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Hook Timers to Measure the Capture Time of Individual Fish

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Introduction

Gear saturation and interspecific competition for hooks complicate the use of longlines for stock assessment. Gear saturation occurs when fish density is so high the proportion of unoccupied, baited hooks approaches zero before the longline is retrieved. If this occurs, catch is not a continuously increasing function of time, and catch per unit effort (CPUE) is not proportional to abundance (Ricker, 1975). Interspecific competition for hooks occurs when the CPUE of one species is reduced by the catch of other species on the same longline. Such an effect is especially pronounced when the gear approaches saturation (Rothschild, 1967).

These problems led us to search for other ways of using longlines to estimate relative abundance, and from a theoretical standpoint, the most promising alternative was a method based on the time required to hook each fish (Somerton[1]). The abundance estimates used by this method are unaffected by gear saturation because they are completely determined when the last fish is caught. The estimates are also unaffected by interspecific competition, as long as one species does not physically exclude another from taking the hook, because they are computed for all species jointly.

This method requires development of a small, inexpensive timing device that will activate when the hook is struck by a fish. We describe and test two different designs for such a device: A corrosion timer and a digital timer.

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ABSTRACT—*To measure capture time of individual fish on a longline, two types of hook timers installed in the leaders and activated by a striking fish were designed and tested: 1) A corrosion timer that measures time indirectly from the mass loss of the anode in a galvanic corrosional reaction and 2) a digital timer that measures time directly by a digital watch module. The digital timer proved to be superior because it is reusable, quicker to deploy and retrieve, and measures time directly with little error.*

Methods

Corrosion Timer

The corrosion timer is based on the principle that, when two dissimilar metals are connected electrically and placed in seawater, a galvanic cell is created and one of the metals (anode) is ionized. The exposure time to seawater can be estimated from the anode mass loss, which depends on the electromotive potential of the two metals, the size and shape of the anode and cathode, and the salinity and temperature of the seawater (Loose, 1948). For our objectives, the corrosional reaction had to be consistent from one timer to the next and rapid enough so that mass loss in a 15-minute period is sufficient to be easily detectable but not so rapid that the anode corrodes completely in <4-6 hours.

The anode was a 38 mm long × 3.9 mm diameter magnesium welding rod (93.3 percent Mg, 5.5 percent Al, 1.0 percent Zn, 0.2 percent Mn); the cathode was two 25 mm stainless steel (304 grade) fender washers secured by stainless steel nuts to the threaded ends of the welding rod (Fig. 1). To isolate the timers from seawater until the hooks were struck by fish, they were placed in watertight containers (35 mm film cannisters) attached to the leaders (Fig. 2). The rims of the cannister openings were sanded until the caps released with 1 kg of pull, a tension weak enough for the cannisters to be opened by all target species yet strong enough that few opened accidentally as the longlines were set. In addition, the cannisters were filled with a 1:1 mixture of distilled water and isopropyl alcohol to prevent them from collapsing under hydrostatic pressure and thereby changing the activation tension.

Anode mass loss as a function of exposure time was initially estimated in the laboratory. Twenty-four timers were placed simultaneously in seawater (salinity, 34.7‰; temperature, 23.5°C) in a 4,000-liter tank and removed, three at a time, at 15-minute intervals for up to 2 hours. The resulting mass loss was linear with time, and variability among replicates was so low that there was no overlap in mass loss between adjacent 15-minute intervals (Fig. 3). Although additional laboratory calibration experiments were run at approximate in situ temperatures and salinities, we suspected that pressure (the timers were intended to be used at <1,000 m depths),

[1]Somerton, D. A. A method of stock assessment using the time-to-capture of individual fish on a longline and its application to pelagic armorhead, *Pseudopentaceros wheeleri*, on the Hancock seamount. Manuscr. in prep. Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, 2570 Dole Street, Honolulu, HI 95822-2396.

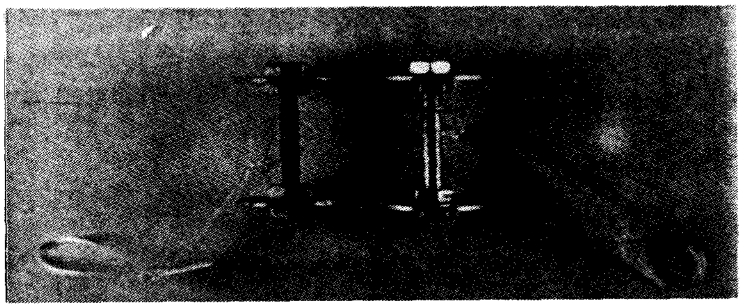

Figure 1.—Corrosion timers before (right) and after (left) exposure to seawater for 2 hours. Note the loss of material from the anode (central rod) and the deposition of material on the cathode (end pieces).

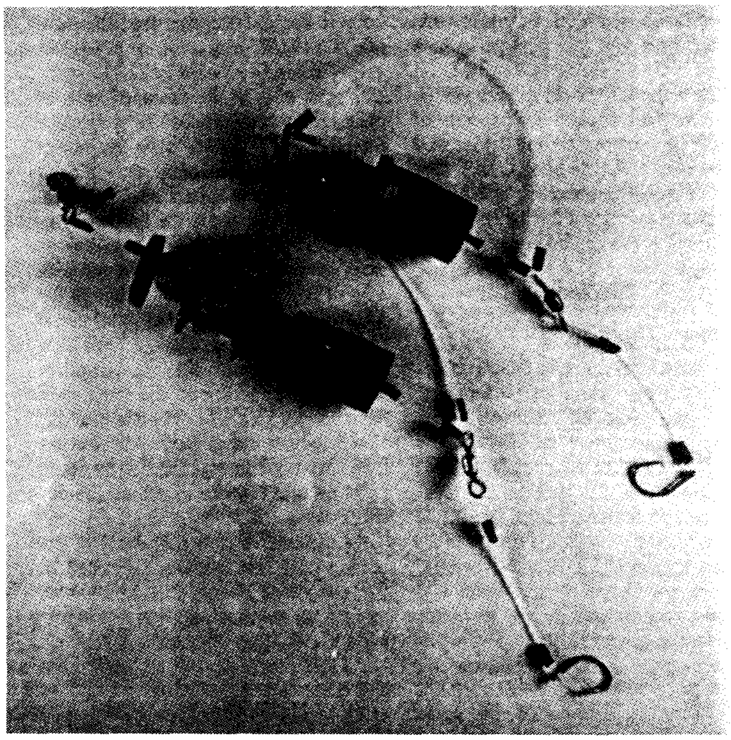

Figure 2.—Corrosion timer cannisters as they would appear when the longline is set (upper) and after a fish has struck the hook (lower).

dissolved oxygen concentration, and water movement would likely affect the corrosion rate.

We therefore attempted an in situ calibration by exposing the timers to seawater (salinity, 35.0‰; temperature, 15.5°C) at depth by using a shipboard water sampling rosette. The one successful in situ calibration showed greater variability in mass loss than did the lab-

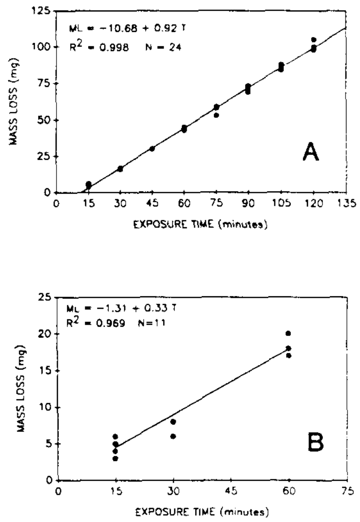

Figure 3.—Anode mass loss of corrosion timers and exposure time to seawater: A) in a laboratory experiment (salinity, 34.7‰; temperature, 23.5°C) and B) at the Hancock Seamount (salinity, 35.0‰; temperature, 15.5°C).

oratory calibrations, and perhaps some nonlinearity with time (Fig. 3); however, the linear fit of the data was sufficiently good that the in situ calibration rather than the laboratory calibrations was used in the field tests.

Digital Timer

The digital timer (65 mm long × 29 mm diameter) consisted of a digital clock module with a liquid crystal display (Sterling Electronics, Taipei, Taiwan[2]), an alkaline disc battery, and a magnetic reed switch (single pole double throw; Hermetic Switch, Inc., Chickashs, OK 73018), which were enclosed in metal hardware cloth and embedded in a cylinder of polyester casting resin (Fig. 4). A hole at one end of the cylinder contained a ceramic magnet used to activate the reed switch (Fig. 4). When the magnet was pulled out of the

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

hole, the reed switch closed and the digital clock started from its reset value of 1:00; when the magnet was reinserted, the clock was reset. The pull required to activate the digital timers was standardized to 1 kg by an adjustable, spring-loaded pin assembly that rested against the magnet (Fig. 4). The rigidity of the timer was sufficient to withstand short-term (about 5-minutes) exposure to chamber pressures equivalent to 1,000 m in depth. The reed switch was partially shielded from external magnetic fields with metal hardware cloth to minimize the chance of the timers being accidentally reset by a struggling fish. Ceramic magnets and stainless steel springs and pins were used to prevent corrosion of either the magnet or the spring-loaded pin assembly that could potentially alter the activation tension of the timer.

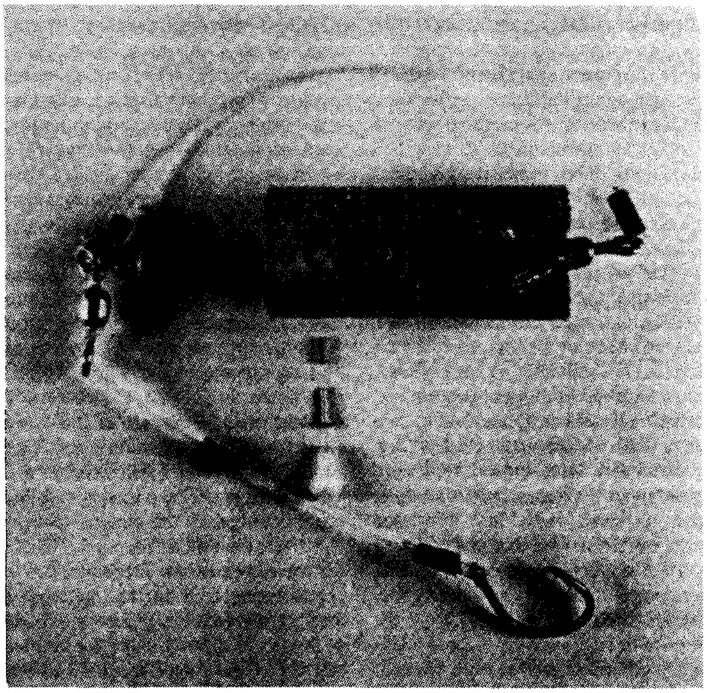

Figure 4.—Digital timer as it would appear 9 minutes after being struck by a fish.

Field Trials

All field trials were conducted on the Southeast Hancock Seamount (lat. 29°48′N, long. 179°E) at depths of 250-800 m. The primary fish species encountered here is pelagic armorhead, *Pseudopentaceros wheeleri*, a small (≈1 kg), sluggish species often forming dense aggregations near the summit.

The timers were tested, based on handling time and failure rates, with Kali longlines, a fishing gear used repeatedly for stock assessment of pelagic armorhead (Shiota[3]). This gear consisted of rigid poles (droppers) snapped on a groundline at 20 m intervals. Each dropper (3.2 m long) had five hooks on short, equally spaced leaders and was weighted so that it was positioned vertically while fishing. The only modification to this gear was the replacement of the normal leaders with leaders having timers spliced in (Fig. 5).

Corrosion timers were field tested once in July (N = 3,264) and once in October 1986 (N = 1,332). Droppers with and without timers were alternated on the groundline to assess the influence

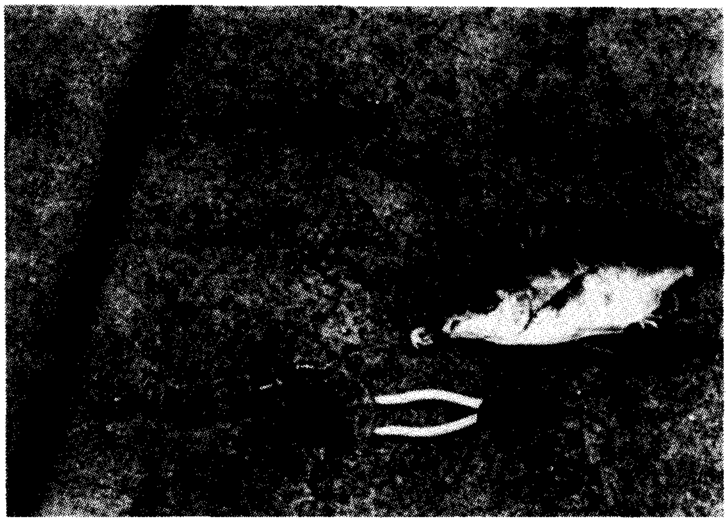

Figure 5.—Corrosion timers in use. Note that the hook leaders are attached to a rigid pole rather than directly to a groundline.

[3]Shiota, P. M. 1987. A comparison of bottom longline and deep-sea handline for sampling bottom fishes in the Hawaiian Archipelago. Honolulu Lab., Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 95822-2396. Southwest Fish. Cent. Admin. Rep. H-87-5, 18 p.

of timers on fishing characteristics of the gear. In the first field test, the corrosion timers sustained accidental damage severe enough to invalidate the mass loss weights; therefore, statistical tests involving time information omit the first trial. Digital timers were field tested in August 1987 ($N = 3{,}840$); no side-by-side comparisons were made.

The general times and procedures for using the longline gear were as follows: 1) Baiting hooks (20 minutes), 2) setting (10 minutes), 3) soak time (60 minutes), and 4) retrieval and recording the catch data (30 minutes). The use of hook timers required additional procedures. Corrosion timers were attached to cannisters with monofilament leashes (Fig. 2); cannisters were closed while immersed in an alcohol and water mixture. Upon retrieval, individual corrosion timers were removed and placed into a bucket of alcohol to slow corrosion and, after complete recovery of the longline, were air dried and separated from the cathodes to stop corrosion. In the laboratory, corroded anodes were washed, dried, and weighed to the nearest milligram, and the exposure times were estimated by using a previously determined time and mass loss function. For digital timers, the display was read immediately when the gear was brought aboard the vessel, and the timer was reset later by reinserting the magnet into its retaining hole.

Results

Hook timers tended to affect preparation and processing times more than setting and retrieval times. For corrosion timers, attaching new timers increased gear preparation time by about 100 percent, and depending on the size of the catch, deactivating the timers increased processing time by up to about 50 percent. For digital timers, the resetting process increased gear preparation time by about 15 percent, but all other times were unaffected.

Longlines with timers were subject to a variety of failures in addition to the usual modes of failure of the unmodified longlines (e.g., hook loss, bait loss), resulting in losses of time data and sometimes species identity. Two types of failure were premature activation and nonactivation of timers. Premature activation occurred when the timers were prepared improperly (e.g., cannisters not closed completely, magnets not inserted sufficiently to deactivate the reed switch) or were activated accidentally prior to setting. Nonactivation occurred when a fish was too small or too sluggish to activate a timer.

Our experience with both of these failures was as follows: For corrosion timers, 5 percent of 547 activated timers (October 1986 data only) were premature and 16 percent of 1,260 captured fish failed to activate the timers; for digital timers, 6 percent of 2,185 activated timers were premature and 7 percent of 700 captured fish failed to activate the timers. These modes of failure are influenced by the tension required to activate the timers: Increasing tension decreases premature activation but increases nonactivation. The appropriate tension, one balancing these two modes of failure, is a function of the size and activity of the target species and may only be an important consideration for such species as armorhead that are relatively small and sluggish.

Another type of failure was simple mechanical failure or breakage. Corrosion timers rarely failed in this manner, but leashes (Fig. 2) broken when the timer was snagged during recovery resulted in the loss of 13 percent of 1,281 activated timers. We believe this failure rate can be reduced by increasing the strength of the leashes. Digital timers were subject to several types of mechanical failure. Some liquid crystal displays became totally or partially blackened and unreadable after prolonged exposure to direct sunlight and high deck temperatures. Repeated use of timers at $\geqslant$500 m depths sometimes resulted in a total loss of power to the display or a malfunction of one or more digits on the display. The ceramic magnet sometimes fractured when struck on the deck. Although these failures, taken together, resulted in a loss of 50 percent of the 300 digital timers used in the field trials, each timer was used an average of 19 times before failure occurred, and such failures resulted in a loss of only 7 percent of the 2,185 times obtained. We believe the failure rate of digital timers can be reduced by shielding them from direct exposure to sunlight and casting the electronic components in either a harder or larger cylinder of resin.

In addition to data losses attributable to timer failures, we probably also lost data on species identity if timers were activated by fish not subsequently caught. The frequency of activated timers without fish was quite high: 42 percent of 1,831 activated corrosion timers and 70 percent of 2,185 activated digital timers. Although data are not sufficient to determine whether these hooks were actually struck by fish or were snagged on an object, we speculate that the momentary drop in tension that occurs when a timer is activated may decrease the likelihood of catching a fish.

We examined this possibility by comparing the proportion of hooks recovered with fish for the gear with and without corrosion timers. Thirty-eight percent of 3,337 hooks with timers caught fish, whereas 46 percent of 3,347 hooks without timers caught fish. Although hooks without timers caught significantly more fish ($\chi^2 = 46.1$, $P < 0.01$), it is not clear whether this gear was more attractive and had a higher rate of strikes than timer gear or had a higher retention rate when struck. If all hooks without bait presumably were struck, then 49 percent of 2,519 strikes on hooks with timers retained fish compared with 58 percent of 2,674 strikes on hooks without timers. Thus, the retention rate is significantly lower for hooks with timers ($\chi^2 = 34.0$, $P < 0.01$) and is likely responsible for the relatively low occupancy rate of activated timers. We believe the failure of timer gear to hook fish is, like timers prematurely activated, potentially preventable by increasing the activation tension.

Discussion

Although the abundance estimates we use for stock assessment require time-to-capture data (Somerton[1]), both timers are activated when fish strike and, therefore, measure time-since-capture data. For work in shallow water, time to capture can be calculated by subtracting time since capture from total elapsed time (surface to surface). For armorhead, however, fishing is conducted at depths of 250-900 m, so time to capture must be corrected for sinking time of gear. Currently, we estimate sinking time with time and depth recorders (Wildlife Computers, Woodenville, WA 98072) attached to the longline, but are considering a modified digital timer, attached to the base of a dropper, that will be activated when the gear hits the bottom.

We now use digital timers exclusively in our armorhead stock assessment because they are preferable to corrosion timers in three respects. First, digital timers are reusable and, if gear loss is low and reuse is high, are cheaper than corrosion timers to collect equal sample sizes. Second, digital timers require less time to set and retrieve than corrosion timers and require no additional processing time. Third, digital timers are more precise because time is measured directly rather than estimated from mass loss. Digital timers, however, are made from parts that may be difficult to obtain and that require skill and specialized equipment to assemble, whereas corrosion timers are made from inexpensive, readily available materials and can be fabricated by inexperienced personnel.

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