Notes on the Tracking of the Pacific Blue Marlin, *Makaira nigricans*

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ABSTRACT

In July of 1971 and 1972 five Pacific blue marlin, *Makaira nigricans*, were tagged with temperature sensing, ultrasonic transmitters off the west coast of Hawaii. These were tracked for durations up to 22½ h. The paths of three showed movement in a northerly direction. The other two showed no movement. Average swimming speed ranged from 2.2 km/h to 3.4 km/h for the three fish tracked. Swimming depths differed considerably among the three.

The Pacific blue marlin, *Makaira nigricans*, found off the Kona coast on the west side of the island of Hawaii has attracted sport fishermen from all over the world. Veteran anglers of that area usually fish where the bottom slopes steeply from 200 to 2,000 m; but movement patterns of this prized fish, if patterns do indeed exist, are unknown.

The Honolulu Laboratory of the National Marine Fisheries Service initiated a project in 1971 to study the movements of the blue marlin using a fish tag that transmitted ultrasonic pulses. The research ship, *Charles H. Gilbert*, tracked one blue marlin during 13-16 July 1971, and four during 24-29 July 1972. Fish were tracked for periods ranging from 1 to 22½ h. Path, depth, and speed of swimming are reported.

MATERIALS AND METHODS

Transmitter and Receiving Equipment

The basic unit of the system is the ultrasonic tag. The tag, cylindrical with faired ends, measures 16.5 cm long and 1.8 cm in diameter (Fig. 1a). It produces a 50 kHz carrier signal with a pulse rate that is a function of the surrounding water temperature. Estimation of depth of fish is then possible. The tags have a temperature range of 7°-27°C, an active life of 10 days, and a reception range of about 1.2 km with the equipment aboard *Charles H. Gilbert*.

The tags are attached to the fish with a leader of fine monel wire rope (0.7 mm diameter). The 25-cm leader is embedded at one end of the tag and crimped to an anchor plate of curved, stainless steel (Fig. 1b). The plate is 7.4 by 1.8 cm with a sharpened end. A specially tooled rod at the end of 2½ m pole (Fig. 1c) is used to force the anchor plate into the back of the marlin. The drag of the tag and the curvature of the plate move the plate into position under the skin. The toughness of the skin holds the plate in place.

Ultrasonic signals are received via a hydrophone (Honeywell, model HX-74C[2]) mounted in a well in the hull of *Charles H. Gilbert* and a low-frequency receiver (Lawson) mounted on the bridge. Pulse frequency is determined by visually displaying output signals on a storage oscilloscope (Tektronix, model 564). Sensitivity of the hydrophone to 50 kHz transmission is minus 70 db volt/microbar. The cone-shaped beam of the hydrophone has a width of 25° at the minus 3 db level. The hydrophone can be rotated horizontally 125° on both sides of the bow and vertically 90° by electric scan motors controlled by the tracker on the bridge.

Capture and Tagging of Blue Marlin

Bart Miller and his sport fishing boat, *Christel*, (Kona, Hawaii) were engaged to catch and tag marlins. Fish were caught by trolling. As soon as a marlin struck, the line was pulled in by hand to bring

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[2] Reference to trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service.

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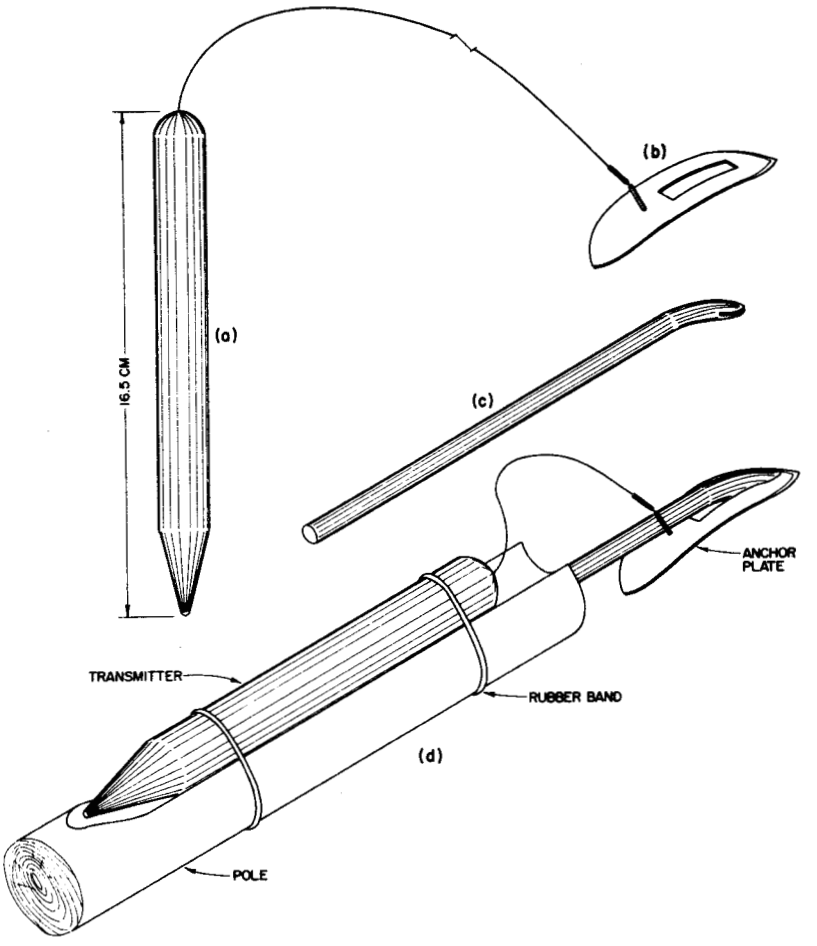

Figure 1.—Ultrasonic transmitter and tagging apparatus. **a.** Temperature sensing transmitter. **b.** Anchor plate. **c.** Rod for applying anchor plate. **d.** All items assembled.

the fish alongside as quickly as possible. When the fish was alongside the boat, its condition was checked and its size was estimated. If the fish appeared to be in good condition, the tag was inserted and the fishing line was cut to release the fish.

Many of the people of the sportfishing community took an active interest in the tracking project. As a result several fishermen offered to donate their marlins. Upon receiving radio communication that a fisherman was willing to donate a hooked marlin, *Christel* transferred the tag, harpoon, and sometimes a crew member. Tagging operations on the other boats were similar to those aboard *Christel*.

Tracking Procedures

During the catching and tagging operation *Charles H. Gilbert* was positioned 200-300 m away from the fishing boat. Upon release of the fish, the following data were recorded at 5-min intervals: time, ship's heading, relative bearing of the hydrophone, tilt angle of the hydrophone, and pulse rate of the tag. Ship's position was determined and recorded at half-hour intervals. Because of poor signal-to-noise ratios, it was not always possible to measure the pulse rate. Because of a malfunction in the tilt angle indicator during the 1972 operations, the observer was sure of the tilt angle only when the hydrophone was at 0° or 90°.

The ship was guided to maintain a distance of approximately 800 m from the estimated position of the tagged marlin. Actual distance between ship and fish continually varied from about 400 to 1,200 m for the following reasons: (1) the minimum forward

speed of the ship was 4 knots; (2) the ship was not permitted to go astern because the cavitation bubbles from the propeller would completely block the tag signals; (3) the distance between tag and ship could only be estimated from the strength of the signals from the tag.

A bathythermograph cast was made every 4 h to obtain temperature-depth profiles. These profiles and the temperature-dependent pulse rates of the tags enabled estimation of swimming depth of the marlin.

RESULTS

Five blue marlin were tagged and tracked, one on 14-15 July 1971 and four between 25 and 28 July 1972. Dates, size of fish, duration of tracking and remarks on each fish are listed in Table 1.

The first tagged marlin was tracked for 22 h 25 min before an equipment breakdown forced a stop. The second fish was in doubtful condition when released. It was difficult to track and contact with it was lost after an hour. The third marlin was tracked for 5 h 22 min before it was lost because of a tactical error. Marlin #4 was abandoned after 7 h because it remained stationary on the bottom soon after it was tagged. After 2 h of swimming the fifth marlin also went to the bottom.

Path

The paths of the marlin tracked are shown in Figures 2 and 3. The path of the last marlin is, of course, of questionable value as the fish lived only 2 h after being tagged. A feature that stands out is that all three marlin moved in a northerly direction. North of Keahole Point there is only one instance where the

Table 1.—Data on blue marlin tagged.

Marlin No.	Estimated weight	Date tagged	Duration tracked	Remarks
	kg (lb)		*h*	
1	270 (600)	7/14/71	22½	Lost—equipment failure.
2	225 (500)	7/25/72	1	Lost—no movement.
3	135 (300)	7/25/72	5½	Lost—tactical error.
4	160 (350)	7/27/72	7½	Abandoned—no movement.
5	70 (150)	7/28/72	8	Abandoned—no movement after 2 h.

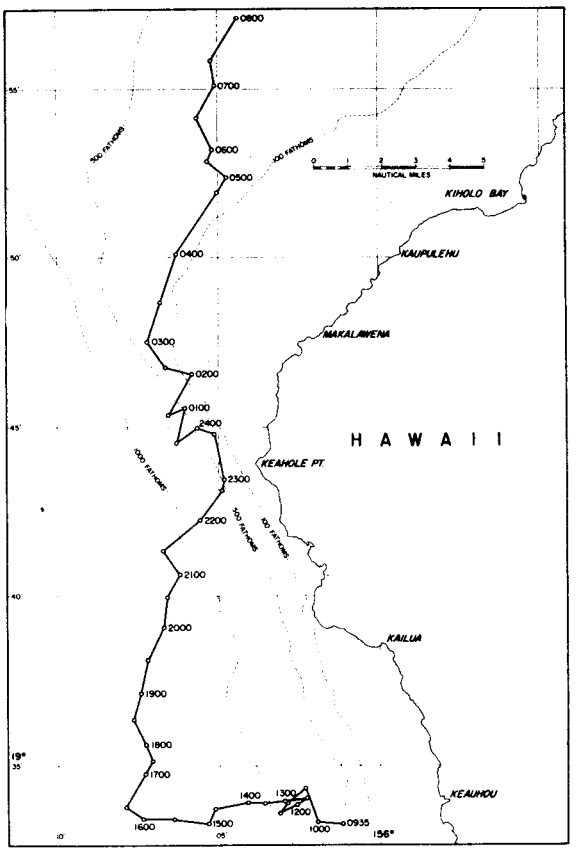

Figure 2.—Path of blue marlin tracked in 1971. Numbers along track denote hour of day.

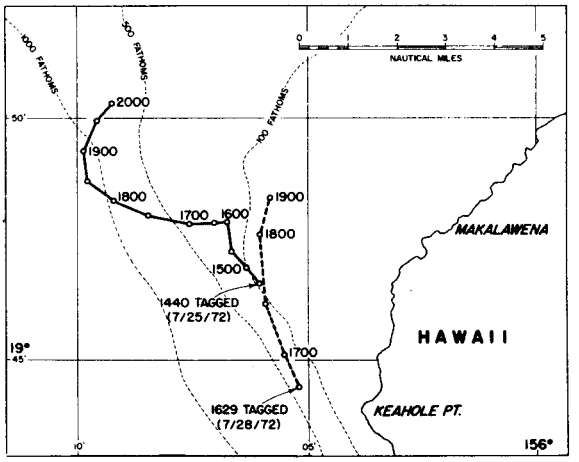

Figure 3.—Path of two blue marlin tracked in 1972. Numbers along track denote hour of day.

marlin ventured beyond a bottom depth of 2,000 m (Fig. 3). This marlin appeared to be returning to shallower water when contact with it was lost.

Swimming Depths

The choices of swimming depths were quite different among the three marlin tracked. The largest marlin (#1), estimated at 270 kg (600 lb), spent half of the time within 10 m of the surface, a sixth of the time between 10 and 30 m, and the remaining third of the time deeper than 30 m. The maximum swimming depth, which was 80 m, was reached only on one occasion. The next largest marlin tracked (about 135 kg or 300 lb) remained at depths between 115 and 185 m throughout the 5½ h that it was tracked. The last and smallest blue marlin tracked (about 70 kg or 150 lb) remained in a depth zone of 60-85 m before it went to the bottom after 2 h.

The vertical movements of the largest marlin did not show any pattern that could be related to time of day. The other marlin were not tracked long enough to determine if any pattern existed.

Swimming Speeds

Swimming speeds of the three marlin were calculated based on the distance traveled every half hour. Results are in Table 2. The average swimming speed of the last marlin is high compared with the others especially in terms of body lengths per second. Marlin #1 and #3 had an average swimming speed of 0.23 body length/sec. Marlin #5, in contrast, averaged 0.45 body length/sec. The higher speed of the last marlin may be a reflection of the distress of a dying marlin.

The maximum for the largest (#1) and the smallest fish (#5) were 0.62 and 0.68 body length/sec compared with 0.32 body length/sec for marlin #3. The two larger marlin (#1 and #3) both had minimum speeds of 0.09 body length/sec while the minimum speed of the smallest was 0.19 body length/sec.

DISCUSSION

A counterclockwise eddy west of the northern half of the island of Hawaii persists there most of the time (R. A. Barkley, pers. comm.). The area of our marlin tracking coincides with that part of the eddy which flows northward. The fact that all three marlin tracked exhibited a northerly movement suggests the possibility that the blue marlin orients or drifts with currents.

One of the problems in tracking marlin is getting one that will survive the trauma of being caught. Of the five marlin tagged two died and one probably died. Three others were caught and not tagged because of their poor condition. To enhance the probabilities of success in marlin tracking, consideration should be given to ways of attaching the tag without catching the fish.

ACKNOWLEDGMENT

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Table 2.—Swimming speeds of blue marlin.

Marlin No.	Minimum			Maximum			Average		
	km/h	knots	body-length/sec	km/h	knots	body-length/sec	km/h	knots	body-length/sec
1	1.1	0.6	0.09	8.2	4.4	0.62	3.0	1.6	0.23
3	0.9	0.5	0.09	3.1	1.7	0.32	2.2	1.2	0.23
5	1.5	0.8	0.19	5.4	2.9	0.68	3.4	1.9	0.45