Fishers' Perception Survey on the Causes and Effects of Derelict Gillnets in Republic of Korea

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Acknowledgments

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Cover picture:A diver rescuing a fish (Gyoam, Goseong-gun, Gangwon-do, Republic of Korea

Acronyms

ALDFG	Abandoned, Lost or otherwise Discarded Fishing Gear
APEC	Asia-Pacific Economic Cooperation
DFG	Discarded Fishing Gear
EPS	Expanded Polystyrene
FAO	Food and Agriculture Organization of the United Nations
IUU	Illegal, Unreported and Unregulated (fishing)
KOEM	Korea Marine Environment Management Corporation
MARPOL	International Convention for the Prevention of Pollution from ships
MOF	Ministry of Oceans and Fisheries
UNEP	United Nations Environmental Programme

TABLE OF CONTENTS

Tables

Figures

Executive Summary

Marine plastic pollution is being discussed as one of the three major global crises of climate change, nature loss, and pollution. Although the amount of marine plastic litter entering the sea is relatively smaller than total plastic wastes generated in the globe, it causes various and serious damages in the sea. Many literatures mention that the majority of marine plastic litter comes from land. However, the damage caused by derelict fishing gear from seaborn sources is not negligible but widespread, persistent, and irreversible. Among the derelict fishing gears, gill nets are reported on the seriousness of several literatures. In the case of Republic of Korea, the fishing nets used by gillnet fishing account for an important portion of the total fishing net use, and the report on the damage to the seabed ecosystem showed that the ghost fishing and the ecosystem damage caused by gillnets were the most serious.

In this study, we directly heard opinions on the causes and countermeasures of gillnet waste from gillnet fishermen in Republic of Korea and collected information on gillnet fishing gear. A total of 61 gillnet fishermen catches 22 different species, including akiami paste shrimp, swimming crab and angler fish. Fishers responded that the causes of derelict gillnets mainly generated due to being lost, followed by abandonment, discarding and others. Gear loss rate was estimated to be 16.9% and it was ca. three times higher than that of global average of gillnets in the recent research. ‘Extreme weather’ did not receive a high score of cause because of the fact that fishers may refrain from deploying their nets in bad weather conditions according to forecasts. In relation to gillnet types, drift nets were found to be longer and heavier on average than the set gillnets and encircling nets.

In general, fishers preferred government interventions such as collection projects and installing collection facilities over measures that required more active participation among fishers. They considered mandatory retrieval of fishing gear as well as implementing gear marking system as acceptable. On the other hand, reporting gear loss or zoning schemes to avoid gear conflict were not favorable. The low level in perceived efficacy in the case of reporting gear loss may indicate general rejection to the measure. ‘Gear marking’ and ‘extending outreach program for fishers’ were considered mostly ineffective by fishers despite its importance being emphasized among many other stakeholder groups and scientific research. The results imply that it is necessary to develop policies in which fishermen can actively participate for the effective implementation of the government interventions. Involving fishermen in policy development through workshop and providing compensation to fishermen who actively participate in measures can be helpful.

The most negative impact of DFG was ‘reduction of fishery resources’, followed by ‘destruction of marine habitats’, ‘damage to ships’, ‘generation of microplastics’, and ‘damage to marine life’. The most reported type of damage from DFG among 53 fishing vessels was propeller entanglement with 77%. The cost incurred by damages to vessels was the highest by ‘engine failure’ on average among all major target species, ranging from US $841 to US $8411 per one repair. The results indicate that the impact of DFG on gillnet fishery is ubiquitous and improved management by fishermen and

government should be urgently implemented.

It is only a basic study conducted on only 61 of the 13,000 gillnet vessels. In the future, we will need to meet more fishermen and get more opinions before we can come up with a viable alternative to this problem.

I. Introduction

In recent years, marine debris has been recognized as a major threat to the marine ecosystem and its sources, transports and impacts have been intensively researched. Among them it is widely documented that the majority of it originated from land. However, the contribution of ocean-based sources has been greater than land-based sources in some regions and fisheries are the major contributors. Abandoned, lost or otherwise discarded fishing gear (ALDFG) originated by the fishery industry, has long been reported to have caused a lot of damage both to the fishery industry and the marine environment (Gilman et al., 2016; Kuemlangan et al., 2011; Macfadyen et al., 2009). In the mid-1960s, ghost fishing, in which discarded fishing gear returned damage to the fishery industry by retaining its capture function underwater, became widely recognized as a serious problem (Matsuoka et al., 2005). There have also been frequent reports of cases when even protected species of marine mammals were being entangled and killed by abandoned fishing gear that acts as a trap (NOAA Marine Debris Program, 2015). Specifically, during the early years of International Marine Debris Conferences, relatively more attention was put on the derelict fishing gears and their impact (Ryan, 2015). Recent study revealed that industrialized fishing countries largely contribute the floating plastics in the North Pacific subtropical gyre (Lebreton et al., 2022).

These findings led to an improved management of waste from ships around the globe through the revision of MARPOL73/78 (Julian, 2000), despite its implementation, however, the problem of abandoned gear does not seem to have been reduced (Chen, 2015). This may be because many small sized fishing vessels, notably those under 12 m, are exempted from the MARPOL regulation or because there are no fundamental measures in place to control illegal, unreported, and unregulated fishing (Richardson et al., 2018).

It is noteworthy that ALDFG was defined by McFadyen et al. (2009), reporting on the problem of abandoned gear and its damage synthesized. They pointed out that gillnets among various types of fishing gears cause a lot of damage internationally stepping up to classify the cause or motive of the occurrence of abandoned gear and present measures to determine an appropriate response to it. Since then, some reports of the FAO have shown that the problem of abandoned gear is getting more serious, and they are trying to solve this problem through a voluntary gear marking system or the Glolitter project in recent years (Stöfen-O'Brien et al., 2022).

Fisheries take up a significant portion of the Korean Economy (OECD, 2021), thus it is possible to deduce that the problem of derelict fishing gear (DFG) looms large. As a country surrounded on all three sides of the peninsula by the sea with a diverse natural environment, Korean seas are suitable grounds for which the fishing industry can be well developed. Among these fisheries, numerous fishing gears and methods are developed and used, which on the flip side leads to an increase of fishing gears discarded in the ocean. Jang et al. (2014) was the first to estimate that on average 91,195 tons of marine litter flow into the sea annually, among them, 53.1% or 48,463 tons of litter originates from the fishing industry. About 48.3% or 44,081 tons are DFG from the fishing boat industry and 4,382 ton is from

Styrofoam buoys used for aquaculture (Table 1). The result of this research is based on the data of a nationwide online survey on 1,371 fishers conducted in 2007. Another estimate of the gross quantity of gears generated was examined in Kim et al. (2014) that focused on traps and gillnets which consist 95% of all DFG. Questionnaire survey one on one and via mail was conducted and the result was analyzed using regression analysis on the aforementioned two types of fishing, on a total of 381 fishers (247 gillnet fishers) (Kim et al., 2014). It was claimed in this research that a total of 49,970 ton, 11,436 tons of traps and 38,535 tons of gillnets, were annually abandoned (Table 1).

Table 1. *Previous research on derelict fishing gears quantitatively estimated in Korean seas*

References	Number of fishers	Estimated quantities of derelict gillnets	Remark
Jang et al. (2014)	1,371 fishers nationwide surveyed by mail in 2007	44,081 ton per year Fishing gears lost per boat per year: 894 kg Multiplied by number of capture fishing boats of 49,308 (coastal 46,463 ton and offshore fishing 2,845)	48.3% of annual input of marine litter nationwide
Kim et al. (2014)	247 (212 interviewees +35 mails) gillnet fishers	9.64 sets of gillnets are discarded annually and multiplied by national number of tons for gillnet operation numbers 41,789/5 t x 9.64 set x 478.4 kg = 38,535 ton of gillnets	

Despite the economic importance, the commercial fishing boat industry in Korea is in a steady decline and so the amount of abandoned fishing gears needs to be reduced. According to the past 10 years of data from Statistics Korea (kostat.go.kr), the fisher population was 149,000 households in 1970 to 51,000 households in 2019. The significant decline in the overall fisher population, together with the fact that the Ministry of Oceans and Fisheries is actively undergoing cleanup projects, must guarantee that the amount of DFG generated and existing amount in the ocean is declining.

Contrary to this speculation, however, marine litter found in Korean beaches consists largely of DFG. In 2008~2009, 35.3% out of all marine litter in coastal areas consisted of DFG (Hong et al., 2014), and in terms of numbers it mostly consisted of Styrofoam buoy and rope that even after 14 years still make up a large majority (MOF, Ministry of Oceans and Fisheries) and KOEM (Korea Marine Environment Management Corporation, 2021). Especially, in the case of nets, although speculated to have significant impact, its significance is not reflected data wise. In other words, the data on nets tends to be underestimated than actuality due mainly to the fact that it is often discovered tangled in large volume which makes it hard to count individually.

1.1. Navigational Threats Caused by Derelict Fishing Gear and Derelict Gillnet

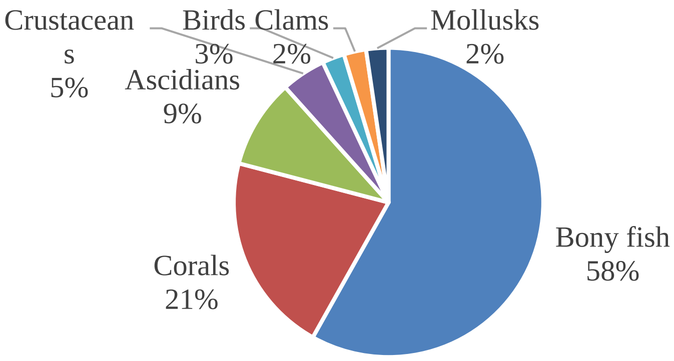
A recent study has found that DFG poses navigational hazards to ships at sea due to entanglement with propellers. Hong et al. (2017) assessed that the annual average number of incidents for derelict fishing gear (DFG) entanglement with Korean navy vessel propellers reached up to 400 cases, with its frequency showing only a negligible decrease from 465 cases in 2010 to 383 cases in 2015. Despite this, it was also proven that the weight of DFG removed from the entangled propellers increased in the same period. In relation to sea areas, entanglement by DFG was reported on all sea areas, with the highest quantity reported in the western and southwestern sea than any other, while the southeastern sea area showed an increasing trend from 2010 to 2015.

1.2. Impacts on Marine Life caused by Derelict Fishing Gear and Derelict Gillnet

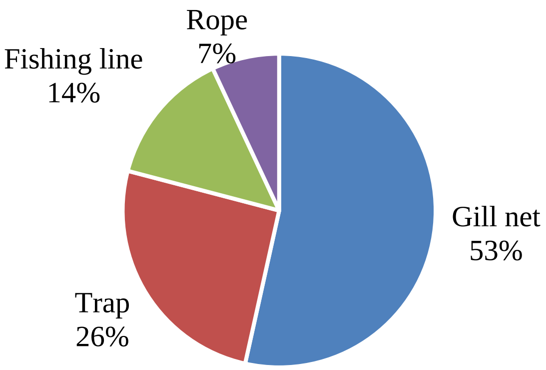
DFG plays a significant role in the research on its impact of marine litter on the ecosystem. A study on the impact of marine litter on wildlife in coastal ecosystems in Korea, Hong et al. (2013) analyzed 45 cases of wildlife damage due to marine litter founded from 2003 to 2012, a total of 21 animal species in 11 orders were affected by marine litter including species of birds, mammals, and crustaceans. Despite not being quantitative research, this study identified main types of debris affecting wild animals to be from recreational and commercial fishing activities such as nets, hooks, ropes, lines, traps, and lead weights. Due to the difficulties in collecting observational data of wildlife impacts and the fact that some data on wildlife impact were gathered from wildlife rescue centers located inland and cases caused by by-catches or active fishing gears were excluded, this study put more emphasis on recreational fishing gears such as hooks, lines, and lead weights. Although limited, in the sense that it does not provide quantitative analysis of the threats that DFG pose on coastal ecosystems, there were still few cases where derelict fishing nets had lethal impact on bird and mammal species.

A recent report based on data collected by scuba divers during 2013 to 2020, focuses more on the underwater ecosystem and provides a clearer view on wildlife impact from DFG (Kwak et al., 2021). A total of 43 cases recorded by professional scuba divers were analyzed, identifying underwater DFG such as nets, traps, fishing line and ropes to be the main causes of marine wildlife impact. In this study, gillnets more than any other DFG submerged, were found to be the most destructive to wildlife in marine ecosystems.

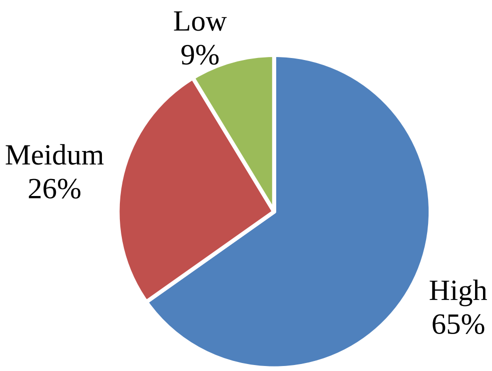
Based on the analysis obtained from the photos collected by scuba divers in the eastern and southern seas of Korea (Kwak et al., 2021), one can take a close look at the devastating impacts that DFG, including gillnets, has on marine life. In fact, according to eight years of underwater photographs documenting the damages, the most affected species was the bony fish (Osteichthyes) which accounted for 23 out of 43 cases (Figure 1a). In addition, it was found that DFG was also impacting various marine life such as corals, ascidians, crustaceans, cephalopods, bivalves, and algae.



(a) Percent of total impact of marine litter on marine life by species



(b) Percent of marine life impacted by litter types



(c) Percent of marine life impact according to degradation level of litter

Figure 1*. Impacts of marine litter on underwater ecosystem (Kwak et al., 2021)*

When categorizing marine life impact by types of marine litter, the greatest number of cases were identified to be impacted by gillnets, which were 23 cases and accounted for 53% of the total 43 cases

(Figure 1b). Other causes they have found in order of occurrence were trap 11 cases, recreational fishing line 6 cases, and rope 3 cases. Such findings made it possible to estimate the risk posed by DFGs.

When classified according to the condition of the gillnet, it was found that gillnets, both old and new, were posing a risk to marine life. Of 23 cases of marine life impacts caused by gill nets, 15 cases were caused by old gillnets which accounted for 65% of the cases (Figure 1c). Such findings illustrate DFG such as gillnets has the potential to continuously impact marine life even after a substantial lapse in time.

1.3. Purpose

Unlike the growing importance of land borne marine litter in the international community, debris from capture and aquaculture fisheries are more abundant and impactful in Korea. This is also why the Ministry of Oceans and Fisheries' policies centered around DFG policies sustain. According to the prolonged coastal marine litter monitoring in Korea, the cause of major types of marine litter was identified to be seaborne. Most significant among these seaborne marine litters were, EPS buoys used in aquaculture, ropes and traps (Hong et al., 2014) in order of number. There have been various research and policy development to resolve problems related to Styrofoam buoy used in aquaculture (Lee et al., 2015). On the other hand, in a research estimating annual amount of waste generated (Jang et al., 2014), it was discovered that DFG from capture fishery made up a much more significant proportion than light and brittle Styrofoam buoys in weight. Furthermore, it has been mentioned in studies such as Kim et al. (2014) that 95% of all discarded fishing nets found in Korea's coastline were trap net and gillnet. Despite the significance of the impact sustained from various fishing gears including gillnets, there has never been a thorough study that directly interviews fishers, specifically gillnet users among them, to approximate the types and amounts used and identify the cause of DFG from their practices.

The purpose of this research is to focus on DFG, specifically gillnets, as they have the most devastating impact on marine life as well as the fishing industry that depend heavily on it. We aim to collect basic information through one-on-one interviews of gillnet fishers regarding the use of fishing gear, the causes that lead to the loss and discarding of fishing gears, the effectiveness of policies that manage derelict gillnets, and the level of marine environmental awareness among gillnet fishers. We also try to estimate damages of DFG on ships by frequency and cost. By understanding the level of awareness on marine litter among local residents, their fishing methods and types of fishing gear used at the local level, we hope to provide preventive measures and countermeasures that can be recommended worldwide.

This research, as follow-up research of Kwak et al. (2021) and preliminary research on gillnets, will contribute to a more specific assessment of the status. We expect future research based on this report will utilize systematic research design to lend more statistically meaningful assessment.

2. Current Status of Gillnet Fishing in Korea

2.1. Current Status of Fishing Operations and Fishing Vessels

The number of domestic fishery households significantly decreased from 149,000 households in 1970 to 51,000 households in 2019. At the same time, the number of fishing vessels fishing inshore and offshore also clearly decreased (Figure 2). In 2019, there were 2,677 offshore fishing vessels and 37,785 inshore fishing vessels. Compared to 2000, inshore fishing vessels decreased by 49.4% and offshore fishing vessels decreased by 40.3% (Figure 3). The continuous decrease in the number of fishery households and fishing vessels is thought to be due to the aging of the fishers and the decrease in the amount of fishery resources in the fisheries.

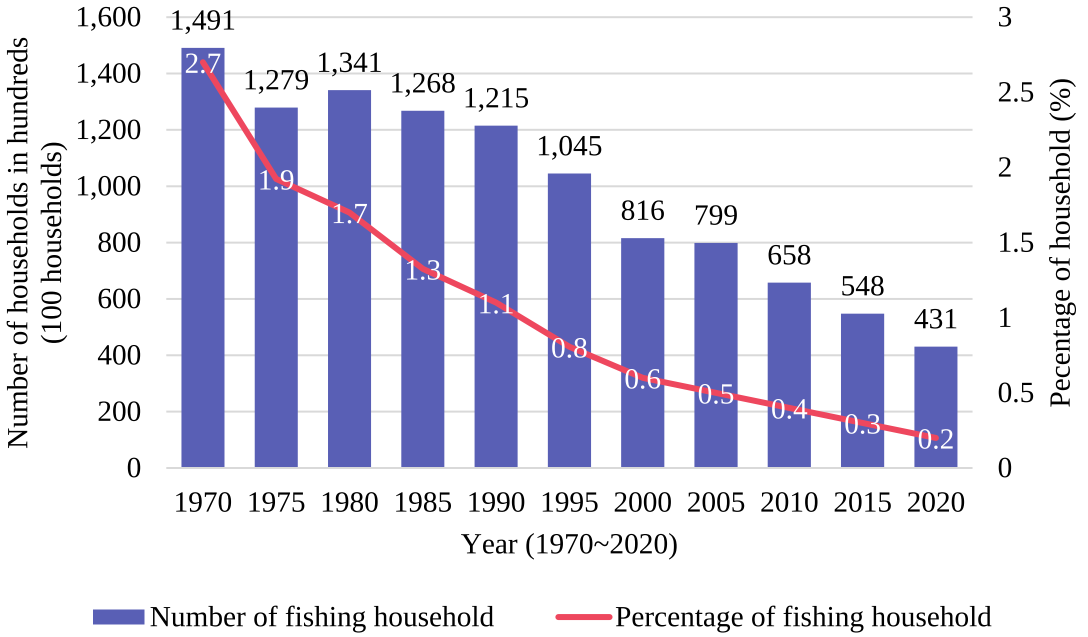


Figure 2. *Changes in the number of fishing households nationwide and percentage of fishery households to nationwide households (Source: Statistics Korea)*

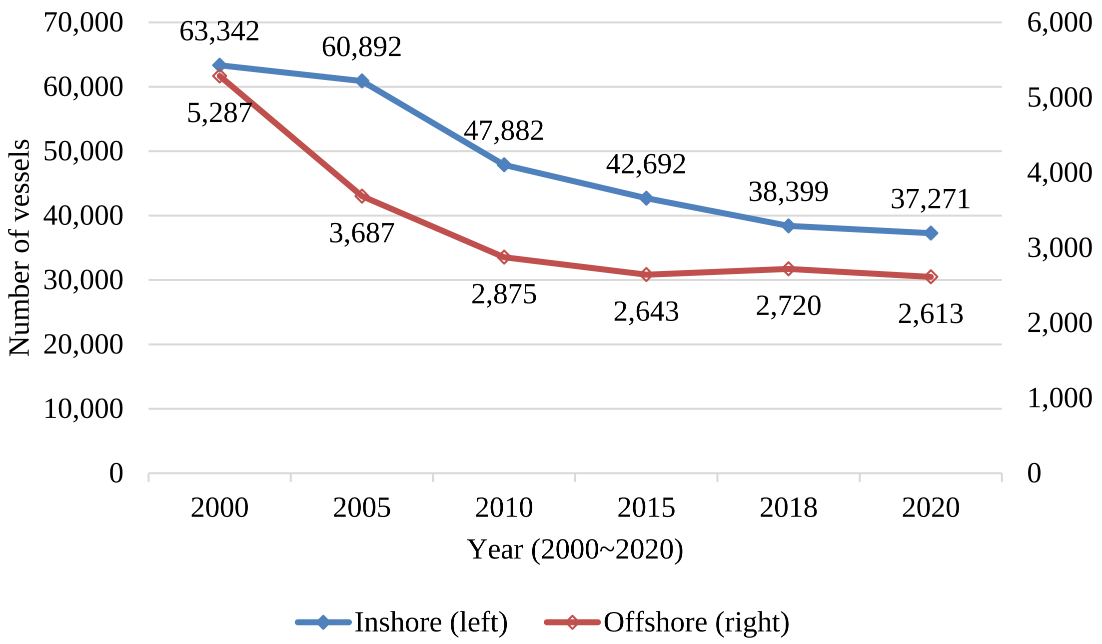


Figure 3. *Number of domestic inshore and offshore fishing vessels (Source: Statistics Korea)*

2.2. Current Status of Gillnet Fishing

In 2019, there were 419 inshore gillnet vessels and 12,592 offshore gillnet vessels. This is a decrease of 63.4% for inshore gillnet vessels and 27.5% for offshore gillnet vessels compared to 1992 (Figure 4). Fishery resources caught using inshore gillnet peaked at 106,742 tons in 1999 (Figure 5). Since then, it has markedly decreased only to be slowly increasing in recent years. The recent increase in fishery catches could be due to more widespread use and development of fish detecting devices and other advanced technology often used in gillnet fishing operations.

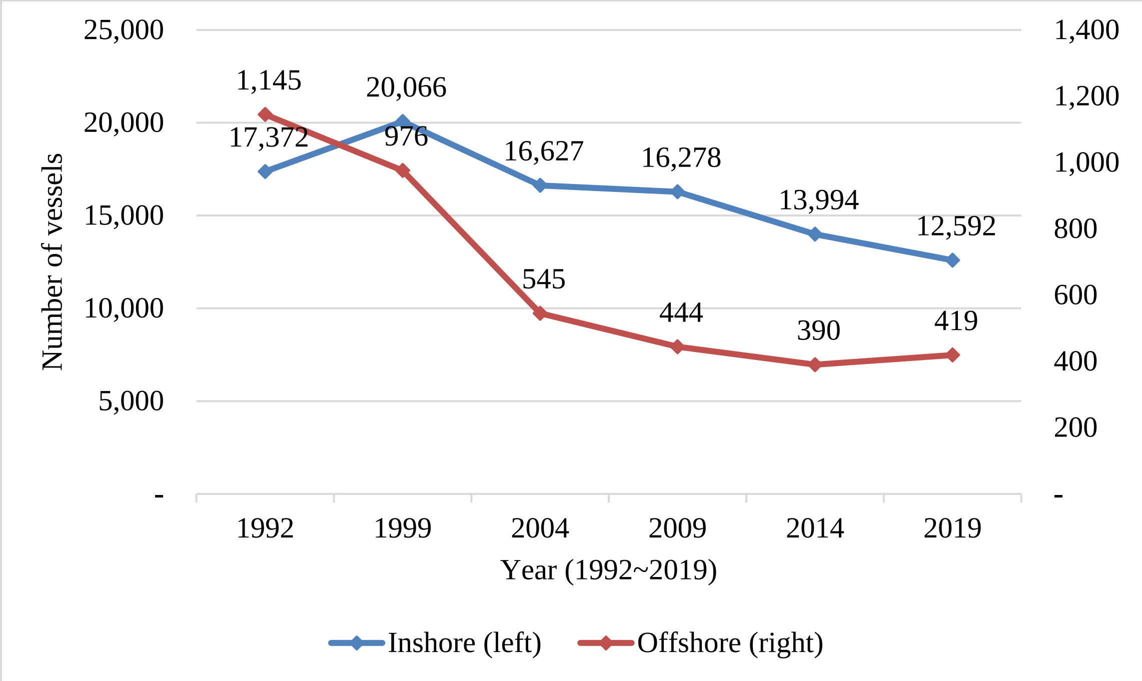


Figure 4. *Domestic offshore and inshore gillnet fishing vessels (Source: Statistics Korea)*

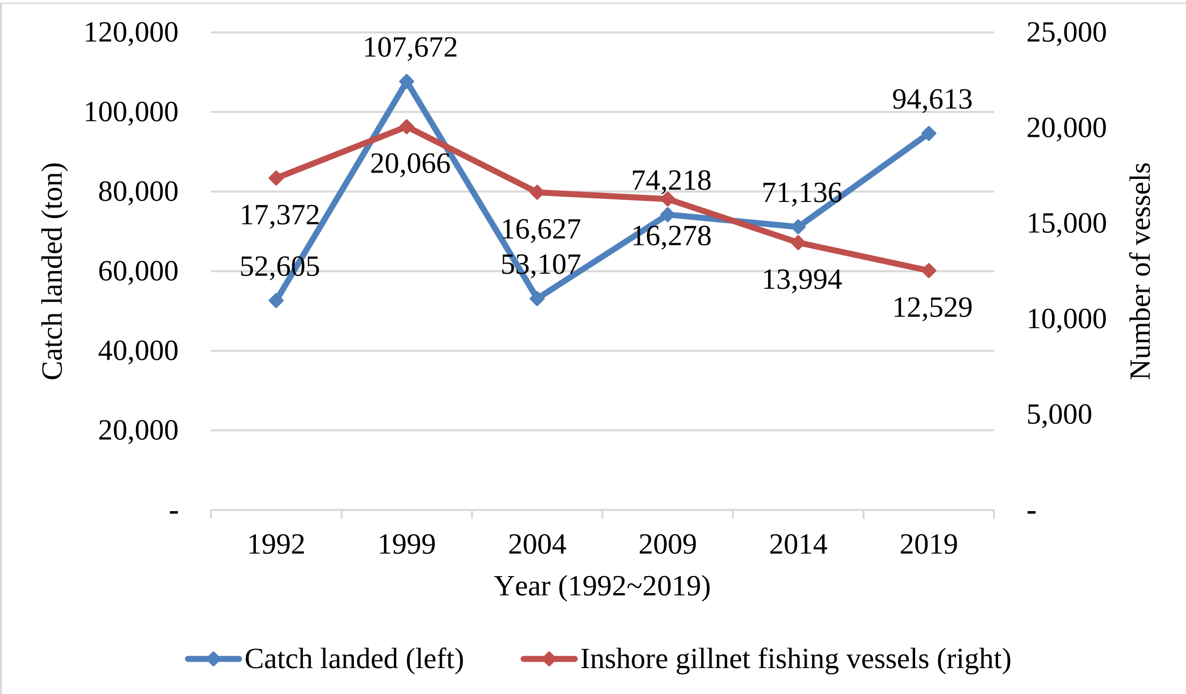
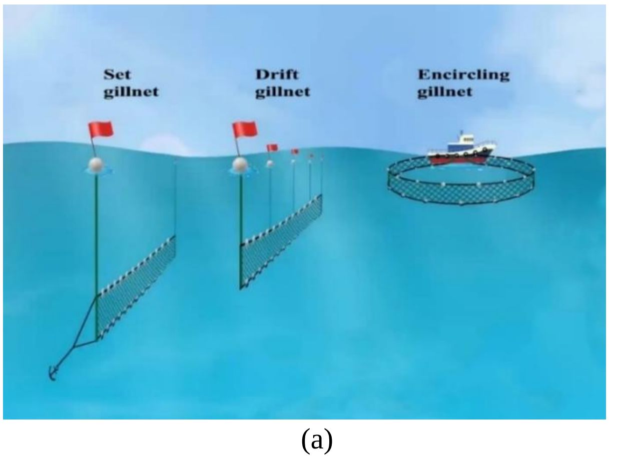


Figure 5. *Estimated catch and number* of fishing vessels in inshore gillnet fishery *(Source: Statistics Korea)*

2.3. Types of Gillnets

Gillnetting is a fishing method that uses a long rectangular wall of mesh netting that hangs vertically in the path of fish schools for a set period. Utilizing knowledge on feeding habits of fish living in a particular swimming zone, gillnet fishers adjust the depth by modifying the head rope (or float line attached with small floats) and foot rope (attached with small weights or sinkers) and keep the nets vertically opened in the water column where target species are found (Figure 6). Gillnets are passively operated stationary gears as they are left in the water unattended until retrieval, thus being more susceptible to being lost due to factors such as weather conditions or currents when compared to active fishing gears.

Gillnets are classified by the fishing methods (set, drift, or encircling), installation depths (surface, midwater, or bottom), and fishing locations (inshore or offshore) (Figure 6).



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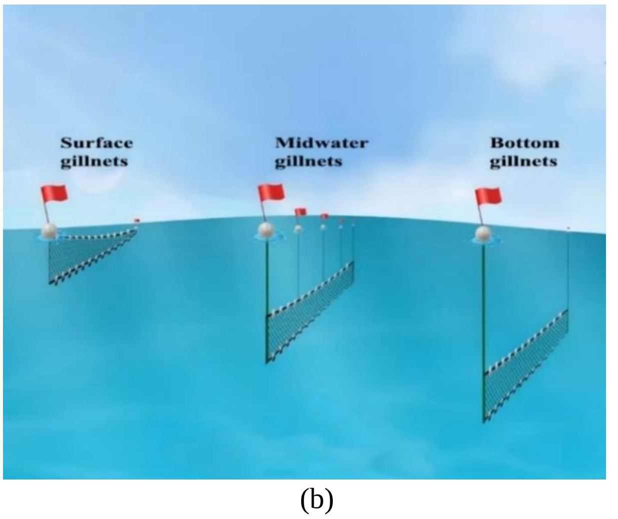


(b)

Figure 6. *Classification of gillnet fishing*

(a: classification by installation depth, b: classification by fishing method, Source: National Institute of Fisheries Science)

Set or fixed gillnet is the most common type of gillnets and entangle nets. Set gillnet is secured to the seabed by placing anchors on one or both ends of the net. Drift gillnet is a type of gillnet not fixed to the seabed that freely drift with the current. This type of net usually fish on or near the surface or mid water and often attached on one end with a vessel or a buoy. Encircling gillnet is a long gillnet set in a circular shape to encircle the fish aggregation and capture them in the mesh by driving them to the net either with audio or visual stimuli or other means. This type of gillnet is used in shallow waters (Figure 6a).

Gillnet fishing can also be classed as either inshore or offshore (Table 2). Inshore gillnet fishing refers to when a non-motorized or a motorized fishing vessel uses a rectangular gillnet. In Korea, inshore gillnet fishing targets saury, herring, and filefish in all coasts. The average carrying capacity of fishing vessel is less than 10 tons, the engine averages 236 horsepower, and approximately 2 to 6 crew members are on board. In offshore gillnet fishing, motorized fishing vessel is used targeting species such as croaker, squid, saury, and yellow tail in all offshore waters. The average carrying capacity ranges from 10 to 90 tons with an average of 709 horsepower for the engine. On a 20-ton vessel, approximately 7 to 8 crew members are on board (National Federation of Fisheries Cooperatives, 2019).

Table 2*. Classification and details of gillnet fishery by fishing locations (National Federation of Fisheries Cooperatives, 2019)*

Category	Size of fishing vessel (Average horsepower)	Major target species	Average number of crew members
Inshore gillnet fishing	Non-motorized or Motorized – less than 10 tons (236 horsepower)	Japanese anchovy, Squid, Pacific saury, Pacific herring, Mullet	2 to 6
Offshore gillnet fishing	Motorized – 10 to 90 tons (709 horsepower)	Japanese anchovy, Croaker, Mackerel, Squid, Pacific saury	7 to 8 (20-ton vessel)

2.4. Components of a Gillnet

The component of a gillnet differs by each type of set, drift or encircling, however, the most basic components are as follows: buoys indicating the location of fishing gears; buoy ropes connecting the buoy and gillnet; floats and head rope attached near the top of the net; weights and foot rope attached to the bottom of the net erecting the net vertically. In case of set gillnet, anchor or weight and anchor rope connecting the net to the anchor or weight is used to secure the net to the sea bottom (Figure 7). Depending on the number of overlapping nets with different mesh sizes, gillnets are divided into single gillnet, double gillnet, and triple gillnet (Figure 8). In Korea, the use of gillnet with more than double layers is prohibited by the law (Fishery Resources Management Act, 2019). Only particular licensed industries may use with permission.

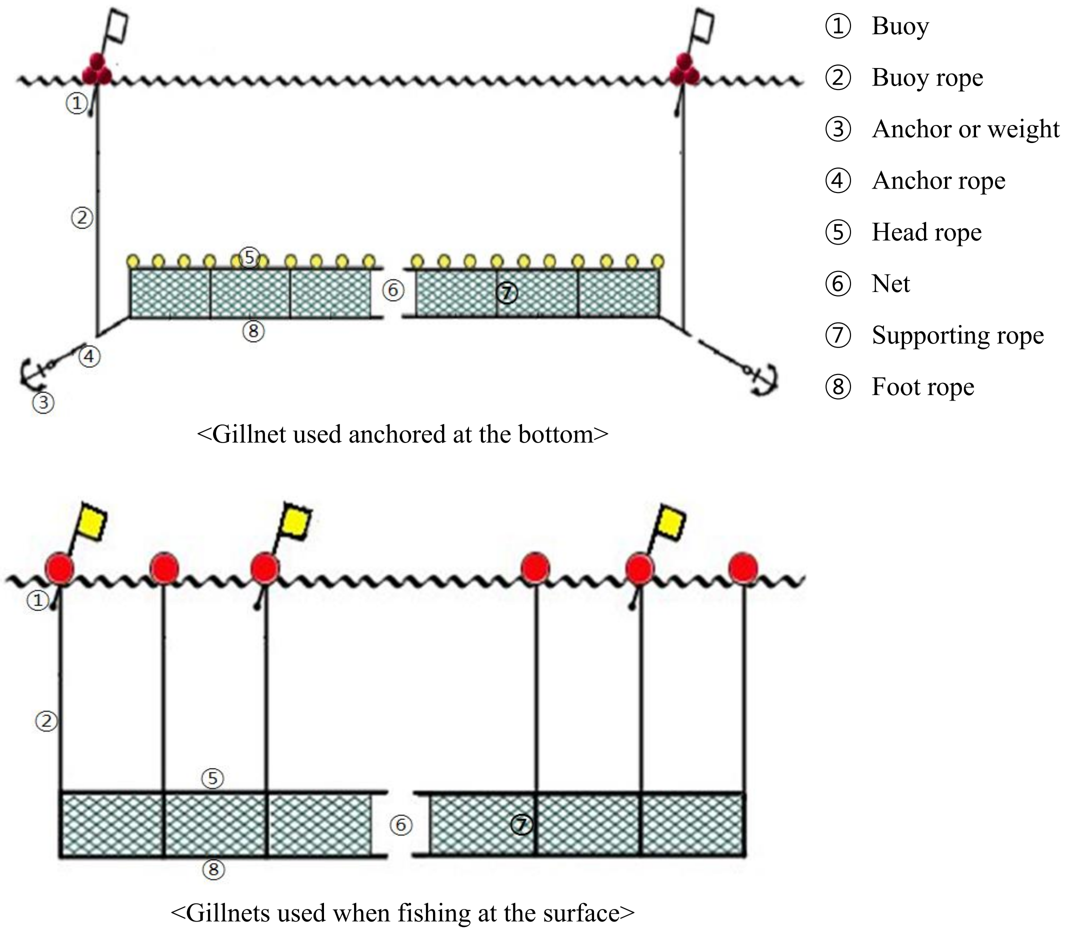
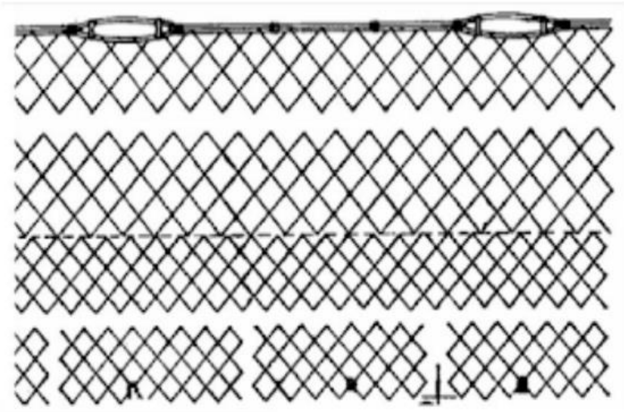


***Figure 7**. Basic components of a gillnet (Source: Ministry of Oceans and Fisheries)*



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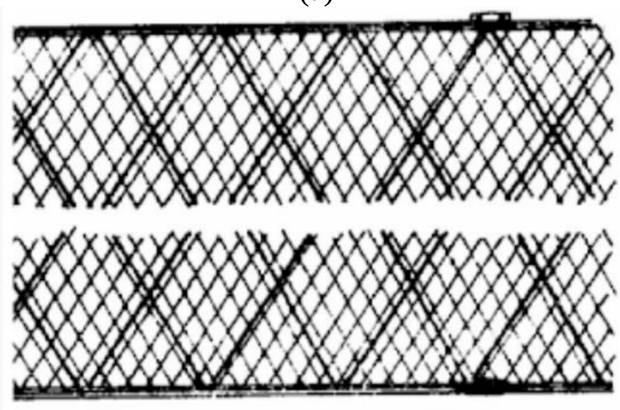

(b)

Figure 8. *Different gillnet structure*

(a: double gillnet structure, b: triple gillnet structure, Source: National Institute of Fisheries Science)

In Korea, the use of gillnet with more than double layers is prohibited by the law (Fishery Resources Management Act, 2019). Only particular licensed industries may use with permission.

2.5. Main Target Species and Fishery Catches of Inshore Gillnet Fishery

The five major target species with highest catches over the past five years in inshore gillnet fishing are flounders, anchovy, anglerfish, akiami paste shrimp, and swimming crab (Figure 9). The catches of each target species show different trends from year to year. Currently, the target species of gillnet fishing are determined by the fisher's authority. Due to the inability of ensuring the catching of desired target species, fishers have the authority to change their target species based on the size of their vessel.

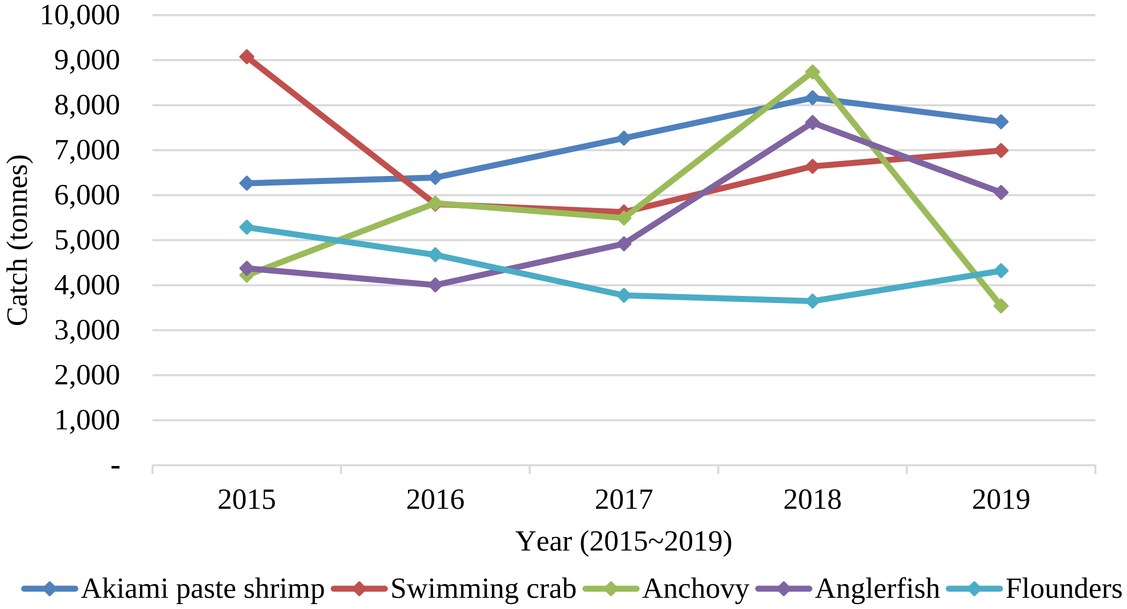

Figure 9. *Catch weight of major target species in inshore gillnet fishing (Source: Statistics Korea)*

2.6. Gillnet Construction Classified by Target Species

Gillnets are constructed differently according to the characteristics of target species to maximize catch efficiency. Below are some of the available examples and pictures of gillnet constructed for major target species such as swimming crab, snow crab, flounder, and Japanese sandfish (Figure 10). All target species except for Japanese sandfish are covered in this report. Although excluded from this survey, example of gillnets constructed for Japanese sandfish can shed light to how gillnets targeting bony fishes (or Osteichthyes) are designed.

a) Swimming crab **(Unit: mm)**

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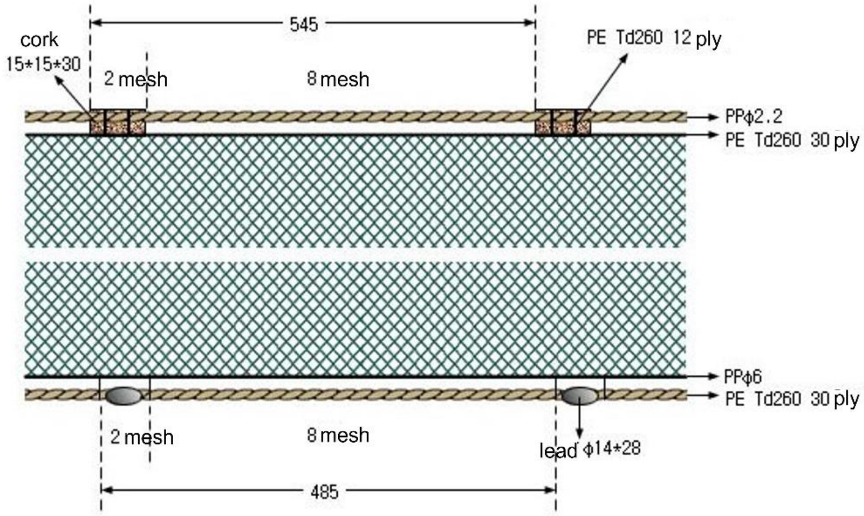

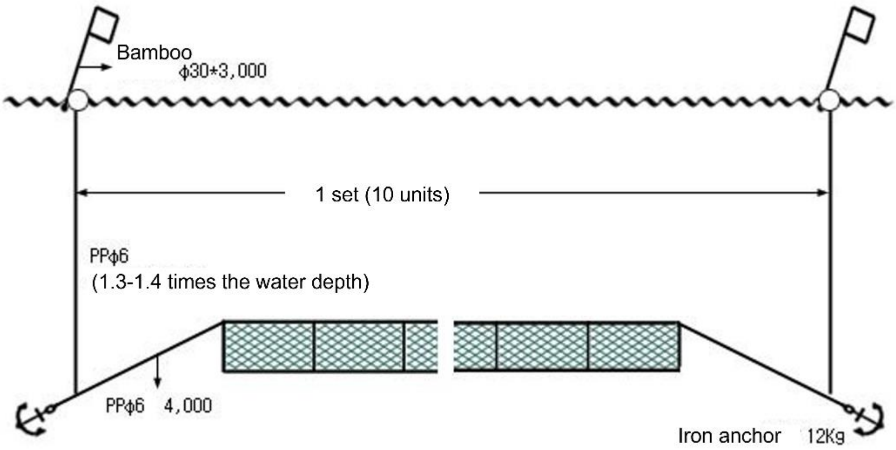

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b) Snow crab	**(Unit: mm)**

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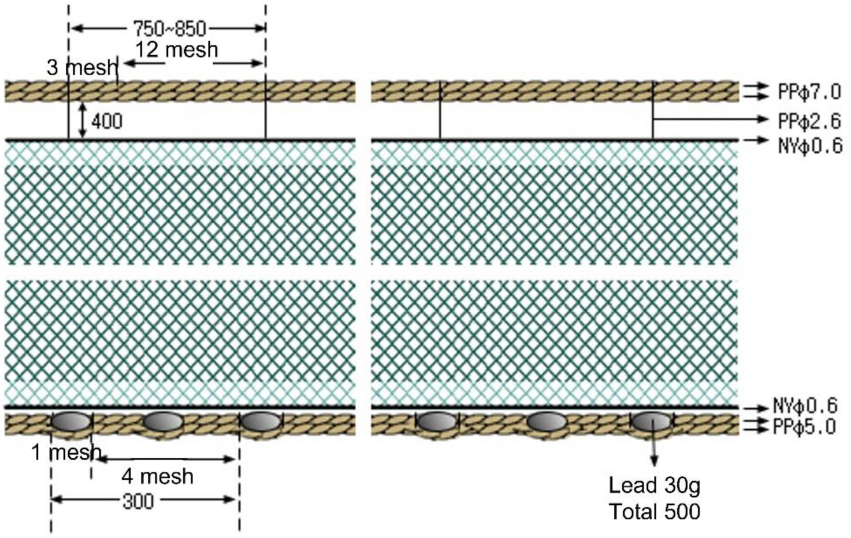

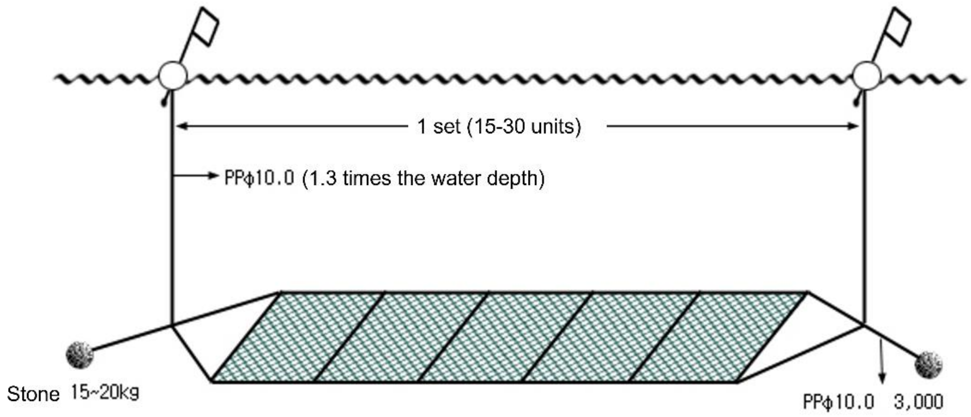

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c) Flounder **(Unit: mm)**

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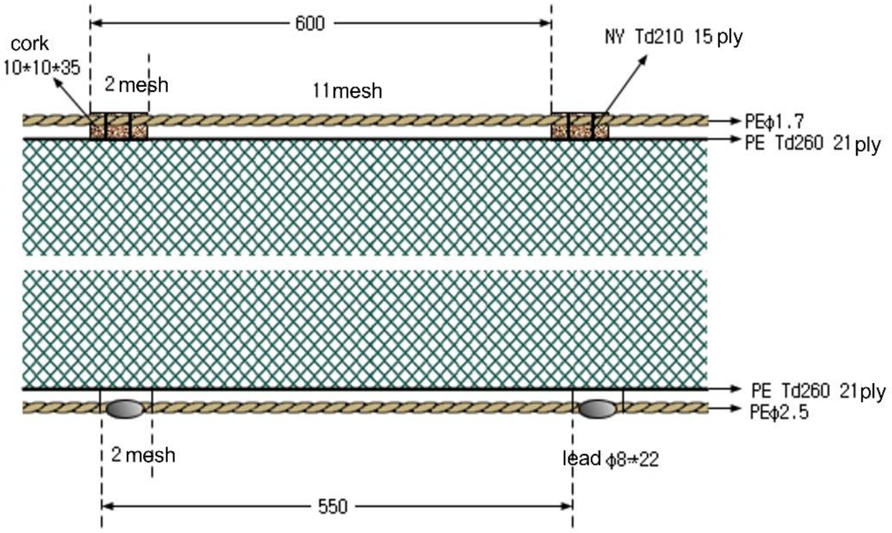

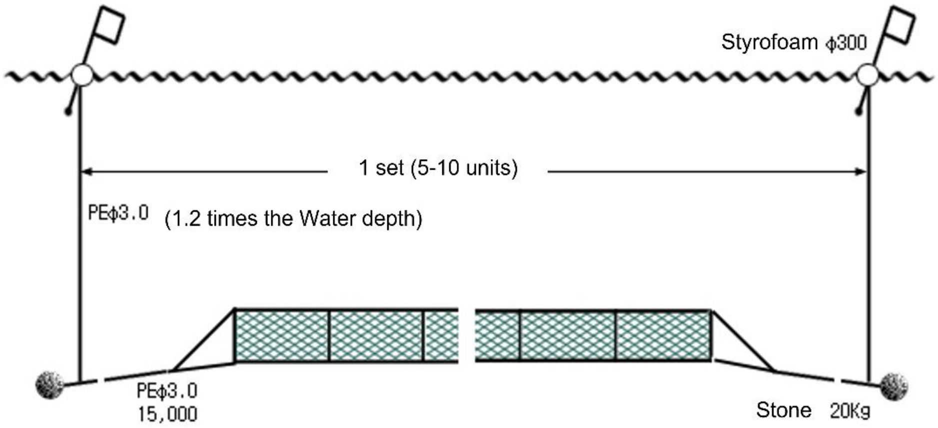

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d) Silver Pomfret	(Unit: mm)

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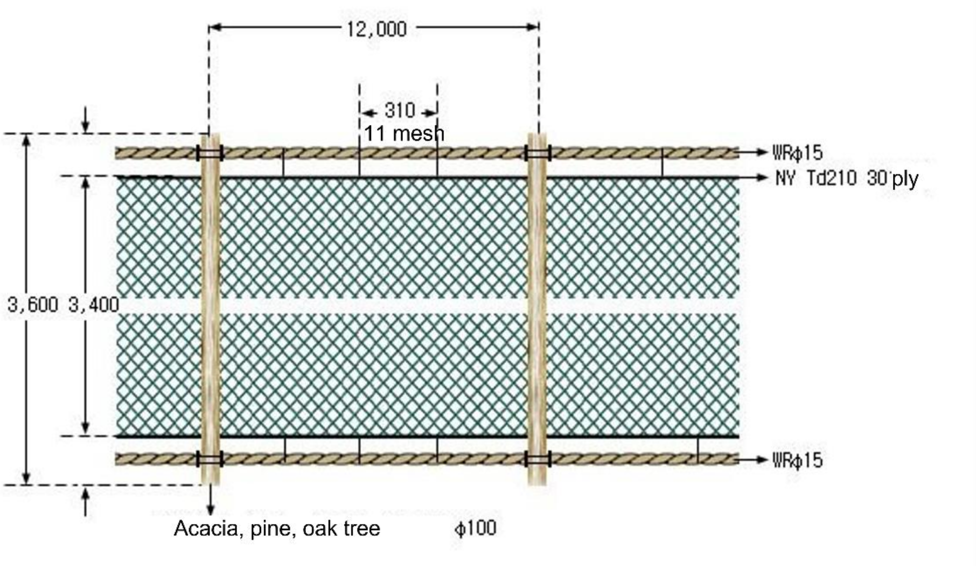

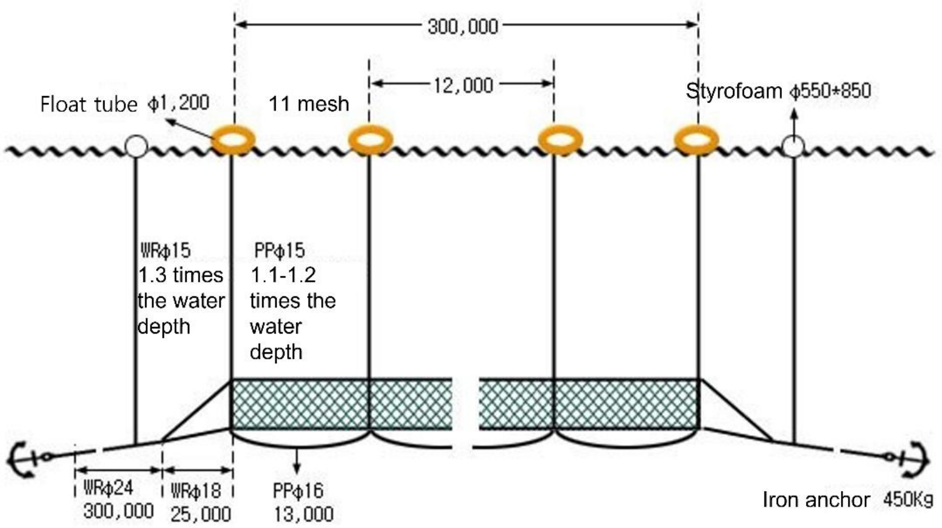

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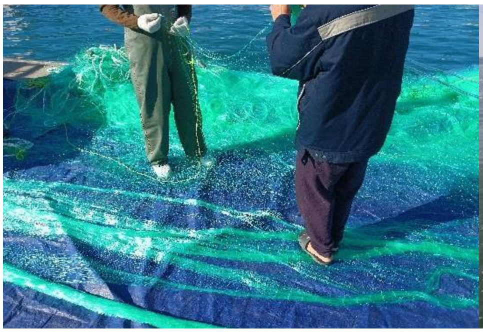
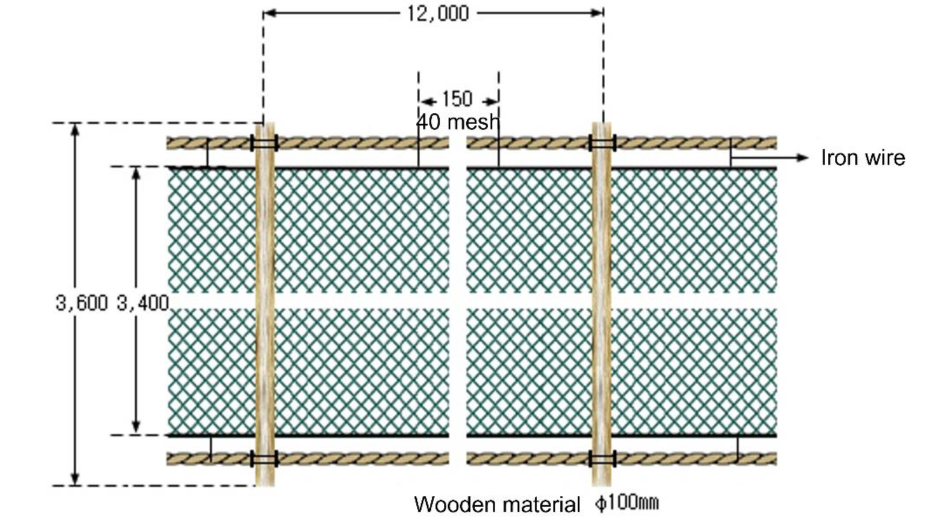
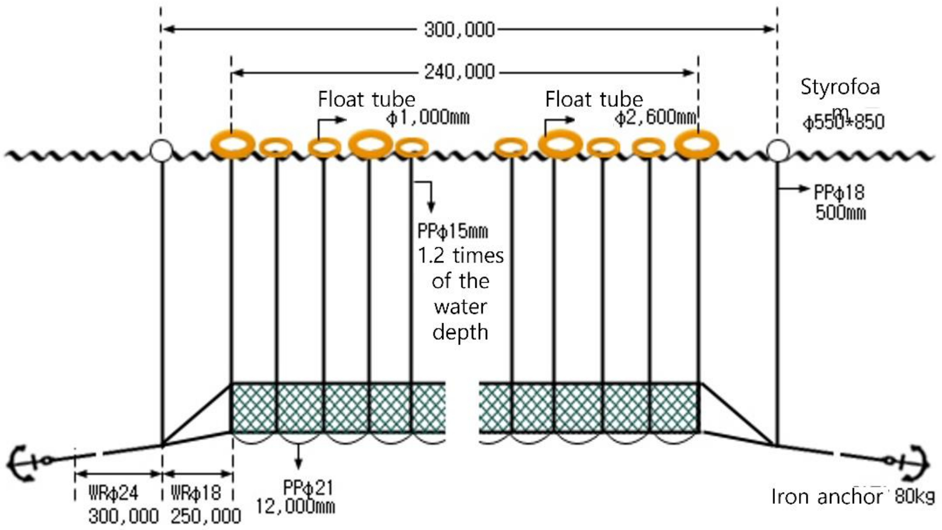


e) Akiami paste shrimp **(Unit: mm)**

<Illustrations>





<Pictures>

Figure 10*. Illustrations and pictures of gillnet construction for major target species*

(a) swimming crab, b) snow crab, c) flounder, d) silver pomfret, e) akiami paste shrimp,

(Source: National Institute of Fisheries Science)

3. Method

3.1. Survey Participants

The survey respondents were selected in consideration of classification of target species of coastal areas. We classified fish species caught in excess of 3,000 tons by three coastal area (eastern, southern, and western) based on the current status of catches in coastal gillnet fishing in 2019 by sea, and selected fishers who caught them as survey candidates of the respondent (Table 3). For each sea area, fishers catching herring and flounder on the eastern coast, shrimp and swimming crab on the western coast, and anchovies and anglerfish on the southern coast were targeted. The reason for this selection was that it was expected that the fishing boat industry with a large catch would provide representative information on gill netting fishing gear due to the large number of fishing vessels, the use of large amounts of fishing gear, the long fishing period, and the frequent use of the fishing gear. In addition, the survey of gillnet fishers about the major fish species caught differs in the material, shape, size, installation method, fishing period, etc.

Table 3. *Coastal gillnet fisheries by target species and catch landed (as of 2019) (National Federation of Fisheries Cooperatives, 2019)*

Rank	Common name of fish species	Landed Weight (ton)	Coastal area
1	Akiami paste shrimp	7,629	western sea
2	Swimming crab	6,991	western sea
3	Angler fish	6,059	southwest sea
4	Herring	5,438	eastern sea
5	Flounders	4,319	all seas
6	Anchovy	3,537	all seas
7	Others	2,898	-
8	Gizzard shad	2,451	southwestern sea
9	Mullet	2,089	all seas
10	Other shrimps	2,047	-
11	Pacific saury	1,913	eastern and southern sea
12	Halibuts	1,857	all seas
13	Mackerels	1,679	southern and western sea
14	Sea snails	1,565	-
15	Pomfret	1,492	southern and western sea
16	Sand lance	1,462	all seas
17	Lady crab	1,377	all seas
18	Small yellow croaker	1,329	southern and western sea
19	Sailfin sandfish	1,328	eastern sea
20	Hake	1,207	all seas
21	Red Snow Crab	1,154	eastern sea
22	Cuttlefish	1,045	all seas

The survey was designed to be conducted with 60 or more gillnet fishers fishing in the eastern, western, and southern seas of the Korean peninsula with 20 gillnet fishers per sea. However, due to the Personal Information Protection Act in place, finding fishers according to target species was a difficult task. Therefore, we expanded the survey participants to include fishers who catch other target species not listed above. Eventually, as Figure 11 shows, the survey was conducted on fishers who catch a total of 12 different target species without being limited to the survey participants selected according to the targeted species in the original design. The recruited survey participants were residents of Goseong Gun (n=11), Uljin Gun (n=14), Tongyeong (n=12), Goheung Gun (n=8) and Seocheon Gun (n=16). More details are elaborated in survey results.

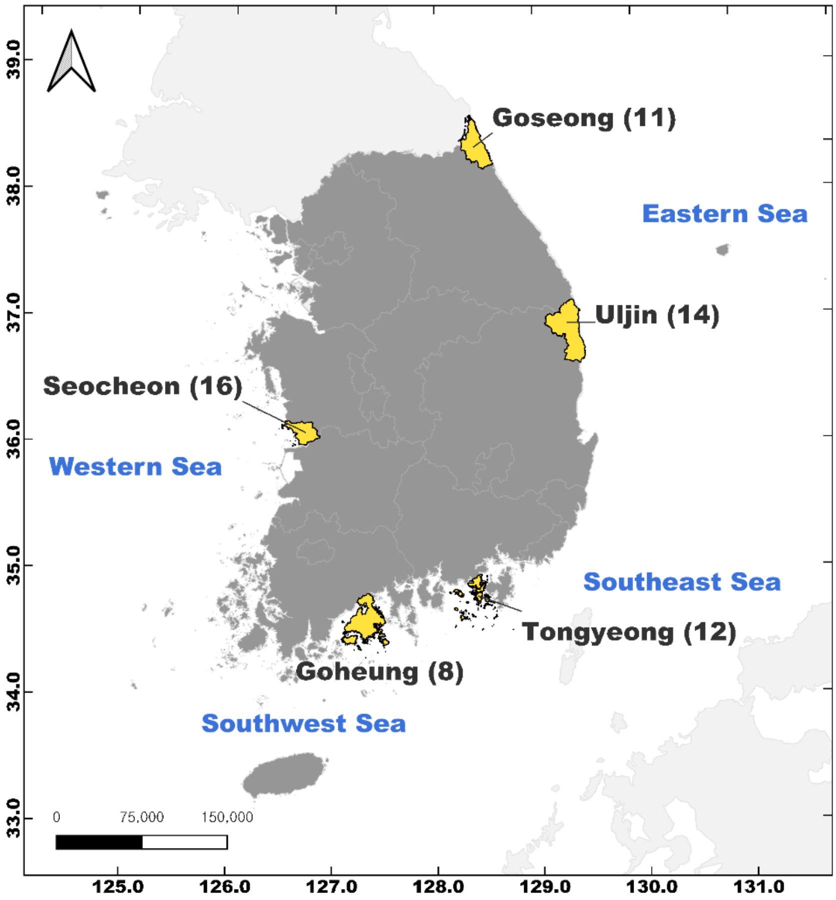


Figure 11. *Geographical distribution of survey participants (numbers in brackets represent the number of respondents)*

3.2. Survey Contents

Considerable efforts were made to develop a survey form. The preliminary form was developed to close the information gap between the interviewer with no background knowledge on gillnet fishing and gears and the interviewee, i.e., gillnet fishers. The researchers then met with two gillnet fishers in order to test whether the content of the survey was easy to understand, structured appropriately and the survey process was straightforward. During which, we have also gathered basic information on the gillnet fishing gear type and some advice. Afterwards, survey questionnaires were refined, along with some revisions and improvements on the structure and content. Specifically, additions and corrections were made based on a review of existing survey questionnaires devised by FAO's and UNEP's classification on the main types and causes of ALDFG (Macfadyen et al., 2009) (Figure 12). The final structure and content of the completed survey questionnaire are composed of six categories as follows; Basic information of fishers (gender, age, years of fishing); Classification and composition of gillnet fishing (target species caught, size of fishing vessels, types of gillnets, composition and loss rate of gillnets, etc.); Causes (abandoned, discarded, lost); Evaluation of the effectiveness of measures and policies intended to prevent; Level of awareness on the damages and impacts; and Assessment of damage to vessels. The entire process of the survey including making the questionnaire draft, testing, revising, conducting and analyzing the survey took 5 months, with each step taking 3 weeks, 2 weeks, 3 weeks, and 3 months respectively.

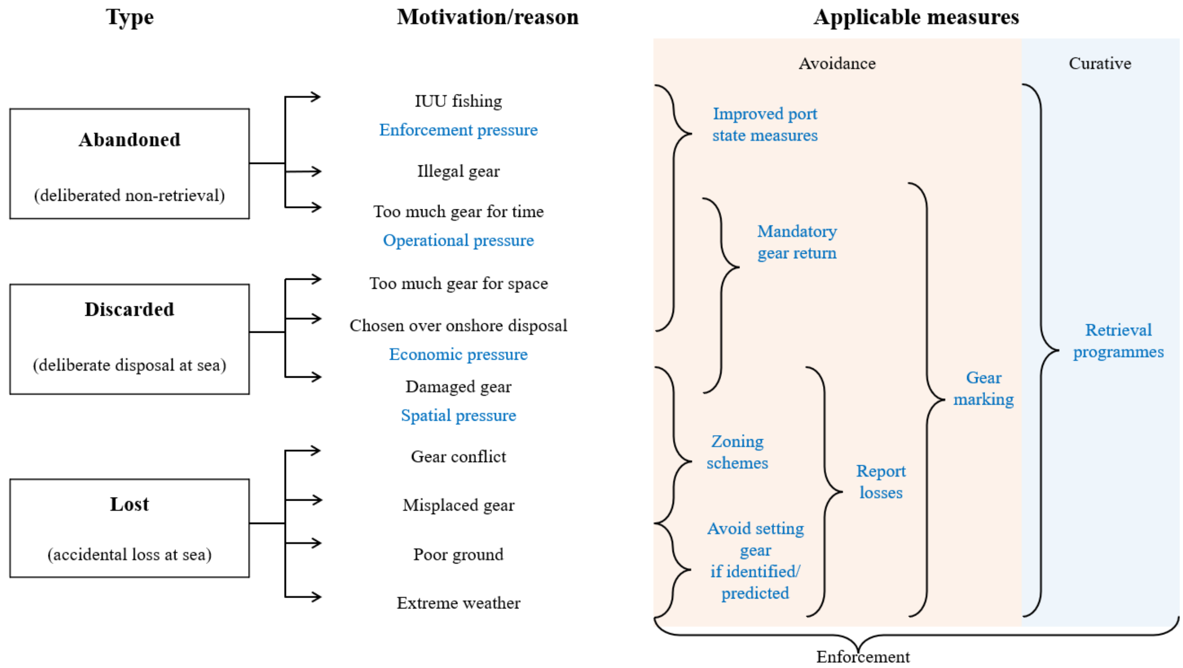


Figure 12. *Types, causes, and applicable measures for ALDFGs by FAO (Macfadyen et al., 2009)*

3.3 Survey Method

An in-person survey interview on a one-on-one basis was employed to collect data in this survey. We actively surveyed during the months of September through November 2021. All three participating interviewers were well informed and educated on the content of the survey prior to contacting their fisher counterpart to schedule an appointment and visited accordingly. In order to overcome challenges of recruiting fishers (as they are based at different ports and frequently out at sea), for each study site, relevant personnel (fishing village chief, gillnet association, and acquaintances in fishing operations) were contacted beforehand in order to be introduced to or to obtain the contact information of gillnet fishers. The survey was conducted by visiting voluntary community meetings held among fishers or through the introduction of other fishers made by those who have completed the survey (Figure 13). The survey interviews on average lasted approximately 30 minutes to an hour.

Analysis of the survey was done on valid responses for each question. Where survey responses were insufficient or incomplete, thus not amounting to a total of 100% and deemed statistically invalid, values were proportionately adjusted to equal 100%. Also, in this report the results were analyzed to best show the correlation among responses. During the survey, we have also documented additional information shared by the fishers such as the common fishing practices, usage and maintenance of their gears and so on. When more information was needed to understand the survey data, fishing net manufacturers

Figure 13. *Pictures taken during survey*

4. Results and Discussions

4.1. Fisher's Basic Information

A total of 61 fishers participated in the survey to provide their perception on the causes and effects of derelict gillnets (Table 4). All survey participants were male (n=61) and more than half in their sixties (n=36) with over 30 years of fishing experience (n=40). This coincided with a press release from the Korean Statistics "Structural changes in Fisheries from a statistical perspective" (https://eiec.kdi.re.kr/policy/materialView.do?num=208178) in the sense that the population of the fishing community in Korea is decreasing and aging. Participants represented southern, eastern, and western coastal regions, with the eastern group being the largest (n=25) followed by southern (n=20) and western (n=16) groups.

Table 4. *Demographic characteristics of the respondents*

Classification		Respondents (N=61)	
		Frequency	**Proportion (%)**
Gender	Male	61	100
	Female	0	0.0
Age	30s	3	4.9
	40s	5	8.2
	50s	17	27.9
	60s	30	49.2
	70s≤	6	9.8
Year of experience	Less than 10 years	7	11.5
	10~19 years	6	9.8
	20~29 years	8	13.1
	More than 30 years	40	65.6
Region	Western coast	16	26.2
	Southern coast	20	32.8
	Eastern coast	25	41.0

4.2. Target Species

Most targeted species in gillnet fisheries were swimming crab (n=23) followed by flounder (n=15), snow crab (n=6), silver pomfret (n=6). When the data was insufficient for a statistical analysis, it was compiled under the 'others' category (n=11) as seen in Table 5. Species in 'others' category included croaker, bastard halibut, red sea bream, squid, Japanese anchovy, red snow crab, pacific cod and miscellaneous. The target species of respondents from each region were as follows. In the southern sea, Goheung (for location, see Figure 11), there were 6 and 2 fishers targeting swimming crab and silver pomfret respectively whereas in Tongyeong respondents answered 4 for silver pomfret, 2 for bastard halibut, 2 for croaker, 2 for red sea bream, 1 for flounder, 1 for swimming crab. In the eastern sea, out of a total of 11 respondents from Goseong, 9 answered flounder, 1 for pacific cod and 1 for red snow crab. In Uljin respondents answered 5 for snow crab, 4 for flounder, 1 for Japanese anchovy, 1 for miscellaneous. In the western sea, Seocheon, all 16 respondents were targeting swimming crabs.

***Table 5**. Fishery characteristics of the respondents*

Classification		Frequency	Proportion (%)
Target species	Swimming crab	23	37.7
	Flounder	15	24.6
	Snow crab	6	9.8
	Silver Pomfret	6	9.8
	Others	11	18.0
Total		61	100.0

4.3. Size of Fishing Vessel

In this part of the survey, we asked the fishers to identify the size of their vessels. It is important to note however, some answers from fishers were excluded when their reported size of the vessel did not match their fishing practice either by mistake or misinformation. For instance, one swimming crab fisher reported that he fishes in inshore area with a 48.6 tons vessel. The Korean laws regarding fishing license on gillnet fishery limits the size of vessel by fishing area. Inshore gillnet fishing vessels are limited to unmotorized or motorized vessels under 10 tons while offshore gillnet fishing vessels are limited to motorized vessels larger than 10 tons and under 130 tons. Therefore, erroneous answers like the one mentioned above are excluded for this analysis, allowing a total of 53 valid responses for analysis.

The largest of the vessels used by surveyed fishers were 39 tons offshore fishing vessels targeting anchovies and croakers. The smallest was a 1.98 tons vessel used for inshore swimming crab fishing. Among inshore fishing vessels, the largest vessel was a 9.77 tons vessel used for fishing snow crab and silver pomfret. However, the average size of the vessels was the largest in silver pomfret fishing. In the case of offshore fishing vessels, the largest was a 39 tons vessel used to fish anchovy, while the flounder fishing vessel was the smallest at 24 tons (Table 6 and Figure 14).

***Table 6**. Average tonnage of the gillnet vessels (n=53)*

Classification			Average (ton)	Range (ton)
Inshore	Target species	Swimming crab	3.61	1.98-7.93
		Flounder	4.60	2.66-6.63
		Snow crab	6.55	4.14-9.77
		Silver pomfret	7.42	3.10-9.77
		Others	7.07	4.99-9.77
Offshore		Flounder	24.00	24.00
		Others	34	24.00-39.00

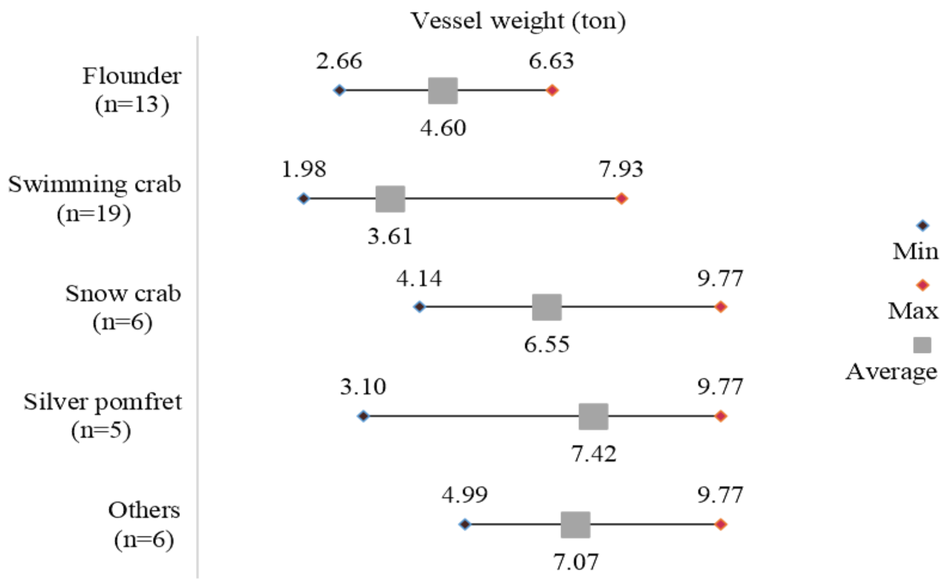


***Figure 14**. Average tonnage of the inshore gillnet vessels (n=49)*

4.4. Size of Gillnets

According to survey responses, respondents use longer gillnets when they are fishing for highly active species with broad distribution area, when in the opposite case, they use shorter length. Respondents also mentioned that the vertical profile of gillnet is measured not in meters but in number of mesh and in most cases the nets are in mesh count of 100. The net construction is determined by the changes in the range of water column, the width and flow resistance and constructed by fishing net manufacturers accordingly. This means that although the survey result provides an estimated range of length, weight, and mesh sizes useful in identifying derelict gillnets, the nets are not standardized, leading to difficulties in identifying and recording nets used in each fishery.

Disregarding the ‘others’ category, gillnets used in silver pomfret fishing had the longest average length and weight. This was followed by flounder, snow crab and swimming crab in order. While ‘others’ category showed the heaviest average weight, it was mostly due to croaker fishing as it had the longest average length of 15,325 m and the heaviest average weight of 7,750 kg. In relation to gillnet types, drift nets were found to be longer and heavier on average than the set gillnets and encircling nets. This coincided with fishers’ accounts that longer (therefore heavier) nets were used for highly active species with larger distribution areas. Such target species include silver pomfret, croaker, pacific cod and anchovies in this survey (Table 7 and Figure 15).

Table 7. Average length and weight of the gillnet

Classification		Average length (m)	Average weight (kg)
Target species	Swimming crab	668	132
	Flounder	3,405	690
	Snow crab	3,267	527
	Silver Pomfret	5,958	1,438
	Others	4,695	2,157

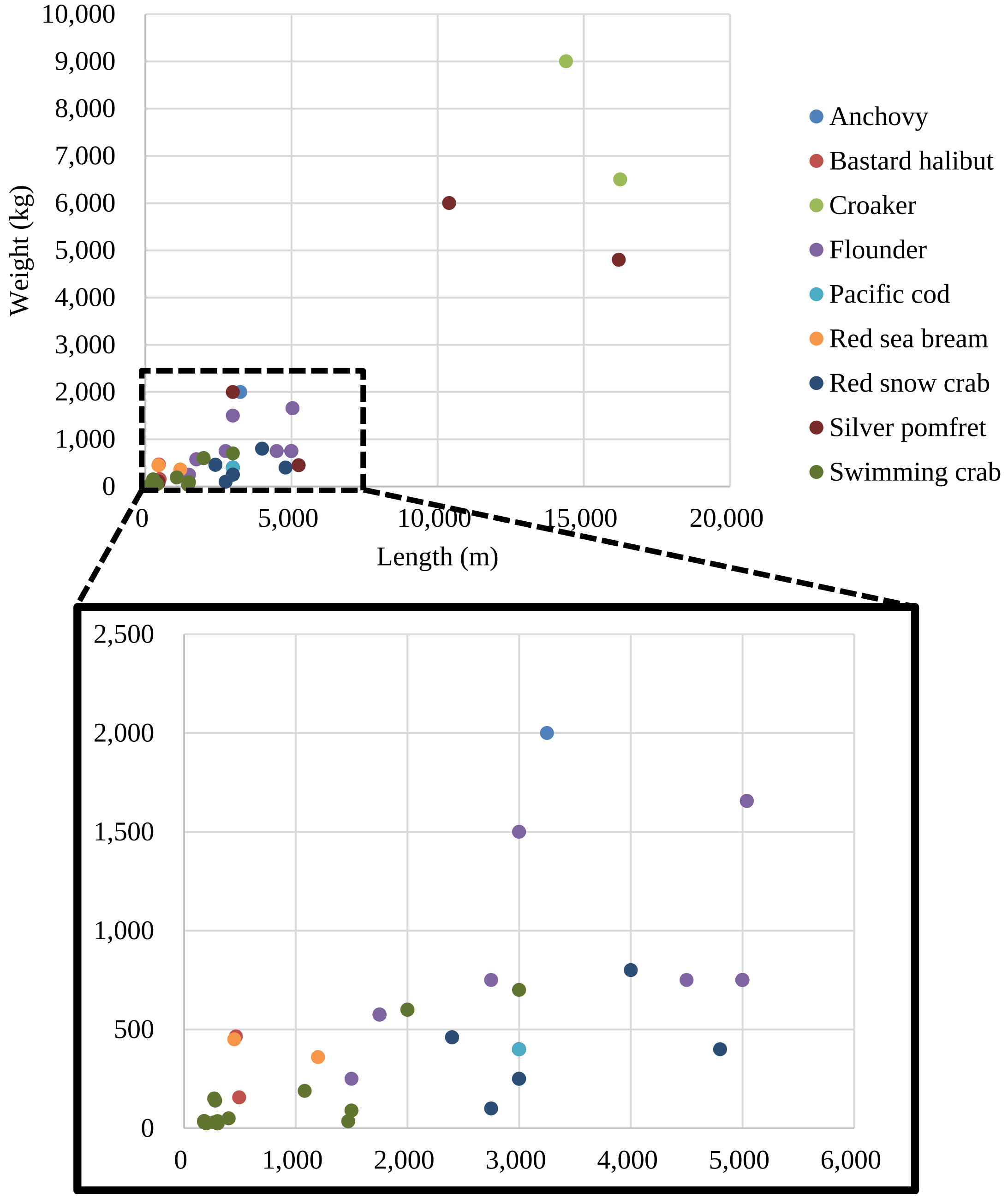


***Figure 15**. Relationship between length and weight of the gillnet according to target species*

4.5. Types of the Gillnet

Gillnets can be classified by deployment method and location. Types of gillnets used by the survey respondents were drift nets, set gillnets and encircling gillnets (Table 8). Among these, drift nets were most widely used (n=31). The second most used gillnet was the set gillnet (n=28), and the third was the encircling gillnet (n=2). Almost all gillnets were deployed to the bottom of the sea and set inshore rather than offshore (Table 8, Figure 16, and Figure 17).

Table 8. *Gillnet types of respondents*

Types	Position	Frequency
Set gillnet (n=28)	Bottom	27
	Middle	1
Encircling gillnet (n=2)	Bottom	2
Drift net (n=31)	Bottom	27
	Middle	3
	Surface	1
Total		61

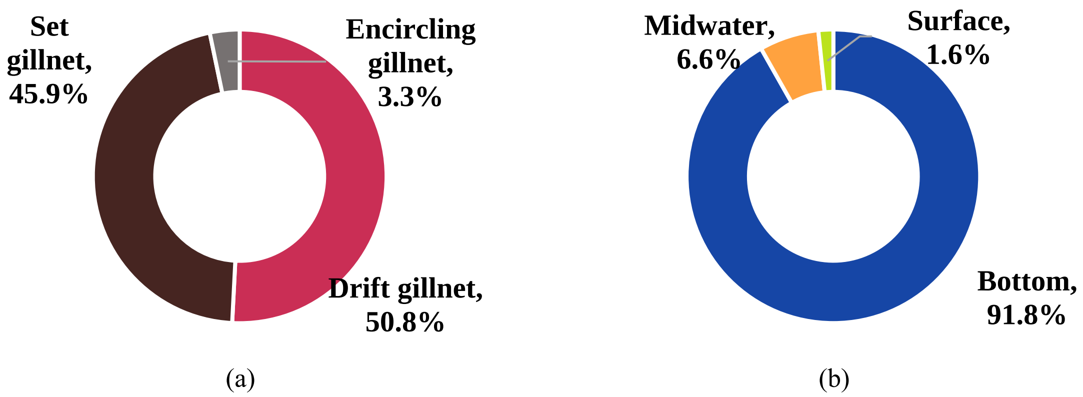
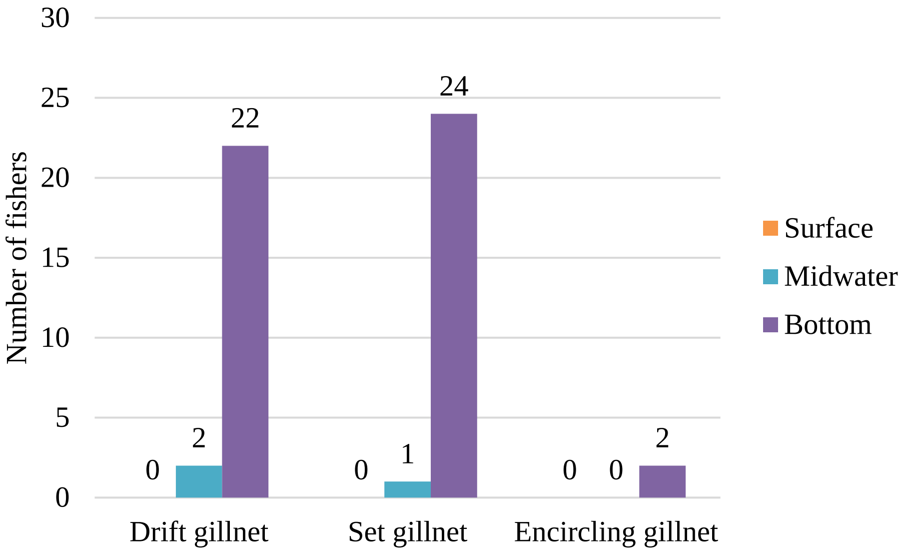
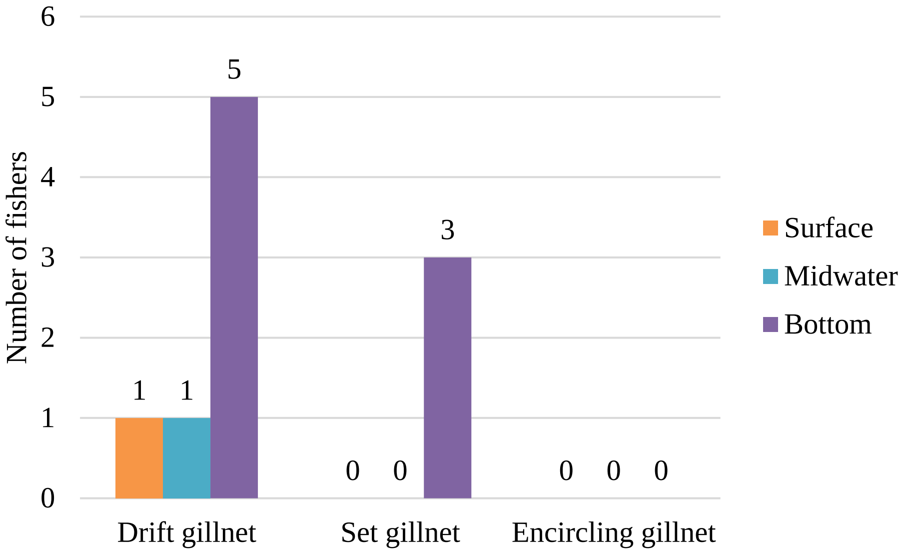


Figure 16. *Features of gillnets used by respondents (a: percentage of gillnet types, b: distinction by installation depths)*



(a) inshore (n=51)



(b) offshore (n=10)

Figure 17. *Installation depths for each gillnet type for inshore and offshore gillnet fishing*

4.6. Loss Rate of Gillnets

To understand how much the derelict gillnet is released by the gillnet fishery, we asked the fishers the loss rate of gillnet in their fishing. In this part loss of gillnet means total loss of gillnet while they are engaging in their fishing, including 'lost', 'abandoned', 'discarded'. By target species, loss rate was the highest in swimming crab fishing, followed by snow crab fishing and fishing targeting other species (Table 9). In terms of type and position, the loss occurred the most in surface drift net. The rest were in descending order of bottom encircling gillnet, bottom drift net, and bottom set gillnet (Table 10). Combined with the findings shown in 4.2.3, size of gillnets, drift nets, especially those deployed at the surface, had the most impact in terms of DFG.

***Table 9**. Loss rate of gillnet by target species*

Target species	Loss rate
Swimming crab	20.4
Flounder	13.2
Snow crab	17.2
Silver pomfret	14.1
Others	16.0
Average	16.9

***Table 10**. Loss rate of gillnet by type and installation depth*

Type	Installation depth	Loss rate	Average
Set gillnet	Bottom	15.0	14.9
	Middle	10.0	
Encircling gillnet	Bottom	20.0	20.0
Drift net	Bottom	18.7	18.6
	Middle	13.4	
	Surface	30.0	
Average		16.9	

4.7. Causes for the Loss of Gillnets

In this survey the fishers were asked to rank the likelihood of each cause (namely abandonment, discarding or loss) for derelict gillnets on a scale of 1 to 3, 3 being the most likely and 1 being the least likely. In general, when inquired to specify the causes of derelict gillnets, the respondents indicated that most gillnets were generated due to being lost, followed by abandonment, discarding and others (Figure 18). In relation to fisheries, all of the surveyed snow crab fishers said that the cause of derelict gillnets was due to lost gear. On the other hand, 55% of fishers of other fish species said that discarded fishing gear was the biggest cause of derelict gillnets. Across all gear types, loss was the highest rated among other causes for derelict gillnets followed by abandonment and discarding.

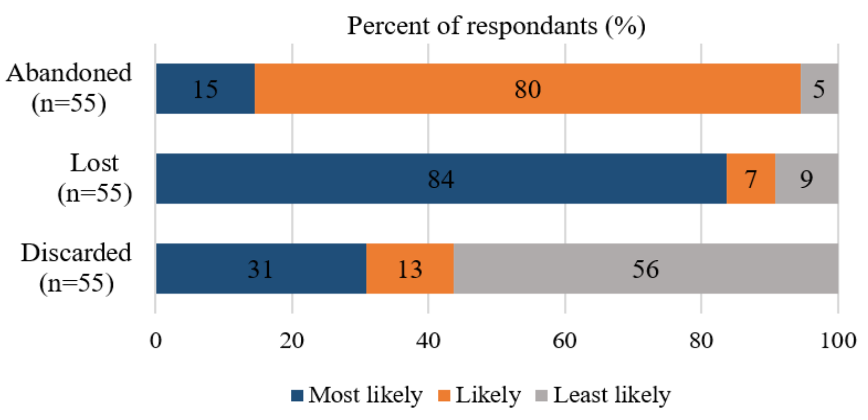


***Figure 18**. Survey responses of gillnet fishers on the causes for derelict gillnets (n=55)*

4.8. Detailed Causes of the Derelict Gillnets

In this part of the survey, we asked the fishers what they believe to be the cause of derelict gillnets generated from gillnet fishing. We used the Likert scale for this portion of the survey. A scale of 1-5, with 5 being ‘strongly agree’, 3 being ‘neutral’, and 1 being ‘strongly disagree’ was used. The figures shown are the percentage of respondents for each answer, then the numbers were arranged in cumulative bar graphs from -100 to +100 to visualize the general perception towards subjects in question. It should be noted that the number of responses for neutral was divided in half. The same visualization method is used for other questions using Likert scale in this report.

In the survey, three causes for ‘abandoned’ fishing gear were provided to the respondents. The three causes, ‘IUU (illegal, unreported, and unregulated) fishing’, ‘illegal fishing gear’, ‘use of excessive fishing gear in comparison to the general time spent’ and ‘others’ were rated from 1 to 5. Results showed almost all fishers answered ‘strongly disagree’ for all three causes of abandoned gear (Figure 19a).

For causes of ‘lost’ fishing gear, we listed ‘overlapping areas of installed fishing gears’, ‘installing in wrong areas’, ‘installing despite inadequate conditions’, ‘extreme weather’, and ‘others.’ Respondents gave the most diverse answers to the causes of the lost fishing gear. Overall, fishers ranked ‘overlapping areas of installed fishing gears’ or gear conflict in short, to be the most severe causes of loss (Figure 19b). Next in line was loss from ‘extreme weather’. They evaluated that the causes of loss by ‘installing in wrong areas’ and ‘installing despite inadequate conditions’ were very low. By target species, fishers except for the silver pomfret fishing answered positively for ‘overlapping areas of installed fishing gears’ and swimming crab fishers said positively for ‘extreme weather’. Unlike our expectation, ‘extreme weather’ did not receive a high score. This is likely to have been caused by the fact that fishers may refrain from deploying their nets in bad weather conditions according to forecasts and not because fishing gears are rarely lost in bad weather conditions (Figure 19b).

For the causes of ‘discarded’ fishing gear, respondents were able to again rate from 1 to 5. The causes provided in the survey were ‘excessive use of fishing gear’, ‘preferring at-sea discarding over on-land disposal’, ‘discarding damaged fishing gear’, and ‘others.’ Almost all of the fishers responded ‘disagree’, or ‘strongly disagree’ for all four causes (Figure 19c). Among all the respondents, swimming crab fishers answered most positively for all three causes except for ‘others.’

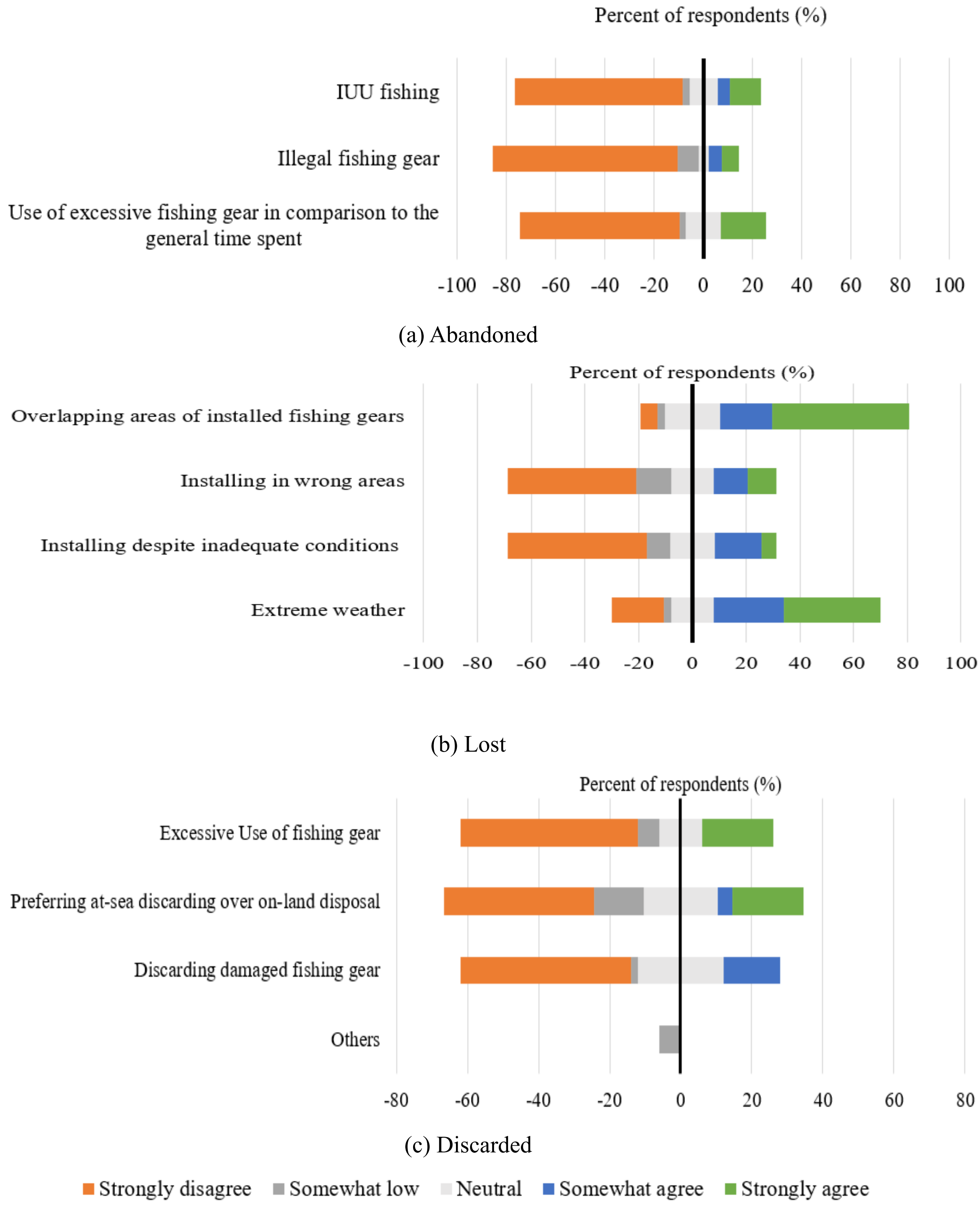


Figure 19. *Evaluation of the causes for DFG by fishers (n=61; from the top: abandoned; lost; discarded)*

4.9. Evaluation of the Effectiveness of Potential Measures for Derelict Gillnets

In the survey, we asked the fishers to evaluate the effectiveness of potential preventive measures for derelict gillnets. First, the survey asked the fishers to evaluate the measures to prevent 'lost' fishing gear. The measures included: 'adjusting the installation location and time of fishing gears'; 'adjusting the fishing gear installation areas'; 'installing fishing gear collection facilities at the port'; 'mandatory retrieval of fishing gear'; 'reporting the loss of fishing gear'; 'gear marking system for fishing gear'; 'increased collection projects'; and 'enforcing regulations and strengthening the application of laws.' In general, more than 50% of fishers evaluated 'increased collection projects' and 'installing fishing gear collection facilities at the port' as the most effective measures in reducing loss of fishing gears (Figure 20). Followed closely behind were 'mandatory retrieval of fishing gear' and 'gear marking system for fishing gear' which 48% of fishers thought of as effective. Although contested, 30% of fishers considered 'enforcing regulations and strengthening the application of laws' as an effective measure (48% considered it ineffective). These results show that fishers preferred government interventions such as collection projects and installing collection facilities over measures that required more active participation among fishers. Here, the fact that fishers considered 'mandatory retrieval of fishing gear' as well as 'gear marking system for fishing gear' as acceptable as government intervention is noteworthy (Figure 20 and Figure 21).

On the other hand, 'reporting the loss of fishing gear', 'adjusting the installation location and time of fishing gears' and 'adjusting the fishing gear installation areas' were deemed the least effective. These results indicated that reporting gear loss or zoning schemes to avoid gear conflict is not favorable. The low level in perceived efficacy in the case of reporting gear loss may indicate general rejection to the measure. It is often believed that direct reporting from the operator of the gear is rare due to issues regarding the confidentiality of precise fishing location and professional pride in admitting gear loss, even with "no blame" approach as in the case of Norway (Macfadyen et al., 2009). However, further research is required as this result does not suffice to conclude that lost gear reporting is ineffective as the survey question did not specify on who reports or whether anyone is held responsible.

In regard to gear types, fishers using drift net (n=31) and set net (n=28) considered 'increased collection projects' as the most effective whereas drift net fishers chose 'adjusting the installation location and time' as the least effective measures and set net fishers similarly chose 'adjusting the fishing gear installation areas' (Figure 21).

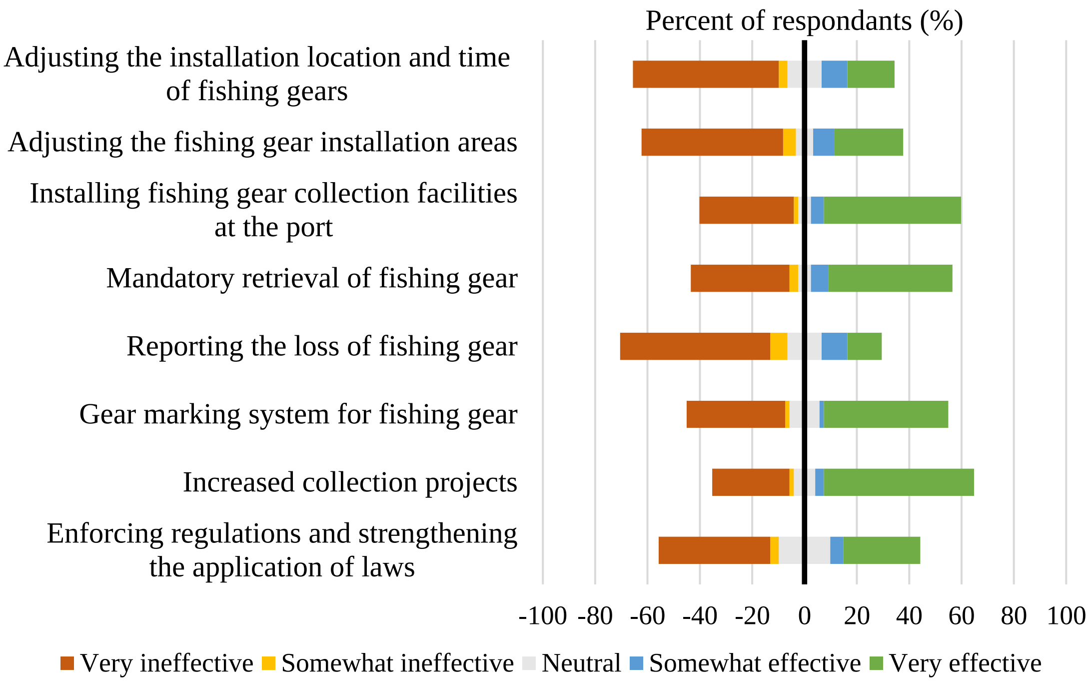


***Figure 20**. Evaluation of the effectiveness of potential measures for 'lost' fishing gear in general (n=61)*

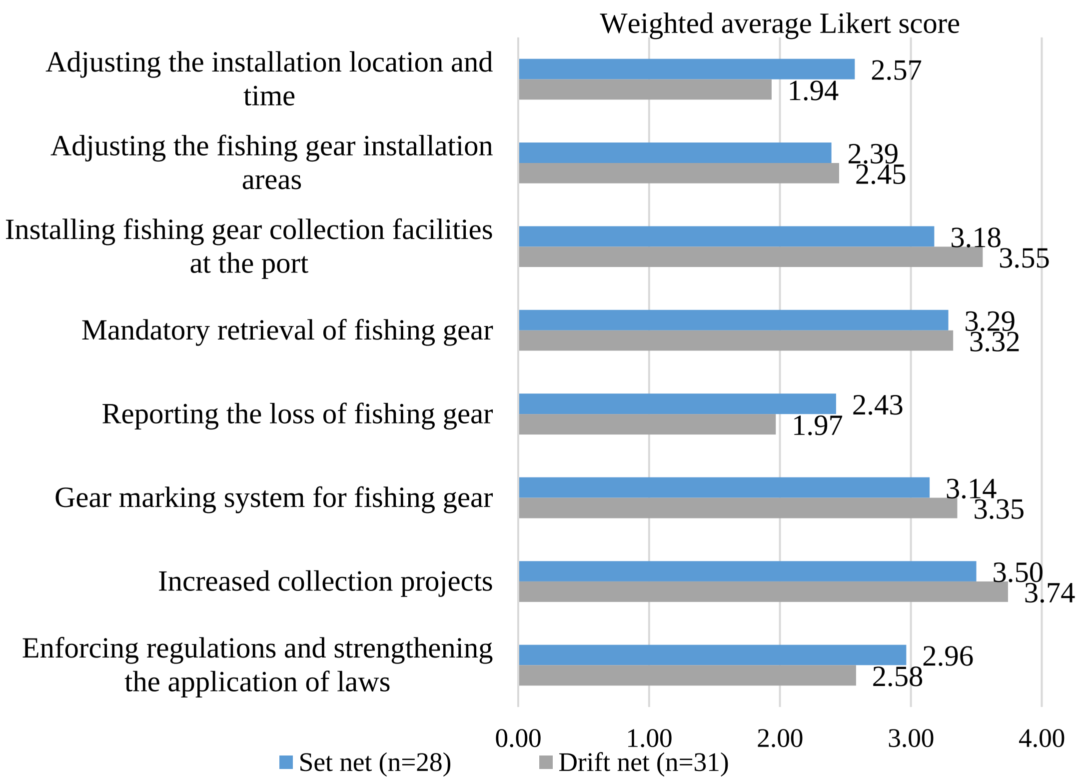


***Figure 21**. Evaluation of the effectiveness of potential measures for 'lost' fishing gear by fisher group of each gear type (n=59; The Likert scale is converted to average score))*

Second, the survey asked the fishers to evaluate the effectiveness of potential measures against ‘discarded’ fishing gear. The measures offered in the survey were: ‘strengthening enforcements against discarding gillnets at sea’; ‘returning derelict fishing gears and implementing a compensation system’; ‘expanding education programs for fishers’; ‘providing simplified and convenient disposal methods’; ‘gear marking system for fishing gear’; and ‘establishing a rapid retrieval system for derelict fishing gears.’

In general, fishers considered ‘establishing a rapid retrieval system for derelict fishing gears’ as the most effective, followed by ‘providing simplified and convenient disposal methods’ and ‘returning derelict fishing gears and implementing a compensation system’ (Figure 22). This general evaluation shows that fishers considered reducing the cost and providing accessibility in disposal are the most effective. In Matthews and Glazer (2010), surveys conducted on net fishers showed that causes of improper disposal at sea were due to the high cost of onshore disposal or lack of appropriate discard options. Macfadyen et al. (2009) also suggests that it may be in the fishers economic and financial interest to deliberately discard fishing gears to avoid reduced fishing time and greater fuel costs. Although quantification of such costs is required for a more definitive understanding of the issue, gillnet fishers in Korea were aware of the relevance of high cost related to proper retrieval and disposal with discarded fishing gears.

Another noteworthy finding was that ‘gear marking system for fishing gear’ and ‘expanding education programs’ were considered mostly ineffective by fishers despite its importance being emphasized among many other stakeholder groups and scientific research (Cho, 2011; DelBene et al., 2021; Macfadyen et al., 2009; Wyles et al., 2019). The importance of the outreach program is well expressed in the research evaluating the ‘Fishing for Litter’ scheme in the UK (Macfadyen et al., 2009; Wyles et al., 2019) as being more effective and longer lasting than monetary incentives that the fishers herein are found to prefer. In this part of the survey, there were less differences by gear types except for drift net fishers (Figure 23). Unlike set net users that chose ‘establishing a rapid retrieval system for derelict fishing gears’ as the most effective, drift net users evaluated ‘providing simplified and convenient disposal methods’ as the most effective. Moreover, this group also evaluated outreach program as the least effective whereas in other two groups gear marking was evaluated the least effective.

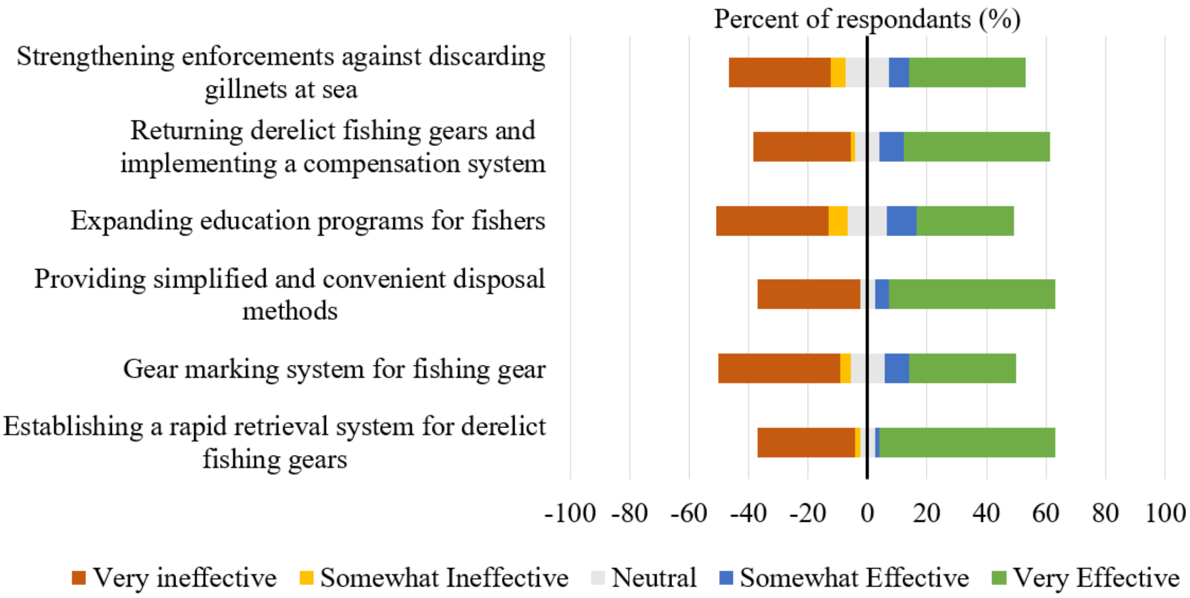


Figure 22. *Evaluation of the effectiveness of potential measures for 'discarded' fishing gear in general (n=61)*

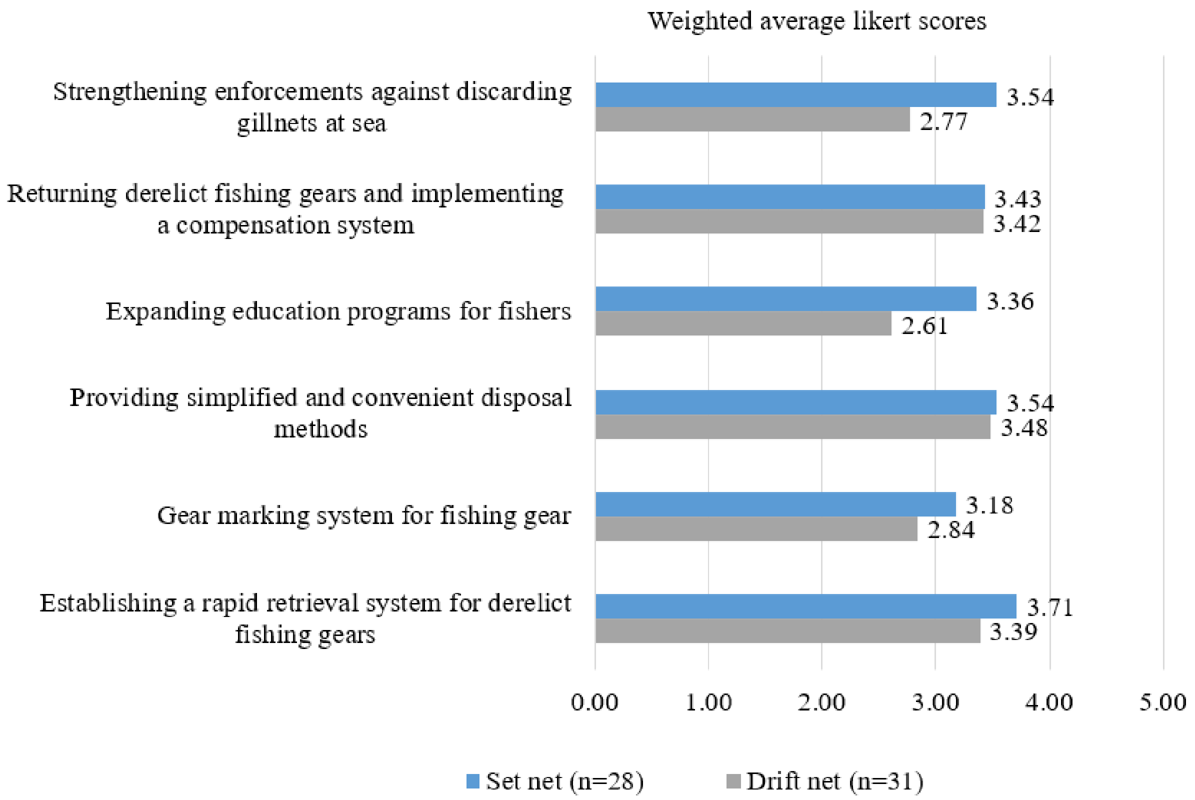


Figure 23. *Evaluation of the effectiveness of potential measures for 'discarded' fishing gear by fisher group of each gear type (n=59; The Likert scale is converted to average score)*

4.10. Evaluation of the Effectiveness of Implemented Policies and Future Policies

The Korean government has been implementing various policies to prevent derelict gillnets and DFG. Such policies include 'purchasing projects: a government project purchasing the waste collected during fishing operations in weight or by volume,' 'waste collection barges: waste is collected using barges at ports and removed by local governments', 'fishing ground cleanups: collecting waste using vessels,' and 'supporting cleanup efforts by fishers: fishers voluntarily retrieve and clean while local governments subsidize collection and processing efforts'. The survey asked the fishers to evaluate the effectiveness of current policies that are in place to prevent DFG. According to the results, all the fishers evaluated the policies to be effective. However, among the surveyed fishers, the swimming crab fishers gave the lowest ratings for the policies (Figure 24).

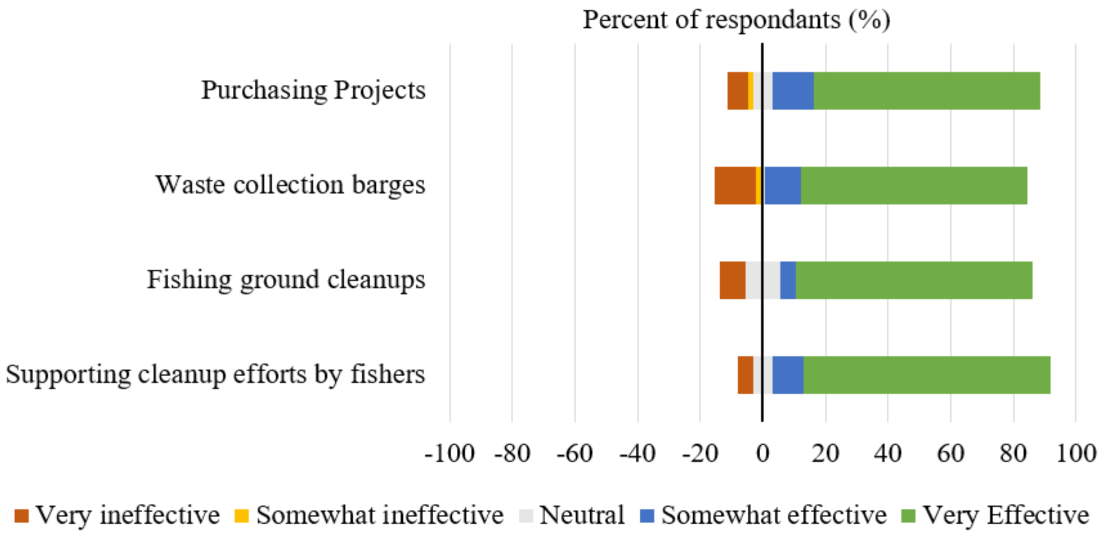


***Figure 24**. Evaluation of the effectiveness for current policies preventing DFG in general (n=61)*

For future policies that are expected to be implemented, surveyed fishers were asked to evaluate the effectiveness of these to be implemented policies that include: 'mandatory retrieval of derelict fishing gear: when purchasing new fishing gear fishers will be required to turn in old fishing gear'; 'deposit system for disposing old fishing gear: deposit a certain amount of money for fishing gear'; 'utilizing an extended producer responsibility system: requiring fishing gear manufacturers to be responsible for recycling fishing gears. ; and 'gear marking system for fishing gear'. Red sea bream fishers and fishers that catch other target species evaluated all policies to be effective (Figure 25). Meanwhile, swimming crab fishers rated the policies as somewhat effective, and flounder, and snow crab fishers evaluated the effectiveness of the policies more diversely. Snow crab fishers said that they disagree with 'utilizing an extended producer responsibility system' as an effective policy and flounder fishers deemed the 'deposit system for disposing old fishing gear' to be neutral in terms of effectiveness.

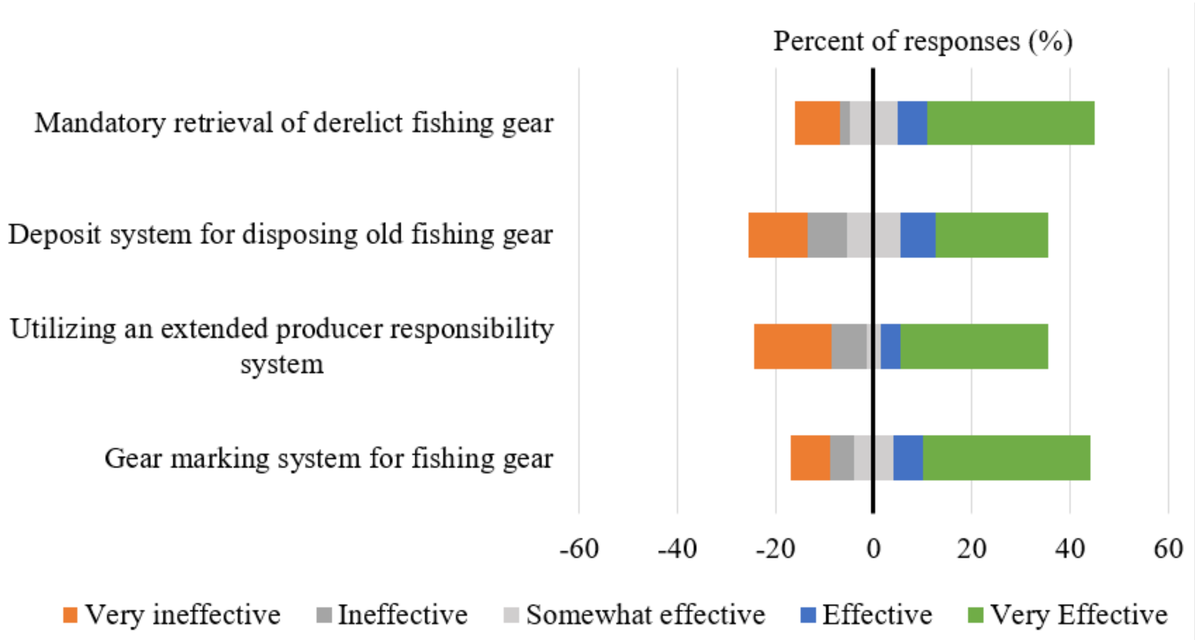


Figure 25. *Evaluation of the effectiveness for future policies preventing DFG in general (n=60)*

4.11. Evaluating the Awareness of Damages

For this part of the survey, we asked the fishers to choose the most serious damages impacted by DFG. Such damages included: 'decrease in catch (including marine resources) due to ghost fishing'; 'damages to vessels'; 'destruction of marine life habitats'; 'harm to marine predator species' and 'generation of microplastics'. The responses from all fishers indicated that the most negative impact of DFG was 'decrease in catch (including marine resources) due to ghost fishing', followed by 'destruction of marine life habitats', 'damage to vessels', 'generation of microplastics', and 'harm to marine predator species' (Figure 26). Similar results were obtained from swimming crab fishers and flounder fishers. However, all responses from snow crab fishers indicated that reduction of fishery resources is the only serious impact of DFG. Fishers that fish for other target species said that the most serious impact of derelict fishing is 'destruction of marine life habitats.'

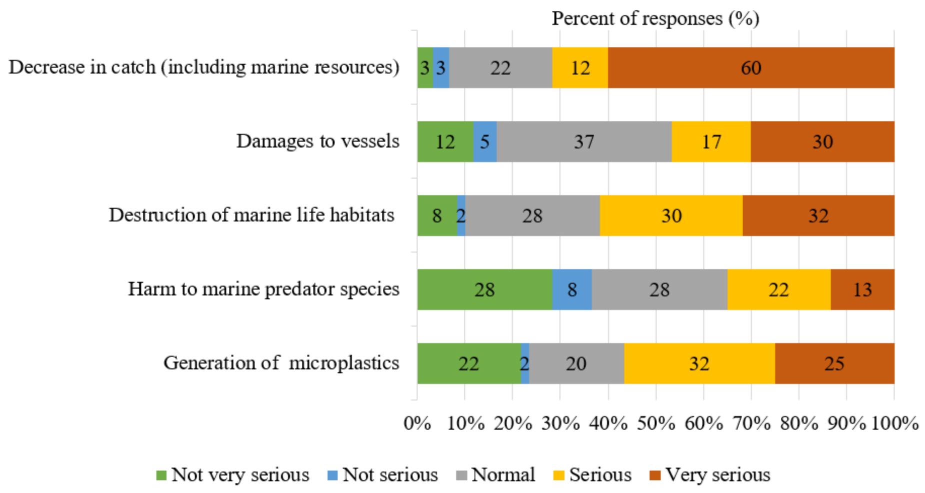


Figure 26. *Evaluation of impacts of DFGs on the marine environment (n=60)*

4.12. Frequency of Damages to Vessels Caused by DFGs

The last part of the survey asked about damages to fishing vessels caused by DFG. The survey questions were composed of four common damages experienced by vessels. These included: 'propeller entanglement'; 'engine failure'; 'rudder failure'; and 'route obstruction and/or needing to change course'. The survey also asked how often these damages occurred in a year. The most reported type of damage from DFG among 53 fishing vessels was propeller entanglement with 77% or 41 vessels reported having experienced (Table 11). The most common damages that followed were 'engine failure' (49% or 26 vessels), 'route obstruction and/or needing to change course' (36% or 19 vessels), and 'rudder failure' (19% or 10 vessels). Among the reported cases, the most recurring type of damage was 'route obstruction and/or needing to change course', numbering in at 12.92 average annual frequency per vessels reported. 'Propeller entanglement' followed next with an average annual frequency of 9.28. 'Engine failure' numbered average annual frequency of 2.33 and 'rudder failure' was in average annual frequency of 1.25 per vessel.

Table 11. *Number of vessels that reported and the average annual frequency of damages from DFG (n=53)*

Classification		Number of vessels reported	Average annual frequency
Propeller Entanglement	Inshore	37	9.93
	Offshore	4	3.25
	Total	41	9.28
Engine failure	Inshore	22	2.48
	Offshore	4	1.5

	Total	26	2.33
Rudder failure	Inshore	8	1.31
	Offshore	2	1
	Total	10	1.25
Route obstruction and/or needing to change course	Inshore	15	15.9
	Offshore	4	1.75
	Total	19	12.92

Analyzing this data in relation to the size of vessel shows vessels belonging to class 3, with size greater than 7 and lesser than 10 tons, were most affected by any type of damage (Figure 27). This result was followed by those in the class 1 with size greater than 1 to no greater than 4 tons; class 2 with size greater than 4 to no greater than 7 tons; and class 4 with size over 10 tons in order. In 'rudder failure' however, only class 3 showed higher frequency, and other classes showed no difference.

Combined with the findings in Table 11, the results suggest some insight. Whenever the fishers were informed of or able to detect areas with large amount of DFG, they generally avoid it by changing the course of their fishing trip. However, when the fishers were unaware, most damages were done on the propellers by entanglement. In terms of size of vessels, the results seem to show some correlation with vessel size and its susceptibility to different types of damages from DFG, but due to the small size of sample analyzed in this survey, further research is needed to show the relationship between the frequency of damage from DFG and the size of fishing vessel.

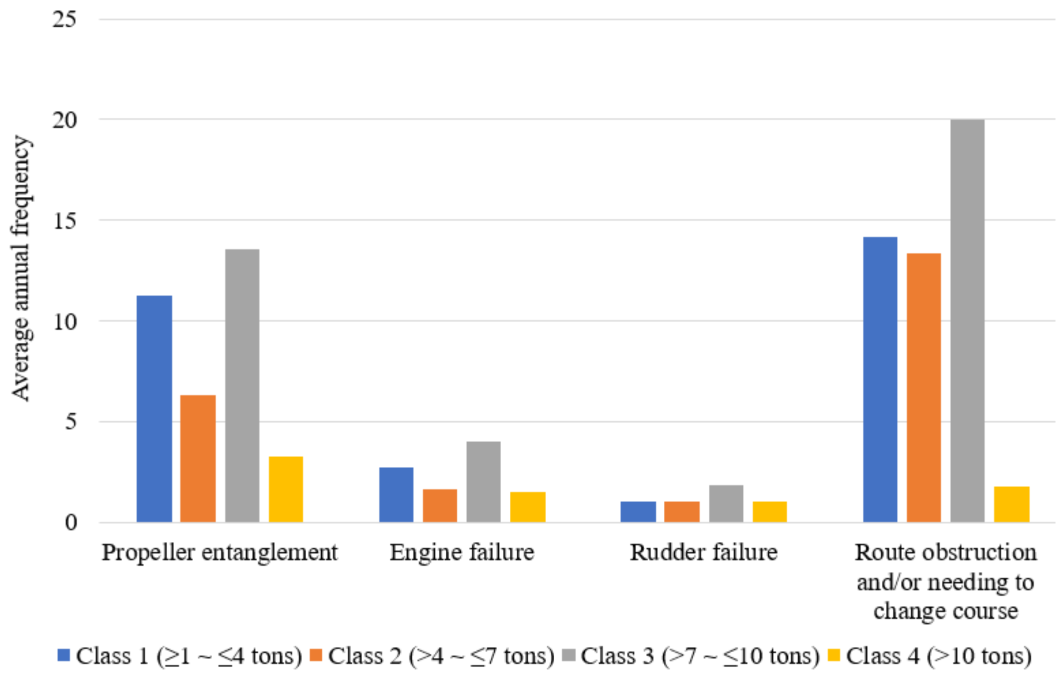


Figure 27. *Average annual frequency by size of vessels (n=53)*

4.13. Cost of Damages to Vessels Caused by DFGs

The cost of damage to vessel caused by DFG was relatively high and frequent in ‘engine failure’. In the survey, the cost incurred by damages to vessels was asked and the responses showed that ‘engine failure’ imposed the highest cost on average among all major target species (flounder, swimming crab, snow crab, and silver pomfret), ranging from US $841(snow crab fisher; Class 3 size vessel) to US $8411(swimming crab fisher; Class 1 size vessel) per one repair (Figure 28). Among other target species categories, ‘engine failure’ repairs were the most expensive as well, with croaker fishers paying a minimum of US $1,935 (Class 4 size vessel) and anchovy fishers paying a maximum of US $29,435 (Class 4 size vessel) per one repair.

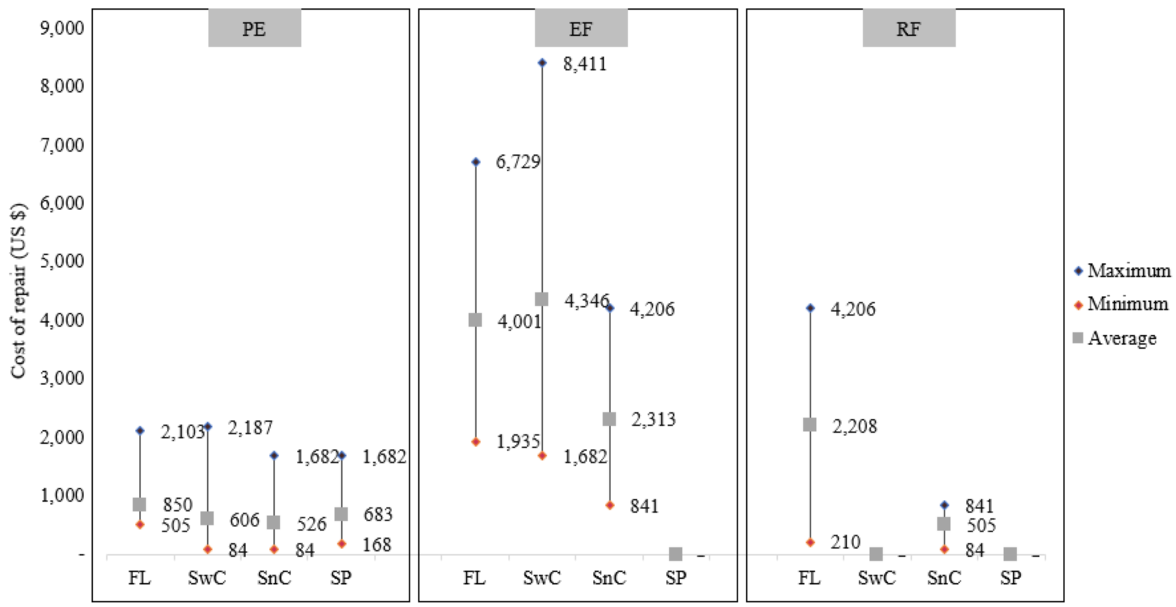


Figure 28. *Cost per repair by target species for each damage type (n=53; PE: propeller entanglement, EF: engine failure, RF: rudder failure, FL: flounder, SwC: swimming crab, SnC: snow crab, SP: silver pomfret)*

In relation to size of vessel, the average cost of ‘engine repair’ was the most expensive across all size. (Figure 29). In Class 1 and 3 vessels, repairing ‘propeller entanglement’ was more expensive than ‘rudder failure’. In Class 2 and 4 vessels, the order was reverse with ‘rudder failure’ repairs being more expensive than ‘propeller entanglement’ repairs. Like the assessment of frequency of damages from DFG, more specific research with bigger sample must proceed to infer a more meaningful conclusion. Also, it must be noted that the cost indicated in this survey is only the cost for repairs and does not include the amount that was lost from not being able to use the vessel due to the damage.

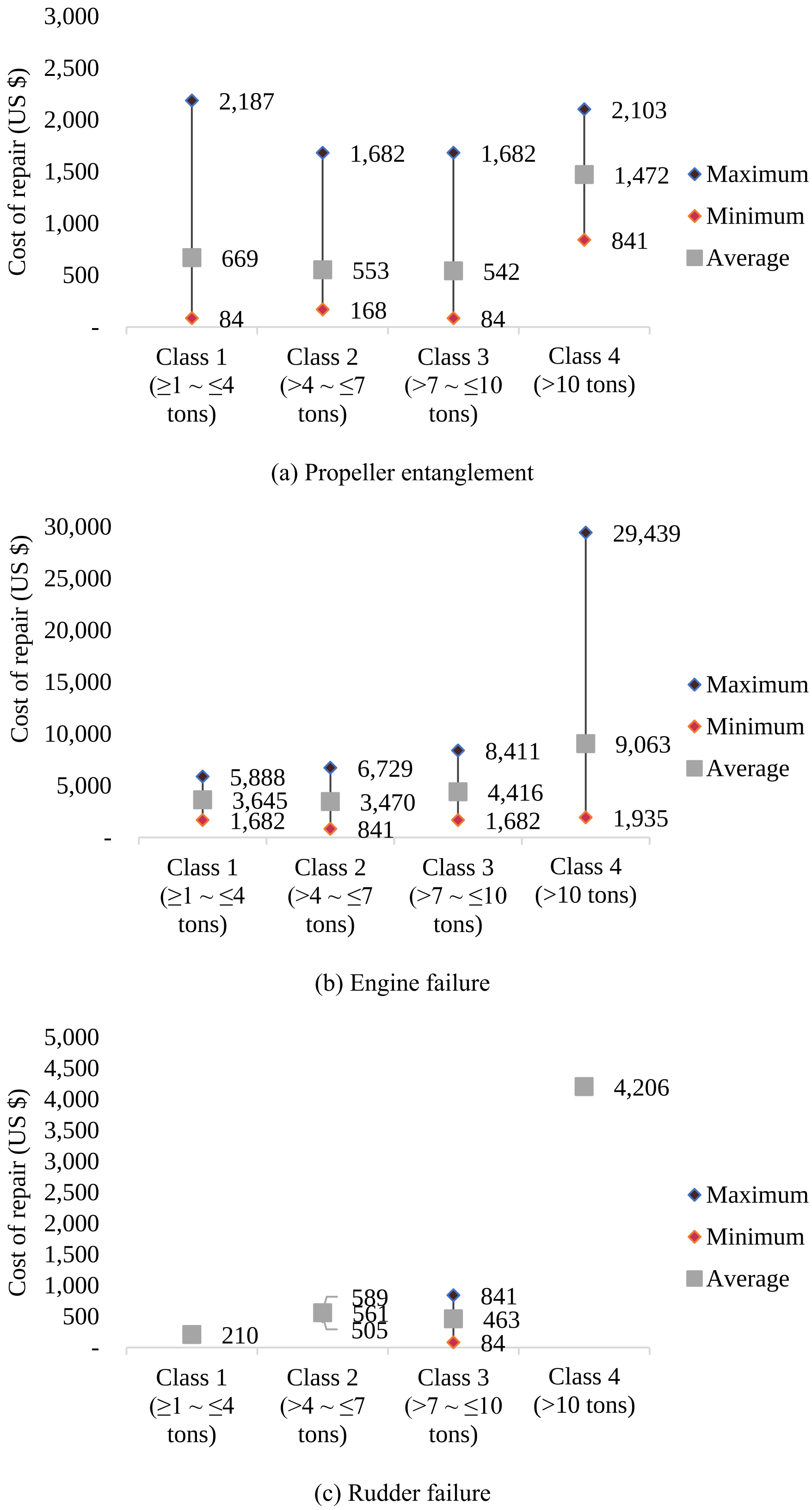


Figure 29. *Cost of repair by size of vessel for each damage type (n=53; from the top; propeller entanglement, engine failure, rudder failure)*

5. Conclusion

Information on the gear loss and fishers' perception for it is not well studied in the globe. For the preliminary research, this study elucidated gear loss rates from gillnets and perceptions of 61 fishers for causes of the DFG and its impact in Korea. Overall, gear loss rate was 16.9% and it was ca. three times higher than that of global average of gillnets. Among three types of gillnets such as drift net, set gillnet, and encircling gillnet, gear loss was the highest in drift nets showing 30.0%. For the causes of gear loss fishers pointed out the 'lost' gear the greatest cause of the gear loss.

When asked to evaluate the causes for the DFG, fishers disagree with the specific causes for the 'abandoned' and 'discarded' fishing gear. It is partly because they didn't either abandon or discard fishing gear and that thought they should answer related questions negatively (authors' personal communications when surveying). 'Extreme weather' was not the greatest cause for 'lost gear' although it was the most common cause on global study. It seemed since fishers didn't deploy their fishing gear if the weather forecast predicts extreme weather in Korea. Gear conflict was the most common causes for 'lost gear', indicating if we are to reduce gear loss from 'lost' fishing gear, we should address the gear conflict.

For the potential measures against 'lost gear', fishers preferred government interventions such as collection projects and installing collection facilities over measures that required more active participation such as reporting gear loss or zoning schemes. It implies that it is necessary to develop policies in which fishers can actively participate. Involving fishermen in policy development through workshop and providing compensation to fishermen who actively participate in measures can be helpful.

Fishers cited 'reduction fishery resources' was the biggest damage by DFG and the damage was serious. It implies they are well aware of the damages of the DFG. They experienced direct damages from DFG such as propeller entanglement, engine failure, rudder failure and route obstruction. The most reported type of damage was propeller entanglement with 77%. The results indicate that the impact of DFG on gillnet fishery is ubiquitous and improved management by fishermen and government should be urgently implemented.

This research was the preliminary study for understanding fishers' perception to develop preventive measures against DFG. It helps figure out their attitude and behavior for manipulating their fishing gear. For better understanding, further survey with large pool of gillnet fishers as well as other fishing activities is necessary.

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Appendix. Survey Form

Survey of Fishers' Perceptions on the Causes and Damages of Derelict Gillnets

Based on your responses and opinions, we hope to find an effective solution that addresses the causes and damages of derelict gill nets significantly disrupting your fishery catches. The result of this survey is expected to be entirely dependent on your active and honest responses and will serve as an important resource to develop relevant measures. Please note that your responses will only be used as statistical analysis data. We thank you for your participation and greatly appreciate your time. June 2021 Supervising agency: NOWPAP (Northwest Pacific Action Plan) Authorized agency: OSEAN (Our Sea of East Asia Network) TEL: +82-55-649-5224 E-mail: osean@osean.net

Survey Information

Date:	Surveyor (Name):	Survey sheet number:
Location: Province/ City/ Town/		

General Information of Respondents

Gender ① Male ② Female
Age ① 20s ② 30s ③ 40s ④ 50s ⑤ 60s ⑥ Over 70s
Number of years working in the fishing industry 1 Less than 10 years ② 10-Less than 20 years ③ 20-Less than 30 years ④ Over 30 years

1. What kind of fish are your main target species?

(One main target species or 3-4 seasonal target species)

( )

2. What is the size of your fishing vessel?

( ) Ton

3. What type of gillnet fishing do you do? (Please select one)

3-1. Classification by fishing method

① Set gillnet ② Drift gillnet ③ Encircling gillnet ④ Other ( )

3-2. Classification by installation depths

① Surface gillnet ② Midwater gillnet ③ Bottom gillnet

3-3. Classification based on fishing operation distance

① Offshore fishing ② Inshore fishing

4. How many measurement units does one gillnet consist of? How long is one measurement unit?

( ) units

Length of 1 measurement unit: ( )

5. What is the approximate weight of one unit? or one gillnet? (Please answer only one)

( ) kg/unit,

or ( ) kg/gillnet

6. How many gillnets do you possess and use?

6-1. Total number of gillnets in possession (including warehouse inventory):

6-2. Total number of gillnets in use (including underwater and on the ship):

7. What is the average replacement cycle (such as durability in years) of gillnets and the average number of new gillnet purchases per year?

▶ Replacement cycle (year(s))

▶ New purchases (units, or gillnet/year)

8. What is the approximate percentage of gillnets lost at sea during one operation at sea? (including those abandoned, discarded, etc.)

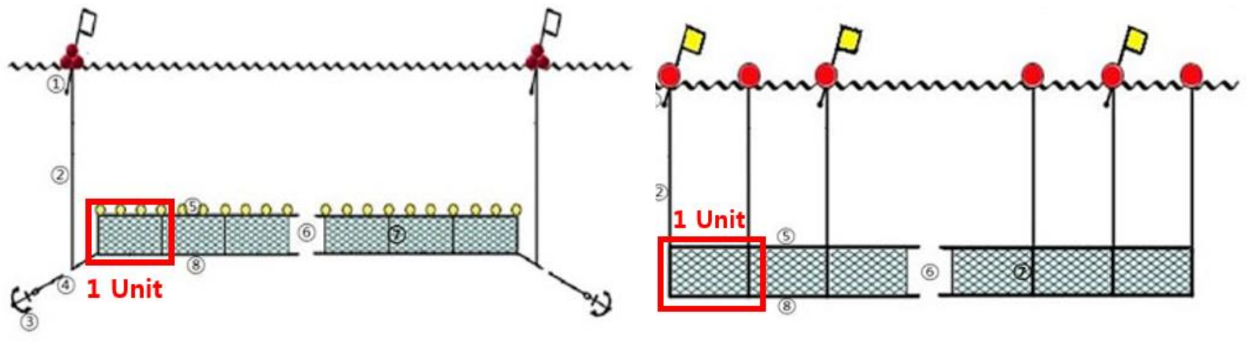
( )%

[Method of disposing and managing gillnets]

9. The Food and Agriculture Organization classifies the causes of the derelict gillnets into three categories. Which of the following reasons do you think is the most serious cause of the derelict gillnets? (Please rank in the order of 3-2-1, with 3 being the most serious)
(- - -)

(1) Abandoned gillnets (unintentional failure to retrieve after installation)
(2) Discarded gillnets (if intentionally thrown away)
(3) Lost gillnets (if lost in an accident)
(4) Other (Please be specific)

Example)



10. Which of the following do you think is the most serious key factor for each cause of derelict gillnets?

○ **Abandoned gillnets**

Severity (as a specific cause of abandonment)	Very low	Somewhat low	Neutral	Somewhat high	Very high
(1) IUU (Illegal, unreported and unregulated) fishing (Fishing in unauthorized regions and seasons)	①	②	③	④	⑤
(2) Illegal fishing gear (Using prohibited fishing gears)	①	②	③	④	⑤
(3) Use of excessive fishing gear in comparison to the general time spent	①	②	③	④	⑤
(4) Others ( )	①	②	③	④	⑤

○ **Discarded gillnets**

Severity (as a cause of discarding)	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
(1) Excessive use of fishing gear (In most authorized fishing areas, intentionally discarded fishing gear results due to excessive use of fishing gears that were not retrieved.)	①	②	③	④	⑤
(2) Preferring at-sea discarding over on-land disposal (due to fuel costs and other management costs being too high or due to the lack of adequate collection and processing facilities at ports)	①	②	③	④	⑤
(3) Discarding damaged fishing gear (when fishing gear are cut and discarded because retrieving damaged fishing gears requires labor and money)	①	②	③	④	⑤
(4) Others ( )	①	②	③	④	⑤

○ **Lost gillnets**

Severity (as a specific cause of loss)	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
(1) Overlapping areas of installed fishing gears	①	②	③	④	⑤
(2) Installing in wrong areas (forgetting the areas where the fishing gears were installed)	①	②	③	④	⑤
(3) Installing despite inadequate conditions	①	②	③	④	⑤
(4) Extreme weather	①	②	③	④	⑤
(5) Others ( )	①	②	③	④	⑤

【Causes and countermeasure efficacies regarding discarded gillnets】

11. Please evaluate the efficacy of the following measures to prevent gillnets from being discarded.

The anticipated degree of efficacy (when using the following measures to solve the cause of discarded gillnets):	Very ineffective	Ineffective	Somewhat effective	Effective	Very effective
(1) Adjusting the installation location and time of fishing gears	①	②	③	④	⑤
(2) Adjusting the fishing gear installation areas	①	②	③	④	⑤
(3) Installing fishing gear collection facilities at the port	①	②	③	④	⑤
(4) Mandatory retrieval of fishing gear	①	②	③	④	⑤
(5) Reporting the loss of fishing gear	①	②	③	④	⑤
(6) Gear marking system for fishing gear	①	②	③	④	⑤
(7) Increased collection projects	①	②	③	④	⑤
(8) Enforcing regulations and strengthening the application of laws	①	②	③	④	⑤
(9) Others ( )	①	②	③	④	⑤

【Causes and countermeasure efficacies regarding discarded gillnets】

12. Do you think the following measures are viable in solving the causes of derelict fishing gears?

Preventive measures on discarding gillnets	Very ineffective	Ineffective	Somewhat effective	Effective	Very Effective
(1) Strengthening enforcements against discarding gillnets at sea	①	②	③	④	⑤
(2) Returning derelict fishing gears and implementing a compensation system (deposit system, etc.)	①	②	③	④	⑤
(3) Expanding education programs for fishers	①	②	③	④	⑤
(4) Providing simplified and convenient disposal methods (establishing sorting facilities and collection points)	①	②	③	④	⑤
(5) Gear marking system for fishing gear	①	②	③	④	⑤
(6) Establishing a rapid retrieval system for derelict fishing gears	①	②	③	④	⑤

13. The countermeasures below are already in place or will soon be in effect in the Republic of Korea. Which policy measure do you believe is most effective in solving the causes of derelict fishing gears?

Classification	Effectiveness (to solve the causes of derelict fishing gear listed below)	Very ineffective	Ineffective	Somewhat effective	Effective	Very Effective
Already in effect	(1) Purchasing Projects: A government project purchasing the waste collected during fishing operations in weight or by volume	①	②	③	④	⑤
	(2) Waste collection barges: Waste is collected using barges at ports and removed by local governments	①	②	③	④	⑤
	(3) Fishing ground cleanups: Collecting waste using vessels (existing projects include marine litter purification project and fishing ground purification project and others)	①	②	③	④	⑤
	(4) Supporting cleanup efforts by fishers: Fishers voluntarily retrieve and clean while local governments subsidize collection and processing efforts.	①	②	③	④	⑤

Planned to be in effect	(5) Mandatory retrieval of derelict fishing gear: When purchasing new fishing gear fishers will be required to turn in old fishing gear.	①	②	③	④	⑤
	(6) Deposit system for disposing old fishing gear: Deposit a certain amount of money for fishing gear	①	②	③	④	⑤
	(7) Utilizing an extended producer responsibility system: Requiring fishing gear manufacturers to be responsible for recycling fishing gears.	①	②	③	④	⑤
	(8) Using real-name identification systems for fishing gears in general	①	②	③	④	⑤
	(9) Any Other proposals?					

【Level of awareness on the damages and impacts of gillnets】

14. What do you think is the most serious damage caused by derelict fishing gears? (Please rank in the order of 3-2-1, with 3 being the most serious)
(- - - - -)

(1) Decrease in catch (including marine resources due to ghost fishing)
(2) Damages to vessels
(3) Destruction of marine life habitats
(4) Harm to marine predator species (such as sea turtles, whales, and sharks)
(5) Generation of microplastics
(6) Others ( )

Impact on the marine environment	Not serious	Slightly serious	Somewhat serious	Serious	Very serious
(1) Decrease in catch (including marine resources) due to ghost fishing	①	②	③	④	⑤
(2) Damages to vessels	①	②	③	④	⑤
(3) Destruction of marine life habitats	①	②	③	④	⑤
(4) Harm to marine predator species (such as sea turtles, whales, and sharks)	①	②	③	④	⑤
(5) Generation of microplastics	①	②	③	④	⑤

15. Which of the following damages to vessels due to derelict fishing gear (such as ropes, gillnets, etc.) cause the most serious economic harm?
(Please rank in the order of 3-2-1, with 3 being the most serious)
(- - - -)

(1) Propeller Entanglement
(2) Engine failure
(3) Rudder failure
(4) Route obstruction and/or needing to change course
(5) Other ( )

16. Please indicate your experiences regarding damaged vessels due to derelict fishing gear. (rope, gillnet, etc.)

Experience of damages	Frequency of occurrence (number of incidents/year)	Cost of damages (USD/year) (including repairs, replacements, and other costs)
(1) Propeller Entanglement		
(2) Engine failure		
(3) Rudder failure		
(4) Route obstruction and/or needing to change course		
(5) Other ( )		

Reference Guide to Fishers' Perception Survey on Gillnet Fishing Gear
(Source: National Fisheries Research Institute in Korea)