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REPORT ON MINIMUM FLOW CONSIDERATIONS, TERRESTRIAL MITIGATION AND ECOLOGICAL EFFECTS ON CADDO LAKE ASSOCIATED WITH LITTLE CYPRESS RESERVOIR DEVELOPMENT

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1.0 INTRODUCTION

This report discusses the ecological considerations relevant to a minimum flow release program, project mitigation and effects on Caddo Lake associated with the development of Little Cypress Reservoir.

Water quality analyses undertaken to describe effects on Caddo Lake are described in a separate Espey, Huston & Associates, Inc. (EH&A) report. The results of those analyses have been utilized in this report to describe the effects of Little Cypress Reservoir development on Caddo Lake.

2.0 MINIMUM FLOW RELEASE PROGRAM

EH&A was asked by the Little Cypress Utility District (LCUD) to examine the existing estimates of minimum flow release made by the U.S. Army Corps of Engineers (USCE) and U.S. Fish and Wildlife Service (USFWS) for Little Cypress Reservoir.

Further, EH&A was to examine appropriate information to develop a recommended minimum flow to be released from Little Cypress Reservoir to protect the stream fishery during all conditions except periods of drought.

The USCE had applied the Habitat Evaluation Procedure (HEP) analysis and generated a set of recommended flows largely designed to offset the loss of stream habitat due to reservoir construction. The Instream Flow Incremental Methodology (IFIM) used by USFWS is a fishery management tool designed to provide estimates of habitat at various flow levels to allow agency personnel to negotiate a final flow release program with a permit applicant who wishes to develop the water resource.

Both the HEP and IFIM are strictly biological models for assessing impacts. Neither system includes use of any data other than hydrological or biological. There is no consideration of other values attendant with project development. Therefore, no credit is for social or economic benefits of the project; neither is the reservoir aquatic habitat factored into the analysis.

As a result, the reservoir fishery could be impacted negatively due to the requirements of a minimum flow release program, but such impacts would not be considered in the analysis.

The main thrust of the HEP is mitigation, while the IFIM is used to identify streamflow levels or other management features necessary to meet fishery management objectives for the stream. Therefore, neither methodology is applied primarily to determine a minimum flow requirement which would protect the ecological integrity of the stream during low-flow periods. Rather, both are utilized by the agencies to assess flow levels to manage the fishery at some level well above the maintenance level.

The recommended flows of the two methodologies are quite different from each other as presented in the 1986 Feasibility Report for Marshall Reservoir. Table 2-1 presents the recommended flows and the fish species utilized by both techniques to generate recommendations based upon habitat availability at different flow levels. Subsequent to the analyses presented in the Feasibility Report, additional biological studies have been performed by the USCE and USFWS. While EH&A is aware of no new flow recommendations, we have reviewed the hydrologic and biological data associated with the analyses.

Estimates of weighted useable area for various fish species at different flow levels vary significantly between the USCE and USFWS analyses.

Estimates of stream cross-sections at the same flows vary considerably between the USCE and USFWS studies.

Furthermore, the majority of the habitat suitability curves for both the USCE and USFWS were obtained from the literature, rather than being based upon field data specific to the Little Cypress Bayou system.

The Habitat Units (USCE) and Weighted Useable Areas (USFWS) available for the various study species are based very heavily on the velocity depth and substrate distribution within the stream channel. The preferred habitat conditions for the study species are related to particular combinations of these features.

TABLE 2-1

RECOMMENDED FLOW PROGRAMS AS DETERMINED BY THE IFIM AND HEP ANALYSES IN CFS BY MONTH

Methodology	J	F	M	A	M	J	J	A	S	O	N	D
IFIM	100	100	100	100	100	100	75	75	75	75	75	100
HEP (maintenance)	190	215	215	270	270	40	14	3	3	3	16	55
HEP (Compensation Flows)	>425	>425	>425	>425	>425	100	50	10	10	10	85	150

FISH SPECIES UTILIZED IN ANALYSES

IFIM	HEP
channel catfish	grass pickerel
spotted bass	spotted bass
white bass	flathead catfish
longear sunfish	longear sunfish
river darter	spotted sucker
	blacktail shiner
	ironcolor shiner
	brook silverside
	slough darter

Considering the variance in the results between the techniques, it is not surprising that the recommended maintenance flows are different.

Additionally, other factors need to be mentioned. The USFWS selection of white bass and river darter as study species is very questionable, even though both have been collected in Little Cypress, as it is doubtful that either represents a significant species in this system. However, both species would demonstrate higher optimum flow requirements than species more typical of the bayou.

The use of the term "maintenance" associated with the flows in Table 2-1 should be defined by the USCE and USFWS. It is unclear whether maintenance is used to imply that these flow regimes are required to maintain the system status quo during low-flow periods or whether they are meant to mean the maintenance of an enhanced or optimum level of habitat. An examination of the hydrologic data from Little Cypress Bayou clearly shows that routine summer flows are normally much lower than the USFWS recommendations and much closer to the USCE recommendation. Even the USCE HEP compensation flows do not approach the USFWS summertime recommended flows.

It should be noted that simulations of the effect of these recommended minimum flow programs by KS&A indicates that the IFIM flow program will reduce the firm yield of the reservoir from 129,000 ac-ft per year to only 66,300 ac-ft per year. The HEP maintenance flow release program will reduce the firm yield to 64,000 ac-ft per year while the HEP compensation flow program would result in -300 ac-ft yield annually. These reductions in yield are such that the reservoirs would become economically infeasible.

Several factors mitigate the need for the relatively high flows recommended by both the USFWS and USCE. First, there is no real discussion of the value of the fishery in Little Cypress Bayou. The USCE estimates that the available acreage of aquatic habitat varies over a 7.3-mile stretch of bayou studied from

28 acres (ac) at 10 cubic feet per second (cfs) to 165 ac at 300 cfs and up to 523 ac at 1,000 cfs. Unfortunately, neither study presents any standing crop estimates for the various fish species studied. Nevertheless, based on data collected in Little Cypress and other streams in east Texas, the normal standing crop of fishes is generally much lower than that of reservoirs in the areas.

Even though the feasibility report lists over 60 species of fish as occurring in Little Cypress, it is doubtful that in any given sample, more than 5 or 6 species would be collected and generally represented by relatively few individuals, except for the lower trophic forage species. The amount of fish habitat and the relative standing crop of the proposed Little Cypress will be enormously more productive than Little Cypress Bayou. This fact is not included in any of the analyses performed. The USCE did provide a HEP analysis for the reservoir which does support the above contention concerning the productivity of the reservoir versus the bayou.

The recommended flow regimes would require releases to maintain those flow levels in all but drought conditions. An examination of the hydrology of Little Cypress Bayou, however, demonstrates that the flows would place an unnecessary flow requirement on the proposed project to maintain a questionable fishery at enhanced levels when a clearly superior fishery would already be created within the reservoir.

EH&A has examined the hydrology of the system and recommends the following minimum flow maintenance program which we feel will protect the integrity of the downstream fishery during periods of low flow and would indeed provide a buffer against normally very low to zero flow which occurs frequently during the summer months.

Jan-Feb	5 cfs
Mar-Apr	30 cfs
May	20 cfs
June-Dec	5 cfs

The above minimum flow maintenance program is based upon an examination of the Little Cypress USGS monthly streamflow data from the gage near Jefferson, Texas, to determine baseline conditions over the 1947-1984 period of record and simulations of the monthly flows which would occur in Little Cypress below the reservoir based on full firm yield conditions predicted for 2030 (worst-case condition). Additionally, daily flows at the Jefferson gage for the period of record of 1964-1984 were examined to support the validity of utilizing monthly flow to predict the minimum flow regime recommended.

Table 2-2 presents the average and median monthly flows for the historic period of record and the simulated full reservoir development of a firm yield of 129,000 acre-feet (ac-ft). Flows are as measured at the Jefferson gage downstream of the proposed reservoir. The simulated full reservoir development flows include the incremental flows below the reservoir and the gage. The historic average monthly flows are relatively high during the months of January through March, moderately high during June, November and December, and relatively low from July through October. The historic flows show a similar pattern except that the median flows indicate that June, November and December are the more highly variable months of the year, while January through May are consistently high and July through December are consistently lower flow months. Examination of the average daily flows by month for the period of record available (1964-1984) support this representation. Within a given month during periods of high flow, the pattern is sustained whereas in periods of low flow, the flows throughout the month remain consistently low. The system is not flashy in the short term. Therefore, the variation in the average is based more upon the water year than upon the within-month variation.

TABLE 2-2

COMPARISON OF HISTORICAL (BASELINE) AND FULL RESERVOIR MONTHLY AVERAGE AND MEDIAN FLOWS IN CFS BY MONTH

	J	F	M	A	M	J	J	A	S	O	N	D
	Monthly Average Flows (cfs)											
Historical Flow*	652	868	889	1,054	1,066	405	114	52	119	111	263	504
Full Reservoir Dev.**	364	504	542	746	834	215	32	10	39	32	175	246
	Monthly Median Flows (cfs)											
Historical Flow	435	772	799	581	718	158	49	11	20	18	76	235
Full Reservoir Dev.	61	120	426	431	457	19	6	1	2	1	11	32

* 38 year period of record.

** Full reservoir development indicates demand of 129,000 ac-ft per year as water supply as simulated for the 38 year period of record.

Table 2-3 presents a comparison of the average number of days in various flow classes for the ten highest and lowest flow years over the 38-year period of record. Note that, even in the high flow years, flows less than 5.2 cfs occurred an average of 35.5 days per year. During low-flow years, the average is 95.5 days per year, or approximately 26% of the time, when flows were less than 5.2 cfs. Flows less than 21 cfs occurred 38.2% of the time; flows less than 50 cfs, 50.5% of the time; and less than 120 cfs, 71.7% of the days in the year. Even in the high-flow years, flows of less than 120 cfs occurred 39.7% of the time.

As described above, the months of July through October are those with the generally low flows.

Tables 2-4 and 2-5 present the historic flows by year and month for the period of record 1947 through 1984 and a simulation of the downstream flows at full reservoir demand (129,000 ac-ft/yr) for the same period, respectively. The data in Table 2-2 is extracted from these tables.

Table 2-6 displays the percentage of months in various flow categories by month for baseline, full reservoir development and full reservoir development plus the proposed minimum flow program conditions for the period of record. The removal of the firm yield from the reservoir on an annual basis substantially increases the number of months in which the average low flow falls at or below 5 cfs. The effect of the proposed minimum flow program is to insure that flow is maintained at no less than 5 cfs at all times, at no less than 30 cfs during March and april, and no less than 20 cfs during May. The increases in the March-May period are to provide additional habitat during the peak spawning period. The increase to 20 and 30 cfs is suggested by a review of the data developed by the USCE for their study species. That analysis indicates that reasonable increases of habitat could be gained by such increases. In order to provide additional significant gains in habitat, overbanking flows would have to be released which, according to the USCE, are in excess of 425 cfs. During many medium- and high-flow years, such flows will occur,

TABLE 2-3

AVERAGE NUMBER OF DAYS PER FLOW CLASS FOR THE TEN HIGHEST AND LOWEST FLOW YEARS FOR THE 38-YEAR PERIOD OF RECORD

cfs	0-5.2	0-21	0-50	0-120	120+
Low Flow Average	95.5	139.4	184.5	261.6	101.7
High Flow Average	35.5	66.3	108	145	215.6

TABLE 2-4
USGS STREAMFLOW DATA, LITTLE CYPRESS CREEK NEAR JEFFERSON, TEXAS
GAGE NO. 7346070 (CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVERAGE
1947	1149.6	687.2	1292.5	1261.0	852.4	209.5	33.5	8.6	18.0	11.9	85.5	1041.3	6651.0	554.3
1948	832.4	1958.4	1962.2	608.7	1556.4	151.0	46.4	3.2	0.1	0.3	55.1	90.1	7264.2	605.3
1949	439.8	912.2	845.4	895.9	734.9	100.0	309.1	173.1	124.2	927.9	904.0	378.4	6744.9	562.1
1950	2417.7	2851.2	759.5	499.3	2538.1	575.4	159.0	177.5	920.1	168.7	150.9	156.7	11374.1	947.8
1951	386.2	1215.9	801.1	549.0	636.0	129.5	26.8	3.5	132.6	15.1	72.4	200.3	4168.6	347.4
1952	302.8	486.0	624.8	1358.8	664.1	485.4	12.8	4.8	0.0	0.0	14.8	231.2	4185.4	348.8
1953	501.8	618.1	1154.7	552.9	3566.4	115.9	188.1	106.1	69.2	1.6	80.1	423.5	7378.3	614.9
1954	638.1	571.0	274.8	335.8	764.5	333.5	4.1	0.0	0.0	0.4	105.0	131.8	3159.0	263.3
1955	238.5	744.1	1361.0	1228.2	252.7	80.1	48.2	150.8	84.2	52.2	15.9	71.3	4327.3	360.6
1956	117.8	799.9	279.2	146.3	603.3	9.3	0.5	0.0	0.0	0.0	0.0	0.5	1956.8	163.1
1957	8.3	169.9	353.5	3139.9	2865.1	2353.7	135.9	21.2	21.3	614.4	2708.2	910.0	13301.4	1108.4
1958	1640.0	831.4	797.1	2056.3	4213.9	497.1	575.3	65.6	180.1	200.4	137.4	244.4	11439.1	953.3
1959	229.7	891.0	945.0	1693.4	1099.4	698.9	183.9	97.0	28.2	60.4	86.2	605.2	6618.2	551.5
1960	1718.1	951.3	1461.0	299.7	197.7	120.3	57.4	5.2	27.9	115.4	240.9	3392.3	8587.2	715.6
1961	1472.6	1477.6	1596.1	1501.9	221.8	333.1	668.5	52.4	105.0	114.7	323.1	1540.8	9407.6	784.0
1962	1150.5	1218.6	1480.6	758.4	757.2	134.2	63.9	10.7	43.8	90.9	117.4	215.1	6041.4	503.4
1963	250.6	207.0	334.7	320.2	976.4	34.8	9.4	1.0	0.0	0.0	1.0	34.2	2169.2	180.8
1964	40.3	94.7	244.0	186.3	160.7	11.5	0.2	13.5	24.0	28.5	22.0	166.3	992.2	82.7
1965	335.7	987.3	654.1	418.3	628.0	609.2	40.8	0.3	2.4	1.8	0.3	17.6	3695.8	308.0
1966	46.9	150.8	100.1	4583.0	3162.9	67.9	7.2	11.5	33.9	18.4	36.0	74.7	8293.1	691.1
1967	135.0	120.8	111.3	259.6	551.9	1160.7	48.8	1.4	1.6	0.4	7.8	101.5	2500.8	208.4
1968	728.1	488.2	819.8	913.6	2652.0	322.9	208.6	39.4	122.3	74.0	203.3	763.6	7335.7	611.3
1969	384.9	1170.5	2367.3	2069.8	995.4	137.1	7.2	0.4	0.0	0.0	162.5	294.5	7589.7	632.5
1970	751.2	540.5	1270.7	632.7	704.2	86.5	56.9	5.8	3.3	25.4	112.7	95.5	4285.5	357.1
1971	102.0	166.0	201.3	117.9	61.7	4.7	0.6	52.6	7.8	3.9	34.6	332.4	1085.4	90.4
1972	909.0	443.5	274.0	116.9	96.3	64.5	32.9	1.0	3.0	74.7	432.9	836.8	3285.5	273.8
1973	631.1	1051.7	1871.1	4109.3	872.2	1600.4	101.2	30.3	569.0	863.4	1191.1	2203.0	15093.8	1257.8
1974	1528.2	1073.3	751.7	774.0	534.8	2051.3	50.1	25.9	886.7	350.3	1874.9	1520.3	11421.4	951.8
1975	968.2	2381.4	1153.4	929.5	1729.5	589.0	172.0	43.9	16.3	6.5	53.6	91.9	8135.3	677.9
1976	357.3	359.1	905.8	342.2	437.2	160.3	611.3	37.7	40.3	40.7	61.2	410.7	3763.6	313.6
1977	429.7	1719.0	1477.6	1708.6	352.9	75.3	7.8	122.5	111.9	18.1	72.6	238.7	6334.5	527.9
1978	346.2	534.8	755.4	332.3	308.6	43.3	1.3	1.6	0.1	0.0	5.9	77.1	2406.8	200.6
1979	1123.3	941.2	1428.3	2835.8	1988.2	609.8	190.8	666.9	941.1	258.4	423.9	710.5	12118.4	1009.9
1980	1602.1	1594.1	673.7	1253.6	1177.0	164.3	14.0	0.1	0.0	7.7	42.2	63.5	6592.3	549.4
1981	68.2	110.0	179.0	133.9	731.3	957.8	100.7	13.7	14.6	67.0	129.0	179.6	2684.7	223.7
1982	174.4	438.1	358.4	239.7	354.7	93.6	54.7	6.4	0.0	0.0	35.3	945.0	2700.3	225.0
1983	480.9	1438.6	1225.9	542.0	418.0	194.0	77.0	2.6	0.1	0.0	8.8	368.7	4756.5	396.4
1984	139.8	596.3	617.1	357.8	73.7	22.7	5.5	0.7	0.1	0.0	0.0	0.0	1813.7	151.1
TOTAL	24777.1	32990.9	33763.0	40062.8	40491.5	15388.4	4312.3	1958.6	4533.4	4213.6	10008.5	19158.6	231658.7	
AVG	652.0	868.2	888.5	1054.3	1065.6	405.0	113.5	51.5	119.3	110.9	263.4	504.2	6096.3	

TABLE 2-5

INITIAL CONDITIONS - 129,000 AC-FT/YEAR FIRM YIELD
DOWNSTREAM SPILLS PLUS INCREMENTAL RUNOFF (CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	AVERAGE
1947	1033.5	538.1	1191.8	1120.6	714.7	28.3	4.5	1.2	2.4	1.6	11.5	140.5	4788.6	399.0
1948	264.4	1865.9	1829.1	429.2	1425.2	20.4	6.3	0.4	0.0	0.0	7.4	12.2	5860.6	488.4
1949	59.3	123.1	163.3	783.3	543.6	13.5	41.7	23.4	16.8	427.8	703.1	229.6	3128.5	260.7
1950	2343.9	2758.8	600.7	361.4	2421.7	341.2	21.4	23.9	458.1	22.8	20.3	21.1	9395.5	783.0
1951	129.7	1098.6	658.1	357.9	440.3	17.5	3.6	0.5	17.9	2.0	9.8	27.0	2763.0	230.2
1952	40.8	65.6	84.3	959.7	517.7	211.8	1.7	0.6	0.0	0.0	2.0	31.2	1915.4	159.6
1953	67.7	83.4	417.7	433.4	3476.7	15.6	25.4	14.3	9.3	0.2	10.8	57.1	4611.7	384.3
1954	85.9	77.0	79.0	177.2	680.7	45.0	0.6	0.0	0.0	0.1	14.2	17.8	1177.4	98.1
1955	32.2	100.4	434.1	1087.8	110.9	10.8	6.5	20.3	11.4	7.0	2.1	9.6	1833.1	152.8
1956	15.9	107.9	37.7	19.7	81.4	1.3	0.1	0.0	0.0	0.0	0.0	0.1	264.0	22.0
1957	1.1	22.9	47.7	1092.8	2708.0	2183.0	18.3	2.9	2.9	82.9	2330.1	745.1	9237.7	769.8
1958	1518.5	684.7	651.8	1973.6	4058.8	295.2	254.0	8.8	24.3	27.0	18.5	33.0	9548.2	795.7
1959	31.0	459.5	788.4	1561.3	1002.0	499.2	24.8	13.1	3.8	8.1	11.6	81.7	4484.5	373.7
1960	1235.5	821.8	1311.0	106.5	26.7	16.2	7.7	0.7	3.8	15.6	32.4	2339.1	5917.0	493.1
1961	1345.0	1350.3	1475.2	1303.4	29.9	180.7	400.8	7.1	14.2	15.5	43.6	994.3	7160.0	596.7
1962	1052.2	1076.6	1323.8	636.5	559.2	18.1	8.6	1.4	5.9	12.3	15.8	29.0	4739.5	395.0
1963	33.0	26.8	45.4	46.6	123.0	1.0	1.1	0.1	0.0	0.0	0.3	1.2	278.4	23.2
1964	5.6	13.0	32.3	25.7	19.6	1.5	0.0	1.9	3.3	3.3	2.5	18.6	127.3	10.6
1965	40.0	128.5	82.6	51.1	86.1	75.8	4.8	0.0	0.4	0.9	0.1	2.3	472.8	39.4
1966	6.4	19.1	12.7	1726.6	2871.0	8.2	0.8	1.3	4.1	2.4	5.1	10.1	4667.9	389.0
1967	17.7	15.7	14.8	37.7	73.2	157.7	5.8	0.2	0.3	0.1	1.5	16.9	341.5	28.5
1968	101.0	64.8	114.6	286.3	2563.8	43.1	29.6	5.3	16.2	9.6	27.1	103.3	3364.6	280.4
1969	51.0	1104.0	2174.0	1911.4	850.9	17.8	1.0	0.1	0.0	0.0	19.0	43.9	6173.2	514.4
1970	103.4	75.6	754.5	658.6	474.4	11.6	6.4	0.7	0.6	3.9	14.9	12.3	2116.9	176.4
1971	13.0	22.3	26.6	15.3	8.0	0.6	0.7	7.8	0.9	0.7	5.9	51.8	153.4	12.8
1972	132.6	59.1	36.2	15.8	12.3	9.8	3.9	0.1	0.8	9.8	56.4	108.5	445.3	37.1
1973	87.7	140.0	595.1	4074.3	581.3	1360.0	12.9	4.0	78.3	359.1	1117.9	1953.1	10363.7	863.6
1974	1311.1	854.0	572.1	643.5	301.1	1718.5	6.3	3.8	125.0	134.2	1887.5	1373.6	8930.7	744.2
1975	842.9	2243.1	1045.3	795.9	1503.1	353.9	23.1	5.8	2.2	1.0	8.0	13.4	6837.8	569.8
1976	45.7	45.9	122.8	45.4	125.0	20.2	226.3	4.5	5.6	5.5	7.8	54.1	708.7	59.1
1977	54.8	1170.5	1373.4	1523.3	86.0	10.2	1.1	17.5	16.2	2.8	12.1	32.5	4300.2	358.4
1978	49.5	72.2	107.3	41.8	43.3	6.1	0.3	0.2	0.0	0.0	2.3	10.6	333.5	27.8
1979	145.8	116.5	921.3	2552.0	1757.7	293.4	32.4	191.5	652.3	31.2	220.6	586.1	7500.9	625.1
1980	1408.2	1382.5	544.4	1077.4	970.1	21.3	1.8	0.0	0.0	1.4	5.7	8.6	5421.4	451.8
1981	9.2	15.1	25.4	17.5	108.7	134.4	14.1	1.8	1.7	10.6	18.3	23.4	380.0	31.7
1982	24.4	58.3	48.7	33.0	47.3	11.9	7.0	0.7	0.0	0.1	5.6	127.2	364.4	30.4
1983	62.7	197.1	756.4	299.7	265.4	10.3	23.2	0.7	0.1	0.0	1.5	43.2	1660.3	138.4
1984	18.4	75.7	82.0	46.7	9.1	2.7	0.6	0.1	0.0	0.0	0.0	0.0	235.2	19.6
TOTAL	13820.9	19134.4	20581.7	28330.0	31677.9	8167.2	1229.1	366.6	1478.8	1199.6	6653.3	9363.0	142002.5	
AVG	363.7	503.5	541.6	745.5	833.6	214.9	32.3	9.6	38.9	31.6	175.1	246.4	3736.9	

TABLE 2-6

PERCENTAGE OF AVERAGE MONTHLY FLOWS FOR PERIOD OF RECORD IN VARIOUS LOW-FLOW CATEGORIES FOR HISTORIC AND SIMULATED FULL RESERVOIR DEVELOPMENT CONDITIONS (129,000 ac-ft firm yield)

cfs	J	F	M	A	M	J	J	A	S	O	N	D
	Baseline											
0-5	0	0	0	0	0	3	13	37	39	37	10	5
6-10	3	0	0	0	0	0	13	10	3	5	8	0
11-15	0	0	0	0	0	5	5	10	3	3	3	0
16-20	0	0	0	0	0	0	0	0	5	8	3	3
21-30	0	0	0	0	0	3	3	5	10	5	3	0
31-40	0	0	0	0	0	3	5	8	3	0	8	3
	Full Reservoir Development											
0-5	3	0	0	0	0	13	42	68	63	58	26	10
6-10	8	0	0	0	5	8	21	13	8	13	21	5
11-15	3	3	5	0	3	16	5	5	5	5	16	13
16-20	8	8	0	10	3	13	3	3	10	5	10	8
21-30	3	8	5	3	5	10	16	8	3	5	5	10
31-40	10	0	8	3	0	0	3	0	0	3	3	8
	Proposed Minimum Flow Program Results											
0-5	0	0	0	0	0	0	0	0	0	0	0	0
6-10	10	0	0	0	0	21	63	82	71	71	47	16
11-15	3	3	0	0	0	16	5	5	5	5	16	13
16-20	8	8	0	0	0	13	3	3	14	5	10	8
21-30	3	8	0	0	16	10	16	8	3	5	5	10
31-40	10	0	18	16	0	0	3	0	0	3	3	8

but it is unreasonable to release such large quantities of water during low-flow years. The gains in fish production would be minor and the cost to the LCUD excessive.

EH&A utilized the USFWS IFG-U hydrologic data to estimate the average stream widths, greatest depths and stream widths less than 1-ft deep for the two USFWS sampling stations (Hwy. 154 and Hwy. 3001).

Table 2-7 presents the results of our estimation of these parameters at various flow levels in Little Cypress Bayou. These values are averages for three transects at the Hwy. 154 station and four transects at the Hwy. 3001 station. The average widths and greatest depths are self explanatory. The inclusion of the measurement of stream width with a depth of less than 1 ft was to provide an estimate of the steepness of the bank slope. Additionally, this parameter, when viewed with the others, provides an estimate of sheltered shallow water habitat versus more mainstem deeper water stream areas which offer less protection. Note that generally, as the flows increase, less shallow protected edge is proportionally available indicating relatively steep bank. Flows much higer than 200 cfs appear to be necessary before overbanking and creation of extensive shallow water habitat occurs.

Note also that from 5 to 200 cfs at Hwy. 154, the width is only slightly more than two times as great and only slightly more than three times as great for Hwy. 3001. The flow, however, was increased 40 times.

There is a significant gain in the greatest depth at 200 cfs over 5 cfs, but considering the steepness of the banks and relatively little shallow water habitat, such conditions are not necessarily conducive to prime habitat. Forage species have relatively little protected habitat from predatory species under these conditions.

TABLE 2-7

HABITAT PARAMETERS AS ESTIMATED FROM IFG-U HYDROLOGIC DATA FOR HWY. 154 AND HWY. 3001 STATIONS

Flow (cfs)	Average width (ft)	Greatest depth (ft)	Average width of less than 1 ft depth
	Hwy. 154		
5	42	2.3	11.0
20	48	3.6	4.0
50	53	5.1	3.7
70	57	6.2	4.3
100	65	7.0	8.7
150	90	8.1	18.7
200	101	9.1	11.7
	Hwy. 3001		
5	25	2.2	9
10	31	2.6	11
20	34	3.2	9
25	37	3.5	8
50	44	4.4	9
75	55	5.1	14
100	60	5.6	15
150	74	6.4	16
200	80	7.1	11

Gain in depth is the only significant habitat increase over the flow range presented in Table 2-7. While some increase in depth is valuable at the lower flows, it is not really required once depths of 4 or 5 ft are attained. Rather, it would be desirable to have more width. This is not possible given the steep banks until much higher flows are attained. However, as described earlier, such flows would require so much water as to consume the firm yield of the reservoir as downstream releases. Therefore, it is impossible to provide such high flow levels.

EH&A has examined the weighted useable area tables for the study species at various flow levels in Little Cypress Bayou. These data sheets were provided by the USFWS and are included in Appendix A (Tables 1-6) as received (handwritten). The tables display the amounts of weighted useable area (WUA) available at Hwy. 154 and Hwy. 3001, as calculated using the USFWS fish curves and another set calculated for the same stations utilizing USCE Waterways Experiment Stations (WES) fish curves. There exists a considerable difference in the conclusions of the two sets of analyses.

EH&A has graphically depicted the results of the WUA analyses. The graphs are presented in Appendix A. Please refer to the legen page preceding the graphs for an explanation of the graphic content.

Figure 1 (Appendix A) displays the adult habitat as WUA's for the HEP species, while Figure 2 (Appendix A) displays the adult habitat for the IFIM species. These values were taken from the composite WUA analyses (Tables 1 and 4, respectively).

Note that the WUA's for the HEP species indicate substantial habitat available at flows of 50 cfs or less whereas WUA's for the IFIM species indicate that little habitat is available at or below 25 cfs. Only one species (spotted bass) is common to both analyses. Figure 3 (Appendix A) presents the composite and individual station WUA's for spotted bass, as determined by the WES fish curves while Figure 4 (Appendix A) presents the same information as determined by the USFWS curves. While the WES curves indicate substantial habitat at flows from 5 cfs through 25 cfs, the USFWS curves indicate very little habitat should be present at those flows.

Table 7 (Appendix A) provides an examination of the relative amounts of habitat availabel to the study species at various flow levels for the analyses utilizing the WES fish curves. At each flow level, the habitat, as a percentage of the largest amount of habitat predicted over the flow range of 5 to 300 cfs, is presented. Therefore, any flow depicted as 100% habitat contained the highest WUA estimate for that study species. For instance, the spotted bass estimate indicated that 300 cfs produced the high WUA value, whereas 5 cfs produced a value 37.1% of that predicted at 300 cfs. Note that, at flow levels of 25 and 50 cfs, 94.3 and 97.6% of the highest WUA's were predicted. Examination of Table 7 indicates very high levels of habitat available for all study species with the exception of the blacktail shiner at flows from 5 to 25 cfs. This data corresponds to the habitat requirements of those species and the physical habitat limits predicted by the hydrologic analysis referred to in Table 2-7 support the contention that such habitat would exist. This is in opposition to the estimates predicted by the USFWS curves. However, as described earlier in this report, EH&A does not feel that the species chosen for the IFIM analyses are as representative of the bayou as the HEP species. The results depicted in Table 7 are graphically displayed in Figure 5 (Appendix A). Figures 6-17 (Appendix A) display the WUA's for the HEP study species for both the Hwy. 154 and Hwy. 3001 stations at various flow levels. Figures 18-27 (Appendix A) portray similar information for the IFIM study species using the USFWS fish curves.

An important consideration to the maintenance and enhancement of the downstream fishery involves the occurrence of downstream releases of water for water supply purposes to the City of Marshall and others. These releases are not proposed as part of a downstream flow maintenance program, but are flows which will occur and should be considered in assessing the effect of reservoir development on the downstream fishery. Table 2-8 presents two alternative scenarios of the annual release of approximately 15,500 ac-ft of water for the City of Marshall. Alternative I displays the option where Marshall would recline its water supply from Little Cypress Reservoir only during the months of June through December, acquiring its water supply needs from the Big Cypress Bayou run of the river water only from January through May. Alternative II is a scenario where Marshall would acquire approximately 42% of its monthly demand from run of the river flows and 58% from Little Cypress releases. Either alternative results in a considerable enhancement of summertime flows. Considering that most of the spills from the reservoir occur from January through May or June, Alternative I provides the greatest enhancement by substantially increasing the summertime flows. Reservoir spills, or water not able to be stored, have been simulated by KS&A for the historical 38-year period of record. Their results indicate that spills in excess of 50 cfs will occur 47% of the time for the months of January through June and 62% of the months of March, April and May.

Alternative I would provide flows matching or exceeding the minimum flows for the HEP maintenance from July through November based on water supply release for Marshall, alone. Spills in the winter and spring would equal or exceed the USFWS recommended flows 44% of the time and the HEP maintenance flows 42% of the time. Flows would exceed the USFWS and HEP flows during March, April and May 59% and 54% of the time respectively. These values do not include any minimum flow releases.

Alternative II would approach the HEP maintenance flows in July and exceed those flows from August through September. Springtime spills from the reservoir will be as in Alternative I. However, in those cases where no spills would occur, Alternative II would provide more flow than the proposed minimum flow maintenance program during January, February and June.

TABLE 2-8

CITY OF MARSHALL
MONTHLY RAW WATER DEMAND IN CFS
(YEAR 2030)
ON LITTLE CYPRESS RESERVOIR

Month	Alternative I*	Alternative II**
January	0	17
February	0	17
March	0	17
April	0	18
May	0	19
June	7	24
July	53	31
August	54	31
September	45	26
October	34	19
November	31	18
December	32	18

* Marshall demand only from June-December; remaining months utilize Big Cypress run of river water.

** Marshall acquires 58% of raw water demand monthly from Little Cypress Reservoir and 42% run of river water from Big Cypress Bayou.

Both alternatives provide enhancement level flows during the summer months and provide flows in addition to estimated maintenance level flows during other months.

3.0 LITTLE CYPRESS RESERVOIR PROJECT MITIGATION

3.1 EVALUATION OF EXISTING INFORMATION

The initial step in mitigation analysis for the proposed reservoir was to assemble, evaluate, and compare all existing data and analyses relevant to the problem. The report and vegetation map prepared by Freese and Nichols (F&N, 1986) presented a comprehensive analysis of the potential impacts on water quality and fish and wildlife resources. The preliminary draft feasibilty report for Cypress Bayou basin prepared by the USCE (1986) was also evaluated. The data for the compensation analyses being performed by the Texas Parks and Wildife Department (TPWD) and USFWS for the proposed Little Cypress Reservoir were obtained from representatives of those agencies. However, results of the TPWD and USFWS analyses are not yet available. An EH&A representative accompanied TPWD personnel during the site visit conducted by that agency.

3.2 VEGETATION MAPPING

Previously-available acreage estimates for the various vegetation cover types within the project area available from Freese & Nichols and USFWS were sufficiently dissimilar to leave questions about the actual acreage of several important habitat types. Therefore, it was determined that detailed vegetation mapping was necessary. Concurrent with our effort, the TPWD prepared vegetation estimates for the project area as well. The map produced by EH&A included an expanded set of cover types, to include cover types not determined in previous mapping efforts for the project. The categories selected by EH&A also facilitate comparison with the previous acreage estimates. The habitat types delineated on the map represent that area which would be inundated by the proposed Little Cypress Reservoir at maximum flood elevation (245 feet (ft) above mean sea level (MSL)). Acreage summaries were prepared for each habitat type that falls within the normal conservation pool area (below 230 ft MSL) and, additionally, for the area between 230 ft and 245 ft.

3.3 METHODS

Thirteen cover types which are representative of typical habitat types found along Little Cypress Bayou were identified within the proposed reservoir site. These are: swamp (map symbol = S), alluvial hardwood forest (A), riparian habitat (R), cut-over and regeneration areas within bottomlands (CB), pine forest (P), pine-hardwood forest (PH), upland hardwood forest (U), cut-over and regeneration areas within uplands (CU), young pine (YP), grassland (G), open water (W), marsh (M) and disturbed areas (D). Detailed descriptions of these habitat types are presented in the next section.

The habitat type map was produced from photo-interpretation of 1984 and 1985 USDA color infrared photography enlarged to a scale of 1"=1320'. Several sources of support data were used in conjunction with the photography: U.S. Fish and Wildlife Service National Wetlands Inventory Maps, USGS topographic maps, and field reconnaissance of the proposed reservoir site conducted February 1-3, 1987.

After completion of the field work, the preliminary map was finalized and drafted onto black-and-white mylar transparencies of the original color infrared photos. The mylars were also at a scale of 1"=1320'.

The final maps were electronically digitized to produce acreage summaries for each habitat type. Total digitized acreage varied less than 1% from the total known acreage of 13,760 for the proposed reservoir's normal pool. Acreage values for each habitat type were normalized and are presented in the following section and in Table 3-1.

3.4 HABITAT DESCRIPTIONS AND ACREAGE

The swamp (S) category is represented by semi-permanently flooded forest, typically adjacent to main creek channels. During all but about three months

TABLE 3-1

ACREAGE SUMMARIES FOR HABITAT TYPES WITHIN THE PROPOSED LITTLE CYPRESS RESERVOIR

Habitat Type	Normal Pool (230 ft msl)		Maximum Flood (230-245 ft msl)	
	Acres	%	Acres	%
Swamp (S)	2,195	16	1,063	12
Alluvial Hardwood Forest (A)	5,196	38	2,245	26
Riparian (R)	60	< 1	92	1
Cut-Over & Regeneration-Bottomland (CB)	838	6	308	4
Pine Forest (P)	478	3	594	7
Pine-Hardwood Forest (PH)	1,984	14	1,407	16
Upland Hardwood Forest (U)	39	< 1	110	1
Cut-Over & Regeneration-Uplands (CU)	39	< 1	82	< 1
Young Pine (YP)	363	3	2	< 1
Grassland (G)	1,910	14	2,393	27
Water (W)	74	1	82	1
Marsh (M)	557	4	349	4
Disturbed (D)	27	< 1	33	< 1
TOTAL	13,760	100	8,760	100

of the year, water will stand in these areas. Baldcypress (Taxodium distichum) is an indicator species for this community type, although it was infrequently observed during field reconnaissance. More common species included overcup oak, water oak, laurel oak (Q. laurifolia), blackgum (Nyssa sylvatica), sweetgum, and swamp privet (Forestiera acuminata). This community type covered 2,195 ac (16%) of the area (Table 3-1).

Alluvial hardwood forests (A) occur on the terraces which are slightly higher than the main channel of Little Cypress Creek. These areas are inundated during flood episodes but are drained between episodes. Hardwood tree species make up 75% or more of the community. Typical dominant species include willow oak (Quercus phellos), water oak (Q. nigra), sweetgum (Liquidambar styraciflua), river birch (Betula nigra), overcup oak (Q. lyrata), and southern red oak (Q. falcata). This community type comprises 5,196 ac (38%) of the proposed normal pool site.

Riparian types (R) are narrow bands of vegetation along the banks of streams and drainages. Often phreatophytic plants such as black willow (Salix nigra) occur in riparian habitats, taking advantage of full sun and ample water. In other cases, riparian stands are remnants of alluvial forest left along streams and drainages when forests were cleared for pastureland. Less than 1% (60 ac) of the proposed normal pool area is represented as riparian habitat.

The cut-over and regeneration type is a varied category including: (1) recently harvested pine or hardwoods (most cutting has been selective rather than clear-cut), and (2) natural woody and weedy regrowth during the first few years following harvest. Cutting which has occurred within the broad alluvial floodplain of Little Cypress Creek has been termed cut-over bottomland (CB) and cutting which has occurred in the drier upland sites has been termed cut-over upland (CU). These types comprise 838 ac (6%) and 39 ac (<1%) of the proposed normal pool (Table 3-1).

Pine forests (P) are typically managed for timber production and are, therefore, pure stands (>75%) of loblolly pine (Pinus taeda). About 3% of the area (478 ac) was mapped into this category.

Mixed pine-hardwood forests (PH) occur throughout the proposed reservoir site and are comprised of <75% but >25% pine. Both short-leaf pine (Pinus echinata) and loblolly pine were observed intermixed with hardwoods. The type of hardwoods which occurs in any particular stand depends on stand location. Pine-hardwood stands occurring within the floodplain tend to support hardwoods from the surrounding alluvial hardwood forest such as southern red oak, water oak, white oak, sweetgum, and Florida maple (Acer barbatum). Mixed forests in the drier upland sites tend to support hardwoods found in the upland hardwood forests such as post oak (Quercus stellata), black hickory (Carya texana), and blackjack oak (Q. marilandica). About 1,984 ac of mixed forest occurred within the proposed normal pool area.

Upland hardwood forests (U) were uncommon in the proposed reservoir site, comprising only 39 ac (<1%) of the area. They occurred primarily along higher, somewhat drier slopes. Typical hardwoods in this habitat type were post oak, blackjack oak, sweetgum, and black hickory.

The young pine (YP) category represents planted pine plantations in seedling or sapling stage. In some areas, mature seed trees are intermixed. This type covers about 363 ac or 3% of the proposed normal pool area.

Grasslands (G) include both native grassland (which is not common) and domesticated pastureland. Pastureland is primarily seeded with bermuda grass while native grasslands are bluestem communities with little bluestem (Schizachyrium scoparium), splitbeard (Andropogon ternarius), and broomsedge bluestem (A. virginicus) predominating. Many unmanaged pastures have become invaded with weedy species such as goldenrod (Solidago spp.) and upright prairie coneflower

(Ratibida columnaris). Several isolated areas were also overgrown with honeysuckle (Lonicera japonica) and dewberry (Rubus sp.). Grassland totals 1910 ac (14%) within the proposed normal pool area.

Open water (W) was represented primarily by stock ponds and by a few areas where the main channel of Little Cypress Creek was not obscured by canopy closure. Seventy-four (74) ac (1%) of the proposed reservoir site was mapped as open water.

Marshes (M) are areas which are seasonally or semi-permanently inundated. Many of these areas appear as open water in the 1984-1985 photography. Closer examination of the photos together with field reconnaissance showed these areas to support emergent herbaceous vegetation, much of which was characteristic marsh species. These included various species of sedges and rushes. Sumpweed (Iva sp.), smartweed (Persicaria sp.) and rosemallow (Hibiscus sp.) were also common. Marshy areas comprised about 557 ac (4%) of the proposed normal pool area.

Disturbed (D) areas are typically unvegetated and include oil well pads, major roadways, and parking areas. This mapping unit totaled 27 ac.

3.5 COMPARISON OF ACREAGE ESTIMATES

Results of the EH&A vegetation mapping effort were summarized along with the estimates of Freese and Nichols, TPWD, and USFWS (Table 3-2). Note that the acreage estimates for the bottomland forest subtotal category is not that dissimilar for the Freese and Nichols, TPWD, and EH&A estimates, whereas the USFWS estimate is substantially higher. A comparison of the USFWS habitat acreage estimates and percentages for the Marshall Reservoir and Little Cypress Reservoir indicates that the two were not determined independently. The percentages of the various habitats are identical for both reservoirs. This indicates that the habitat estimates were scaled down from the Marshall Reservoir acreage to the Little Cypress acreage. This probably accounts for much of the discrepancy between the USFWS estimates and the other estimates.

TABLE 3-2

VEGETATION COVER TYPE ESTIMATES FOR LITTLE CYPRESS RESERVOIR PROJECT*

	Freese and Nichols	Texas Parks and Wildlife Dept.[3]	U.S. Fish and Wildlife Service	Espey, Huston and Associates	Average
Flooded Hardwood Forest	2,471 (18)	263 (2)	ND	2,195 (16)	
Bottomland Hardood Forest	4,786 (35)	7,854 (57)	9,907 (72)	5,196 (38)	
Riparian Woodland	ND	ND	ND	60 (<1)	
Cutover Bottomland Forest	ND	ND	ND	838 (6)	
Bottomland Forest Subtotal	7,257 (53)	8,117 (59)	9,907 (72)	8,289 (60)	8,392 (61)
Pine Forest	610 (4)	706 (5)	1,100 (8)	478 (3)	
Mixed Pine/Hardwood Forest[1]	3,587 (26)	2,454 (18)	ND	1,984 (14)	
Upland Hardwood Forest	ND	ND	138 (1)	39 (<1)	
Cutover Upland Forest	ND	ND	ND	39 (<1)	
Shrubland	ND	754 (5)	275 (2)	363 (3)	
Upland Forest Subtotal	4,197 (30)	3,914 (28)	1,513 (11)	2,903 (21)	3,132 (23)
Grassland, Crops, etc.	2,024 (15)	1,656 (12)	2,064 (15)	1,910 (14)	1,914 (14)
Water[2]	110 (1)	12 (<1)	276 (2)	631 (5)	257 (2)
Other	172 (1)	60 (<1)	ND	27 (<1)	65 (<1)
TOTAL	13,760 (100)	13,759 (100)	13,760 (100)	13,760 (100)	13,760 (100)

1 Pine/Hardwood Forests generally occur on higher terraces within the floodplain, and contain bottomland hardwood species.

2 Includes Riverine and Lacustrine (USFWS) and Marsh (EH&A) categories.

3 TPWD estimates are normalized to 13,760 total acres (from 13,299 acres).

ND = Not Determined.

(rev. 2/17/87)

* Normal pool elevation, 230 ft MSL. (Estimates given in acres; percent of total area shown in parentheses.)

3.6 TERRESTRIAL MITIGATION

Neither the TPWD or USFWS have produced terrestrial mitigation estimates for the Little Cypress Reservoir at the time this report was written. The USFWS did produce a terrestrial mitigation estimate for the Marshall Reservoir, using the HEP, that 35,088 acres of bottomland hardwoods and 14,731 ac of riverine habitat would be required to fully compensate for the adverse impacts of Marshall Lake. The estimate was calculated based on the guide take line of 241.7 ft MSL including 20,172 ac. The conservation pool elevation and acreage for Marshall Reservoir were 233.1 ft MSL and 15,763 ac, respectively. Little Cypress Reservoir has a conservation pool elevation of 230 ft MSL or 13,760 ac.

Since the Little Cypress Reservoir contains substantially less acreage than the Marshall Reservoir, and since the USFWS estimates of bottomland hardwoods are substantially larger than three other estimates available, the Marshall HEP results should not be represented as applicable to the Little Cypress Reservoir. Furthermore, it should be noted that the mitigation requirements for Marshall Reservoir were based upon the assumption by the USFWS that all bottomland hardwoods should be compensated for as a resource category 2 habitats when, in fact, little of the reservoir is actually classified as resource category 2, but rather as resource category 3. Resource Category 3 allows out-of-kind mitigation, whereas resource category 2 does not. Also, the text of the USFWS coordination letter assumes that all HSI's for Marshall Reservoir would go the maximum value of 1.00 at TY100 under the future with project and management scenario. However, A-8 in the report, providing the assumed HSI value, does not indicate maximum values at TY100.

Since Little Cypress Reservoir is smaller than Marshall Reservoir, contains substantially less bottomland hardwoods than the USFWS estimate and the majority is not designated as a Priority 2 area in the Texas Bottomland Hardwoods Preservation Program, considerably less acreage should be required to mitigate the impacts than would be required by a HEP analysis, as performed for the Marshall Reservoir. It should also be noted that the HEP analysis does not credit the project with any gains associated with reservoir development such as aquatic habitat, increased riparian habitat along the lake or the recreation, water supply or economic benefits associated with the project. For instance, the aquatic HEP performed for the new reservoir indicated approximately 15.5 times more aquatic habitat would be created than habitat lost through construction of Marshall Reservoir. Neither is any credit given for any downstream minimum flow program.

Furthermore, a basic assumption of the HEP analysis for Marshall held that bottomland hardwood loss without the project would be 25% over the 100-year analysis. This assumption was based on information prepared by the East Texas Council of Governments which projected a 5-10% decrease in woodlands in the region during the 20-year period from 1976-1996 (USCE 1986, App. H, Sec. 2, p. 5). The USFWS utilized the lower value of the range indicating that only 25% of the bottomland hardwoods would be lost. If the 10% value in 20 years had been utilized, a reduction of 50% bottomland hardwoods would have been utilized in the HEP analyses.

A similar estimate was recently reported by the Southern Forest Experiment Station. This report stated that in northeast Texas there was a 6% reduction of bottomland forests during the 11-year period of 1975-1986 (McWilliams and Bertelson, 1986). The 6% reduction is for a 21-county area of northeast Texas and is due to several causes, including reservoir construction. If bottomland forest acreage is reduced at the rate of 6% every 11 years, then in 99 years 42.7% of the original amount will have been lost. Therefore, it could be assumed that, without the project, 57.3% of the bottomland forests in the project area would remain in 99 years. While this estimate falls within the range predicted by the East Texas COG, LCUD in discussion with individuals knowledgeable of the timber industry in the area, has determined that this estimate may be low. This is due to advances in the paper industry which can now utilize lower quality wood sources than previously possible. Therefore the demand on additional acres of lower-quality hardwoods may well increase.

Replacement of 57.3% of the bottomland forests in the Little Cypress Reservoir impoundment area would require the acquisition of 4,750 ac. Without the project, it is assumed this amount of bottomland forest habitats would be lost incrementally over the 99-year period of analysis. Since the existing habitats would be converted to aquatic habitats at the beginning of the project life (during filling of the reservoir), intensive management of habitat quality in the mitigation area is necessary to offset the immediate loss in habitat quantity.

3.7 DISCUSSION OF MITIGATION ALTERNATIVES AVAILABLE TO LCUD

The LCUD has investigated numerous potential mitigation alternatives since project inception. The following description outlines the present preferred scenario of mitigation activities.

Discussions with the TPWD have determined that a fish hatchery would be desirable below the dam. LCUD would provide 60 ac of land, an access road (50% pro rata), a 24-inch pipe through the dam for water supply to the hatchery, and the necessary valves, fittings, etc. required to bring water to the facility. The land and improvements described above represent a cost of $72,750 to LCUD.

As part of the development process, numerous prehistoric and historic artifacts will be recovered during archaeological investigations. LCUD proposes to provide permanent curation of the artifacts on site. This will entail construction of an approximately 3,000 sq-ft facility to house and display the artifacts. All too frequently, such artifacts are simply curated in permanent storage where only the professional archaeologist would have access. As part of a public information program, LCUD would provide the public with displays and descriptions of the cultural resources recovered from the reservoir. This facility represents a cost of $225,000 to LCUD.

LCUD, in working with the regulatory agencies, has developed a proposed clearing plan for the reservoir which, while advantageous to fisheries management and recreational activities, will be more costly. Traditional clearing would have called for 8,280 ac to be uncleared with boat lanes and 5,520 ac to be completely cleared. The cost for the typical clearing plan is estimated at $2,622,000. The proposed clearing plan includes 3,173 ac uncleared with boat lanes, 1,597 ac completely cleared, 2,143 ac of trees felled in place and 6,887 ac cleared with the trees stacked and anchored.

The cost estimate for this clearing plan is $4,218,050. Therefore, the more innovative clearing plan alternative will cost LCUD $1,596,050 more than the traditionally-accepted clearing plan.

LCUD is investigating various recreational site development plans. Currently, 355 ac are planned for recreational development. Such planned recreational areas are definitely needed in east Texas. The land costs and site development represent a cost of $3,000,000 to LCUD with over 90% of the cost represented by site improvements.

LCUD intends to purchase additional lands which may be periodically flooded above (1,500 ac) and below (2,200 ac) the reservoir, as well as approximately 1,000 ac in the periphery of the reservoir to be utilized as wildlife management areas. The estimated cost to purchase the land is $3,300,000. Since the final management plan has not been developed for such areas as yet, no annual costs for management efforts have been presented. These costs, however, could be significant over the life of the project.

The estimated total costs for the above described mitigation activities is approximately $8,200,000.

This plan includes sufficient acreage to directly offset the loss of bottomland hardwoods estimated to be lost by the project development. The land will be managed to achieve optimum wildlife habitat value. Additionally, the plan goes on to offer substantially more mitigations than required to directly offset the bottomland hardwood loss. Given the costs associated with these numerous mitigation activities if more acreage were to be required by the various agencies to offset bottomland hardwood losses, various of the above described activities would necessarily have to be dropped from the proposed mitigation plan. Altogether, the cross-section of mitigation activities described would provide numerous benefits to the environment, the general public and agencies involved in supplying the recreational and cultural needs of society. It must be recognized that these mitigation activities are offered in addition to the increase in permanent jobs, local revenues, recreational potential and the improved water supply for the area.

4.0 EVALUATION OF THE EFFECTS OF RESERVOIR DEVELOPMENT ON CADDO LAKE ECOLOGY

This section of the report is based on the EH&A evaluation of water quality and hydrologic impacts to Caddo Lake and on data contained in the USCE Caddo Lake Enlargement Study (1985).

The areas of concern to the ecology of Caddo Lake relative to Little Cypress Reservoir development include alterations to the water surface elevation, reduction of flushing flows, and degradation of water quality.

Caddo Lake has a storage capacity of 128,600 ac-ft at elevation 168.5 NGVD. At this level, the lake covers 26,800 surface acres. Kindle, Stone & Associates (Joe Harle, pers. comm.) indicated that the volume of Caddo Lake is now replaced an average of ten times a year. With Little Cypress Reservoir in place, this value would be reduced to a little over nine replacement volumes or flushings per year. This is not a significant reduction in the lake flushing effect. Furthermore, the full development scenario will only change the average elevation of Caddo Lake less than one inch. In fact, the minimum pool elevation will rise almost two inches under the worst-case scenario. A change in elevation of one inch will be lost in the noise of the normal fluctuations of Caddo Lake. The lake has historically varied from 166.0 NGVD to 182.6 NGVD. The average annual fluctuation usually ranges from approximately 168.25 to nearly 170 NGVD. Obviously, the level change due to Little Cypress Reservoir will not be significant. At that, the USCE report indicates that no effect on the fishery of Caddo Lake would be expected by periodic drawdowns in the summer or fall.

Water quality and growth of aquatic plants in the lake will remain unaffected by the minor reduction in net volume pass-through. Furthermore, the intensity of the flows associated with larger inflow effects will remain largely the same. Therefore, mechanical flushing of brush, logs and aquatic plants should remain very similar to present conditions.

Limited water quality data for Caddo Lake prevents a quantified assessment of potential changes in water quality.

As stated in the EH&A report, positive water quality impacts related to Little Cypress Reservoir would include reduction of nutrients and suspended solids. As noted in that report, Lake O' the Pines has improved the downstream water quality in Big Cypress Creek. The EH&A report notes that the only negative water quality effect would be reduced instream flow during low-flow periods. The proposed minimum flow program will offset this effect and actually improve the situation over the historic low-flow events.

Reduction in nutrients from Little Cypress Bayou will probably not affect the growth of aquatic plants in the reservoir as aquatic macrophytes can obtain nitrogen and phosphorus from the sediments. Limited data on sediment chemistry in Caddo Lake indicates that more than sufficient nutrients are available to support macrophytes. Lower solids and turbidity could increase light penetration which could promote algal growth; however, reduced nutrient levels could offset that effect.

Overall, Caddo Lake water quality appears to be dominated by inflow quality. This is not susprising considering the volume of pass-through. Considering the relatively minor potential changes in flushing due to Little Cypress Reservoir, it would be difficult to demonstrate any change in Caddo Lake. Overall, the net result would be either not detectable or slightly positive.

5.0 LITERATURE CITED

Freese and Nichols, Inc. (F&N). 1986. Little Cypress Reservoir effects on water quality and fish and wildlife. Freese and Nichols, Inc. Fort Worth, Texas.

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APPENDIX A

1" HABITAT Run Results
– Summary Sheets –

BI

WUA for Little Cypress Bayou Fish Evaluation Species
(Composite of Hwy 154 and Hwy 3001 Study Sites, U.S.FWS fish curves)

12-18-86

Stage / Species	5	10	15	20	25	50	75	100	125	150	200	250	300
DULTS													
annel catfish	798	1523	2,545	4,060	5,993	16,094	24,561	29,074	31,337	33,400	37,973	42,231	46,147
otted bass	0	337	1,277	2,825	5,114	16,635	24,962	28,357	29,934	31,673	34,465	36,051	38,548
hite bass	0	36	606	1,814	3,162	12,267	21,003	26,706	30,703	33,820	39,105	43,443	48,528
hite crappie	476	2,887	6,180	9,208	11,703	22,642	25,653	26,757	27,711	28,310	28,225	29,993	34,510
izzard shad	164	1,265	2,653	4,234	6,290	16,655	24,612	29,738	33,521	36,318	40,825	45,710	51,049
AVG.	288	1,210	2,652	4,428	6,452	16,859	24,158	28,139	30,641	32,704	36,119	39,486	43,756
UVENILES													
hannel catfish	332	609	844	1,077	1,311	2,175	2,598	2,665	2,647	2,693	3,090	3,545	3,882
potted bass	2,790	5,344	8,375	11,327	13,780	21,925	24,463	25,503	26,384	27,361	27,080	31,551	35,432
hite bass	4,002	8,023	12,016	15,776	19,073	29,649	35,197	39,796	43,538	46,513	53,010	60,846	67,154
hite crappie	18,483	24,418	27,688	30,431	32,885	35,444	35,687	33,496	32,322	35,444	43,153	45,405	44,346
izzard shad	164	1,265	2,653	4,234	6,290	16,655	24,612	29,738	33,521	36,318	40,825	45,710	51,049
AVG.	5,154	7,932	10,315	12,569	14,668	21,170	24,571	26,290	27,682	29,666	33,832	37,411	40,373
PAWNING													
hannel catfish	306	1,345	2,648	4,702	7,172	18,177	25,486	28,645	27,740	30,660	30,140	28,507	28,189
potted bass	11,264	16,350	21,999	25,861	28,203	35,295	35,375	34,467	32,456	31,728	37,172	42,978	45,228
hite bass	4,511	7,718	11,093	12,711	14,325	19,693	22,958	26,487	28,815	30,980	37,518	43,309	46,710
hite crappie	12,119	16,674	20,642	23,957	26,498	34,724	35,127	33,242	31,092	32,338	35,787	39,737	41,317
izzard shad	11,018	17,037	22,890	25,921	28,303	36,103	37,520	40,929	37,441	38,093	42,545	46,880	49,594
AVG.	7,844	11,825	15,850	19,629	20,900	28,808	31,693	32,754	32,309	32,760	36,652	40,282	42,208
RY													
hannel catfish	25,259	30,441	33,574	35,543	37,306	44,498	49,633	53,583	60,876	65,671	68,507	66,954	65,086
potted bass	2,153	4,459	7,689	10,935	14,191	25,372	30,034	32,464	34,374	35,798	37,620	39,250	43,507
hite bass	10,971	17,015	22,530	25,340	27,437	33,395	32,296	32,491	31,621	31,658	38,268	43,235	45,117
hite crappie	20,067	24,806	27,005	28,771	30,197	26,230	22,018	18,328	17,850	21,907	29,590	30,763	27,541
izzard shad	15,591	20,782	23,617	25,589	26,603	25,744	23,167	20,014	19,868	21,417	26,587	28,816	27,203
AVG.	14,808	19,514	22,883	25,236	27,747	30,848	31,430	31,556	32,918	35,290	40,074	41,804	41,691

WUA = weighted usable area – typically reported in ft² / 1000 ft of stream

B 2

WUA for Little Cypress Bayou @ Hwy 154
(Based on USFWS FISHFIL curves)

Final file copy
12-10-86

Life Stage / Species	5	10	15	20	25	50	75	100	125	150	200	250	300
ADULTS													
Channel catfish	1,188	2306	3,714	6,134	9,379	24,891	35,717	40,698	42,454	45,594	48,405	55,081	56,979
Spotted bass	0	615	2,179	4,890	8,816	26,219	37,925	42,331	44,020	45,739	50,100	52,014	55,844
White bass	0	72	1,191	3,193	5,373	17,205	31,426	38,470	42,048	44,853	49,381	57,927	58,388
White crappie	797	4,897	9,982	14,578	19,413	35,220	37,792	40,501	42,387	43,767	43,414	46,542	55,125
Gizzard shad	327	2,067	4,246	6,666	9,725	24,783	35,241	40,956	44,634	47,119	51,125	56,507	63,375
River darter	12,970	17,577	21,301	24,198	26,438	35,395	39,858	43,503	49,683	55,075	63,425	70,541	77,399
AVG.	2,547	4,592	7,166	9,943	13,024	27,619	34,660	41,077	44,204	46,691	50,975	55,269	61,185
JUVENILES													
Channel catfish	454	808	1,115	1,431	1,750	2,698	2,834	12,530	2,205	2,073	2,399	2,742	2,944
Spotted bass	3,984	7,708	12,793	17,429	21,105	37,132	30,234	34,865	37,440	38,911	41,134	45,603	56,829
White bass	6,022	11,431	16,748	21,747	26,212	37,914	43,470	47,888	51,089	53,300	57,948	69,172	75,252
White crappie	23,107	31,505	36,925	39,127	40,936	39,104	36,125	30,321	26,303	31,997	41,727	43,946	43,145
Gizzard shad	327	2,067	4,246	6,666	9,725	24,783	35,241	40,956	44,634	47,119	51,125	56,507	63,375
Avg.	6,779	10,744	14,365	17,280	19,746	27,726	30,781	31,704	32,334	34,680	35,267	43,474	47,309
SPAWNING													
Channel catfish	518	2,168	4,254	7,519	11,494	27,571	37,131	40,570	41,153	40,949	38,222	37,735	32,640
Spotted bass (habit.)	15,425	21,888	28,788	33,604	36,288	42,129	36,419	31,273	25,215	23,457	32,085	40,929	42,493
White bass	6,371	9,674	13,834	15,604	18,000	22,749	24,196	27,565	28,881	27,796	37,580	42,102	47,864
White crappie	15,358	22,065	26,878	30,700	35,666	47,666	36,346	27,019	23,243	24,579	30,345	36,401	38,560
Gizzard shad	15,244	22,323	29,850	33,838	37,137	43,864	45,853	44,425	38,165	33,496	37,642	45,274	48,089
Avg.	10,683	15,624	20,721	24,253	27,317	35,476	36,029	34,574	34,331	30,455	35,549	39,688	41,129
FRY													
Channel catfish	37,051	37,626	40,521	42,266	43,694	49,097	53,379	55,200	62,949	66,881	65,682	60,041	55,175
Spotted bass	3,048	6,437	11,503	16,276	20,626	35,912	42,456	45,439	47,875	51,418	55,957	69,729	67,560
White bass	15,198	22,447	29,956	33,934	37,093	40,027	37,219	35,928	32,733	31,761	47,031	49,810	51,219
White crappie	25,043	32,757	36,821	38,629	39,090	30,235	23,572	17,387	16,381	25,863	36,870	57,113	36,194
Gizzard shad	20,361	27,987	32,554	35,485	36,737	33,535	28,655	24,523	22,526	25,408	38,297	38,462	36,457
Avg.	19,140	25,451	30,251	33,318	35,448	37,861	37,044	35,695	36,493	40,282	47,168	49,631	49,721

Table 2

Fuss Field Copy
12-17-86

B3

WUA for Little Cypress Bayou @ Hwy 3001
(Based on USFWS Fishfil Curves)

Life Stage/Species	5	10	15	20	25	50	75	100	125	150	200	250	300
ADULTS													
Channel catfish	408	740	1,376	1,986	2,607	7,277	13,405	17,450	20,220	23,205	27,541	31,381	35,315
Spotted bass	0	62	355	760	1,412	7,051	11,998	14,376	15,847	17,606	18,830	20,088	21,251
White bass	0	0	21	434	950	5,328	10,579	15,082	19,357	23,787	28,829	33,958	38,668
White crappie	154	877	2,377	3,837	4,993	10,064	11,513	13,000	13,035	12,852	13,036	13,444	13,894
Gizzard shad	0	462	1,060	1,802	2,855	8,527	13,982	18,519	22,407	25,516	30,525	34,913	38,722
River darter	7,518	10,486	13,159	15,485	17,586	26,603	32,548	38,496	43,638	48,374	55,890	61,764	66,990
JUVENILES													
Channel catfish	210	410	573	723	871	1,652	2,362	2,800	3,088	3,312	3,780	4,347	4,820
Spotted bass	1,595	2,780	3,956	5,225	6,454	10,717	12,691	14,140	15,327	15,811	17,025	18,099	19,036
White bass	1,981	4,614	7,284	9,804	11,934	20,383	26,924	31,744	35,986	39,226	46,071	52,519	59,055
White crappie	13,859	17,331	18,950	21,734	24,833	31,784	35,249	36,671	38,341	38,888	44,578	46,864	45,546
Gizzard shad	0	462	1,060	1,802	2,855	8,527	13,982	18,519	22,407	25,516	30,525	34,913	38,722
SPAWNING													
Channel catfish	94	521	1,041	1,885	2,850	8,782	13,841	16,700	18,326	20,370	22,058	23,278	23,738
Spotted bass (built)	7,103	10,811	15,210	18,118	20,118	28,461	34,130	37,660	39,696	38,999	42,258	45,026	47,963
White bass	2,650	5,761	8,352	9,817	10,649	17,237	21,720	25,412	28,749	32,164	37,456	44,515	49,556
White crappie	8,380	11,283	14,405	17,202	19,330	27,881	33,907	37,464	38,940	40,096	41,558	43,073	44,073
Gizzard shad	6,792	11,750	15,890	18,003	19,469	28,341	33,187	37,432	40,716	42,690	45,447	48,486	51,098
FRY													
Channel catfish	18,466	23,256	26,626	28,819	30,918	39,898	45,886	51,966	58,802	64,461	71,332	73,866	74,996
Spotted bass	1,257	2,481	3,875	5,593	7,757	14,832	17,611	19,489	20,872	20,098	19,281	17,771	17,454
White bass	6,744	11,575	15,204	16,745	17,780	24,763	27,373	29,054	30,509	31,554	33,105	36,660	39,014
White crappie	15,091	16,994	17,189	18,912	21,303	21,725	20,523	19,268	19,318	17,951	22,309	22,412	18,887
Gizzard shad	10,821	13,576	14,680	15,692	16,466	17,952	17,678	17,305	17,209	17,425	18,876	19,169	17,949

Table 3

HABSIM [illegible] [illegible]
– Summary Sheets –
AI

WUA for Little Cypress Bayou (Composite of Sites 154 & 3001, using W.E.S. Fish Curves)

File Copy
12-19-86

Life Stage / Species	5	10	15	20	25	50	75	100	125	150	200	250	300
ADULT													
Spotted bass	9,072	14,176	18,277	21,075	23,094	23,894	19,995	17,053	16,991	18,102	19,790	22,619	24,459
Spotted sucker	5,238	8,632	11,425	12,600	13,716	15,893	13,652	12,222	12,377	12,875	12,685	13,989	15,866
Brook silverside	14,245	16,234	16,403	15,691	14,737	12,402	12,004	11,263	12,535	14,873	15,780	13,515	12,451
Blacktail shiner	5,796	8,691	11,148	13,134	14,922	23,430	29,471	32,449	33,297	33,512	34,841	34,724	34,336
Ironcolor shiner	15,207	14,327	13,670	12,435	11,310	7,989	7,257	7,115	9,119	10,926	12,172	9,949	7,405
Longear sunfish	24,149	24,631	24,602	23,608	22,496	17,763	16,471	16,484	20,139	24,907	28,103	23,302	17,990
Pickerel	12,445	14,000	14,405	14,359	13,960	10,872	8,492	7,571	8,681	10,641	12,069	11,738	10,199
AVG.	12,307	14,384	15,717	16,129	16,319	16,032	15,335	14,880	16,163	17,891	19,349	18,548	17,541
JUVENILE *													
Spotted bass	19,039	16,983	16,847	14,953	13,317	10,231	10,295	9,425	11,830	14,258	17,783	13,824	9,325
Spotted sucker	14,570	15,355	15,331	14,027	13,053	9,384	7,678	7,799	9,349	10,528	12,230	11,135	9,052
Brook silverside	6,665	6,165	5,319	4,826	4,293	2,991	2,161	1,839	2,754	3,036	2,810	3,270	2,671
Blacktail shiner	22,874	22,234	20,976	18,424	16,602	12,786	10,923	10,823	17,681	20,141	18,102	12,637	9,834
Ironcolor shiner	5,324	5,433	5,243	4,898	4,159	1,977	2,372	2,133	2,819	5,268	4,956	2,456	1,856
Longear sunfish	23,246	22,701	22,132	20,803	19,447	13,977	13,056	12,728	16,586	21,279	22,610	17,716	13,353
Pickerel	13,845	14,364	13,920	12,944	11,892	8,421	6,853	6,288	7,577	8,847	10,166	9,585	7,943
AVG.	15,080	14,748	14,253	12,982	11,823	8,541	7,620	7,291	9,799	12,197	12,665	9,946	7,719

* Note: Juvenile and other non-adult life stages were not used in CE streamflow study due to inadequate field data. Therefore, these WUA figures may not be reflective of preferred habitats. Use only adult life stage of CE (W.E.S.) generated fish curve data.

Table 4

A2

WUA for Little Cypress Bayou @ Hwy 154
(Based on W.E.S. developed fish curves, dated 10-6-86)

WUA's using W.E.S. developed Fish SI
Cameron 10-6-86

File Copy

Life Stage/Eval. Species	Q(cfs) 5	10	15	20	25	50	75	100	125	150	200	250	300
ADULT													
Spotted bass	11,734	18,654	24,429	28,476	31,911	32,106	24,241	20,369	20,465	22,416	26,209	31,668	35,926
Spotted sucker	7,277	13,269	17,614	13,348	21,002	22,676	17,962	14,295	14,418	15,051	15,188	17,730	21,505
Brook silverside	20,266	25,385	25,430	23,818	21,859	16,673	15,505	13,706	15,516	19,637	21,651	17,441	15,181
Blacktail shiner	7,161	10,660	13,616	15,940	18,043	28,332	35,863	37,812	37,611	37,128	37,635	38,412	38,873
Ironcolor shiner	22,030	20,982	19,916	18,078	16,094	10,187	9,221	8,856	11,922	15,357	18,226	14,217	9,600
Longear sunfish	30,836	32,219	32,141	29,837	27,518	19,710	18,104	17,217	23,344	31,560	37,121	30,042	21,376
Pickerel	17,532	20,069	20,745	20,789	20,103	14,639	10,690	9,105	11,357	14,031	17,979	18,059	15,708
JUVENILE*													
Spotted bass	25,511	23,843	23,362	19,506	16,783	11,173	12,134	10,229	14,183	22,529	24,861	15,778	10,189
Spotted sucker	21,596	23,618	23,565	21,190	19,598	12,838	9,774	9,765	12,387	14,569	18,204	16,585	12,411
Brook silverside	11,330	10,096	8,632	7,681	6,859	4,549	2,756	2,708	4,464	4,931	4,676	5,772	4,656
Blacktail shiner	31,986	30,545	28,313	24,984	22,293	15,958	13,256	12,526	23,927	27,949	26,226	17,915	12,322
Ironcolor shiner	6,150	8,410	6,932	6,454	5,936	2,181	3,601	2,875	3,776	7,754	8,361	4,164	2,099
Longear sunfish	30,958	31,591	30,170	27,513	25,026	16,116	14,573	13,504	19,993	28,169	30,900	23,075	15,121
Pickerel	21,051	22,142	21,081	19,522	17,731	11,394	8,872	7,887	10,271	12,991	15,618	14,857	11,963

*Note: Due to the smaller # of observations, juvenile data is not as reliable from a statistical standpoint. Evaluations should concentrate on adults.

Table 5

U.S. FWS
FWS File Copy
12-18-86.

A3 WUA for Little Cypress Bayou @ Hwy 3001
(Based on W.E.S. developed fish curves, dated 10-6-86)

Life Stage/Species	5	10	15	20	25	50	75	100	125	150	200	250	300
ADULT													
Spotted bass	6,410	9,697	12,124	13,673	14,277	15,681	15,799	13,737	13,516	13,787	13,371	13,550	12,942
Spotted sucker	3,199	3,994	5,236	5,851	6,429	9,070	9,341	10,148	10,335	10,699	10,181	10,247	10,226
Brook silverside	8,223	7,082	7,376	7,563	7,615	8,131	8,503	8,819	9,553	10,109	9,909	9,588	9,721
Blacktail shiner	4,430	6,722	8,679	10,327	11,801	18,528	23,078	27,086	28,983	29,896	32,047	31,036	29,799
Ironcolor shiner	8,383	7,671	7,424	6,791	6,526	5,791	5,292	5,373	6,316	6,494	6,118	5,681	5,370
Longear sunfish	17,461	17,043	17,063	17,379	17,394	15,815	14,837	15,751	16,933	18,254	19,085	14,561	14,603
Pickerel	7,357	7,931	8,065	7,928	7,817	7,104	6,294	6,036	6,004	6,051	6,158	5,417	4,690
JUVENILE													
Spotted bass	12,566	10,122	10,332	10,400	9,851	9,288	8,456	8,621	9,476	9,986	10,705	9,869	8,460
Spotted sucker	7,544	7092	7,097	6,963	6,507	5930	5,581	5,833	6,311	6,487	6,255	5,684	5,693
Brook silverside	2,000	2,233	2,005	4,970	1,727	1,432	1,565	970	1,043	1,141	943	768	686
Blacktail shiner	13,761	13,923	13,638	11,863	10,910	9,613	8,589	9,119	11,435	12,332	9,977	7,358	7,345
Ironcolor shiner	4,498	2,455	3,554	3,341	2,382	1,772	1,142	1,371	1,841	2,781	1,551	788	1,613
Longear sunfish	15,533	13,810	14,094	14,093	13,867	11,887	11,538	11,951	13,178	14,388	14,320	12,356	11,535
Pickerel	6,638	6,585	6,759	6,366	6,053	5,448	4,833	4,688	4,883	4,743	4,714	4,312	3,918

Table 6

LEGEND FOR TABLE 7 AND FIGURES 1-27

A1 refers to the composite WUA's as calculated using the WES fish curves for Hwy 154 and Hwy 3001.

A2 refers to the WUA's as calculated using the WES fish curves for Hwy 154.

A3 refers to the WUA's as calculated using the WES fish curves for Hwy 3001.

B1 refers to the composite WUA's as calculated using the USFWS fish curves for Hwy 154 and Hwy 3001.

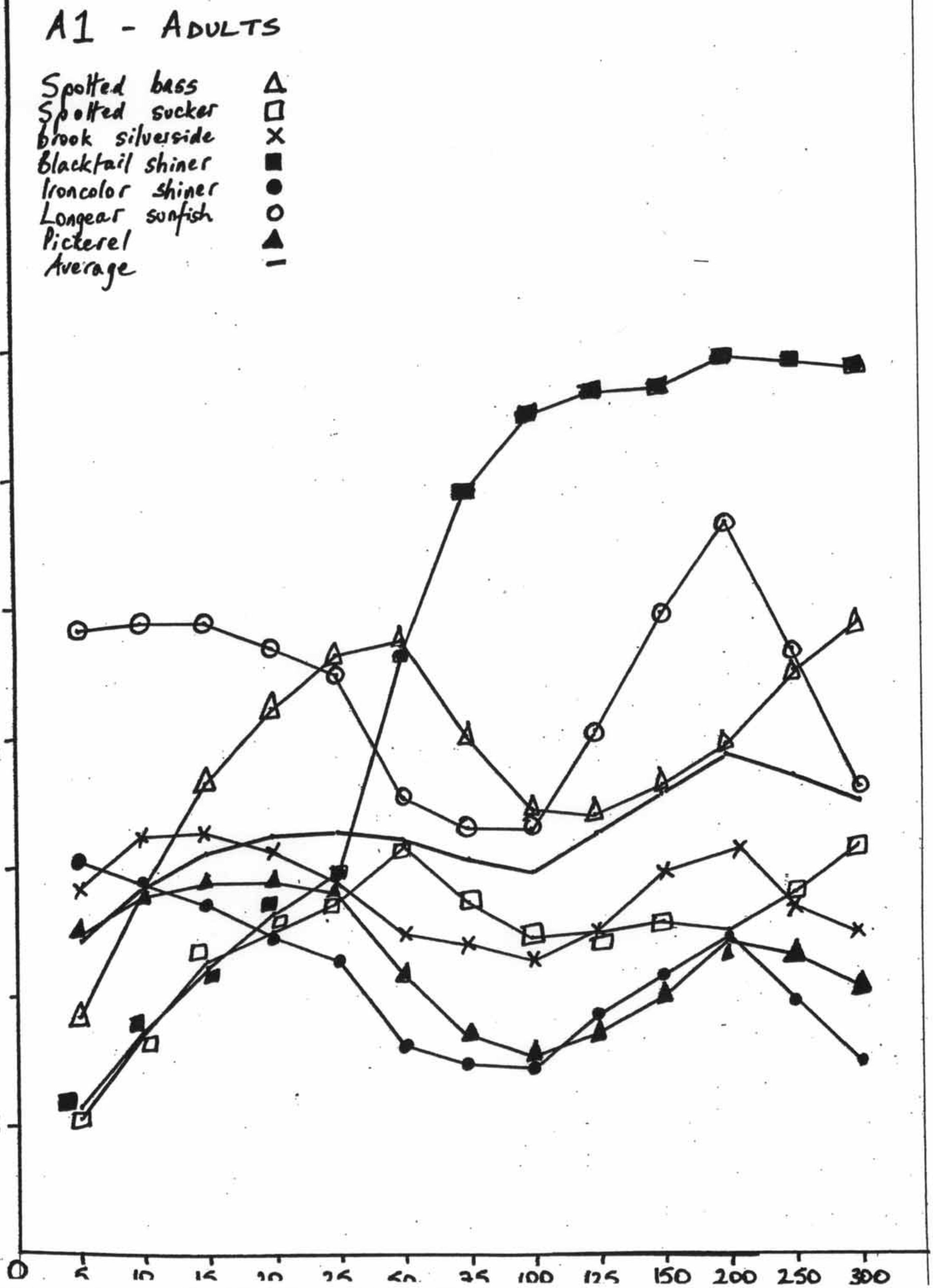
B2 refers to the WUA's as calculated using the USFWS fish curves for Hwy 154.

B3 refers to the WUA's as calculated using the USFWS fish curves for Hwy 3001.

WUA = weighted useable area in thousands of sq ft/1000 ft of stream

cfs = in all cases, represents flow levels in Little Cypress Creek

Fig I


A1 - Adults
Spotted bass
Spotted sucker
brook silverside
Blacktail shiner
Ironcolor shiner
Longear sunfish
Pickerel
Average
5
10
15
20
25
30
35
0
5
10
15
25
75
100
125
150
200
250
300

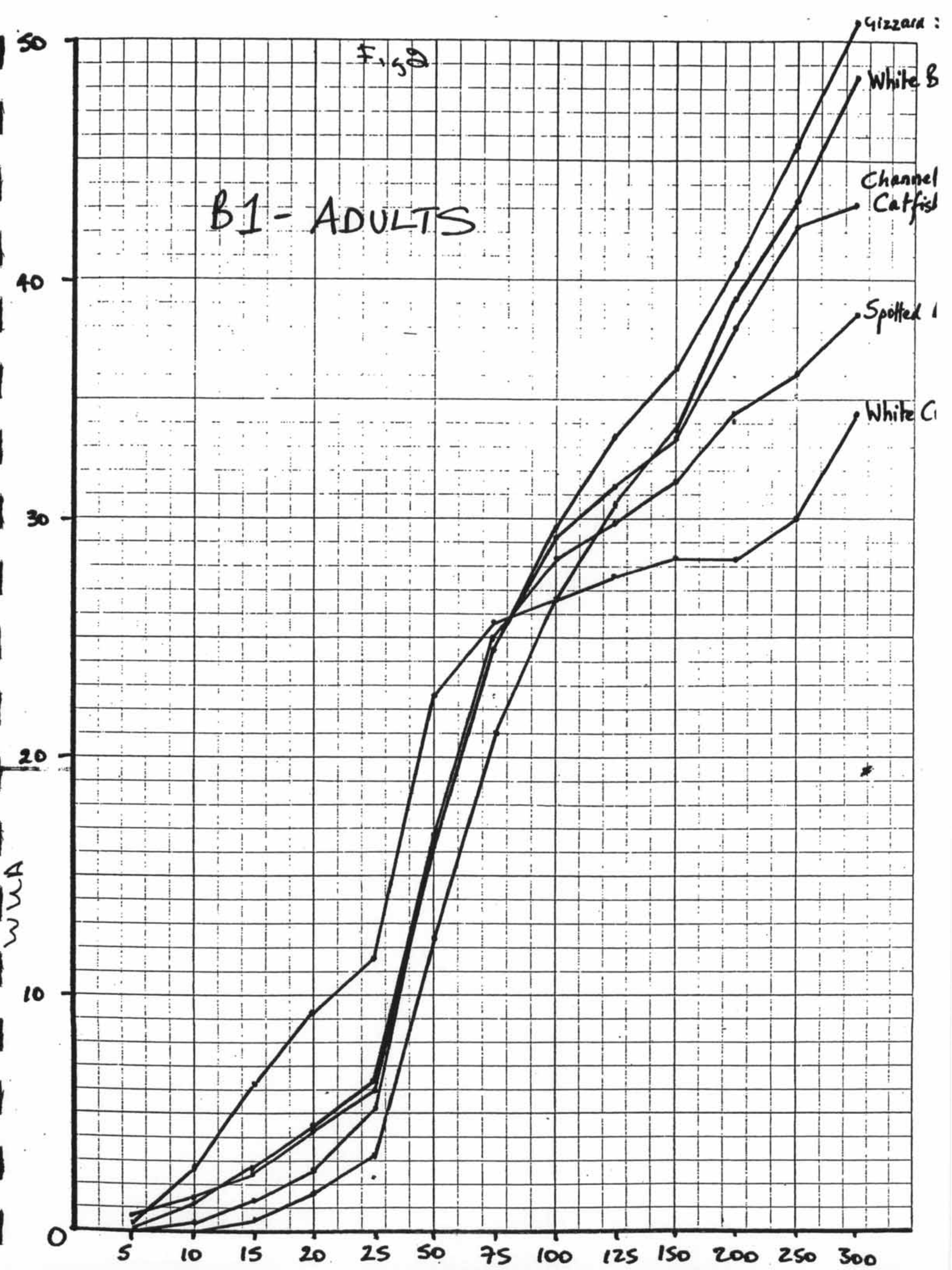


Fig 2
B1 - ADULTS
WUA
0
10
20
30
40
50
5
10
15
20
25
50
75
100
125
150
200
250
300
Gizzard
White B
Channel Catfish
Spotted
White C

Fig 3

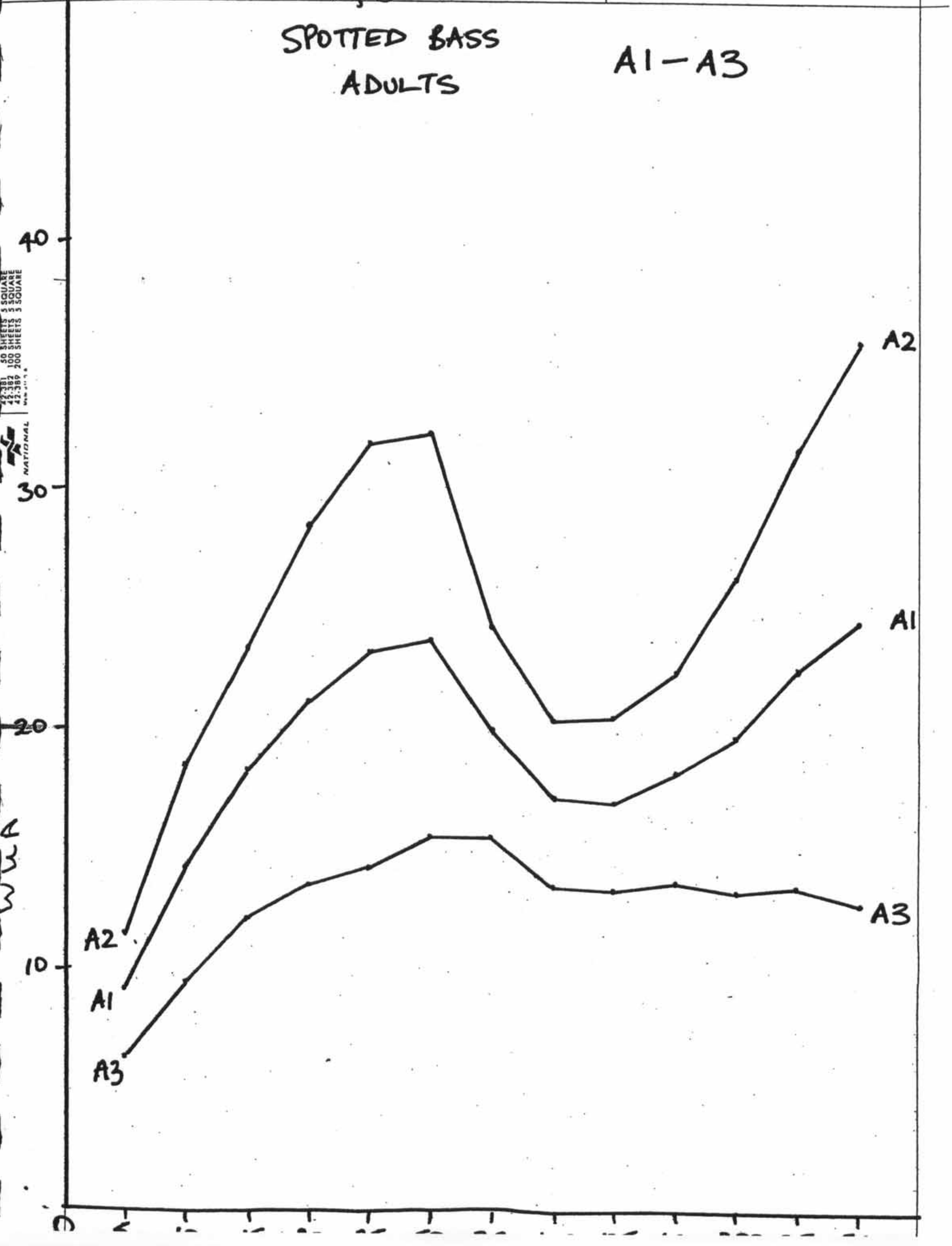
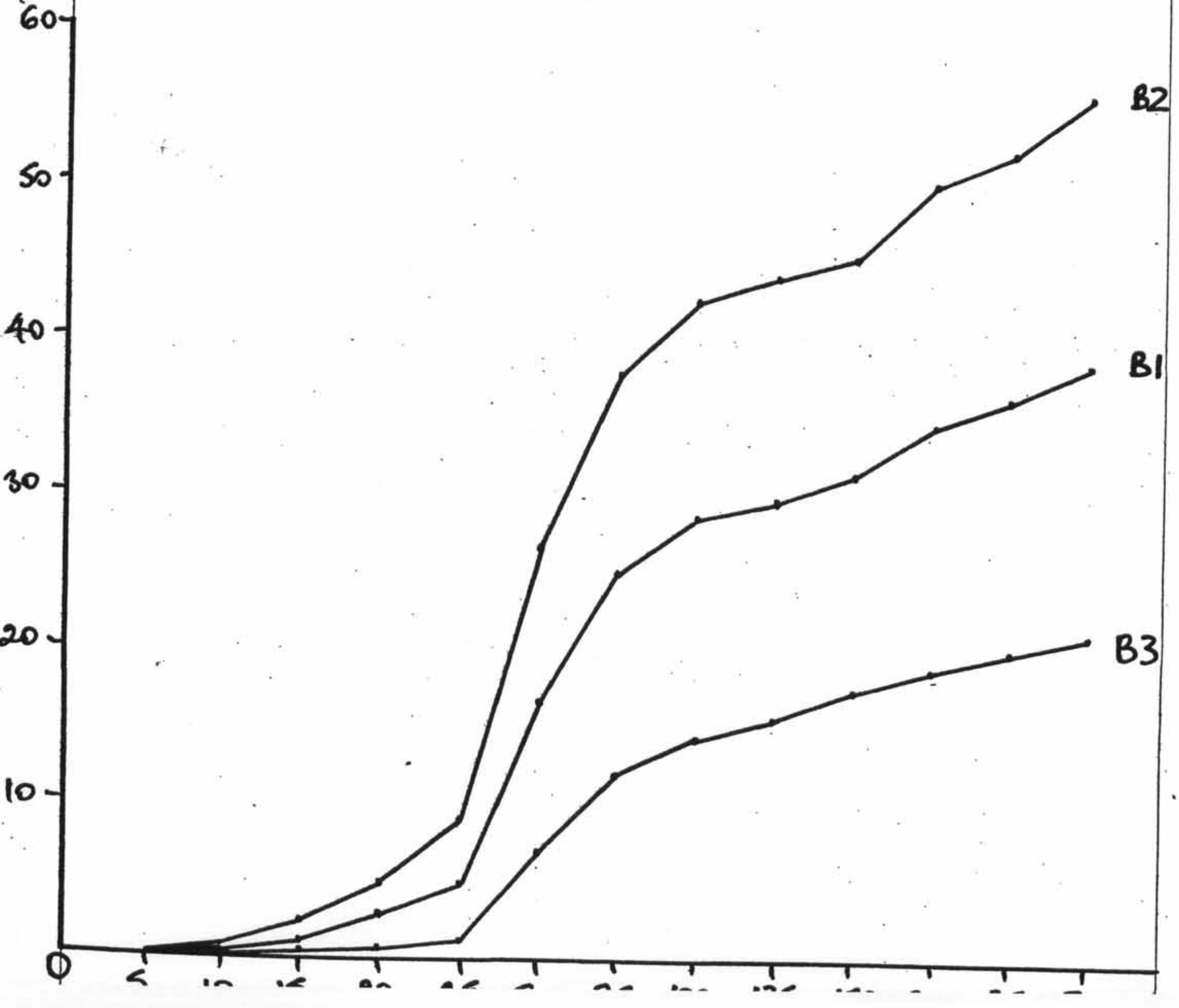


Fig 4

SPOTTED BASS

ADULTS B1-B3



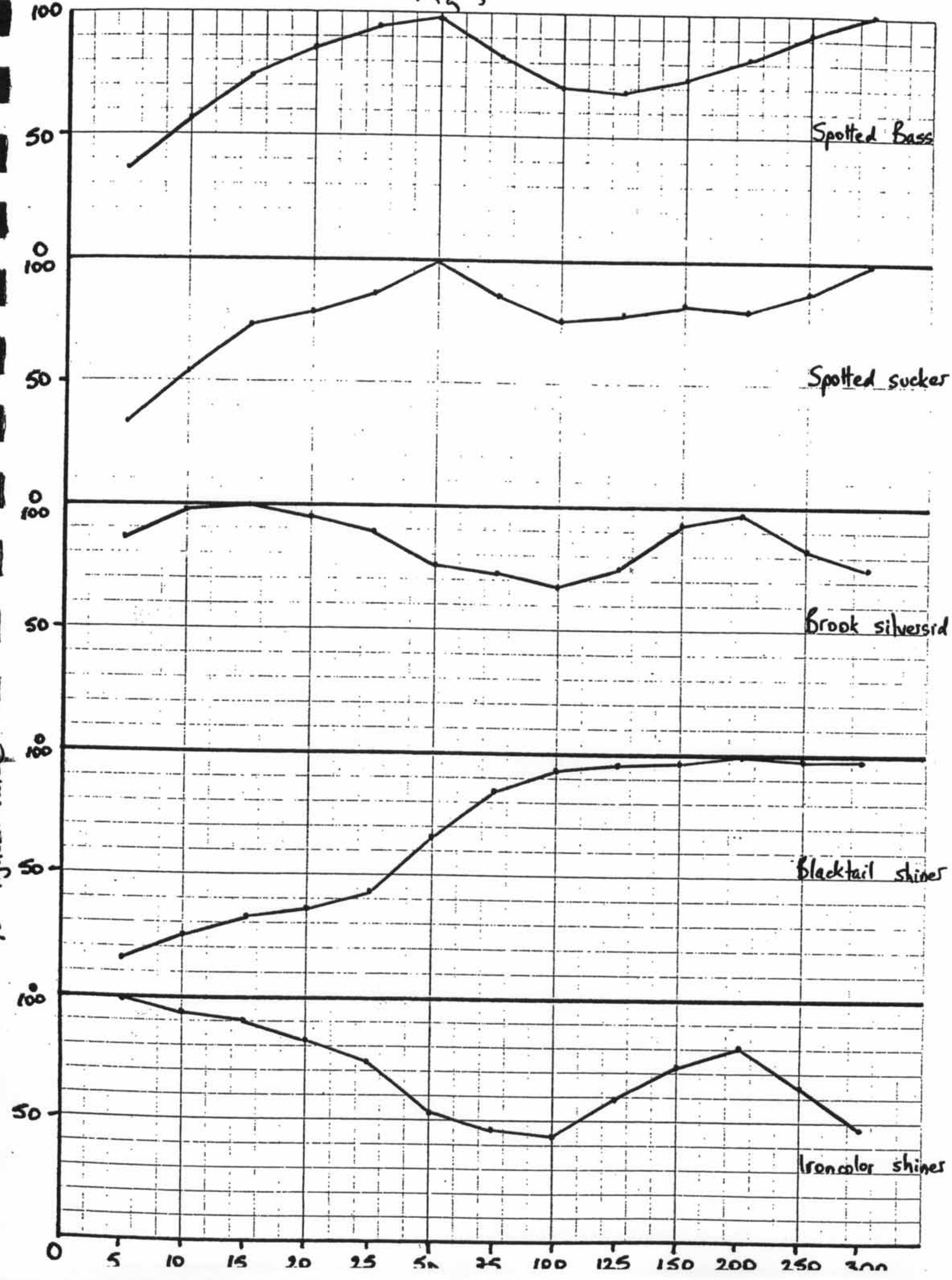
Al

Table 7 % Highest Value.

Life stage/Species	5	10	15	20	25	50	75	100	125	150	200	250	300
<u>ADULT</u>													
Spotted bass	37.1	58.0	74.7	86.1	94.3	97.6	81.6	69.8	69.4	73.9	80.8	92.2	100
Spotted sucker	32.7	54.1	71.7	79.2	86.2	100	86.2	76.7	78.0	81.1	79.9	88.1	100
Brook silverside	86.6	98.8	100	95.7	89.6	75.6	73.2	68.9	76.2	90.9	96.3	82.3	76.2
Blacktail shiner	16.7	25.0	31.9	37.6	42.8	67.2	84.8	93.1	95.7	96.3	100	99.7	98.6
[illegible]oncolor shiner	100	94.1	90.1	81.6	74.3	52.6	48.0	46.7	59.9	71.7	80.3	65.1	49.3
Longear sunfish	85.8	87.5	87.5	84.0	80.1	63.3	58.7	58.7	71.5	88.6	100	82.9	64.1
Pickerel	86.1	97.2	100	100	97.2	75.7	59.0	52.8	60.4	69.4	84.0	81.3	70.8

IA1

Fig 5



100
50
0
Spotted Bass
100
50
0
Spotted sucker
100
50
Brook silversid
100
50
Blacktail shiner
100
50
0
Ironcolor shiner
% highest value
5
10
15
20
25
50
75
100
125
150
200
250
300

A1 (continued)

Fig 5 (concl'd)

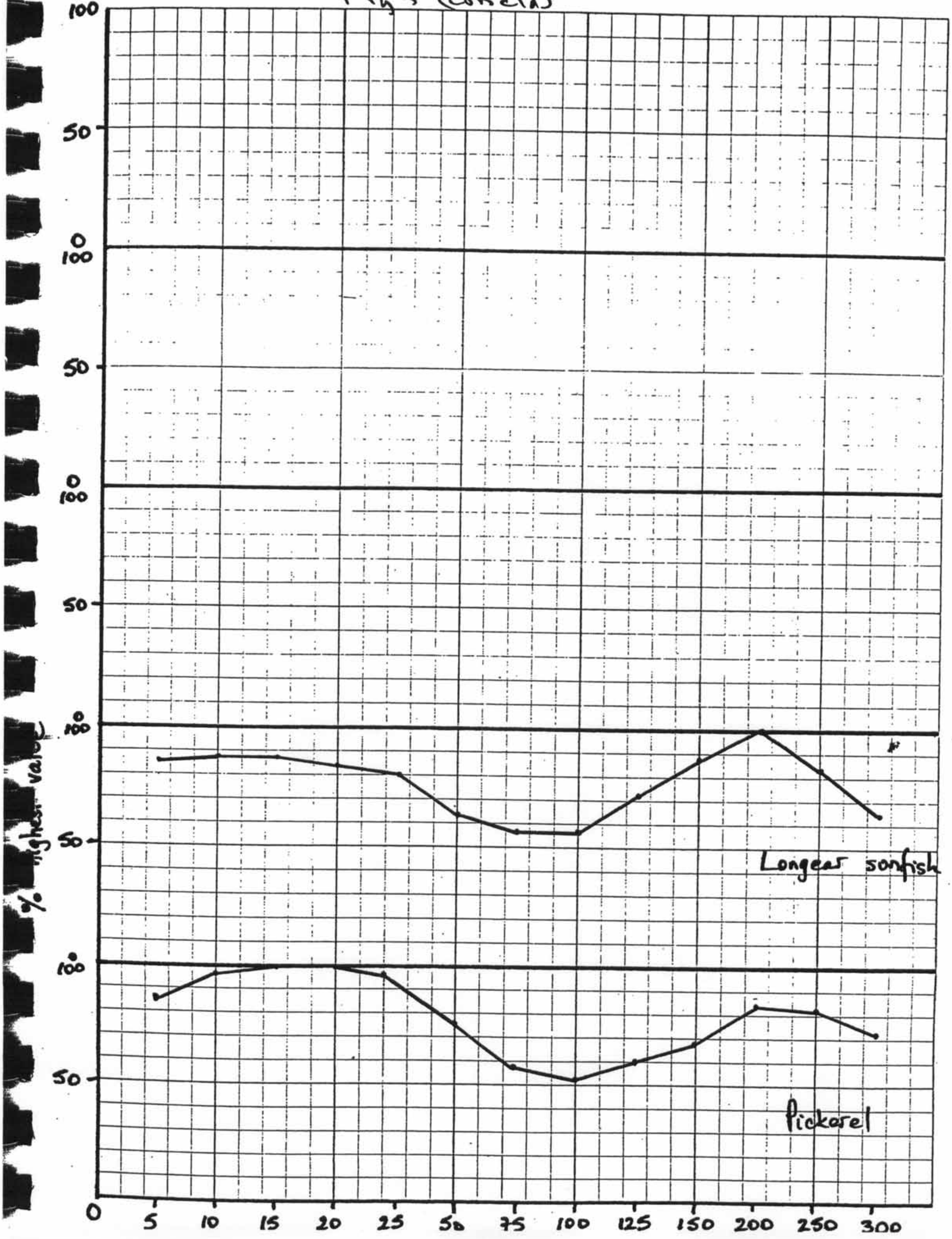


Fig 6

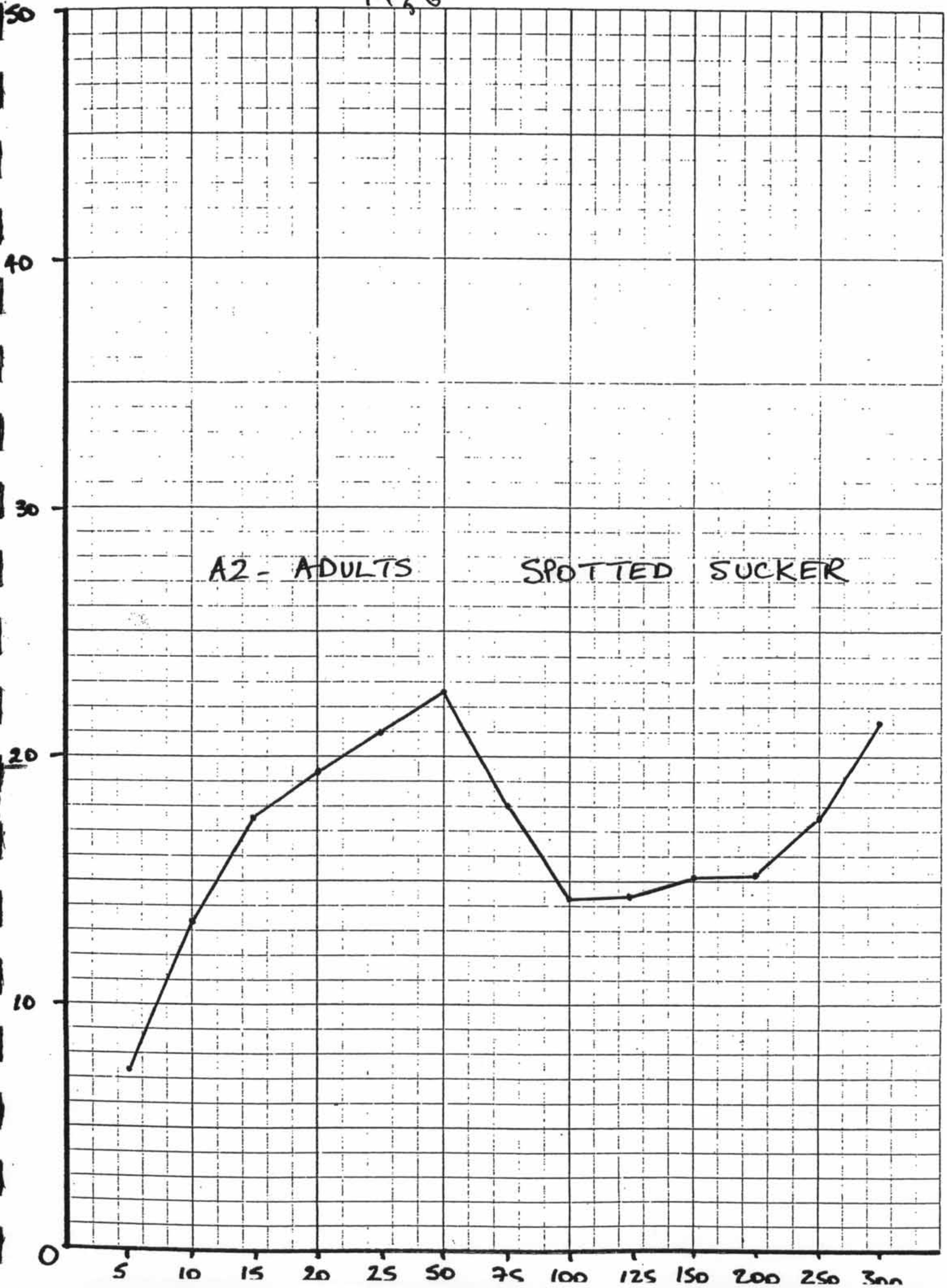
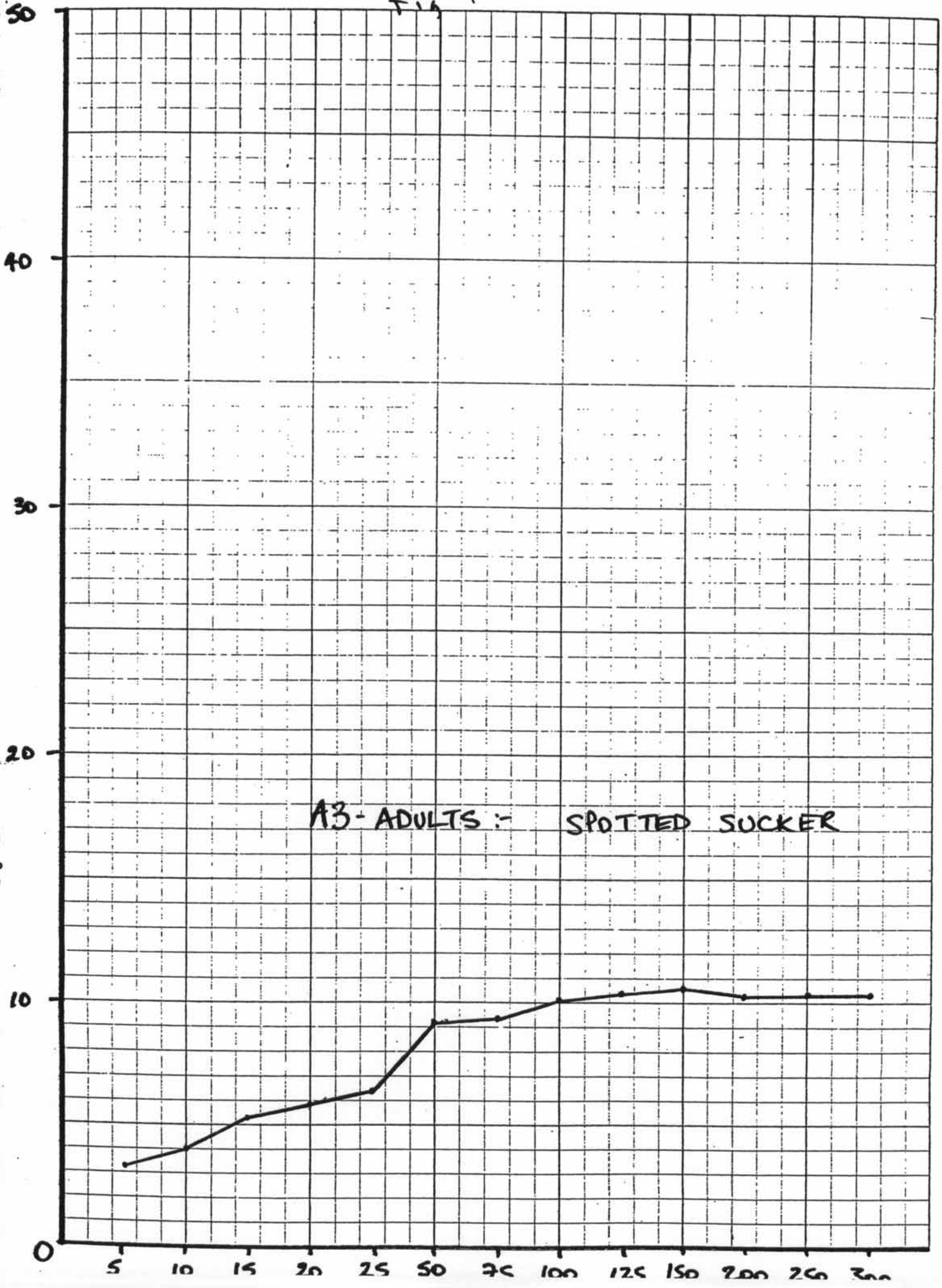
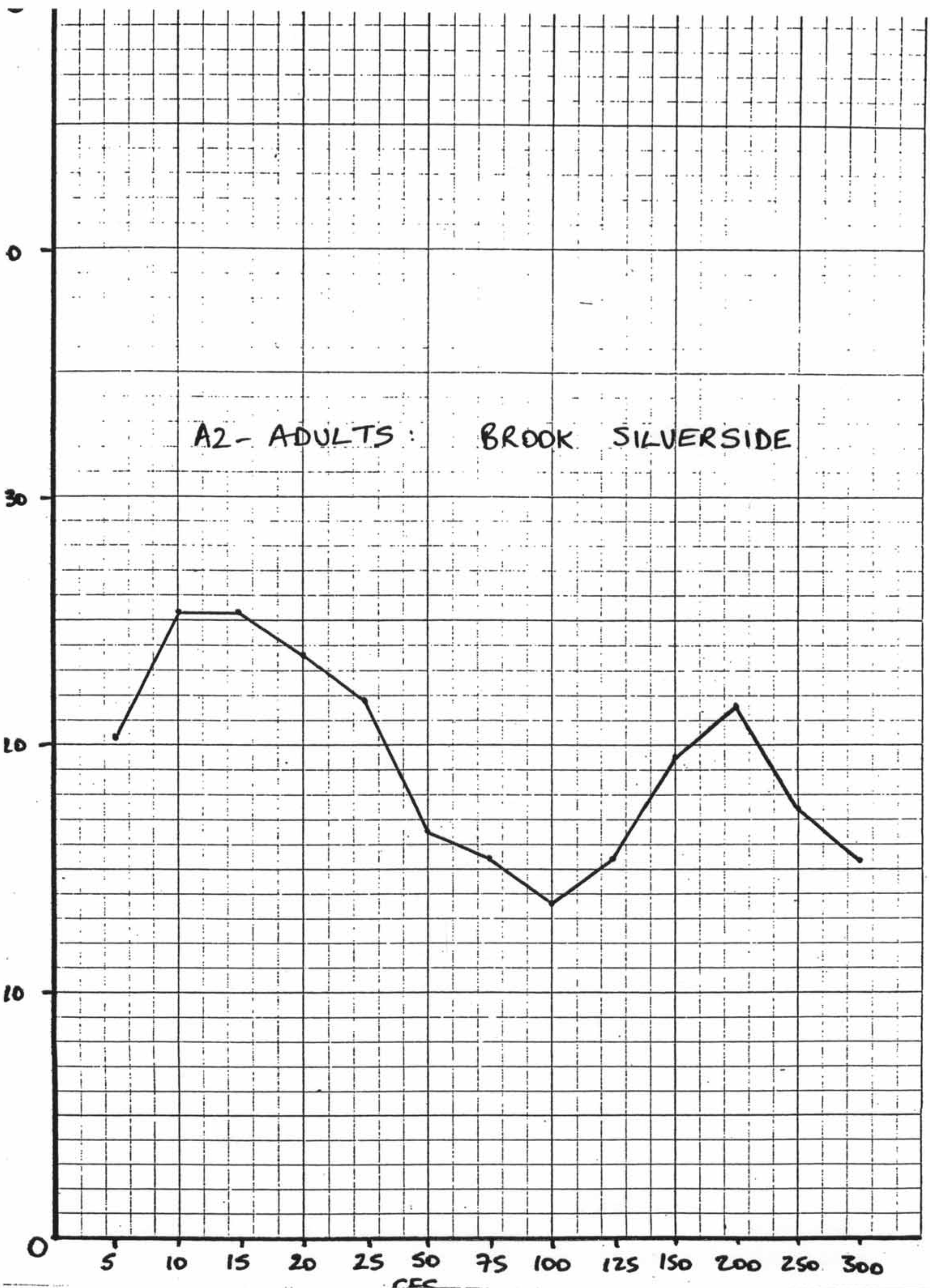

A2 - ADULTS
SPOTTED SUCKER
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 7


50
40
30
20
10
0
A3 - ADULTS :- SPOTTED SUCKER
5
10
15
20
25
50
75
100
125
150
200
250
300


A2- ADULTS: BROOK SILVERSIDE
0
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300
CFS

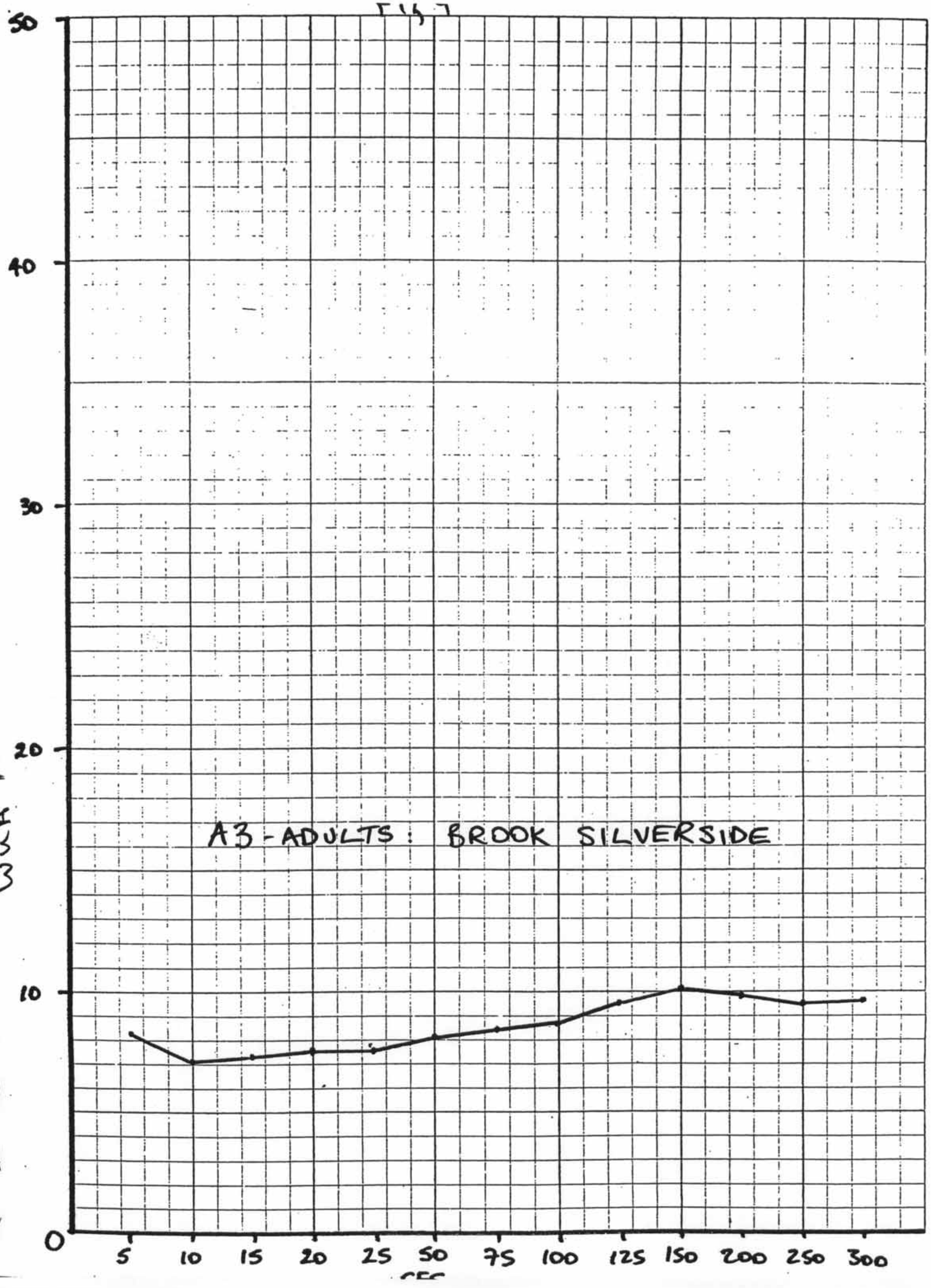

A3 - ADULTS : BROOK SILVERSIDE
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 10

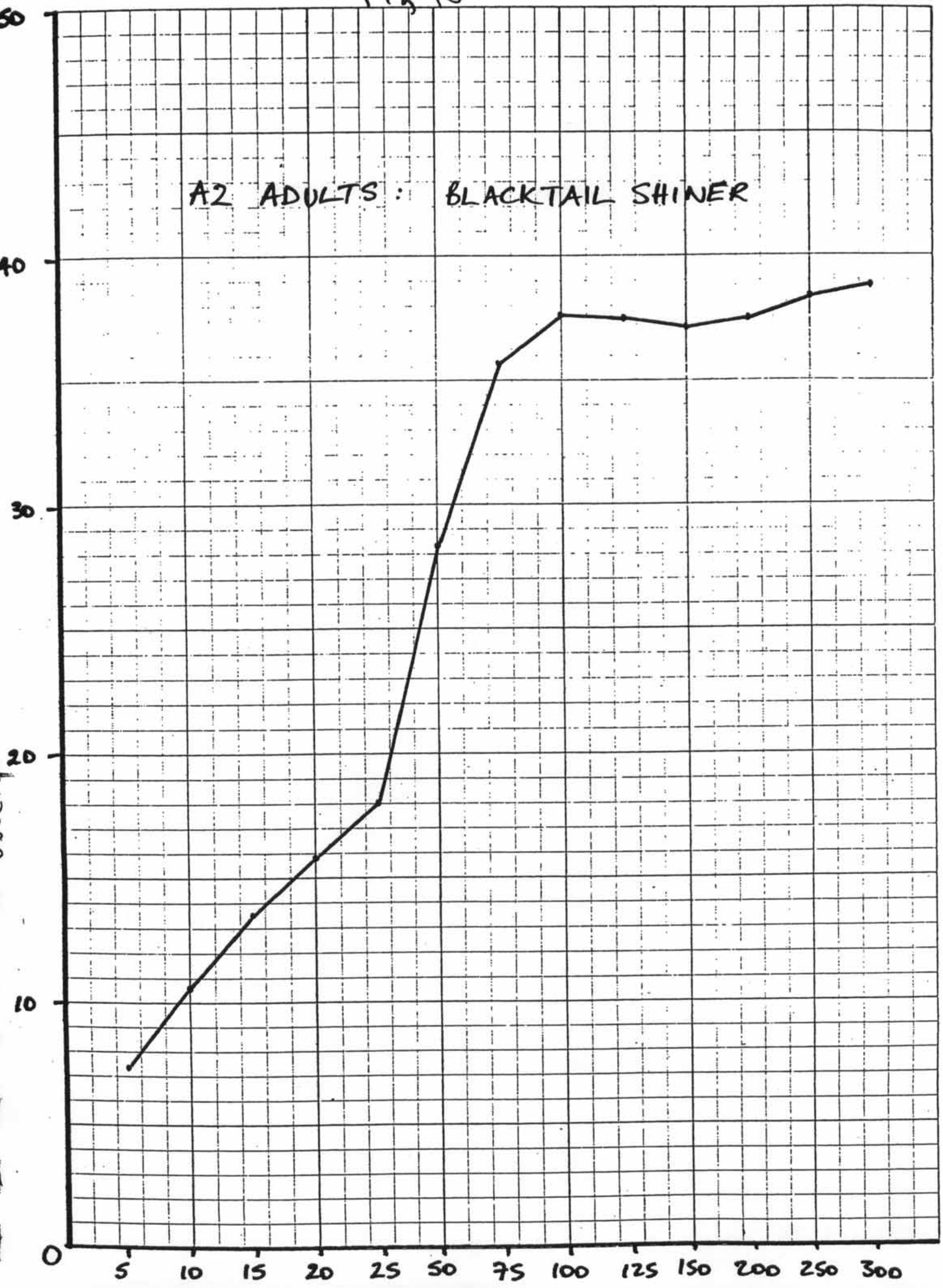

A2 ADULTS : BLACKTAIL SHINER
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 11

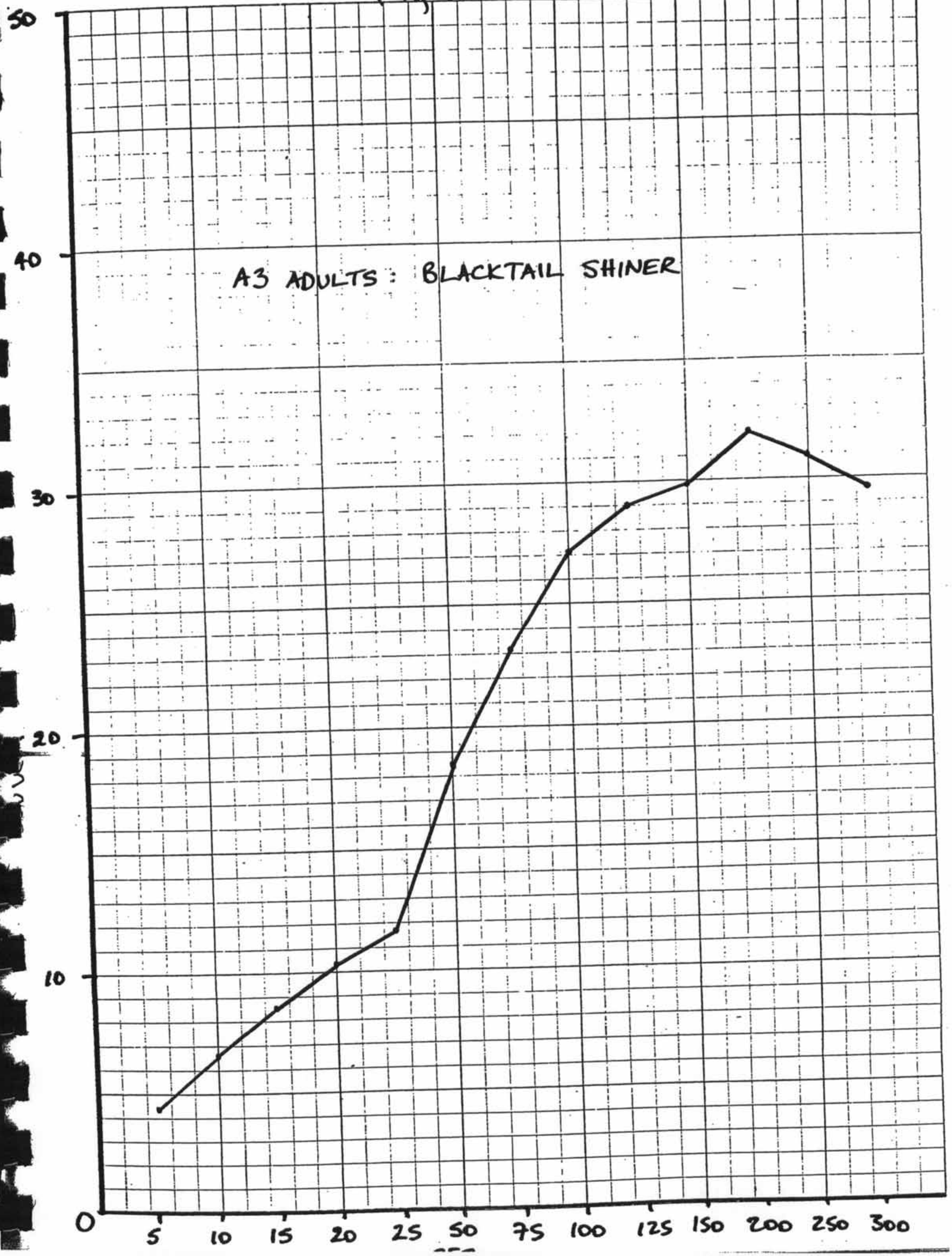
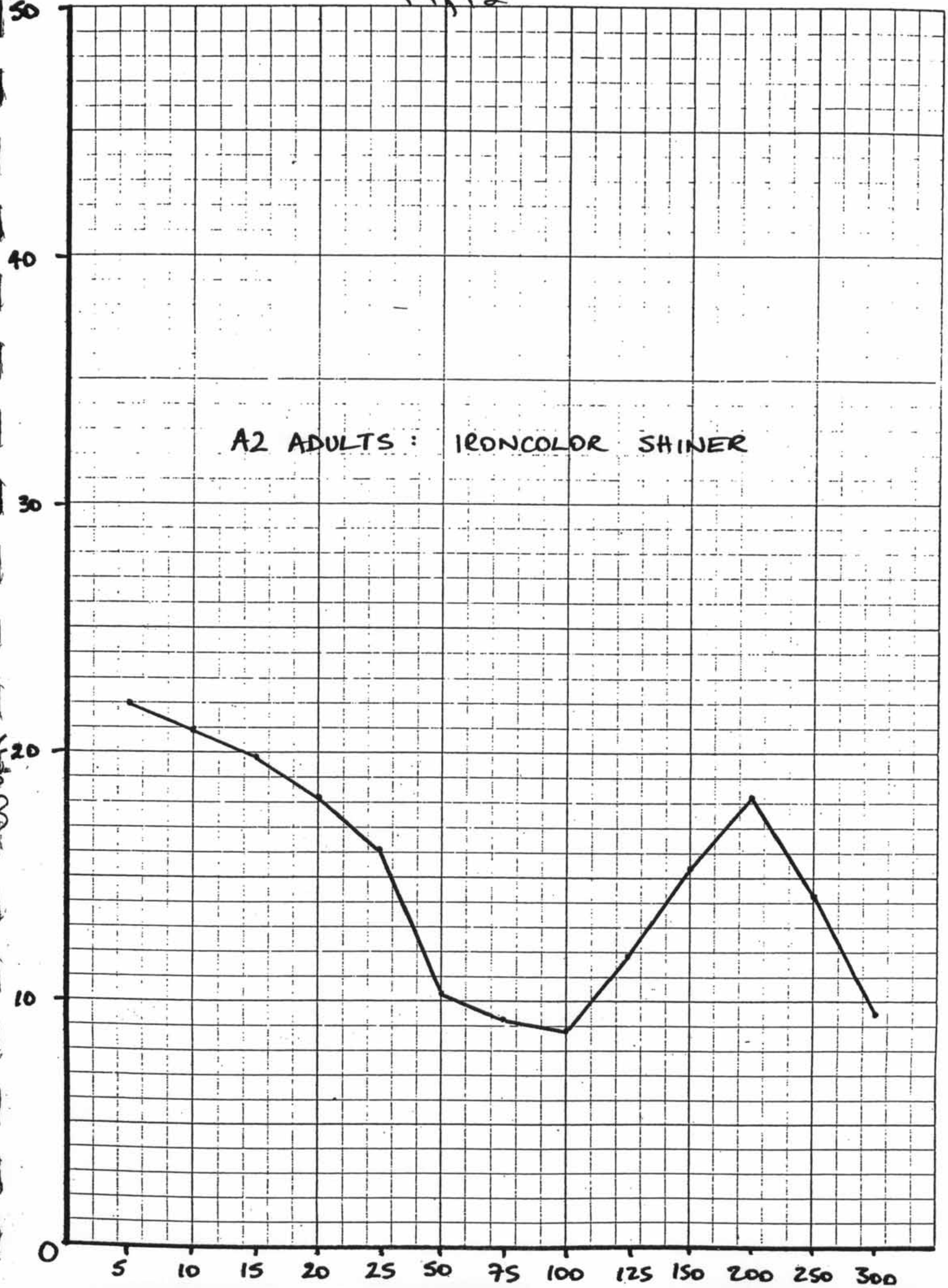

A3 ADULTS: BLACKTAIL SHINER
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 12



A2 ADULTS : IRONCOLOR SHINER
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 13

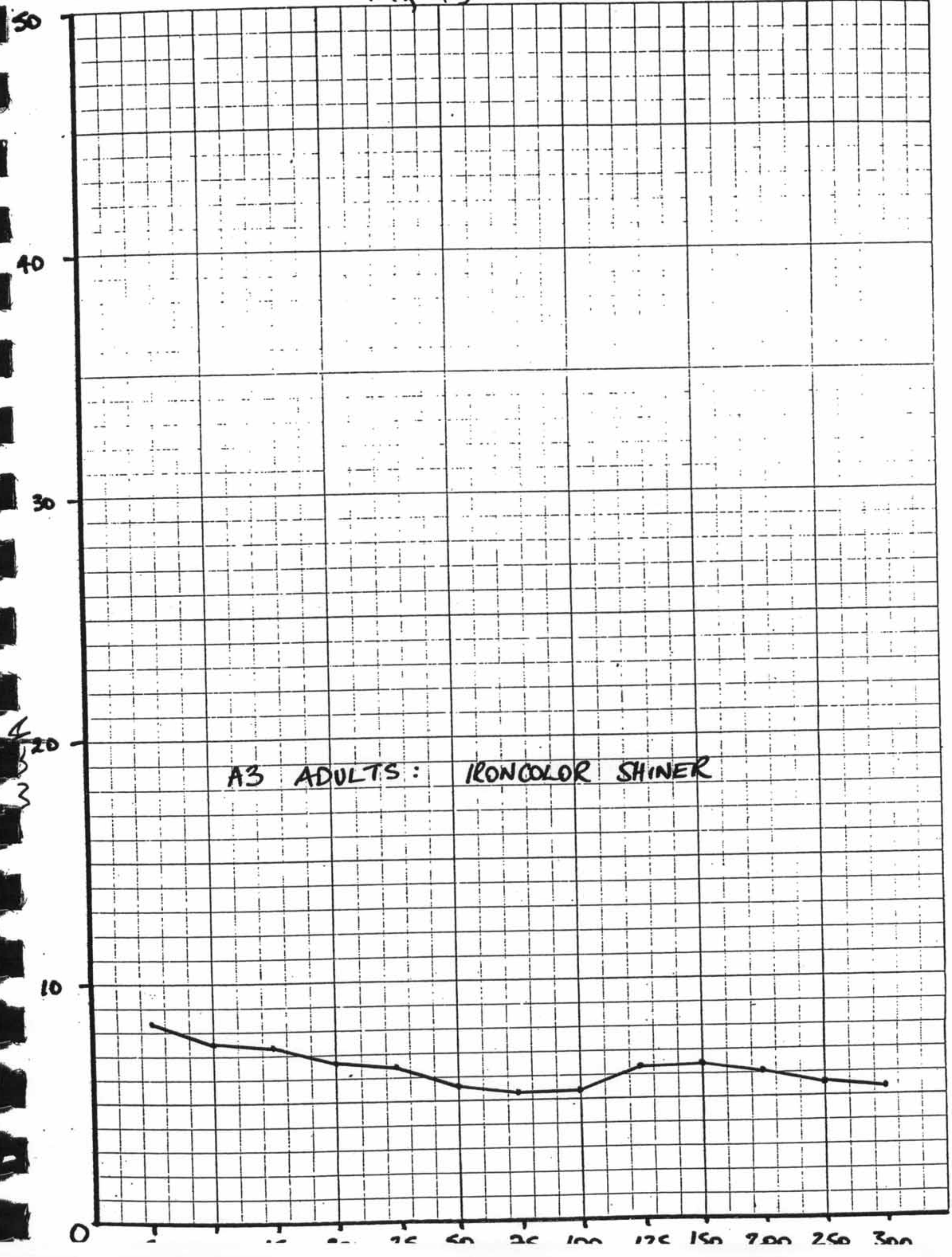
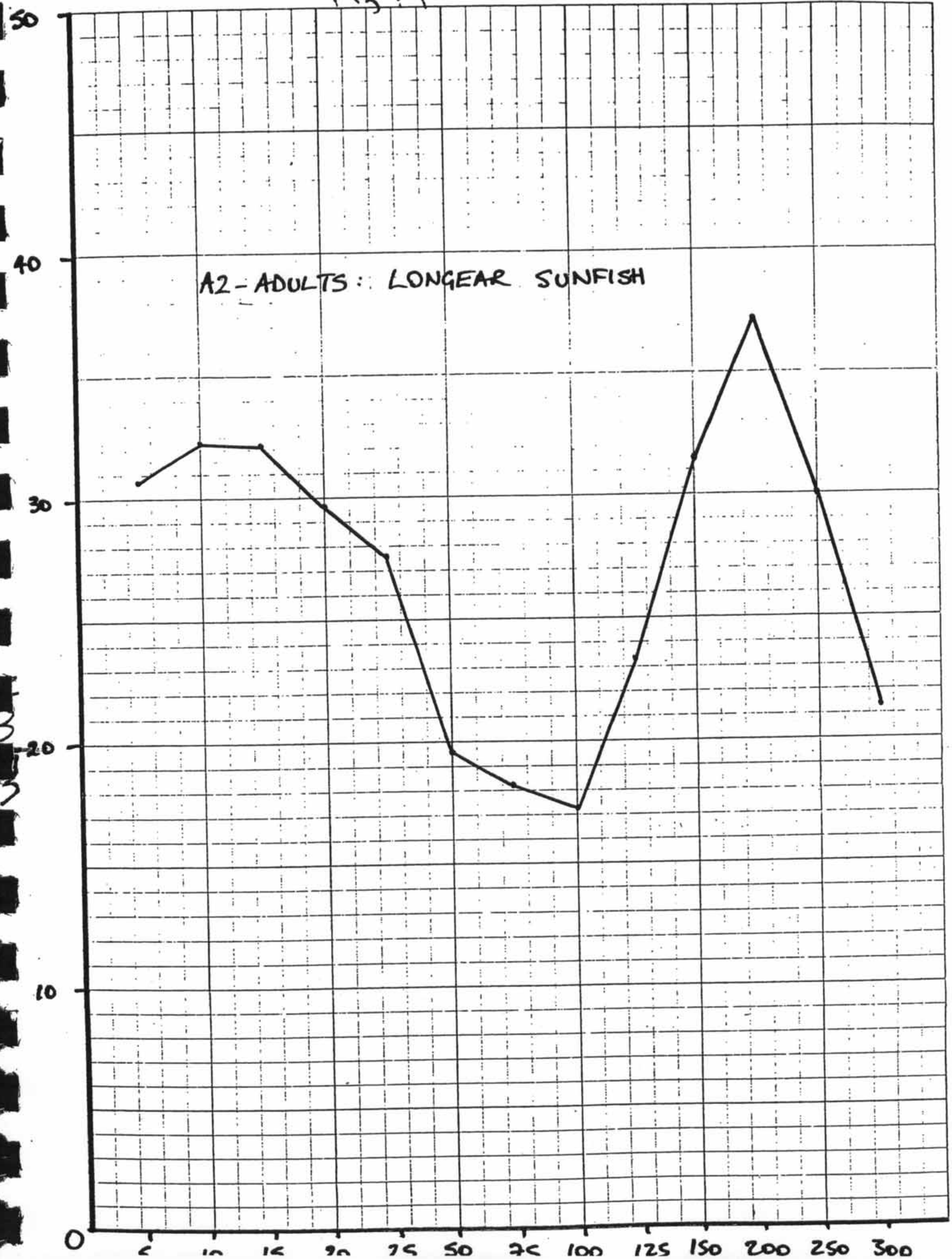


Fig 14



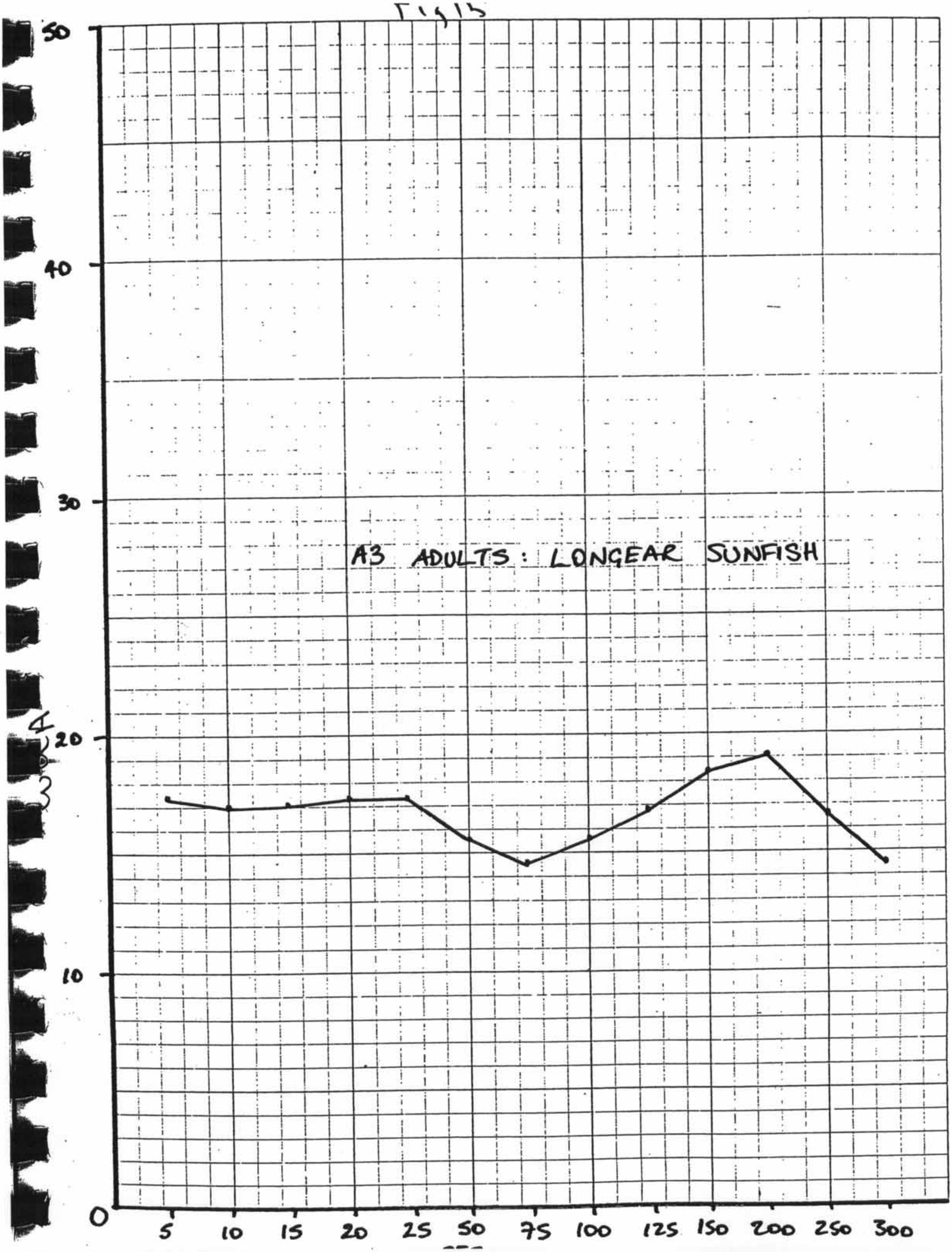
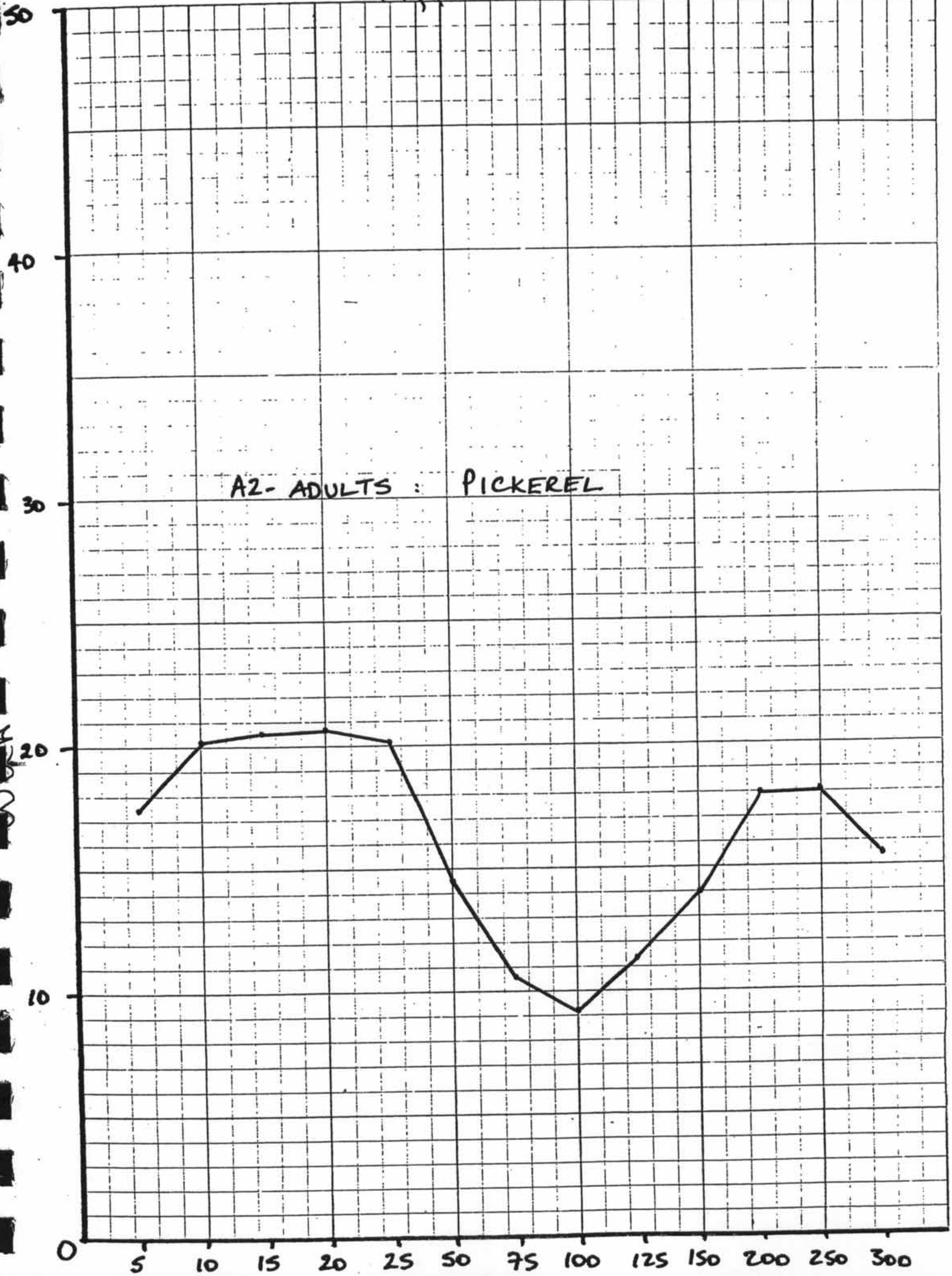


Fig 13
A3 ADULTS: LONGEAR SUNFISH
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 16


A2- ADULTS : PICKEREL
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

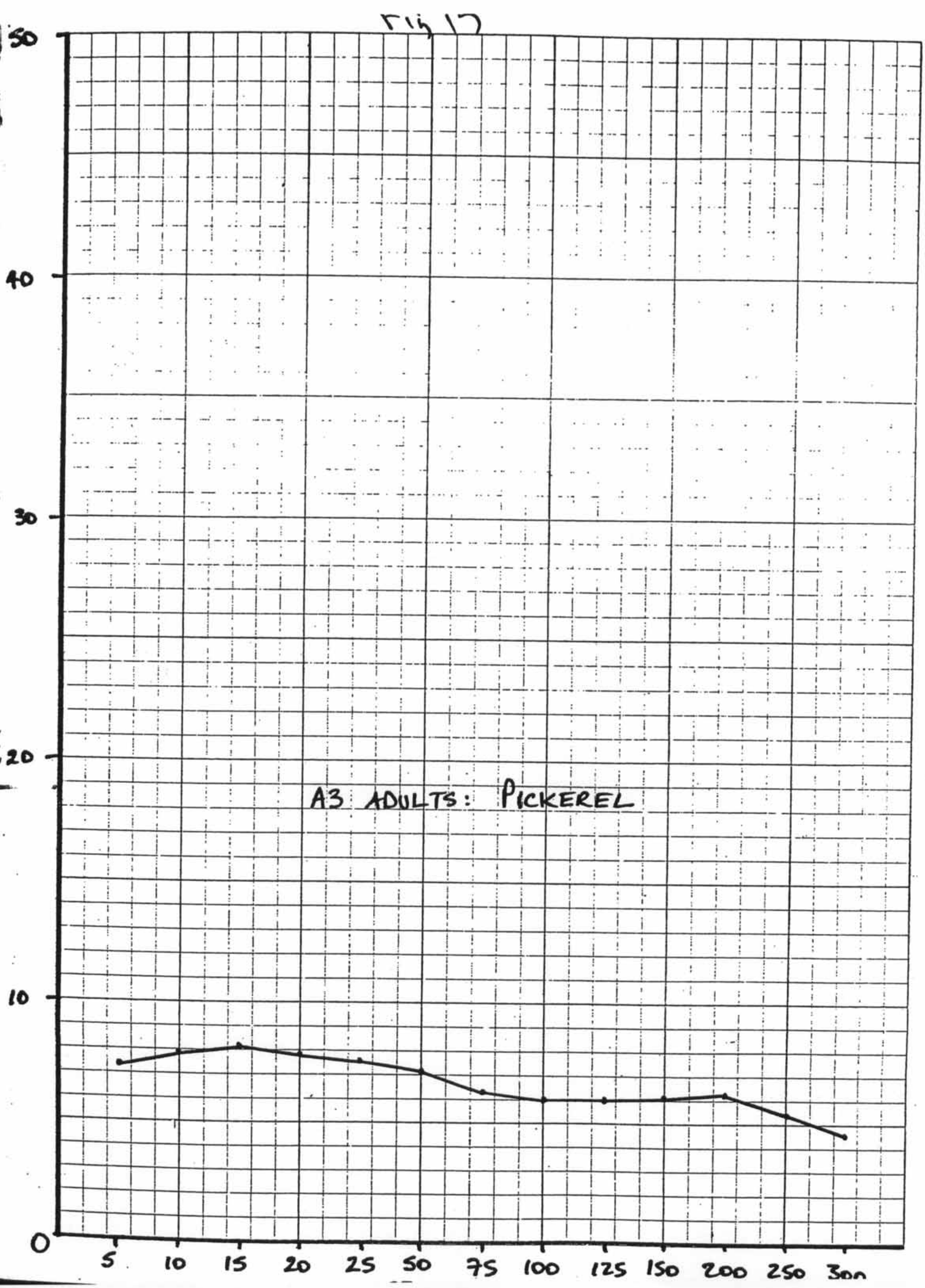
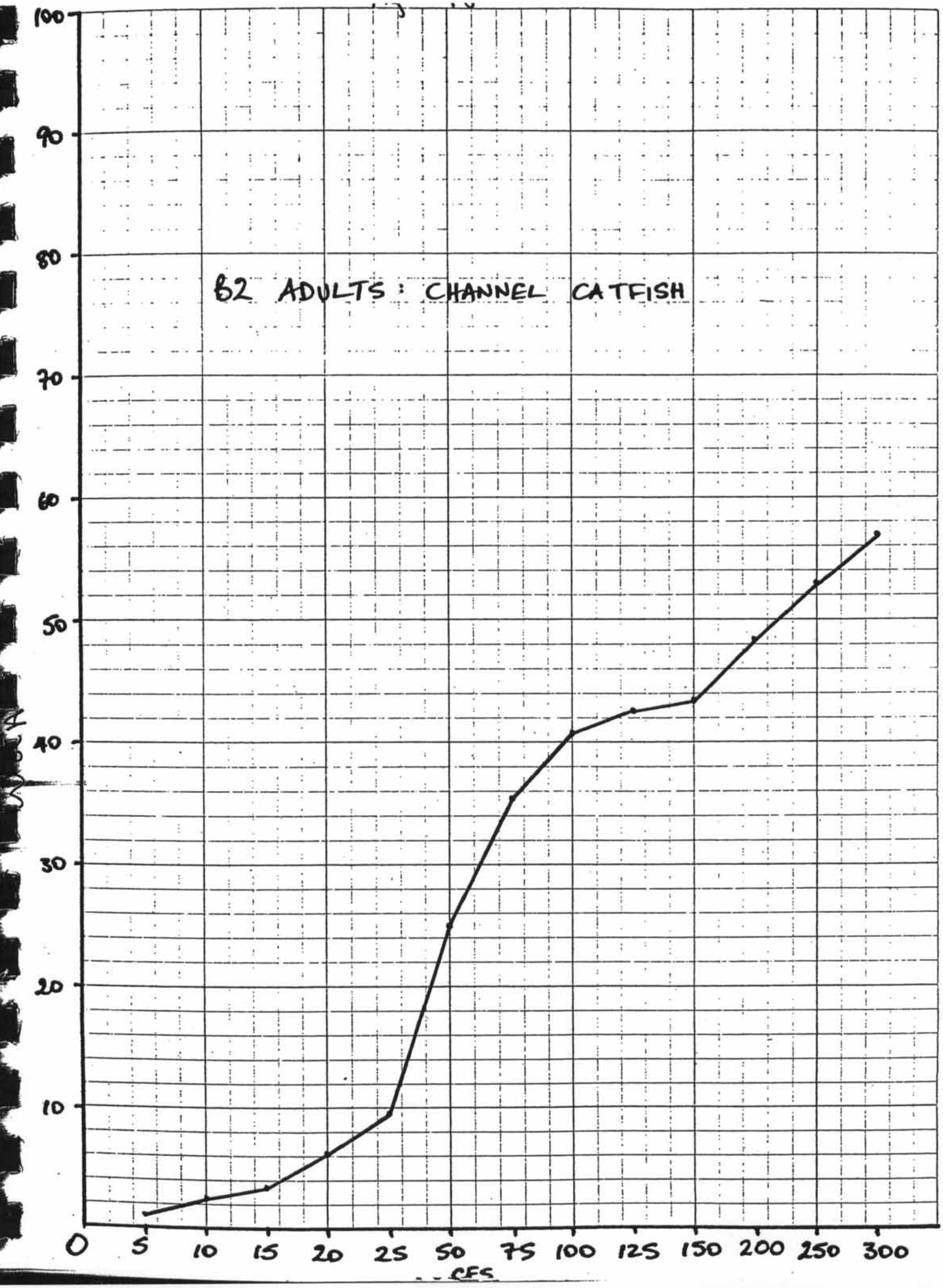


Fig 17
A3 ADULTS: PICKEREL
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300



B2 ADULTS: CHANNEL CATFISH
WUA
CFS
0
5
10
15
20
25
50
75
100
125
150
200
250
300
10
20
30
40
50
60
70
80
90
100

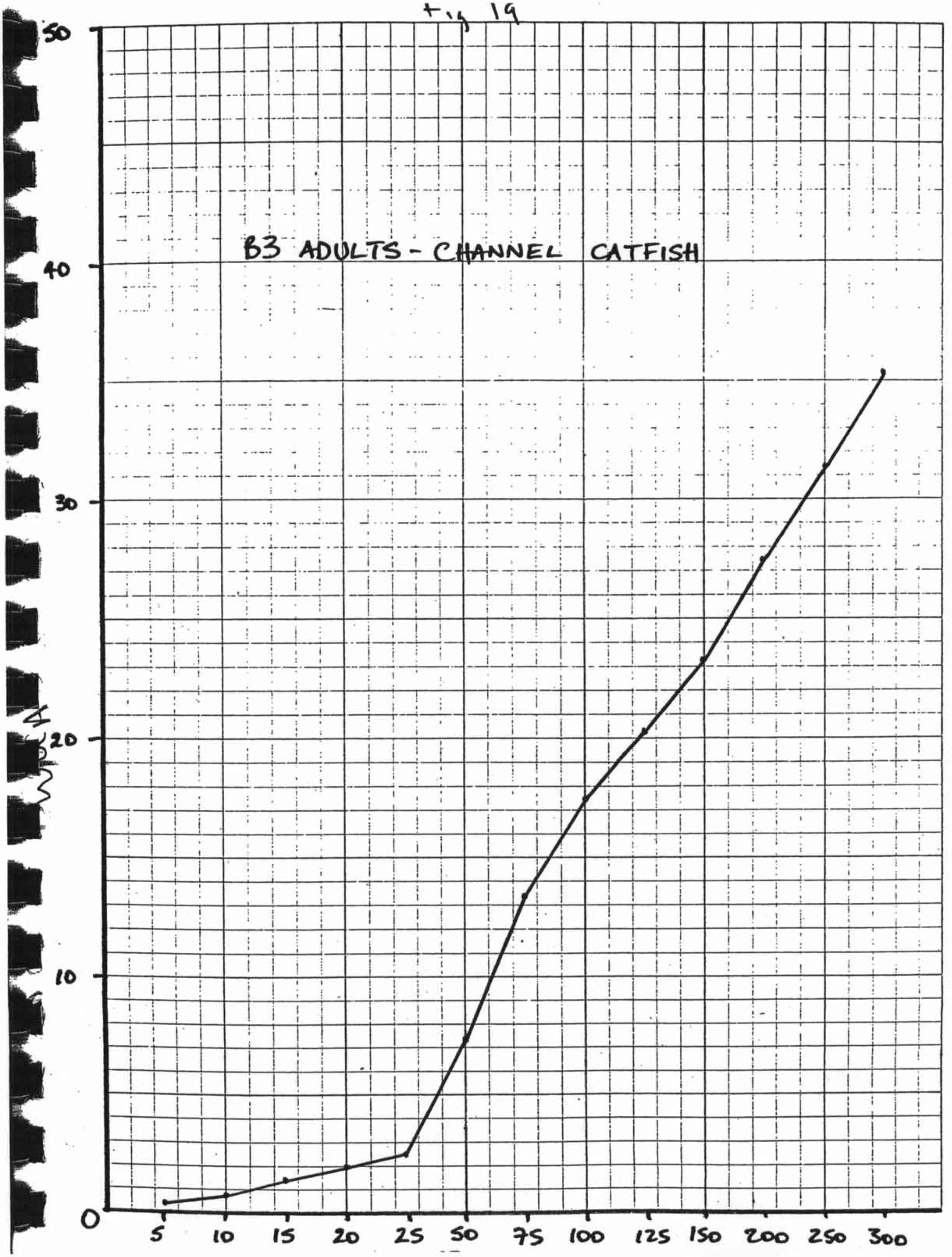


Fig 19
B3 ADULTS - CHANNEL CATFISH
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 20

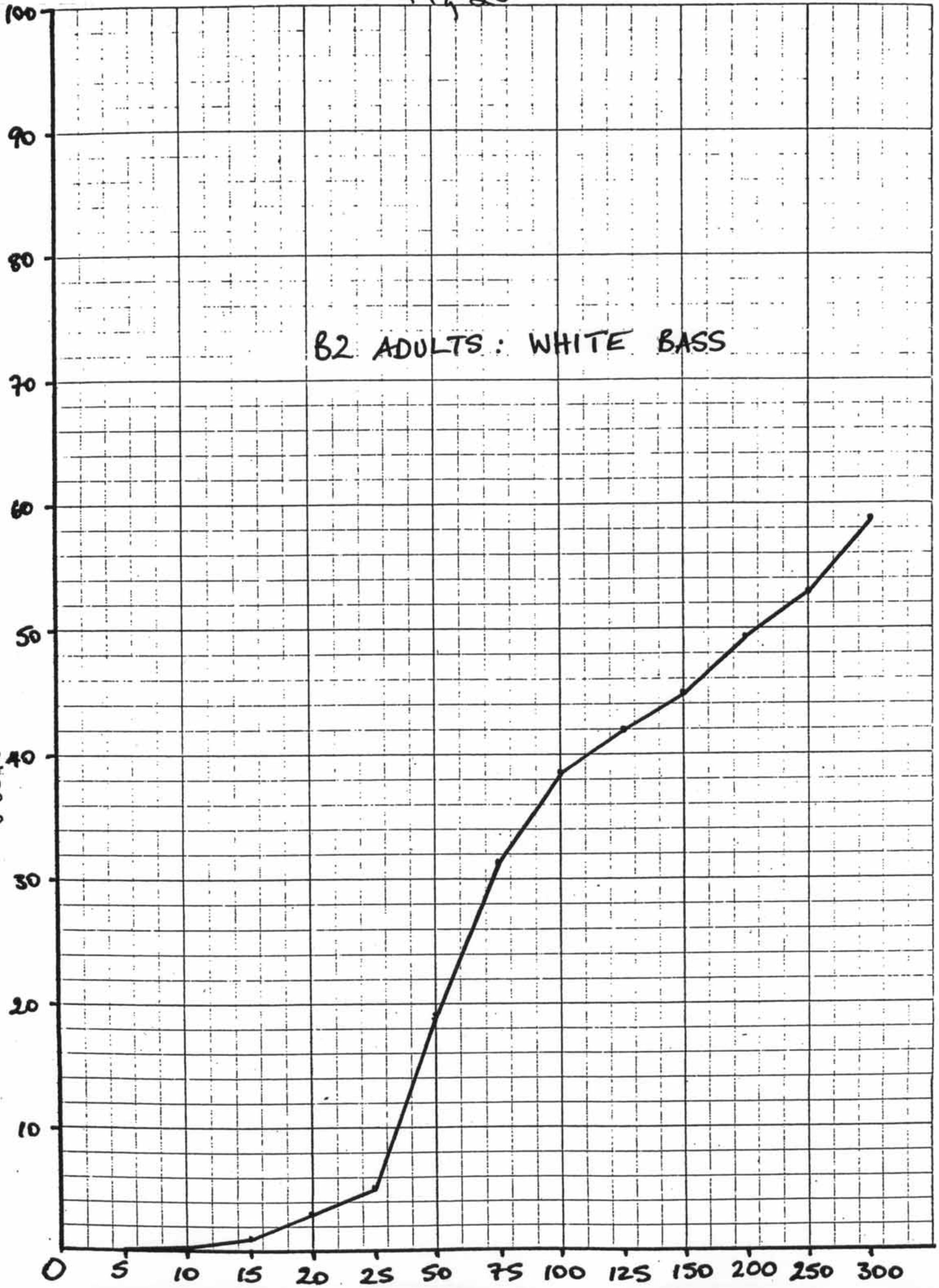

B2 ADULTS : WHITE BASS
100
90
80
70
60
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 21

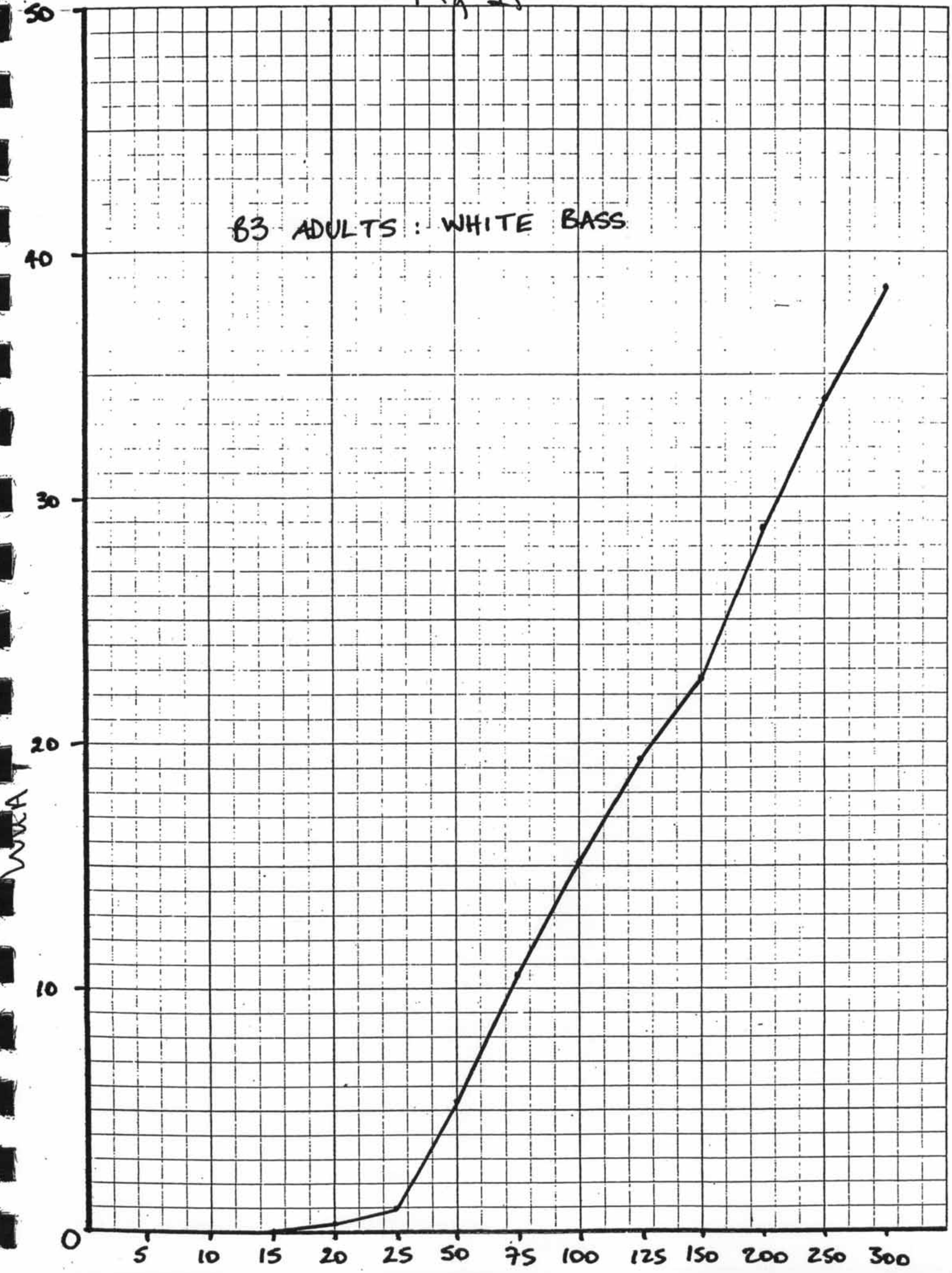

B3 ADULTS : WHITE BASS
WUCA
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 22

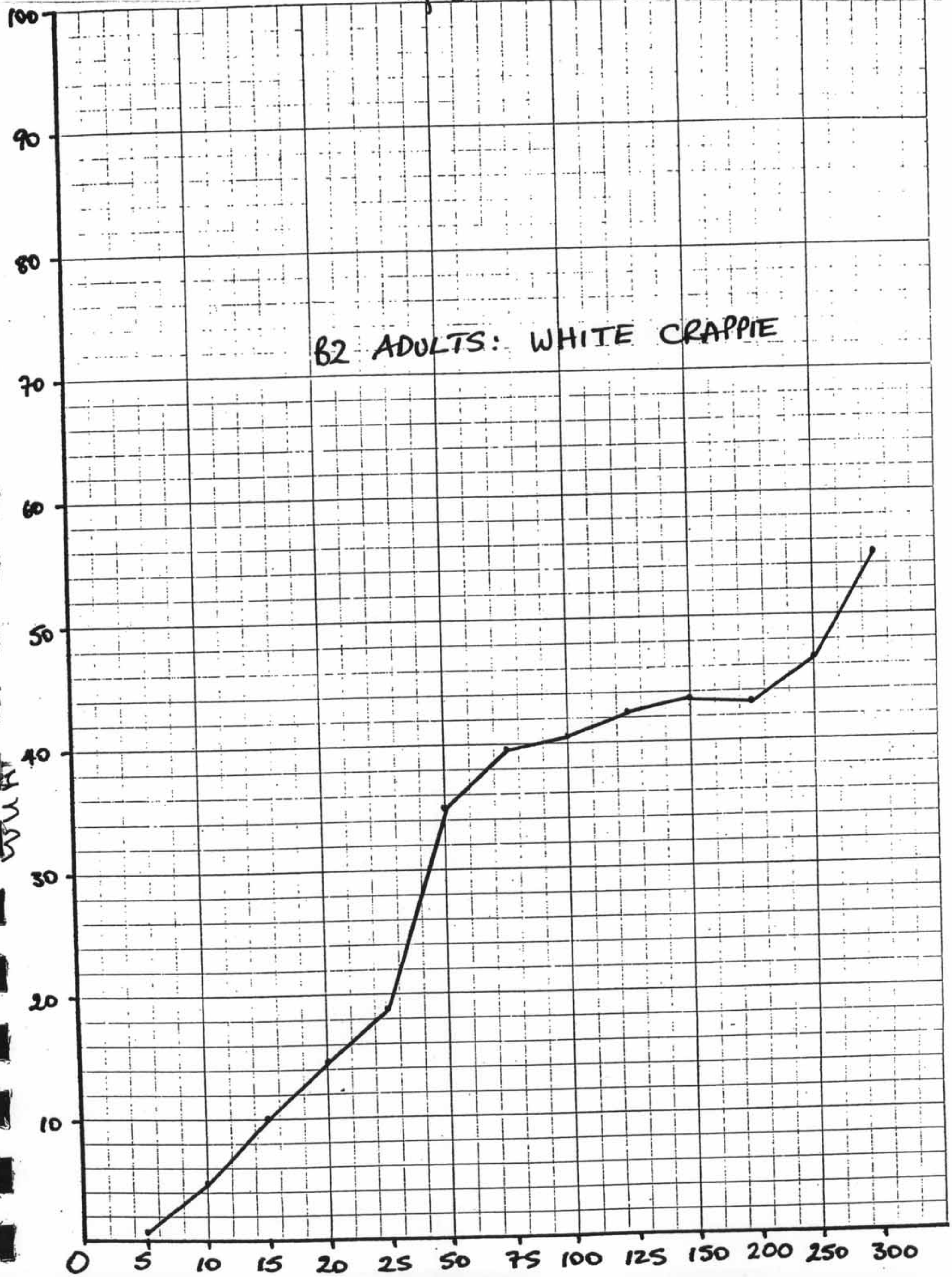
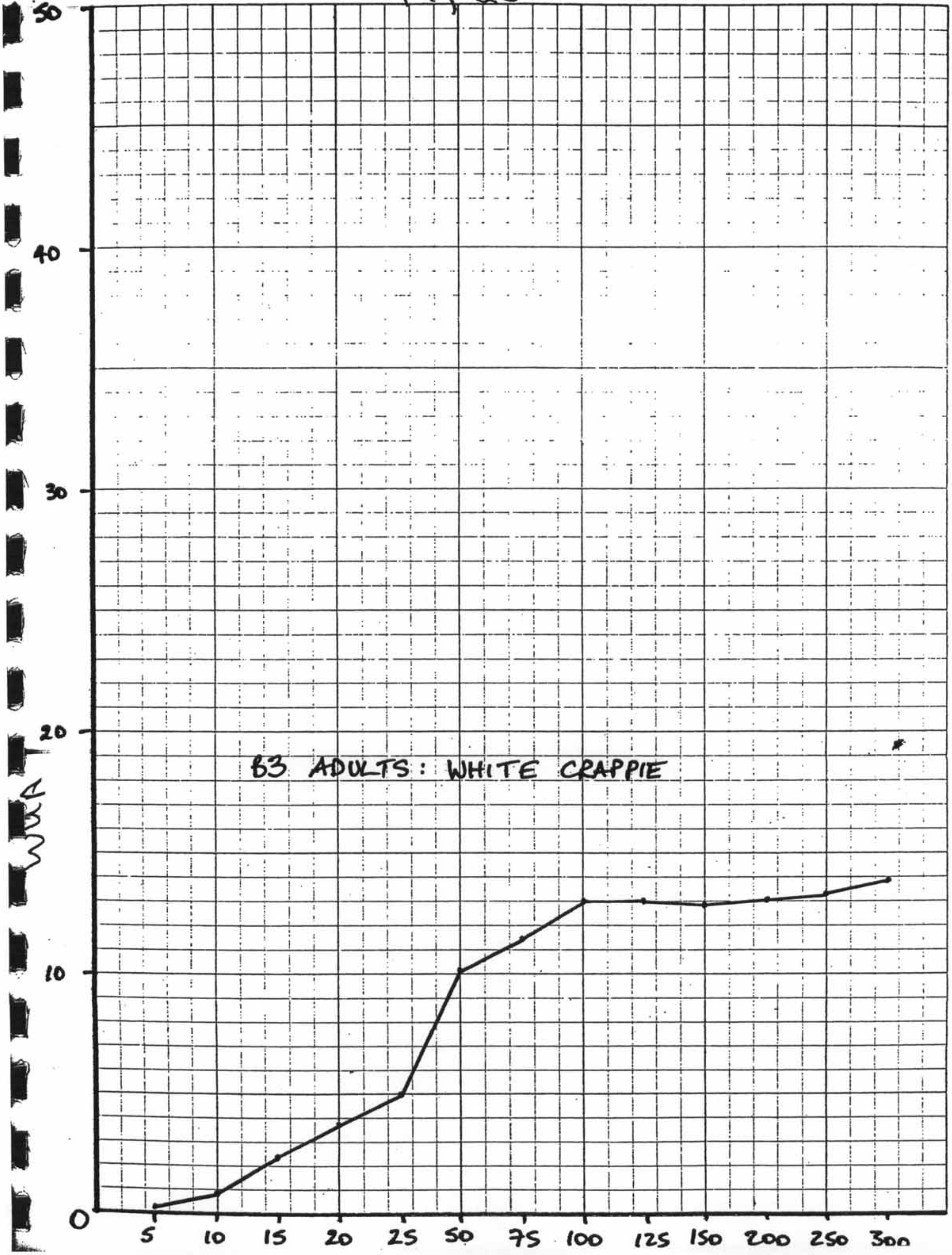
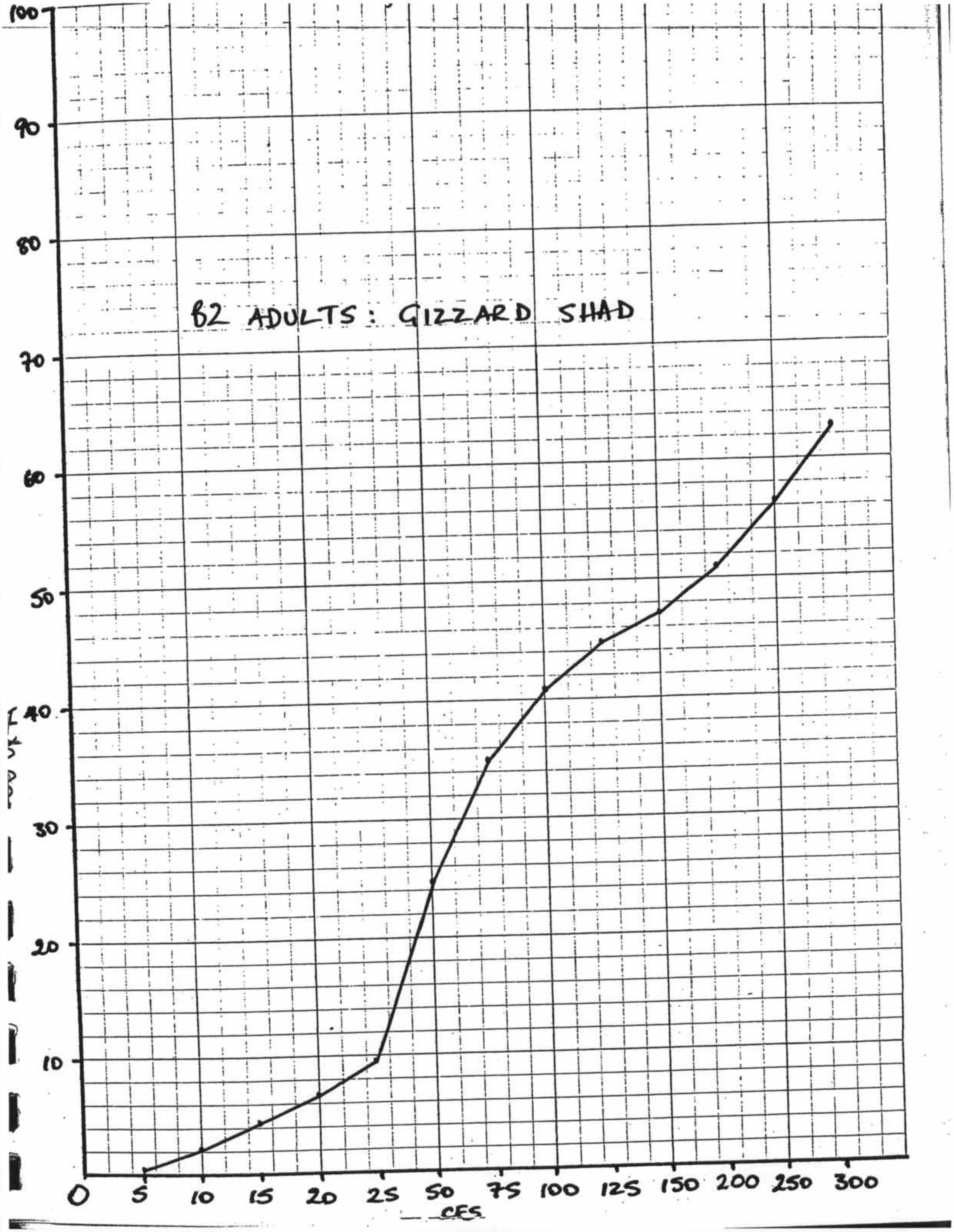
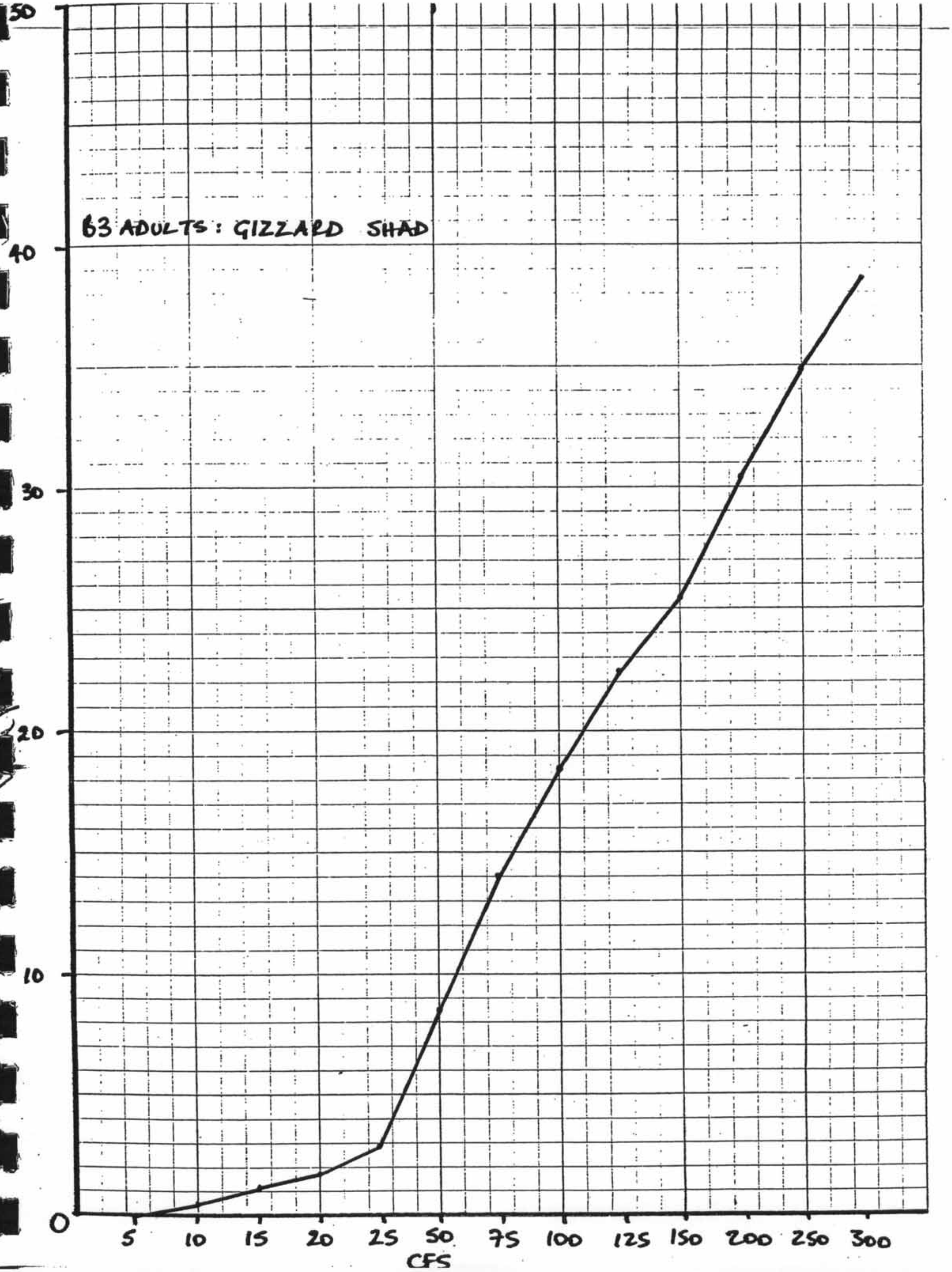

B2 ADULTS: WHITE CRAPPIE
100
90
80
70
60
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 23


B3 ADULTS: WHITE CRAPPIE
WUA
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300


B2 ADULTS: GIZZARD SHAD
100
90
80
70
60
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300
CES



63 ADULTS : GIZZARD SHAD
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300
CFS

Fig 26

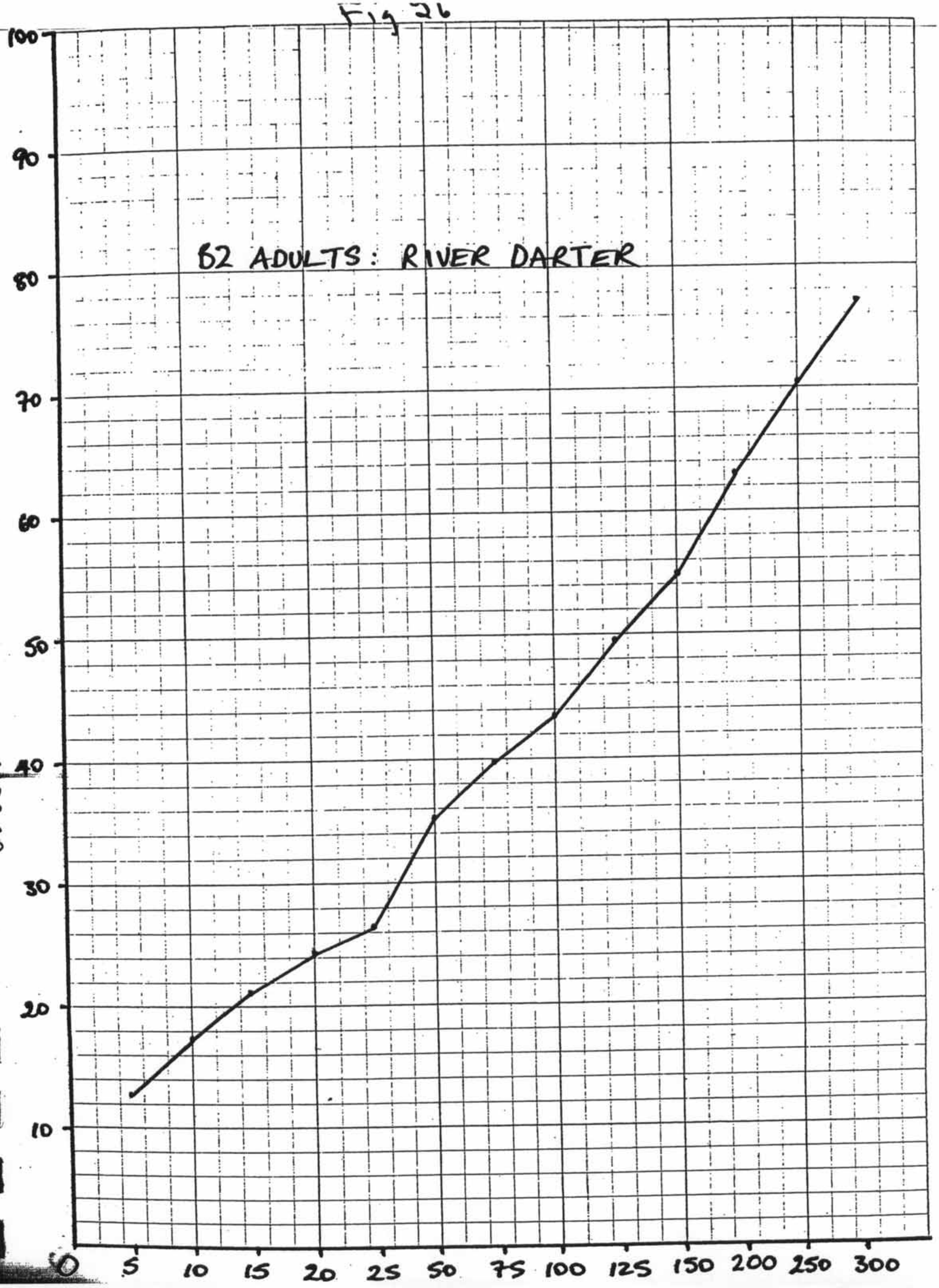

B2 ADULTS: RIVER DARTER
100
90
80
70
60
50
40
30
20
10
0
5
10
15
20
25
50
75
100
125
150
200
250
300

Fig 27