AN EVALUATION OF MARK AND RECAPTURE TECHNIQUES FOR ESTIMATING TIGERFISH BIOMASS IN LAKE KARIBA.

LAKE KARIBA FISHERIES RESEARCH INSTITUTE

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by

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Part 1 : The Techniques.

1. Introduction.

Ways of marking fish have been used widely in studies of stock assessment, growth, distribution and movement of fish populations. Most marking techniques fall within three categories, (1) Excision of body parts, (2) tagging and (3) biological staining (Phinney et al, 1967). Tagging methods have been used in estimation of tigerfish biomass in Lake Kariba (Junor, pers. comm.) and while successful, limitations in sampling of the fish led to dubious results. In 1977 the relatively new method of fluorescent spray marking was introduced to the tigerfish programme in Kariba. It was applied again in 1978, and again in conjunction with a tagging programme in 1979.

Fluorescent spray marking was developed by Jackson (1959) and has been used on Salmon by a number of workers (Phinney et al, 1967 : White 1976 : Hennick & Tyler, 1970). The technique basically involves the use of dry, finely-ground fluorescent pigments which are sprayed onto the dermis and epidermis of fish with compressed air. Most of the pigment only penetrates the mucous layer which is sloughed off, but the remaining pigment is embedded in the epidermal and dermal layers covering the scales. The mark is therefore soon invisible to the naked eye, but fluoresces when activated by ultra-violet light.

Tagging has been used successfully on tigerfish in Lake Kariba (L.K.F.R.I., unpublished data). A plastic tag, commonly used in the clothing industry, is introduced into the musculative adjacent to the dorsal fin of the fish by means of a tag gun and provides a clearly visible mark which causes no apparent distress to the fish.

2. Material and Methods.

2.1 Fluorescent Spray Marking.

2.1.1 Materials.

The pigments used in the exercise consisted of a solid solution of

fluorescent dyes in a resin of melamine-sulphonamide-formaldehyde. Because of their insolubility in water, these pigments are non-toxic to fish (Phinney et al, 1967). The compounds consisted of powders with a particle size of less than 20 u in diameter and came in four colours : red, green, blue and yellow. This material was imported from the U.S.A. but remaining equipment was obtained in this country.

The marking equipment consisted of a spray-gun with a 2-litre cannister, of the type commonly used by garages for cleaning engines. This type of gun uses the 'venturi' principle to lift material from the cannister and blast it through a nozzle. The spray-gun was connected, by high pressure hosing, to a 100kg compressed air cylinder through a regulator capable of delivering 1000 kpa.

Detection equipment consisted of ultra-violet lamps, with 125 watt bulbs, connected to a 220 volt A.C. power source. The scanning procedure normally had to be carried out in a darkened room.

2.1.2 Preliminary tests.

The fluorescent spray marking technique was tested on captive tigerfish in the laboratory prior to its application in the field. The tests were designed to determine mark retention and to assess post-marking mortality in tigerfish. The procedures for testing are summaries in Table 1.

Table 1 : Fluorescent Spray Marking - Preliminary Tests.

MARKING

SPRAY GUN PRESSURE 400 kpa to 650 pka DIST. NOZZLE TO FISH 10 to 35 cm				
DATE	NO. FISH MARKED	SIZE FISH	% MORTALITY	SAMPLE CODE
21.9.77	11	18 - 22 mm	NIL	1
27.9.77	5	6 - 8 cm	NIL	2
3.1.78	10	19 - 25 cm	20	3

2.1.3 Application in the Field.

The spray technique was used to estimate standing crop of tigerfish in the Sanyati Gorge in 1977, 1978 and 1979. The exercise was aborted in 1978 because of adverse weather conditions, but some measure of success was achieved in the application of the technique in the other two years. The numbers of fish marked are shown in Table 2.

Table 2 : Fluorescent spray marking in the Sanyati Gorge.

DATE	STATION	NO. MARKED
5.12.1977	1	299
	2	183
	3	183
	TOTAL	703
1.12.1979	1	548
	2	1548
	TOTAL	2096

2.2 Tagging

2.2.1 Materials

The equipment required for tagging is very simple and light, consisting primarily of a tag-fastener and clips of plastic tags. The tag fastener or 'tag gun', in conjunction with the tags are designed for use in the clothing industry, but the system lends itself to the marking of fish.

The instrument used in our programme was a "Mark II Swiftacher" tag fastener with a detachable 2cm needle. The plastic tags, coloured red and white, were 5cm in length and arranged in clips of 25.

2.2.2 Tagging

A tagging programme was begun in 1977 but the equipment failed and the attempt abandoned. However, in 1979 an extensive tagging exercise was carried out with new equipment in the Sanyati Gorge with very gratifying results. At each of the stations fish were either spray-marked or tagged,

and, until the tags were exhausted, this system kept pace with the spray marking. A total of 984 fish were tagged, 535 at Station 1 (with 548 sprayed) and 449 at Station 2.

3. Results.

3.1 Fluorescent Spray Marking

The results of the preliminary tests on spray marking were variable, and were very much a function of the distance and pressure of dye application. The results are shown in Table 3.

Table 3 : Fluorescent Spray Marking - Preliminary Tests.

DATE OF DETECTION	NUMBER MARKED	NUMBER RETAINING MARK	TIME ELAPSED	SAMPLE CODE
6.10.77	11	4 (36%)	15 days	1
25.11.77		4	65 days	
6.10.77	5	1 (20%)	9 days	2
25.11.77		1	59 days	
9.8.78	10	5 (62.5%)	219 days	3
4.4.79		1	457 days	

In samples 1 and 2 mark retention was low after only two months and this was attributed to insufficient pressure from the spray gun. In sample 3, mark retention was fairly good, but at the cost of a 20% mortality rate in the marked population. It was noticed that at pressures approaching 100 p.s.i. and distances below 10cm there was a loss of scales during application. This could have lead to fungal infection and subsequent death.

Of 700 tigerfish marked in the gorge in 1977, 19 were recovered. In all cases the marks were clearly visible to the naked eye and indications were that mark retention was good. However, in 1979, only 4 marked tigerfish were recovered even though more than 2000 were marked. The recapture exercise that year involved returning the fish to a factory in Kariba where they were examined the following day. On the night of

recapture several fish with clearly visible dye marks were seen as they were landed, but these had disappeared by the time the fish reached the factory. Features contributing to the failure of the spraying exercise in 1979 probably included:

a) Deterioration of the skin of the fish through bruising, rough handling and rotting. Many of the tigerfish inspected at the factory had lost a large number of scales, and the skin had become discoloured and soft. The majority of marks were probably lost for this reason.

b) Spraying technique and spray gun failure; often very little dye was lifted by the 'venturi' and so consequently only compressed air was blown onto the fish. This was often shown by a shower of scales being blown off the fish.

3.2 Tagging

Tag recoveries in the 1979 marking exercise were encouraging. On the night of recapture 68 tagged fish were recovered, and an interesting feature was that none of these showed any adverse effects from the tagging trauma. During the subsequent week a small tagged tigerfish was recovered from a gill-net some 3km from the point of release. Later during the same month, an angler caught a male tigerfish which carried a tag from the 1976 programme (Junor, pers. comm.). The 1980 International Tigerfish Tournament produced a tigerfish that had been tagged in 1979 and a further report of a tagged tigerfish came in from the angling census in the Sanyati Gorge.

4. Discussion.

The use of both spray marking and tagging in the 1979 mark and recapture exercise afforded the opportunity to evaluate and compare the two techniques. Obviously there are limitations to both methods and at present there is a puacity of data on such aspects as post marking mortality and mark retention under Kariba conditions. However, this pertains particularly to stock assessment studies and, as will be discussed in Part 2, these limitations may well be overshadowed by far greater sources of

error in population estimates. There is, therefore, adequate potential for the utilization of these techniques in other studies such as growth, distribution and movement of fish populations.

An evaluation of the two techniques, within the constraints of the tigerfish study, must favour tagging as the logical method to use. The reasons may be summarised as follows:

a) Tagging is the simpler method, requiring only a small, light tag gun and tags. Conversely the spray-marking technique requires heavy bulky equipment subject to the capriciousness of faulty regulators and leaking valves.

b) It was found that the nozzle of the spray gun tended to clog-up periodically under the damp conditions in which the work was conducted. No such fault lay with the tag gun.

c) The argument that the spraying is a much quicker technique proved unfounded in our exercise.

d) A severe shortcoming of the spray marking technique was the very rapid deterioration of the mark when fish were handled roughly. Under similar conditions tags were found to remain securely in place.

e) Detection of tagged fish is far easier than sprayed fish. Scanning each individual fish with U.V. lights proved to be a laborious and time consuming job. Further, in tagging there is far more potential for recaptures to be recorded through anglers and commercial fishermen.

f) In terms of capital outlay, maintenance and operation, tagging is more cost-effective than spray-marking.

5. Conclusions.

Marking techniques have numerous applications to fish biology in Lake Kariba and will remain an important ecological tool. The advantages of simplicity, flexibility and cost effectiveness has made tagging the preferred marking technique for local conditions.

Part 2 : Estimations of Tigerfish Biomass based on mark and recapture methods (Petersen Method).

1. Introduction:

The marking and recapture of fish is one of the principal techniques employed in the estimation of fresh water fish populations (Robson & Reiger, 1968). Petersen developed the practice of using marked fish to estimate populations in closed bodies of water towards the end of the last century (Ricker, 1975).

The method involves marking fish from a population, releasing them, and then taking a subsequent sample and examining it for marked fish. The population size, N, is then estimated by the formula:

$$N = \frac{M.C.}{R}$$

Where, N = size of population,

M = number of fish marked,

C = sample taken for census,

R = number of recaptured marks in sample.

The formula was slightly modified by Chapman (1951) to give an unbiased estimate of population size and now becomes:

$$N = \frac{(M + 1)(C + 1)}{R + 1}$$

This method was used in 1977, 1978 and 1979 in an attempt to estimate the standing crop of tigerfish in the Sanyati Gorge, Lake Kariba.

2. Materials and Methods:

The spray-marking and tagging techniques have been described in Part 1 of this report.

The tigerfish were generally captured with a purse-seiner using light-attraction in the Sanyati Gorge. In each case a commercial fishing company was asked to undertake the capture exercises. The Sanyati Gorge was considered the most suitable locality for the mark and recapture programme because of the congregation of mature fish there prior to their

spawning run. Generally the exercises were completed in late November each year, just before the start of the main rains.

2.1 First mark and recapture exercise - 1977.

The first exercise was carried out on the night of 5th December 1977, using a chiromila net and three light boats. Two hauls were made at each light boat and a total of 703 tigerfish marked. Recaptures were done with the same fishing unit on the nights of the 9th, 13th, 14th and 15th December.

2.2 Second mark and recapture - 1978.

This exercise was abandoned because of very poor weather.

2.3 Third mark and recapture - 1979.

Two sampling stations were chosen, one at the first crossroads and the other about 1,5km nearer the mouth of the gorge. The captures were made with a purse-seine net measuring 100m x 20m and the fish were attracted by means of a light boat at each station. The recaptures were made on the following night, 24 hours after the marking exercise. The same stations were chosen and it was considered that 24 hours between marking and recapture was sufficient to allow the marked fish to mingle with the population without migrating too far from the experimental area. All the recpatured fish were returned to the factory at Kariba for mark detection.

3. Results and Discussion.

The results for the 1977 and 1979 mark and recapture exercises are summarised in Table 1.

Table 1 : Results of Mark and Recapture exercises.

YEAR	NO. MARKED	NO. RECAPTURED	NO. MARKED FISH IN SAMPLE	MEAN WT. RECAPTURED FISH (kg.)
1977	703	341	7	1,04
		2631	5	0,64
		4279	4	0,66
		3012	3	0,56
1979	SPRAYED TAGGED		SPRAYED TAGGED	
	2096 984	3253	4 68	1,57

An adjusted Petersen estimate was applied to this data to obtain an estimation of biomass and the results are shown in Table 2. Also included in the table are the biomass estimates for 1976 (L.K.F.R.I., unpublished data) for comparison.

Table 2 : Estimates of Tigerfish populations.

YEAR		NO. FISH	BIOMASS IN TONNES	kg./ha.
1976	1	1 936 968	1976	564,6
	2	1 385 942	1414	404,0
	3	237 328	76	21,7
	4	292 218	140	40,0
	5	549 108	417	119,1
1977	1	30 096	31,3	89,0
	2	306 628	300,5	85,9
	3	594 920	392,6	112,2
	4	521 249	302,3	86,3
1979	1	45 481	71,4	20,4
	*	140 000	210	59,5

* The Petersen estimate of 45 481 tigerfish in 1979 related to a very small sampling area, and was therefore adjusted to include the entire gorge, assuming a uniform distribution of tigerfish throughout the gorge. The two sampling stations were assumed to be representative of only a third of the

gorge area, and so the adjusted estimate was 140 000 fish.

The Petersen estimates of tigerfish biomass show a great deal of inconsistency. The 1976 estimates are very variable and range extremely high. A figure of 564kg per ha., or two million fish for the Sanyati Gorge, is without doubt an overestimation. The estimates were again variable in 1977 and high compared to the 1979 figure. One reason for this could be poor tag recovery in 1976 and 1977. In 1976 a total of 20 tags were recovered during the course of five recapture exercises, while in 1977 the total was 19 during four recaptures. In 1979, 68 tags were recovered from a single recapture exercise and there is no doubt that the larger percentage tag recovery, the more accurate the final estimate will be. Another reason could have been the time interval between the work and recapture phases of the exercise. During the 1976 and 1977 programmes, at least a week elapsed between the marking and recapture. This may well have resulted in marked fish migrating out of the area, resulting in fewer tag recoveries and exaggerated estimates of biomass. The 1979 exercise lasted 48 hours, which allowed sufficient time for the marked fish to be absorbed into the unmarked population while not enough time for large scale movement of marked fish out of the area. Consequently, the 1979 mark and recapture programme was considered more successful than previous attempts, although the final estimate of biomass may not be realistic. However, data from commercial catches and angling have suggested that the tigerfish population has decreased over the last two years, and the results of the mark and recapture programmes do reflect this trend.

4. Conclusions.

Mark and recapture techniques for the estimation of population size of tigerfish cannot be considered completely reliable for Lake Kariba. The method has a number of limitations, some of which are particularly applicable to Kariba. Conditions which must be met include (Ricker, 1975):

a) Marked fish must suffer the same natural mortality as unmarked fish, i.e. mortality due to marking should be neglible.

b) Marked fish must be equally vulnerable to fishing as unmarked fish.

c) Marks should not be lost.

d) Marked fish must become randomly mixed with unmarked fish upon release.

e) There should be no emigration of marked fish during the exercise.

f) There should be only a negligible amount of recruitment to the catchable population during the exercise, i.e. no immigration.

Our work has shown that there is low mortality amongst marked tigerfish and that mark retention is good; at least during the mark and recapture exercise. However, the question of emigration and immigration of fish from and to the gorge during the mark and recapture exercises could well invalidate our estimates. In addition, we may not have marked sufficient tigerfish in our programmes to give meaningful estimates. Although the method cannot be used for estimates of absolute biomass, it has reflected the general downward trend in the tigerfish population in Basin 5.

However, while the method may have limited use in population estimates, marking does have application in other fields in tigerfish biology in Kariba and is being used in studies of its growth, movement and distribution.

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