PRIMARY PRODUCTION AND FISH YIELD IN A TROPICAL IMPOUNDMENT, STANLEY RESERVOIR, METTUR DAM, MADRAS STATE, SOUTH INDIA

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Oxygen production and fish yield in Stanley Reservoir, Mettur Dam, have been studied. Stable thermal stratification never occurred in the deep reservoir but oxygen stratification was common, especially in summer. Oxygen deficit ranged from 0·64 mg/l to 5·84 mg/l. Below the dam, pick up of oxygen was good and the stream was well oxygenated. The gross primary production in the reservoir ranged from 1·05 g O_2/m^2/day to 10·97 g O_2/m^2/day. Lower values were due to silt turbidity during floods. Nannoplankton were responsible for the high photosynthetic productivity. Measurements of productivity rates based on changes in CO_2 and alkalinity and in dissolved oxygen in the open waters correlated well with primary production data. The average fish yield worked out from 55 to 60 kg/ha/annum. 0·25 per cent of primary production was harvested as fish.

INTRODUCTION

Larkin (1964) has very aptly remarked that 'most of the fishery biologists will agree that a considerable gap still exists between our growing knowledge of the dynamics of aquatic production and the application of the knowledge in the estimation and prediction of fishery'. He recommended the 'Rawson tradition of fisheries management based on limnological survey'. This author (1966*a*) has explained the application of limnological and primary production results in estimating the productivity of ponds. Studies on the physico-chemical conditions of the waters together with data on primary production would be of immense use in fishery management problems. The 155 km^2 (60 sq m) Stanley Reservoir in Mettur was taken up for studies since complete commercial fishing data was available for this reservoir, for over a decade. Discussions will be limited only to a few of the parameters.

MATERIAL AND METHODS

Depth samples of water were collected with a Friedinger sampler from the deepest part of the reservoir and analysed immediately according to standard methods. Dates of collection are indicated in Table I. Primary production was estimated by the oxygen method as enumerated in earlier publications (Sreenivasan 1964). The gross primary production for each 1 m interval was integrated (Rodhe 1958) to obtain the yield in g of O_2 per m^2 for 12 hours (day).

Discussion

Thermal Conditions—The thermal conditions during the present study were not much different from those reported in an earlier study (Sreenivasan 1966*b*). The only occasion when a near stratification was noted was in March 1964, when an ephemeral 'epilimnial thermocline' was formed. The inflow and outflow of water seemed to influence the thermal conditions.

Table I

Primary production and allied data of Stanley Reservoir

Date	Primary production g. O_2/day		Community respiration mg O_2/1/hr	Seechi disc. visibility m	Productivity measurements		By max. rate of photosynthesis in euphotic zone μ mol/O_2 1/hr
	Maximum rate per m^3 in euphotic zone	Gross primary production per m^2			By natural changes in O_2/μ mol/ 1/hr	By changes in CO_2 and alkalinity μ mol CO_2/ 1/hr	
14-5-1962	4·20	8·46	0·10	1·04	—	—	—
14-10-1962	4·80	8·82	0·07	1·12	15·7	50	11
21-1-1963	2·10	7·35	0·05	0·72	4	34	5·6
7-3-1963	2·40	4·80	0·30	0·64	—	—	—
29-4-1963	2·10	1·05	0·13	0·50	—	—	—
31-7-1963	1·80	3·60	0·00	0·85	4	17·5	4·8
4-12-1963	1·50	6·00	0·00	1·05	0	5·0	4·0
31-1-1964	6·17	10·97	0·30	0·67	2	—ve	16·0
23-3-1964	3·00	4·35	0·05	—	14	—ve	9
30-12-1964	3·60	2·10	0·05	—	3	—ve	6
23-1-1965	3·4	7·5	0·07	0·80	7·7	32	9
29-4-1965	4·5	6·15	0·03	1·25	7·3	23·0	11·7
10-7-1965	5·7	9·53	0·01	0·78	8	2·5	14·8

Oxygen regime—This has a bearing on the distribution of fishes and other organisms in the reservoir and on self-purification downstream. The surface water of the reservoir invariably had an oxygen content over 5·0 mg/l. In summer months, oxygen deficit was severe in bottom layers (May 1962, March 1963, April 1965) and oxygen gradient was established between the surface and bottom. Harding (1961) noted oxygen depletion below the thermocline in Lake Kariba in Africa. The very low oxygen content in the surface water in May 1963 was due to the very low water level when wind action, bringing up suspended silt, prevented photosynthesis and also removed oxygen. An inverse correlation was noted between the surface temperature and dissolved oxygen. On many occasions a mild oxygen supersaturation was noted in the surface water. 'Oxygen deficit' was worked out taking the entire reservoir as unit. The deficit ranged from 0·64 mg/l to 5·84 mg/l. Hypolimnial oxygen deficit is an indication of eutrophication (Thienemann 1928). The total oxygen content of the reservoir for some days was worked out from the dissolved oxygen profile and the volume of water under each profile. It ranged from 306,400 kg oxygen in May 1962 to 20,715,000 kg in October 1962. This is a tremendous quantity and would be of immense use downstream for purification. An interesting observation was that, even when the oxygen content of lower layers was poor or nil, the same water issuing out through the power-house turbines or low-level sluices was very well oxygenated within a distance of 100 metres downstream. Even when the bottom water was devoid of oxygen, the outlet water acquired 6·4 mg/l within 100 m downstream. Thus, in our reservoirs, the discharge of bottom waters with oxygen deficits through sluices or turbines does not affect the quality of river water. Actually, better oxygenated water issues forth in contrast to American experience (Churchill 1958); Reid (1961) also remarked that: 'The release of water from the reservoir through deep level intakes . . . introduce poorly oxygenated water from the hypolimnion into the stream below'. But Neel (1963) agrees that: 'Reservoirs often increase a stream's oxygen resources'.

Primary production—The gross primary production in this reservoir ranged from 1·05 g O_2/m^2/day to 10·97 g_2O_2/m^2/day. The lower yield was due to high silt turbidity during the very low water-level in April 1964. Primary production was generally high. Secchi disc visibility was about 1·0 m and the photosynthetic zone extends a little below 5·0 m. The silt turbidity following the floods settles down soon and the water is clear giving scope for phytoplankton to carry on photosynthesis. Lower primary production in July is correlated with higher water-level, floods, dilution and turbidity being the causes. Higher primary production in January follows fairly stable water levels and higher phytoplankton content. The primary production in this reservoir is higher than in some Russian impoundments for which data are available (Sorokin 1958, 1959). A 'river lake' on White Nile showed a primary production of 2·2 g C/m^2/day (5·87 g O_2/m^2/day) (Prowse and Talling 1958).

A parallel trend was noted between gross primary production and the dissolved oxygen content of surface water—the two curves are almost parallel (Fig. 1), indicating that the dissolved oxygen was mostly derived from photosynthesis. As noted by McQuate (1956) there was no consistent correlation between photosynthesis and temperature. Though 'net' plankton was poor in this reservoir, primary production was fairly high. Nannoplanktonic organisms were present in considerable numbers—twelve times that of net plankton. The diatoms *Nitzschia* and *Navicula* were ubiquitous, while the blue-green algae were next in abundance. Photosynthetic production of oxygen is, therefore, mainly due to nannoplanktonic algae. Rodhe (1958), Gilmartin (1964) and McQuate (1956) also agree that the smaller algae contribute up to 80–90 per cent of primary production.

Productivity rates measured by observing the natural changes in dissolved oxygen in the open water and the maximum rate of photosynthesis in the euphotic zone (in the bottle) agreed closely with each other, while the changes in CO_2-alkalinity did not correlate well with these two measurements. Gilmartin (1964) also agrees that: 'changes in the *in situ* concentration of non-conservative water properties yield a more accurate estimate of production'. McQuate (1956) noted that photosynthetic rates between CO_2 changes agreed closely with those based on O_2 changes. The photosynthetic rates obtained by us (Table I) are high and comparable with the results obtained by Verduin (1959). The diurnal and depth variations, occurring in CO_2-alkalinity, also indicate this reservoir to be productive.

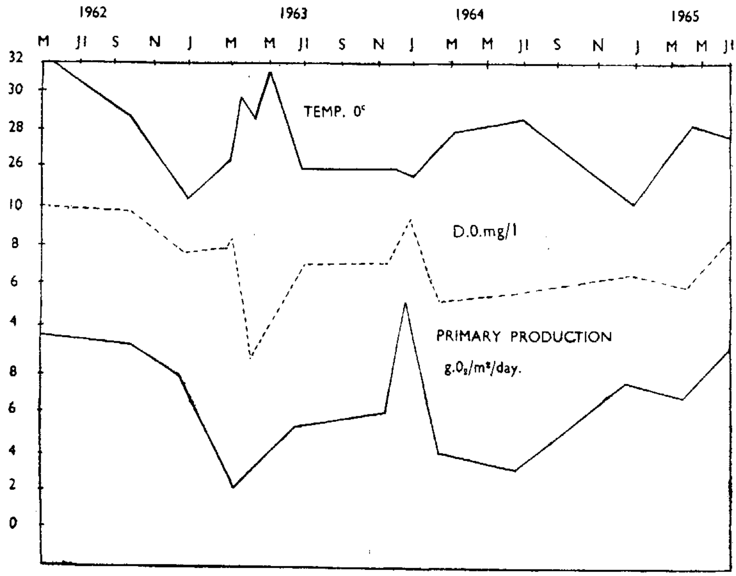

FIG. 1. Stanley Reservoir: D.O. Temp. and primary production

Fish yields in the reservoir—Fish catches in this reservoir, with species composition for five years, are indicated in Table II. The catches of 1960-61 to 1963-64 are of the same magnitude as in earlier years. The reduction in catches during 1964-65 was due to low water conditions (fishing restricted). The average fish yield for the four normal years is approximately 400,000 kg. The effective waterspread of the reservoir may be taken to be 7,500 ha (half the area at full reservoir level). On this basis the yield works out to 55–60 kg/ha. The average primary production for the period under study was above 6·3 g O_2/m^2/day or 23,000 kg/ha/A. The conversion amounts to about 0·25 per cent of primary production. The catches consist of a large percentage of carnivores also and hence there is some loss through secondary production. In smaller pieces of water such as ponds and tanks, higher conversions have been obtained. At least 1 per cent of primary production could be converted to fish, yielding about 225 kg/ha/A, through plankton feeding major carps species. Rupp and Roche (1965) obtained 4·5 per cent

TABLE II

Fish catches and species composition of fishes from Stanley Reservoir *

Species	1960-61		1961-62		1962-63		1963-64		1964-65	
	Weight in kg	% of total	Weight in kg	% of total	Weight in kg	% of total	Weight in kg	% of total	Weight in kg	% of total
Catla catla	150,732·2	37·2	137,734·5	39·6	168,906·5	38·1	125,745·1	30·8	38,991·8	17·5
Cirrhina cirrhosa	156,130·8	38·7	123,513·2	36·2	92,184·0	20·8	82,402·4	20·2	54,663·8	24·5
C. mrigala	20,890·4	5·2	21,239·9	6·1	34,853·0	7·9	42,469·1	10·4	14,691·8	7·6
Catfishes	72,979·5	18·0	60,308·1	17·3	131,407·7	30·0	140,963·4	34·6	111,689·3	50·1
Other species	3,544·4	0·9	2,569·9	0·7	7,104·8	1·6	16,401·4	4·2	411·0	0·2
TOTAL	403,739·0	—	347,645·0	—	443,450·0	—	407,981·4	—	222,646·6	—

* From the registers of Mettur Dam Fishermen Co-operative Marketing Society

of net primary production as fish in a small lake. In laboratory controlled microcosms, McConnell (1965) obtained with *Tilapia* a conversion of 10 per cent of primary production. Wright (1965) recorded that 4·3 to 9·2 per cent of gross primary production was converted to *Daphnia* in a small reservoir. Naturally with a fish species grazing on this, the conversion would be reduced much. In comparing these data with our results, it is felt that there is scope for increasing the fish catches from Stanley Reservoir.

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