Interactions Between Platform Terminal Transmitters and Turtle Excluder Devices

ERIN E. SENEY, BENJAMIN M. HIGGINS, and ANDRÉ M. LANDRY, Jr.

Introduction

Advances in the global satellite network, satellite transmitter miniaturization, and new deployment techniques have allowed for increased use of satellite telemetry as a tool for examining long-term movements of sea turtles and other vertebrate species (Coyne and Godley, 2005). The Texas A&M University at Galveston (TAMUG) Sea Turtle and Fisheries Ecology Research Laboratory attached platform terminal transmitters (PTT's) to eight Kemp's ridley sea turtles, *Lepidochelys kempii*, using Power-Fast+[1] two-part marine epoxy during 2004–05 (Seney, 2008). All transmitted for considerably shorter periods than expected, with five immature individuals tracked for 12–57 d ($\bar{x}$ ± 1 SD = 37 ± 17 d) and three adult females for 20–50 d ($\bar{x}$ ± 1 SD = 38 ± 16 d). Several different transmitter models were utilized, but battery lives of 180–365 d or more were anticipated for all units. This discrepancy prompted concerns regarding causes for premature transmission loss including turtle mortality, biofouling, antenna damage, and attachment failure (Tucker et al., 2007; Seney and Landry, 2008; Seney et al., 2010).

Antenna damage or loss of the entire PTT could be due to multiple factors including insufficient attachment method, rapid turtle growth, or an "impact" event such as a boat strike or contact with the grid of a turtle excluder device (TED). We conducted trials to examine interactions between PTT-outfitted loggerhead sea turtles, *Caretta caretta*, and TED-equipped shrimp trawls and assessed potential for subsequent antenna and PTT damage and loss.

Materials and Methods

A pilot study was conducted with eight 34-month-old captive-reared loggerheads on 22 June 2006 (mean straight carapace length [SCL] = 42.5 cm, SD = 1.2 cm), and a follow-up trial was conducted with twenty 34-month-olds on 22 and 24 June 2007 (mean SCL = 47.0 cm, SD = 1.1 cm). Loggerheads were transported from the NMFS Sea Turtle Facility in Galveston, Tex., to Panama City, Fla., in mid May of each year and then semi-wild conditioned in outdoor pens for about 4 weeks (Higgins, 2003). Turtles were evenly split between experimental (PTT) and control (no PTT) groups. Replica (dummy) Sirtrack KiwiSat 202 PTT's measuring approximately 8×4×2 cm were attached along the first two vertebral scutes (Seney et al., 2010) of each experimental loggerhead. In 2006, PTT's were attached with Power-Fast+ two-part marine epoxy (PF-only, *n* = 2) or Power-Fast+ covered with Sonic-Weld steel-reinforced epoxy putty (PF/SW, *n* = 2), whereas the 2007 trial utilized the PF/SW attachment (*n* = 4) and a new method incorporating neoprene to the PF-only protocol (PF/neoprene, *n* = 6; Seney et al., 2010). Two modifications were made to the basic attachment

Erin E. Seney and André M. Landry, Jr., are with the Sea Turtle and Fisheries Ecology Research Laboratory, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX 77553, and the Department of Wildlife & Fisheries Sciences, Texas A&M University, 2258 TAMU, College Station, TX 77843. Benjamin M. Higgins is with the Sea Turtle Facility, Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, 4700 Avenue U, Galveston, TX 77551. Corresponding author is Erin E. Seney (eeseney@gmail.com).

[1] Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—Satellite telemetry is a common tool for examining sea turtle movements, and many research programs have successfully tracked adults. Relatively short satellite track durations recorded for juvenile Kemp's ridley sea turtles, Lepidochelys kempii, *in the northwestern Gulf of Mexico raised questions regarding premature transmission loss. We examined interactions between juvenile sea turtles outfitted with platform terminal transmitters (PTT's) and turtle excluder devices (TED's) and the potential for transmission loss due to this interaction. A pilot study was conducted with eight 34-month-old, captive-reared loggerhead sea turtles,* Caretta caretta*; a larger trial the following year used twenty 34-month-olds. Half of the turtles in each trial were outfitted with dummy PTT's (8×4×2 cm), and all turtles were sent through a trawl equipped with a bottom-opening Super-Shooter TED. No apparent damage was sustained by any PTT, but four of five PTT-outfitted loggerheads encountering the TED carapace-first exhibited increased escape times when the PTT wedged between the TED deflector bars (10.2 cm apart). Overall, 15 loggerheads (54%) impacted the TED carapace-first. Attachment of PTT's to smaller sea turtles may slow or, in worst cases, inhibit escape from TED's. Likewise, loose or poorly secured PTT's could impede escape or be shed during such an interaction. Researchers tracking small turtles in or near regions with trawling activity should consider PTT size and shape and the combined PTT/adhesive profile to minimize potentially detrimental interactions with TED's.*

protocol in 2007: 1) 60-grit sandpaper was utilized instead of 100-grit to sand the turtles' carapaces and PTT's; and 2) the first 10–15 cm of Power-Fast+ epoxy discharged from an applicator nozzle was discarded after discovery that epoxy initially discharged from a new nozzle and/or cartridge may not ever fully cure due to inadequate mixing (Morehead[2]).

Two trials examining TED–PTT interactions were conducted near Panama City from the NMFS *RV Caretta* and in accordance with the NMFS standard small turtle TED test protocol (NMFS, 1990). The trials were conducted over substrates with relatively low finfish and shellfish biomass, resulting in trawl tows with very little or no catch (i.e. a "clean" trawl). Control and experimental loggerheads were individually sent through a 15.2 m (50 ft) "Western jib" trawl equipped with a bottom-opening Super-Shooter (BOSS) TED installed at a 50-degree angle. The space between TED deflector bars was 10.2 cm (4 in), which is the maximum permitted in the U.S. (NMFS, 1999). Each turtle was released into the trawl at the headrope by one member of a three-person NMFS dive team. A stopwatch was started upon the turtle's release, and each loggerhead allowed up to 5 min to escape through the TED. If at the end of 5 min, the turtle was still within the trawl, it was removed by a diver and scored as a "capture." Loggerheads were returned to the surface using floats immediately following their exit or removal from the trawl. All turtles were video-recorded while in the trawl by a diver with a hand-held underwater video camera. Dummy PTT's were removed after each trial, and loggerheads were later released at Sebastian Inlet, Fla., in July 2006 and July 2007.

Video footage was examined to time each loggerhead's passage through the trawl accurately and record outcome (capture or escape) and orientation of the turtle with respect to the TED (carapace-, plastron-, or head-first). Data were compared between the two years using analysis of variance, and the merged dataset was subsequently examined using the Levene's F test, Shapiro-Wilk test, and Mann-Whitney U test.

Table 1.—Summary of 2006 PTT-TED interaction trial (pilot study) results.

Turtle	Transmitter attachment	Time in net (min:sec)	Turtle orientation to TED	Result
1	None (Control)	01:06	Plastron-first	Escape
2	PowerFast only	01:05	Carapace-first	Escape
3	None (Control)	01:14	Carapace-first	Escape
4	PowerFast/Sonic-Weld	05:00	Plastron-first	Capture
5	None (Control)	05:00	N/A – did not reach TED	Capture
6	PowerFast/Sonic-Weld	03:03	Carapace-first	Escape
7	None (Control)	00:16	Carapace-first	Escape
8	PowerFast only	02:13	Carapace-first	Escape

Table 2.—Summary of 2007 PTT-TED interaction trial results.

Turtle	Transmitter attachment	Time in net (min:sec)	Turtle orientation to TED	Result
1	None (Control)	01:00	Carapace-first	Escape
2	PowerFast/Neoprene	00:38	Plastron-first	Escape
3	None (Control)	05:00	Carapace-first	Capture
4	PowerFast/Sonic-Weld	04:54	Plastron-first	Escape
5	None (Control)	00:44	Plastron-first	Escape
6	PowerFast/Neoprene	00:14	Head-first	Escape
7	None (Control)	01:12	Carapace-first	Escape
8	PowerFast/Sonic-Weld	02:05	Carapace-first	Escape
9	None (Control)	00:40	Carapace-first	Escape
10	PowerFast/Neoprene	02:13	Plastron-first	Escape
11	None (Control)	01:38	Carapace-first	Escape
12	PowerFast/Sonic-Weld	04:20	Plastron-first	Escape
13	None (Control)	00:46	Plastron-first	Escape
14	PowerFast/Neoprene	01:55	Carapace-first	Escape
15	None (Control)	02:04	Carapace-first	Escape
16	PowerFast/Sonic-Weld	00:14	Head-first	Escape
17	None (Control)	00:28	Carapace-first	Escape
18	PowerFast/Neoprene	00:51	Plastron-first	Escape
19	None (Control)	00:52	Carapace-first	Escape
20	PowerFast/Neoprene	00:24	Plastron-first	Escape

Results

Two loggerheads out of 8 in the initial trial (1 experimental and 1 control) and 1 out of 20 in the second trial (1 control) failed to escape within 5 min and were recorded as "captures" (Tables 1 and 2); however, the PTT did not impede the "captured" experimental individual's passage through the trawl. The other 25 turtles successfully escaped via the TED, but 4 experimental loggerheads (2 per trial) were slowed after they encountered the TED carapace-first and their PTT's temporarily wedged between its bars (Fig. 1). None of the 14 dummy PTT's, their antennas, or adhesives sustained any obvious damage after passage through the trawl and TED.

Among all turtles in the first trial, 5 individuals encountered the TED carapace-first (Fig. 2a) in 2006, whereas 2 hit plastron-first (Fig. 2b), and 1 control did not reach the TED within 5 min (Table 1). Experimental loggerheads in the second trial encountered the TED in varied orientations (2 carapace-first, 6 plastron-first, 2 head-first), whereas most controls did so carapace-first (8 carapace-first, 2 plastron-first; Table 2).

Escape times were not significantly different between the two trials for either control ($F_{1,10} = 0.251$, $p = 0.627$) or PTT-outfitted loggerheads ($F_{1,11} = 0.105$, $p = 0.752$), and the data were combined for further analyses. The controls that exited the TED during both trials did so in 16–124 sec ($\bar{x} \pm 1$ SD = 60 ± 30 sec, median = 56 sec; $n = 12$, excludes 2 "captures"), whereas the PTT-outfitted loggerheads did so in 14–294 sec ($\bar{x} \pm 1$ SD = 111 ± 91 sec, median = 115 sec; $n = 13$, excludes 1 "capture"). The 2006–07 dataset violated parametric statistical assumptions of normality (Shapiro-Wilk $W = 0.833$, $p = 0.001$) and equal variances (Levene's $F = 9.132$, $p = 0.006$). As such, the non-parametric Mann-Whitney test

[2] Morehead, R. 2007. NMFS Sea Turtle Facility, SEFSC, Galveston, Tex. (Volunteer). Personal commun.

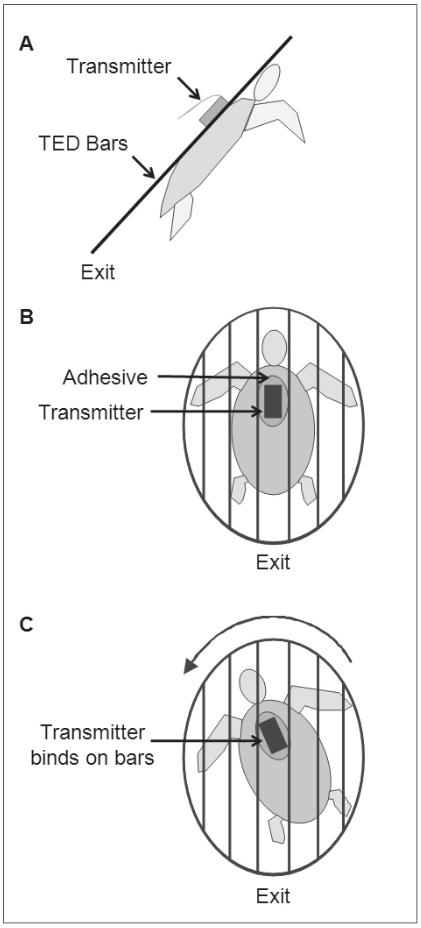

Figure 1.—Side view of interaction between PTT-outfitted sea turtle (A) and TED deflector bars and overhead view of initial interaction (B) and turtle attempting to free itself (C; arrow indicates movement direction of turtle).

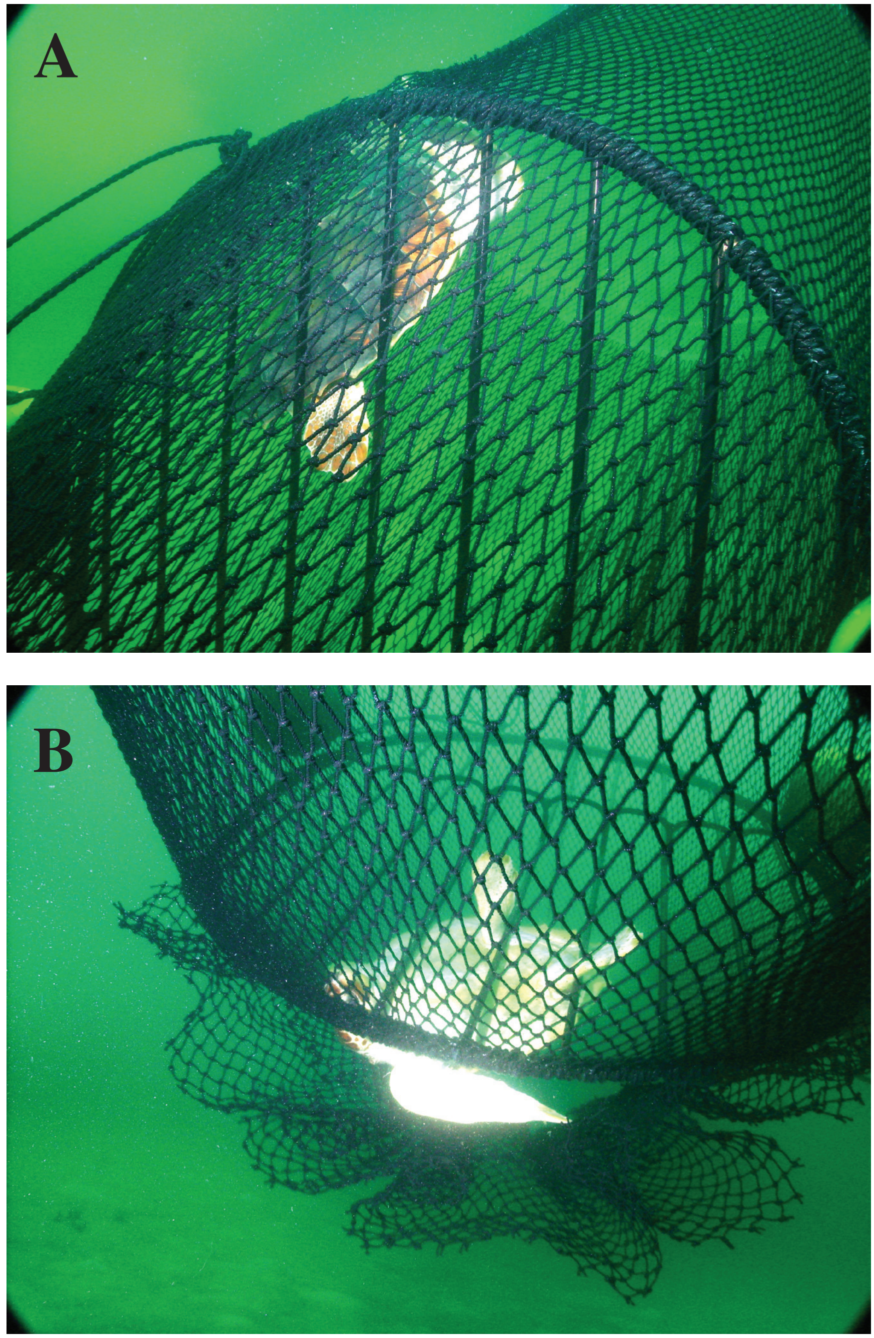

Figure 2.—Juvenile loggerheads encountering bottom-opening TED carapace-first (A) and plastron-first (B). Photographs courtesty of NMFS Harvesting Systems Branch, SEFSC, Pascagoula, Miss.

was utilized to compare escape times, and results indicated there was no significant difference between control and PTT-outfitted loggerheads (U = 58.000, p = 0.276).

Discussion

Passage through a TED installed in a "clean" trawl did not damage any transmitters or attachments, but 4 of 14 PTT-outfitted loggerheads (29%) were slowed when their PTT's became wedged between TED deflector bars. This indicates attachment of PTT's to smaller sea turtles may slow escape from trawls. Orientation of PTT-outfitted loggerheads to the TED likely accounted for some of the difference in variance between the control and PTT-outfitted groups' escape times (Levene's F = 9.132, p = 0.006). This was exemplified by longer exit times for 4 of the 5 experimental loggerheads that struck the TED carapace-first during the trials. Each of these four interactions resulted in the PTT's becoming wedged between the TED's bars, and only after periods of swimming upward (away from the TED opening) was the turtle able to turn and free itself.

While we did not observe situations in which escape via the TED was prevented by a PTT, we believe such an event is possible, and efforts should be taken by researchers to minimize this worst case scenario. Likewise, while the dummy PTT's utilized in the trials were secure prior to the turtles' passage through the trawl, a loose or poorly secured PTT could impede escape or be shed if it became caught on or wedged between TED deflector bars.

Under typical shrimping conditions, sea turtles come in contact with other organisms and debris in a trawl. Such interactions could either promote or hinder a PTT-outfitted individual's exit from the TED, depending on the size and volume of other items in the trawl. Additionally, interactions with a large animal or piece of debris, or high catch or debris volumes, could also result in PTT damage or loss. Bottom-opening TED configurations, including the BOSS utilized here, probably have the greatest potential for interactions between a carapace-mounted PTT and the TED deflector bars, given the tendency of turtles to swim upward, away from the exit, when trapped against the bars (Mitchell[3]).

Overall, 15 of 28 loggerheads (54%) in the trials impacted the TED carapace-first, suggesting that conditions allowing or promoting carapace-first encounters, and associated TED-PTT interactions, are common. As such, researchers tracking small turtles in or near regions with trawl fisheries that require TED's should consider size and shape of the PTT, adhesive(s), and their combined footprint and profile in order to minimize potentially detrimental interactions with TED's. Specifically, adhesive should be applied around the transmitter to cover a larger surface area and increase the angle between the PTT and carapace (Fig. 3), and/or a PTT design with a lower profile should be employed on smaller turtles.

[3]Mitchell, J. 2006. NMFS Harvesting Systems Branch, SEFSC, Pascagoula, Miss. Personal commun.

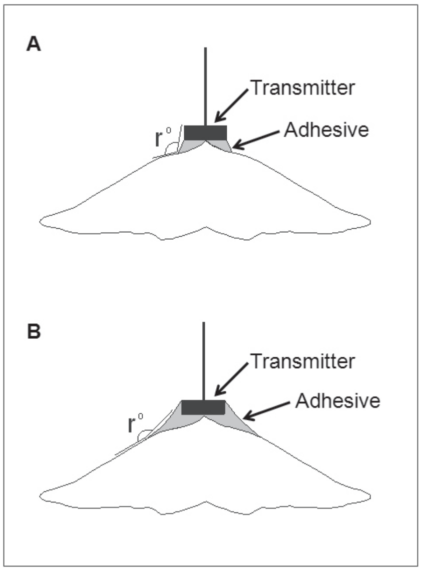

Figure 3.—Head-on view of a PTT-outfitted sea turtle carapace with a relatively small adhesive footprint and angle, r° (A; not recommended), and a larger adhesive footprint and angle, r° (B; recommended).

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