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# SIMULATION MODEL FOR PHYSIOLOGY AND DISTRIBUTION OF TUNALIKE FISHES IN TEMPERATURE GRADIENTS

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## ABSTRACT

The long-range goal of the Honolulu Laboratory's program on Life Studies of Tuna and Tunalike Fishes is to generate a predictive model of tuna distribution, abundance, and availability to fisheries. The basis of the model is to be the joint-physiological and behavioral responses of tunas to environmental variables, as determined in part through experimental work with captive fishes. To explore the potential value of such a modeling approach and to provide an objective framework for further experimental work, we have developed a simulation model for the responses of fishes to temperature, a variable of recognized importance in the ecology not only of tunas but also of fishes in general.

The procedure used in constructing the model was 1) to create a hypothetical tunalike fish (based on skipjack tuna) endowed with a simple set of capabilities and responses, all well recognized or reasonably deducible from extant experimental results; 2) "follow" the fish in computer-generated one-dimensional environments with temperature the only variable; and 3) look for consistencies between distributional features of the hypothetical fish and those reported

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for real tunas in real heterothermal environments. Physiological acclimation, accumulation and decay of thermal "doses" leading to lethal-temperature mortality, temperature preference, gradient perception, and basal swimming speed were treated deterministically; perception-contingent increases in swimming speed and the tendency to change swimming direction were modeled stochastically as a biased random walk with constant step-time (10-min., in most simulations).

First runs of the model (without any aposteriori manipulation of process functions or input parameters) suggested a number of similarities between the behavior of the model and that of real tunas as observed at sea:

Hypothetical 50 cm long fish weighing 2 kg

1) tended to "seek out" and remain within a few degrees of their preferred temperatures in a linear gradient as steep as 1°C/km but to randomly disperse in gradients of 0.1 or 0.01°C/km until encountering temperatures near the upper or lower lethal limits;
2) tended to "aggregate" at randomly encountered thermal fronts, regardless of temperature;
3) tended to become "trapped" and concentrated in areas of unfavorable temperature under certain conditions of temporal change in the distribution of temperature; similarly, tended to be absent from areas of favorable temperature under certain conditions of temporal change in the distribution of water temperature;

4) tended to be distributed within narrower thermal limits than conspecific fish of smaller size.

Next steps in development of the model will involve attempts to experimentally test the validity of proposed process functions and to more accurately parameterize verified functions for tunas. Simultaneously, the model will be optimized and extended for simulation in three-dimensional space characterized by variation in both temperature and oxygen concentration.