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WORKSHOP ON REDUCING SEA TURTLE TAKES IN LONGLINE FISHERIES MIAMI, AUGUST 31–SEPTEMBER 1, 1999

Pierre Kleiber and Christofer Boggs

Honolulu Laboratory
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
2570 Dole Street, Honolulu, Hawaii 96822-2396

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INTRODUCTION

U.S. pelagic longline fleets operate in two broad areas: 1) Atlantic waters off the east coast of North and South America from the equator to the Grand Banks plus the Caribbean with vessels based in numerous locations along the U.S. east and Gulf of Mexico coasts; and 2) North Pacific from tropical waters to transition zone waters (up to 45°N) in longitudes from just west of the date line to about 140°W with vessels almost exclusively based in Honolulu.[1] In all areas, longline vessels incidentally take sea turtles. All species of sea turtles are listed as threatened or endangered under the Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) is responsible for 1) monitoring the numbers of turtles taken and numbers killed, and 2) taking steps to reduce the take. Pursuant to these responsibilities, NMFS has been conducting scientific observer and logbook programs and has a number of experimental projects underway or in planning stages. Management of these activities and analysis of data resulting from them have been for the most part conducted independently at NMFS facilities in the southeast, acting for the U.S.-based Atlantic fishery, and in the southwest, acting for the Hawaii-based fishery.

A two-day workshop at the Southeast Fisheries Science Center in Miami was organized to review approaches towards satisfying the above two charges undertaken by the two regions, to share ideas and to explore possible areas of useful cooperation. This report is a summary of the deliberations at that workshop.[2] The agenda of the workshop is reproduced in Appendix A, the list of participants in Appendix B, and a list of background papers in Appendix C.

BACKGROUND REVIEW

The participants reviewed and compared the fisheries and the sources of information about longline turtle takes in the fisheries. A major difference was noted in the character of U.S. longline fisheries in the Atlantic and the U.S. Hawaii-based longline fishery. The Atlantic fishery tends to make shallow (deepest hooks less than 90 meters), nighttime sets (Hoey, 1998), and targets primarily yellowfin tuna and swordfish. A portion of the Hawaii fishery operates in a similar fashion while targeting swordfish, but a large portion of the fishery makes daytime sets using line shooters to depths of hundreds of meters primarily in search of bigeye tuna. Longline gear depth has a profound effect on its selectivity for target species and bycatch (Boggs, 1992).

The data collected on logbook forms are very similar in the two regions, the main differences being that Atlantic logbooks are more detailed with respect to gear configuration

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[1] More recently there has been a segment of this fishery operating between Hawaii and the west coast of North America and landing fish at west coast ports.

[2] This report represents a working document and does not represent the policy or opinion of the National Marine Fisheries Service.

(e.g., float lines and gangion lengths), whereas the Pacific logbooks are more detailed in the locations of both ends of the main line, at set time and at haul time.

The observer programs in the two regions have different origins. The Atlantic program is mandated by the Highly Migratory Species Fishery Management Plan (FMP) and was designed to obtain fishery and biological data on fish. The Hawaii program is mandated by the 1998 Biological Opinion on sea turtles in the Hawaii longline fishery as well as the Pelagic FMP and was designed to monitor turtle take rates. Though the foci of the two observer programs is different, the information collected with respect to sea turtles is evolving to be similar. The turtle life history form for the Atlantic observer program is being revised to resemble the turtle life history form used by the Hawaii program with a few changes to clarify aspects of each turtle's physical treatment and condition at release. The Hawaii form, in turn, is currently under review to achieve much the same clarification.

Several at-sea longline experimental projects were discussed: one conducted from a research vessel and the other on board commercial longline vessels. Although both projects were actually investigating methods to reduce albatross takes in the Hawaii longline fishery, they produced information on the efficacy of blue dyed bait for catching target fishes, gave tentative indication that blue dyed bait might act as a deterrent for turtles, and sparked an idea for a new type of fish hook (see below). A third project, still in planning stages, was also discussed. This project, to be conducted in the Azores longline fishery, deals directly with evaluating factors that could influence turtle take rates.[3] A fourth project, a laboratory experiment being conducted by Dr. Kenneth Lohmann, University of North Carolina, is underway. Its purpose is to evaluate the responses of pelagic-stage loggerhead turtles to light sticks and branch lines used in the fisheries.[4]

Recent results were presented from Argos satellite tags placed on turtles caught in the Hawaii longline fishery. Course tracks for loggerhead turtles indicate that they congregate in two relatively narrow oceanographic frontal structures whose locations correlate well with the 17°C and the 21°C surface isotherms. Both deeply hooked and lightly hooked turtles were tracked. Of the deeply hooked turtles, 11 ceased satellite transmission immediately on release. The 14 remaining deeply hooked turtles behaved much like the lightly hooked turtles, traveling an average of around 2,000 km against the prevailing current for an average duration of 3 to 4 months before transmission ceased. The duration of satellite transmission from these tags may be very short due to immediate mortality, or longer and terminated by either mortality or battery failure. The tracking investigation is continuing with longer-lasting batteries and with transmitters capable of relaying dive depths and durations.

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[3] This project is now underway under the direction of Alan Bolten of the University of Florida, Gainesville.

[4] Preliminary results indicate that these turtles are more attracted to green than to yellow light sticks and that they are not attracted to unbaited branch lines.

A study in the vicinity of the Azores used satellite telemetry to determine the effects of incidental capture by longlines on behavior and mortality of juvenile loggerheads (Bjorndal et al., 1999). Preliminary results indicate that turtles' post-hooking behavior differed significantly from that of turtles dipnetted in the area. In 1999 no deeply hooked animals were telemetered, precluding a comparison of behavior/mortality between lightly and deeply hooked animals as above.

The group reviewed methods and results of data analyses to estimate annual turtle takes and to find variables statistically associated with turtle takes. Total takes in the two fisheries have been estimated by expanding takes in observed fishing trips to all trips in the fishery, usually with some kind of stratification of the data, either by area or by one or more independent variables determined by regression tree analysis. Examination of observer data to determine factors that are significantly associated with turtle takes tends to give confounded results because of correlation between factors (e.g., use of light sticks and area fished). Multivariate analysis of the Hawaii data with regression trees has revealed few significant factors, partly because of the factor correlation problem, but also because turtle takes are relatively rare events, resulting in a paucity of data. In the latest analyses (data through 1998), statistically significant variables were found only for loggerheads. The most significant of these were variables of location, with location relative to the extant sea surface temperature regime being more significant than simple geographic location.

Hawaii observers collect data on proximity of hooked turtles to hooks fitted with light sticks and also proximity to the floats. Analysis of the light stick data reveals no statistically significant results for either leatherbacks or loggerheads. However, the float data revealed a highly significant preference for both species to be caught on hooks adjacent to or near the floats. The implication is that shallower hooks are more likely to catch turtles because the shallowest hooks in a longline set are the ones nearest to the floats. However, it could be equally possible that turtles are attracted to the floats or to the float lines and that this attraction is the operant factor in this case rather than shallower depth of hooks near the floats. Similar proximity data are not as yet collected in the Atlantic/Gulf observer program.

DELINEATION AND EVALUATION OF MEASURES TO ADDRESS THE PROBLEM

To produce a comprehensive outline of possible approaches to reducing or mitigating turtle takes, much of the workshop was conducted in an informal, brainstorming style. At first, various measures that could be taken were listed on flip charts and categorized. Then the group evaluated each measure on its degree of promise and on its likely impact on the fishery, taking particular note of areas of weak or absent knowledge.

Measures to Reduce Turtle Takes

Table 1 lists measures proposed by the group that might reduce takes. Reducing fishing effort across the board would be expected to reduce takes in proportion to the degree of effort reduction, but would also be expected to affect the fishery in like proportion. A more targeted closure, or reduction in effort, in specific seasons and specific areas might be just as effective in reducing take of a particular turtle species but with less impact on the fisheries than blanket reduction in effort. The finding that loggerhead turtles associate with oceanographic frontal structures in the Pacific gives hope that keeping fishing effort away from a portion of these structures might significantly reduce loggerhead take (Polovina et al., 2000). However, the same structures often comprise the best fishing areas. To function effectively without untoward reduction in catch of swordfish and other targeted fishes, this strategy would probably require flexible regulation boundaries which adjust to seasonal movements of oceanographic features. Additional tracking research and modeling is required to evaluate the potential of this strategy. Also, consideration must be given to the displaced fishing effort and whether it will result in more takes of any of the turtle species. It was noted that with the advent of vessel monitoring systems, time/area closures are readily enforceable.

Several gear modifications were discussed. It was thought at one time that banning light sticks might be effective, but regression tree and light stick proximity analyses of Hawaii data suggest that the association between turtle takes and light sticks may be an artifact of the correlation between light sticks and area fished. Similar analyses for Atlantic/Gulf fisheries have yet to be done. Gear modifications with the most immediate promise have to do with setting the hooks at a greater depth, assuming that deeper hooks catch fewer turtles. This also assumes that setting deep enough to avoid turtles will not unduly affect shallow, swordfish style, longline fishing. If attraction of turtles to floats is an operant factor and not depth, then setting hooks farther from floats would still be effective. "Guarded" hooks are an untested notion suggested by Balazs and Pooley (1994) and further inspired by the use of large safety pins in place of hooks in albatross deterrent experiments (so that the birds would not actually be caught). The idea is to invent a fish hook that can be closed in some why that would effectively disable it until needed. Another idea is to disable a hook with a retractable spur that makes the hook too large to swallow. Either mechanism would disable the hook at shallow depths where turtles are more likely to be taken and would enable the hook for catching fish at greater depths.

The only suggested modification in day-to-day fishing operations was to change the timing of operations so that hooks are soaked and hauled during a period in which turtles are less vulnerable, which would probably be at night. However, it is not known during which part of the operation turtles are most vulnerable

Table 1. Suggested variety of measures to reduce turtle take in longline fisheries, the prospective effectiveness of the measures and the expected impact on the fisheries.

Measure	Prospects for reducing turtle takes	Expected fishery impact
Reduce total fishing effort	Very effective	High impact - (proportional to reduction)
Season-area closures/restrictions	probably effective; issue of fixed vs adjustable space or time boundaries	depends on degree of segregation between turtles and target species - modeling and tracking research needed
Gear Modifications:		
Remove light sticks	evidence to date not promising - more analysis of Atlantic data needed	Pacific: high impact on swordfish, low on tuna Atlantic: unknown
Deeper hooks: longer float and branch lines more hooks per float hooks set farther from floats line shooter	probably effective - needs research to distinguish between depth and attraction to floats	moderate - depending on depth of hook, could have high impact on swordfish
Guarded hooks	could be very effective	depends on degree of depth segregation between turtles and target species.
Modify Operation:		
Time of set and haul vs daylight	some effectiveness, needs research	depends on scenario, needs research
Deterrents:		
Colored bait	tentative evidence of promise - needs research	some evidence of improved catch
Bait type	unknown, some	unknown - could be low impact or even an improvement
Odors	unknown (probably low)	unknown
Sounds	low	unknown
Change float color	unknown	unknown
Remove strobe lights	unknown	high

Adding turtle deterrents to the longline gear could be an effective way to reduce turtle takes, and a variety of possible deterrents was suggested including food color and physical deterrents that prevent a sea turtle from swallowing the bait. In trials with sea bird deterrents in the Hawaii fishery some sea turtles were taken but none on blue-dyed bait; however, the results were not statistically significant. Food color preference studies conducted on Kemp's ridleys hatchlings at the Galveston laboratory in 1984 suggest that sea turtles possess strong food color preferences (Fontaine et al., 1985). Kemp's ridley hatchlings that were offered shrimp that was dyed red, yellow, green, blue, or undyed showed a strong preference for red followed by yellow. Blue was the least preferred color. The other deterrent suggestions depend on assumptions about turtle behavior for which there is no evidence one way or the other.

Measures to Mitigate Turtle Takes

Turtles caught on longline gear face a series of serious hazards that can affect the chances of survival both before and after release. Turtles can remain underwater for considerable lengths of time on their own volition, but in struggling against forced submergence, they can become comatose within 10 to 20 minutes. Thus, both the risk of drowning and the stress level increase with the time they remain hooked. The gravity of injury from the hook depends on where the hook is situated. An external hook injury is less likely to be serious than injury from an ingested hook. If the turtle is cut free with line (possibly including metal leader) still attached to the hook, there can be considerable problems either from line ingested with the hook or from entanglement in external line. Table 2 lists measures suggested by the group that might improve survival of turtles taken and released by the longline fishery. These measures were suggested as an adjunct to several procedures for mitigating the effect of turtle takes that have already been published (Balazs et al., 1995).

Circle hooks are used in some fisheries to promote hooking fish in the jaw rather than internally. Therefore, use of such hooks might substantially improve turtle survival. Circle hooks appear to function well for catching tunas, but there is reason to suspect that they would inhibit catch of swordfish though they have not been tested for swordfish longlining. To clear up evident confusion between circle hooks and the commonly used J hooks and tuna hooks used in longline fisheries, the group examined examples of each (Fig. 1).

Table 2. Suggested variety of measures to improve survival of turtles that are taken in longline fisheries, the prospective effectiveness of the measures and the expected impact on the fisheries.

Measure	Prospects for Improved Turtle Survival	Expected Fishery Impact
Gear Modification:		
Circle hooks	unknown, some	tuna: could be low swordfish: could be high
Corrodible (dissolving) hooks and/or crimps	unknown but makes sense	low
Gangions longer than float lines	unknown but makes sense	swordfish: low Atlantic tuna: higher Hawaii tuna: impractical
Operational Modifications:		
Shorten soak time	unknown but potentially high	tuna: high swordfish: moderate?
Turtle Handling Guidelines:		
Guidelines in Balazs et al. 1995	high - depending on compliance	low to moderate (specified in Balazs et al. 1995)
Make guidelines into regulations	high - depending on compliance	low to moderate (ibid.)
Tool to cut line short	high - depending on compliance	low

As an alternative to circle hooks, it was suggested that internal injury from ingested hooks might be moderated if the hooks were designed to dissolve quickly once ingested. It was also suggested that if the crimps which attach the hook to the leader would also dissolve quickly, then the leader might pull free before becoming hopelessly entangled in the gut. The impact on the fishery of dissolving hooks or crimps was thought to be the minor expense and nuisance of replacing hooks more frequently. The suggestion of making gangions longer than the float lines

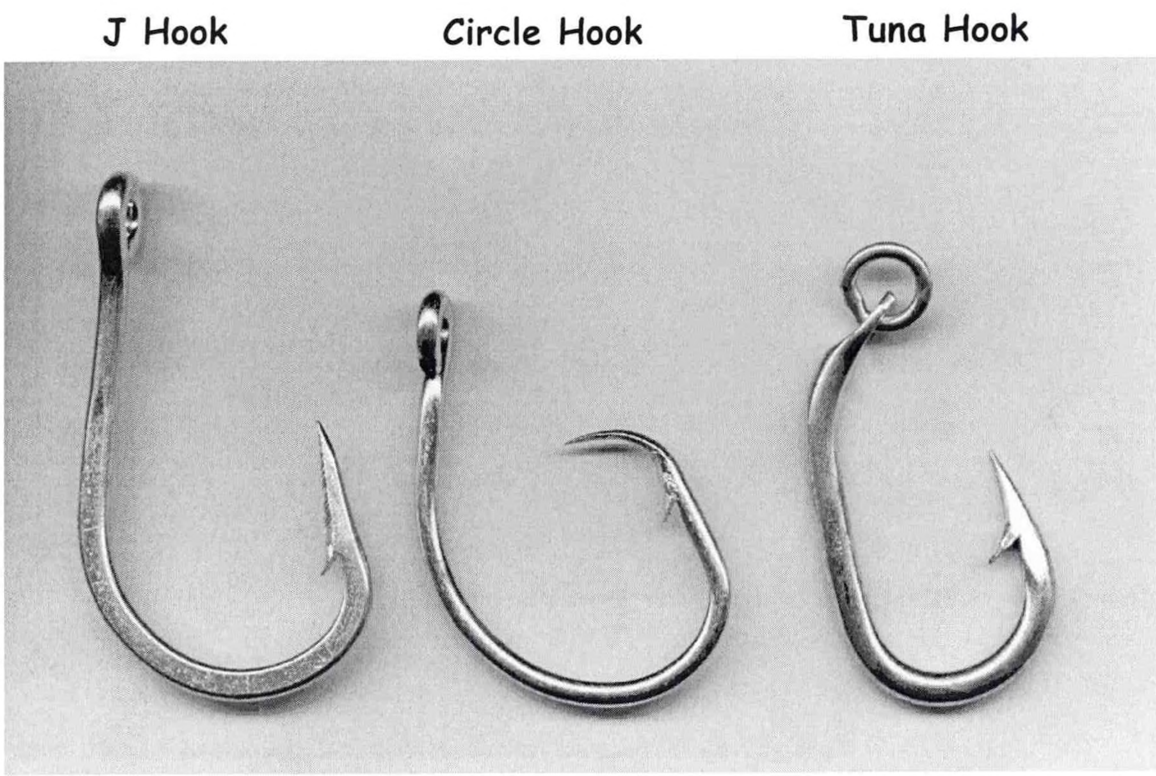

Figure 1. J-hooks, circle hooks, and tuna hooks at approximately their real size.

is aimed at allowing hooked turtles to come to the surface to breathe. For hooks placed at a distance from floats, the gangions would have to be considerably longer to account for the sag in the main line. In the Atlantic this measure would cause more difficulty for tuna longlining than for swordfish longlining because longer float lines are used when targeting tunas. For Hawaii tuna longlining the measure would be almost impossible because the gangions not next to floats would have to be hundreds of meters long. In any case, few turtles are taken in the tuna sector of the Hawaii fishery. Shortening the soaking time would be another potential way to decrease the probability of drowning and also reduce the stress on hooked turtles. This measure would come at a high cost to tuna fishing because catch increases with soak time (Boggs, 1992), but it might only be a moderate cost to swordfish fishing because some fishermen believe that most swordfish are caught within several hours after the set.

The group recognized that several suggested procedures for mitigating the effects of turtle takes have already been published. To give the mitigation guidelines in Balazs et al. (1995) more force, it was suggested that these guidelines be enacted as fishing regulations. Among the guidelines are the recommendations to pull the line gently when bringing the turtle close to the vessel and to cut the line as short as possible. For large, active animals, these exhortations can be mutually exclusive. It was therefore suggested by the group that a line cutting tool be developed to enable cutting the line close to the animal when it is still several meters away from the vessel. The Billfish Foundation has developed a hook removal tool on a pole that is only effective in situations where the point of the hooks protrudes from the animal. Some vessels in Hawaii use a cutting device on a pruning pole that allows the line to be cut at a distance of 2 to 3 meters. Efforts to develop a cutting device that could operate at a greater distance are under way both in Hawaii and in Florida.

RECOMMENDATIONS

Data Collection

In considering desirable improvements to routine data collecting in observer and logbook programs, the group came up with the following list of recommendations for changes to observer data forms. These are mostly aimed at recording more detail about the condition of the turtle. Although this information is often discernable from observer narrative accounts, it was felt that these items should have separate fields in the data forms.

Pacific

- Follow example of Atlantic for recording details on hooking location in/on turtles.
- Record if turtle is brought aboard.
- Separate fields for condition data and for final disposition data.
- Perhaps add field for passive integrated transponder (PIT) tag information and supply observers with PIT tag readers if funding is available ($1,200 per reader).

Atlantic

- Record position of takes in relation to floats and to light sticks.
- Record light stick color.

Both Oceans

- Record an estimate of the length of line trailing from turtle when it is cut free.

Generic Recommendations for Observer Programs

- Modify program objectives to elevate priority of protected species.

- Reevaluate and adjust observer coverage to effectively monitor compliance with new measures, determine the effectiveness of new measures in reducing or mitigating turtle takes, and assess the impact of new measures on fishery.

RESEARCH

Data Collection

The group also generated several recommendations for research projects to address many, but not all, of the unknowns listed in Tables 1 and 2. Most of these projects could usefully be conducted collaboratively between researchers in both the Pacific and Atlantic regions. While all these projects would seem to be of high priority, some of them were tagged as having particularly high priority.

- Conduct multivariate analyses on Atlantic observer and logbook data to determine significant factors affecting turtle bycatch (similar to analyses done on Pacific data). High priority.

- Simulate effects on turtle and fish catch-per-unit-effort (CPUE) of season-area closures. This is a follow-up to Polovina et al. (2000). High priority.

- Continue development of tool to cut leader close to a turtle but at a distance (several meters) from the vessel. High priority.

- Study hook type effects on CPUE of turtles and target species.

- Conduct post-hooking surviviorship investigation with longer lasting (5–year) biotelemetry gear.

- Investigate effects on turtle and fish CPUE of restrictions on time of day for setting and hauling longline.

- Boost priority of hook depth as an experimental factor in Azores longline experiment.

- Conduct lab or field experiments on blue-dyed bait, or both.

- Develop a depth-sensitive guarded hook.

CONCLUSIONS

Most of the measures discussed by the group are untested, with unknown effectiveness or unknown impacts. The only take reduction measure with known effectiveness and impacts is the limitation of fishing effort. In the early 1990s the Hawaii-based fishery was limited in size primarily to prevent increases in turtle takes. The Atlantic fishery also has limits on participation. Well-known measures to mitigate take mortality are the published guidelines for turtle handling, which could be mandated by new regulations. Lack of understanding of the remaining management options highlights the need for further analysis of existing data, modeling of various scenarios, and experimental research. Mandating any of the poorly understood measures should be viewed as experimental and as having potentially serious impacts on the continued viability of the fisheries.

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APPENDIX A

Agenda

1. Review relevant data collection
   Logbooks
   Observer programs
   Longline experiments
   Other

2. Review progress to date regarding:
   Take estimation methods
   Identification of factors affecting takes
   Take reduction techniques
   Take mitigation techniques
   Other

3. What more/else should we do?
   Promising take reduction/mitigation techniques
   Evaluating effectiveness of take reduction/mitigation
   Evaluating acceptance of take reduction/mitigation measures by fishery
   Data collection improvements
      Observer protocols, coverage, etc.
   Experiments to ascertain effects/test mitigation methods
      Field studies
      Lab studies
   Areas of useful collaboration?

4. Recommendations

APPENDIX B

Participants

Christofer H. Boggs	NMFS – Honolulu	Christofer.boggs@noaa.gov
Craig Brown	NMFS – Miami	Craig.brown@noaa.gov
Therese Conant	NMFS – F/PR	Therese.conant@noaa.gov
Sheryan Epperly	NMFS – Miami	Sheryan.epperly@noaa.gov
Dominy Hataway	NMFS – Pascagoula	Bret.d.hataway@noaa.gov
Ben Higgins	NMFS – Galveston	Ben.higgins@noaa.gov
Pierre Kleiber	NMFS – Honolulu	Pierre.kleiber@noaa.gov
Dennis Lee	NMFS – Miami	Dennis.lee@noaa.gov
Barbara Schroeder	NMFS – F/PR	Barbara.schroeder@noaa.gov
Wayne Witzell	NMFS – Miami	Wayne.witzell@noaa.gov
Cynthia Yeung	NMFS – Miami	Cynthia,yeung@noaa.gov

APPENDIX C

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