A Method for Measuring Lengths of *Tilapia mossambica* by Videotape Techniques

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ABSTRACT

An effective apparatus was constructed (henceforth referred to as "segregator") for measuring the total lengths of *Tilapia mossambica* by videotape techniques. The method of video length measurements was statistically compared to hand measurements. Data for both methods were collected from two size groups: ten 2-3 inch and ten 4-6 inch fishes (*Tilapia mossambica*). According to the "Student's t-test," the mean total length of the fishes from both test groups

were not statistically different. Also, the data collection time in the smaller size fish using the video technique was 25 percent faster than by hand. Time measurements were not measured in the larger size fish. In addition, an analysis of variance to determine repeatability or intraclass correlation showed no difference in the two methods in the amount of error produced. In summary, the mean length and error produced in the video method was not different from the conventional hand method. However, the time it took to collect data of smaller size fish using video was shorter than by hand.

INTRODUCTION

Utilizing photography instead of direct hand measurements for measuring fish lengths is an attractive alternative. In the past, experiments using still photography suggest that measurements with reasonable accuracy in a short time are possible for both large (Hawkes, 1975) and small (Martin, 1967) fishes. Other experiments that produced highly defined photographs of fish scales, operculas and otoliths (Banks and Irvine, 1968) further suggests the potential of obtaining precise measurements. A technique used in this study will be measuring total lengths in fish by videotape technique. This has several advantages in reducing the time and amount of direct handling for minimization of stress. Since time and handling are reduced, the fishes sampled are less likely to be injured and exposed to stress, diseases and contaminants. As a result, aquaculture-fisheries can potentially improve current production yields. Fisheries may find this device especially beneficial while studying species that require minimal handling. Experiments testing fish growth rates, ideal temperature and salinity conditions, geographic distributions and other studies requiring length measurements will find the videotape technique useful.

Therefore, the primary objective of this Marine Option Program (MOP) project is to develop and test a novel method that incorporates the advantages of videotape techniques, and produces accurate and reliable data.

METHODS AND MATERIALS

General Function of Segregator

The basic design of segregator is simple. It essentially consists of two separate holding tanks or reservoirs connected by a narrower transparent glass that will be referred as the "chute" (Figures 1-4). Both of these reservoirs are boxed shaped and used for holding fishes before and after each fish individually swims through the chute to be videotaped. Tank #1 (which holds fishes prior to video-taping) differs from tank #2 in that it includes a water permeable, adjustable inclined ramp that individually force funnels or herds a fish through the chute without direct handling. Likewise, tank #2 differs from tank #1 in that it has a one-way gate that prevents re-entrance back into the chute. The chute primarily serves to segregate the fishes into a single file for individual videotaping and can easily adjust to the width, length, and height of any fish. In addition, the chute includes an adjustable background that prevents the fishes from slumping by holding them upright for accurate measurement. The chute's viewing glass should be thin to reduce distortion (magnification) of the fish. Also, the adjustable background plate should be black or white since it provides a good contrast for *T. mossambica*.

Operating Procedure of Segregator

In this study, the tanks accommodated 10 fishes ranging from 2 to 6 inches long, 1/4 to 4 inches high and 1/8 to 1 inch thick. Before each videotaping session, the water was adjusted to the height of the largest fish's caudal fin to reduce difficulty in herding fishes into the chute. It seemed odd to fill an 18-inch tank with only 4 inches of water but the high walls served to prevent the fishes from jumping out. For detailed tank specifications and construction procedures, see Appendix 1.

The adjustable incline ramp was water permeable and non-hazardous to the fish. To direct the mass of fish towards the entrance of the fish chute, the operator must pull up the nylon rope which lifts up that end of the ramp. As the ramp was lifted, the water seeped through the perforations, sieving the fishes from the water. By lifting the ramp, the fishes were herded one by one through the chute. For ramp specifications and construction procedures, see Appendix 2.

Prior to videotaping, the video camera was placed perpendicular to the chute's viewing glass and the lens focused simultaneously on the fish and ruler (mm) that was taped on the background (Figure 3A in Appendix 3 and Figures 5-8). A trial run was conducted to correctly adjust the distance between the background and the viewing glass in correspondence with the width of the fish. The space should be set such that the fish can barely swim through it. For chute specifications and construction procedures, see Appendix 3. Upon leaving the chute, the fish swims through a one-way gate and into tank #2.

The following is a summary of operating the segregator with videotape technique:

(1) Adjust height of water to the height of fish,

(2) Conduct a trial run to adjust plexiglass background and to sharpen video camera's focus on the fish,

(3) When ready, put fishes into tank #1 and pull up ramp's rope to lift ramp upwards,

(4) As fishes travel through the chute, record with videotape,

(5) After videotaping, release fish through one-way gate,

(6) Get the following fish ready,

(7) Repeat from step 4.

Procedures for Length and Time Measurements

The hand video length measurements were based on the total length (mm) of the fish (Figure 9). Standard length measurements were not used because of the difficulty differentiating the caudal fin from the last vertebrae while measuring the black and white videotaped recordings. Using the hand method, each subject was manually: (1) captured and removed from the water, (2) measured directly with a ruler, and (3) numbered and placed into tank. After all of the subjects were measured, they were similarly measured again but in random order.

The video method involved: (1) putting all ten subjects in tank #1, (2) lifting the ramp to segregate a subject into the chute, (3) adjusting the background, (4) numbering and videotaping the fish, (5) briefly allowing the fish to swim in the chute, (6) repeating steps 3 and 4, (7) releasing subject into tank #2 through the one-way gate, (8) getting the next subject ready, (9) repeating from step 2. Each videotaped recording was measured with a ruler directly from a television monitor. Both recordings of each fish were measured before measuring the next subject.

The data collection time in seconds for both methods included the time to: (1) select an individual, (2) position the subject against the ruler, and (3) read and record the measurement.

Statistical Analysis of Data

The statistical analysis between the video and hand methods was tested by a student's t-test and a nested analysis of variance (ANOVA) for repeatability (Appendix 4). Statistical differences were considered significant at 5% levels. The student's t-test was used to determine statistical differences between the two methods in the mean total length (mm) and the mean collection time (sec) from the data (Appendices 5 and 6). A nested analysis of variance was used to determine variances in each method for repeatability or intraclass correlation.

RESULTS

With restrictions such as 9 degrees of freedom (d.f.) and a 95% confidence level, the critical point was 1.77 for the student's t-test and 3.02 for the ANOVA. The calculated t-values for the total length was 0.78 for large fishes and 0.474 for small fishes (Table 1). This indicated that there was no significant difference between the two methods (Table 2). The t-value for data collection time for small fishes was significant. Video data collection time was significantly faster than the hand method by about 3 seconds. An f-test showed a significant difference in the size of the subjects which was expected since the samples were of different ages, genetic background and origin.

The repeatability (SS_{group}/SS_{total} ratio) was 0.995 for large and 0.990 for the small fishes measured with the hand and 0.992 for the large and 0.987 for the small fishes under the video method. In each case, the high ratios indicate a high repeatability among the replicate measurements per individual. This demonstrates a high level of reliability within the measurements of both test groups using both methods (Tables 3 and 4).

DISCUSSION

Assuming that the hand method is the standard manner of measuring fish, the potential of using segregator in conjunction with video equipment is a highly attractive alternative. Its total length measurements and level of error were no different than that of hand measurement, plus the data collection time was faster. Problems were encountered while adjusting the plexiglass background. Small gaps underneath and on both sides of the plexiglass allowed the small fishes to swim behind the background and conceal themselves from the camera. The gaps were caused by cutting plexiglass pieces smaller than the measurements directed. However, simple corrections significantly improved the chute's performance. The incline ramp and one-way gate performed efficiently during videotape recording. Overall, segregator was a quick, simple and effective design to use with videotape equipment.

On a large scale basis, the manifestation of segregator with videotape equipment is advantageous. For every ten thousand fishes measured, approximately thirty thousand valuable seconds are saved. Commercial fisheries can reduce costly labor expenses and re-invest into more crucial areas. Likewise, researchers will have more freedom. Although the costs of the videotape equipment and segregator's raw materials can't be overlooked, the advantages definitely exceed the costs.

ACKNOWLEDGMENTS

I gratefully acknowledge the technical assistance of Mr. Conrad Geronimo, Mr. Bob Mason and staff of the Health Instructional Resources Unit (HIRU) of the University of Hawaii at Manoa. Special thanks to the staff at the Hawaii Institute of Marine Biology for the use of their shop facilities and assistance. Also, a big mahalo to the MOP for their financial support. But, mostly, I would like to thank Mr. Randolph Yamada for his patience, cooperation and spirit and with that, I would like to dedicate this MOP project in his name.

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1. Banks, J.W. and W. Irvine. 1969. A note on the photography of fish scales, operculas and otoliths using an enlarger.

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5. Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Co., San Francisco. 776pp.

Figures 1 and 2

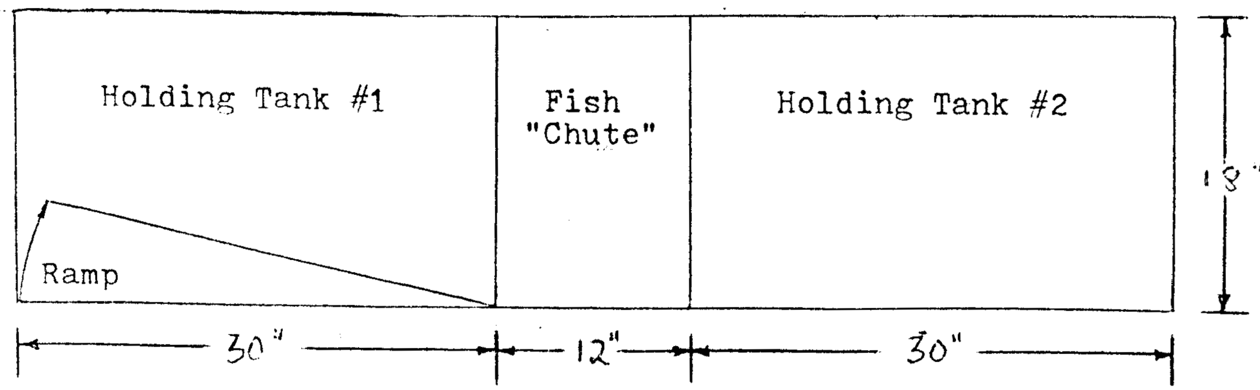

Figure 1: Front view and dimensions of segregator

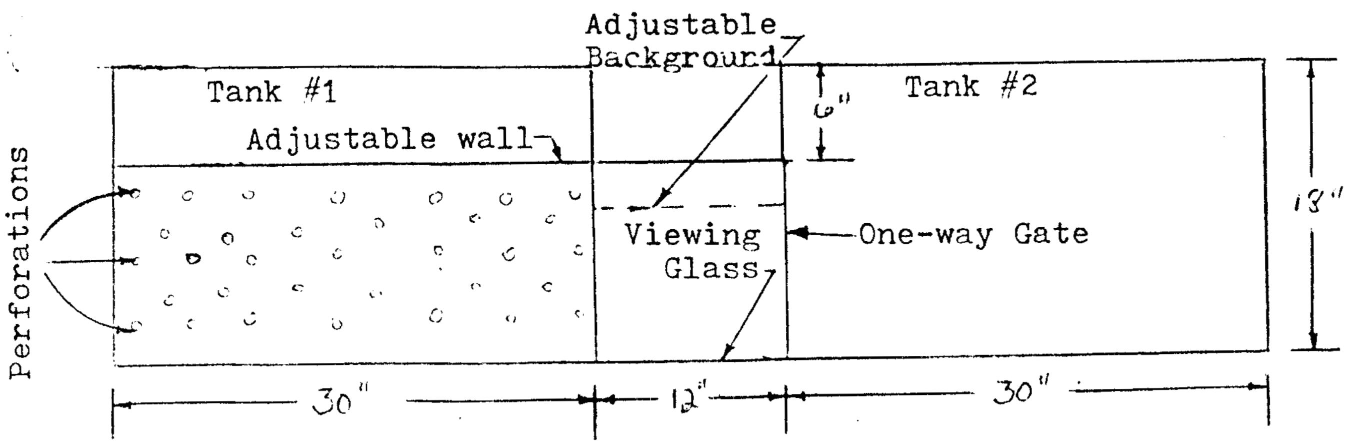

Figure 2: Top view and dimensions of segregator

Figures 3 and 4

Figure 3: Front view of segregator.

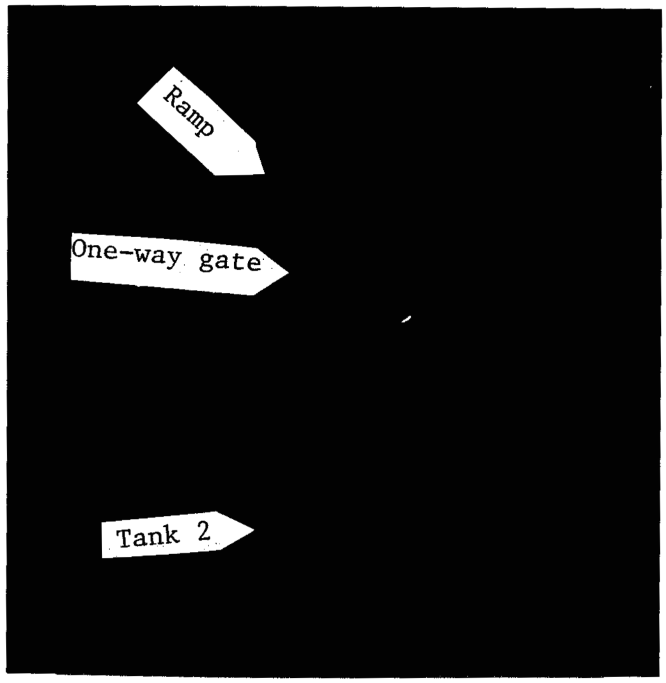

Figure 4: Side view of segregator. (Viewed from tank 2).

Figures 5 and 6

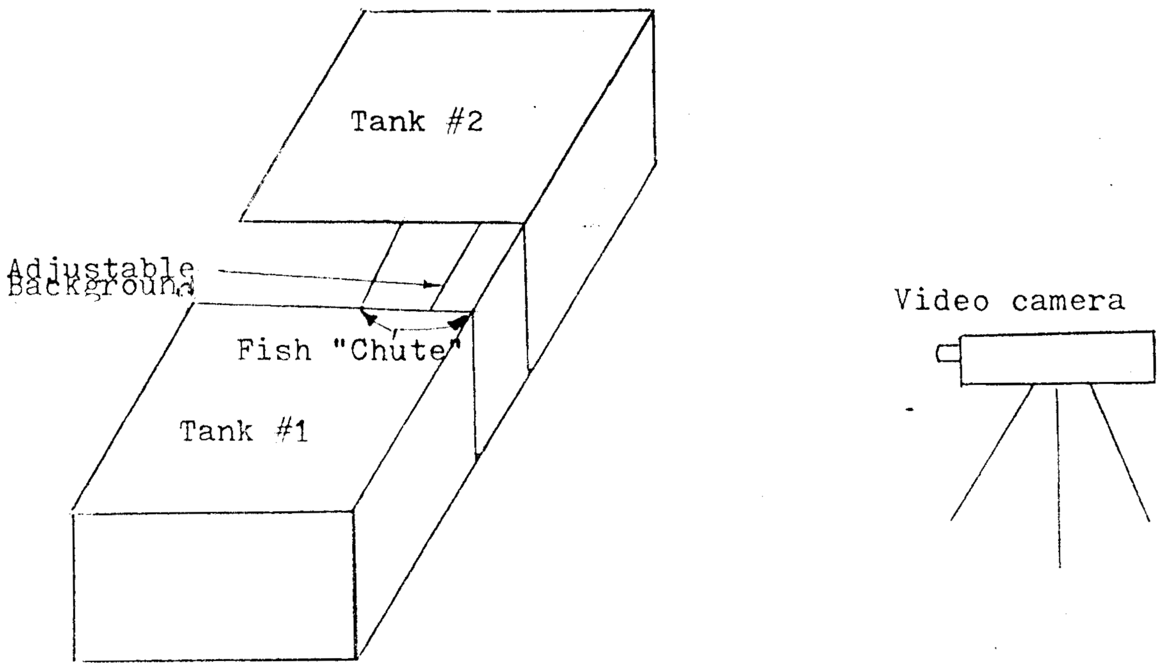

Figure 5: Angle view of segregator and video camera

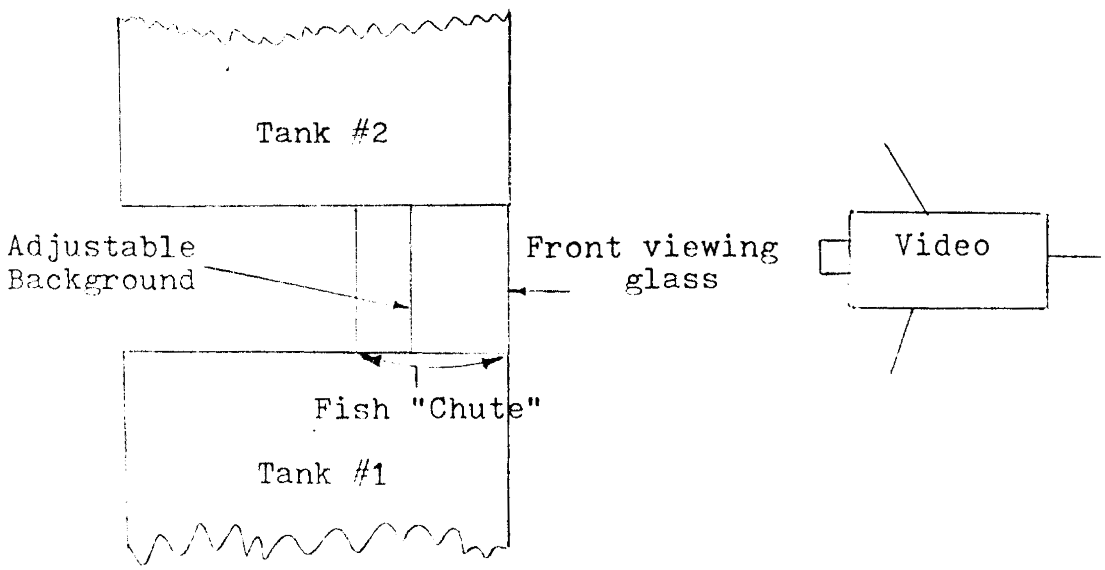

Figure 6: Top view of segregator and video camera

Figures 7 and 8

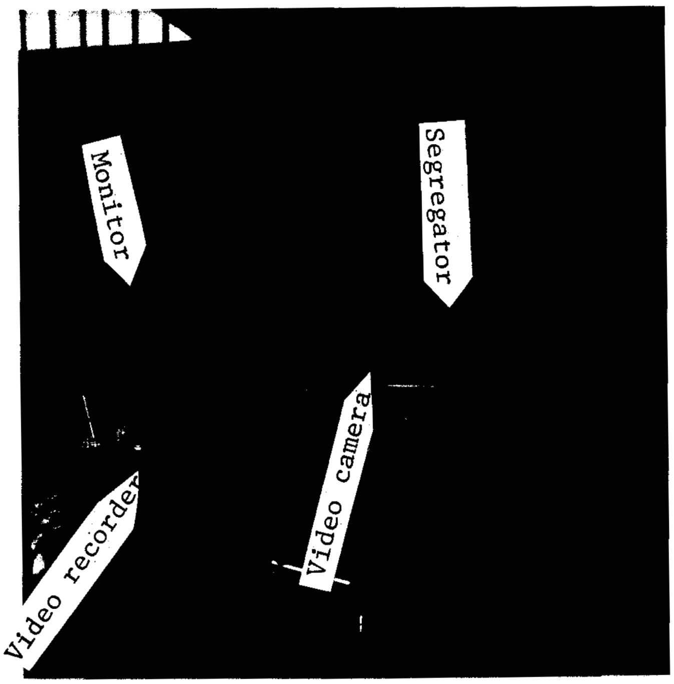

Figure 7: Front view of segregator and video camera.

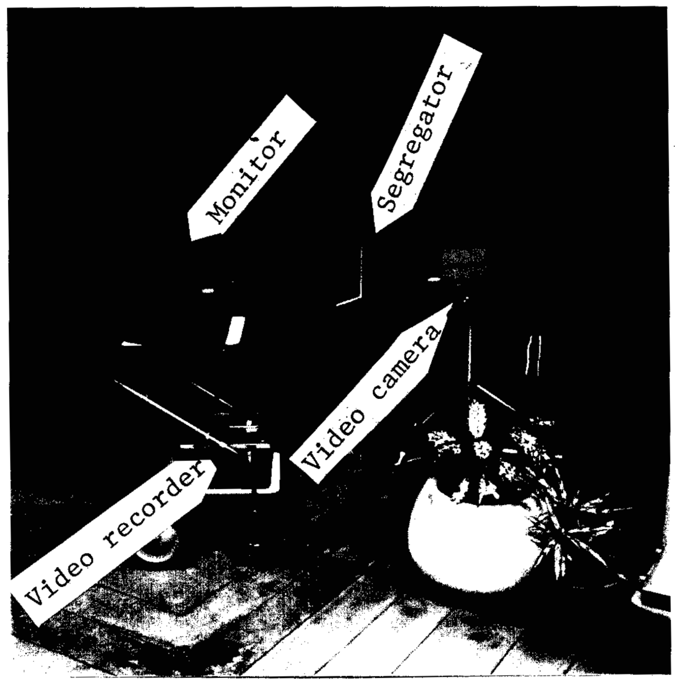

Figure 8: Angle view of segregator and video camera.

Figure 9: Total length of fish

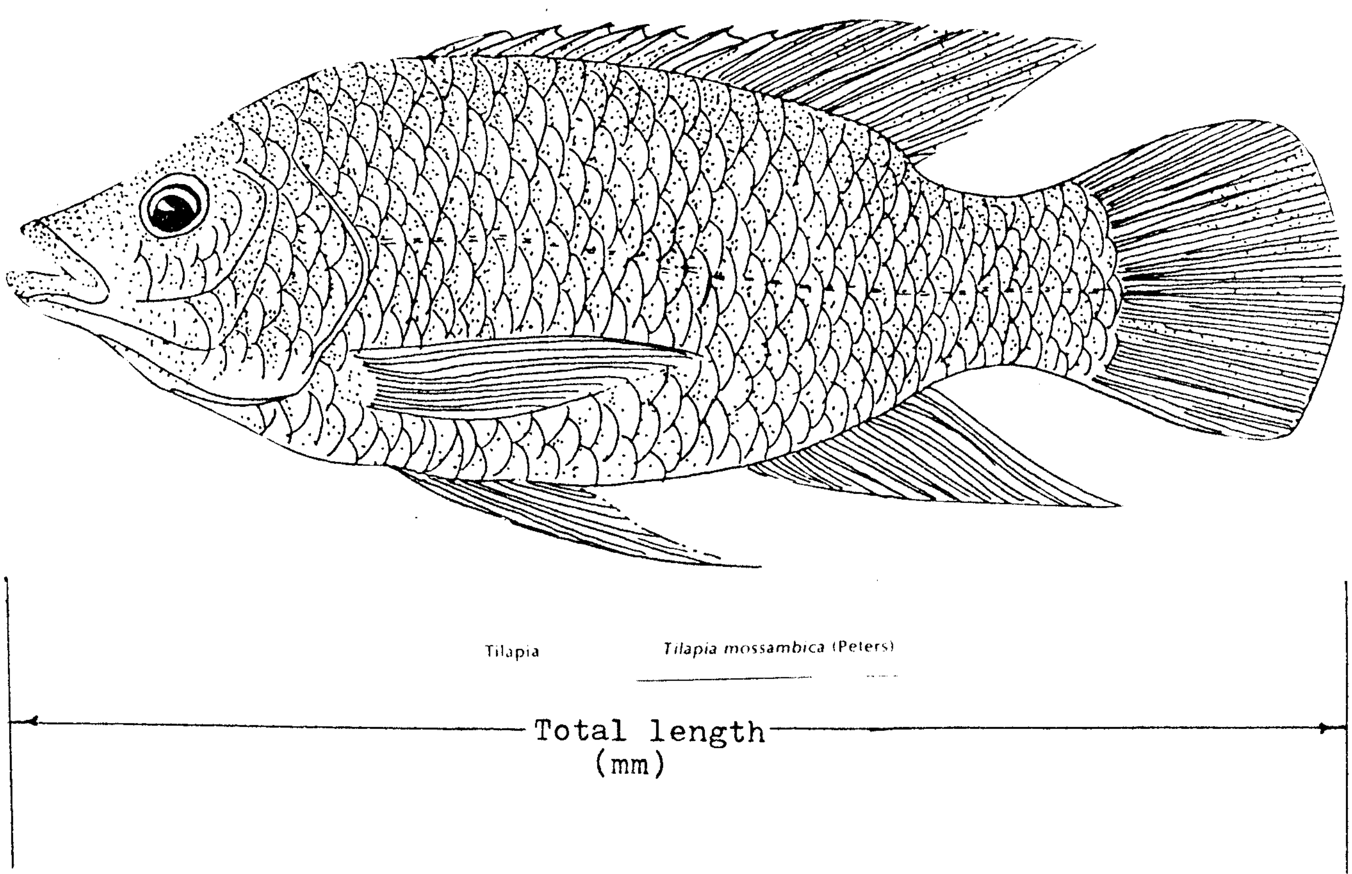

Table 1: Calculated length and time t-values for large and small fishes.

	Length	Time
Small fishes	0.474	5.5
Large fishes	0.78	not available

Critical t-value at 95% confidence level and 9 degree of freedom = 1.77

Table 2: Mean lengths and mean collection time measurements for large and small fishes using hand and video methods.

	Hand		Video	
	Lengths of measurements (mm)	Time (sec)	Lengths of measurements (mm)	Time (sec)
Small fishes	70.35 ± 1.29	15 ± 2.88	70.35 ± 1.35	12.1 ± 1.58
Large fishes	163.25 ± 1.43	not available	163.6 ± 1.36	not available

Table 3: ANOVA for small fishes.

Hand	Source of variation	degrees of freedom	SS	MS	f	Intraclass Correlation
	among subjects	9	739.05	82.12	109.49	0.99
	within subjects	10	7.5	.75		

$F_{0.05\ (9,10)} = 3.02$

Vidéo	Source of variation	degrees of freedom	SS	MS	f	Intraclass Correlation
	among subjects	9	703.05	78.12	82.23	0.987
	within subjects	10	9.5	0.95		

$F_{0.05\ (9,10)} = 3.02$

Table 4: ANOVA for large fishes.

Hand	Source of variation	degrees of freedom	SS	MS	f	Intraclass Correlation
	among subjects	9	2235.25	248.36	236.53	0.995
	within subjects	10	10.5	1.05		

$F_{0.05\ (9,10)} = 3.02$

Video	Source of variation	degrees of freedom	SS	MS	f	Intraclass Correlation
	among subjects	9	2341.45	260.16	133.42	0.992
	within subjects	10	19.5	1.95		

$F_{0.05\ (9,10)} = 3.02$

Appendix 1

HOLDING TANKS #1 and #2

A) Dimensions:	Tank bottom = 30"L X 18" W Tank sides and adjustable wall = 30"L X 18"W One-way Gate (Tank #2) = 18"H X 12"W
B) Tank Size:	Approximately 42 gallons
C) Materials:	3/4" plywood for tank 1/4" plywood for gate and adjustable wall Marine resin 2" brass screws 2 small brass hinges with screws
D) Construction:	1) Cut out plywood pieces (Important note: bottom of tanks and chute is a single piece.) 2) Screw pieces together and screw in hinges 3) Laminate entire area (both internally and externally) with coat of resin.

Appendix 2

ADJUSTABLE INCLINE RAMP (See Figures 2A and 2B)

A) Dimensions: 29 - 3/4"L X 12 - 3/4"W

B) Materials: Ramp = 1/4" plywood

2 small brass hinges with screws

Marine resin

C) Construction:

1) Cut out ramp
2) Drill out 1/4" perforations and attach rope
3) Screw the ramp onto tank #1's bottom
4) Laminate entire area with two coats of resin

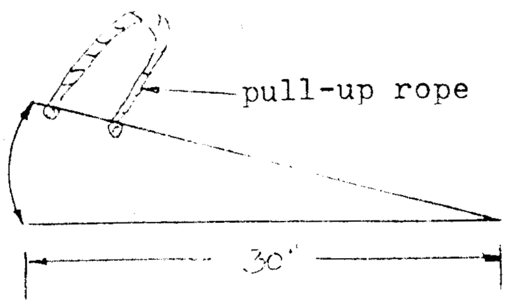

Figure 2A: Side view of ramp

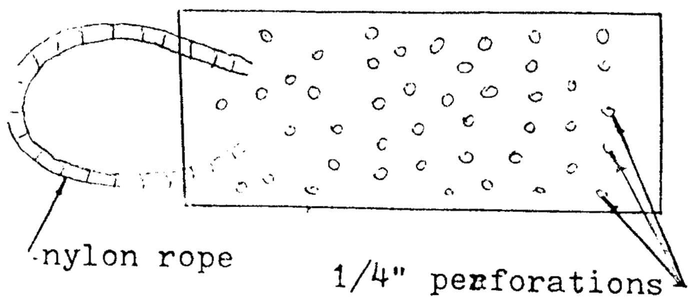

Figure 2B: Top view of incline ramp

Appendix 3

FISH CHUTE (See Figures 3A, 3B, 3C, and 3D)

A) Dimensions: 12"L X 12"W X 18"H

B) Materials:

1 - 12"L X 12"H X 1/8" thick clear glass sheet

1 - 12"L X 18"H X 3/4" thick plywood

1 - 12"L X 18"H X 1/4" thick black and white plexiglass

1 - 10"L X 18"H X 1/4" thick black plexiglass sheet

1 - 6"L X 1/4" thick nut and bolt

1 - tube plexiglass glue

1 - tube marine silicone

1 - 12" white ruler with black mm scale

C) Construction:

1) Screw plywood bottom into adjacent plywood sides.

2) Prepare for installing viewing glass by cutting a slot into the chute's bottom edge.

3) Drill 3/4" hole into the rear side of chute and through the larger piece of plexiglass.

4) Install glass and silicone along the edges of the glass.

5) Glue plexiglass sheets perpendicularly along the edges (see Figure 3C). Smaller plexiglass sheet should be within tank 1.

Appendix 3 (continued)

6) Install nuts and bolts through rear wall of chute and through plexiglass background. The plexiglass background can be adjusted by sliding on the shaft of the bolt and be held secure by the nut and head of the bolt.

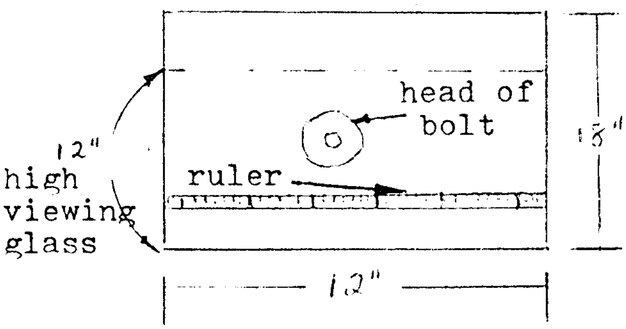

Figure 3A: Front view of adjustable background (close-up)

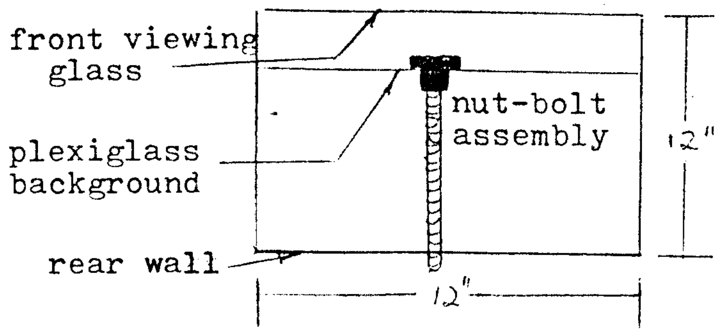

Figure 3B: Top view of chute

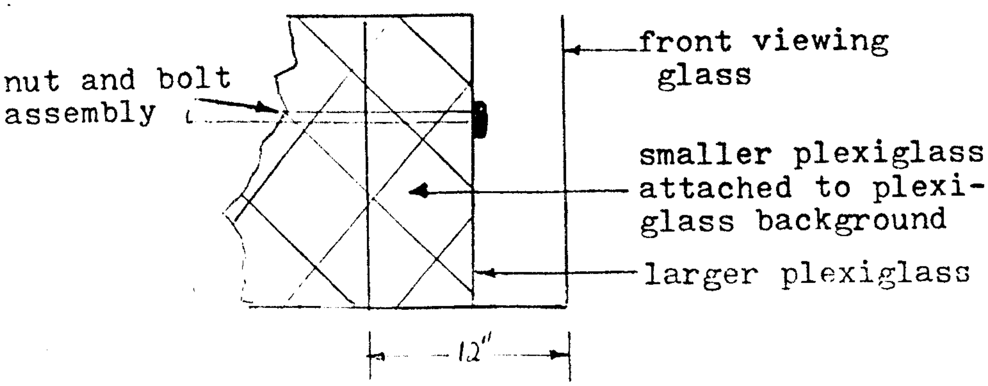

Figure 3C: Side view of chute from tank 1

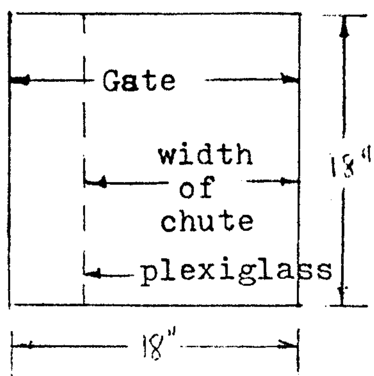

Figure 3D: Side view of chute from tank 2

Appendix 4

Formula using student's t-test (Daniel, 1974):

1) $H_0: \mu_1 = \mu_2$	1) Original hypothesis: The mean of 1 equals the mean of 2.
2) $H_a: \mu_1 \neq \mu_2$	2) Alternate hypothesis: The mean of of 1 not equals the mean of 2.
3) $d_i = v_m - h_m$	3) Video measurement minus hand measur ment equals difference.
4) n	4) Number of subjects
5) $\bar{d} = \frac{\sum d_i}{n}$	5) The mean is equal to the summation of the difference of the total number of subjects divided by the total number of subjects.
6) $Sd^2 = \frac{n \times d_i^2 - (d_i)^2}{n \times (n-1)}$	6) Variance
7) $Sd = \sqrt{Sd^2}$	7) Standard deviation
8) $S\bar{d} = Sd/n$	8) Mean standard deviation
9) $t = \bar{d}/S\bar{d}$	9) Calculated t-value

Formula using the ANOVA (Sokal and Rohlf, 1969):

1) a	1) Number of subjects
2) n	2) Number of measurements
3) $\sum^{n} y$	3) Summation of measurements per subject
4) $\sum^{a} \sum^{n} y$	4) Grand total of measurements
5) $\sum^{a} \sum^{n} y^2$	5) Sum of squared observations

Appendix 4 (continued)

symbols and formulas using ANOVA..............

6) $\frac{\sum^{a} (\sum^{n} y)^2}{n}$ — 6) Sum of the squared group totals divided by sample size.

7) $\frac{(\sum^{a} \sum^{n} y)^2}{n \times a}$ — 7) Correction term

8) SS_{totals} = quantity #5 - quantity #7

9) SS_{groups} = quantity #6 - quantity #7

10) SS_{within} = quantity #8 - quantity #9

ANOVA table	degree of freedom	SS	MS	f	Intraclass Corr
among subjects	a-1	#9	#9/d.f.	$\frac{\text{SS among}}{\text{SS within}}$	$\frac{\text{SS among}}{\text{SS total}}$
within subjects	a	#10	#10/d.f.		

Appendix 5: **Raw** Data for Hand Method

<u>Small fishes</u>

Number of subjects	Trial 1 length	Trial 2 length	Trial 1 time	Trial 2 time
1	77.0 mm	78.0 mm	16 sec.	18 sec.
2	75.0 mm	76.0 mm	17 sec.	18 sec.
3	68.0 mm	70.0 mm	16 sec.	16 sec.
4	76.0 mm	75.0 mm	12 sec.	14 sec.
5	72.0 mm	71.0 mm	14 sec.	13 sec.
6	56.0 mm	57.0 mm	16 sec.	10 sec.
7	62.0 mm	63.0 mm	11 sec.	16 sec.
8	74.0 mm	72.0 mm	14 sec.	14 sec.
9	71.0 mm	71.0 mm	15 sec.	17 sec.
10	72.0 mm	71.0 mm	17 sec.	16 sec.

<u>Large fishes</u>

Number of subjects	Trial 1 length	Trial 2 length	Trial 1 time	Trial 2 time
1	174.0 mm	176.0 mm	not available	not available
2	154.0 mm	152.0 mm	" "	" "
3	172.0 mm	171.0 mm	" "	" "
4	145.0 mm	146.0 mm	" "	" "
5	159.0 mm	160.0 mm	" "	" "
6	156.0 mm	155.0 mm	" "	" "
7	180.0 mm	182.0 mm	" "	" "
8	160.0 mm	161.0 mm	" "	" "
9	158.0 mm	160.0 mm	" "	" "
10	172.0 mm	172.0 mm	" "	" "

Appendix 6: Raw Data for Video Method

Small fishes

Number of subjects	Trial 1 length	Trial 2 length	Trial 1 time	Trial 2 time
1	79.0 mm	77.0 mm	15 sec.	17 sec.
2	76.0 mm	76.0 mm	13 sec.	15 sec.
3	69.0 mm	69.0 mm	12 sec.	13 sec.
4	75.0 mm	74.0 mm	10 sec.	11 sec.
5	71.0 mm	72.0 mm	12 sec.	11 sec.
6	57.0 mm	57.0 mm	12 sec.	13 sec.
7	64.0 mm	62.0 mm	10 sec.	13 sec.
8	74.0 mm	72.0 mm	11 sec.	11 sec.
9	72.0 mm	71.0 mm	11 sec.	10 sec.
10	69.0 mm	71.0 mm	10 sec.	12 sec.

Large fishes

Number of subjects	Trial 1 length	Trial 2 length	Trial 1 time	Trial 2 time
1	176.0 mm	174.0 mm	not available	not available
2	154.0 mm	152.0 mm	" "	" "
3	171.0 mm	171.0 mm	" "	" "
4	146.0 mm	146.0 mm	" "	" "
5	158.0 mm	156.0 mm	" "	" "
6	158.0 mm	155.0 mm	" "	" "
7	183.0 mm	181.0 mm	" "	" "
8	160.0 mm	162.0 mm	" "	" "
9	161.0 mm	160.0 mm	" "	" "
10	175.0 mm	173.0 mm	" "	" "