

Bycatch Mitigation Strategies in Pelagic Longline Fisheries: An aid to the Welfare of the Loggerhead Turtle (*Caretta caretta*)

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Introduction

Although described as a “rare event” in many fisheries (Gilman *et al.*, 2010), sea turtle bycatch is a significant issue in trawl, set-net and pelagic longline fisheries operating in regions that overlap with sea turtle distribution. International trade of sea turtles is prohibited, with six out of seven species listed as endangered or critically endangered by the International Union for the Conservation of Nature (IUCN) (2003). Bycatch mortality from pelagic longline fisheries poses a significant anthropogenic threat to the welfare of the endangered loggerhead sea turtle (*Carreta caretta*) (Echwiki *et al.*, 2010). Recently, numerous bycatch mitigation strategies have been devised to reduce incidental sea-turtle capture while avoiding negative impacts on local fishermen (Gilman *et al.*, 2010).

Discussion

Hook shape, bait choice and catch area have proved to significantly affect numbers of loggerhead turtles caught by pelagic longline fisheries (Gilman *et al.*, 2010). Sales *et al.* (2010) compared the effects of circle hooks and J-shaped hooks on sea turtle bycatch rates and post-release survival. Data were collected on 22 trips by four different vessels from 2004 to 2008 in the south-western Atlantic Ocean. Hook type and location of insertion were recorded with light-hooking indicating attachment to the mouth, and deep-hooking signifying oesophageal or deeper attachment. Results showed a total of 200 sea turtles captured, 85% of which were loggerheads. Capture rate increased by a factor of 2.2 when J hooks were used, and deep-hooking was more frequent than with circle hooks. Furthermore, capture rates of four of the target species, including blue sharks and tuna (42.2% and 14.6%, respectively), were significantly increased when using circle hooks. Only swordfish had significantly decreased capture rates with circle hooks.

The benefits of circle hooks on the welfare of loggerhead turtles are twofold: these hooks decreased loggerhead capture rates and deep-hooking frequency. Additionally, greater catch rates of targeted species with circle hooks may result in boosted economic return for pelagic fisheries, increasing the likelihood of the acceptance of circle hooks by local fishermen (Sales *et al.*, 2010).

Deep hooking by J hooks is likely to increase mortality in loggerhead turtles in comparison to light hooking; deeper hooks cannot be removed as easily and attached branchlines may induce strangulation and traction, resulting in delayed mortality in the loggerhead turtles (Valente *et al.*, 2007). A limitation to this study could be seen in the use of different shipping vessels, since managerial procedures could alter turtle catch numbers and affect post-release survival rates. Similarly, it is unclear whether increased capture of sharks and tuna with circle hooks would adequately negate the loss due to reduced swordfish catch.

Bait variations used in pelagic longline fisheries can further alter bycatch frequencies in loggerhead turtles. Echwiki *et al.* (2010) studied the effect of bait type on 21 fishing trips (48 sets) from July to September over two years, using onboard surveyors. Mackerel was used by 29 fishing sets and 19 used stingray fragments, with the aim of catching sandbar sharks (*Carcharhinus plumbeus*) and swordfish (*Xiphias gladius*). Of the 29 loggerheads that were caught, 26 were off hooks baited with mackerel, while only three were caught off stingray-baited hooks, showing loggerheads' strong preference for mackerel. Furthermore, sandbar shark catch rate was significantly greater with stingray-baited hooks. Thus, while improving the catch rate of targeted species, turtle interactions with longline fisheries can be strongly mitigated by altering the type of bait used. This is supported by a similar study performed by Yokota *et al.* (2009) demonstrating that loggerheads have a higher tendency to feed on squid

than on mackerel. Bait alterations can therefore be seen as a second economically viable option to pelagic fisheries to reduce loggerhead bycatch.

Limitations to the study conducted by Echwikhi *et al.* (2010) principally lie in the use of only one fishery; bycatch mitigation techniques are likely to be influenced by numerous factors, and may not work as well in alternate fisheries, especially when using a sensory-based incentive such as bait. Seasonal variations, time of day, age of interacting turtles and oceanographic region are all likely to play a role in sensory capabilities (Gilman *et al.*, 2010). The importance of oceanographic regions in loggerhead distribution, and subsequent bycatch frequency, is further demonstrated by Howell *et al.* (2010). In the study, 17 juvenile loggerheads were tagged with satellite-linked depth recorders (SDRs) and released back into the central North Pacific Ocean, from which they had come. The SDRs recognised individual dive events, and collected raw time-and-dive data for more than 50 days, with some tags (n=6) transmitting data for more than one year.

Dive-depth distributions showed 80% of dives were to depths of less than 5 metres and 90% to depths shallower than 15 metres. Moreover, 99% of the turtles' time was recorded to be in waters warmer than 15°C, with seasonal migration following warmer temperatures. This is supported by Sales *et al.* (2010), who reported seasonal changes in loggerhead capture. Such information can greatly benefit bycatch mitigation strategies; longline fishing in depths below 25 metres is likely to circumvent shallower regions of the water column where turtles spend 99% of their time. By analysing loggerhead distribution and feeding patterns, probability of fishery interactions with turtles can be determined and consequently, loggerhead bycatch could be significantly reduced. However, a limitation to this study is that the reasoning behind the turtle distribution is unclear as thermal limitations and prey distributions are unknown. Similarly, only juvenile loggerheads were used, and as such the study is restricted to an age class that might display different foraging behaviours to other classes.

Conclusion

In conclusion, altered bait type and use of circle hooks can be used in conjunction with oceanographic data to reduce bycatch mortality in loggerhead turtles. However, while empirical evidence has shown bycatch mortality solutions may benefit the welfare of loggerhead turtles, it is probable that solutions are fishery-specific. Additional reviews are required to enhance understanding of the risk posed by pelagic longline fisheries on loggerhead populations, in order to prioritise limited conservation resources and ascertain appropriate mitigation opportunities.

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