3.5 Models to Evaluate Changes in Relative Efficiency

The nature of the mismarked cables (i.e., discrepancies increasing with wire length) and the basic geometry of asymmetry suggest that the catchability bias should increase monotonically with depth. A variety of simple models were examined to explain potential effects of reduced catchability. A basic derivation of the alternative models is presented below.

Regression analysis of warp difference vs. fishing depth (Fig. 3.1.1) suggests a highly significant regression (R^2=0.98) in which the warp difference ***dW*** is proportional to depth ***D***.

$$dW = 0.0134\,D \qquad (1)$$

Since the NEFSC trawl surveys began in 1963, 99.9% of the tows have been conducted at depths of less than 390 m. This suggests that the maximum value of dW should be about 5.55 m. If the reduction in relative efficiency dE is proportional to the ratio of the ***dW*** to dW_{max} then one can write

$$dE = \left(\frac{dW}{dW_{\max}}\right) H_{effect} \qquad (2)$$

where H_{effect} is an assumed level of reduction in efficiency at the maximum depth. For example, if 99% of the fish would have been captured at shallower depths were not captured at depth D_{max} then H_{effect} = 0.99. The revised estimate of catch can then be written as

$$C_{rev} = \frac{C_{obs}}{1 - dE} = \frac{C_{obs}}{1 - \left(\frac{0.0134\,D}{W_{\max}}\right) H_{effect}} \qquad (3)$$

Equation 3 can be used to explore the consequences of varying levels of reductions in catch efficiency. For example, the ability to the model to explain a 2X increase in abundance (e.g., if the survey estimates in 2002 were actually 100% higher than estimated) can be tested by summing overall depths and catches in a survey.

$$\sum_j C_{j\,rev} = 2\sum_j C_{j,obs} = \sum_j \left(\frac{C_{j,obs}}{1-\left(\frac{0.0134 D_j}{W_{\max}}\right) H_{effect}} \right) \quad (4)$$

Initial tests with this model however, suggested that it was inadequate to explain increases in catch as high as 50%. This occurs because H_{effect} must be less than 1.0. This simple model deduction suggested that the warp offset effect, if it exists, must be nonlinear. Another simple model that allows for more complicated behavior is to define ***dE(D)*** as

$$dE = \left(\frac{dW}{dW_{\max}}\right)^{\theta} = \left(\frac{0.0134 D}{dW_{\max}}\right)^{\theta} \qquad (5)$$

where θ can vary from 0 to infinity. When θ exceeds 1 dE will become smaller. As dE approaches zero, dE will approach 1. Substituting Eq. 5 into Eq. 3 leads to Model 2, which is defined as:

$$C_{rev} = \frac{C_{obs}}{1-dE} = \frac{C_{obs}}{1-\left(\frac{0.0134\, D}{W_{\max}}\right)^{\theta}} \qquad (6)$$

Model 2 (Eq. 6) allows for changes in relative efficiency that are linear when θ is 1, convex when θ <1 concave when θ >1. Note that the expression dW/dW_{max} will always be less than one. Model 2 assumes that the reduction in efficiency will approach 1 as depth approaches Dmax when θ is less than one. Under these conditions, the rescaled catch will be much higher than the observed, and the hypothesized effect of a small warp offset is large even at the most shallow depths. In contrast, the reduction in efficiency will stay near zero at nearly all depths when θ >>1, and relatively little difference in catch rates should be evident. The basic premise of the model is that the effect of the warp offset on gear performance should be a monotonically increasing function of warp offset (Fig. 3.5.1). Since the magnitude of warp offset increases with fishing depth, reductions in catch should be more evident at deeper stations.

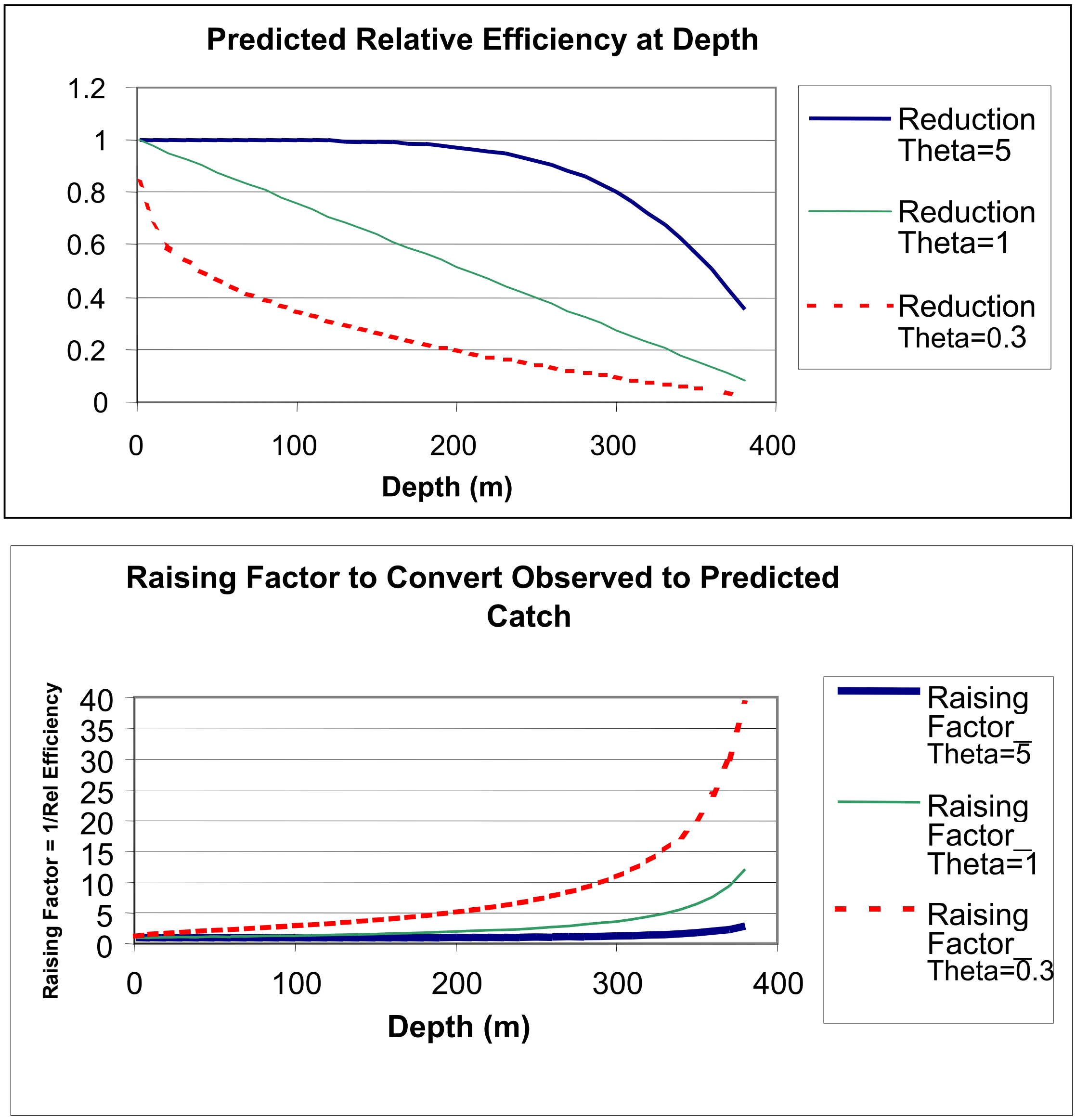

Fig. 3.5.1. Example behavior of Model 2 (Eq. 6) for varying levels of θ. Top panel shows predicted decline in relative efficiency. Bottom panel illustrates raising factor that would be applied to convert observed catch to predicted catch without the warp offset effect.