Catch-Effort Relationship in Pacific Bigeye Tuna Fishery

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Abstract

Some problems associated with fitting surplus production models to unsuitable data are discussed. This is illustrated by an application of the Schaefer, Fox and PRODFIT models to Pacific Ocean bigeye tuna (*Thunnus obesus*) catch and effort data for 1952-1987, which appear to be better described by purely empirical models.

Introduction

Before the advent of length-based stock assessment procedures, stock assessment in so called "tropical waters" tended to be based only on analyses of catch and effort data, wherein a variety of surplus production models were fitted to arrive at much used and abused MSYs. This contribution illustrates a case where such models fail to explain the relationship between catch and effort. Two alternative, purely empirical models are presented, which better describe, but also fail to explain the relationship between catch and effort for the data at hand.

The data used herein pertain to Pacific-wide catches of and fishing effort for bigeye tuna (*Thunnus obesus*, Scombridae), from 1952 to 1987 (Tables 1 and 3 of Miyabe 1989). Miyabe (1989) used the PRODFIT computer program (Fox 1975) to fit generalized stock production models to these data.

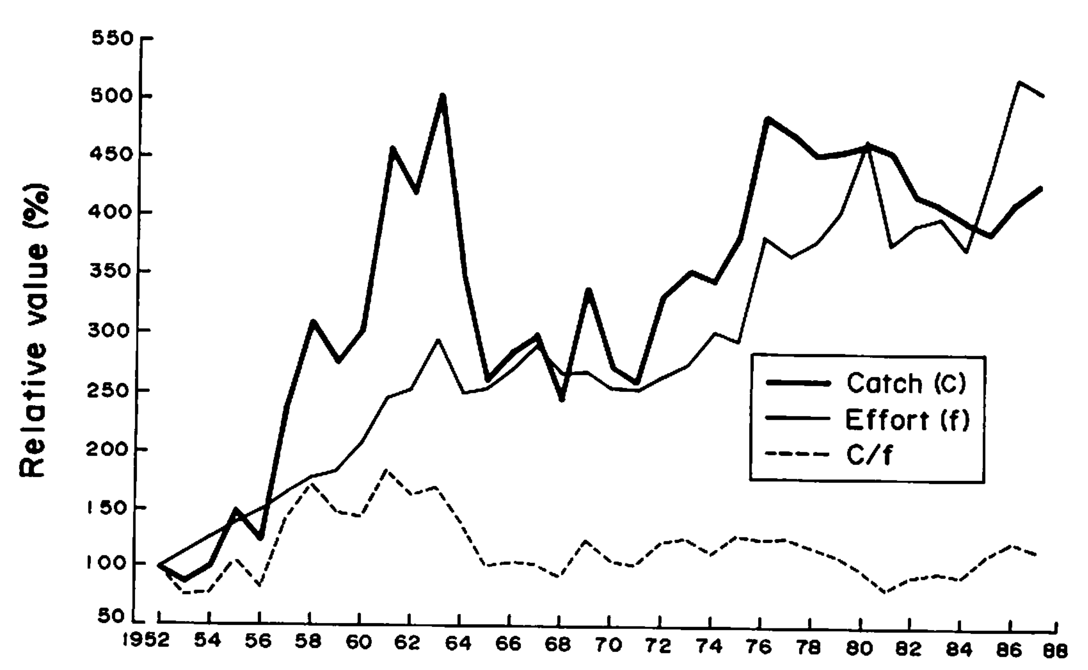

Fig. 1. *Time series of catch, effort and C/f in the Pacific fishery for bigeye tuna* Thunnus obesus *adapted from Tables 1 and 3 in Miyabe (1989).*

The trends of catch, effort and catch in relative terms, taking 1952 as base year is depicted in Fig. 1. The catches increased tremendously up to the early sixties. After a slump in the late sixties, catches have again picked up and in general showed an increasing trend. A more or less similar trend was also observed with regard to effort.

From Fig. 1 it can be observed, on the other hand, that C/f began a declining trend when effort reached a level of 250 million hooks. However, and in spite of such declining trend in C/f, increasing effort has helped realize higher catches. Miyabe (1989) has not offered any reason to this somehow puzzling situation.

Alternative Models

These "seductive" data prompted me to test the models

Table 1. Key features of various surplus production models and empirical equation fitted to the Pacific catch and effort data of bigeye tuna, for 1982-1987, bigeye tuna (from Table 1 and 3 in Miyabe 1989).

Model	Constants	C_{opt}	f_{opt}	Goodness of fit
PRODFIT	m = 0.000	309	-	0.287
	m[a] = 1.001	169	1036	0.295
	m[a] = 2.000	138	627	0.309
Schaefer	a_1 = 319	-[b]	-[b]	$r^2 = 0.009$
$(C/f) = a_1 - b_1 f$	b_1 = 0.0535			
Fox				
$\ln (C/f) = a_2 - b_2 f$	a_2 = -1.200	-[b]	-[b]	$r^2 = 0.002$
	b_2 = 0.00008			
Equation 1	a_3 = 0.00140	133	528	$R^2 = 0.761$
	b_3 = 2.176			
	b_4 = 0.00412			
Equation 2	C_∞ = 242	(242)	∞	$R^2 = 0.726$
	K = 0.00167			

[a] Editor's note: the parameter "m" of PRODFIT expresses the "skewness of the surplus production curves; when m=2, the curve is a symmetrical parabola ("Schaefer model"); when m=1, the curve is akin to that of Fox (1970); when m=0.5, the curve is equivalent to equation 2 below. Values of M>2 lead to curves that are skewed to the right, which may be viewed as expressing some form of stock (recruitment) collapse.

[b] not given, as underlying C/f = f(effort) plot does not explain data at hand.

of Schaefer (1957) and of Fox (1970). The results are presented in Table 1. I have also tried the following two empirical models:

$$C = a_3 f^{b_3} * e^{-b_4 f} \qquad ...1)$$

$$C = C_\infty (1-e^{-kf}) \qquad ...2)$$

where C=catch; f=effort; a_3, b_3, b_4, C_∞ and k are constants whose values were estimated using the nonlinear regression algorithm in SPSS. The results are summarized in Table 1 and the fitted curves are presented in Fig. 2.

Table 1 shows that the Schaefer and Fox models did

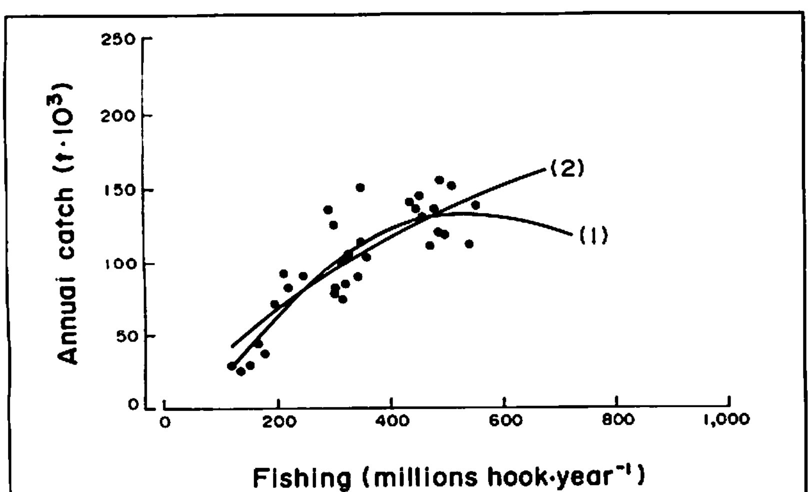

Fig. 2. *Plot of catch vs. effort in the Pacific fishery for bigeye tuna* Thunnus obesus, *fitted with two empirical models (equations 1 and 2, see text).*

not work. Of course, one would not have attempted to fit these two models after a critical examination of the trend of catch at various levels of effort. However, studies of tropical fish resources often ignore critical examination of catch-effort data, leading to poorly fitted production models. Needless to say, the conclusions from such poor fits may prove disastrous. On the other hand, the empirical models (Equations 1 and 2) appear to be adequate representations of the catch-effort relationship (Fig. 2). Also, equation (1) provides an estimate of C_{opt} ("MSY") similar to that suggested from PRODFIT (Table 1).

On the other hand, I am unable to attach any "biological meaning" to equations 1 and 2, which only describe, but do not explain the catch and effort data in Table 1 and Fig. 1.

References

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