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REPORT ON THE SWIMMING ABILITY OF CHUBS, SQUAWFISH, AND SUCKERS IN A ROTATING CIRCULAR TANK

by

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submitted to

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July, 1958

INTRODUCTION

The purpose of this experiment was to determine the maximum length of time that squawfish, suckers, and chubs (from Flathead County, Montana) could continue to swim against different water velocities. An attempt was also made to estimate the maximum distance a fish could swim at several different water velocities.

METHODS AND MATERIALS

The fish were trucked to the University of Washington in a very efficient insulated fiber-glass tank and arrived in excellent condition. Pure oxygen was used to aerate the water. The fish were held at the University in a rectangular hatchery raceway that measures 5 by 29 feet. Water entered the head of the raceway at the rate of about 12 gallons per minute. The water temperature in the raceways during the testing periods ranged from 63 to 65 degrees. The raceways were divided by plywood partitions into 15 compartments; each compartment was 39 inches long, 32 inches wide, and 24 inches deep. Thirty holes of 1/2 inch diameter were drilled in both the upstream and downstream ends of the boxes to provide entrance and exit for the water. Each box was fitted with a plywood lid that shielded the fish from the sun. Three fish were placed in each of the 16 compartments; one each of the three species.

The fish were transported to the testing room by means of a stainless steel carrying box (Fig. 1). To capture the fish, the box was lowered into the holding box by means of two tongs. When the fish entered the carrying box, the movable side was allowed to close, capturing the fish. After excess water was allowed to drain from the box, it was carried into the testing room. The use of this box permitted handling the fish with a minimum of disturbance.

The fish were tested in an 11-foot diameter circular tank, (Fig. 2) in which they were confined to a 12-inch outer channel during testing. The tank turns in a counter-clockwise direction and is supported by a center bearing and 12 rubber casters. The tank is rotated by a five horsepower adjustable-speed electric motor, and the speed and pattern of rotation are controlled by a pneumatic-electronic device which enables the experimenter to select any desired velocity up to about 12 feet per second.

The depth of the water in the channel was about 11 inches. Water was allowed to flow into the tank when not in use at the

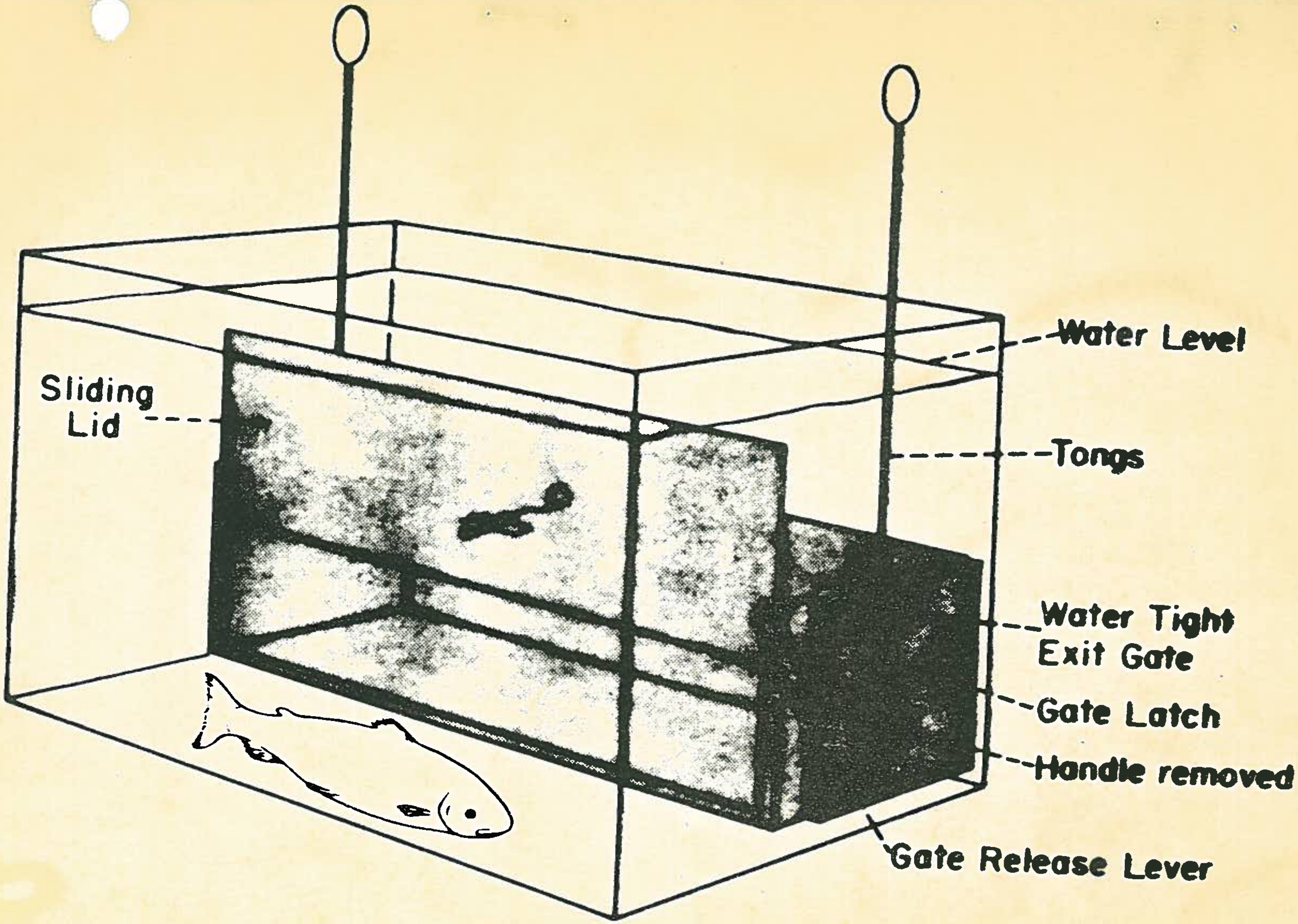


Figure 3. Removal of fish from holding compartment by means of the carrying box.

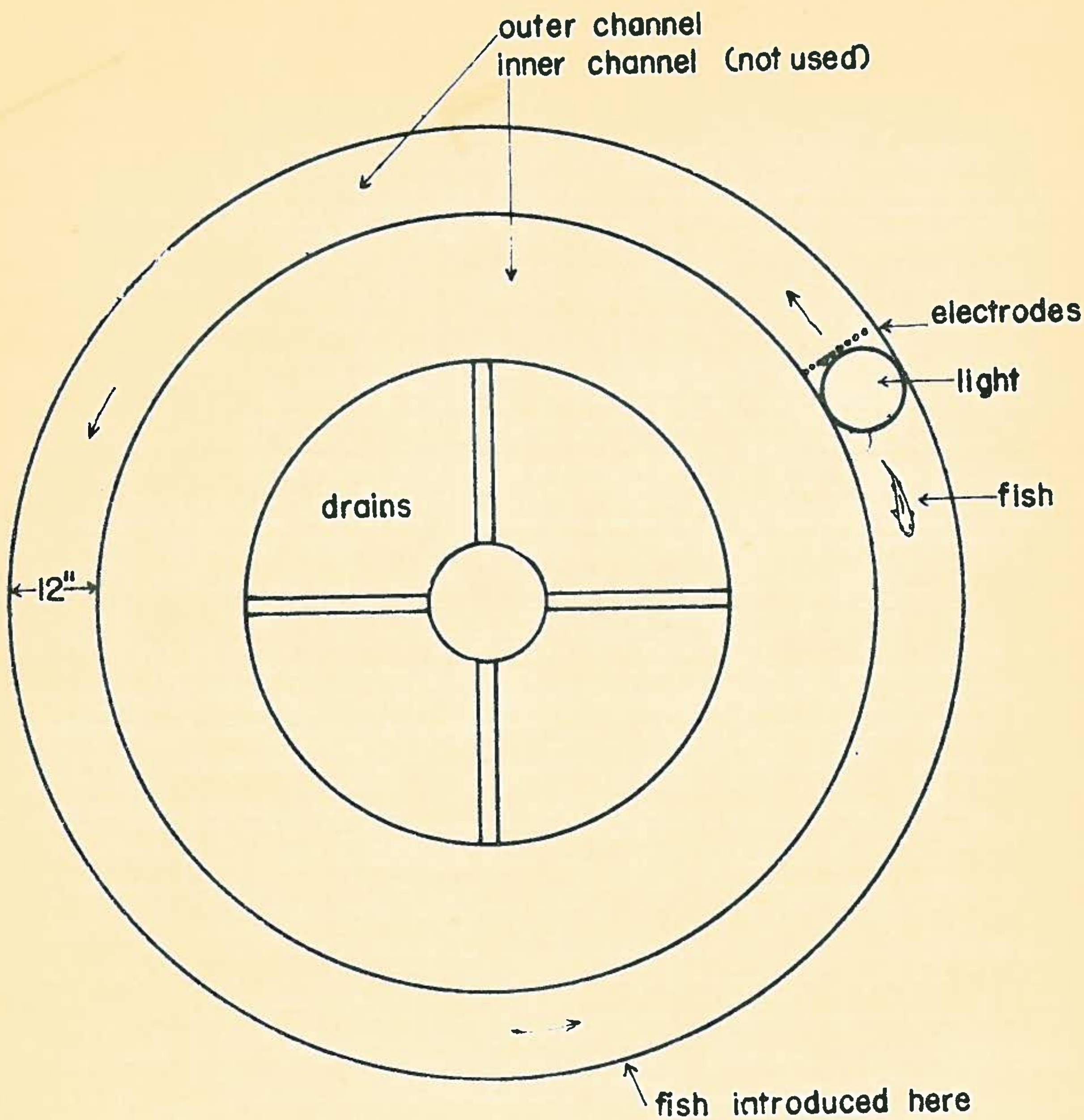


Figure 2. Eleven-foot diameter revolving tank.

rate of about 3 gallons per minute. During a test, the incoming water was turned off, since a constant volume of water was desired throughout the test, and the turbulence was sufficient to keep the water oxygenated.

Fish were induced to swim in the "treadmill" by means of a light-electrode barrier (Fig. 3). The 8 electrodes were spaced 1-3/8 inches apart and were of 1/8 inch diameter oil-temper spring steel wire. The electricity was supplied as A. C. from a 12-volt transformer, and a potentiometer was used to reduce the voltage to between 8 and 9 volts at the barrier.

Before a fish was introduced, the water in the tank was allowed to reach the testing velocity. To start a test, the assistant released the fish from the carrying box into the channel by opening the water-tight trap door on the end of the box. A coarse mesh reversing net (Fig. 4) was held in front of the barrier as the fish was released approximately 8 feet upstream. If the fish swam downstream, head-first into the net, instead of swimming against the current, the net and the electrical field would usually cause the fish to turn and swim upstream. Ideally then, the fish would swim ahead of the barrier until tired, then drop back tail first through the barrier. The stop-watch was stopped when the fish came around the tank and dropped through the barrier for the second time, still attempting weakly to swim.

Pages 6 and 7 contained pictures that could not be reproduced.

Page 6 was labeled: Figure 3. Light-electrode barrier installed in the channel of the circular tank.

Page 7 was labeled: Figure 4. Reversing net.

Often, the fish would be able to swim in front of the barrier for several additional seconds before going through for the second time.

Frequently fish would reverse and head downstream during the test. The reversing net was then employed to turn the fish when it came around again. One or two attempts were usually enough to turn the fish and get it swimming against the current again. A record was kept of the number of reverses that occurred during a test, and if the fish reversed more than 4 times, or if the fish refused to swim at all, the time was not recorded.

The experimenter feels that reverses do not add to, but subtract from the total length of time a fish can maintain itself. The energy expended in turning, swimming actively downstream, and then turning again, seems to be greater than that expended by steady swimming against the water for one circuit of the tank. It has been observed that generally the best performance comes from fish that do not reverse at all during the test.

RESULTS

The results of the tests can be found in Table 1. Table 2 gives the sex, length, and condition at the end of testing for each fish.

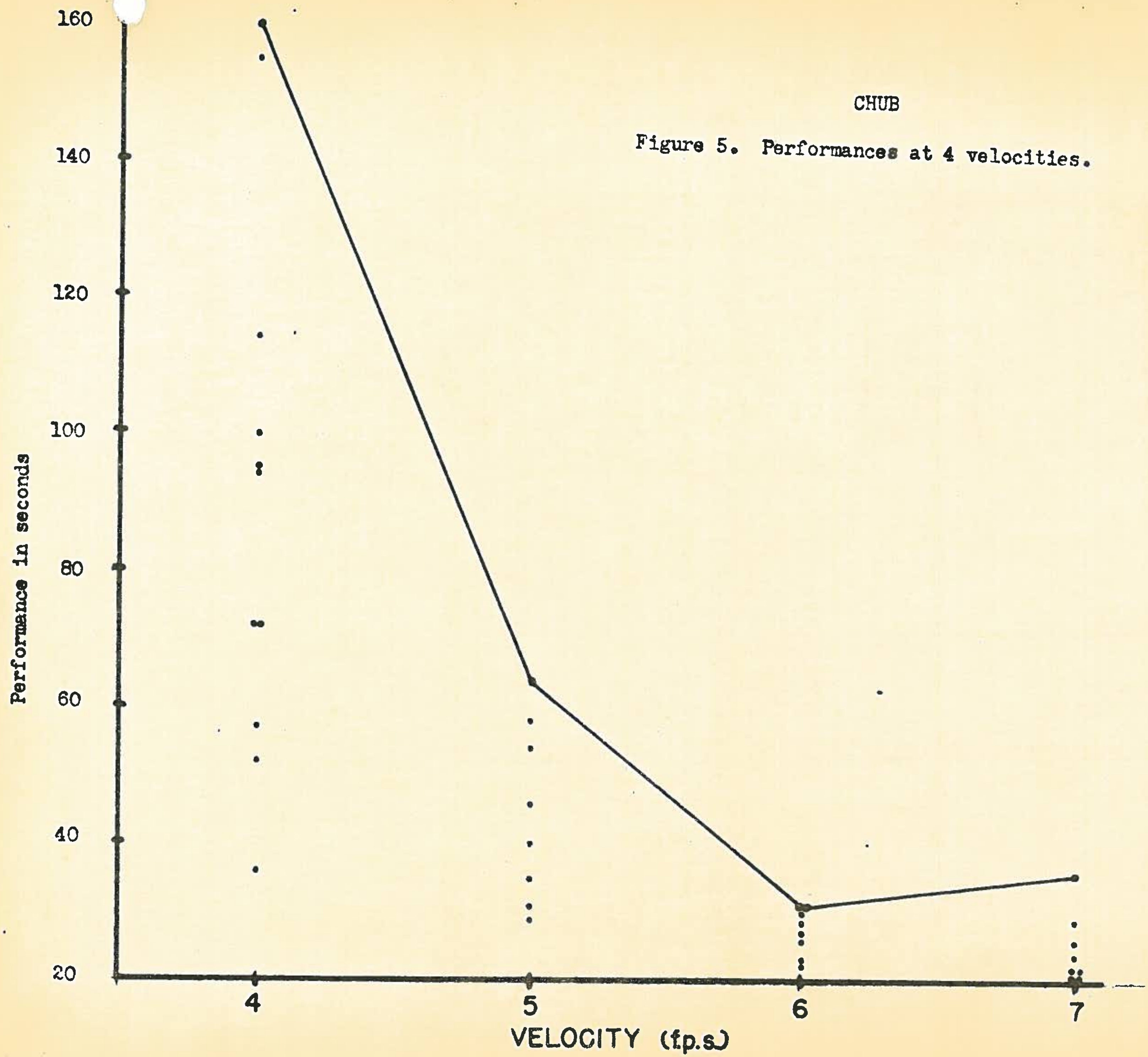

CHUB
Figure 5. Performances at 4 velocities.
Performance in seconds
160
140
120
100
80
60
40
20
4
5
6
7
VELOCITY (f.p.s.)

Figure 6. SQUAWFISH performances at 4 velocities.

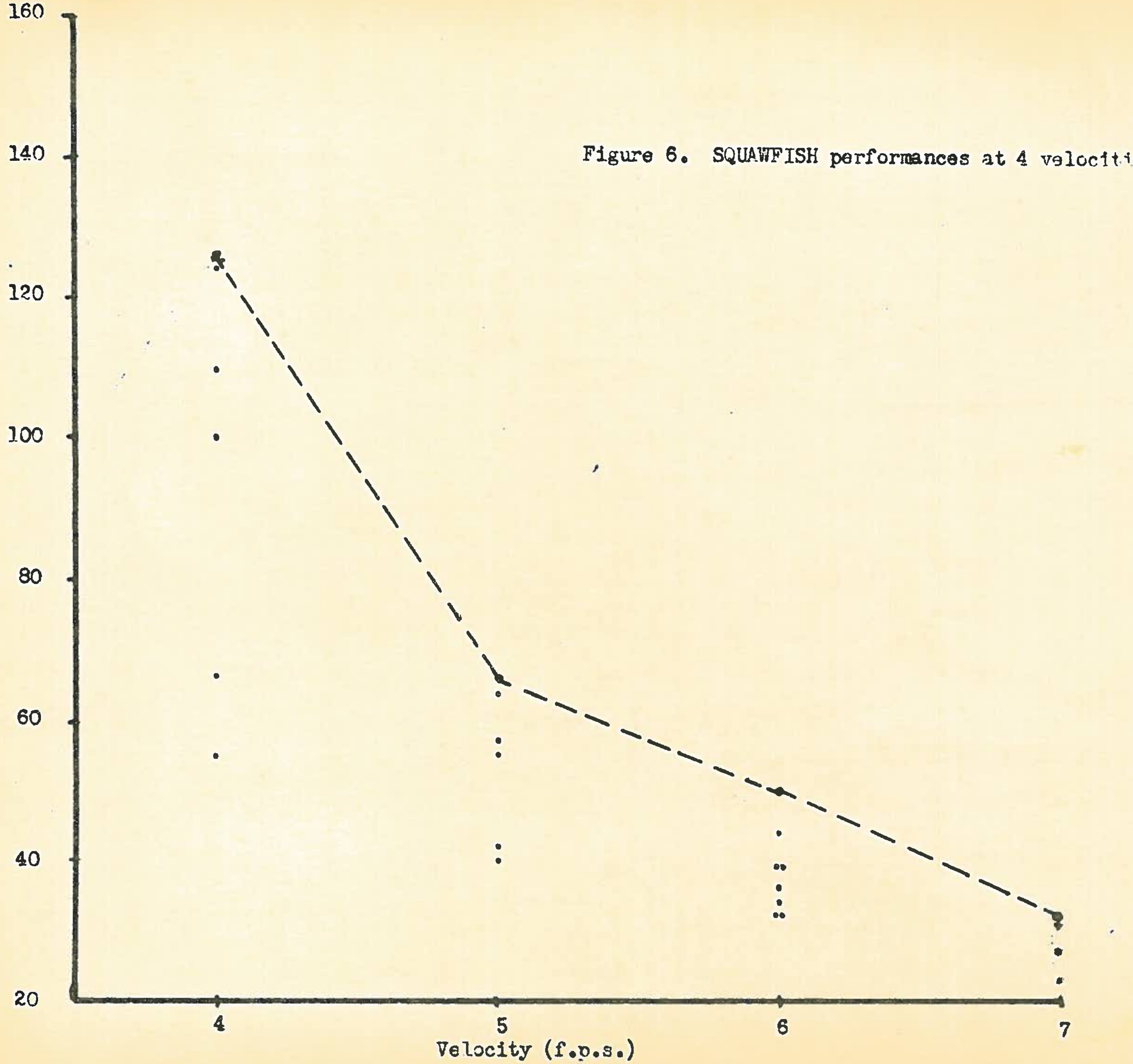
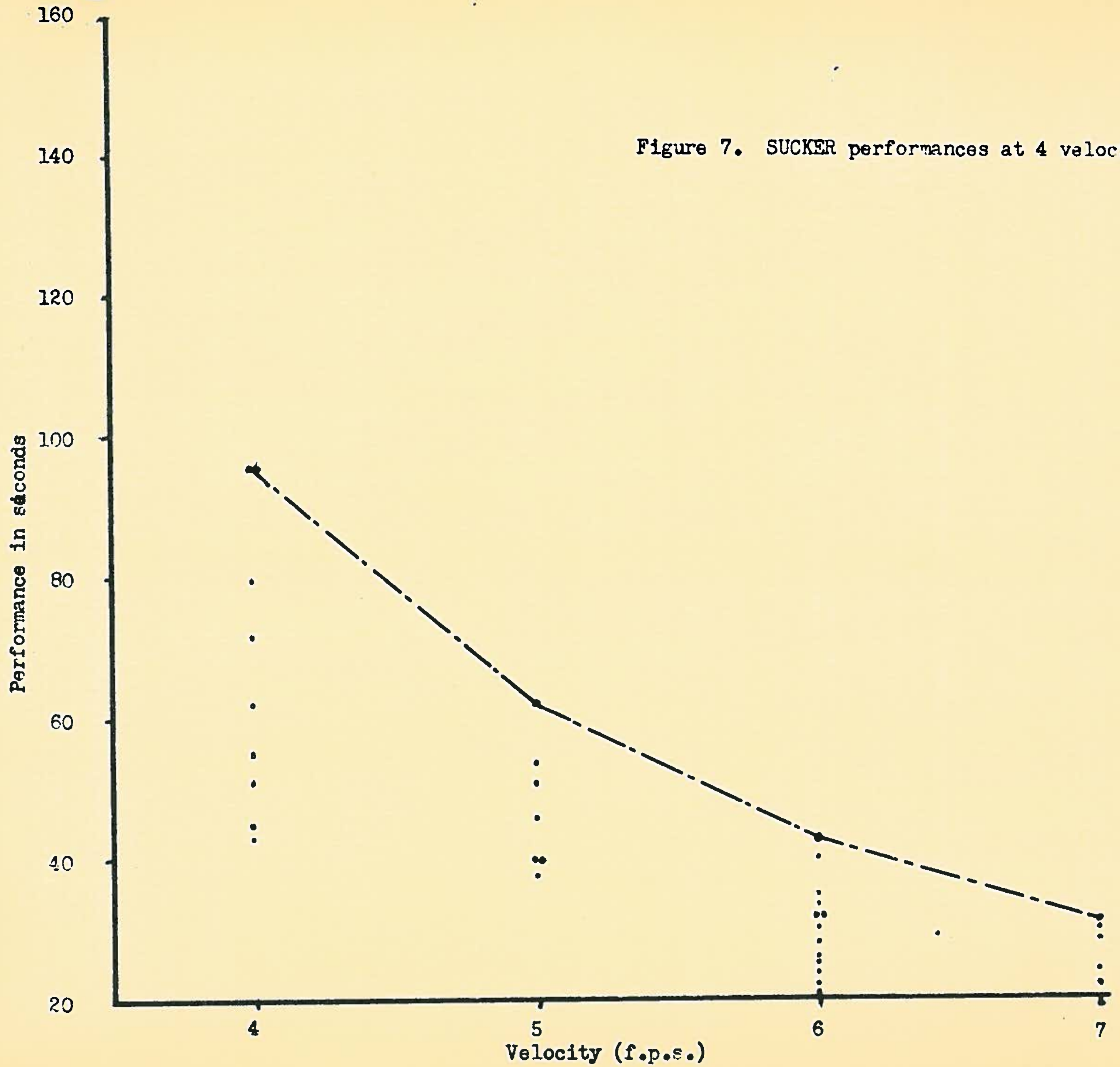


Figure 7. SUCKER performances at 4 velocities.



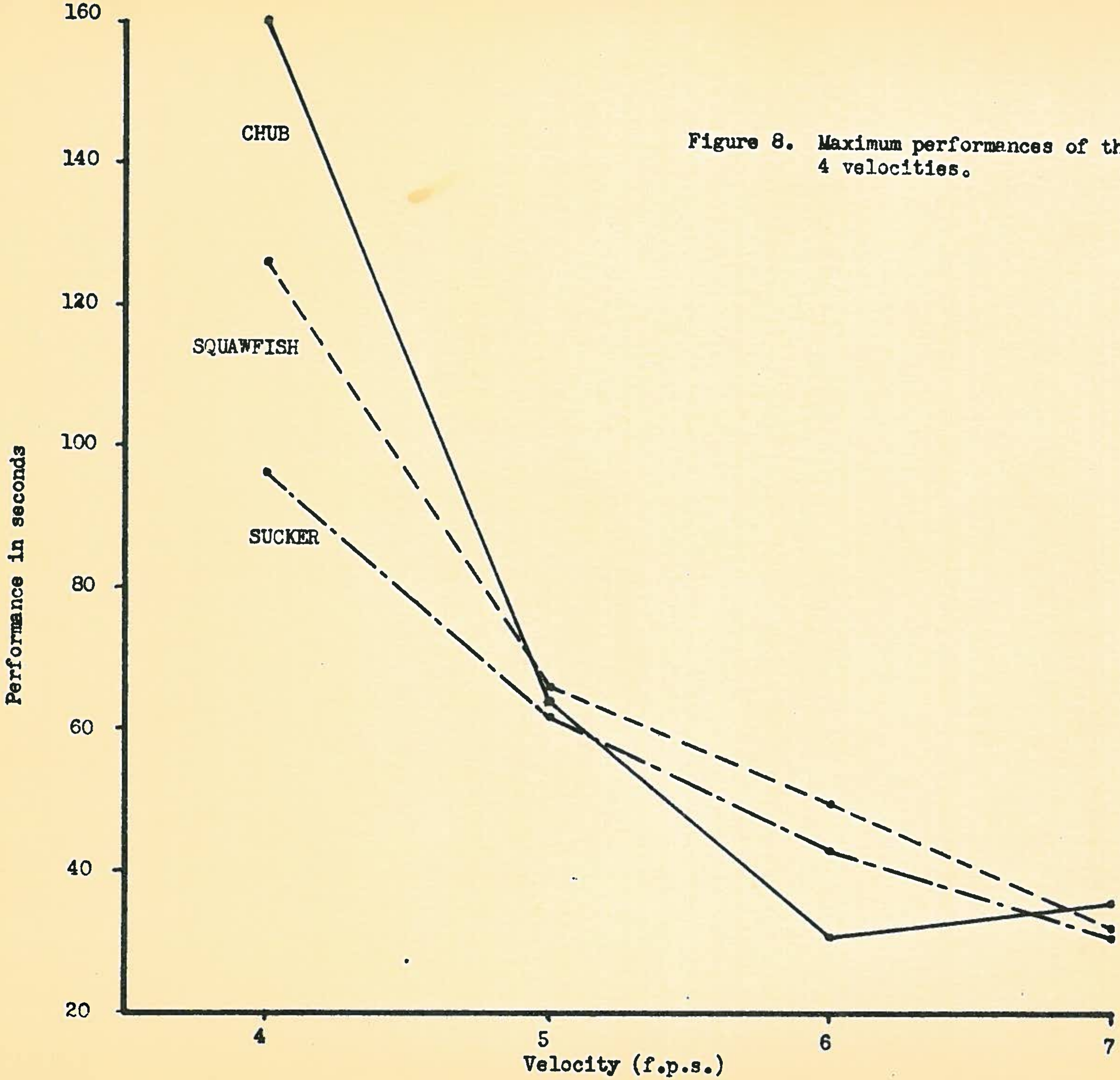


Figure 8. Maximum performances of the 3 fish at 4 velocities.

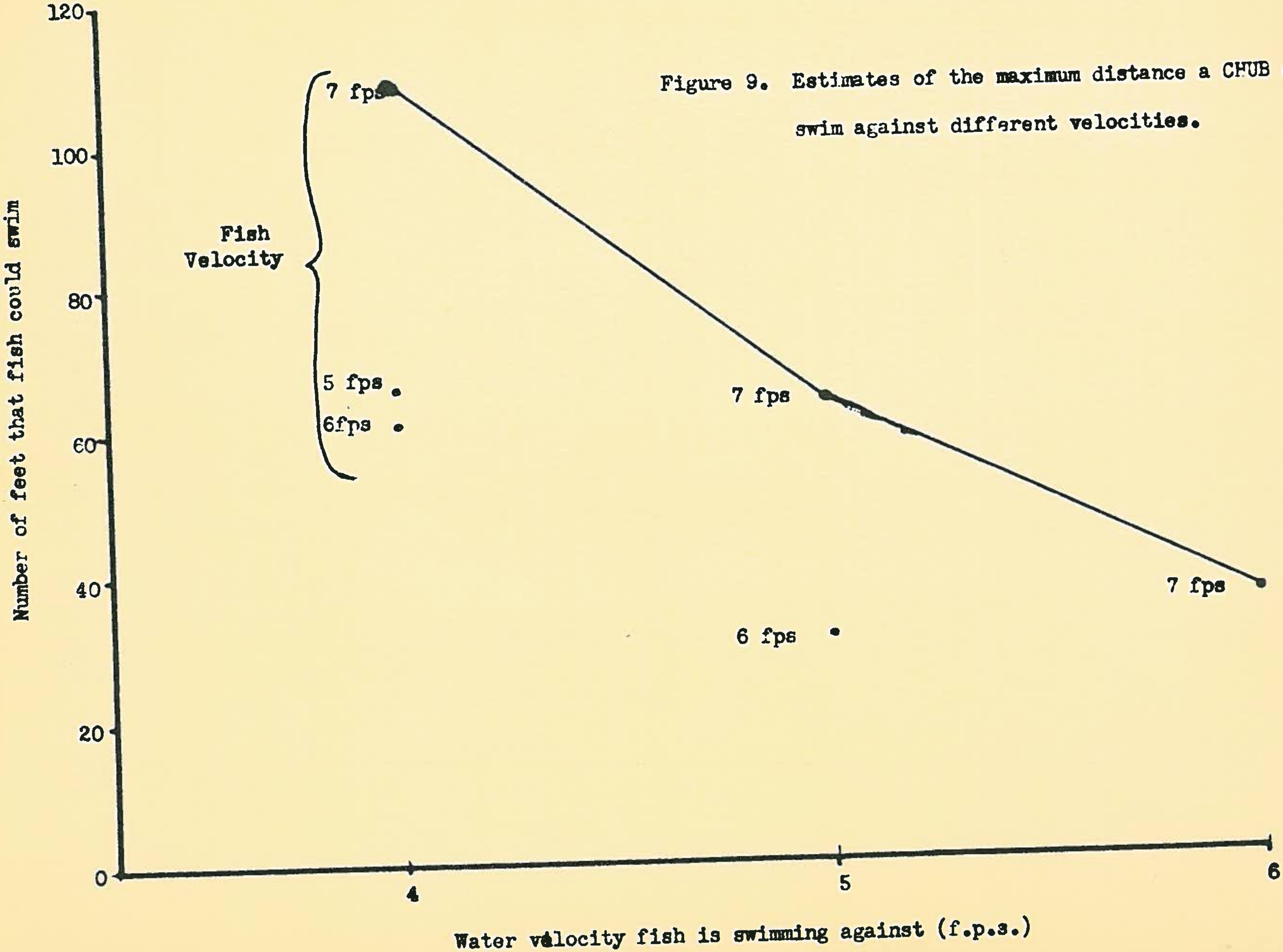


Figure 9. Estimates of the maximum distance a CHUB could swim against different velocities.

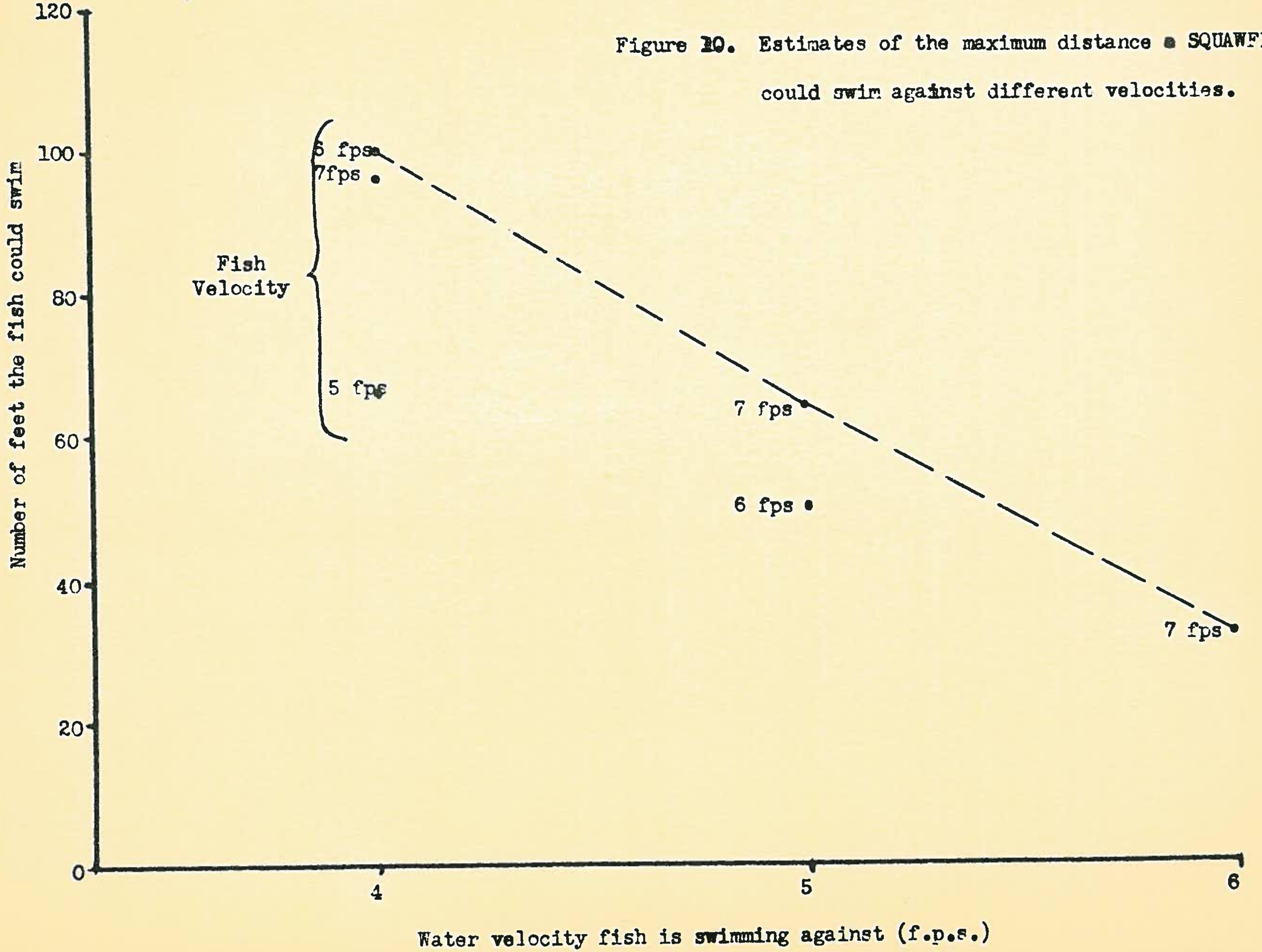


Figure 10. Estimates of the maximum distance SQUAWFISH could swim against different velocities.

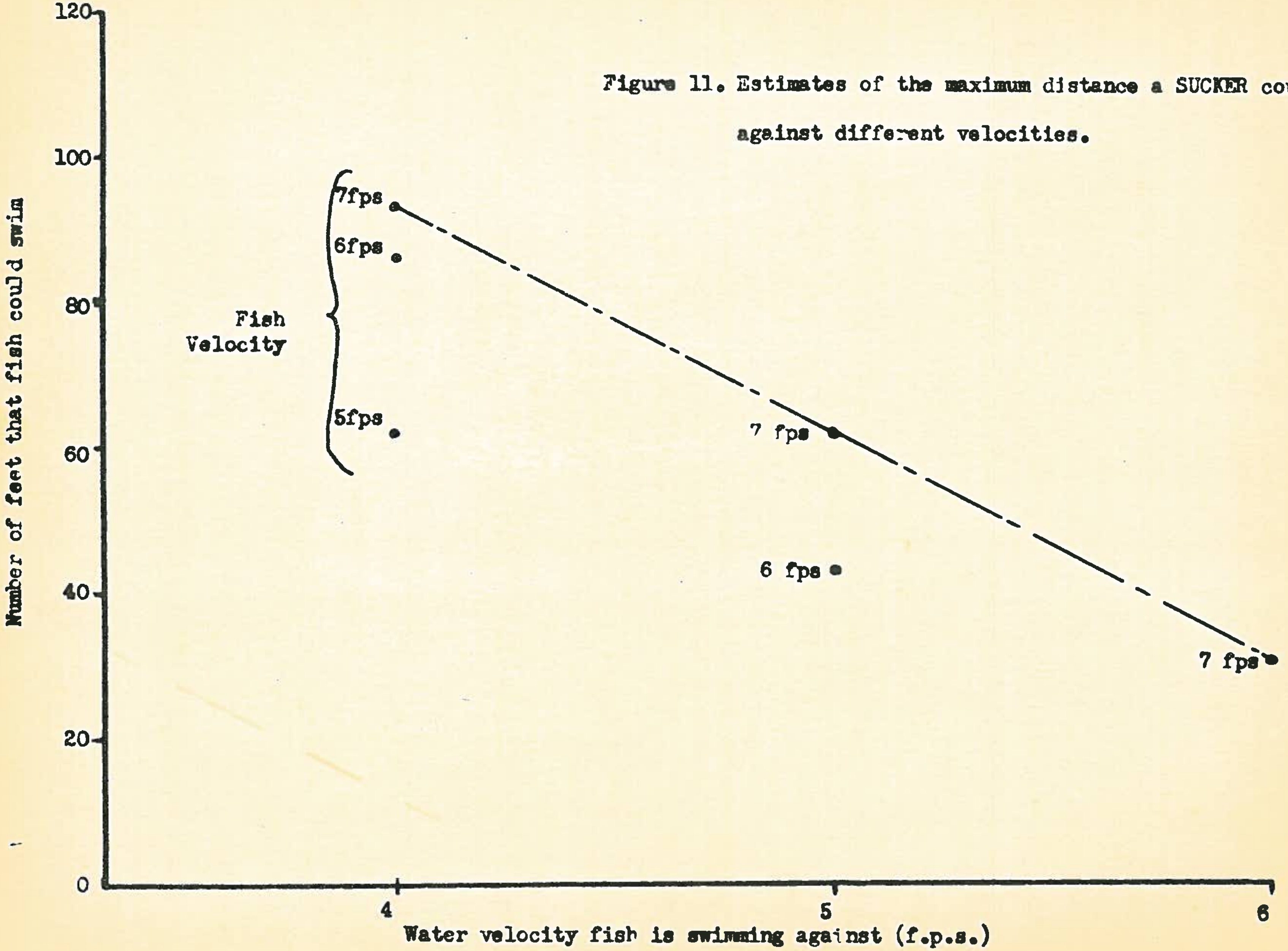


Figure 11. Estimates of the maximum distance a SUCKER could swim against different velocities.

ANALYSIS

Figures 5, 6, and 7 show the performances of the three species at the four water velocities of 4, 5, 6, and 7 feet per second. The points indicating maximum performances are connected by a line. Figure 8 compares the three maximum performance curves. It can be seen that chubs were better swimmers at 4 and 7 f.p.s. Probably a good-performing chub was not tested at 6 f.p.s. Squawfish were the best performers at 5 and 6 f.p.s., and suckers were quite consistantly the poorest performers.

In Figures 9, 10, and 11, the total distance a fish could swim upstream at the velocities of 4, 5, and 6 f.p.s. has been estimated. These estimates are based on the maximum performance curves shown in Figure 8. The estimates were made according to the following simple formula:

$$X = P(H - L)$$

Where: H = the higher velocity in feet per second.
L = the lower velocity in feet per second.
P = performance at the higher velocity in seconds.
X = the distance the fish could swim at the lower velocity.

DISCUSSION

Although the fish seemed in very good condition, perhaps fish taken directly from their native environment might have given better performances. The same fish may well give different performances at different water temperatures and at different times of the year. Also, since it has been observed that there is a great variability among individual fish, there are probably fish in the population that could swim better than those tested in this experiment.

CONCLUSIONS

1. Chubs were generally the best performers and suckers the worst.
2. The chubs, it is estimated, could swim forward about 108 feet against a water velocity of 4 feet per second, 64 feet against 5, and 36 feet against 6 feet per second.
3. Squawfish, it is estimated, could swim about 100 feet against 4, 64 feet against 5, and 32 feet against 6 feet per second.
4. Suckers, it is estimated, could swim about 93 feet against 4, 62 feet against 5, and 31 feet against 6 feet per second.

Table 1 . Test Results for Each Day of Testing.

5/29/58 1:00 PM

BOX	SPECIES	VEL.	PERF.	REMARKS
31	Chub	4	——	Rev.
	Squawfish	4	——	N.R.
	Sucker	4	55	
45	C.	4	57	3-R.
	Sq.	4	——	C.S.
	Sk.	4	~~114~~	Rev.
20	C.	4	114	
	Sq.	4	100	4-R.
	Sk.	4	——	Rev.
41	C.	4	95	4-R.
	Sq.	4	——	P.
	Sk.	4	45	
18	C.	4	72	3-R.
	Sq.	4	——	P.
	Sk.	4	96	
29	C.	4	160	
	Sq.	4	66	2-R.
	Sk.	4	51	
42	C.	5	54	4-R.
	Sq.	5	55	3-R.
	Sk.	5	62	
32	C.	5	64	
	Sq.	5	40	2-R.
	Sk.	5	46	
44	C.	5	55	
	Sq.	5	——	P.
	Sk.	5	——	P.
30	C.	5.	40	
	Sq.	5	——	P.
	Sk.	5	——	P.
47	C.	5	58	
	Sq.	5	64	
	Sk.	5.	51	
17	C.	6	——	C.S.
	Sq.	6	32	
	Sk.	6	22	

5/30/58 10:00 AM

BOX	SPECIES	VEL.	PERF.	REMARKS
48	C.	6	31	
	Sq.	6	——	C.S.
	Sk.	6	30	1-R.
46	C.	6	——	N.R.
	Sq.	6	——	P.
	Sk.	6	32	
43	C.	6	28	2-R.
	Sq.	6	44	4-R.
	Sk.	6	43	4-R.
19	C.	6	——	Rev.
	Sq.	6	50	2-R.
	Sk.	6	33	3-R.
31	C.	7	29	4-R.
	Sq.	7	31	1-R.
	Sk.	7	22	2-R.
45	C.	7	24	
	Sq.	7	——	Rev.
	Sk.	7	30	2-R.
20	C.	7	21	2-R.
	Sq.	7	32	4-R.
	Sk.	7	31	3-R.
41	C.	7	22	1-R.
	Sq.	7	——	N.R.
	Sk.	7	——	Rev.
18	C.	7	22	
	Sq.	7	——	P.
	Sk.	7	28	2-R.
29	C.	7	26	
	Sq.	7	——	Rev.
	Sk.	7	——	P.
42	C.	6	30	1-R.
	Sq.	6	——	P.
	Sk.	6	25	2-R.
32	C.	6	22	
	Sq.	6	39	1-R.
	Sk.	6	28	2-R.

Table 1 (Continued).

5/30/58 (Cont.)

BOX	SPEC.	VEL.	PERF.	REMARKS
44	C.	6	---	C.S.
	Sq.	6	32	2-R.
	Sk.	6	35	2-R.
30	C.	6	27	
	Sq.	6	---	Sick
	Sk.	6	32	2-R.
47	C.	6	31	1-R.
	Sq.	6	---	C.S.
	Sk.	6	40	
17	C.	5	29	
	Sq.	5	66	2-R.
	Sk.	5	40	2-R.

5/30/58 6:00 PM

BOX	SPEC.	VEL.	PERF.	REMARKS
48	C.	5	31	2-R.
	Sq.	5	42	3-R.
	Sk.	5	40	2-R.
46	C.	5	---	Sick
	Sq.	5	---	Sick
	Sk.	5	54	
43	C.	5	46	
	Sq.	5	---	P.
	Sk.	5	---	Rev.
19	C.	5	---	N.R.
	Sq.	5	57	2-R.
	Sk.	5	38	3-R.

5/31/58 9:00 AM

BOX	SPEC.	VEL.	PERF.	REMARKS
31	C.	6	---	P.
	Sq.	6	36	2-R.
	Sk.	6	---	P.
45	C.	6	23	2-R.
	Sq.	6	---	C.S.
	Sk.	6	---	C.S.
20	C.	6	27	2-R.
	Sq.	6	39	2-R.
	Sk.	6	21	
41	C.	6	26	1-R.
	Sq.	6	---	C.S.
	Sk.	6	26	1-R.
18	C.	6	---	Rev.
	Sq.	6	34	2-R.
	Sk.	6	24	
29	C.	6	21	1-R.
	Sq.	6	---	Rev.
	Sk.	6	---	Rev.
42	C.	7	---	C.S.
	Sq.	7	---	C.S.
	Sk.	7	24	
32	C.	7	---	C.S.
	Sq.	7	27	2-R.
	Sk.	7	---	C.S.
44	C.	7	---	Dead
	Sq.	7	---	Rev.
	Sk.	7	---	N.R.
30	C.	7	21	
	Sq.	7	---	Dead
	Sk.	7	---	Dead
47	C.	7	36	2-R.
	Sq.	7	23	
	Sk.	7	19	
17	C.	4	36	2-R.
	Sq.	4	110	
	Sk.	4	72	
48	C.	4	155	3-R.
	Sq.	4	55	2-R.
	Sk.	4	96	4-R.
46	C.	4	52	
	Sq.	4	---	Dead
	Sk.	4	80	
43	C.	4	72	2-R.
	Sq.	4	126	4-R.
	Sk.	4	62	3-R.
19	C.	4	94	3-R.
	Sq.	4	124	4-R.
	Sk.	4	43	2-R.

Table 1 (Continued). Explanation of abbreviations.

1. Rev. = more than 4 reverses - the time was not recorded.
2. N.R. = the performance was not recorded due to stop-watch failure.
3. R. = reverse (s).
4. C.S. = fish couldn't or wouldn't swim.
5. P. = generally poor test and the time was not recorded.
6. Sick = fish was found to be in bad condition and was not tested.

Table 2 . Length, Sex, and Condition of the Fish at the End of Testing.

BOX #	SPEC.	LENGTH (mm)	SEX	REMARKS
31	C.	226	M	
	Sq.	260	F	
	Sk.	323	M	
45	C.	213	M	
	Sq.	231	F	
	Sk.	358	F	
20	C.	215	M	
	Sq.	365	F	
	Sk.	360	F	
41	C.	183	M	
	Sq.	229	F	
	Sk.	334	F	
18	C.	206	F	Tail ½
	Sq.	351	F	
	Sk.	354	F.	
29	C.	210	F	
	Sq.	248	F	
	Sk.	371	F	
42	C.	204	F	
	Sq.	228	F	
	Sk.	321	M	Dead
32	C.	228	F	Dead
	Sq.	345	F	
	Sk.	308	M	
44	C.	196	M	
	Sq.	262	F	
	Sk.	355	F	
30	C.	205	F	
	Sq.	215	F	
	Sk.	386	F.	
47	C.	213	M	
	Sq.	356	F	
	Sk.	339	F	
17	C.	209	F	
	Sq.	342	F	
	Sk.	372	F	
48	C.	194	M	
	Sq.	392	F	
	Sk.	369	F	

BOX #	SPEC.	LENGTH (mm)	SEX	REMARKS
46	C.	216	M	
	Sq.	251	F	
	Sk.	310	M	
43	C.	200	M	
	Sq.	238	M	
	Sk.	320	M	
19	C.	210	F	
	Sq.	427	F	
	Sk.	345	M	