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Per Recruit Models for Stock Assessment and Management of Carp Fishes in the Pattipul Stream, Sheetalpur, Saran (Bihar)

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ABSTRACT

The Per recruit models were applied to assess Major carp stock in the Pattipul of Bihar showed rapid increment in Yield per recruit (Y/R) at low values of fishing mortality (M=0.17/year) and age at first capture (Tc=0.5 years and increasing F (0.50/year) as 1068 g per year. The Y/R above this level was constant or slightly decreased and the recent F value is higher than the biological reference points as $F_{0.1}$ (0.15 per year), $F_{SB40\%}$ (0.13 per year), $F_{SB50\%}$ (0.08 per year) and $F_{SB25\%}$ (0.24 per year). The Tc increase by one year resulted in slight increase in Y/R, while additional Tc increase led to decrease in Y/R values. The Tc increase in F required to obtaining the maximum Y/R until reaching a optimum state as initial recruitment at constant M, while recent F value gives small increase in recent level of F, increasing the Tc by one year would result in a small increase in biomass per recruit (B/R). The Tc increase caused a gradual increase in B/R, followed by a decline after a certain value of Tc. These results provide evidence of recruitment over-fishing at all optimum fishing levels, and so sustainable management and conservation of Major carps in Pattipul would require a decrease in F to levels less than $F_{0.1}$ and $F_{SB40\%}$, which can be achieved through a reduction in fishing effort but not through an increase in Tc.

Keywords: Per recruit models, Major carp, Pattipul stream

INTRODUCTION

The carp fishes are widely distributed throughout the RIver and Streams of Ganga and its other tributaries throughout the year. The carps are generally long-lived with low natural mortality rates like greasy grouper in Indo-pacific region (Ferreira and Russ 1994; Grandcourt et *al.* 2005).

The carps are a major guild of fishing in the Pattipul and they have a high market value which is caught using mahajaal with small mesh of different sizes. There are several carp species recorded in this stream. However, major carps are the most important and dominating in the Indian rivers and streams.

The carp population in the Pattipul stream has been heavily exploited. Therefore, it is essential to frequently evaluate their biological status and the health of the fisheries in order to sustainably manage these fish.

This study was conducted to assess the stock status of the Major carps in the Pattipul stream, Sheetalpur, Saran of North Bihar. There yield per recruit (Y/R) (Beverton and Holt 1957) and biomass per recruit (B/R) (Sparre and Venema 1998) models were used, which are adequate to define management measures, such as minimum size limit, closed season and optimum fishing strategy (Al-Husaini et *al.* 2002).

METHODS AND MATERIALS

The carp samples used in the present study were collected bi-monthly from commercial catch of Mahaajal trap nets in the Pattipul fish market, Sheetalpur, Saran n Bihar A total of 200 fish representing a wide range of total lengths (24-97 cm) and weights (0.2-2.5 kg) were collected. The total length (cm) and weight (g) of each fish were recorded, and their sex, stage of sexual maturity and age were determined. These data were used ∞to estimate Von Bertalanffy growth parameters (L∞=136.26 cm, K=0.059, t_0 = –1.68 year) and mortality rates (Z=0.57 per year; M=0.17 per year; F=0.4 per year), which are used as input parameters of the per recruit models in the present study.

Yield Per Recruit Analysis: The Y/R as a function of fishing mortality, F was calculated using the Beverton and Holt (1957) method as:Y/R=F exp (-M (Tc-Tr)) W∞[1/Z-3S/ (Z+K) + 3S^2/ (Z+2K)-S^3/ (Z+3K)] where F = fishing mortality coefficient, M= natural mortality coefficient, Tc=age at first capture in +years, Tr= age at first recruit in years, Z=total mortality coefficient, S=exp [-K (Tc-T_0)], and W∞ and K are growth constants of the Von Bertalanffy growth formula.

Biomass Per Recruit Analysis: The B/R as a function of age was calculated using the Sparre and Venema (1998) model: B/R=Y/R (1/F)

The Biological Reference Point: The biological reference point, $F_{0.1}$ (the value of F at marginal increase in Y/R is 10% of its value at F=0) was calculated according to Gulland and Boerema (1973), as described by Cadima (2003) as: dV/dF=dY/dF-0.1B_0 = 0 or dY/dF=0.1B_0 where V=Y-0.1B_0, dY is the change in the Y/R, dF is the change in the F and B_0 is the B/R when F=0. Therefore, the value of F at which dY/dF=0.1B_0 represents the value of $F_{0.1}$. $F_{0.1}$ can then be calculated by maximizing the function V=Y-0.1B_0. Note that V is at a maximum when F=0.1, i.e., when dV/dF=0.

RESULTS AND OBSERVATIONS

Effect of fishing mortality on Yield Per Recruit: The response of Y/R to different values of F and age at first capture, Tc is represented in Figure 1. Y/R increased rapidly at low values of F. At present natural mortality, M (0.7 per year) and Tc (0.5 year), the Y/R increased with increasing F to reach a maximum value of 1085 g per recruit at F = 0.21 per year. Above this level of F, Y/R was constant or slightly decreased. This value of Y/R is very close to the value attained at F (current value) = 0.4 per year (1070 g per recruit).

The current level of F is higher than $F_{0.1}$ (0.15 per year), $F_{SB25\%}$ (0.24 per year), $F_{SB40\%}$ (0.13 per year) and $F_{SB50\%}$ (0.08 per year) (SB25%, SB40% and SB50% are different level of stock biomass in relation to the virgin biomass which is the biomass at F = 0). At these levels of reference points, the Y/R were 234, 1085, 1070 and 990 g per recruit, respectively.

Effect of Tc on Y/R: At the present level of F, increasing the Tc by 0.5 year resulted in a slight increase in the Y/R, while further increases in Tc led to a decrease in Y/R values (Figure 1). At Tc values of 0.5 (current value), 1.0, 1.5 and 2 years, the Y/R were 880, 930, 950 and 960 g per recruit, respectively. At constant M, the increase in Tc caused an increase in the F required to obtain the maximum Y/R until reaching a non-maximum state at the oldest Tc (Figure 1).

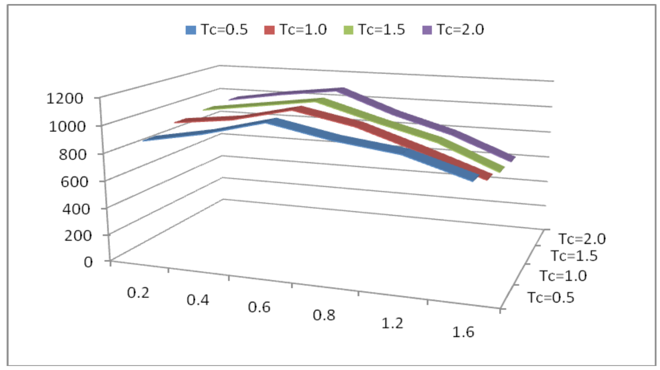

Figure 1: Y/R Model as a function of Fishing mortality (F) and Recruit per unit (Tc) for major carp in Pattipul, Sheetalpur, Saran.

Biomass Per Recruit Effect of fishing mortality: The relationship between B/R and F is illustrated in Figure 2. At the current level of F, the B/R (4.700 g per recruit) is about 18% of biomass at the unexploited level. The B/R decreased with increasing F.

Effect of Tc on B/R: At the current level of F, increasing Tc by one year would result in a small increase in B/R, while further increases would lead to a decrease in B/R (Figure 2). At Tc values of 0.5 (current value), 1.0, 1.5 and 2.0 years, the corresponding B/R values were 2646, 2664, 2632 and 2560 g per recruit, respectively, indicating that the B/R showed a slight decrease only at older Tc (1.5 and 2.0 year). At higher levels of F, the increase in Tc causes a gradual increase in B/R until a certain threshold, after which any further increase in Tc leads to a decline in B/R.

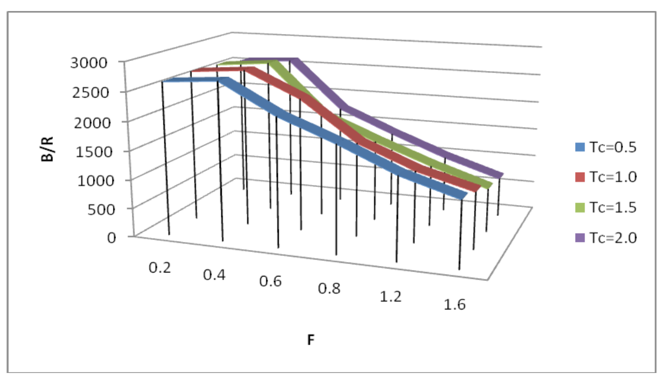

Figure 2: Biomass (B/R) Model as a function of Fishing mortality (F) and Recruit per unit (Tc) for major carp in Pattipul, Sheetalpur, Saran.

The values of B/R computed at different levels of reference points, namely, $F_{0.1}$ (0.15 per year), $F_{SB25\%}$ (0.24 per year), $F_{SB40\%}$ (0.13 per year) and $F_{SB50\%}$ (0.08 per year), were 6077.7, 4174.4, 6679 and 8348.8 g per recruit, respectively.

DISCUSSION

These results indicate Y/R of major carp increases with increasing F, reaches a peak, and then slightly declines with further increases in F. Increasing Tc by one year caused a small increase in Y/R, while further increases in Tc resulted in a decline in Y/R. This finding indicates that increasing Tc does not improve the yield status of these fish. The current level of Y/R was achieved at a higher level of F than $F_{0.1}$, which is the reference point at which the yield is marginally stable with the least risk of collapse (Punt 1993; Clark 1993; Mace 1994). When compared with other levels of reference points such as $F_{SB25\%}$, $F_{SB40\%}$ and $F_{SB50\%}$ (0.08 per year), it appeared that the current F is higher than that of computed levels. This suggests that grouper stocks in Qatari waters are subject to high fishing pressure.

Theoretical predictions of the B/R also showed a decrease in B/R with increasing F. The current biomass level is equivalent to 18% of the unexploited level (virgin biomass, i.e., no F). This indicates heavy loss in the population biomass, presumably due to increasing fishing pressure on grouper stocks.

Increasing the Tc by one year caused a small increase in B/R, whereas further increases in Tc caused a decline in B/R. This suggests that there are not enough adult fish being taken from the stock, which in turn indicates recruitment overfishing. The Tc in the present study (0.5 year) is older than the age at first maturity (0.45 year). Therefore, it appears that major carp in Pattipul stream are not fished under the age of first maturity; instead, fishing operations appear to target the large, adult individuals. Thus, increasing the Tc may not improve the state of the stocks of these fish.

The results indicate that decreasing the value of current F to levels of reference points would cause an increase in B/R. These reference points can be used by fishery managers to evaluate and manage fish stocks in their various locations and systems, as has been reported by researchers (Griffiths 1997; Booth and Buxton 1997; Kirchner 2001). Previous studies have used various reference points, and reference points differ according to the conditions of the stocks and the availability of application of the reference points that provide better management of these stocks. Clark (1991) reported that $F_{SB35\%}$, reduces the stock to 35% of the unexploited stock, would provide high yield at low risk, regardless of the spawner-recruit relationship. However, Punt (1993) showed that the $F_{SB35\%}$ strategy sometimes reduced the spawner biomass to less than 20% of unexploited levels. Therefore, Clark (1993) and Mace (1994) recommended a strategy of $F_{SB40\%}$.

Other studies found that the marginal yield strategy, $F_{0.1}$, is the most stable reference point, and could be adopted with the least risk of stock depletion (Clark 1993; Mace 1994). Booth and Buxton (1997) clarified this assumption at levels of F > 0.4 per year (the present level of F) and found that spawner B/R would be reduced to 1 or 2 year classes. They also suggested that maintaining such high F is risky if a year class failure occurs.

Based on the results, it may be advised that reducing the present F of major carp stock in Pattipul stream to the level of $F_{0.1}$ (0.15 per year) or $F_{SB40\%}$ (0.13 per year). Such a reduction in F would likely result in a higher B/R than under current levels. It also appears that mortality of major carp in Pattipul stream has a stronger effect on the B/R than Tc. Thus, controlling fishing effort would be a more effective and reliable strategy to manage major carp stock than changing Tc through technical changes in the fishing gear (Mahaajal trap nets).

These results indicate that the current level of F in major carp fisheries in Pattipul stream should be reduced to $F_{0.1}$ (0.15 per year) or $F_{SB40\%}$ (0.13 per year). Strategies directed at controlling fishing effort, such as closing fishing area or seasons, should be adopted.

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