Marine Policy 46 (2014) 119–122

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

The estimation of derelict fishing gear in the coastal waters of South Korea: Trap and gill-net fisheries ☆

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ARTICLE INFO

Article history:
Received 15 July 2013
Received in revised form
7 January 2014
Accepted 7 January 2014
Available online 1 February 2014

Keywords:
Discarded fishing traps and gill-nets
Coastal waters
Marine debris
Eco-friendly gear
Marine policy

ABSTRACT

This study estimates the gross quantity of discarded fishing traps and gill-nets in the coastal waters of South Korea. Using regression analysis it is estimated that 11,436 t of traps and 38,535 t of gill-nets are abandoned annually. Experts on marine debris recommend replacement of traditional fishing gears with eco-friendly designs and establishment of incentive programmes for the fishermen in order to promote eco-friendly gear designs.

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1. Introduction

Fishing and other various marine activities in coastal areas inevitably result in pollution of coastal waters [1]. Moreover, such marine activities account for a large proportion of coastal pollution [2,3]. Specifically, waste dumping by various vessels, including fishing boats, cargo ships, passenger ships, warships, and oil tankers triggers coastal pollution. Fishing nets and gears lost or disposed of by fishermen threaten the circle of marine life, by entangling and killing marine organisms, and cause severe trouble to ships [4].

This study was performed to estimate the gross number of abandoned fishing nets around the eastern, western, and southern coasts of South Korea. By doing so, the study ultimately aims to contribute to reducing pollution by suggesting more efficient and practical management solutions for these problems. In fact, of all the thrown fishing nets found in the coastal areas, 95% are fish trap nets and gill-nets. Other fish nets, such as squid traps and line hooks are not usually discarded, and even if they are discarded, the number is insignificant and not worthy of consideration [5]. In this context, this paper attempts to estimate the number of discarded nets of two fishing types and explores some feasible management solutions for the problems based on the estimate and advice from the experts on the issue [8].

2. Method of survey and statistical analysis

Two types of surveys were designed: one for coastal fishermen using fish traps and the other for coastal fishermen using gill-nets. The survey used one dependent variable and 10 independent variables and included different indicators to measure the variables. The dependent variable, the number of discarded nets, was measured by investigating the number of the traps and gill-nets lost. The respondents were asked to answer the questions regarding the tonnage of fishing boats, the average fishery months per year, the average number of fishing days per month, the depth of water for fishing, the annual average number of nets purchased, the number of nets used per fishing trip, the proportion of worn-out nets, the proportion of missed nets, and the proportion of nets collected back to land or dumped into the ocean. This study used each of the questions to measure the independent variables.

The data for this study were collected using three different methods. Both face-to-face field surveys (interviews) and mail surveys were applied to fishermen, and an e-mail survey was sent to experts in marine pollution. For the field survey, the respondents were selected from "The National List of Fishermen by Regional Groups" and the face-to-face interviews were conducted with respondents who agreed to participate. To minimize sampling errors, this study

☆This paper supplements and modifies the report "Research about the real condition of fishing gears for understanding distribution of jetsam" published in 2001 by International Marine Laboratory, Korea Maritime University, with the request of Ocean Technology ENG. Co.

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http://dx.doi.org/10.1016/j.marpol.2014.01.006

Table 1
Number of cases by source.

Source of data	Trap fishing union	Gill-net fishing union	Expert group	Total
Number of cases	136	247	29	412

used the quota sampling method, which allocates sample sizes in proportion to the gross number of fishermen of each coastal area of South Korea. To secure sufficient samples, surveys were also mailed to the respondents who reside in Jeju Special Self-Governing Province, Ulsan Metropolitan City, or Gyeonggi Province, where the investigators were not able to visit. Finally, the study also sent e-mail surveys to marine pollution experts. All of these surveys were conducted for 19 days from January 6th to 24th, 2011.

As shown in Table 1, a total of 412 cases were collected. Specifically, through face-to-face interviews, 100 cases (trap, 52; gill-net, 48) from 19 fishing unions in the eastern coast, 128 cases (trap,29; gill-net, 99) from 30 fishing unions in the western coast, and 97 cases (trap, 32; gil1-net, 65) from 40 fishing unions in the southern coast were collected. An additional 58 cases (trap, 23; gill-net, 35) were obtained from 34 fishing unions by the mail survey. A total of 30 cases were collected from e-mail surveys sent to the experts, but one of surveys was not used because of the lack of reliability.

The analyses of the data were conducted in two steps. First, the mean of each variable was calculated by examining the frequencies according to the fishing types. Second, using a multiple regression analysis, this study constructed a regression equation to estimate the number of discarded fishing nets. During this process, multi-collinearity between the independent variables was verified.

3. Analysis of features by fishing types

Ten independent variables were used to estimate the occurrence and the number of discarded fishing nets from fishing with either fish traps or gill-nets. These variables include tonnage of fishing boats, the average months of fishing per year, the average days of fishing per month, the depth of water for fishing, the annual average number of nets purchased, the quantity of net for each type of fishing, the proportion of worn-out nets, missed nets, withdrawn nets back to the land, and nets dumped into the sea.

As shown in Table 2, trap fishery and gill-net fishery involved use of slightly different size boats. These frequency distributions imply most the fishing vessels weigh below 5 t, regardless of the type of coastal fishery being performed.

Table 3 shows the operating hours, average days of fishing per month, and depth of water for fishing according to the type of fishing. Research indicated that most of the inshore fisheries work for 9–10 months per year on average regardless of fishing types, and most of coastal fishermen operate their boats for 10–20 days per month on average, and whereas the fishermen using fish traps fishing approximately 114 m under the sea, the gill-net fishermen work at a depth of 61 m on average.

Table 4 shows the number of fishing gear purchased by fishing type, the number of fishing gear used per fishing activity, the proportion of abandoned and lost gear by fishing type, the proportion of recovered and dumped gear by fishing type, and the number of traps gill-nets lost per year.

4. Estimation of the number of discarded fishing nets

To estimate the number of abandoned fish traps and gill-nets around the coast, this research utilized 10 independent variables including tonnage of fishing vessels, operating months per year, average days of fishing per month, depths of fishing activities, number of fishing gears purchased per year, number of nets used per fishing activity, number of discarded gears, number of lost gears, number of gears recovered back to the land, and number of gear dumped into the sea per year, which were also considered in preceding research [4].

Before conducting multiple regressions, this research checked the multicollinearity and found the possibility of its presence between the independent variables. Generally, the maximum tolerance for the collinear limit is 1 with a maximum VIF of 10. The universal standard of multicollinearity; however, has stricter criteria with below 0.1 tolerance limits and above 10 VIF [6]. According to the standard, there are multicollinearities between some independent variables, for example, between the number of discarded gears and the number of lost gears. In these relationships, the tolerance limit is 0.045 which is below 0.1, and VIF is 22 which exceed 10. However both the ratio of discarded gears and the ratio of lost gears were found to have no significant influence on the regression, with probabilities of 0.910 and 0.542, respectively so that they were excluded from the regression.

Table 2
Type and size of fishing vessels.

Division	Size of fishing vessel				Total
	Under 3 t	3–5 t	5–8 t	Over 8 t	
Trap	42(31.3)	53(39.6)	29(21.6)	10(7.5)	134 (100)
Gill-net	84(34.0)	89(36.0)	39(15.8)	35(14.2)	247 (100)

Table 3
Period and depth of fishing activities by type.

Division	Trap	Gill-net	Total
Months of fishing			
Less than 5 months	18(13.5)	21(8.8)	39(10.2)
6–8 Months	34(25.4)	89(35.9)	123(32.3)
9–10 Months	82(61.2)	137(55.3)	219(57.5)
Total	134(100)	247(100)	381(100)
Days of fishing			
Less than 9 days	1(0.7)	4(1.6)	5(1.3)
10–18 Days	67(50.1)	104(42.1)	171(44.9)
19–20 Days	66(49.3)	139(56.3)	205(53.8)
Total	134(100)	247(100)	381(100)
Fishing depth	114 m	61 m	

Table 4
The number of gear purchased, used, and lost per year and the ratio of abandoned/lost and recovered/discarded gear by fishing type.

Division	Trap	Gill-net
Fishing gear purchased per year	1189.26	109.8 sets
Fishing gear used per year	1561.88	8.69 sets
Fishing gear lost gear per year	670.3	25.5 sets
Proportion of abandoned and lost gear		
Abandoned gear	44.90	69.25
Lost gear	55.10	30.75
Total	100.0	100.0
Proportion of recovered and dumped gear		
Recovered gear	90.80	91.47
Discarded gear	9.20	8.53
Total	100.0	100.0

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