International community's efforts to mitigate sea turtle bycatch and status of implementing relevant measures by Korean tuna longline fishery

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Abstract

Longline fishery targeting tunas and tuna-like species is known to produce a significant amount of catch not only for the target species, but also for ecologically related species like sharks, marine turtles, sea birds and marine mammals. Recognizing this seriousness, tuna related regional fisheries management organizations (t-RFMOs) have established conservation and management measures (CMMs) to reduce bycatch and/or interaction with ecosystem vulnerable species including sea turtles and are obliged to implement bycatch mitigation measures and guidelines on safe release to their member countries. Along with development and strengthening of those measures, various case studies have been conducting to verify the effectiveness of bycatch mitigation for ecologically related species. This study examines the background and progress on developing CMMs of t-RFMOs and regulation programs of the United States related to sea turtles, which have recently become one of the main issues, and reviews case studies on sea turtle bycatch mitigation measures to find out the effectiveness of reducing bycatch rate and impacts to the fisheries. In order to respond the consultation process on certification determination with the United States, it was confirmed the current status of implementation on related measures conducted by Korean tuna longline fishery based on scientific observer data and survey for captains. Even though all Korean tuna longline fleets belong to the deep-set longline fishery (100–300 m), which is not subject to the obligation of those mitigation measures, they are voluntarily implementing both measures, use of circle hook and whole finfish bait, regardless of which RFMO's Convention area they operate. And the national regulatory and management programs for sea turtle bycatch prevention adopted by Republic of Korea seems to be comparable in effectiveness to that of the United Stated. However, Korea needs to take preemptive measures in establishing sustainable fisheries, including the protection of the marine ecosystem and environment, as stronger requests are anticipated to be made by the international community on this matter.

Keywords: Longline fishery, Sea turtles, Conservation and management measures (CMM), Circle hook, Bait

Introduction

Tunas are the most important commercial species, which mainly caught by longline, purse seine and pole-and-line fisheries operating in the tropical and temporal areas around the world. The tuna related fisheries have significant socioeconomic importance due to the high economic value and extensive international trade of tuna products. Tunas and tuna-like species account for over 9% of total marine fisheries catch, are the fifth most valuable globally traded fishery product, and occupy 9% of the $164 billion value of internationally traded seafood products (FAO, 2020; Gilman et al., 2020). Of those fisheries, longline fishery is one of the main tuna related fisheries, especially for countries having distant water fisheries such as Korea, Japan and Chinese Taipei and so on. In case of Korea, tuna longline fishery is the first Korean distant water fishery, which began in the Indian Ocean in 1957 (NIFS, 2007).

Longline fishery has a fishing method using a very long main fishing line (mainline), to which many smaller lines (branchlines) with hooks are attached (ISSF, 2022a). Floats spaced along the mainline keep it elevated horizontally in the water, and the branchlines hang vertically from it. A variety of bait is used, with whole fin-fish or squid (FAO, 2010). Longline fishery targeting tunas and tuna-like species is known to produce a significant amount of catch not only for the target species, but also for ecologically related species like sharks, marine turtles, sea birds and marine mammals. In particular, shallow-set longline fishery, which set hooks within 100 m in depth targeting swordfish and shark species, has higher interaction rate with ecologically related species than in deep-set longline fishery (100–300 m), because shallow-set longline is set in the depth where those species can easily access to hooks with bait (Clarke et al., 2016; Curran & Bigelow, 2011; FAO, 2010; Gilman et al., 2007). International Seafood Sustainability Foundation (ISSF) indicated that the average bycatch rate for longline fishery is more than 20% of the its total catch (ISSF, 2022b; NOAA, 2021). That is, fisheries targeting tuna and tuna-like species are likely to have considerable impacts on incidentally caught species with lower reproduction rates and long lifespan which is commonly called ecosystem vulnerable species including sea turtles, sea birds, marine mammals and elasmobranch. As a result, those species are more vulnerable to its fishing activities (Gilman et al., 2020). In case of sea turtles, 6 sea turtles (hawksbill sea turtle, olive ridley turtle, leatherback turtle, loggerhead turtle, green sea turtle, Kemp's ridley turtle)

are currently listed in threatened categories by the IUCN Red List (Clarke et al., 2016).

Recognizing this seriousness, tuna related regional fisheries management organizations (t-RFMOs) have established conservation and management measures (CMMs) to reduce bycatch and/or interaction with ecosystem vulnerable species including sea turtles and are obliged to implement bycatch mitigation measures and guidelines on safe release to their Cooperating Members, Cooperating Non-Members and Participating Territories (CCM). The initial effort of t-RFMOs to reduce bycatch of ecologically related species was to develop related CMMs at the level of voluntary implementation based on the FAO's International Plan of Action (IPOA) underlying the United Nations Convention on the Law of the Sea (UNCLOS) and the United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks (UNFSA). However, those CMMs have gradually being strengthen and the scope of application target has also been expanding.

Along with those efforts from international societies, the United States recently designated 28 countries, which classified as not implementing regulatory program comparable in effectiveness to that of the United States for reducing bycatch of sea turtles through the 2021 U.S. Biennial Report to Congress on Improving International Fisheries Management. In order to lift the designation, it is required to take actions to adopt a comparable regulatory program and support in strengthening the t-RFMOs' CMMs for sea turtles. If these requirements are not met, a negative certification determination is possible, resulting in denial of port privileges for fishing vessels flagged to those countries, denial of entry into navigable waters of the United States, and potential restrictions on imports of certain fish or fish products from those countries (NOAA, 2021).

Tuna fisheries are not only important in terms of economic importance, but also a symbolic fishery representing Korean distant water fisheries. Therefore, implementation of measures to reduce bycatch of ecosystem vulnerable species, especially sea turtles is no longer avoidable issue since it is closely linked to the sustainability of the Korean distant water industries. In this context, it should be responded based on the positive and/or negative impacts of implementing these measures to the fisheries considering the fishing characteristics of Korean tuna fleets, accordingly.

This study examines the background and progress on developing CMMs of t-RFMOs and regulation programs of the United States related to sea turtles, which have recently become

one of the main issues in the international societies, and reviews domestic and international case studies on sea turtle bycatch mitigation measures to find out the effectiveness of reducing bycatch rate and impacts to the fisheries. To confirm the current status of implementation on related measures conducted by Korean tuna longline fishery, scientific observer data and survey results from the captains belonged to Korean tuna longline fishery. Lastly, we proposed several actions to adequately respond to the international community's current calls for the preservation of ecologically related species and to prepare for the strengthening of related measures in the future.

Materials and Methods

In order to examine the background of the establishment of CMMs on sea turtle by the t-RFMOs, the Food and Agriculture Organization of the United Nations (FAO) Guidelines to Reduce Sea Turtle Mortality in Fishing Operations, which are the basis of all t-RFMOs resolutions and CMMs for reducing bycatch of sea turtle, was reviewed. Those CMMs and resolutions of each t-RFMOs were referred to confirm the progress of development and revision on those CMMs. And the 2021 U.S. Biennial Report to Congress on Improving International Fisheries Management was reviewed to understand the background of the designation to Korea as the nation where needs to take consultation process on sea turtle bycatch issue, and to identify the main topics to be discussed in the process of bilateral technical consultations with the United States for positive certification determination. To confirm the effectiveness of the bycatch mitigation measures, several domestic and international case studies focusing on the use of circle hook and finfish bait were summarized to compare bycatch reduction rate and impacts on catchability for target species. Scientific observer data collected from Korean tuna longline fleets operated in the Pacific, Atlantic and Indian Oceans were used to figure out the current status of implementing measures such as using circle hook and bait type. Since the period of available information for each measure is different due to the revision of the observer data format, current states of using each measure were analyzed using data from 2018 to 2020 for hook type and from 2016 to 2020 for bait type, respectively. Lastly, a questionnaire survey was conducted for captains of Korean tuna longline fleets who participated in a training program during 2018. The questionnaire consists of contents to seek information and opinions from fishermen on whether to implement conservation measures and the efficiency of mitigation measures of ecologically related species including sea turtles. 41 captains participated in this survey, accounting for 40% of all the captains who belong to the Korean distant water tuna longline fishery.

Results

Background of establishment for conservation and management measures on sea turtles

The basis for the CMMs related to ecologically related species, which easily interact with tuna fisheries comes from the UNCLOS that provides a legal framework for the sustainable conservation and management of marine living resources, as well as commercially important species. In particular, as the UNFSA strengthens UNCLOS rules on fisheries, incorporating the precautionary approach and the concepts of compatibility of measures, and providing additional responsibilities to States for enforcement of CMMs (FAO, 2010). The 1995 FAO Code of Conduct for Responsible Fisheries (CCFR) is based on international laws including UNCLOS and provides principles and standards which request sustainable use of aquatic ecosystems. And it also demands that fisheries be conducted with due regards for the environment. Article 6.6 of the CCFR specifically addresses biodiversity issues and conservation of endangered species, requiring the bycatch of non-target species and the impacts of fisheries on biodiversity to be minimized (FAO, 1995).

As part of the implementation of the CCFR on sea turtles, two expert consultations on interactions between sea turtles and fisheries (longlines, purse seines, gillnets, trawls, and traps) were held in 2004 to present measures for avoiding or minimizing sea turtle interactions in fisheries, and to consolidate existing handling and release guidelines. Based on the outputs from both consultations, the 'Guidelines to Reduce Sea Turtle Mortality in Fishing Operations' was developed and then adopted at the 26th FAO Committee on Fisheries (COFI) in 2005. And based on this guideline, t-RFMOs started to develop the CMMs and resolutions including several mitigation measures for sea turtle (FAO, 2010). Table 1 shows the summary of methods used to reduce sea turtle interactions introduced by this guideline. Among those measures, Korean tuna longline fleets voluntarily implement circle hooks and whole fin-fish.

Table 1. Summary of methods used to reduce sea turtle interactions introduced by Food and Agriculture Organization of the United Nations (FAO) Guidelines to Reduce Sea Turtle Mortality in Fishing Operation

1. Fishing gear designs and fishing method	
Gill net	- Lower-profile (narrower), stiffer nets
	- Deeper setting for surface gillnet fisheries
	- Use longer tie-downs of avoid their use in demersal gillnets
	- Avoid exceeding a maximum threshold for mesh size
Pelagic longline	- Replacement of J and tuna hooks with large (wider) circle hooks[1]
	- Use of whole fish instead of squid for bait[1]
	- Setting hooks deeper than turtle abundant depths (40–100 m)
	- Use of dyed bait/camouflaged gear
	- Reduced gear soak time
	- Avoidance of fishing in certain sea surface temperature
	- Use of intermittent flashing light sticks in place of traditional continuous flashing light sticks and not using luminous gear
Coastal Trawl	- Turtle excluder devices (TEDs) for shrimp fisheries
Purse seine	- Avoidance of encircling sea turtles
	- Modified designs for fish aggregating devices (FAD)
Demersal longline	None
2. Sea turtle bycatch hotspot avoidance	
	- Time-area closures/marine protected areas (MPAs)
	- Fleet communication for real-time bycatch hotspot avoidance
3. Adjust input and/or output controls	
	- (Input) Fishing effort and capacity limits
	- (Output) Sea turtle caps and/or target specie caps per fishery or per vessel
4. Other measures	
	- Bycatch fees and other methods of compensation
	- Avoidance and reduction of derelict fishing gear and other marine debris
	- Retrieval of derelict fishing gear and other debris
	- Consideration of effects on other sensitive species groups
	- Changing gear type to one with a lower turtle bycatch to target catch ratio

5. Best practices for sea turtle handling and release

a) Retrieving a sea turtle: Assess the turtle's size, then release it or bring in on board. (Large turtle) Bring it as close to the boat as possible without putting too much strain on the line, then cut the line as close to the turtles as practical. (Small turtle) Use a dip net to lift it on board. DO NOT use a gaff and DO NOT pull on the line or grasp the eye sockets to bring the animal on board.

b) De-hooking a sea turtle: Place a piece of wood in the turtle's mouth so it cannot bite, then cut the hook or line. If the hook's barb is visible, use bolt cutters to cut the hook in half, and remove the two parts separately. If the hook is not visible, remove as much line as possible without pulling too hard on the line, and cut it as close to the turtle as practical.

[1]Among the measures in the pelagic longline, the marked measures are being voluntarily taken by Korean tuna longline fishery.

Conservation and management measures on sea turtles related to tuna related regional fisheries management organizations (t-RFMOs)

Western and Central Pacific Fisheries Commission (WCPFC)

The Western and Central Pacific Fisheries Commission (WCPFC) developed the Resolution (Resolution-2005-04) on sea turtles, which urged to undertake research trial for effectiveness of using circle hooks and to carry on the necessary equipment for the prompt release of incidentally caught sea turtles according to the FAO guidelines above. In 2008, the Commission adopted a recommendation (CMM 2008-03) to make it mandatory for the shallow-set longline fishery for implementing at least one of the three mitigation measures from January 1st 2010; 1) Use only large circle hooks which have an offset not to exceed 10 degree, 2) Use only whole finfish for bait, 3) Use any other measures, mitigation plan or activities that has been reviewed by the Scientific Committee and the Technical and Compliance Committee and approved by the Commission. In 2018, the CMM (CMM 2018-04) is expanding the scope of implementation of measures by urging to conduct

research trials on the use of circle hooks in the deep-set longline fishery.

Inter-American Tropical Tuna Commission (IATTC)

The Inter-American Tropical Tuna Commission (IATTC) established the Resolution on sea turtles (Resolution C-04-07), which urged to undertake research for determining the effectiveness of the use of circle hooks and other measures for mitigating incidental catch and mortality of sea turtles, and to assess their effects on the catch availability of target species. And it also included the industry education for treating incidentally caught sea turtles properly to improve their survivability. In 2019, the resolution (Resolution C-19-04) urged that at least one of the three mitigation measures be implemented for shallow-set longline fishery like those of WCPFC, and monitoring and reporting bycatch information should be strengthened.

Indian Ocean Tuna Commission (IOTC)

Under the Recommendation 05/08 in 2005 and Resolution 09/06 in 2009, the Indian Ocean Tuna Commission (IOTC) encouraged the use of whole finfish bait for all longline fisheries and requested to CCMs for undertaking research trials of circle hooks, use of whole finfish for bait and other mitigation methods which may improve the mitigation of adverse effects on sea turtles. In 2012, the IOTC recommended to ensure that the Resolution applies equally to all sea turtle species and that CCMs annually report data related to all interactions and mortalities of sea turtles in fisheries according to the Resolution 12/04.

International Commission for the Conservation of Atlantic Tunas (ICCAT)

The International Commission for the Conservation of Atlantic Tunas (ICCAT) encouraged the release of sea turtles that are incidentally caught alive and share all available information such as technical measures to reduce incidental catch of sea turtles, and to ensure the safe handling of all turtles in the way of improving their survivability under the Resolution (Res. 03-11) in 2003. In 2010, the ICCAT made it mandatory to collect and report operating information on bycatch of sea turtles and stipulated that shallow-set longline fleets operating in the ICCAT Convention area should carry on board designated equipment capable of releasing sea turtles in a manner that maximizes the survival rate. The ICCAT improved the related recommendation (Recommendation 13-11) by adding standard

for release equipment and the guideline for safe release of sea turtles.

Commission for the Conservation of Southern Bluefin Tuna (CCSBT)

The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) does not have its own conservation measures, and it stipulates that fishing vessels targeting Southern Bluefin tuna should follow the conservation measures related to ecologically related species of t-RFMOs, which has jurisdiction over the waters being fished.

As such, all t-RFMOs are required to have guidelines on safe release for sea turtles by fishery (longline, purse seine and drift gill net) and devices or equipment for releasing them. In particular, all t-RFMOs, except for the ICCAT, have a mandatory regulation for shallow-set longline fishery to implement mitigation measures such as use of large circle hooks and use of whole finfish as bait.

Since all Korean tuna longline fleets belong to the deep-set longline fishery (100–300 m), they are not subject to the obligation of those mitigation measures. However, it is necessary to voluntarily implement such measures in advance because the implementation of those mitigation measures is expanding to the entire longline fisheries. In addition, all t-RFMOs are required to collect detailed information on interactions with sea turtles from fishing vessels and scientific observers and report them to the Secretariat of each t-RFMO. In order to accurately estimate the impact of fishing on ecologically related species, t-RFMOs continue to demand an increase in observer coverage, and actively encourage the introduction of electronic monitoring system as a role to compensate for the limitations of human observer deployments.

The United States domestic law for the protection of sea turtles

Under the High Seas Driftnet Fishing Moratorium Protection Act (16 U.S.C, §§ 1826h–1826k), U.S. Congress requires the Secretary of Commerce to submit a biennial report identifying nations or entities whose vessels have been engaged in illegal, unreported, and unregulated (IUU) fishing, bycatch of protected species, unsustainable fishing for sharks on the high seas, or whose own actions or failures undermine conservation measures of a RFMO. After consulting with identified nations and entities on improving their relevant fisheries management and enforcement practices, the Secretary must certify in the

next biennial report whether actions by the identified nations and entities have adequately addressed the activities of concern (NOAA, 2021).

In the biennial report to the Congress issued on August 12, 2021, the United States was identified several nations and entities that need consultation with the United States to encourage them to take appropriate remedial measures for three major sections of IUU fishing, bycatch of Protected Living Marine Resources (PLMR) and shark conservation and protection. Regarding on the section of bycatch of PLMR, the United States is identifying 28 nations and entities for bycatch of sea turtles in longline fisheries managed under ICCAT, which has failed to implement effective measures to reduce such bycatch (Korea, China, European Union, France, Italy, Japan, Portugal, Spain, Taiwan and so on). And the United States evaluated them not to have adopted regulatory measures that are comparable in effectiveness to those of the United States to reduce or end bycatch PLMRs.

For evaluating comparability of effectiveness between regulation of the United States and those of other nations, the United States used the sea turtle bycatch provisions from the U.S. Atlantic highly migratory species fisheries regulations (Code of Federal Regulations [CFR] Title 50 Part 635) as a baseline. These regulations involve the obligations and guidelines that should be required to implement for the U.S. shallow-set longline fleets operate in the Atlantic Ocean. These regulations for protecting sea turtles have a variety of complicated and specific measures compared to the those of t-RFMOs, however, of the key measures are required to use large circle hooks (18/0 or larger with an offset not to exceed 10 degreed, or 16/0 or larger non-offset circle hooks) and use only whole fin-fish or squid as bait, which are similar to those of t-RFMOs. Table 2 shows the comparison of sea turtle mitigation measures and safe release equipment for longline fishery among t-RFMOs and the U.S. Code of Federal regulations.

In this regards, various domestic and international research studies have been conducted to prove the efficiency of those mitigation measures (use large circle hooks and whole fin-fish bait) for reducing sea turtle bycatch and interaction with fisheries.

Case studies on the bycatch mitigation measures for sea turtles
Use of circle hook

Longline fishery targeting tuna and tuna-like species has been

Table 2. Comparison of sea turtle mitigation measures and safe release equipment for longline fishery among tuna related regional fisheries management organizations and U.S. CFR

		Mitigation measures	Safe release equipment
WCPFC	Shallow-set	Employ or implement at least one of the three measures a. Use only large circle hooks (offset not exceed 10 degrees) b. Use only finfish for bait c. Use any other mitigation or activity approved by the Commission	Line cutters, de-hookers
	Other (deep-set)	Undertake research trials of circle hooks and other mitigations	
IATTC	Shallow-set	Employ or implement at least one of the three measures a. Use only large circle hooks (offset not exceed 10 degrees) b. Use only finfish for bait c. Use any other mitigation or activity approved by the Commission	
	Other (deep-set)	Undertake research trials of circle hooks and other mitigations	
IOTC		Use of whole finfish for bait	
ICCAT		None	
U.S. CFR		Required to implement all measures; • Use only 16 or larger (non-offset) or 18 or larger (offset not exceed 10 degrees) circle hooks • Use only whole Atlantic mackerel and/or squid bait	Line cutters, de-hookers, extended reach handle, long-handled device to pull an 'inverted V', dip-net, tire, bolt cutters, long-nose or needle-nose pliers, mouth openers etc.

WCPFC, Western and Central Pacific Fisheries Commission; IATTC, Inter-American Tropical Tuna Commission; IOTC, Indian Ocean Tuna Commission; ICCAT, International Commission for the Conservation of Atlantic Tunas; CFR, Code of Federal Regulations.

mainly used three type of hooks: J-hooks, Japanese tuna hooks and circle hooks, however Korean tuna longline fleets no longer use J-hooks since early 2010s (Fig. 1). Circle hooks are generally circular or oval in shape and have a point perpendicular to the shank that curves inward and is less exposed in comparison to J-hooks and tuna hooks where the point is parallel to the shank (FAO, 2010). Using circle hooks is known as one of the most effective measures to reduce sea turtle bycatch proven by various on-site experiments with various setting conditions. This is because circle hook has a wider width than other hooks, making it difficult for sea turtles to swallow hooks, so it leads to not only greatly reduce the possibility of sea turtle bycatch but also remove the hooks more easily due to lower possibility to be caught deeply (An et al., 2011; Clarke et al., 2016; FAO, 2010).

Numbers of studies that analyzed the effectiveness of circle hook have been conducted focusing on comparing catchability and/or reduction rate by species according to the hook type and size. The results of each study were somewhat different on whether circle hook was effective in reducing bycatch of ecologically related species by species and which circle hook size was most effective in this regard. However, a common result of these studies is that the use of circle hook is very effective in mitigating bycatch of sea turtles and has even higher fishing efficiency for target species such as bigeye and yellowfin tunas (Andraka et al., 2013; Curran & Bigelow, 2011; Foster et al., 2012; Huang et al., 2016; Pachecoa et al., 2011; Promjinda et al.,

2008; Sales et al., 2010). In the case of experiments conducted by Korean tuna longline fleets, it also showed that the catch rate of bigeye tuna, which is the target species, was higher when using circle hooks (An et al., 2011; Kim et al., 2006). In the same manner, the catch rate of elasmobranch, especially blue shark, also tends to be high with the use of circle hooks (Afonso et al., 2011; Andraka et al., 2013; Foster et al., 2012; Huang et al., 2016; Sales et al., 2010).

Use of whole finfish

The use of a whole finfish is known to decrease bycatch rate of sea turtles. This is because that the larger the bait, the lower the relative catchability of smaller species which has smaller mouth dimension (Gilman et al., 2020; Yokota et al., 2012). The feeding characteristics of sea turtles is another reason why whole finfish baits can be more efficient in mitigating sea turtle bycatch than squid baits. That is, sea turtles are known to stay and finish up the whole piece of bait on a hook, and since squid flesh is firm and rubbery in texture, sea turtles tend to ingest an entire squid bait and hook in a single gulp. On the other hand, sea turtles can more easily tear pieces of fin-fish bait off in small bites as fish flesh is softer, reducing the chances of hook ingestion (Gilman et al., 2020; Parga et al., 2015; Watson et al., 2005).

A number of studies have demonstrated the effectiveness of the sea turtle bycatch mitigation measures including those involving the use of circle hooks with whole fin-fish

Fig. 1. Hook type used in the Korean tuna longline fishery. (left) Circle hook (C14), (right) Japanese tuna hook (3.4 sun).

baits. However, most of the relevant experiments have been conducted for shallow-set longline fishery, whose fished depths were mainly within 100 m; therefore, it is yet to be clear whether the study results can be applied for deep-set longline fishery, which is the case of the Korean tuna longline fishing vessels. According to An et al. (2011), the use of circle hooks had no negative impact on the catch rates of the target species of Korean tuna longline fishery, and especially the catch rate of bigeye tuna was found to be even relatively higher, and mean length of caught individuals were larger than those caught with J hooks. With regard to the bycatch reduction rate and fishing efficiency by circle hook size, it showed that the larger hook size the less sea turtle bycatch, however, there were no significant difference in the catch rate of the target species when the circle hook size was at 16 or larger.

Current status of implementation on sea turtle bycatch measures by Korean tuna longline fishery

As noted, most Korean tuna longline fleets are voluntarily implementing both measures, circle hook and whole finfish bait.

According to the scientific observer data collected, the ratio of circle hooks over the total hooks used in the Korean tuna longline fishery during 2018–2020 were 95% in the Pacific Ocean and 78% in the Indian and Atlantic Oceans. In the case of the Pacific Ocean, mostly 14 and 15 sized circle hooks (C14, C15) were used, with C14 being the largest proportion (71%) and C15 for 10%. C13 accounted for 9%, and both mixed use of circle hooks (C14 & C15) and circle hook (C14) and Japanese

tuna hook accounted for 5%, respectively. In the case of the Indian and Atlantic Oceans, C15 accounted for the largest proportion (40%). Both C14 and mixed use of circle hooks (C14 & C15) accounted for 19% over the total, respectively. All hooks other than the circle hooks used were Japanese tuna hooks, which accounted for 22%, and notably, in the Atlantic Ocean, fishing vessels targeting Atlantic bluefin tuna used 100% Japanese tuna hooks. There was no J hook used in the Korean tuna longline fishery since 2018 (Fig. 2).

In terms of bait type used in the Pacific Ocean, the proportion of whole finfish showed an increasing trend, while that of squid showed the opposite trend to finfish (Fig. 3). The species used as bait are mainly jack mackerel, sardines, scads, milkfish and so on.

With regard to the question on the proportion of circle hook in a set, 64% of the responders claimed to use circle hooks of over the 80%, especially, all captains who were about to fish in the Pacific Oceans in the coming season said they use all or most portion of their hooks with circle hooks. Regarding to the question on whether the use of circle hook negatively affects fishing operations or not, most of the users said there was no negative impact on the catch rate of target species (89%) and were willing to keep using the circle hooks regardless of the implementation of the measure (Fig. 4). The opinions of those who answered that there was a negative impact also pointed out economic aspects such as rising operation costs rather than operating effects such as a decrease in the catch rate of target species.
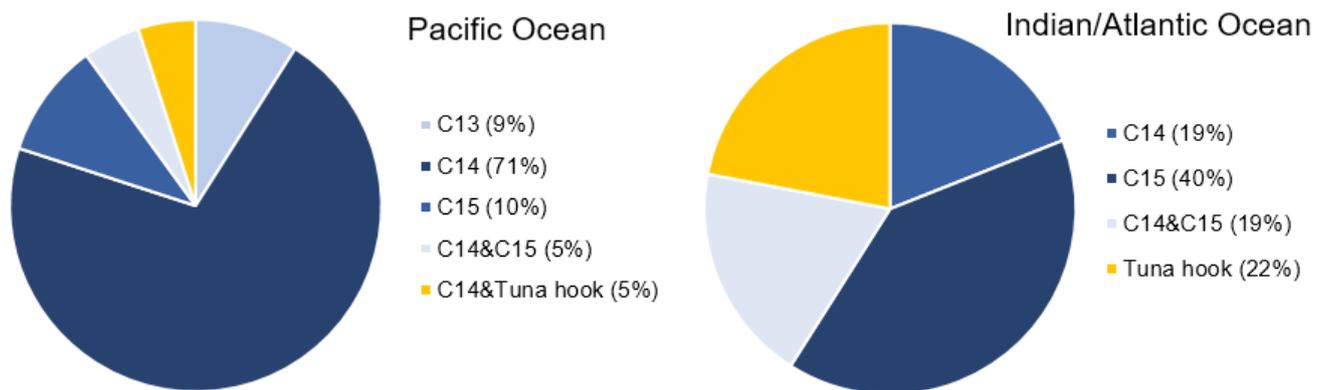

Fig. 2. The proportion of hook type and size used in the Korean tuna longline fishery based on the scientific observer data collected during 2018–2020. Tuna hook indicates Japanese tuna hook.
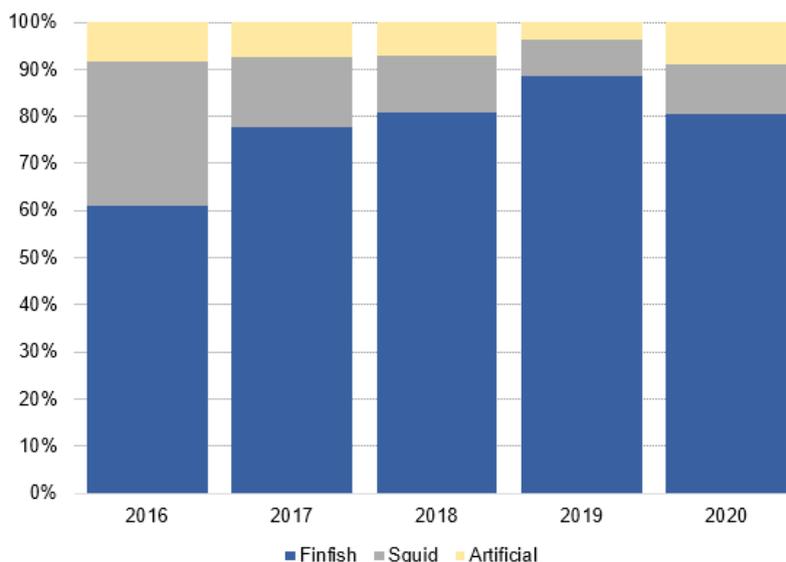
Fig. 3. The proportion by bait type used in the Korean tuna longline fishery operating in the Pacific Ocean based on the information collected by scientific observers, 2016–2020.
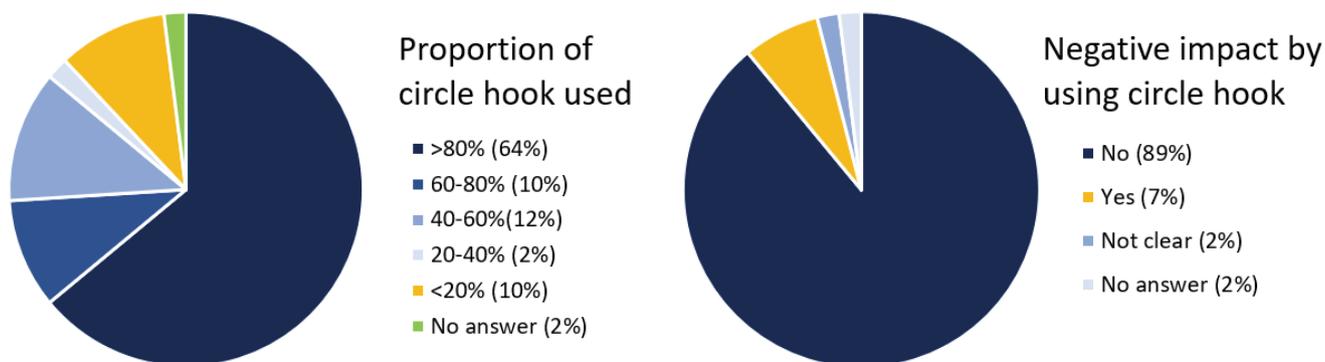

Fig. 4. The result of survey on proportion of circle hook used and the fishermen's opinion related to negative impact by using circle hook.

National regulatory and management programs for sea turtle bycatch prevention and mitigation of Republic of Korea

In the 2021 U.S. Biennial Report to Congress on Improving International Fisheries Management, Korea was identified for having vessels that engaged in fishing activities or practices that result in bycatch of sea turtles, in longline fisheries in the ICCAT Convention area beyond national jurisdiction without a regulatory program comparable in effectiveness to that of the United States. Following the consultation period, the NOAA Fisheries will make a certification determination based on any

actions taken by the Korea to adopt a comparable regulatory program as well as the establishment of a management plan that includes gathering species-specific data to support international stock assessments and conservation enforcement efforts for PLMRs. To receive a positive certification determination, Korea needs to take sufficient steps to address the issues for which it was identified.

In this regard, it is necessary to look at the national regulation and management programs for sea turtle bycatch prevention and mitigation currently implemented in Korea.

Act to Conserve and Manage Marine Ecosystem

The Act to Conserve and Manage Marine Ecosystem designated 5 species of sea turtles (*Eretmochelys imbricate, Chelonia mydas, Caretta caretta, Dermochelys coriacea, Lepidochelys olivacea*) and prohibits any catching, harvesting, offering for sales, etc. of these species unless authorized by the Minister of Oceans and Fisheries for the purpose of research, protection, reproduction or restoration. This Act applies to all fisheries in Korea.

Article 18 paragraph 2 (1) the Act to Conserve and Manage Marine Ecosystem also stipulates that "anyone shall make efforts not to interact with marine mammals and protected marine species, and shall cooperate with bycatch prevention polices established by the central and local governments." Paragraph 2 (2) stipulates that the central and local governments shall make efforts to undertake research and development for the prevention of bycatches of non-target species.

This means that Korea has domestic law that is more stringent than what is required by ICCAT.

Distant Water Fisheries Development Act

Paragraph 6, Article 7 of the Distant Water Fisheries Development Act of Korea stipulates that the authority can determine the terms and conditions for license for the management of marine living resources. With this provision in place, the license for the ICCAT longline fishery can specify sea turtle mitigation measures as terms and conditions.

Paragraph 2 (9), Article 13 of this Act provides that not reporting or false reporting of data on fishing operations, catches, landing and transshipment is a serious violation.

Korean-flagged distant water tuna longline vessels are required to report their catches (Attachment 17[iv] of the Distant Water Fisheries Development Act) and bycatches, including sea turtles (Attachment 17[xvi]). The formats include the date and location of set, conservation measures codes, species, number of release and discards, etc.

Non-reporting or false reporting of these data is subject to administrative fine of at least KRW 200 million (approx. USD 240,000) or up to five times the value of the fish sold in accordance with paragraph 1(iii), Article 31-2 of this Act. The first-time violation results in 60-day suspension of fishing authorization and master/officer's license, 120 days for a second time violation, and the cancellation of authorization and master/officer's license for the third time offender.

Management programs for sea turtle bycatch prevention and mitigation

Data collection

Korean distant water fishing vessels, regardless of the areas they operate, are required to make species-specific reports on interactions with ecologically related species, including sea turtles, through an electronic monitoring system. The report includes the date and location of set, number of release/discards and status by species. Scientific observers also collect biological information on these species. Relevant data are submitted to the Secretariat of respective RFMOs.

Education and training

The National Institute of Fisheries Science (NIFS) extends pre-trip education sessions to vessel masters on conservation and management measures for the ecologically related species including safe handling and release and provides posters for safe handling and release of bycatch species. The vessels are instructed to have this poster on board the vessel.

Sea turtle guidelines

Korean tuna longline vessels operating in the IOTC Convention area are required to comply with the FAO sea turtle bycatch mitigation guidelines in accordance with the IPOA on sea turtles. The implementation is reviewed and assessed annually at the IOTC Scientific Committee. And all guidelines on safe releasing of sea turtles from t-RFMOs are based on this FAO guideline. Therefore, Korea applies these guidelines not only to the IOTC Convention area but also in other t-RFMOs Convention areas as well.

Voluntary actions by fishing industries

Although the ICCAT has yet to introduce sea turtle bycatch measures comparable to other t-RFMOs such as the WCPFC and IATTC, Korean tuna longline fleets operating in the ICCAT Convention area are implementing the measures adopted by these RFMOs. Both the WCPFC and IATTC's requirements for use of circle hooks or whole fin-fish applied only to shallow-set longline fishery, Korean tuna longline vessels, which set deeper than 100 meters are using both circle hooks and whole fin-fish/squid baits in the ICCAT Convention area. These vessels also have on board graphic materials for the safe handling and release of sea turtles adopted by WCPFC and sea turtle handling and release posters issued by NIFS.

In addition, Korean tuna longline vessels operating in

the ICCAT Convention area are usually operate in the IOTC Area as well. Therefore, these vessels implement requirements adopted by both RFMOs at the same time.

Discussion

Through this study, it was able to confirm that the sea turtle bycatch mitigation measures voluntarily implemented by the Korean tuna longline fisheries are quite comparable with the regulations designated and implemented by t-RFMOs and the U.S. domestic laws and are not lacking in terms of the severity of regulation. It is regretful that Korea had less opportunity to convey both a government and fishing industries' efforts to the international communities. Luckily, there were several bilateral consultations between Korea and the U.S. held this year which provided an opportunity for the experts of both countries to discuss the current regulations and other measures on the mitigation of sea turtle bycatch in Korea, and Korea was able to deliver its thoughts on some of the questions made by the U.S. experts. However, Korea needs to take preemptive measures in establishing sustainable fisheries, including the protection of the marine ecosystem and environment, as stronger requests are anticipated to be made by the international communities on this matter.

Firstly, since the main reason why the U.S. report to Congress considered Korea as an unsatisfactory country in managing sea turtle bycatch was because Korea has been operating a longline fishery in the ICCAT Convention area, where, at present, no regulation on sea turtle bycatch is in place, we must actively support the establishment of relevant measures in the ICCAT. Secondly, we must fully utilize the available information including the vessel reports and scientific observer reports to find out the impacts of sea turtle bycatch mitigation measures to Korean longline fisheries. Based on the results, we need to come up with an option that is favorable to the Korean fleets' characteristics, in preparation for future discussions on strengthening the relevant regulations. What should be produced from the data review process is not a simple study result like the usage and size of circle hooks but a comprehensive study result incorporating the spatio-temporal elements (e.g., location, time, and season fished), bait type, fishing methods (deep-set, shallow-set), and fished depths (by hook location). Also, regular capacity-building workshops should be provided to fishery employees so that precise information on the status of sea turtle bycatch can be reported, and guidance can be distributed to facilitate the species identification and safe release of sea turtles.

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