Yield per Recruit Analysis of the Mackerel Fishery in Trinidad

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ABSTRACT

The mackerel fishery in Trinidad comprises *Scomberomorus brasiliensis* and *S. cavalla*. The fishery is artisanal in nature and the fish are caught by drift gill nets (stretched mesh 113 mm), trolling, beach seines and lampara seines. Yield per recruit analysis showed that both species were underexploited as regards fishing effort, with *S. brasiliensis* being able to sustain a greater increase in fishing effort than *S. cavalla*. *S. brasiliensis* is underexploited and *S. cavalla* optimally exploited as regards gill net mesh size. A decrease in mesh size would result in an increased yield of *S. brasiliensis*, but would exploit immature fish. Management strategy should be directed at increasing the fishing effort while retaining the present net mesh size.

INTRODUCTION

The mackerel fishery of Trinidad exploits two species, the "carite" *Scomberomorus brasiliensis* Collette, Russo and Zavala-Camin, and the "kingfish" *Scomberomorus cavalla* (Cuvier). The fishery is artisanal in nature and employs drift gill nets.

with kingfish approaching it in importance. As a result, studies have been made on the biology and fishery of both species in recent years (Sturm, 1974; 1978; Sturm and Julien, 1984; Julien et al., 1984; Sturm et al., in press; Sturm and Salter, in press). This paper attempts to provide a yield per recruit analysis of carite and kingfish.

METHODOLOGY

The Data

Parameters were taken mainly from previous work in the biology of carite (Sturm, 1978; Julien et al., 1984), and kingfish (Sturm and Salter, in press). Carite were sampled by gill nets (average stretched mesh size = 113 mm = 4.5 in) and beach seines (Sturm, 1978) and from the Port of Spain fish market (Julien et al., 1984). Kingfish were sampled by gill nets (mesh size as above) and trolling, and from the Port of Spain fish market

(Sturm and Salter, in press).

Yield Per Recruit

The yield per recruit equation (Beverton and Holt, 1957) may be written as:

$$\frac{Y}{R} = Fe^{-M(t_c-t_o)}\, W_\infty \left[\frac{1}{Z} - \frac{3e^{-K(t_c-t_o)}}{Z+K} + \frac{3e^{-2K(t_c-t_o)}}{Z+2K} - \frac{e^{-3K(t_c-t_o)}}{Z+3K} \right]$$

where Y = yield in weight; R = number of recruits; Z = instantaneous total mortality; F = instantaneous fishing mortality; M = instantaneous natural mortality; W_∞ = asymptotic weight; K = growth coefficient; t_o = hypothetical age at zero length; t_c = age at first capture.

Growth Parameters

The parameters K, t_o and t_c were taken from previous work on carite (Sturm, 1978; Julien et al., 1984) and kingfish (Sturm and Salter, in press).

Asymptotic Weight

Asymptotic weight (W_∞) corresponds to asymptotic length (L_∞). Therefore,, the usual weight equation may be written:

$$W_\infty = aL_\infty{}^b$$

where a and b are constants.

Mortality Parameters

Total mortality (Z) was obtained from previous work on carite (Julien et al., 1984) and kingfish (Sturm and Salter, in press). Natural mortality (M) was obtained by Pauly's (1983) general formula:

$$\log M = 0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

where T is the mean annual water temperature.

Total mortality (Z) is the sum of natural mortality (M) and fishing mortality (F).

RESULTS

Growth Parameters

These are as follows:

Carite: K = 0.29 $year^{-1}$; t_o = -0.55 years, t_c = 3 years

(Sturm, 1978; Julien et al., 1984).

Kingfish: $K = 0.19$ year^{-1}, $t_o = -0.50$ years; $t_c = 4$ years; (Sturm and Salter, in press).

Asymptotic Weight

The L_∞ values and length weight coefficients are as follows:

Carite: $L_\infty = 73$ cm form length (FL); $a = 1.47 \times 10^{-2}$; $b = 2.85$ (Sturm, 1978) which gives $W_\infty = 3043$ g.

Kingfish: $L_\infty = 130$ cm FL; $a = 1.16 \times 10^{-2}$; $b = 2.89$ (Sturm and Salter, in press) which gives $W_\infty = 15287$ g.

Mortality Parameters

The mean annual water temperature to a depth of 20 m around Trinidad may be taken as 27.5°C (Edwards-Lequay, personal communication) which is used in Pauly's formula to obtain M. The mortality parameters are as follows:

Carite: $Z = 0.88$ year^{-1} (Julien et al., 1984); $M = 0.61$ year^{-1}; $F = 0.27$ year^{-1}.

Kingfish: $Z = 0.65$ year^{-1} (Sturm and Salter, in press); $M = 0.31$ year ; $F = 0.34$ year^{-1}.

Yield Per Recruit

Yield per recruit curves for values of $F = 0.0$ to 3.0 year^{-1} are shown for carite for a range of M from 0.3 to 0.8 year^{-1} (Fig. 1) and for t_c from 1 year to 6 years (Fig. 2) and for kingfish for a range of M from 0.1 to 0.6 year^{-1} (Fig. 3) and for t_o from 1 year to 6 years (Fig. 4).

DISCUSSION

The use of a general equation to establish M can only give an approximate value, and hence the need to produce yield curves using a range of values around the empirical value. Figure 1 shows that for fish of age 3 carite are underfished at $M = 0.61$ year^{-1} and for values of 0.4 year^{-1} and over. Figure 2 shows that at the 1982 level of fishing, fish recruited at ages 1 and 2 would give maximum yields. These would be recruited by a smaller mesh size and are immature (Sturm, 1978) and hence recruitment to the fishery at these ages would be undesirable. However, the present mesh size recruits at 3 years and gives the next highest yield which increases with fishing effort. The curve flattens out after $F = 1.4$ year^{-1}, and yield increases beyond this value are insignificant, making further fishing effort impractical.

Figure 3 shows that the stocks of kingfish for fish of age 4 to be underfished at $M = 0.31$ year-1 and above. However, at M =

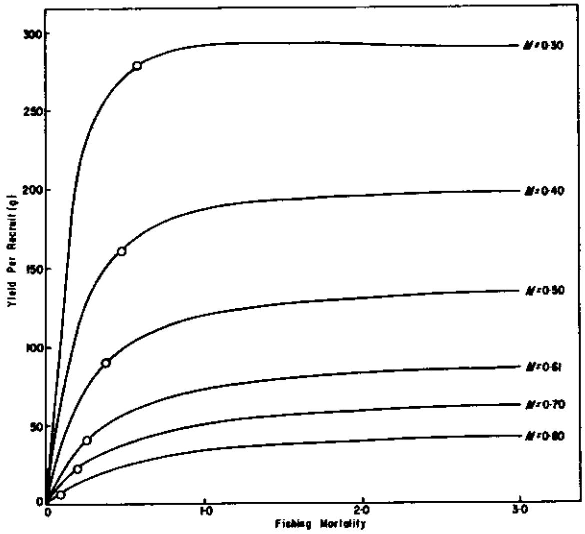

Figure 1. Yield per recruit for carite against fishing mortality for different values of natural mortality (M) from 0.3 to 0.8 $year^{-1}$. o = fishing mortality values for 1982 for different values of natural mortality.

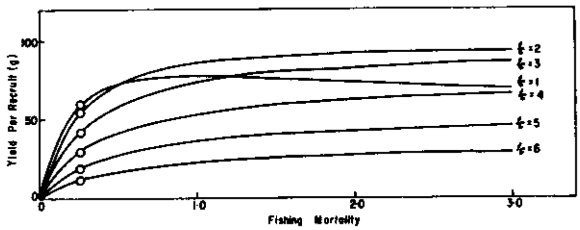

Figure 2. Yield per recruit for carite against fishing mortality for different values of age at entry (t_c) from 1 to 6 years. o = fishing mortality values for 1982 for different values at age of entry.

$0.2\ year^{-1}$ and less the stocks would be overfished. Figure 4 shows that at $F_{1981-82}$, maximum yields are obtained at $t_c = 4$ years recruited by the present mesh size. This curve is domed, with decreased yields beyond $F = 0.8\ year^{-1}$. A two-fold fishing effort with a larger mesh size to allow recruitment at age 5 would give maximum yields.

The above yield per recruit curves are presented, bearing in mind the following limitations of the data. Age at entry (t_c) and total mortality values have been calculated from market data incorporating combined gears. However, gill net catches predominate for carite, and also constitute about half the kingfish catch. Modal age of recruitment for carite is the same at 3 years for both gill nets and combined gears (Julien et al., 1984). For kingfish the modal age for combined gears is 4 years, whereas for gill nets it is 3 years, but in both cases recruitment is almost constant at ages 3 to 5 years (Sturm and Salter, in press).

Another difficulty is the use of 1971-73 values of L_∞, K and t_o in yield per recruit analysis to define the state of the fishery for carite in 1982. The maximum lengths of fish measured in 1981 and 1982 were 78 and 88 cm respectively (Julien et al., 1984) which compare well with the maximum length of 79 cm recorded by Sturm (1974; 1978). Therefore, the L_∞ values for both periods are assumed to be similar. Since K and t_o are related to L_∞ it can be expected that K and t_o for both periods are similar.

A further difficulty is the use of an age-length key for 1971-73 (Sturm, 1974) to determine Z and t_c values for 1982 (Julien et al., 1984). However, the Z value ($0.98\ year^{-1}$) for the former period agrees well with that ($0.88\ year^{-1}$) for 1982. The above comparisons of L_∞ and Z suggest that the carite stocks for both periods were subjected to similar fishing experiences.

MANAGEMENT CONSIDERATIONS

At present there is little direct management of the mackerel fishery, apart from data collection and research. Ongoing data collection includes the measurement of length frequences of carite, separated by different gears where possible at the Port of Spain fish market. It is hoped to use these data to update stock assessment studies. A tagging program for both species, using Floy internal anchor tags, has been in progress for a year. The numbers of fish tagged have been short of target rates for to various reasons, but the rate of recaptures (4%) of carite has been encouraging. These recaptures have shown little migration, but it is hoped that recaptures made in years subsequent to tagging will provide more information on migratory patterns. An attempt is being made to improve the quality of beach landing data by documenting the number of hours fished and the weights of fish caught by different types of gear, so as to better describe fishing effort. Recreational fishing for both species is undoubtedly responsible for a large proportion of landings, and a start has been made in collecting data from this fishery. The latter two projects are being carried out by the

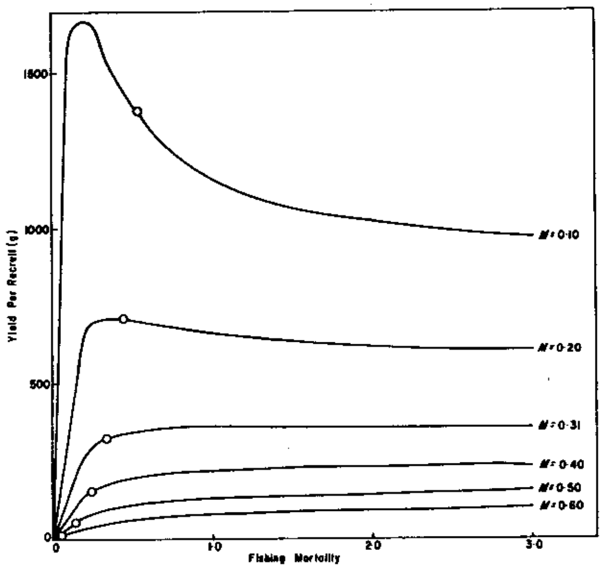

Figure 3. Yield per recruit for kingfish against fishing mortality for different values of natural mortality (M) from 0.1 to 0.6 $year^{-1}$. o = fishing mortality values for 1981-82 for different values of natural mortalitv.

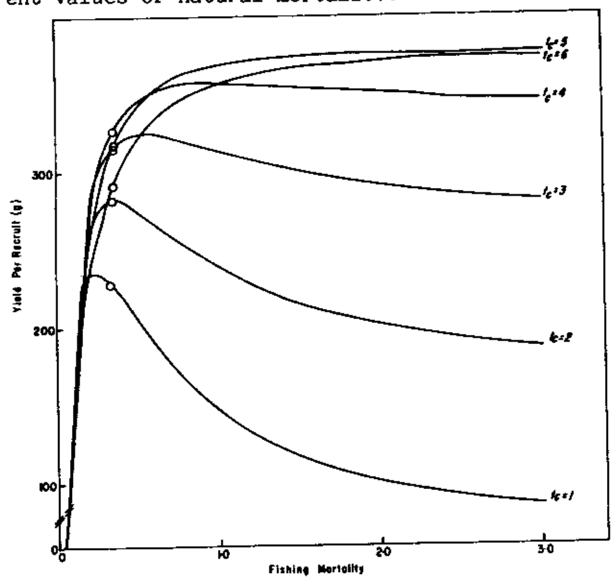

Figure 4. Yield per recruit for kingfish against fishing mortality for different values of age at entry (t_c) from 1 to 6 years. o = fishing mortality values for 1981-82 for different values of age at entry.

Fisheries Division of the Ministry of Agriculture, Lands and Food Production.

Yield per recruit analysis in this paper indicates the stocks of both species to be underexploited as regards fishing effort, and that the present mesh size which is optimal for carite (excluding immature fish) and kingfish, should be retained. Although no direct measures are being taken to increase fishing effort, it is to be noted that with the recent completion of three new fish markets with cold storage facilities, and with several more in the developmental stage, fishing effort would be automatically increased. Extra fishing effort could also be permitted by the licensing of additional fishing boats.

Overexploitation as defined by yield per recruit analysis has been taken as fishing at a level which exceeds the maximum sustainable yield: this is termed growth overfishing (Cushing, 1976). Recruitment overfishing occurs when the stock size is reduced to a level at which enough young fish are not produced to maintain the stock. Yield per recruit analysis does not include a stock-recruitment relationship, and therefore cannot define recruitment overfishing. For both species, yield increases well beyond the present F values, especially in the case of carite. Carite and kingfish are fecund species and as such probably do not exhibit a strong stock-recruitment relationship. The above points suggest it is plausible to assume that recruitment overfishing does not occur at present fishing levels. With improved beach landing data it should be possible to establish stock-recruitment relationships for both species, to determine whether high values of F would result in recruitment overfishing.

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