Pauly, D. 1989. A simple index of metabolic level in fishes. *Fishbyte, Newsletter of the Network of Tropical Fisheries Scientists* 7(1): 22.

A Simple Index of Metabolic Level in Fishes[a]

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Gray (1954) noted that "it is desirable, but difficult, to obtain comparative metabolism data on marine fishes. From necessity, most data are obtained from sluggish and moderately active species. Active species are hard to keep in captivity, or even to get to the laboratories, without becoming partially asphyxiated." This problem has not changed in the 35 years since Gray's complaint, and I have noted in the literature, besides Gray's, several comparative studies on physiological process in fishes which would have benefited from the availability of an easy-to-estimate index of metabolic level in fishes.

Two questions can be asked with regard to such index: (i) which external attributes common to a large number of fishes is *most* different between species with different habits? (ii) can the attribute identified in (i) be easily turned into a number, such that different species can be compared in quantitative terms?

Several years ago, I figured that the aspect ratio of the caudal fin of fishes might well be a promising attribute with regard to these two questions. This aspect ratio (A) is defined, for any fish species with a caudal fin, as:

$$A = h^2/s \qquad \ldots 1)$$

where h^2 is the height of the caudal fin, and s its surface area (Lindsay 1978, and see Fig. 1). [Obviously, this index will work only in fishes in which the caudal fin is the *only*, or at least the main, organ of propulsion, see Lindsay 1978.]

A preliminary study was recently concluded at ICLARM in which the usefulness of the aspect ratio of fishes' caudal fin as an index of metabolic level was tested. The results exceeded expectations: the variable A explained over 50% of the variance in a set of 33 population-weighted food consumption estimates! (See Box.)

Follow-up studies show that A, besides correlating with food consumption, also has close relationships - other things being equal - with (i) natural mortality, (ii) longevity, (iii) red muscle content, (iv) gill area, (v) growth performance, etc. I.E. Gray would have been happy about that.

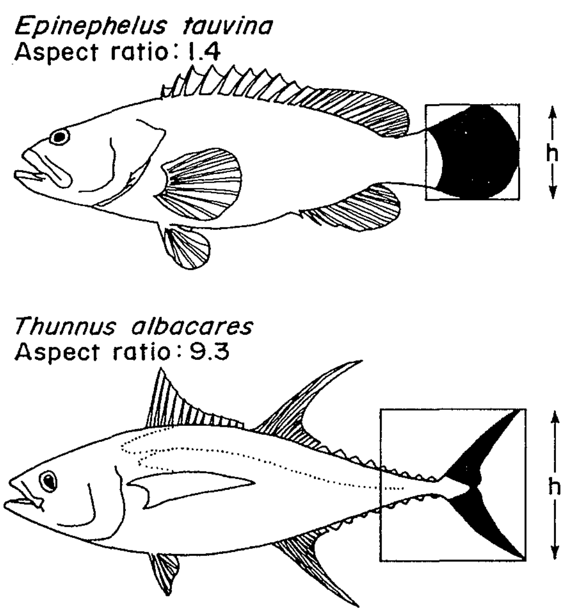

Fig. 1. Definition of the aspect ratio of the caudal fin of fishes. Note large differences between pelagic and demersal species.

Model for estimating the annual food consumption (Q) per unit biomass (B) of a population of carnivorous fishes:

$$Q/B \approx \frac{T^{0.61} \times A^{0.52}}{1.2 \times W^{0.2}}$$

where T is the mean water temperature (°C), W is the asymptotic (or maximum) live weight of the fish (g) in the population in question and A is the aspect ratio of their caudal fin (Palomares and Pauly in press). The log linear version of this model has a value of R = 0.865 and residuals (mean = 0.22 $\log_{10}$ units) evenly distributed about the predicted values.

[a]Excerpts from the text of a lecture entitled "Population physiology of fishes: a new look at old data," given on the 21st March 1989 at the Alfred-Wegener Institute for Polar and Marine Research, Bremerhaven, Fed. Republic of Germany at a seminar to celebrate the 60th Anniversary of its Director, Prof. Dr. Gotthilf Hempel, to whom this note is dedicated.

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