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Development and Testing of a Tow Time Data Logger to Monitor and Enforce Tow Time Restrictions in Trawl Fisheries

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Development and Testing of a Tow Time Data Logger to Monitor and Enforce Tow Time Restrictions in Trawl Fisheries

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ABSTRACT

Tow time restrictions have been discussed as a potential alternative for sea turtle conservation in fisheries where Turtle Excluder Devices (TEDs) are known to reduce the targeted catch. Although the length of time a turtle can remain submerged in a trawl is still being evaluated, tows less than 1 hour are expected to result in a negligible number of sea turtle mortalities. Discussion about the feasibility of tow time restrictions often results in concerns about the feasibility of monitoring and compliance with any limit on tow times. The Protected Species Branch of the National Marine Fisheries Service (NMFS)'s Northeast Fisheries Science Center (NEFSC) solicited a contractor to develop and construct a robust, simple, and inexpensive data logger that can be used to enforce tow time restrictions on commercial bottom trawl fishing vessels. These loggers, which are attached to the trawl net or the trawl doors, record the time the units are below a predetermined depth and have a signal (light) alarm to indicate when the time limit has been exceeded. Additionally, the units have a battery life of approximately 4 years and can store up to 4 months' worth of data with the option to overwrite the oldest memory. The units were tested for their ability to reliably record trawl fishing tow duration and detect when a tow has exceeded a time threshold. The loggers have been tested on 9 different vessels fishing for 7 different target species and have held up to the abuses of the salt environment and the shock and vibration of commercial fishing practices. Additionally, because these loggers are programmable, they may have applications in other fisheries where there is a need to monitor, record, or enforce soak durations.

BACKGROUND

In the early part of this decade, the National Marine Fisheries Service (NMFS) recognized the need to address sea turtle bycatch in a more comprehensive manner across jurisdictional boundaries and based on gear type. Trawling is a method of fishing that involves actively pushing or towing a net through the water, where it may incidentally capture sea turtles and other species. This need was identified as a priority to address and reduce sea turtle bycatch. Reducing sea turtle bycatch in trawl fisheries has been identified as an action necessary to achieve recovery goals (NMFS and USFWS 1991, 2008; NMFS et al. 2011).

Turtle excluder devices (TEDs) are an effective method to minimize adverse effects related to sea turtle bycatch in several trawl fisheries around the world. However, TEDs are not feasible for some trawl fisheries given the size of the target catch or the configuration of the gear. In the event that TEDs are not feasible, other mitigation measures (e.g., tow time restrictions, time/area closures) need to be considered (DeAlteris 2010).

The Greater Atlantic Fisheries Office (GARFO) and The Gear Research Group of Northeast Fisheries Science Center (NEFSC) held 2 open trawl workshops (DeAlteris 2007, 2010). The attendees included fishermen, scientists, research institution representatives, and fisheries managers. The goal was to identify possible solutions for sea turtle bycatch in trawl fisheries and to solicit information to help NMFS determine which solutions were most viable. During the workshops, it became clear that because of the varied species targeted in the Northeast, it was necessary to research and develop not only TEDs but other options as well. One of the proposed options to reduce sea turtle mortalities in trawl fisheries was a tow time data logger (DeAlteris 2010). Fishing industry members are interested in this technology instead of TED requirements as a potential tool to mitigate the take of sea turtles.

The theory behind tow time restrictions is that increased tow durations are associated with increased mortality (Sasso and Epperly 2006). Incidental take data from the Northeast Fisheries Observer Program (NEFOP) (Figure 1) shows trends for the Northeast and Mid-Atlantic regions that suggest sea turtles survive tow durations under 60 min and even 90 min, with some turtles needing resuscitation from a comatose condition (Figure 1).

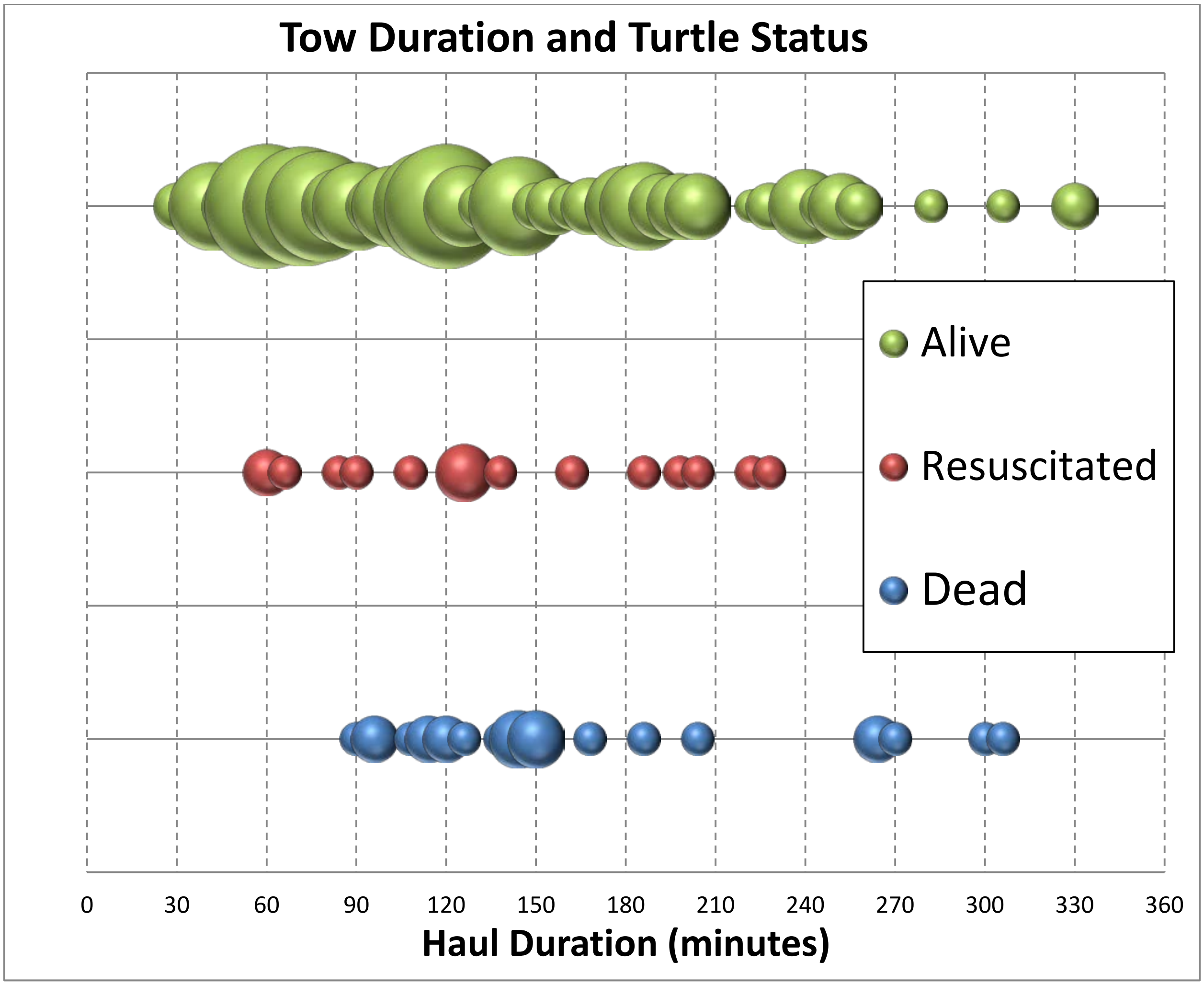

Figure 1. Incidental take data from the Northeast Fisheries Observer Program (NEFOP) for 2005-2010 showing trends for the Northeast and Mid-Atlantic regions. Size of the circles represents the relative frequency of occurrence.

METHODOLOGY

The purpose of this project is to develop an affordable logger that efficiently and reliably detects when a trawl net has been fishing past a set time threshold (e.g., when a net is fished for more than 1 hr). A request for proposals (RFP) was issued by the NEFSC Gear Research Group to find a contractor to assist in development of this tow time logger. The RFP set forth 10 requirements. The logger should:

(1) Accurately measure the amount of time the net is in the water past a certain depth. The logger must measure depth (accuracy $\pm$ 2 m), have an accurate time and date stamp (acceptable tolerance $\pm$ 30 sec over a 6 mo period), and either measure/store the depth every 30 sec after the unit/net has entered the water or record the duration of time the unit was deeper than 5 m after entering the water. This criterion is important to

determine if the net was fishing on the bottom. A switch activated when in contact with saltwater cannot be used, as the unit may switch on while wrapped in wet twine on deck.

(2) Be designed so the data in the unit cannot be erased or tampered with. To ensure that accuracy, it is imperative that the data stored cannot be modified or deleted by the user.

(3) Be designed to operate to a minimum depth of 300 m. This depth was chosen because it encompasses all the trawl fishing in the research area.

(4) Be constructed to withstand repeated falls from a minimum height of 15 ft without damage, and be generally rugged enough to withstand the rough handling while the logger is attached to the trawl net.

(5) Have a reliable battery life of a minimum of 1 yr, and have a reliable indicator that the unit is operational. It is important that the user have an effective and simple way of determining when the unit is not functioning.

(6) Be capable of storing data from a minimum of 1 mo of sampling at a minimum sampling rate of 1 reading every 30 sec. It is important to understand the fishing operation history to determine if haul durations were frequently exceeded or if an infrequent situation caused the net to be in the water past the predetermined time (e.g., if the net is caught on an obstruction on the bottom).

(7) Have an easy means to determine whether tow durations have been exceeded. If necessary, the logger should be able to download the data reliably for later inspection via non-proprietary or contractor-supplied computer software. Ideally, a unit would signal/alarm to facilitate the determination of whether maximum tow durations were exceeded.

(8) Have a unique serial number on both the logger and the data it records. The serial number on the data should match the serial number on the logger. It is important that the data and the logger be easily matched so the possibilities of incorrectly attributing data to a vessel are eliminated.

(9) After development, have a final cost below $500/unit.

(10) Be constructed in a manner that allows the unit to be attached to a trawl net easily and securely by untrained people. The units must be securely attached to the trawl nets with tamper-resistant ties so they cannot be removed during operations.

The chosen proposal was submitted by Onset Computer (Bourne, Massachusetts)

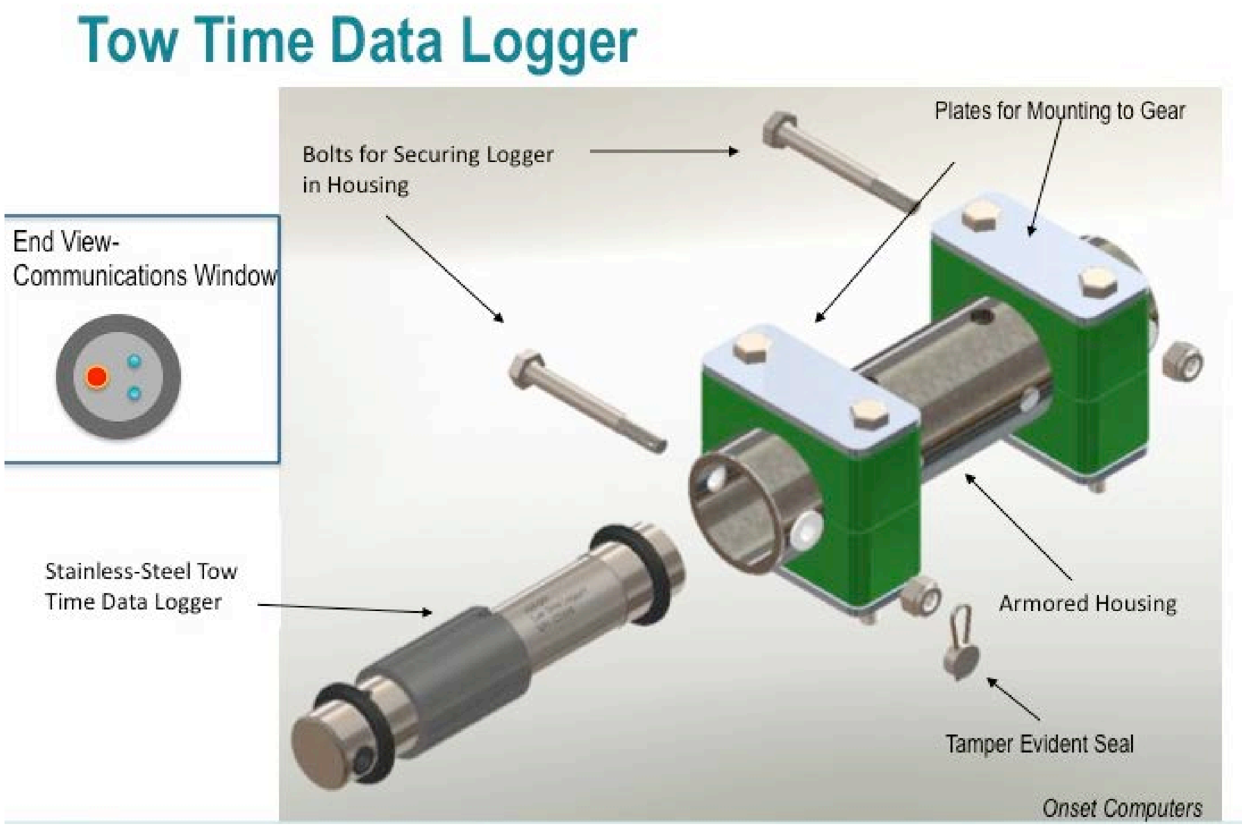

Figure 2. Diagram of the HOBO U25 Tow Time Logger and its protective housing.

The HOBO U25 Tow Time Logger (Figure 2) records trawl fishing times and detects when a tow has exceeded a time threshold. The configuration is easily modified, but is configured to take pressure (depth) measurements every 30 sec and initiate a “tow started” event after the logger exceeds a preprogrammed depth. If the pressure does not indicate that the logger has returned above the preprogrammed depth within the set limit, an “alarm” event is recorded to the data file.

The logger contains a light emitting diode (LED) that blinks every 4 sec to confirm that it is functioning properly. The LED can also be used to determine if an alarm has been tripped during deployment. When the logger is removed from the protective steel housing and the PVC collar is slid into an alarm status position (forward and aligned with a magnet), the LED blinks to indicate if the tow duration was exceeded. The logger body is made of machined stainless steel and depth-rated to 300 m. It is able to connect to a base port or data shuttle, which is used to download the data through an optical interface communications window. As the gear is being deployed, the logger begins a fast logging interval (Figure 3) at the programmed depth and begins the timer function. If the programmed tow duration is exceeded the visual alarm is triggered.

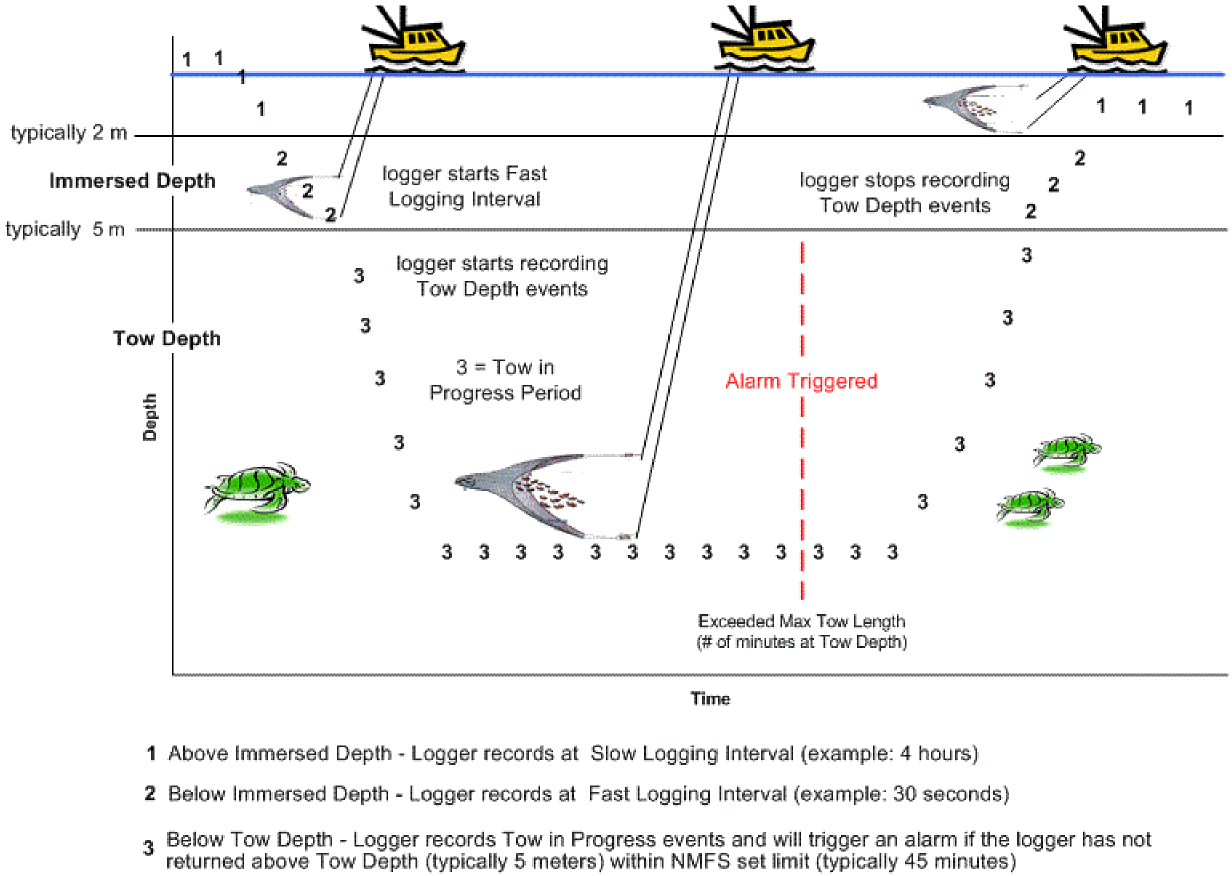

Figure 3. Depth- and time-triggered functions of tow time data logger

The housing that contains the logger allows for attachment to the trawl door or fishing gear and is made of 2 polypropylene and stainless pipe clamps. These clamps hold a galvanized pipe into which the data logger body is fastened with 2 stainless bolts. A tamper-evident seal can be placed in the bolt so any loosening of the nut to remove the logger from the housing will destroy the seal.

Software

The accompanying HOBO software allows the user to interface with the logger to set up logging parameters and quickly plot the tow time data (Figure 4).

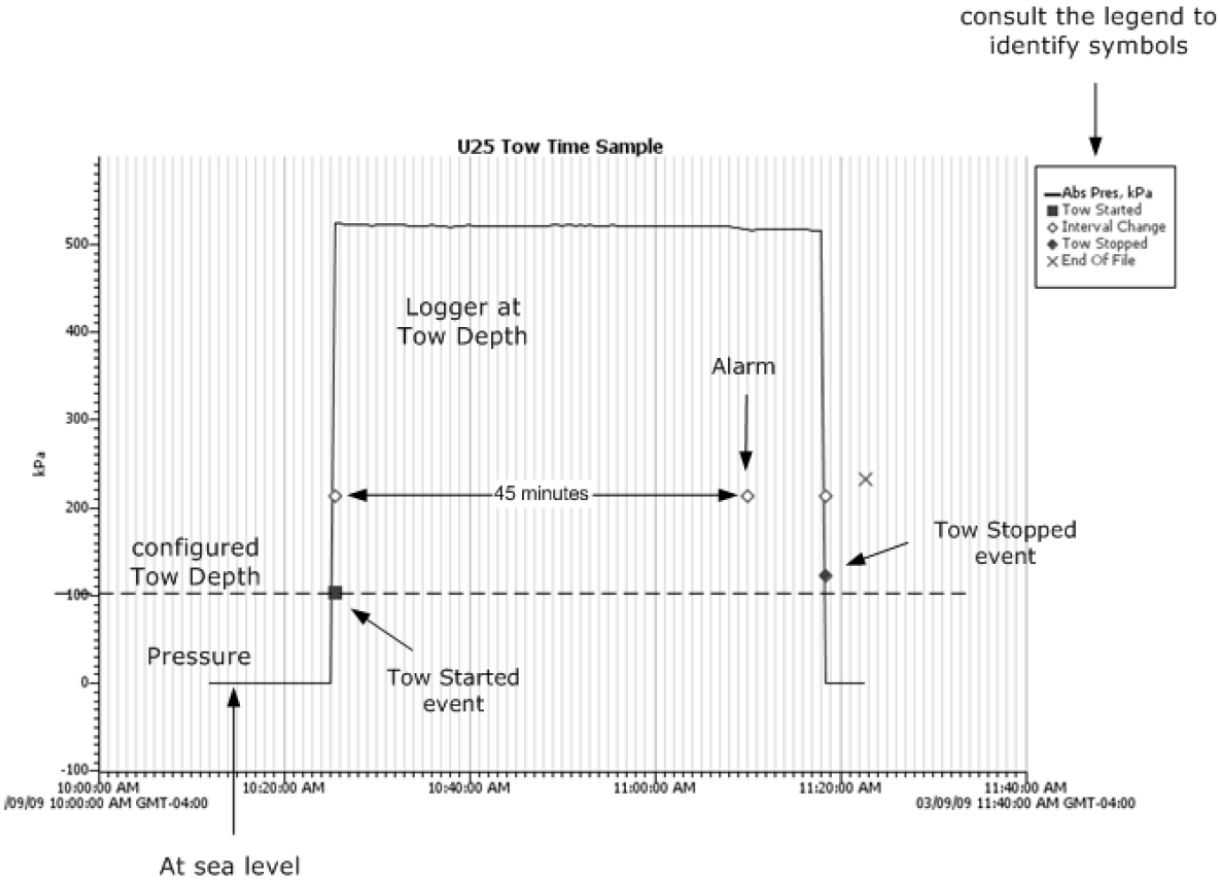

Figure 4. Example of tow plotted on the tow time data logger's HOBO software, which allows the user to set up logging parameters and quickly plot the tow time data.

The HOBO Tow Time Logger is programmable and can be configured to specific fishing areas, depths, setting/hauling operations, and desired tow time limits (Figure 5). Generally, trawl gear needs a few meters' depth before the doors spread the trawl mouth open, but if a vessel tends to fish in estuarine or shallow coastal waters the tow time data logger may be configured to begin the fast logging interval and begin the tow timer at a shallower depth (e.g., 1 m). Although this trial focused solely on trawl gear, it may be applicable in some gillnet fisheries as there has been a direct relationship shown between mortality of bycatch species (Atlantic sturgeon [*Acipenser oxyrinchus*]) and soak time (ASMFC 2007). Hypothetically, a gillnet fishery soak time limit could be enforced by programming the logger's maximum tow length setting to the predetermined soak duration.

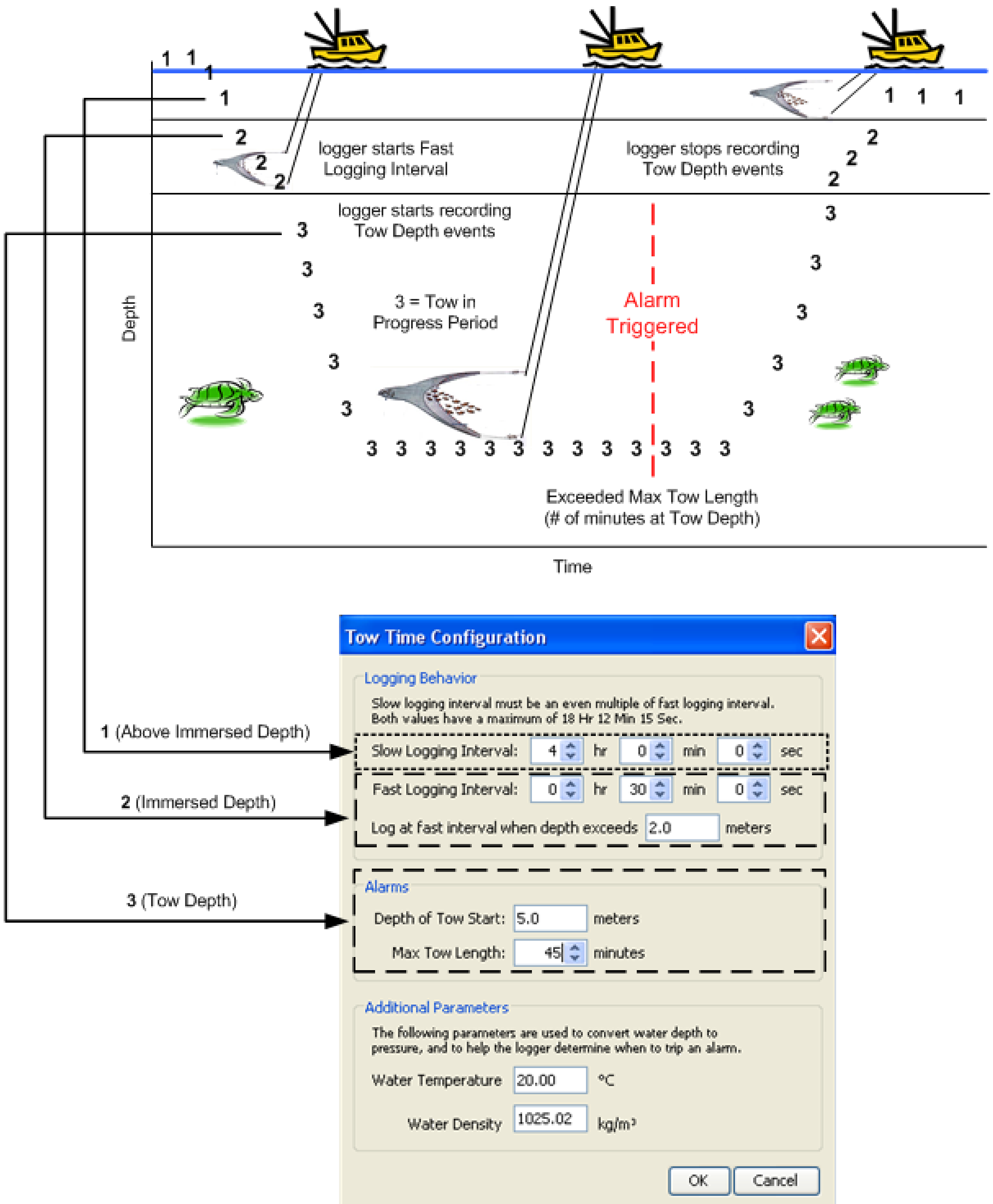

Figure 5. The HOBO Tow Time Logger's setting configurations. The logger can be configured to specific fishing areas, depths, setting/hauling operations, and desired tow time limits.

Enforcement

To be an effective management tool, the tow time data logger needs to be checked by enforcement officers. The data logger can be monitored at the dock or at sea, and can be checked for proper installation and functioning without removing the housing. An agent can remove the logger from the housing to check if the alarm was triggered. If the light indicates an alarm status through the communications window, the officer can download the data to a waterproof shuttle to review later, remove the logger for later analysis, or download the data to a laptop computer to view immediately (Figure 6).

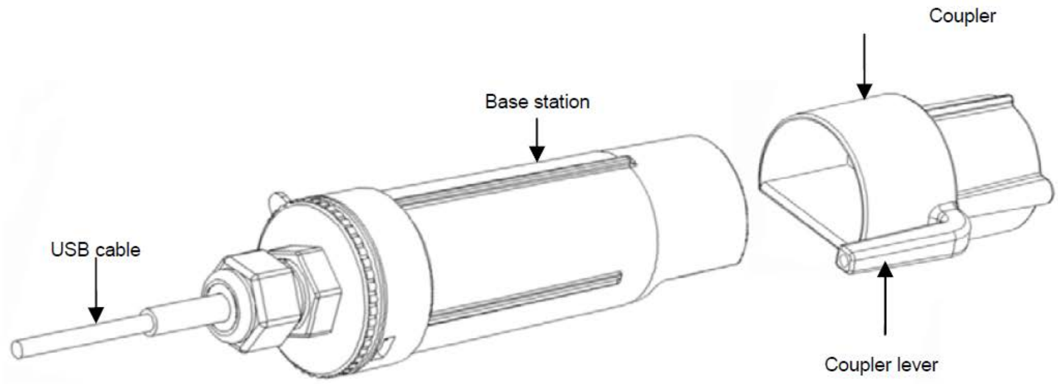

Figure 6. HOBO Tow Time Logger's wet-connect base station coupler.

FIELD TRIALS

Identifying volunteer vessels willing to attach the tow time data logger to their trawl gear was the initial step in this project. Industry participants from the trawl workshops were interested in the technology and several volunteered to assist in testing. In order to accommodate volunteer vessel schedules, most of the testing occurred by mounting a logger onto a trawl door of a vessel that continued fishing as usual without regard to tow time limits or logger settings. In some instances, set and haul back times were recorded on separate logs and compared to logger readouts. Short- and long-term deployments were tested to attain a reasonable assessment of the durability, corrosion resistance, accuracy, and data storage capacity of the logger. The tow time data loggers remained attached to the door for multiple data offloads during long-term deployments.

The tow time data logger was deployed aboard 9 different vessels and recorded hauls for 7 different target species (Table 1) as identified by the captain.

Table 1. Tow time data logger trial effort by target species.

Target	Hauls Recorded	Data Points	Days Deployed
Summer flounder (*Paralichthys dentatus*)	484	126,018	193
Horseshoe crab (*Limulus polyphemus*)	316	65,521	424
Sea scallop (*Placopecten magellanicus*)	53	13,535	21
Atlantic croaker (*Micropogonias undulatus*)	45	21,557	117
Mixed species*	32	23,402	76
Striped bass (*Morone saxatilis*)	22	4,017	64
Longfin squid (*Loligo pealei*)	2	804	2
Total	**954**	**254,854**	**897**

*Mixed species target was reported as groundfish/mixed species hauls occurred off Georges Bank.

The logger mounting location was determined by each vessel's captain or owner and the field technician. In most situations, an area could be found on the trawl door next to an eye or shackle to provide extra protection from impact and chaffing. It was thought by all involved that the logger would be less likely to encounter heavy impacts by rocks and debris on the outside of the door (Figure 7), although there was increased difficulty in the installation and accessibility of a logger mounted in this location. The process of installation was to tack-weld the stainless steel mounting plates to the trawl door; the housing was then bolted into the mounting plates.

Figure 7. One common tow time data logger mounting location is on the outside of the trawl door near an eye and shackle.

RESULTS

The tow time data loggers have been tested for 897 days on 954 hauls, collecting 254,854 data points. Aside from some initial setbacks (reviewed in discussion section), they have withstood the abuses of commercial fishing activities. The stainless logger bodies suffered little to no corrosion over the testing period, merely showing surface staining and light abrasion from sand and sea grit. The logger housings have proven an effective method of mounting and protecting the logger. The galvanized pipe section lost some of its coating, but the structural integrity of the housing was intact. The longest attached deployment of the logger housing was 3 yr, 4 mo, 11 da. The photo in Figure 8 was taken at the end of this deployment and the housing was still in good condition.

Figure 8. Condition of the tow time data logger housing after 3 yr, 4 mo, and 11 da.

The testing has shown that the battery life lasts multiple years. All loggers received new batteries due to a battery recall in January 2010, and after 3 yr and 4 mo are still functioning above 10% of the battery capacity.

The depth readings were tested at the dock using a marked line and were shown to accurately record the depth. The loggers have also been used on trawl projects to measure inches of differences in depth (Gahm et al. 2014).

The logger has the ability to store about 3 mo of haul data recording a fast logging interval below a predetermined depth threshold. The more time the logger is below the depth threshold and “fast logging,” the more data is collected. We chose a fast logging interval of 1 record every 30 sec and a slow logging interval of 1 record every 4 hr. When the memory reaches capacity, the logger continues functioning by overwriting the oldest data.

After repeated long deployments, there have been no failures due to shock or vibration. Failure due to silt, and the remedy to this failure, are covered in the Discussion.

The tow time data logger was also tested on vessels participating in gear trials where protocols required specific tow times to ensure comparable catch data. During these studies, accurate set and haul times were recorded on a haul log. The data logger records matched the haul log very accurately and it was clear from the pressure readings when the gear entered and exited the water. As the depth increased, haul start and end times recorded on the logger grew longer than those recorded on the paper log. This is explained by the intention of the recordkeeping. For one set of trials, the captain’s goal was a 30 min tow duration. According to the paper log data, the mean of these tows on paper was 30.125 min, var = 0.308 (n=72). Alternately, the recorded tow duration from the data loggers produced a mean of 34.181, var = 0.347 (n=72). These tow durations were statistically different (p =1.190E-84;[∞ =0.5]). The variance around these means was very close, indicating that the difference was consistent. Therefore, the logger consistently measured the duration of the tows approximately 4 min longer than the captain did. For another set of trials, the study attempted to achieve a 90-min tow duration. During this study, the captain’s paper records showed a mean of 90.619 min with a variance of 8.048 (n=21), while the logger had a mean of 111.429 min with a variance of 10.557 (n=21). These results were statistically different (p=4.898E-26) ;[∞ =0.5]. Again, this shows that the logger consistently measured the tow at approximately 21 min longer than the captain’s estimates. These differences are due to the logger measuring the start and end time based on when the logger was below 5 ms, while the captain measured haul duration based on winch lock (set) and winch start (haul back). The difference between the first and second set of trials is due to depth of water, vessel haul back speed, and location of the logger on the gear.

The haul log record is intended to ensure equal time spent fishing on the bottom, so “haul begin” was recorded when the winches were locked and “haul end” when the winches began hauling the gear. This is often how vessel operators will record tow time and may result in exceeded set tow durations as recorded by the logger. One vessel operator was willing to keep and share a logbook of commercial fishing activity to be compared to the data from the logger. This comparison showed that the operator was able to time hauling the gear within the tow duration limits. The key to timing the haul back efficiently (maximizing the time the gear was fishing) was to understand how the data logger worked; specifically, what depth triggered the “haul begin” and “haul end” demarcations on the software. With this information, the vessel operators could accurately account for the tow durations and keep the hauls within the allocated time.

The tow time activity of the volunteer industry participants followed the pattern in Table 2. Tows targeting horseshoe crab (*Limulus polyphemus*) had a mean duration of 59 min, with a maximum duration of 1:21 min and a minimum of 0:24 min. Tows targeting sea scallops (*Placopecten magellanicus*) had a mean duration of 0:49 min, with a maximum duration of 1:23 min and a minimum of 0:15 min. The data for the remaining target species (summer flounder [*Paralichthys dentatus*], Atlantic croaker [*Micropogonias undulatus*], striped bass [*Morone* *saxatilis*], mixed species, and longfin squid [*Loligo pealei*]) showed a majority of tow durations longer than 1:30 min. Tows with a predetermined duration (e.g., catch comparison or trawl gear testing tows for other projects) were removed from this part of the analysis.

POTENTIAL USERS

Certain fisheries may want to use the data logger technology rather than installing and using TED gear. Most of these fisheries already have shorter tow times and would be affected minimally by constrained tow durations. Other fisheries that may benefit from this technology are those targeting a species with a morphology not conducive to passing through the bars of a TED. According to NEFOP data (2005-2012), bottom otter trawl gear tows targeting sea scallop, horseshoe crab, whelk (*Buccinum undatum*), and southern kingfish (*Menticirrhus americanus*) show 50% or more of all recorded observed tow durations as less than 60 min (Table 2; Figure 9). Observed bottom otter trawl tows targeting Atlantic croaker, smooth dogfish (*Mustelus canis*), striped bass, scup (*Stenotomus chrysops*), and butterfish (*Peprilus triacanthus*) show 20%-50% of all recorded tow durations as less than 60 min (Table 2; Figure 9).

Table 2. The tow time activity of the volunteer industry participants in the tow time data logger trials followed this pattern with tows targeting horseshoe crab having a mean duration of 59 min, with a maximum duration of 1:21 min and a minimum of 0:24 min. Tows targeting scallops having a mean duration of 0:49 min, with a maximum duration of 1:23 min and a minimum of 0:15 min. The data for the remaining target species (summer flounder [*Paralichthys dentatus*], Atlantic croaker [*Micropogonias undulatus*], striped bass [*Morone saxatilis*], mixed species, and longfin squid [*Loligo pealei*]) showed a majority of tow durations above 1:30 min.

50% or greater total observed bottom otter trawl tow durations less than 60 min.	**20% - 50% of total observed bottom otter trawl tow durations less than 60 min.**
Sea scallop (*Placopecten magellanicus*)	Atlantic croaker (*Micropogonias undulatus*)
Horseshoe crab (*Limulus polyphemus*)	Dogfish, smooth (*Mustelus canis*)
Whelk, conch (*Buccinum undatum*)	Striped bass (*Morone saxatilis*)
Southern kingfish (*Menticirrhus americanus*)	Scup (*Stenotomus chrysops*)
	Butterfish (*Peprilus triacanthus*)

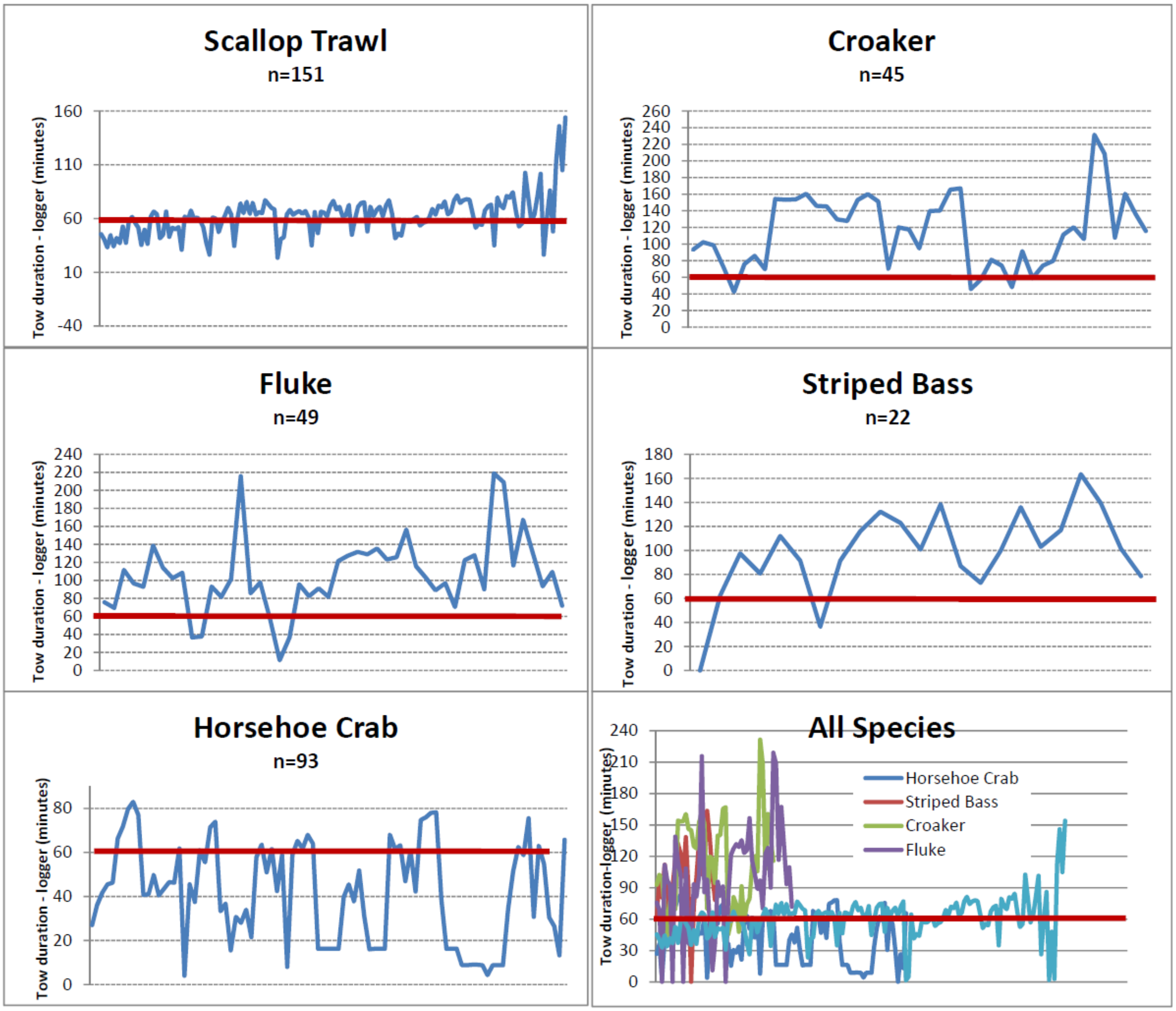

Figure 9. Tow durations by target species (scallop [*Placopecten magellanicus*], croaker [*Micropogonias undulatus*], fluke (summer flounder [*Paralichthys dentatus*]), striped bass [*Morone saxatilis*], horseshoe crab [*Limulus polyphemus*]) and all species during the tow time data logger trials. Data includes only tows unaffected by research time constraints.

DISCUSSION

TEDs are an effective method to minimize adverse effects related to sea turtle bycatch in several trawl fisheries around the world. However, TEDs are not feasible for some trawl fisheries given the size of the target catch or the configuration of the gear. In the event that TEDs are not feasible, other mitigation measures (e.g., tow time restrictions or time/area closures) need to be considered (DeAlteris 2010). Trawl tow time restrictions have potential to mitigate sea turtle mortality and the tow time data logger has potential as an effective method for tow time compliance verification.

In order to mandate the use of tow time data loggers, there would need to be some training of vessel operators and enforcement officers in use of the data loggers, but the training effort needed for use, installation, and monitoring of tow time loggers, should be compared to the use, installation, and compliance monitoring of other available bycatch mitigation tools such as TED gear. Enforcement officers could be trained at different levels. For example, at a minimum an officer could be trained to remove the logger from the housing and check for the alarm signal. If the alarm signal was triggered, the officer could transfer the data to someone trained to analyze it. Other compliance verification issues like location, seasonality, and target could be addressed as tow time rules are written.

There were setbacks at the beginning of this project. Any new software package can have issues to work out; this was the case with the tow time data logger software. In the first trials of the data logger, failures were due to a recall from the battery manufacturer. This resulted in significant loss of mission time, as time was spent on coordination and deployment of the loggers with vessel captains then on coordination and retrieval of the loggers to be serviced, without collecting any usable data. Once all the loggers had been serviced with replacement batteries, they functioned through the rest of the study without needing battery replacement or recharge.

One unexpected problem encountered while developing the tow time data logger was the clogging of the pressure sensor with silt substrate on deep deployments. This problem first occurred on a mixed species deployment attempt to catch redfish at 200 m. Because the pressure sensor was stuck at depth, the data read that the gear was set and never hauled. The issue was corrected by installing a filter through the pressure access hole that stopped silt and sand from clogging the pressure sensor.

The tow time data logger is reliably able to verify tow durations for bottom otter trawl gear, with adequate data storage to allow enforcement to attain history of the vessel's fishing practice. This data logger could be a tool that resource managers use to mitigate sea turtle mortalities in fisheries where TEDs are not economically or operationally feasible.

ACKNOWLEDGEMENTS

This project was a collaboration of the fishing industry, the Northeast Fisheries Science Center Gear Research Group, and the Greater Atlantic Regional Fisheries Office. The Gear Research Group makes every effort to involve the fishing industry at every step of the process of developing bycatch reduction devices and methods, from the generation of the idea to testing to implementation.

This study was only possible with the volunteer assistance of Jeff Eutsler, Dave Trader, Andrew Jackson, Jim Brindley, Pat Kavanagh, Chris Roebuck, James Lund, and Jimmy and Bobby Rhule.

The authors would also like to thank Heather Haas, who helped in many aspects of this project.

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Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

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