An Attempt to Determine the Time of Death of the Catches during Long-line Fishing

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Abstract

Body temperatures of tuna caught by long line were measured at different locations. The pattern of heat distribution was observed on "live" and "dead" fishes. An attempt was made to determine the rate of cooling and its relation to time, ambient temperature, and body measurements. A further attempt was made to determine the depth of capture from the temperature.

INTRODUCTION

In studies on the biology of tuna, one question is the time of the day at which the peak of feeding activity occurs. The knowledge of the time of capture and/or death on long-line hooks would solve the problem.

Various methods were considered. The hard struggle of fishes on a hook modifies the chemical characteristics of the flesh and muscle to such an extent that the normal tests (blood CO_2 or pH, ATP content of the muscle, glucose, etc.) are of no practical value. The methods employed to ascertain the freshness of fish flesh are sufficiently sensitive for long-time periods only. A device triggered by the fish itself, which would give the elapsed time, was built, but was not practical in the normal, rough handling conditions during long-line operations.

The body temperature of tuna is known to be higher than that of the surrounding water; and since the cooling of a body is used in forensic observation, this could be an answer to the problem (Barrett and Hester 1964; Konagaya *et al.* 1969; Uda 1941).

MATERIAL AND METHODS

The fishes were caught by long line during various cruises in the New Hebrides - Loyalty Islands area. Only yellowfin *(Thunnus albacares)* (YF), albacore *(Thunnus alalunga)* (Al), and big-eye *(Thunnus obesus)* (BE) were considered in this study. Most of them weighed about 20 kg.

Immediately after hauling on board, the still-living fish were killed by a blow on the head; the others were recorded as "dead" or "dead, stiff" (i.e., presenting rigor mortis). The temperatures were measured as soon as possible, with a Y.S.I. Telethermometer n° 42.SC, fitted with a stainless steel probe YSI n° 418, 25-cm long. The location of the measurements is given in fig. 1.

The variation of temperatures with elapsed time was followed on three individuals: "14" and "15" were yellowfins, "8" an albacore; all of them, weighing about 20 kg, had been hauled still living, and died shortly afterwards on the deck. They were immersed in a trough containing sea water, the temperature of which, while not regulated, was lowered, at the start of the experiment, by the addition of ice. The temperature along several radii was measured by sinking the probe to the vertebrae and withdrawing it one centimetre at a time.

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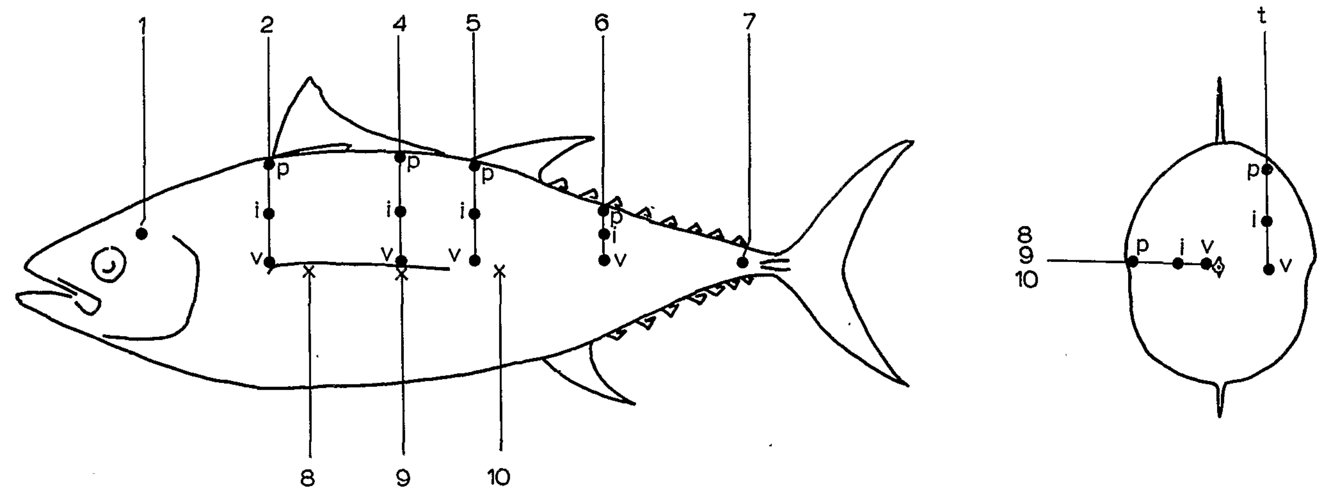

FIG. 1. Location of the points of temperature measurements.

RESULTS AND DISCUSSION

Pattern of Temperature Throughout the Body

One of the main difficulties was to assess the state of the fish. The arbitrary division between "live", "dead", and "stiff" is rather crude and relies upon external characters only; as we have seen, at least once, the heart of a "stiff" tuna still beating (whether the prodding of the knife initiated some systoles, or otherwise), we must consider that the classes we used are probably confused by individual variations.

In the "live" fishes, the pattern, taken as the difference between the temperature at a given point and the lowest temperature of a particular fish, establishes itself as shown in table 1. The points of measurement were too widely spread to enable us to find the pattern observed by Carey and Teal (1969). As far as an average through such a population is significant, and keeping in mind that the accuracy of the measurements is in the range 0.2–0.4°C, we can see that:

1. Head and tail have approximately the same, and lowest, temperature;
2. In yellowfins, the skin is also cool;
3. Albacores have a warmer body (the maximum, 32°C, was observed in an 18 kg albacore).

In the "dead" and "stiff" fishes, the pattern changes towards a greater homogeneity, with individual transitions between the two main patterns (see table 2). Further, there is a general rise of the relative temperature of the skin, probably due to the hauling through warmer surface water.

TABLE 1. Temperature Pattern of "Live" Fishes, taken as Mean Difference ("Relative" Temperature) between Temperature at a given Point and Lowest Temperature Observed in the same Fish

——	1	7	2			4			5			t.4,5			9			10		
			v	i	p	v	i	p	v	i	p	v	i	p	v	i	p	v	i	p
YF	0.0	0.5	2.7	2.1	0.5	2.8	2.6	0.5	3.1	2.2	0.4	3.0	1.9	0.3	2.9	2.8	0.8	..	..	..
Al	0.5	0.2	..	..	..	4.2	3.1	1.5	6.0	5.6	1.3	..	..	..	3.7	3.3	2.2	..	..	..
BE	0.8	0.0	1.7	0.6	0.8	..	..	..	1.4	0.4	0.5	..	..	..	3.0	4.0	2.7	1.6	1.8	1.4

TABLE 2. Temperature Pattern of "Dead" and "Stiff" Fishes, taken as Mean "Relative" Temperature

——	1	7	2			4			5			t.4,5			9			10		
			v	i	p	v	i	p	v	i	p	v	i	p	v	i	p	v	i	p
YF	0.4	0.7	0.6	1.0	0	1.6	1.4	1.2	3.0	0	1.0	0.7	0.8	0.2	1.5	1.2	2.1	..	..	..
A1	0.2	0.6	1.0	1.2	2.5	0.8	0.5	1.4	3.0	1.0	1.8	1.4	1.2	2.1	0.9	0.5	1.3	1.6	1.2	2.6
BE	0.0	1.1	..	..	..	1.6	0.1	1.4	..	..	..	3.1	1.1	1.6	..	..	..	..	..	..

Temperature Variation with Time

We tried to determine a relation between the temperature of the flesh at given point and time (Θ_i), the ambient (Θ_e), the time elapsed (t) and the thickness of flesh (x) between the considered point and the skin. The theoretical handling of the problem has eluded us, especially since there is a pre-existant gradient. The shape of the graphs (figs. 2 and 3) hinted at an exponential form; however, a plot of $\frac{\Delta\Theta}{\Delta t}$ versus $(\Theta_e-\Theta_i)/x.t$ yielded too widely scattered points, and the precise law cannot be expressed.

It is, however, possible to see that:

1. The rate of cooling is also a function of the depth and temperature of the flesh beneath the considered point, and is greater for a smaller overall diameter;
2. The rate of cooling is small. Under 9 cm ($3\frac{1}{2}$ in.) of flesh, it varies from $-0{,}4$°c/hr to $-1{,}1$°c/hr, with $(\Theta_e-\Theta_i)$ in the range of 3–5°c. If we consider the maximum average difference observed (6°c), a fish would need at least 6 hours to cool down to ambient; a more probable maximum value would be 10 hours.
3. Under 4 cm of flesh, the rate of cooling is approximately $-1{,}0$ to $-1{,}5$°c/hr with $\Theta_e-\Theta_i = 2{,}0$ $-3{,}0$°c. Since the line is hauled at a speed of 100 m/min. the tail stem and occipital muscles should maintain their temperature during the ascent.

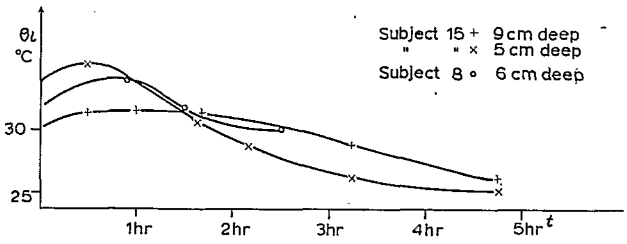

FIG. 2. Absolute temperature evolution.

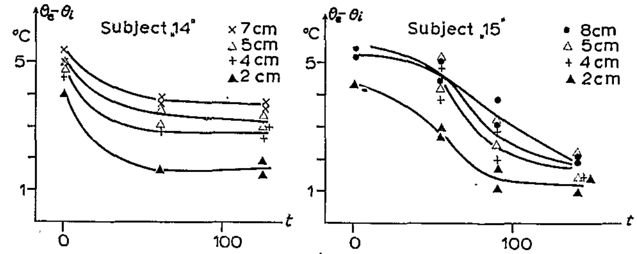

FIG. 3. Relative temperature evolution, at different depths beneath the skin.

Depth of Capture

The form taken by a line in the water can be worked out theoretically (Bourret, pers. comm.). The depths of the hooks are shown to vary to a great extent with the distance between two consecutive buoys. This distance can be difficult to ascertain at sea, and the drift can further modify the form of the line.

As seen above, we could consider that the head or tail temperature, or the overall minimum temperature of a given fish, mirrors the in situ temperature if the fish has been dead for 1 hour. By comparison with a B.T. diagram, we should have the depth of capture of the animal ("zθ" on fig. 4).

However, the results of both methods present a heavy discrepancy, even after considering the various possible sources of error (inaccuracy of the temperature measurement by both thermocouple and BT., etc.), and we have no means yet to decide which of the two methods is the more reliable.

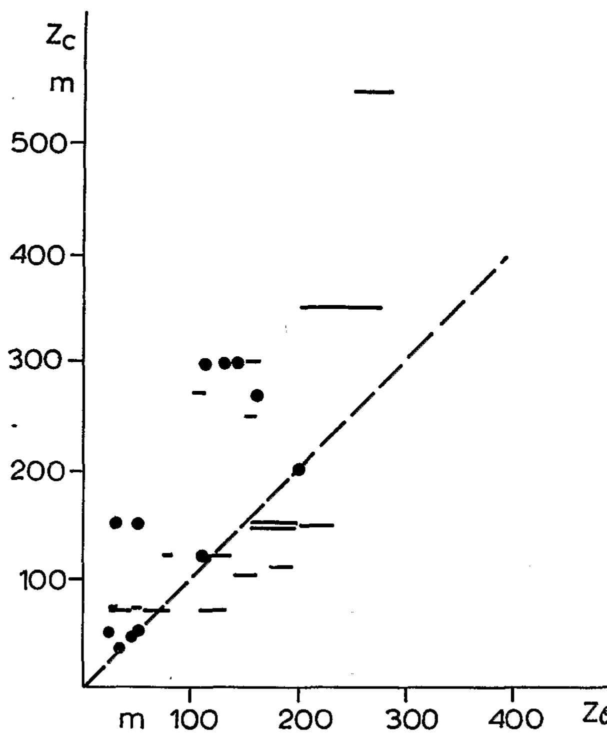

FIG. 4. Comparison of depths of hooks. $Z\theta$: derived from the temperature of the catches. Zc: theoretical, from the supposed form of the line.

CONCLUSIONS

More data, and more precise ones, would be necessary for the accurate knowledge of the rate of cooling. But the individual and specific variations must be better known, and could prove to be an unsuperable obstacle to a fair approximation of the time of death.

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