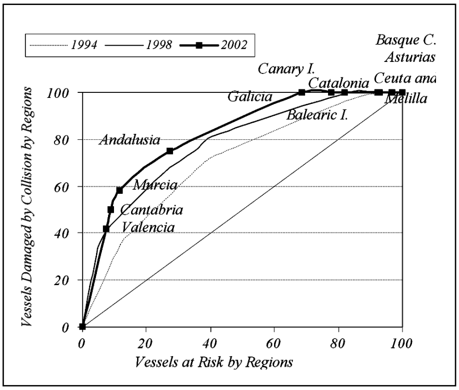

Fig. 4. Lorenz curves for collisioned Spanish fishing vessels, by regions.

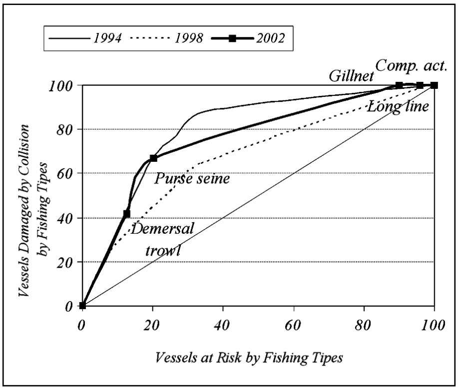

Fig. 5. Lorenz curves for collisioned Spanish fishing vessels by fishing types.

any other similar analysis in the spatial (local, national and supranational) and functional domain (vessel type, transport type, etc.) or other type of accident.

In Spain, in the period 1994-2002, a notable increase can be appreciated in the disparities in the regional distribution of collisions, both for fishermen and for fishing vessels, the Communities of Valencia, Murcia and Cantabria being those that suffered or concentrated the highest percentage of collisions.

By fishing types, for the same period 1994-2002, the inequality increased slightly with respect to fishermen injured in collisions and decreased significantly for fishing vessels. The highest rates of accidentality by collision both for fishermen and for the Spanish fishing fleet, took place in the fishing modalities of dermesal trawl and purse seine.

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COLISIONES DE BUQUES PESQUEROS: CURVAS DE LORENZ E ÍNDICES DE GINI

Resumen

Las colisiones de pesqueros son accidentes que en la mayoría de los casos desencadenan posteriormente otros accidentes como la explosión, la vía de agua e incluso el hundimiento. Se trata de accidentes que suelen tener fatales consecuencias para las tripulaciones y en numerosos casos suponen la pérdida del buque. Tales siniestros pueden evitarse o reducirse si los pesqueros cuentan con medios tecnológicos suficientes y las tripulaciones actúan correctamente y de forma inmediata. En tal sentido, los países deben incorporar en la ordenación de su sector pesquero los mecanismos de control adecuados que garanticen unos buques correctamente pertrechados de recursos y unas tripulaciones bien formadas en seguridad. Dichos recursos y su distribución deben asignarse de acuerdo con las necesidades de la flota, lo que requiere un conocimiento pormenorizado del grado de concentración de la siniestralidad por colisiones del sector pesquero del país.

En dicho contexto, el objetivo del trabajo que se presenta es doble. Por un lado, formalizar una metodología para el sector pesquero de un país, que permita analizar la desigualdad en la concentración de colisiones. Por otro, aplicar dicha metodología a la flota pesquera española en el período 1994-2002. Así se construyen índices por regiones y tipos de pesca, para dos variables: pescadores y buques. En dichos ámbitos, se obtienen resultados tanto de la concentración de colisiones como de las curvas de Lorenz asociadas. Se verifica un incremento de la desigualdad en la distribución espacial y funcional de dichos siniestros.

INTRODUCCIÓN

La ordenación de una flota pesquera debe incorporar mecanismos de control adecuados que garanticen unos buques correctamente pertrechados con recursos suficientes y unas tripulaciones bien formadas en seguridad. Si no se cumplen tales condiciones las consecuencias pueden ser fatales. En tal sentido, la mejora de la seguridad en el mar ha constituido durante varios decenios una de las principales preocupaciones de diversas instituciones supranacionales, administraciones nacionales y organizaciones no gubernamentales. Sin embargo, las estadísticas de accidentes indican que la pesca comparada con otros sectores ha sido y sigue siendo una de las actividades humanas más peligrosas.

Los trabajos de investigación sobre seguridad y siniestralidad en buques pesqueros comerciales son escasos. En los mismos son tratados aspectos relacionados con daños personales y/o materiales originados por la actividad pesquera, tales como:

la mortalidad de pescadores en los accidentes (Reily, 1985); equipos, medios de salvamento y percepción sobre normas de seguridad de buques pesqueros (Lagares, 1990; Poggie et al., 1995); las enfermedades y accidentes de pescadores (Goethe & Vuksanovic, 1995); la cognición del peligro y las actitudes de los pescadores en la seguridad al gestionar pesquerías (Poggie et al., 1996; Kaplan, & Kite-Powell, 2000); los daños a pescadores en el trabajo (Jansen, 1996); los riesgos y aspectos determinantes de las pérdidas personales y materiales en buques pesqueros (Dyer, 2000; Jin et al., 2001); y la formulación de modelos de probabilidad de accidentes en pesqueros (Jin et al., 2002).

En el presente trabajo centramos la atención en las colisiones de pesqueros. Se trata de un tipo de siniestro que suele desencadenar otros accidentes posteriores como la explosión, vía de agua y el hundimiento, con consecuencias fatales para las tripulaciones y la pérdida del buque. Las investigaciones específicas sobre colisiones de pesqueros son muy escasas y suelen analizar diversas cuestiones, como:

Aspectos del reglamento internacional de abordajes como los concernientes al alcance, la navegación en canales angostos, las luces y la velocidad.

Causas que originan las colisiones de pesqueros.

Desarrollo e implantación de medidas anticolisión como los sistemas de control integral en el puente, los sistemas basados en la audición y la visión, los sistemas de identificación de buques y los de control de operaciones de las tripulaciones.

Medidas estructurales de protección en la construcción de los pesqueros como la utilización de refuerzos en la estructura y de elementos ligeros de mayor protección.

Informes sobre actuaciones de los pesqueros en colisiones.

En este trabajo se aborda el fenómeno de la siniestralidad por colisiones de pesqueros desde una óptica diferente a la desarrollada en las referencias indicadas. Se pretende analizar las colisiones de los buques pesqueros desde el punto de vista de su distribución espacial y funcional. Con tal finalidad nos planteamos un doble objetivo. Por un lado, formalizar una metodología para el sector pesquero de un país, que permita analizar la concentración de colisiones, por regiones pesqueras y tipos de pesca. Por otro, aplicar dicha metodología a la flota pesquera española en el período 1994-2002.

En los epígrafes siguientes se presentan la formalización de la metodología, los datos utilizados, los resultados obtenidos y las conclusiones generales de la investigación desarrollada.

METODOLOGÍA

Las medidas de desigualdad tratan de poner de relieve el mayor o menor grado de proximidad en la distribución total de los valores de una variable en una población. Por tanto, son indicadores del grado de concentración de la variable. En el campo de las ciencias de la salud, las investigaciones sobre siniestralidad utilizan de forma habitual el análisis de desigualdad (concentración).

Existen numerosos estudios sobre aspectos metodológicos para la medición de las desigualdades en salud. Entre los trabajos clásicos más conocidos están los que analizan y examinan los diferentes índices de desigualdad en salud y aquellos otros que proponen una clasificación de los índices según su nivel de complejidad, posibles usos e idoneidad de las diferentes medidas para el estudio de las desigualdades en salud. En trabajos más recientes se han incorporado nuevos índices para medir las desigualdades de salud basados en la noción de entropía.

Asimismo y en línea con el ámbito espacial de análisis en que se centra el presente trabajo, se han descrito diferencias en las condiciones de salud entre diferentes zonas geográficas de un mismo país. Entre todas las medidas de desigualdad utilizadas en salud, en el presente trabajo nos centramos en el coeficiente de Gini. A partir del mismo se formaliza la expresión general que nos permita determinar índices de concentración de colisiones en el sector pesquero, para distintas variables poblacionales (pescadores, buques, etc.) y diferentes agrupaciones de las mismas (regiones, tipos de pesca, etc.).

CONCLUSIONES

Los índices de concentración de siniestralidad por colisiones y las curvas de Lorenz asociadas a los mismos se muestran como un instrumento útil en el análisis de la concentración de siniestralidad del sector pesquero de un País. Además dichas herramientas podrían aplicarse a cualquier otro análisis similar de ámbito espacial (local, nacional y supranacional) y funcional (tipo de buque, tipo de transporte, etc.) u otro tipo de siniestro.

En España, en el período 1994-2002, se aprecia un incremento importante de las disparidades en la distribución regional de las colisiones, tanto para los pescadores siniestrados como para los buques pesqueros, siendo las Comunidades de Valencia, Murcia y Cantabria, las que aglutinaron o concentraron un mayor porcentaje de las colisiones.

Por tipos de pesca, en el mismo período 1994-2002, la desigualdad se incrementa ligeramente respecto a los pescadores accidentados en las colisiones y se reduce sensiblemente respecto a los buques. Las mayores tasas de siniestralidad por colisiones se, tanto de los pescadores como de la flota pesquera española, se originaron en las modalidades de arrastre y cerco.