APPENDIX 2. AN ANALOGY AND GENERAL RULE?

There is a generally accepted power law for animal (mainly mammal) metabolic rates (Klieber 1947, Peters 1983). The law states that for any given sized animal, the relationship between metabolism and body size is a ¾ scaling:

$$M = aW^{b} \qquad \text{EQ B2.1}$$

where *a* varies by body shape, temperature, etc., but *b* is usually ~0.75.

There is also a general relationship for fish between fish weight and length (cf. Fulton 1902, 1904, von Bertlanffy 1957, Froese and Pauly 1994, Froese 2006, Froese 2011; e.g. Wigley et al. 2003). This relationship generally has weight as a function of length to the 3rd power:

$$W = aL^{b} \qquad \text{EQ B2.2}$$

where *a* varies widely based upon body shape, sex, maturity state, etc., but *b* is usually ~ 3.

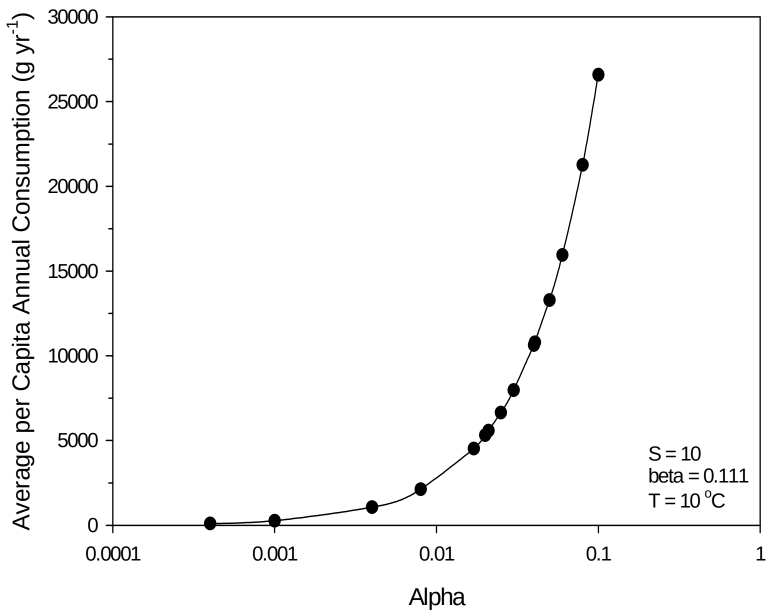
We assert that for fish consumption, there may indeed exists a similar, general power law for gastric evacuation (as corrected for temperature). Recall that evacuation *E* is:

$$E_i = \alpha e^{\beta T} \qquad \text{EQ B2.3}$$

where α varies widely based upon body type, physiology, prey type, prey size, etc., but β is usually ~ 0.1. We note that simple sensitivity analyses inform this choice. Examining sensitivities to the various parameters and variables used in the gastric evacuation shows that for the scalar constant α, results appear to be realistic if constrained between 0.015 and 0.045, which corresponds to the previously reported range from the literature (Durbin et al. 1983, Tsou and Collie, 2001a, 2001b, Overholtz et al. 2000; Figures B2.1, B2.2). For the power parameter β, results appear to be robust around 0.11 (Figures B2.1, B2.2). The literature reports values of β with additional significant figures, which may not be necessary. It is probably reasonable to fix β at approximately 0.1. For both parameters, when within the normal range, the change in per capita consumption is minor, much less than one half an order of magnitude. These results demonstrate that within the range of fish field studies and modeling efforts, evacuation effectively functions as a tenth power.

Thus, similar to the ¾ power scaling law for mammal metabolism and 3rd power for fish weight-length relationships, there may exist a one-tenth power for fish evacuation based on average stomach contents. Theoretically, this tenth power law can be understood to be reflective of the maximal assimilation efficiency of material consumed, indicative of transfer efficiency across trophic levels, all realized as the rate and amount of food being digested, as modulated by temperature, not to exceed a power of approximately 1/10th due to inherent physiology of fishes. Certainly further exploration and verification of this hypothesis is warranted. But if validated, the tenth power of evacuation may ultimately end up serving as one of those useful approximations to facilitate much further extension of efforts while minimizing excessive need for copious laboratory studies.

A



B

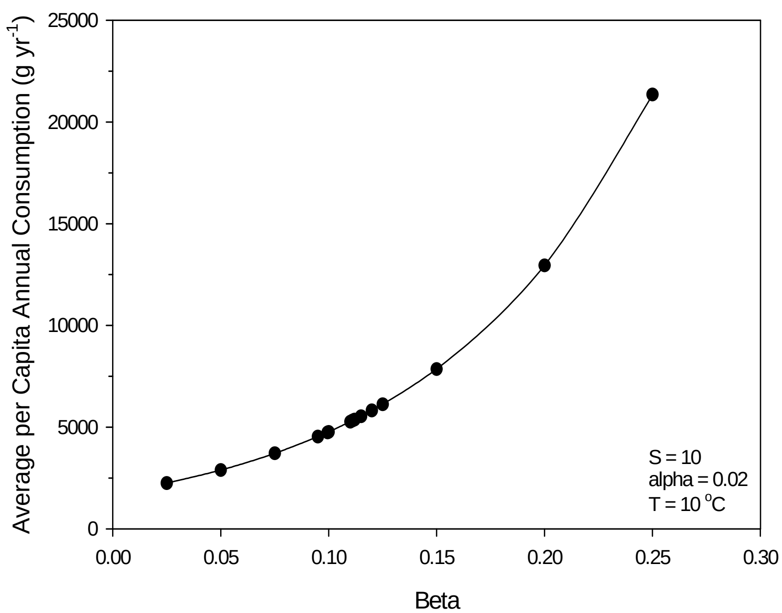


Figure B2.1. Sensitivity analysis of parameters in the gastric evacuation model. A. Evaluation of alpha. B. Evaluation of beta. Adapted from NEFSC 2007b.

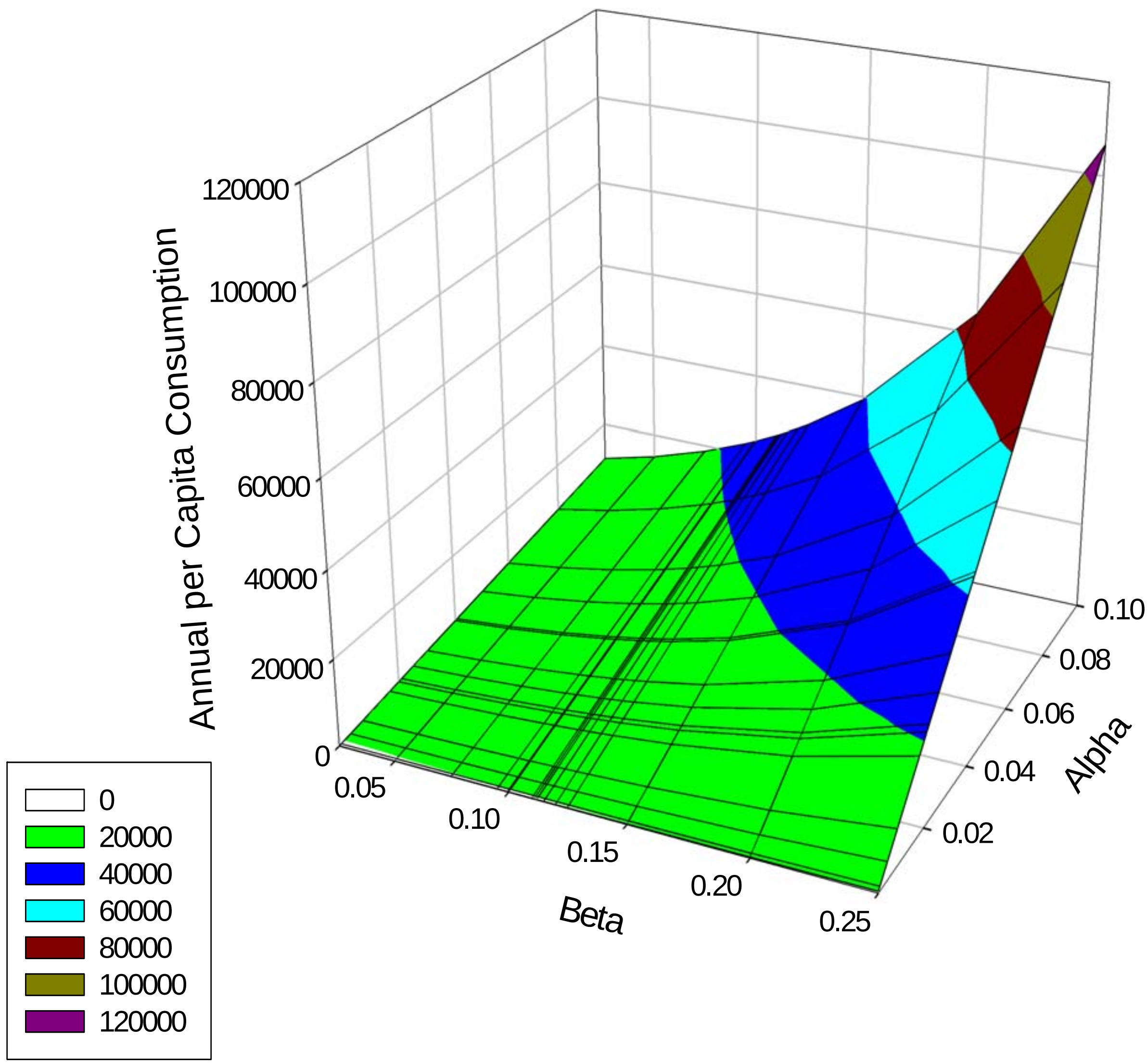


Figure B2.2. Paired sensitivity analysis of parameters and data inputs in the gastric evacuation model. Adapted from NEFSC 2007b.