A Fish Mark-Recapture Study in Boskop Dam, Western Transvaal

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Abstract

A fish population study was made in Boskop Dam during September, 1974 using the population estimate formulae of Schnabel and De Lury (Ricker, 1975). Fish were caught with a seine net of 100 m x 3 m and a mesh size of 25 mm. A total of 34 244 fish were captured, 33 459 marked and 1 794 recaptured during the experiment, which lasted 18 days. The estimation of the numbers of the Cyprinid *Labeo capensis* was found to be approximately 265 400 individuals; that of *L. umbratus* 38 600 and that of the smallmouth yellow fish *Barbus holubi* 8 100 which are 81,7%, 11,9% and 2,5% respectively of the total number of the larger fish species present in the dam.

Representative population estimates of the common carp *Cyprinus carpio*, sharptooth catfish *Clarias gariepinus*, and the smallmouth black bass *Micropterus dolomieu* could not be made, possibly due to the ability of these fishes to avoid the nets.

In this study, the De Lury method yielded the generally higher estimate for the fish species studied.

Introduction

The construction of weirs in rivers for irrigation and other purposes, affects their natural flows to such an extent that it could have a detrimental effect on many riverine fish species. Other fish, more adapted towards a standing water environment, in turn might benefit, resulting in population explosions. Impoundments in the larger river systems can also have another effect on the presence and abundance of river fish in so far that some species are cut off from their natural spawning grounds with the result that the usual pre- or post-spawning migrations of the fish can be obstructed.

Although much research has been done on the systematics of fish in Southern Africa, e.g. Barnard (1943); Jubb (1961, 1967); Du Plessis (1963); and Le Roux and Steyn (1968), very little work was done prior to 1960 on the ecology and population structure of fish in the larger rivers, lakes and inland impoundments. Largely as a result of the annual increase in the number of anglers in the Transvaal (approximately 120 000 according to the latest statistics of the Division of Nature Conservation for the year 1977/78) and a need for an assessment of fish populations in impoundments, a series of fish ecological and population studies were initiated after 1964. The fish population study of Lake Baberspan (Göldner, 1967; Schoonbee, 1969) was followed by those of the Loskop Dam reservoir, Eastern Transvaal (Göldner, 1969; Göldner *et al.* 1972), Doorndraai Dam, Northern Transvaal (Batchelor, 1978) and Boskop Dam, Western Transvaal (Koch, 1975).

Results discussed in this paper from part of the work done on the ecology of fish in Boskop Dam conducted during the spring and summer of 1974.

Conditions at the Boskop Dam Reservoir at the Time of the Study

During the period of survey, large portions in the littoral zone of the reservoir were invaded with the submerged aquatic weed *Potamogeton pectinatus* estimated to cover approximately 50% of the total surface of the dam. Rooted plants were observed to a depth of 6 m so that a virtually continuous belt of plants 120 – 200 m wide occurred along the perimeter of the impoundment (Brandt, 1975). Despite declines in growth of *P. pectinatus* on the Highveld during winter, active winter growth of this weed was observed to take place in isolated spots.

The use of seine-netting for capturing fish was extremely difficult due to masses of the vegetation accumulating in the nets at times. The vegetation also provided shelter for the fish and hampered the mark-recapture process.

Water temperatures monitored during the year showed fluctuations between winter and summer from 11 – 26°C. The water, being largely dolomitic in origin, is very alkaline and rich in dissolved solids with pH values nearly always exceeding 8.

Materials and Methods

A mark-recapture fish population experiment commenced during Spring on 3 September, 1974 and ended 25 days later on 28 September. This time was chosen mainly because it coincided with the onset of the breeding season of the majority of the fish species. During this period the fish migrate closer to the littoral region of the dam where they can easily be sampled with seine-nets. It is also known that *Tilapia sparrmanii*, which is not an angling fish but is an important food for predator fish, migrates into deeper water during the winter months and is difficult to catch. In Spring, however, they also return to shallow water for breeding purposes. Another important consideration for the survey to take place during this period is that most of the larger fish species which hatched during the breeding season of the previous year, can already be caught during the next Spring and can thus be included in the population census of fish.

Sampling localities

Ten representative sampling stations were selected around Boskop Dam (Figure 1). Eighteen seine-net collections were made from each site during the period of study.

Fish species studied

The following fish species were included in this survey:

Family Cyprinidae: *Labeo umbratus* (A. Smith), 1841; *L. capensis* (A. Smith), 1841; *Barbus holubi* Steindachner, 1894 and *Cyprinus carpio* Linnaeus, 1758.

Family Clariidae: *Clarias gariepinus* (Burchell), 1822.

Family Centrarchidae: *Micropterus dolomieu* Lacépède, 1802.

Family Cichlidase: *Tilapia sparrmanii* A. Smith, 1840.

Marking of fish

Different methods of marking fish can be used e.g. "Floy F.D. 67" Anchor Tags (Blaber, 1973), identity discs, (Jones, 1966; Kimsey, 1957), branding with a heated wire (Gerking, 1963) and the fin clip method where parts of different fins of fish are removed (Batchelor, 1978; Göldner, 1969; Ricker, 1958, 1968).

Caudal fin clipping was used for several reasons. For example, it is a quick and effective method when marking a large number of fish and it results in low fish mortalities. This type of marking does not cause any problems for the fish as tags normally do. The method is also preferred since it complies with the requirement that a population estimate study must be completed in the shortest possible time to minimize changes in population size, mainly through deaths, immigration and emigration (Göldner *et al.*, 1972). It was also experienced that the clipped fin of a fish usually recovers within 3 months with no permanent damage and this also allows ample time for the completion of a mark-recapture experiment in dams.

In this study a portion of the ventral part of the caudal fin was clipped. It was not difficult to identify fish marked in this way, especially when large numbers were caught in nets. The removal of a small, but easily recognizeable portion from the caudal fin had no effect on the swimming ability of the fish.

Nets used

A nylon seine net of 100 m x 3 m with a mesh size of 25 mm was used. The net was laid from a motor boat in a semi-circle from the shore and pulled in by hand. Samples were taken between 07h00 and 18h00.

Statistical calculation and computations

A Fortran IV program developed at the Rand Afrikaans University was compiled in which the estimates of the population size of the fish species under consideration were made for consecutive time units (t-units) by using the methods of estimate of Schnabel and De Lury (Ricker, 1958; 1975).

Requirements for Population Size Estimates

Batchelor (1978), Blaber (1973), Göldner (1969) and Ricker (1958, 1975) give some requirements for successful fish population size estimation in lakes. These are that (ideally speaking) no

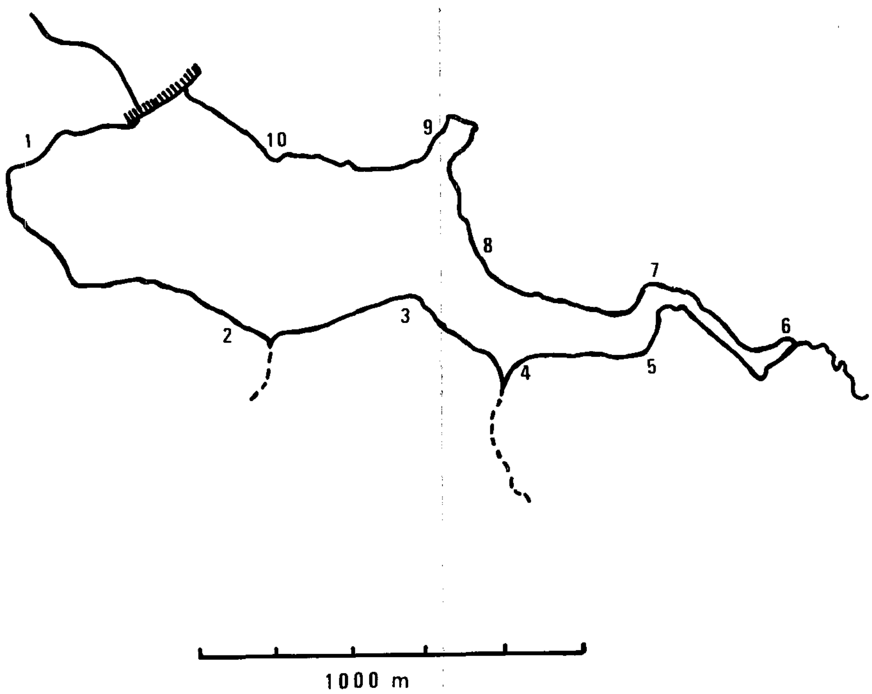

Figure 1
Sampling sites at Boskop Dam

immigration, emigration or mortalities due to natural causes or netting activities, should occur during the experiment and that the experiment should be completed as quickly as possible in order to minimize the above-mentioned causes of population variation. Furthermore, random mixing of marked and unmarked fish must occur after marking and release, in other words, sufficient time should be allowed between consecutive sampling periods at a given locality and no active avoidance of the nets by fish should take place. The type of marking should also in no way influence the subsequent capture or mortality rate of fish involved and samples should be drawn as far as possible at random from the population in a water body being investigated.

The above-mentioned requirements are usually difficult to meet. For example, it is known that fish like *Clarias gariepinus, Cyprinus carpio* and *Micropterus dolomieu* have the ability to avoid nets by either diving under or jumping over them (Göldner *et al.*, 1972). Consequently estimates for such species could be higher than the actual size of a population.

Discussion of Results

During the experiment 35 253 fish were caught. This amounted to an average of 1 752 fish per day or 196 fish per seining. The total number of fish captured (Ct), marked (Mt) and recaptured (Rt) over this period are represented in Tables 1 and 2. The selectivity of the mesh size of the net allowed fish of less than approximately 10 cm in length to escape.

TABLE 1
SUMMARY OF FISH POPULATION CENSUS DATA COLLECTED IN BOSKOP DAM DURING SEPTEMBER 1974

t-units	*L. capensis*		*L. umbratus*		*B. holubi*		*C. carpio*		*C. gariepinus*		*M. dolomieu*		*T. sparrmanii*	
	Ct	Rt	Ct	Rt	Ct	Rt	Ct	Rt	Ct	Rt	Ct	Rt	Ct	Rt
1	2 233	0	80	0	9	0	14	0	2	0	0	0	10	0
2	2 500	31	86	0	20	0	2	0	3	0	0	0	2	0
3	3 141	68	374	1	8	0	5	0	1	0	1	0	7	0
4	3 883	144	218	10	16	0	2	0	1	0	1	0	6	0
5	3 616	226	257	17	20	0	9	0	3	1	1	0	9	1
6	1 119	34	124	4	15	0	14	0	3	0	0	0	8	0
7	1 860	62	78	1	7	0	13	0	7	0	1	0	2	1
*8	1 906	129	343	4	29	3	8	0	1	0	0	0	11	3
*9	540	21	83	5	34	0	9	0	9	0	2	0	3	0
*10	1 306	73	409	9	29	1	6	0	3	0	5	0	6	0
*11	519	11	44	2	13	0	11	0	3	0	0	0	11	0
*12	1 156	92	73	3	15	0	1	0	0	0	0	0	43	3
13	1 022	104	66	10	2	1	2	0	2	0	0	0	158	13
14	579	37	139	13	1	0	0	0	0	0	1	0	4	0
15	1 432	152	434	25	29	0	0	0	1	0	2	0	121	4
16	1 937	222	254	16	20	0	4	0	4	0	2	0	227	23
*17	489	62	96	6	12	0	1	0	0	0	1	0	592	56
18	977	80	116	5	19	0	10	0	11	0	2	0	62	5
Total	30 215	1 548	3 274	131	298	5	111	0	54	1	19	0	1 282	109

Ct = Fish captured
Rt = fish recaptured
* = cold, windy days

TABLE 2
THE TOTAL NUMBER OF FISH CAPTURED (Ct), MARKED (Mt) AND RECAPTURED (Rt) DURING THE FISH POPULATION CENSUS AT THE BOSKOP DAM, SEPTEMBER 1974

Fish species	Ct	% of ΣCt	Mt	Rt	% of ΣRt
Labeo capensis	30 215	85,7	28 667	1 548	83,6
Labeo umbratus	3 274	9,3	3 143	131	7,3
Barbus holubi	298	0,8	293	5	0,3
Cyprinus carpio	111	0,3	111	0	0
Clarias gariepinus	54	0,2	53	1	0,1
Micropterus dolomieu	19	0,1	19	0	0
Tilapia sparrmanii	1 282	3,6	1 173	109	6,1
	ΣCt: 35 253	100	ΣMt: 33 459	ΣRt: 1 794	100

Population size estimates of the different fish species

Results on the final (t = 18) values of population size estimates for the Schnabel and De Lury methods as well as the mean values for the estimates obtained for each fish species are summarized in Table 3. From Table 2 it follows that no marked specimens of *C. carpio* and *M. dolomieu* were recaptured while only one specimen of *C. gariepinus* was recaptured. As mentioned earlier, it is known that *C. carpio* when once captured in a net, actively avoids being caught (Göldner, 1967, 1969). It is also known that both *M. dolomieu* and *C. gariepinus* usually attempt to escape from under nets and often succeed (Göldner, personal communication.

the highest with the greatest difference occurring during the periods t = 10 — 12. Hereafter, the differences between values obtained for population size of *L. capensis* for the corresponding t-periods decline with the estimate given by De Lury at t = 18 only being 7 000 higher than that of Schnabel. It can also be seen that in the case of the Schnabel method, the 95% confidence limits are more closely grouped around the values of estimate. This applies in particular to the upper limits (Figures 2 and 3). Furthermore, the narrowing of the confidence limits (t = 4 and t = 5) coincides with better recapture results at that stage (Table 1).

TABLE 3
FISH POPULATION SIZE ESTIMATES ($\hat{N}$) FOR THE DIFFERENT FISH SPECIES ACCORDING TO THE SCHNABEL AND DE LURY METHODS

Fish species	Method of estimate	$\hat{N}$	95% Confidence limits
Labeo capensis	Schnabel	263 414	250 006 — 278 341
	De Lury	270 948	235 685 — 318 618
	$\bar{x}$	267 181	242 845 — 298 480
Labeo umbratus	Schnabel	36 409	30 719 — 44 686
	De Lury	39 614	30 412 — 56 799
	$\bar{x}$	38 011	30 565 — 50 742
Barbus holubi	Schnabel	8 092	4 163 — 143 524
	De Lury	11 612	3 977 — 12 628
	$\bar{x}$	9 852	4 070 — 78 076
Cyprinus carpio	Schnabel	—	— —
	De Lury	—	— —
	$\bar{x}$	—	— —
Clarias gariepinus	Schnabel	1 252	403 — 00
	De Lury	5 718	606 — 00
	$\bar{x}$	3 485	504 — 00
Micropterus dolomieu	Schnabel	—	— —
	De Lury	—	— —
	$\bar{x}$	—	— —
Tilapia sparrmanii	Schnabel	5 074	4 221 — 6 359
	De Lury	6 435	4 846 — 9 580
	$\bar{x}$	5 754	4 533 — 7 969

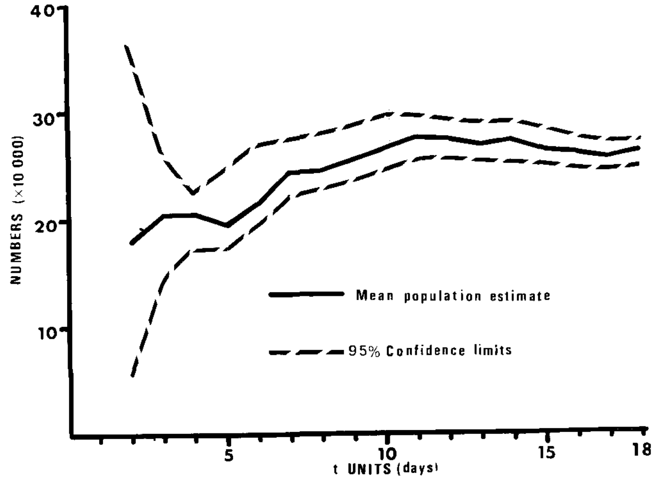

Figure 2
Estimates of the numbers of Labeo capensis *in Boskop Dam according to the Schnabel method*

Observation on population estimates

Labeo capensis

From the results obtained for the fish population size estimates, *L. capensis* is the dominant fish species in the Boskop Dam with an esstimated number of 267 000* fish larger than 10 cm in size. This represents 81,7% of the total number of the larger fish species estimated to be present in the dam. In comparing the patterns of population size estimates of *L. capensis* for the De Lury and Schnabel methods of population size estimate (Figures 2 and 3), it can be seen that with the exception of the t = 5 period, all other values obtained with the De Lury method are

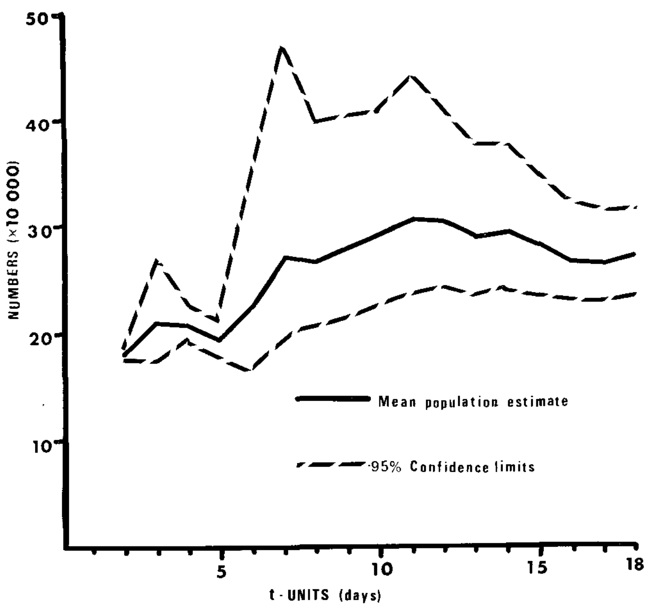

Figure 3
Estimates of the numbers of Labeo capensis *in Boskop Dam according to the De Lury method*

*Means of t = 18 values of estimate for Schnabel and De Lury taken as representing estimate of population size of fish in Boskop Dam.

Labeo umbratus

This species, with a mean estimate number of 38 000 fish larger than 10 cm in Boskop Dam, is the second most abundant after *L. capensis* (Table 3). Tendencies in values of estimate as well as those for the grouping of the 95% confidence limits around the estimated values in many ways resemble those for *L. capensis* (compare Figures 2 — 5). The end values of the two methods for this species namely 36 409 (Schnabel, Fig. 4) and 38 614 (De Lury, Fig. 5) both fall within the confidence limits of that of the Schnabel method and the difference between these two estimates is only 8%. As in the case for *L. capensis* the final (t = 18) estimates of the two methods obtained are near each other by the end of the experiment.

Barbus holubi

Due to the poor recapture data, no valid estimate is possible for this species in Boskop Dam for either of the two methods of estimate. (Figures 6 and 7). As a result, the 95% confidence limits are widely scattered around the estimate values, especially in the upper limits. In both methods there was no stabilization in the population size estimates towards the 20th day. In the case of *B. holubi*, therefore, the mark-recapture experiment should have been extended.

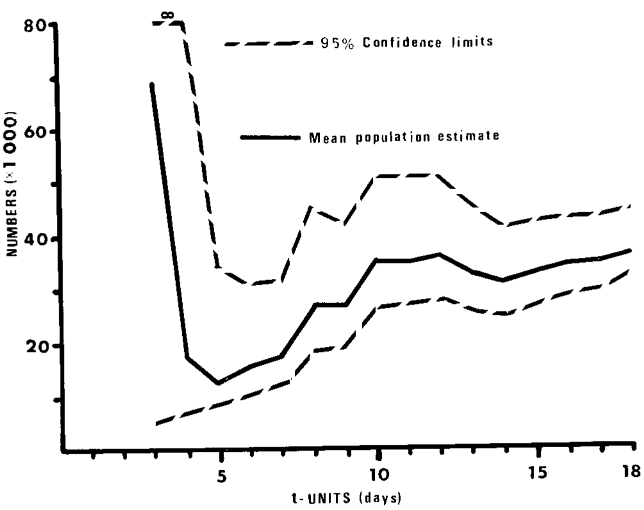

Figure 4
Estimates of the numbers of Labeo umbratus *in Boskop Dam according to the Schnabel method*

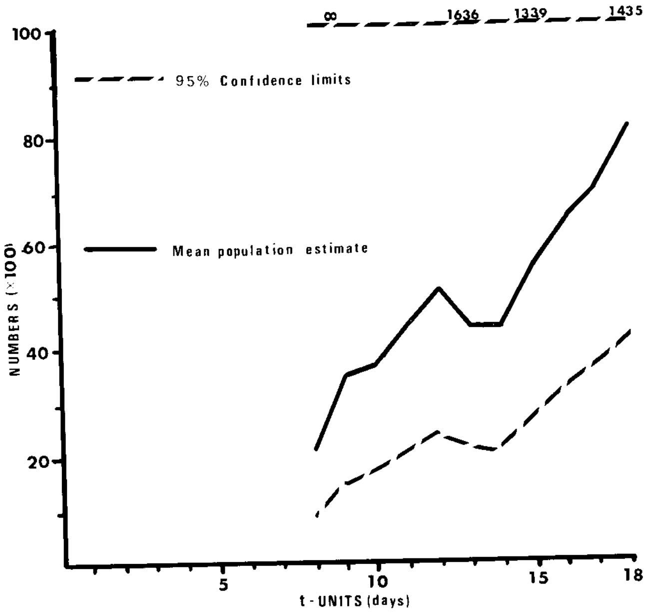

Figure 6
Estimates of the numbers of Barbus holubi *in Boskop Dam according to the Schnabel method*

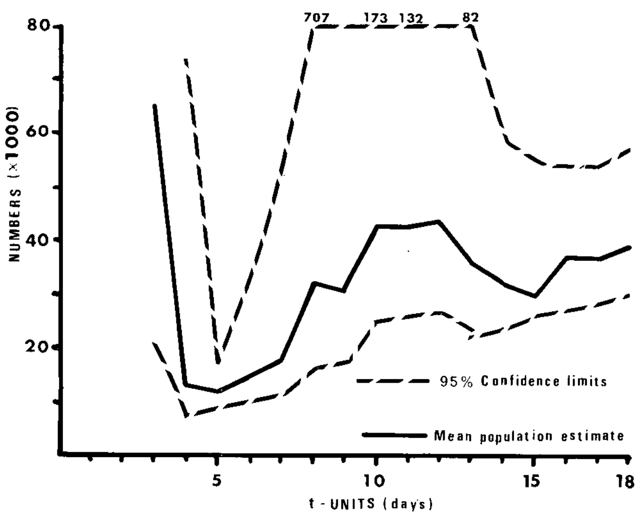

Figure 5
Estimates of the numbers of Labeo umbratus *in Boskop Dam according to the De Lury method*

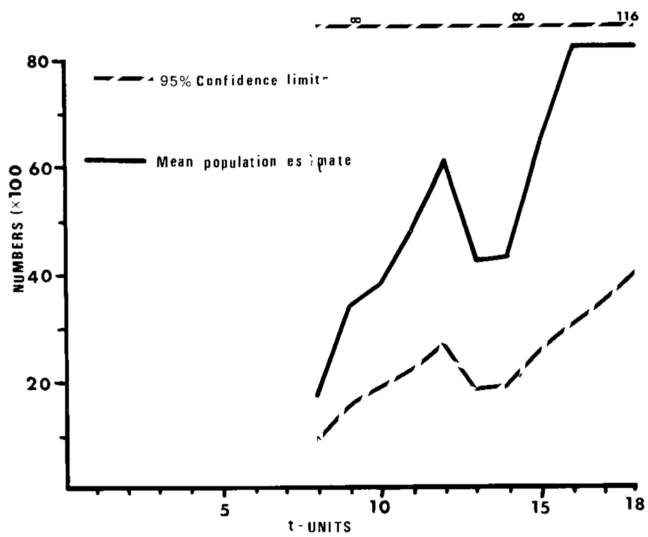

Figure 7
Estimates of the numbers of Barbus holubi *in Boskop Dam according to the De Lury method*

Cyprinus carpio

No recapture was made and therefore no estimate could be obtained. Although the actual numbers of this fish species are apparently low, it nevertheless shows a good breeding potential as one *C. carpio* gravid female of 5 kg in mass was found to contain 838 500 eggs.

Clarias gariepinus

Only a few specimens were caught and marked with only one recaptured. No reliable estimate was possible.

Micropterus dolomieu

A total of 19 specimens were caught with none of the marked fish recaptured. Twenty thousand *M. dolomieu* fingerlings were introduced into Boskop Dam from 1969 – 1977. From the results obtained *M. dolomieu* either does not breed actively in the dam and/or this fish is able to avoid the nets.

Tilapia sparrmanii

T. sparrmanii is not an angling fish but serves as an important prey for predator fish. Due to its relatively small size of usually under 20 cm in length, this species is considered by anglers as a problem fish.

The mean population estimate for *T. sparrmanii* is 5 754 (Table 2). For both methods of estimate (Figures 8 and 9), values continued to increase for consecutive t-units with no sign of stabilizing towards the end of the experiment (Figures 8 and 9). This trend suggests that despite the recapture of marked specimens there was also a possible recruitment to the *T. sparrmanii* population from the deeper water areas of the dam. The mark-recapture experiment of this species, therefore, should also have been extended over a longer period. The estimated number of 5 700 fish for this species in Boskop Dam may thus be too low.

Conclusions and Recommendations

Labeo capensis and *Labeo umbratus* are clearly the numerically dominant species in Boskop Dam, representing approximately 93% of the total estimated number of the larger fish species. As a result of their benthic feeding habits, these species are to a certain extent also in competition with the more popular angling fish species such as *Barbus holubi*. Both species of *Labeo* are not easily caught on the hook. They have a high production potential which explains their numerical dominance in Boskop Dam.

Excessive growth of the sago pond weeds *Potamogeton pectinatus* interfered with the seining efforts during the mark-recapture experiment. This, in part, accounts for the relatively poor capture and consequent recapture of *C. carpio, C. gariepinus* and *M. dolomieu*. The only way in which better estimates could have been obtained would have been to extend the mark-recapture experiment for these fish species, but then factors such as the gradual recruitment from previously smaller fish over a longer period may have interfered in the estimates.

The value of fish population studies of impoundments in the proper management of such water bodies was again illustrated by the present study. Based upon the present findings, a certain number of both species of *Labeo* were removed by seine-netting, thereby reducing competition with the more popular angling species such as *B. holubi*. It is recommended that the cropping of *Labeo* from Boskop Dam be done regularly. As an alternative measure to control the numbers of *Labeo* it is suggested that for the sake of the anglers, the number of the predators such as *M. dolomieu* and the large-mouth yellow fish *Barbus kimberleyensis* be increased in the dam by means of a

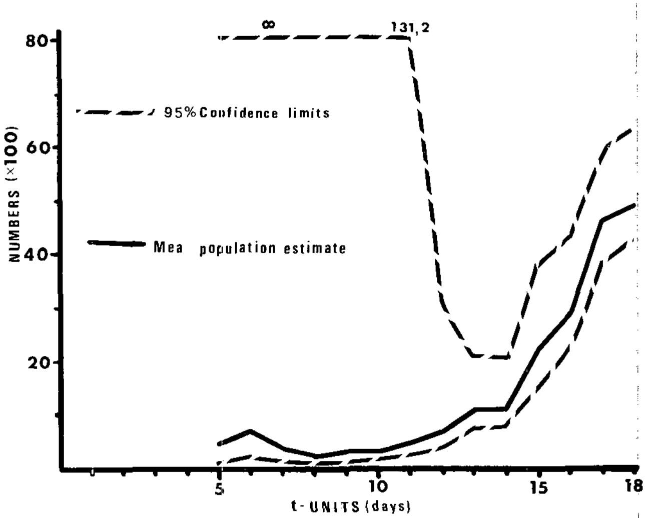

Figure 8
Estimates of the numbers of Tilapia sparrmanii *in Boskop Dam according to the Schnabel method*

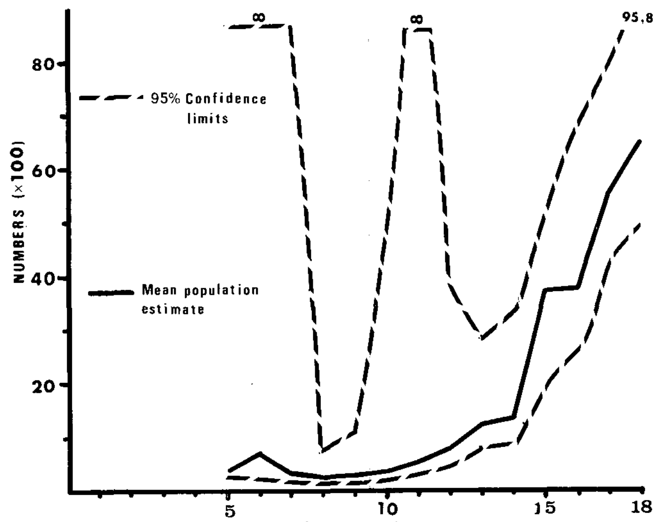

Figure 9
Estimates of the numbers of Tilapia sparrmanii *in Boskop Dam according to the De Lury method*

regular stocking programme. It is further proposed that the Chinese grass carp, *Ctenopharyngodon idella,* which has been spawned artificially on a large scale at Marble Hall (Schoonbee *et al.*, 1978) and which is also an angling fish species, be introduced to combat the growth of the waterweed *P. pectinatus.* This step can, however, only be taken when the present research programme on this fish species has shown that it would not be a threat to indigenous fish species in impoundments such as Boskop Dam.

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3.1 An original typed script in double spacing and two copies should be submitted. The title should be concise and followed by the authors' names and complete addresses. One set of original line drawings on good quality drawing paper or glossy photoprints should be submitted. Photographs should be on glossy and not matt paper, enlarged sufficiently to permit clear reproduction in half-tone. Three sets of copies should accompany each submission. All illustrations (line-drawings and photographs) must be fully identified on the back and should be provided with descriptive legends typed on a separate sheet. Illustrations should be packed carefully, with cardboard backing, to avoid damage in the post. The appropriate positions of illustrations should be indicated in the text.

3.2 Tables are numbered in arabic numbers (Table 1) and should bear a short yet adequate descriptive caption. Their appropriate positions in the text should be indicated.

3.3 The S I system (International System of units) should be used.

3.4 References to published literature should be quoted in the text as follows: Smith (1978) – the date of publication, in parentheses, following the author's name. All references should also be listed together at the end of each paper and not given as footnotes. They should be arranged in alphabetical order (first author's surname) with the name of the periodical abbreviated in the style of the *World List of Scientific Periodicals* (4th edn, Butterworths, London, 1963–1965, with supplements) and appear as follows:

MATSON J.V. and CHARACKLIS W.G. (1976) Diffusion into microbial aggregates. *Water Research* **10**(10) 877–885.

THRING M.W. (1975) *Air Pollution* p 132 Butterworths, London.

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