Assessment of mitigation measures to reduce interactions between sea turtles and longline fishery

MASASHI KIYOTA, KOSUKE YOKOTA, TAKAHIRO NOBETSU, HIROSHI MINAMI and HIDEKI NAKANO

National Research Institute of Far Seas Fisheries, Fisheries Research Agency

5-7-1 Shimizu-orido, Shizuoka, 424-8633 Japan

Email: kiyo@affrc.go.jp

ABSTRACT

Sea turtles have been receiving negative impacts from both human activities and natural factors. Interactions with commercial fisheries are one of the anthropogenic factors affecting sea turtle populations. A variety of mitigation measures have been developed and tested to reduce incidental mortality of sea turtles in longline fishery. We review potential technical measures to alleviate longline-sea turtle interactions and show some preliminary results from our field and laboratory experiments. Fishing gear modifications aim at reducing hooking rates of sea turtles by changing fishing hooks and baits or by the use of additional devices. Results of our field experiments showed that the use of circle hooks altered hooking position and reduced deep hooking of sea turtles. Fish baits showed lower catch rates of sea turtles than squid baits, because sea turtles were more likely to swallow the whole squid bait due to tough and flexible muscle texture of squids. Fishing practice modifications aim at avoiding the overlap between fishing operations and sea turtles either spatially or temporally. In the oceanic area, sea turtles spend most of their time within the shallow surface layer (<40m). Deep-setting longline is effective to avoid incidental capture of sea turtles. Sea turtles have habitat preference for warm water, and migratory species seem to have distinct routes for long-distance migration. Biotelemetry studies play a important role because they provide baseline information on habitat utilization, diving profile, activity pattern, and migratory paths of sea turtles Careful handling and live release is another way to reduce post-hooking mortality of sea turtles because many sea turtles captured in shallow longline are retrieved alive. Several instruments have been developed to haul sea turtles onboard and to remove fishing hooks and lines. Results of our captive experiments indicated that hooked sea turtles survived for a prolonged period and discharged fishing hooks out of the body. Since these mitigation techniques affect the fishing efficiency of target species, we should also assess the economic feasibility of each method to establish a practical way of solution.

KEYWORDS*:* bycatch, circle hook, longine fishery, turtle avoidance methods

INTRODUCTION

Due to their amphibious life cycles, sea turtles have been affected by a large variety of factors. Both human activities (e.g., direct take, beach development, collisions with boats, disturbance of nesting beaches, ingestion of marine debris) and non-human factors (e.g., predation, disease, climatic change) put adverse impacts on sea turtle populations on land and at sea

(Matsunaga and Nakano 2004). Since sea turtles are highly migratory and have wide distribution at sea, they interact with many kinds of fisheries in the coastal shallow waters and in the off-shore oceanic regions. Trawl, gillnet, set-net, trap, purse-seine, and longline are major types of fishing gears that interfere with sea turtles.

Recently, attention has been focused on the possible impacts of longline fishery on some populations of sea turtles. Emergency actions to close fishing season and/or area were taken in some regions for protecting sea turtle populations. For example, seasonal time/area closure was introduced to the U.S. Atlantic longline fishery in the Grand Banks fishing area in late 2000 to reduce the bycatch of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles (U.S. NMFS 2000a). In the Pacific region, in 2002, the U.S. government prohibited Hawaii-based longline fishing targeting swordfish north of the equator to reduce the bycatch of loggerhead and leatherback sea turtles (U.S. NMFS 2000b), although the prohibition was alleviated later. These emergency rules to close fishing operations were effective in reducing incidental mortality of sea turtles, they also put serious impacts on local fishing industry because fishermen lost the opportunity of fishing. To overcome this problem, governments and fisheries managers initiated researches to develop mitigation techniques to reduce incidental mortality of sea turtles in longline fisheries (Simonds 2003, Watson et al. 2003, Boggs 2004, Bolten et al. 2004). Given effective mitigation techniques, it will be possible to manage both sustainable fishing operations and marine wildlife conservation.

In this paper we review potential technical measures to reduce incidental hooking of sea turtles and resultant mortality, in tuna longline fishery. We also show some preliminary results from our field and laboratory experiments.

Table 1. Potential mitigation measures to reduce incidental capture and mortality of sea turtles during longline operations.

1. Fishing gear modifications
Modification of hook design
size, shape, offset, material
Modification of branch line
color, material (camouflaged line)
Use or disuse of additional devices
use of camouflage lighting devices
disuse of light sticks
use of acoustic devices
Modification of bait
bait type (fish/squid, artificial material)
bait color
olfactory cue
2. Fishing practice modifications
Fishing depth (vertical)
deep setting, midwater longline
Fishing area (horizontal)
selection of water mass
Fishing time and season (temporal)
changing fishing schedule
3. Safe handling and release
Careful hauling
Development and use of de-hooking devices

CONTEXT OF INCIDENTAL HOOKING

Incidental hooking of sea turtles in longline fishery occurs in the following manner: 1) Sea turtles swim in the fishing ground and encounter the baited hooks. 2) They recognize the baited hooks as food, prey on the bait, and are hooked while they bite and ingest the baited hooks, or sea turtles are foul-hooked accidentally. 3) Some of the hooked sea turtles may die due to drawing or possibly by trauma caused by hooks and lines. If we can block one of these steps, incidental hooking and/or mortality of sea turtles will not occur. Corresponding to the above steps, three different approaches have been investigated, namely, modifications of fishing gear, modifications of

fishing practices, and handling and release of hooked sea turtles. Table 1 summarizes the potential mitigation techniques.

GEAR MODIFICATIONS

Modifications of fishing gear such as hooks, lines, baits and use or disuse of additional devices have been tried to avoid incidental hooking of sea turtles (Fig. 1). Hook shape, size and material may alter hooking mechanism and post-hooking damage of sea turtles. Large circle hooks are known to reduce the hooking rates of sea turtles compared to conventional tuna hooks, but large hooks may also reduce target catch rates. We compared the effects of hook shape by using similar-sized circle hooks and tuna hooks. Results of our experimental fishing showed that the catch rates of loggerhead sea turtles were similar between the two hook types. But they showed differences in hooking positions: Ingestion of fishing hooks occurred less frequently with circle hooks. In addition, catch rates of targeted fish (tuna and billfish) did not differ between the two hook types (Table 2). Kind of fishing baits also affect target selectivity. Our field experiments showed that fish baits had significantly lower catch rate of sea turtles than squid baits. We also conducted captive experiments about hooking mechanisms. In the experiment, sea turtles were likely to swallow the

Fig. 1 Fishing hooks of different shape and size. From left to right : 3.8-sun (11.5cm) tuna hook, 4.3-sun (13.0cm) circle hook, 5.5-sun (16.7cm) circle hook.

Table 2. Summary of results from field and captive experiments on mitigation measures to reduce incidental mortality of sea turtles in longline fishery.

Mitigation measures	Field experiments	Captive experiments
Hook type	Hooking rates of loggerhead turtles were not different between 3.8-sun circle hooks and 3.8-sun tuna hooks Circle hooks made more mouth hooking and less deep hooking than tuna hooks.	
Bait type	Catch rates of loggerhead turtles were higher with squid baits than with fish baits.	Loggerhead turtles bit and cut fish baits when they fed. They swallowed squid baits whole.
Bait color	Hooking rates of loggerhead turtles were not different between blue-dyed baits and non-dyed baits.	In the feeding trials, loggerhead turtles ate non-colored or red-dyed squid first, but they also ate blue-dyed baits later.
Fishing depth	Hooking of sea turtles occurred more frequently in shallow branch lines (<40m) than in deep branch lines.	
Post hooking survival	Use of large dip nets and de-hookers were effective in rescuing hooked loggerhead turtles but de-hookers need further improvement for practical use.	Seven hooked loggerhead turtles survived for more than one year and ejected fishing hooks.

whole squid bait which had flexible and tough muscle texture. In contrast, turtles bit and cut fish baits and ingested small pieces of fish muscle (Table 2). The results indicate that the bait texture was related to the difference in feeding mechanism and in hooking rates.

Blue-dyed baits are very effective in reducing incidental capture of seabirds because of its visual camouflage (Kiyota 2002). However, results of our field experiments did not show significant difference in sea turtle catch rates. Behavioral observation in captive experiments suggested that loggerhead sea turtles altered feeding behavior according to food color, but that they finally ate all the food items regardless of their color (Table 2). Attempts to induce olfactory aversion by adding chemical substances have not been successful.

FISHING PRACTICE MODIFICATIONS

The overlap between fishing gear and foraging sea turtles can be avoided by changing fishing practices either vertically, horizontally or temporally. In the oceanic area, sea turtles spend most of their time within the shallow surface layer (less than 40m deep) of the water column (Polovina et al. 2004). Empirically, deep-setting longline is known to reduce incidental capture of sea turtles. Analysis of the past sea turtle catch data collected by Japanese research and training vessels showed that hooking of sea turtles occurred most frequently at the shallowest branch line closest to the float line. Removal of the shallow branch lines is an effective option to reduce the vertical overlap of baited hooks and sea turtles. But this option has a drawback to spoil the fishing efficiency of the targeted species. We are developing a new longline configuration called “mid-water float system”, which is designed to set fishing hooks at a certain depth zone (Shiode et al. in press) (Fig. 3).

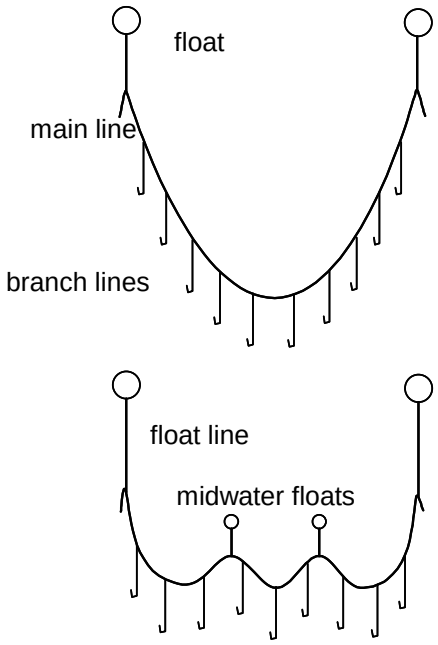

Fig. 3 Diagrams showing fishing gear configuration of conventional longline (upper) and midwater longline (lower) systems.

Sea turtles generally have habitat preference for warm water. Incidental hooking of sea turtles is common at the surface water temperature above 20°C. In the oceanic area, sea turtles, especially loggerheads, are concentrated at the boundary of warm and cold water masses (Nobetsu et al. 2004). As a consequence, migratory sea turtles seem to have distinct pathways for long-distance migration. Specification of the oceanographic characteristics of sea turtle habitats can lead to the segregation of fishing activities and sea turtle distribution. In this respect, biotelemetry studies on habitat utilization, migratory routes, and activity patterns of sea turtles play an important role to provide baseline information for the modification of fishing practices.

HANDLING AND RELEASE

As mentioned above, shallow longline has higher risk of catching sea turtles. But many of the sea turtles caught in the shallow longline are retrieved alive. Therefore, improvement of post-hooking survival is another way to alleviate the impacts of longline fishery to sea turtle populations. Careful hauling, and release can lead to improve post-hooking survival. Commercial longline vessels are

encouraged to carry large dipnets which help to haul live sea turtles onboard without damage. A number of de-hooking and line-cutting devices have been invented (Fig. 4), but they require further improvement.

A question still remains on the fate of hooked sea turtles, "Do they actually survive after release?" So we conducted captive experiments on the survival of hooked sea turtles and on the fate of remaining fishing hooks. Seven hooked sea turtles were kept in tanks for a prolonged period (Table 2). As a result, hooked sea turtles survived for more than one year, and ingested fishing hooks came out of the body. The result indicates that live retrieval and release of sea turtle is effective in improving the post-hooking survival of hooked sea turtles even if the hooks remain in the bodies.

INTERNATIONAL COOPERATION AND EDUCATION

As mentioned so far, there are several promising technical measures to reduce the longline-sea turtle interactions. However, modifications of fishing gear and practices also affect the fishing efficiency (Watson et al. 2003, Boggs 2004). So we should assess the economic feasibility of each method as well as its actual mitigation effects. Both the mitigation performance and economic feasibility of mitigation measures may change according to many factors such as target species, fishing area and the scale of fishing gear and boats. FAO is holding expert consultations to promote international cooperation to collect information and to establish technical guideline for mitigating sea turtle-fishery interactions (FAO 2004). Once the mitigation measures are established, they should be extended to fishermen through outreach programs. Awareness-building and education is another important aspect to solve the fishery interaction problem.

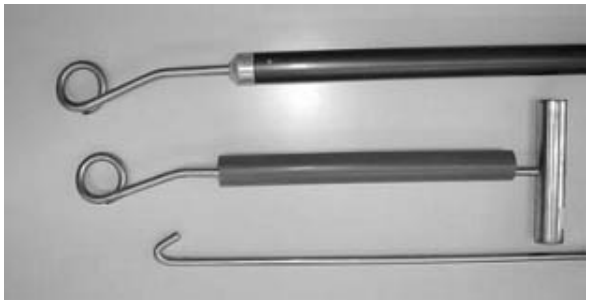

Fig. 4. Three types of de-hookers (supplied by Aquatic Release Conservation).

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