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MORTALITY AND STOCK-SIZE ESTIMATES OF THE BOMBAYDUCK, *HARPODON NEHEREUS* (HAM.), OFF NAWABUNDER, GUJARAT

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ABSTRACT

The estimated total mortality rate of bombayduck, *Harpodon nehereus*, at Nawabunder varied between 2.443 and 2.939 for the period 1976-79. The Natural mortality coefficient (M) was at 1.575 for the unexploited phase and 1.462 for the exploited phase. Exploitation rate (u) was at 0.422. The MSY and the average yield were close to each other as the estimated values were 3918.4 t and 3561.0 t, respectively.

The bombayduck, *Harpodon nehereus* (Ham.), has a discontinuous distribution off both the coasts of India. There are four stocks of *H. nehereus* identified so far, three on the west coast and one on the east coast (Bapat 1970, Zafar Khan 1983). Along the Saurashtra coast, on the west coast of India, its fishery is confined to a narrow belt of 45 km. The author has given the details of this in an earlier paper (Md. Zafar Khan 1985). In this note the mortality rates of the species are presented.

Catches of 4,700 t, 2,690 t and 3,290 t of *H. nehereus* are estimated to have landed at Nawabunder respectively during 1976-77, 1977-78 and 1978-79 fishing seasons (Table 1). The fish has been reported to grow to 199 mm during

the first year and 288 mm the second year (Zafar Khan 1985). As the young ones are fully represented in the catch, the instantaneous total mortality rate 'Z' is calculated employing the formula:

$$Z = -\log_e \left(\frac{N - N_o}{N} \right) \quad \text{(Ricker.....1975)}$$

The total mortality coefficient estimated are 2.655, 2.939 and 2.443 for the years 76-77, 77-78 and 78-79 (Table 2). Z is also estimated by Cushing's (1968) model:

$$Z = \frac{1}{T_{max-1}} \text{Log}_e \frac{N_t}{N_{Tmax}}$$

where N_t is the number of one-year-old fish and N_{Tmax} the number at maximum age of fish in population. Estimated by this method, Z varied between 2.018 and 3.06. Though there is a small difference between the values of Z, the average of both are more or less same.

TABLE 1. *Estimated fishing effort and catch and catch per haul at Nawabunder during* 1976-77 to 1978-79.

	Effort No. of hauls	Catch in tonnes	CPUE in kg.
1976-77	37,108	4700.5	126.7
1977-78	43,840	2690.6	61.4
1978-79	56,972	3291.9	57.8
Average	45,973	3661.0	77.4

TABLE 2. *Estimated mortality rate at Nawabunder during* 1976-77 *to* 1978-79.

	Estimated CPUE of 0 year	Estimated of 1st year	Z (Ricker's model)	Z (Cushing's model)
1976-77	14,085	1054	2.655	3.06
1977-78	6,494	348	2.939	2.018
1978-79	4,579	429	2.443	2.337
Average	8,386	610	2.679	2.472

In the absence of positive linear relationship between Z and effort, estimate of natural mortality (M) is not possible using $Z = M + qf$. Therefore, M is estimated by Cushing's model (1968), wherein the unexploited state, if the number of one-year-olds is taken as 100 and number surviving to an age of 3.918 (N_{Tmax}) years as 1, is:

$$M = \frac{1}{3.918-1} \cdot \text{Log e} \frac{100}{1} = 1.575$$

T_{max} has been calculated as per Pauly's (1980) formula as follows:

$$T_{max} = \frac{3}{K} + t_o$$

where $K = 0.761$ and $t_o = -0.024$ month (*see* Zafar Khan 1985).

Recently, Pauly (1980a) has shown a correlation between M, L_∞, K and T (average annual temperature at the surface). When this is applied to the present data ($K = 0.761$, L_∞ 367 mm and $T = 26.5°C$) thus:

$$\text{Log } M = -0.0066-0.279 \text{ Log } L_\infty + 0.6543 \text{ Log } K + 0.4634 \text{ Log } T,$$

the M arrived at is 0.631.

M is also estimated as follows by the formula of Taylor (1958):

$$M = 2.9957/TM$$

where, TM is maximum age (3.918 years for *H. nehereus*) and M is found to be 0.764.

Rikhter and Effanov (1976) showed a close association between M and t_m or t_{m50}, where t_m is the age at first sexual maturity and t_{m50} the age at which 50% of the population is mature, also called by Rikhter and Effanov "the age at massive maturation". They demonstrated a hyperbolic relation with the equation:

$$M = 1.521 / (t_{m50})^{0.72} - 0.155$$

In the case of bombayduck t_m and t_{m50} are estimated as 202.5 and 266, respectively. So M may vary between 1.285 and 0.874.

Two sets of estimates are thus possible for M, one varying between 0.631 and 0.874, which is close to k, and the other between 1.285 and 1.575, which is almost twice k. *H. nehereus* has been observed to be highly cannibalistic, its own youngones forming a major food component (Zafar Khan, MS). Therefore 1.575, though a relatively high value, may nevertheless be a realistic estimate of M for the unexploited phase.

Independent estimate of Fishing mortality (F) is also made from exploitation rate (u), as the survival rate (S), size at first capture (Lc) and mean size ($\bar{L}$) of fish above Lc are known (Allen 1953).

$$\text{Thus: } U = \frac{Lc}{\bar{L}} = \frac{F}{Z}\left(1 - e^{-Z}\right) = EA$$

where, $1 - e^{-Z} = 1 - S = A$.

The minimum length fully represented in the catch is considered to be the length at first capture (Lc) (Alagaraja 1984), which is 52.5 mm in the present case, as a primary mode at this length is present in most of the months. The mean lengths of the fish above Lc are 122.7, 121.3 and 129.5 for the period 1976-77, 1977-78 and 1978-79, respectively. Estimated F and u are given in Table 3. Based on these estimates, M is also estimated for the exploited phase which varies between 1.358 to 1.595. Average natural mortality coefficient for the period is 1.462. Thus it can be seen that the average annual standing stock of bombayduck off Nawabunder during 1976-77 to 1978-79 is 2926.0 tonnes.

TABLE 3. *Estimation of stock (in tonnes) of bombayduck during* 1976-77 *to* 1978-79.

Year	Z	M	F	Exploitation rate U	Catch Y	Annual stock Y|U	Average stock Y|F	MSY
1976-77	2.655	1.433	1.222	0.428	4700.5	10982.5	3846.6	5106.4
1977-78	2.938	1.595	1.343	0.433	2690.6	6213.8	2003.4	2943.0
1978-79	2.443	1.358	1.085	0.405	3291.8	8127.9	3033.9	3705.9
Average	2.679	1.462	1.217	0.422	3561.0	8438.4	2926.0	3918.4

An approximate estimate of maximum sustainable yield is made by using the equation proposed by Gulland (1979):

$$MSY \simeq PY = Zt.0.5\ Bt.$$

Where Zt is the exponential rate of total mortality (= F + M) in the year t and Bt the standing-stock size in the year. It is evident from the table 3 that MSY varies between 2,943.0 t and 5,106.4 t. The average MSY is 3,918.4 t when the average yield at Nawabunder has been 3,561.0 t, indicating that the level of fishing for bombayduck in this region is rightly around the MSY.

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