

The SWIMMING and SPEED Tables in FishBase

Immersion in water is the closest approximation to weightlessness. Moreover, teleosts, through their invention of the gas bladder, have learned to escape the drag of gravity with the least energy expenditure. The downside of being under water is the fact that any movement has to push aside water, a particularly dense and heavy medium. The physics and physiology of fish swimming are summarized in Blake (1983) and Webb (1984) and a comprehensive review in this field is that of Videler (1993).

This section describes the manner in which fish swim, something they do in a surprising number of ways; also, available records on the swimming speed of fish are presented.

The classification of the swimming modes of fish adopted here stems from Lindsey (1978), who reviewed much of the earlier literature on this topic. This classification consists of two levels, the first (Roman numerals) describing what may be called the swimming 'type', the second (bullets) describing the swimming 'mode' proper, viz.

Movements of body and/or caudal fin:

- Anguilliform;
- Subcarangiform;
- Carangiform;
- Thunniform; and
- Ostraciiform.

Undulation of median or pectoral fins:

- Amiiform;
- Gymnotiform;
- Balistiform;
- Rajiform; and
- Diodontiform.

Oscillations of median or pectoral fins:

- Tetraodontiform;
- Labriform.

The modes in (I) imply a gradual transition from undulation of the entire body (including the trunk) being used for propulsion (anguilliform mode) to propulsive forces being generated only by the oscillating caudal fin (thunniform and ostraciiform modes).

The ranking of the modes in I and II to III further implies a gradual transition from undulations to oscillations as the movements generating the major propulsive force, and thence the above

scheme can also be represented as a graph, with a trunk-to-caudal-fin axis as ordinate and an undulation-to-oscillation axis as abscissa (see Fig. 1 in Lindsey 1978).

This implies that the assignment of a swimming mode to a given fish species will always contain a subjective element, even if we ignore the fact that fish may have two swimming modes (we consider here only the dominant mode, e.g., labriform in parrotfish, Family Scaridae, even if parrotfish revert to the subcarangiform mode when escaping from presumed danger (authors' pers. field obs.)).

Thus, the entries of this table (i.e., the choices of the types and modes listed above) may be revised from time to time as a result of our familiarization with this topic and its literature. This will not, however, affect the first set of entries, based on Lindsey's examples [Species explicitly assigned to a certain swimming mode by Lindsey (1978) in both the **MainRef.** and **Ref.** fields] and their obvious extensions (e.g., from *Anguilla anguilla* to all Anguillidae, and thence to all Anguilliformes).

Note also that this table presently pertains only to juvenile and adult fishes. Fish larvae—for obvious reasons—have a limited repertoire of swimming types and modes.

The aspect ratio of the caudal fin of a species closely correlates with its average level of activity (Pauly 1989). The **Aspect ratio** (A) of the caudal fin is calculated from:

$$A = h^2 / s$$

where **h** is the height of the caudal fin and **s** its surface area (Fig. 1). The proximal border of the caudal fin surface is defined as a straight vertical line through the narrowest portion of the caudal peduncle, i.e., the portion of the peduncle surrounded by the fin is considered part of the caudal fin area (see Fig. 1).

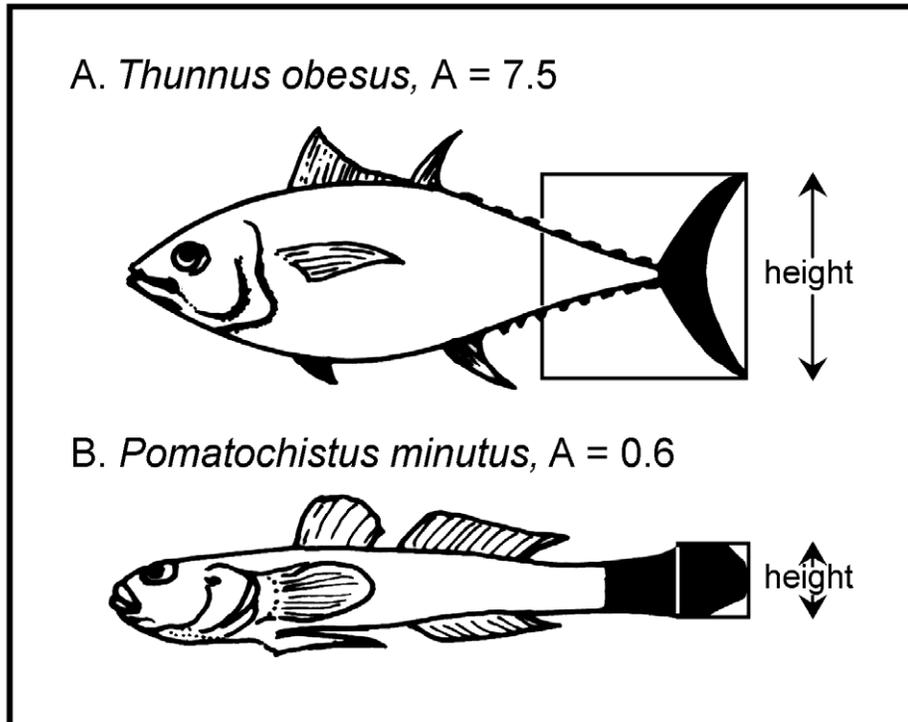


Figure 1. Aspect ratio ($A = h^2/s$, h = height of the caudal fin; s = surface area of fin) of a pelagic fish ($A = 7.5$) and a bottom dweller ($B = 0.6$). Note the correspondence between aspect ratios and modes of life.

Note that this definition of A differs slightly from that presented in Pauly (1989), where only the caudal fin proper was used for calculating s .

A reference may be given to document an aspect ratio; when none is given, the aspect ratio was calculated, by planimetry, from a fish picture in FishBase or another readily available source.

Status

The SWIMMING table contains swimming type and mode for over 2,700 species.

The SPEED table contains about 300 records with maximum swimming speeds for about 90 species. The information was extracted from over 50 references such as Bainbridge (1958, 1960), and Webb (1971) and compilations such as Sambilay (1990). An effort was made to distinguish between ‘sustained’ (i.e., maintained for more than 3 minutes), and ‘burst’ swimming (maintained for a few seconds only) (see Fig. 2), as well as other swimming modes (Hammer 1995).

Fields

The SPEED table consists of the following fields:

Length: This field pertains to the length of fish in cm as stated in the publication. The type of length measurement used consists of the following choices: SL (Standard Length); FL (Fork

Length); TL (Total Length); BL (for the term ‘body length’, stated in the publication but without the type of length measurement being indicated).

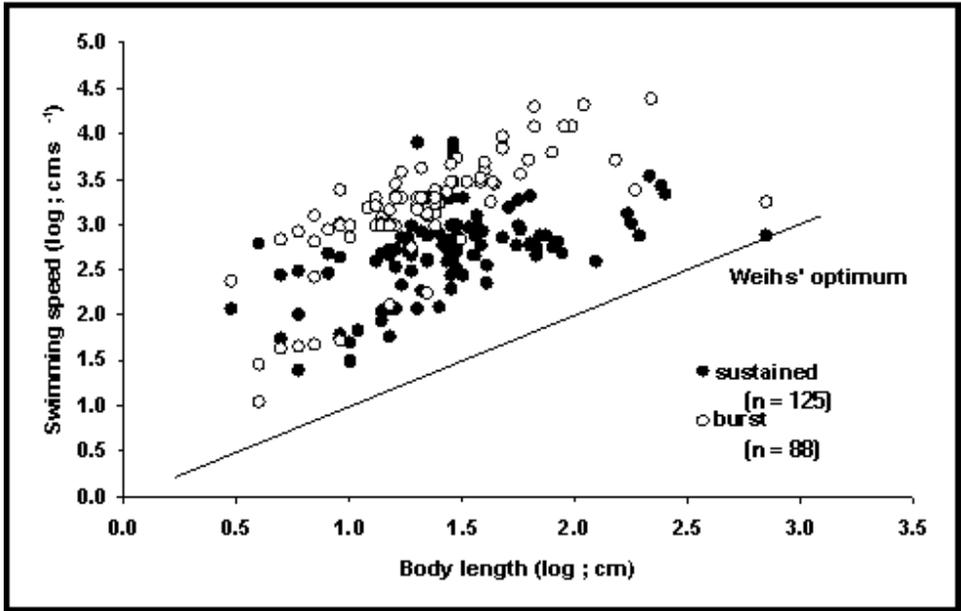


Fig. 2. Relationship between swimming speed and body length of fishes. Note that burst speed is about 10 times higher than sustained speed. Note also that no fish appears to swim at speeds below Weih's (1973) line of minimum energy expenditure per distance covered, whose slope (1 : 1, implying strict proportionality of speed and length), however, is the same as that of the observations in this figure.

The **Swimming speed** gives the speed of the fish per second as reported in the source. A choice field is provided for the type of length measurement used. The choices are the same as above (SL, FL, TL, BL) and m/s (for meter per second). A calculated **Speed** field in meter per second is also provided (see **Derived values**).

Mode: This field describes the mode of swimming as: sustained (swimming at this speed for a prolonged time); burst (a maximum swimming speed which can be maintained for less than a minute only); other.

Comment: States the length or weight measurement, or mode of swimming if not in the choice list. Any transformation of length type should also be stated here.

Derived values: Gives the transformation values from different units of speed to standard length per second (SL/s) and to meter per second (m/s). This makes it possible to compare the swimming performance of fishes with forked, rounded or other shapes of caudal fin. Where available, the **a** and **b** values used to transform fork length or total length to standard length are given as used in:

$$SL = a + b \times L$$

where **L** is the reported fork or total length. If the transformation is based on one measurement only, hopefully a typical adult, the intercept **a** is set to 0 (see also the LENGTH-LENGTH table, this vol.).

Internet

On the Internet, select a species at www.fishbase.org. You get to the SWIMMING table by clicking on the **Swim.type** link in the 'More information' section of the 'Species Summary' page. You get to the SPEED table by clicking on the **Speed** link in the 'More information' section of the 'Species Summary' page. You can create a list of all species with available data by selecting the **Swim. Speed** radio button in the 'Information by Topic' section of the 'Search FishBase' page

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