# Estimation of Fish Production from Hirakud Reservoir

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A suitable procedure based broadly on stratified random sampling for estimation of fish production from Hirakud reservoir is described. The total fish production for the years 1978 and 1979 from Hirakud reservoir, along with seasonal variation of different species is discussed.

Information on the magnitude of the fishery resources is essential for the development, exploitation and conservation of any fishery. This can be achieved by assessing total fish production, species composition and variation in their abundance. Many workers have discussed estimation procedures for marine fish production (Bal & Banerjee, 1951; Sukhatme *et al.* 1958; Panse & Sastri, 1960; Banerjee, 1971; Banerjee & Chakraborty, 1972; and Krishnan Kutty *et al.* 1973). Pillai (1960), Shetty & Ghosh (1963) and Anon (1969) have described the procedures for estimating riverine and estuarine fish statistics. But so far no systematic attempt has been made to estimate the actual fish production from reservoirs. According to Padam Singh *et al.* (1978) and Sastri *et al.* (1979), the state-wise inland fish production is based on marketing figures and personal judgement. Anon (1976) stressed the need for formulating procedures to estimate the fish production from reservoirs. The foregoing is an account of such a procedure to assess the fish production from Hirakud reservoir.


Fig. 1. Hirakud reservoir, Hirakud dam, rail heads and marketing centres

## Materials and Methods

Marketing centres and rail heads were taken as the frame as the boats did not stick to definite landing centres. The weight of the fish despatched from each rail head could be obtained from the daily despatch registers of the railways. As only three rail heads were involved (Fig. 1) a complete enumeration procedure was found feasible for assessing the quantity of fish transported through rail heads. But to estimate the market arrivals the quantity brought to the market were recorded by sample survey method. For this purpose the total number of marketing centres, eight in number were listed (Fig. 1). A stratification based on the intensity of arrivals (Krishnan Kutty *et al.* 1973) was made and this resulted in the formation of two strata, one containing two good markets (Jharsuguda and Raigarh) and the other containing the rest and it was possible to record the whole quantity of fish brought to the marketing centres on selected days. By making the marketing centre days as the sampling units, a single stage sampling was found sufficient. Thus broadly, a stratified random sampling design with marketing centres as the sampling units was planned.

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Selection of the sampling units using simple random sampling, would not be appropriate as this involves space-time-variation apart from causing practical difficulties (Banerjee & Chakraborthy, 1972 and Krishnan Kutty *et al.* 1973). Following these authors, the days of observation were selected systematically with a random start and the centres randomly, in such a way that each cluster of 5 or 7 days was adequately represented. The number of marketing centres to be observed for fixing the sampling error at 10% at the monthly level was found to be approximately 14 a month, from a preliminary sample. However to fully utilise the services of two field staff, 14 days' work was programmed for each staff for sampling and for complete enumeration. In order to work out the species wise composition of the total catch recorded at the rail heads, a sampling of the fish packages brought to the rail heads was also made. For this purpose 6–7 days of observations from the rail heads in turn were made, the observation days being chosen systematically ensuring that each week was represented alike. For the good centres closer to the rail heads, the sampling days were allotted on the basis of the selection made for the rail head sampling by choosing the following day as the day of observation. The first day was chosen randomly out of the first three days of the month and the subsequent days after every fourth or fifth day. An additional day of observation was made on the preceding day of the rail head observation day in such a way that each cluster of two weeks of a month was represented alike. On this basis the sampling fraction worked out to $\frac{7\times100}{2\times30} \simeq 12\%$, for a month of 30 days. For the stratum of minor centres, the first day was selected randomly out of the first 3 days of the month as was done for the other stratum. The other days are selected systematically (every other day basis). As alternate days are included in the sample, each cluster of 5 days was equally represented. The sampling fraction for this stratum was $\frac{14\times100}{6\times30} \simeq 8\%$. Thus the good centres for which the variability in the catch was high was sampled more frequently.

The data were collected regularly both from rail heads and marketing centres as programmed. In the case of the latter, the species wise quantity of fish brought by each vendor on the day of observation was recorded. With regard to rail heads, the quantity of fish despatched on each day of the month was copied down from the concerned registers. A sample from the lot brought for despatch was examined for species-wise and total weights.

The monthly total arrivals for each stratum was estimated as: $\hat{Y} = \frac{N\times D}{n} \sum_{i=1}^{n} t_i$

where N, is the number of marketing centres in the stratum; D, the number of days in the month; n, the number of marketing-centre-days sampled and t, the total arrival at the $i^{th}$ marketing-centre-day included in the sample. The estimated variance of this estimate on random sampling basis was obtained by

$$v\left(\hat{Y}\right) = \frac{N^2 D^2}{n} \frac{1}{n-1} \left\{ \sum_{i=1}^{n} t_i^2 - \frac{\left(\sum t_i\right)^2}{n} \right\}$$

The estimated arrivals and their variances for the entire marketing centres for a month were obtained by adding the corresponding estimates for the two strata. The estimated annual total and its variance were worked out by pooling the respective monthly totals. The standard errors of the monthly estimates (of market arrivals) were worked out as,

$$\sqrt{\sum_{1}^{2} v\left(\hat{Y}\right)}$$

and the percentage errors as,

$$\sqrt{\frac{\sum_{1}^{2} v\left(\hat{Y}\right)}{\sum_{1}^{2} \hat{Y}}} \times 100$$

The corresponding annual estimates were obtained as,

$$\sqrt{\sum_{1}^{12} \sum_{1}^{2} v\left(\hat{Y}\right)} \text{ and } \sqrt{\frac{\sum_{1}^{12} \sum_{1}^{2} v\left(\hat{Y}\right)}{\sum_{1}^{12} \sum_{1}^{2} \hat{Y}}} \times 100$$

respectively.

**Table 1.** *Estimated month-wise landings brought to the marketing centres and rail heads during* 1978 *and* 1979 *(in tonnes)*

| | 1978 | | | 1979 | | |
|---|---|---|---|---|---|---|
| | Marketing centres | Rail heads | Total | Marketing centres | Rail heads | Total |
| January | 25.2 | 15.4 | 40.7 | 25.1 | 18.8 | 43.9 |
| February | 19.0 | 20.4 | 39.4 | 20.6 | 19.1 | 39.7 |
| March | 31.0 | 30.3 | 61.3 | 33.2 | 23.6 | 56.8 |
| April | 29.3 | 47.8 | 77.1 | 39.4 | 28.6 | 68.0 |
| May | 36.0 | 60.4 | 96.4 | 34.5 | 45.5 | 80.0 |
| June | 37.0 | 81.7 | 118.7 | 43.0 | 38.9 | 81.9 |
| July | 34.6 | 50.4 | 85.0 | 48.1 | 51.0 | 99.1 |
| August | 25.5 | 29.1 | 54.6 | 29.2 | 32.0 | 61.2 |
| September | 28.9 | 26.5 | 55.4 | 27.1 | 16.1 | 43.2 |
| October | 25.6 | 20.8 | 46.4 | 33.8 | 25.4 | 59.2 |
| November | 23.5 | 13.5 | 37.0 | 35.7 | 28.7 | 64.4 |
| December | 26.3 | 15.4 | 41.7 | 33.9 | 18.5 | 52.4 |
| Total | 342.0 | 411.7 | 753.7 | 403.6 | 346.2 | 749.8 |

**Results and Discussion**

Annual landings for 1978 and 1979 were estimated at 753.7 tonnes and 749.8 tonnes respectively (Table 1). But Jhingran & Tripathi (1976) have reported the annual production as 15.3 tonnes for 1965–66. This increase in output was attributable to the increased fishing effort by improved techniques in recent years. Moreover their figures were not based on regular sampling. The arrivals at local market have been estimated at 342.0 tonnes (45%) and 403.6 tonnes (54%) respectively for 1978 and 1979 (Table 1 and Fig. 3). The despatches from rail heads for the corresponding years figured 411.7 tonnes (55%) and 346.2 tonnes (46%). This discrepancy may be attributed to the disruption in the movement of boats consequent on lowering of water level in 1979 when compared to 1978. David *et al.* (1969) have observed similar phenomenon in Tungabhadra reservoir.

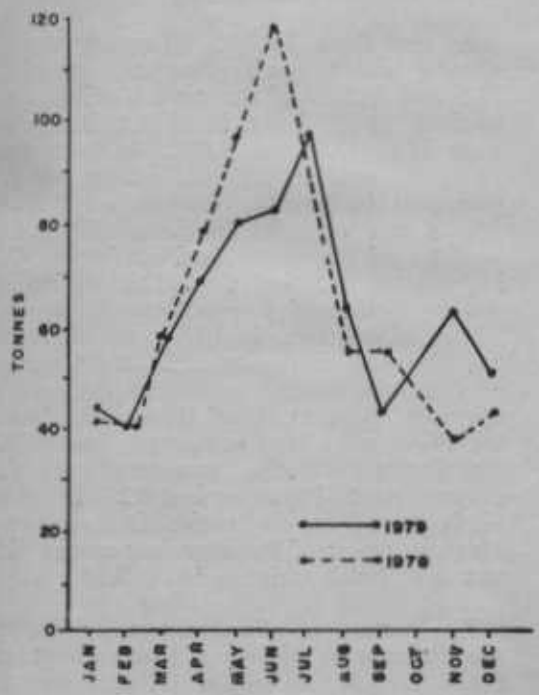


Fig. 2. Seasonal catch of fish from Hirakud reservoir

The percentage of error was the same (2.6%) in both the years and the standard errors were in the order of 8.7 and 10.4 tonnes in 1978 and 1979 respectively. With regard to monthly estimates, the standard error ranged between 1 to 4 and 1 to 6 tonnes for 1978 and 1979 respectively. The percentage error figured 4.1 to 12.2% and 5 to 13.8% for the corresponding years (Table 2). In general a tendency for higher values of error associated with higher quantity was observed. This justified an allocation proportional to the yield, as a near optimum one (Hansen *et al.* 1953) and hence the increased sampling fraction for the stratum containing the two good centres.

**Table 2.** *Month-wise estimated market arrivals (in tonnes), standard errors of the estimates and percentage errors in* 1978 *and* 1979

| | Esimated market arrivals | | Standard error | | Percentage error | |
|---|---|---|---|---|---|---|
| | 1978 | 1979 | 1978 | 1979 | 1978 | 1979 |
| January | 25.3 | 25.1 | 3.09 | 1.91 | 12.2 | 7.7 |
| February | 19.0 | 20.6 | 1.07 | 2.76 | 5.6 | 13.4 |
| March | 31.0 | 33.2 | 3.20 | 2.33 | 10.4 | 7.0 |
| April | 29.3 | 39.4 | 2.75 | 3.51 | 9.4 | 8.9 |
| May | 36.0 | 34.5 | 2.37 | 2.51 | 6.6 | 7.3 |
| June | 37.0 | 43.0 | 3.80 | 3.25 | 10.3 | 7.5 |
| July | 34.6 | 48.1 | 3.81 | 6.46 | 11.1 | 13.8 |
| August | 25.5 | 29.2 | 1.45 | 2.24 | 5.7 | 7.7 |
| September | 28.9 | 27.1 | 1.94 | 1.06 | 6.7 | 11.3 |
| October | 25.6 | 33.8 | 1.73 | 1.70 | 6.9 | 5.0 |
| November | 23.5 | 35.7 | 1.00 | 2.24 | 4.1 | 6.3 |
| December | 26.3 | 33.9 | 1.88 | 2.55 | 7.3 | 7.5 |
| Total | 342.0 | 403.6 | 8.74 | 10.39 | 2.6 | 2.6 |

April to July was found to be the best season for the fishery in both the years (Fig.2). This was in confirmity with earlier observations (George *et al.* 1973). The peaks occurred in June 1978 and July 1979. The peak season accounted for 47% (both years combined) of the total output. The average monthly landings during this period amounted to 88 tonnes whereas it was 50 tonnes for the remaining months. Wide fluctuations in the landings during lean months had not been observed.

The seasonal trends in the market arrivals and rail head despatches coincided with the fluctuation in the total landings (Fig. 3) in both the years. The contribution of the peak season was found to be 50% and 43.9% of the total landings in 1978 and 1979 respectively. The figures in respect of peak season for the marketing centres remained constant, while those of rail head declined from 58.4% in 1978 to 47.4% in 1979. As already stated similar trend was maintained in the annual despatches from rail heads. This variation might have been due to disruption in the transportation of fish, coupled with lesser production of quality fish during the peak season of 1979, when the major carps constituted 21% of the total catch of this period as against 29% in 1979. Since major carps formed the major constituent of fish sent to other places, the decline in landings of these fishes might have reflected in the rail head despatches.

As seen from Table 3, *M. seenghala, S. silondia* and *C. catla* accounted for 12.6, 12.5 and 12.2% of the total landings respectively in 1978, and in 1979 their figures were 16.6, 13.0 and 8.0%. In both the years, *W. attu, R. cotio, L. calbasu* and *L. fimbriatus* individually formed more than 5% of the total fish landings. The total landings of *L. rohita* declined from 6.6% in 1978 to 3.7% in 1979. This decline in the production of *L. rohita* may be due to failure of monsoon in 1979. Anon (1980) has observed similar trend in the landings of *L. rohita* and *C. catla* in Govindsagar reservoir. In the case of *W. attu* the figure for 1979 was low compared to 1978. But during 1979 the percentage of *G. chapra* rose to 7% as against 4.2% in 1978. Similar trend was also noticed in *L. calbasu*. However, most of the abundant species did not show much variation in landings.

The pattern of abundance was more or less the same in the case of predominant cat fishes like, *M. seenghala, W. attu* and *S. silondia* (Fig. 4). But the carps were not showing similar trends in the successive years. As evident from Fig. 4, the best season for

**Table 3.** *Species-wise landings from Hirakud reservoir during* 1978 *and* 1979 *(in tonnes)*

| Name of fish | 1978 | 1979 |
|---|---|---|
| *Catla catla* (Hamilton) | 91.8 | 62.5 |
| *Labeo fimbriatus* (Bloch) | 37.7 | 43.8 |
| *Labeo calbasu* (Hamilton) | 45.8 | 60.4 |
| *Labeo rohita* (Himilton) | 49.6 | 27.6 |
| *Labeo bata* (Hamilton) | 18.7 | 28.2 |
| *Cirrhina mrigala* (Day) | 21.1 | 12.9 |
| *Barbus tor* (Day) | 4.7 | 1.9 |
| *Barbus sarana* (Day) | 15.6 | 15.5 |
| *Mystus seenghala* (Sykes) | 95.3 | 125.1 |
| *Mystus aor* (Hamilton) | 7.4 | 6.6 |
| *Mystus tingra* (Hamilton) | 1.3 | 1.4 |
| *Silonia silondia* (Hamilton) | 94.2 | 97.8 |
| *Wallago attu* (Schneider) | 65.3 | 44.5 |
| *Eutroplichthys vacha* (Hamilton) | 30.6 | 26.2 |
| *Rita chrysea* (Day) | 20.2 | 15.1 |
| *Bagarius bagarius* (Hamilton) | 1.1 | 3.1 |
| *Notopterus chitala* (Hamilton) | 36.7 | 30.6 |
| *Notopterus notopterus* (Pallas) | 1.9 | 8.7 |
| *Gudusia chapra* (Hamilton) | 31.7 | 52.1 |
| *Rohtee cotio* (Day) | 56.3 | 55.0 |
| *Glossogobius giuris* (Hamilton) | 6.0 | 10.3 |
| *Rhinomugil corsula* (Hamilton) | 6.3 | 4.9 |
| *Sciaenids* sp. | 5.3 | 4.1 |
| *Chela bacaila* | 4.6 | 5.3 |
| *Channa* sp. | 3.5 | 3.9 |
| Others | 1.0 | 2.3 |
| TOTAL | 753.7 | 749.8 |

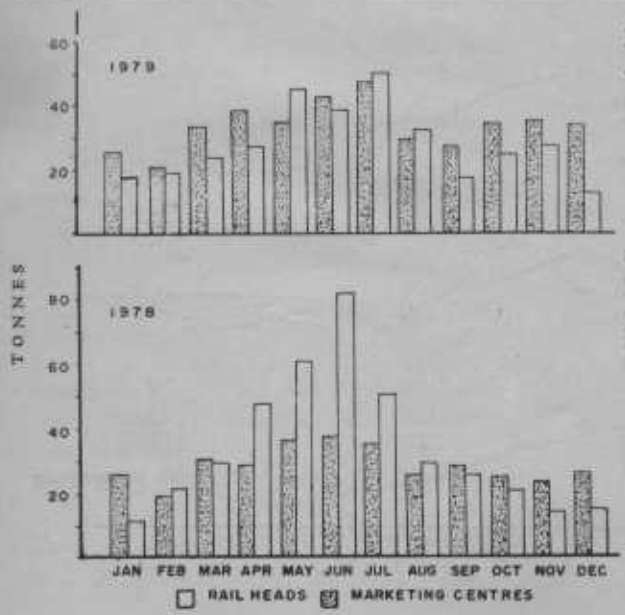


Fig. 3. Seasonal pattern in the quantities of fish arrived in the markets and despatched through rail heads in 1978 and 1979

*M. seenghala, W. attu* and *S. silondia* was observed to be April to August, with peaks in May (1978) and June (1979) in the case of *M. seenghala*, June 1978 and July 1979 for *S. silondia* and June (1978) and August (1979) for *W. attu*.

Of all the major carps *L. fimbriatus* showed more or less similar pattern of occurrence with a peak from May to August. In the case of *L. calbasu*, the peak was noticed in June and July respectively for 1978 and 1979. But the peak season for *C. catla* was different in these years. In 1978 maximum landing was recorded during June, September and October whereas in 1979, it was in August, October and November. However there was not much fluctuation in the landings from January to May. April to July was found to be the best season for *L. rohita* in 1978 but no specific trend could be observed in 1978, except that the catch was declining from June.

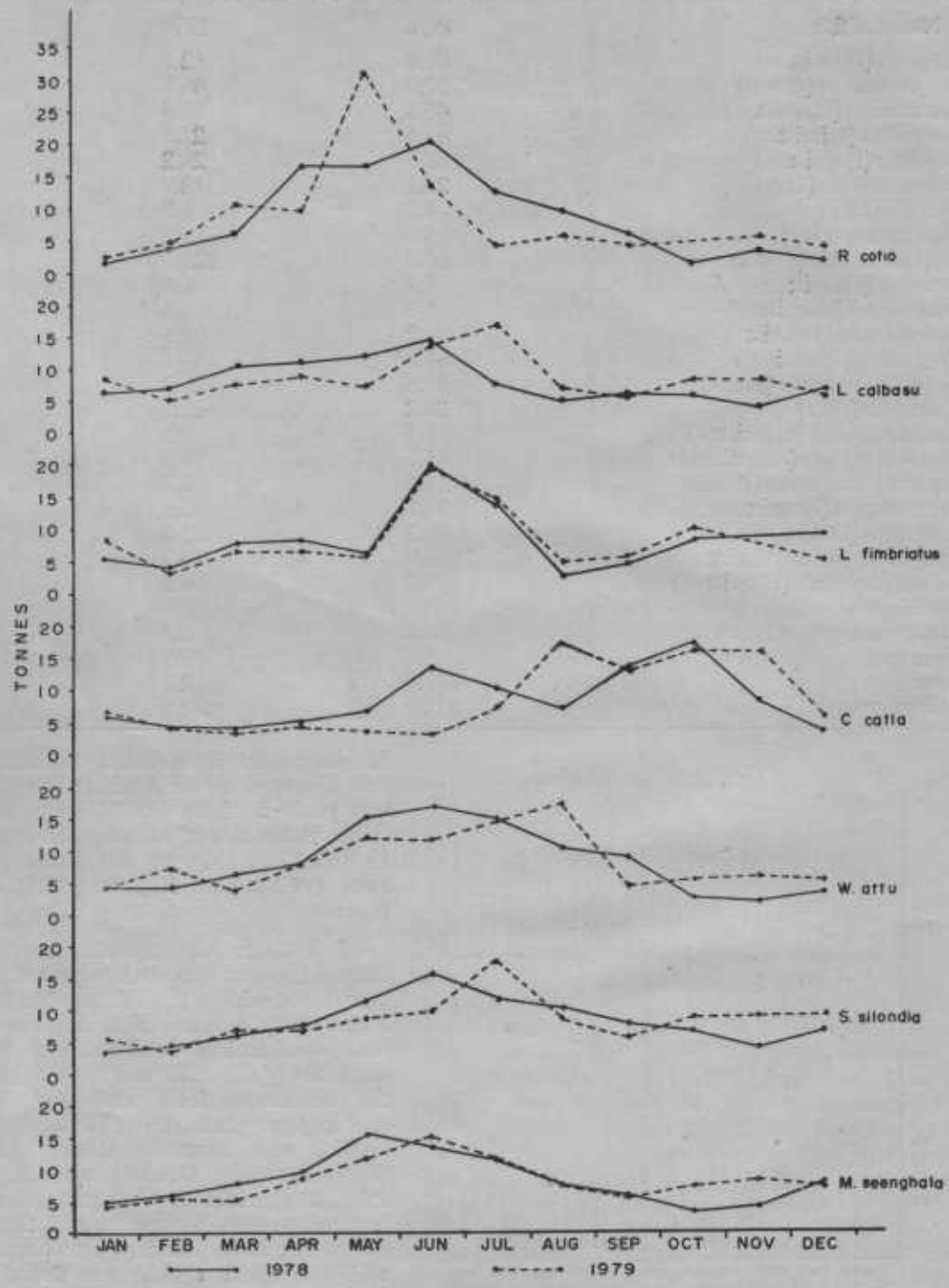


Fig. 4. Seasonal landings of important fishes from the reservoir during 1978-'79

As mentioned already the present survey covered the fish catch of the reservoir brought to the marketing centres for sale and to the rail heads for onward transportation to other places. The quantity of fish purchased direct from fishermen for human consumption could not be included owing to practical difficulties. But this does not appear to be of any significance. As some of the marketing centres are unapproachable, the possibility of omissions could not be ruled out. As is usual with other surveys the frame can be updated periodically. Inclusion of catches from ponds (sources other than reservoir) in the rail head despatches is another source of discrepancy. But this has been found to be of lesser magnitude as identified from the despatches by constant observation.

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