Fishers' perceptions on derelict fishing gears' causes, and mitigation measures in Korea

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Abstract

Derelict fishing gears (DFGs) present a high damage risk for marine ecosystems, navigation safety, fishing resources, and the economy. To mitigate this damage, considering fishers' roles is very important, because they are the main contributors directly exposed to the impact. Since DFGs are significant sources of marine debris in South Korea, we conducted a survey to evaluate fishers' perception of DFGs' causes, reasons, and measures, based on FAO's and UNEP's 2009 suggestions. We also examined which governmental measures they preferred to help decrease DFGs. A total of 134 people participated in the 2015 survey, comprising 55 from capture fishing and 79 from aquaculture. The fishers answered that DFGs are abandoned, discarded, and lost in similar proportions. In terms of abandoned DFGs, they selected similar degrees of impact regarding 'illegal, unreported and unregulated fishing,' 'illegal gear,' and 'too much gear for time.' For discarded DFGs, they mostly agreed that 'chosen over onshore disposal' and 'damaged gear' were more serious causes than 'too much gear for space.' They answered that 'misplaced gear' causes less lost DFGs than 'gear conflict,' 'poor ground condition,' and 'extreme weather.' In total, the fishers found 'improving port facilities' and 'retrieval activities' as more effective and feasible measures than others. They positively evaluated the Korean government's existing measures, and preferred 'mandatory return' and 'strengthening gear marking' for future improvement measures. This study could further contribute to achieving policy goals more effectively and efficiently.

Keywords: Derelict fishing gear, Marine debris, Fishers, Policy, Measures

1. Introduction

Derelict fishing gears (DFGs) appear across the world's oceans and are becoming an increasing concern due to their impact and quantities [1,2]. Recent studies reported that derelict fishing nets occupy a large proportion of the floating debris in the Great Pacific Garbage Patch [3,4]. DFGs cause numerous damages, such as wildlife entanglement and ingestion, benthic habitat destruction [5], navigational threats [6], economic loss in aesthetics and tourism [7], and ghost fishing of non-target species [8]. In particular, since most modern fishing gears are plastics, they are an important source of microplastics when abandoned in the marine environment [9]. For example, expanded polystyrene buoy for aquaculture has produced extreme levels of microplastics in the Republic of Korea [10–14]. In addition, polypropylene fibers (copolymer of polypropylene and polyethylene), mainly used in fishing gear (rope and nets), accounted for a relatively high portion of microplastics at sea and on shore in South Korea [15,16].

In 2009, the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP) [1] published a report reviewing DFGs' incidences and treatments, including types, impacts, and economic damages; their causes, and the responding efforts and outcomes. It also recommended countermeasure strategies to tackle this issue. Since then, in a survey on Caribbean fishers and fisheries' resource managers, Matthews and Glazer [17] investigated DFGs' distribution and causes, and suggested measures for their reduction. Similarly, Mengo [18] examined the current system for reducing DFGs, the industry's efforts, and potential future implementation measures for fishery industries within the OSPAR member countries. Brennan and Portman [19] explored Israeli fishers' perception of marine litter in socioinstitutional and sociocultural contexts. However, research has yet to determine how fishers understand FAO's and UNEP's DFG management strategies.

For decades, the South Korean government has carried out numerous and costly efforts, but due to a lack of preventive measures, DFGs kept continuously flowing into the marine environment [20,21]. To improve this situation, the Korean government is pursuing the establishment of a 'Fishing Gear Management Law' that manages fishing gears' entire life cycles. The bill contains information on fishing gears' entire processes of production, purchase, use, and disposal; enhances fishers' collective obligations, and promotes DFG recycling [22]. In this context, we must grasp fishers perceptions of these fishery management measures to increase legislation effectiveness and success. Thus, this study's purpose is to evaluate fishers perceptions of the FAO's and UNEP's proposed measures for DFGs' prevention and management, and the Korean government's policies. Ultimately, our findings can help the development and application of high acceptability management policies.

2. Material and methods

2.1 Survey

We designed a survey to assess fishers' opinions on international and national measures, because we believe that these direct stakeholders can provide more practical solutions. We took advantage of the opportunity to deliver a lecture on DFGs' problems and solutions in governmental education courses. The three-day courses included various themes related to fishing village promotion or fishing resources preservation. All attendants were fishers from across the country who had the chance to receive governmental support. We conducted each survey

prior to the lecture, targeting capture fishers on April 1st and aquaculture fishers on May 7th, 2015. In each class, we circulated the questionnaire to the participants and explained the terminology, the meanings of the questions, and how to respond, as they may not have been familiar with this type of approach. Completing the survey took almost 30 minutes, without any related or intended lecturer comments that may affect respondents' answers. After the survey, the first author gave a lecture introducing FAO's and UNEP's DFG types and causes, and the measures to resolve and prevent the issues.

We divided the questionnaire into four parts: (1) general information for fishers, targeting their specific fishing activities, (2) DFGs' causes (abandoned, discarded, and lost), (3) a list of measures provided by FAO's and UNEP's 2009 publication, and (4) the Korean government's existing and future policies. To assess the responses, we used a typical 5-level Likert scale: very high (5), high (4), medium (3), low (2), and very low (1). A total of 143 fishers were asked to participate in the survey, of which 134 people were selected for analysis: 55 from capture fisheries and 79 from aquaculture. We excluded nine respondents in the analysis process, because they did not complete all the questions, and divided the response scores for measure preferences into two groups (capture and aquaculture fishers). As such, we obtained the average and standard deviations. The T-test examined the differences between the two groups (significance level: 0.05), and we applied the determined effectiveness and feasibility of the FAO and UNEP proposal to the quadrant analysis.

2.2 FAO and UNEP measures to address DFGs

We provided FAO's and UNEP's classifications on the main types, reasons, and measures to address the issue (Figure 1)[1], and added details on each classification in the questionnaire form. FAO and UNEP classified DFG types into (A) abandoned (deliberated non-retrieval), (D) discarded (deliberate disposal at sea), and (L) lost (accidental loss at sea) [1]. The participants determined each types' relative contributions by selecting their seriousness levels from very high to very low. We requested they also evaluate the seriousness of individual reasons (A1 to L4) in each type. Here, IUU stands for 'illegal, unreported, and unregulated fishing.' Our next questions evaluated FAO's and UNEP's suggested implementation measures' effectiveness and feasibility (M1 to M8) through respondents' responses from very high (5) to very low (1). We added 'enforcement of relevant laws (M8)' to the list, since we believed this measure could improve other measures' efficacy.

2.3 Korean government's measures to address DFGs

We evaluated the effectiveness of the Korean government's measures (KM) addressing DFGs (Table 1), including existing and future policies, and listed their details in the questionnaire form. The government fully implemented the KM3, while KM4 is not very widespread. Among the existing measures, only KM2 centers on avoidance, while the others are curative. Regarding future measures (KM5 to KM8), we incorporated those that were reviewed or prepared at a national level, as some of the present study's authors participated in developing the national marine debris management plan, and that were included in the draft of the 'Fishing Gear Management Law.' KM5 can considerably reduce improperly managed DFGs, KM6 may trigger behavioral changes in fishers,

and KM7 can lead to the production of well-designed gears and strengthen responsibilities for better circular economy. Lastly, KM8 is meant to delegate responsibilities to fishers to prevent accidental losses.

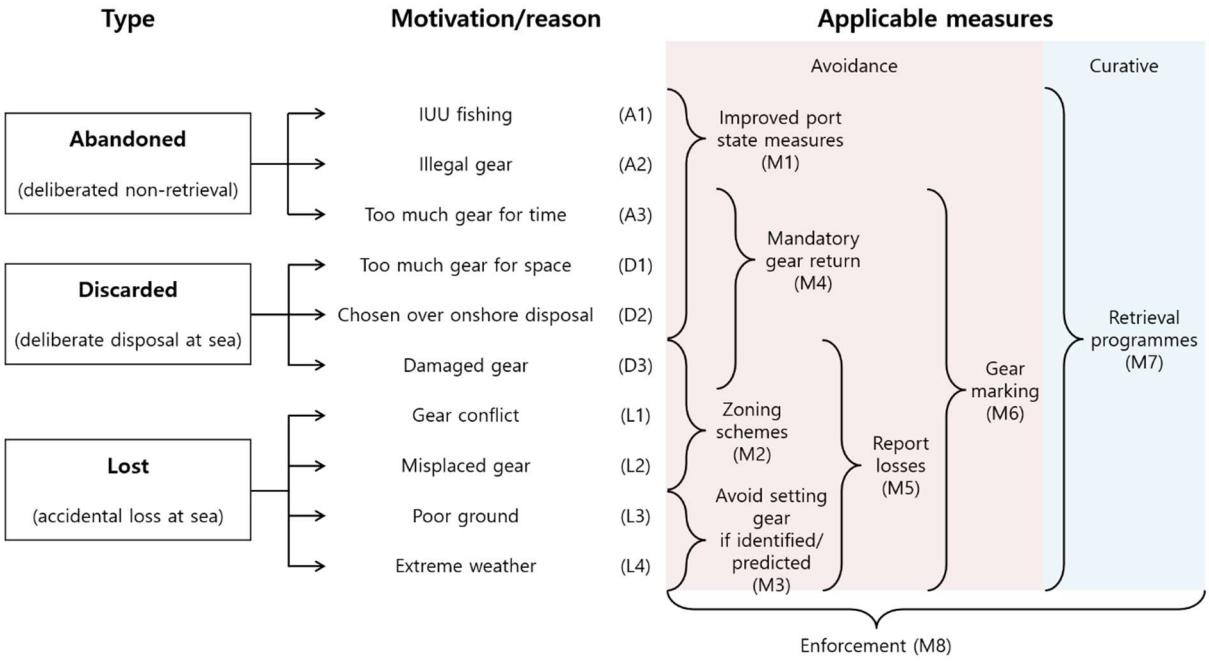

Figure 1. Type, reasons, and applicable measures for DFGs by FAO and UNEP [1]

3. Results and discussion

3.1 Survey respondents

More than half of the survey respondents were in their forties, occupying 58.2% of capture and 55.7% of aquaculture fishers, the latter respondents being generally younger than the former. Their careers varied from 5 to 20 years with 80% of capture fishers and 67% from aquaculture holding the same job for over 10 years. The respondents' ages and careers showed demographic changes typical of the Korean fishery population (www.kosis.kr). For example, in 2017, 35.5% of people engaged in fishery were older than 65, which is double the rate of the total elderly population (13.8%). The elder and poorly educated population made it difficult to promote awareness of DFGs through education and outreach programs [25]. Therefore, we must develop management policies and outreach programs that are easy to follow and participate in. As more young people have recently begun to get involved in the aquaculture industry [26], it would be more effective to educate them first, allowing them to subsequently disseminate information and knowledge to the elders.

Most respondents answered that 10~30% and 30~50% of marine debris could be originating from fisheries (Table 2). The proportion was not very different between capture and aquaculture fisheries, but definitively lower than seen in previous studies. Hong et al. [27] reported that 35~49% of the debris that drifted to the selected 20 coasts were closely related with 'ocean and waterway' or 'fishery-based' sources. When

considering the fisher population, their contribution to marine debris amounts is very serious. However, the lower rate in this study suggests that fishers were not willing to admit the extent of their contribution to avoid facing responsibilities.

Type	Applicable measures		Details
Existing measures	KM1	Buy-back program (curative)	Receiving small economic incentives for returning the DFGs collected during fishing activities, excluding DFGs from one's own boat [23,24].
	KM2	Floating barge (avoidance)	Fishermen are encouraged to voluntarily put their trash, used nets, and DFGs caught during fishing activities on the floating barges installed by government [23].
	KM3	Fishing ground cleanup (curative)	Government's fishing ground cleanup with no fisher obligation and contribution (100% support) [23].
	KM4	Community cleanup (curative)	Fishermen communities' volunteer cleanup with a small grant from government.
Future measures	KM5	Mandatory return (avoidance)	Mandatory return of used gears when buying new ones.
	KM6	Deposit system (avoidance)	Treatment fee deposit when purchasing new gears.
	KM7	EPR (avoidance)	Extended Producer Responsibilities on all types of gears.
	KM8	Strengthening gear marking (avoidance)	Strengthening the gear marking system imposes further responsibilities on fishers. A present gear marking measure does exist, but it is not really functional.

Table 1. Existing and future measures addressing DFGs in the Republic of Korea

Fisheries	Age			Career			Fisheries origins		
	Case	n	%	Case	n	%	Case	n	%
Capture	20~29	0	0.0	~ 5 yrs	1	1.8	~10 %	9	16.4
	30~39	4	7.3	5~10 yrs	10	18.2	10~30 %	17	30.9
	40~49	32	58.2	10~15 yrs	12	21.8	30~50 %	12	21.8
	50~59	19	34.5	15~20 yrs	14	25.5	50~70 %	5	9.1
	60~69	0	0.0	20 yrs~	18	32.7	70~90 %	9	16.4
							90 %~	3	5.5
	Total	55	100.0	Total	55	100.0	Total	55	100.0
Aquaculture	20~29	2	2.5	~ 5 yrs	2	2.5	~ 10 %	10	13.0
	30~39	24	30.4	5~10	24	30.4	10~30 %	32	41.6
	40~49	44	55.7	10~15	21	26.6	30~50 %	14	18.2
	50~59	9	11.4	15~20	22	27.8	50~70 %	9	11.7
	60~69	0	0.0	20 yrs~	10	12.7	70~90 %	10	13.0
							90 %~	2	2.6
	Total	79	100.0	Total	79	100.0	Total	77	100.0

Table 2. Respondents' characteristics and perceptions on the contribution of fisheries' origins to marine debris

3.2 Causes of DFGs

The fishers responded that the three DFG types' seriousness was moderate with no significant statistical difference (all higher than 3 points). Discarded DFGs' occurrences appeared at slightly higher rates than lost-abandoned DFGs (Figure 2). No big difference emerged between the groups although capture fishers leaned more toward 'lost' and aquaculture fishers to 'discarded.' Perhaps this is a confession that abandoned and discarded DFGs could be important types. This result is quite different from the Caribbean case [17], where lost gears occupied the largest proportion of the causes. The differences with this study might partly stem from fishing activities' regional characteristics or from the composition of respondents (mainly researchers, fishery managers, and fishers in the Caribbean study). Presently, not many measures exist or can be established to prevent accidental

loss of gears, but this study demonstrates the possibility for future policies to prevent gears from being deliberately discarded and abandoned.

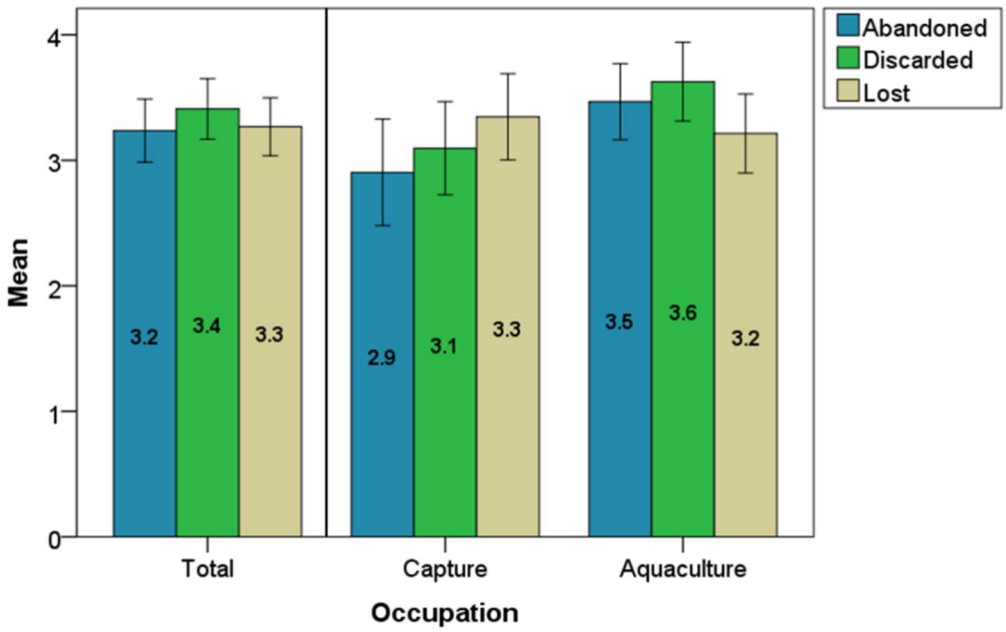

Figure 2. Perception on the three DFG types, and the differences between capture and aquaculture fishers

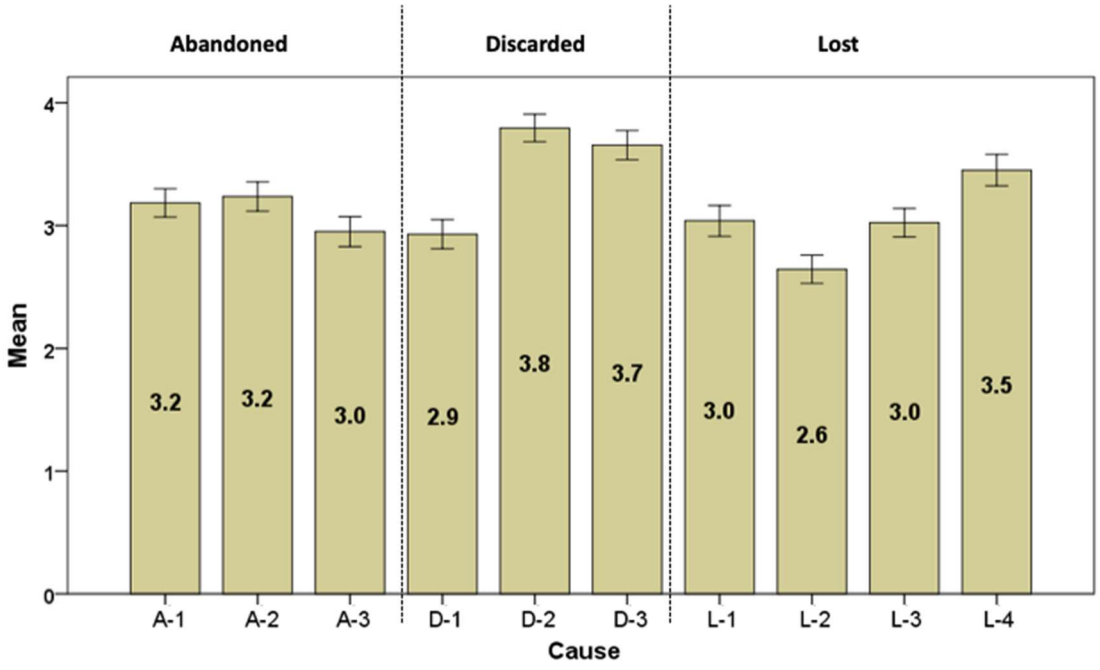

Figure 3. Fishers' perception on the reasons for abandoned, discarded, and lost DFGs

For abandoned DFGs, fishers picked similar degrees of seriousness for A1, A2, and A3: IUU fishing, illegal gear, and too much gear for time, respectively (Figure 3). For discarded DFGs, they mostly agreed that D2 'chosen over onshore disposal' and D3 'damaged gear' were more serious than D1 'too much gear for space.' As for lost DFGs, they answered that L2 'misplaced gear' was less serious than the three others, L1, L3, and L4: gear conflict, poor ground, and extreme weather, respectively.

Comparatively, they generally answered similarly, but for L1, 'gear conflict,' the capture fishers considered it more important than the aquaculture fishers, showing 3.57±1.38 and 2.68±1.35, respectively. Regarding 'extreme weather,' aquaculture fishers picked higher Likert scores than capture fishers, resulting in 3.89±1.12 and 2.78±1.48, respectively. It is likely that capture fisheries, using equipment that moves in the ocean, are more affected by gear conflict, whereas aquaculture fisheries, working in fixed facilities, are more perturbed by extreme weather.

3.3 Effectiveness and feasibility of FAO's and UNEP's reduction measures

The quadrant presents the results of our effectiveness and feasibility assessment for FAO's and UNEP's measures (Figure 4). The fishers evaluated most highly both the effectiveness and feasibility of M1 'improved port state measure' and M7 'retrieval program.' Specifically, aquaculture fishers rated M1's effectiveness (4.08 ± 1.15) and feasibility (4.08 ± 1.12) higher than capture fishers (3.70 ± 1.38 and 3.81 ± 1.25). M1 is a preventive measure that reduces the likelihood of discarding DFGs through the voluntary installation of reception barges or land-side port receptacles. M7 is the most common and familiar measure, obtaining the second highest effectiveness and feasibility scores. It appears to have a relationship with extreme weather, the relatively highly agreed upon cause (3.5) of DFGs (Figure 3). A high score on the retrieval program may be a request for the government to collect DFGs, because it is an significant aid in the case of gear loss due to extreme weather. However, it is a curative measure with prevention limitations. Nonetheless, the fact that respondents evaluated M1 at the same level as M7 demonstrates new potentials and inclinations to switch to preventive measures.

Regardless of groups, the measures evaluated as moderate were M4 'mandatory gear return,' M8 'enforcement,' and M6 'gear marking.' It is very encouraging that fishers evaluated M8 at the same level as M6 and M4, as it suggests a higher than expected level of awareness. It also shows the likelihood of compliance with such measures, even if fishers' responsibilities and roles are further heightened. Participants ranked M5, 'report gear loss,' lower than moderate, and capture fishers evaluated this measures' effectiveness and feasibility noticeably lower than aquaculture fishers. The lowest valued measures were M2 'zoning schemes' and M3 'avoid setting gear if identified or predicted.' These results might be due to the fact that fishers have hardly experienced these situations. In the Republic of Korea, the government has actively collected floating or submerged DFGs, but this process is inefficient for the submerged items due to higher expenses, and collection and recovery difficulties [23]. As the UK Gill net fishers and the French trawl fishers' communities introduced a voluntary convention that reduced the occurrence of gear conflicts and DFGs [28], it is necessary to increase the role of fishing communities in South Korea to decrease DFGs. The fishers should collect DFGs as quickly as possible, because they cause intensive damages in the early days of entering the ocean [29]. The fact that there is not yet a reporting system for lost gears is one reason why fishers underestimate its feasibility. Although the MARPOL

73/78 Convention mandates the notification of missing gears, many countries, including the Republic of Korea, do not have a system to respond to actual reports. We expect that concrete progress for reporting losses will occur from the International Maritime Organization, Marine Environment Protection Committee (IMO MEPC) meeting that recently addressed this issue (http://sdg.iisd.org/news/imo-adopts-action-plan-on-marine-litter).

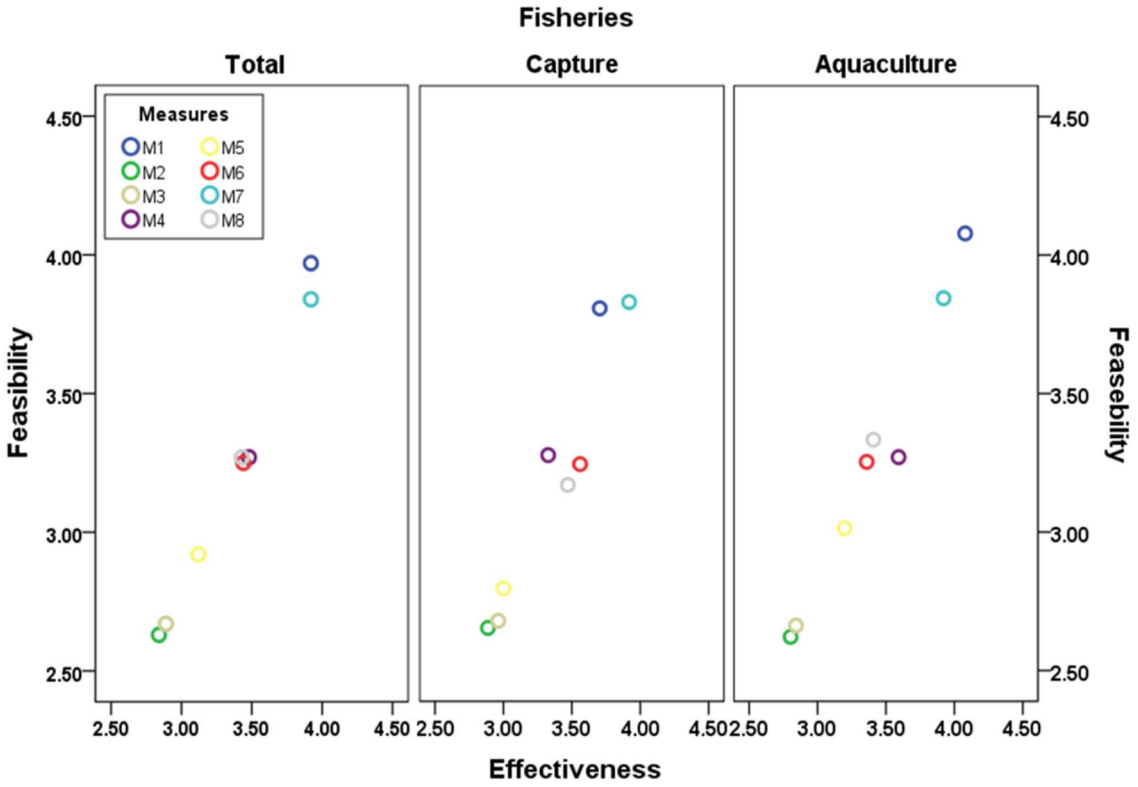

Figure 4. Effectiveness and feasibility of the eight measures against DFGs [1]

3.4 Evaluated effectiveness of Korean government measures

Overall, fishers positively evaluated the Korean government's measures for DFGs, the lowest rating being a 2.8 Likert score (Figure 5). In particular, existing policies, such as KM2 ‘floating reception barge’ (3.7), KM4 ‘community cleanup’ (3.6), KM1 ‘buy-back program’ (3.5), and KM3 ‘fishing ground cleanup’ (3.5), all received higher scores than new potential policies. Among future measures, participants evaluated KM5 ‘mandatory return’ (3.3) and KM8 ‘strengthening gear marking’ (3.2) relatively highly, while KM7 ‘EPR’ (2.8) and KM6 ‘deposit systems’ (2.8) obtained the lowest ratings.

Causes	Fisheries	N	Mean	Standard Deviation	*t*	*df*	*p*
IUU fishing (A1)	CF	54	3.04	1.427	-1.078	130	.283
	AF	76	3.29	1.231			
Illegal gear (A2)	CF	51	3.24	1.394	-.006	127	.995
	AF	76	3.24	1.315			
Too much gear for time (A3)	CF	48	2.92	1.471	-.226	126	.821
	AF	76	2.97	1.296			
Too much gear for space (D1)	CF	54	2.94	1.510	.101	126	.920
	AF	75	2.92	1.228			
Chosen over onshore disposal (D2)	CF	51	3.76	1.350	-.223	128	.824
	AF	76	3.82	1.208			
Damaged gear (D3)	CF	52	3.46	1.501	-1.356	125	.178
	AF	76	3.79	1.225			
Gear conflict (L1)	CF	51	3.57	1.375	3.595	122	.000
	AF	76	2.68	1.349			
Misplaced gear (L2)	CF	49	2.59	1.153	-.375	127	.709
	AF	75	2.68	1.357			
Poor ground (L3)	CF	51	2.94	1.271	-.587	125	.558
	AF	75	3.08	1.323			
Extreme weather (L4)	CF	45	2.78	1.475	-4.558	126	.000
	AF	70	3.89	1.123			

Table 3. Comparison between capture (CF) and aquaculture (AF) fishers' perceptions of DFG causes

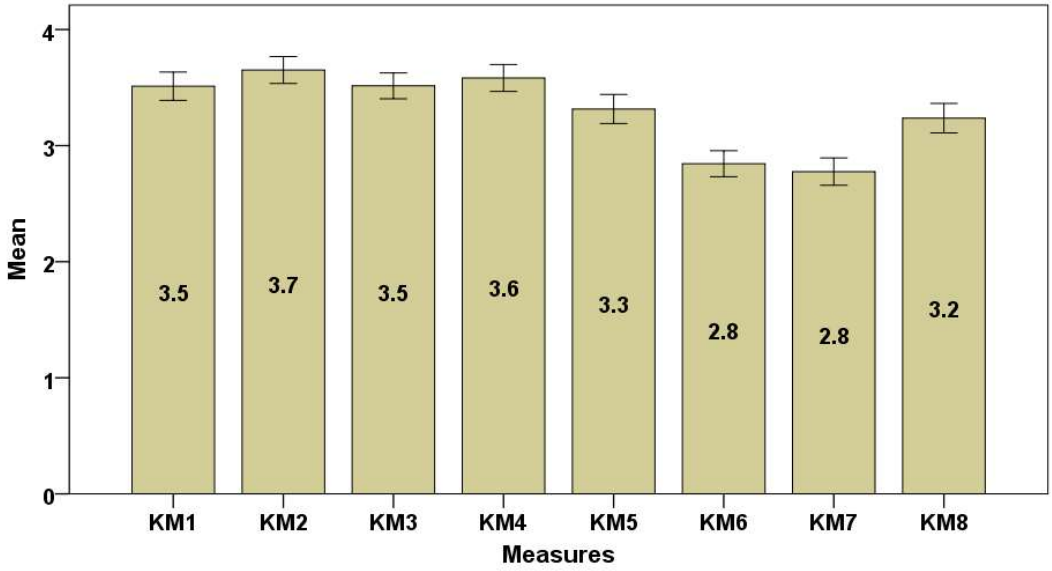

Figure 5. Evaluation of DFG management policies in the Republic of Korea

The measures that showed significant differences between capture and aquaculture fishers were KM3, KM7, and KM8 (Table 4). Aquaculture fishers evaluated the KM3 and KM7 significantly higher (3.77 ± 1.19, 3.00 ± 1.28, respectively) than capture fishers (3.15 ± 1.32, 2.43 ± 1.31, respectively) ($p < 0.05$). However, KM8 obtained significantly lower ratings from aquaculture fishers (3.01 ± 1.37) than from capture fishers (3.56 ± 1.46) ($p<0.05$). The fishers demonstrated a medium to high preference for all the government's measures for DFGs. All existing policies had an average score of 3.5 or higher, and even with the lowest score of 2.8 for two future measures, the overall score for new measures was favorable. The most preferred measures were KM3 and KM4 'community cleanup,' showing an inclination to curative measures that bring immediate results rather than preventive measures. It is encouraging to see that the policies involving fishers' active participation, such as KM2 'floating reception barge' and KM1 'buy-back program,' were highly rated. This shows a willingness to respond to the measures that fishers can easily practice and that these policies can be effective for DFG management. Similarly, Kim [30] reported that Korean fishers highly appreciated the marine environment improvements of floating reception barges and intend to actively participate in that program. Within the new policies, respondents rated KM5, 'mandatory return,' higher than KM6, 'deposit system.' Fishers seemed to view KM6 negatively, because this policy immediately raises prices, while KM5 can increase liability, but does not directly cause financial burdens, most likely the reason for the unexpected high score of 3.3. The Korean government is trying to enact the 'Fishing Gear Management Law,' but it is not active in the legislative process due to concerns that fishers will not fulfill their obligations. However, this study shows that fishers are potentially more positive about new regulations than the Korean government expects. It is also very encouraging that direct-regulated fishers made positive assessments for KM8, as a full-scale gear marking system is one of the main concerns of the 'Fishing Gear Management Law.' Fishers' direct financial burdens are minimal in the strengthening regulations of fishing gear management, and higher measure efficiency results in higher acceptance rates.

Measures	Fisheries	N	Mean	Standard Deviation	*t*	*df*	*p*
Buy-back program (KM1)	CF	55	3.58	1.410	.484	131	.629
	AF	78	3.46	1.411			
Floating reception barge (KM2)	CF	54	3.57	1.422	-.555	130	.580
	AF	78	3.71	1.270			
Fishing ground cleanup (KM3)	CF	54	3.15	1.323	-2.810	130	.006
	AF	78	3.77	1.194			
Community cleanup (KM4)	CF	54	3.48	1.370	-.730	130	.467
	AF	78	3.65	1.308			
Mandatory return (KM5)	CF	53	3.26	1.496	-.339	128	.735
	AF	77	3.35	1.384			
Deposit system (KM6)	CF	50	2.80	1.355	-.311	126	.756
	AF	78	2.87	1.221			
Extended Producer Responsibility (KM7)	CF	49	2.43	1.307	-2.422	123	.017
	AF	76	3.00	1.275			
Strengthening gear marking (KM8)	CF	52	3.56	1.461	2.142	125	.034
	AF	75	3.01	1.370			

Table 4. Comparisons between capture (CF) and aquaculture (AF) fishers' perceptions of Korean measures (KM)

In many cases, reports have shown the main cause of marine litter to be individuals dumping or throwing away garbage [31]. However, fishing-based debris still occupies a large proportion of marine litter [3,4]. Our previous studies [32,33] served to find solutions for the most serious item, expanded polystyrene buoys for aquaculture in the Republic of Korea, and showed some differences between the sought out groups. Governmental officials, NGOs, and experts [33] suggested many potential actions according to causes, such as unintended loss, intended discard, and collection/recycling difficulties, but identifying measures with priority was not easy. In comparison, fishers proposed practical alternatives, such as raising the rate of mandatory returns, supporting collected used buoys' transportation, and raising fishers' awareness for a more effective control of used buoys [32]. In this context, fishers' opinions should be an essential component in designing and implementing new policies, and in modifying existing measures to reflect more preventive and participatory procedures.

5. Conclusion

We assessed Korean fishers' perceptions on DFG causes and measures through FAO's and UNEP's list.

The fishers answered that DFGs are abandoned, discarded, and lost in similar proportions. They evaluated both the effectiveness and feasibility of 'improved port state' and 'retrieval program' as the most important measures, whereas the lowest valued measures were 'zoning schemes' and 'avoid setting gear if identified or predicted.' They positively reviewed the Korean government's measures, and gave 'mandatory return' the highest score within the new potential regulations, showing they can accept measures that are easy to follow and bring quick result. However, all measures that would create financial burden, such as a 'deposit system,' obtained lower ratings. Fishers' participation is very important in establishing and enforcing DFG measures. We will be able to achieve policy goals more effectively and efficiently by collecting fishers' opinions and harmonizing them with initiatives.

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