APPLICATION OF COHORT SLICING AND TUNED VPA TO SIMULATED DATA THAT INCLUDES VARIABILITY IN LENGTH AT AGE

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SUMMARY

Four simulated data sets were created during the July, 1993, ICCAT Workshop on the Technical Aspects of Methodologies which Account for Individual Growth Variability at Age. In this study, "cohort slicing" is used to assign ages to the simulated catch and relative abundance data and the resulting catch at age and abundance indices are then used in sequential population analyses (ADAPT). Three types of analyses were considered for each data set: one using a plus group to lump together all large fish at age 10+, another using a 5+ group, and the other with analyses up to a last true age of 9. Results obtained from the 5+ analyses outperformed the others.

RESUME

Quatre jeux de données simulées avaient été créés à l'occasion de la Consultation ICCAT de juillet 1993 sur les Aspects techniques des Méthodologies pour intégrer la Variabilité individuelle de la Croissance par Age. Cette étude utilise le "découpage des âges" pour assigner des âges aux données simulées de capture et d'abondance relative ; les indices de prise par âge et d'abondance ainsi obtenus sont alors utilisés dans l'analyse séquentielle des populations (ADAPT). Trois types d'analyses ont été considérés pour chaque jeu de données : un qui utilise un groupe plus pour regrouper tous les grands poissons des âges 10+, un autre qui emploie un groupe 5+, et un troisième qui analyse jusqu'à un âge réel de 9 ans. Les résultats obtenus par les analyses du groupe 5+ étaient bien plus performantes que les autres.

RESUMEN

En el curso de la Consulta ICCAT sobre Aspectos Técnicos de las Metodologías que explican la variabilidad del Crecimiento Individual por Edad, celebrado en julio de 1993, se crearon cuatro conjuntos de datos simulados. En este estudio se usa el "corte de cohorte" para asignar edades a los datos de captura simulada y de abundancia relativa, y los índices resultantes de captura por edad y abundancia se usan entonces en el análisis secuencial de población (ADAPT). Se consideraron tres tipos de análisis para cada conjunto de datos: uno, usando un grupo plus para concentrar todos los peces grandes de edad 10+; otro, usando un grupo 5+ y otro con análisis hasta una última edad auténtica de 9. Los resultados obtenidos de los análisis 5+ eran los mejores.

INTRODUCTION

Four data sets for stock assessment were simulated during a July 1993 meeting on methods which account for growth variability (ICCAT 1993). The data sets included two levels of growth variability resulting in either "clear" or "blurred" size modes, and two levels of contrast in recruitment and fishing mortality ("high contrast" and "low contrast"). The simulated data did not include any type of measurement error or any process error other than in growth variability and were intended to initiate basic tests of the performance of various methods. This paper is concerned with the application of "cohort slicing" in which length is converted to age via a growth curve (ignoring variation in length at age) to obtain data for an age-structured assessment and with the subsequent use of the data in a tuned VPA (ADAPT, see Gavaris 1988, Powers and Restrepo 1992). It should be noted that the ICCAT (1993) meeting was intended to study methods which would account for variability in length at age, rather than ignore it as this study does. However, cohort slicing is commonly applied to assign ages to the data for various stocks assessed by ICCAT, and the results presented in this paper can be used for comparison.

METHODS

For the remainder of this paper, the following nomenclature is used to refer to the data sets, following ICCAT (1993): HC and LC denote high and low contrast in recruitment and F, respectively. CM and BM denote clear and blurred size modes, respectively. Thus, the four data sets are: HC_CM, HC_BM, LC_CM, and LC_BM.

Ages (a) were assigned to the catch in numbers at length (L) according to the equation $L_a = 300\ (1.0 - \exp(-\ 0.4\ a))$. It was assumed that catches were taken at the middle of the year. Also, the simulated data were reported in 5-cm intervals; these were redistributed into 1-cm intervals assuming a uniform distribution. In cases where the predicted age was greater than 10 (or impossible to compute if $L > 300$), an age of 10+ was assigned.

Annual indices of abundance were computed for each age (1 to 10+) as follows: For the range of length classes corresponding to a given age group, relative abundance was computed as $I = \Sigma_l C_l / F_l$. This approach assumes that the same ageing errors, if any, apply to the catch and relative abundance data in a consistent manner.

Three sets of analyses were conducted. The first used all data to age 10+. The second used the data only up to age 9, with the 10+ age being left out of the analyses. The third used all data, grouped at age 5+. In all cases, the VPA calibration was made such that the entire fishing mortality at age vector in the terminal year was estimated. This was done so that the VPA calibration exercise would require as few assumptions (constraints) as possible.

RESULTS AND DISCUSSION

Tables 1 through 4 summarize the results for the four data sets. These summaries are the 15-year trajectories of recruitment, stock sizes for all ages (1 to 10+, 1 to 9 or 1 to 5+, depending on the analysis), biomass, and fishing mortality. The estimated fishing mortality trajectory in the three analyses reported in Tables 1 to 4 are the arithmetic means for ages 3 to 6 (10+ analysis), 4 to 7 (age 9 analysis) and 3 to 5+ (5+ analysis). These age ranges generally correspond to the age groups that appeared to be fully selected after analyses.

Figures 1, 2 and 3 present some of the same results given in the tables. Labels correspond to the true trajectories ("T"), the 10+ analyses ("10+"), the 5+ analyses ("5+") and the age 9 analyses ("9"). Figure 1 shows the true and estimated recruitment trajectories. It is evident that the 5+ analyses are less biased than the others. For the high contrast case, however, none of the analyses was able to pick the absolute magnitude of the large recruitment spikes, although the 5+ case did considerably better. Figure 2 shows the biomass trends (note: the lines for the age 9 analyses correspond to the biomass of ages 1 to 9 and therefore are not exactly comparable to the true trajectories). Again, the 5+ analyses outperformed the others in picking up the trends and resulted in estimated biomasses closer to the true one in magnitude. Results for fishing mortality are given in Figure 3. The results are essentially the same, with the 5+ analyses being less biased and better correlated with the true Fs.

The results from this study are not unexpected. If there is considerable variability in length at age and it is ignored, e.g. by use of cohort-slicing, then the estimated catch at age matrix will be biased. Naturally, estimates of stock sizes and fishing mortality rates from a VPA using this catch matrix will also be affected. This serves to highlight an obvious point which should not be overlooked: the biases shown in these results have nothing to do with the calibration procedure (ADAPT) itself.

It is interesting to verify that grouping the catches into a "young" plus group in the face of uncertainty in ageing can provide good results. During the past few years, there has been a tendency in various ICCAT species working groups that use cohort slicing, to lump the catches into a relatively young plus group. This decision has been made because given variability in length at age, it is difficult if not impossible to assign ages accurately to larger fish. The results from the analyses in this study suggest that this is a good idea, if cohort slicing is to be used.

A word of caution also seems prudent in terms of the usefulness (or lack thereof) of cohort slicing. The data sets generated in ICCAT (1993) were a necessary first step for looking at assessment methods which would account for variability in length at age. However, some details which could affect the performance of cohort slicing relative to other approaches were not taken into consideration. In particular, the following two may be important: First, measurement error in the length composition of the catches was not included in the generation of simulated data. It is not clear how the robustness of cohort slicing would compare to that of other approaches under different degrees of measurement error. Second, the simulated length compositions were annual summaries. It is likely that cohort slicing will perform better given samples by shorter time strata, particularly for fast-growing species such as that in the simulations. Indeed, it is common practice in ICCAT Working Groups to carry out cohort slicing with monthly or quarterly data.

ACKNOWLEDGMENTS

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Table 3. Results for Low Contrast Clear Modes data.

Analysis: Year	True N1	True N1-10	True N1-9	True Bio1-9	True Bio	True F	Plus10 N1	Plus10 N1-10	Plus10 Bio	Plus10 F	Age 9 N1	Age 9 N1-9	Age 9 Bio1-9	Age 9 F	Plus5 N1	Plus5 N1-5+	Plus5 Bio	Plus5 F
1	100.0	430.0	421.0	43309	45608	0.10	130.6	710.1	92165	0.05	64.9	259.6	25410	0.15	110.1	596.5	74691	0.06
2	101.0	422.2	412.6	41955	44415	0.11	127.9	699.1	90395	0.06	65.7	254.0	24456	0.15	112.9	579.2	72026	0.07
3	100.0	414.0	404.7	40650	43021	0.11	125.5	668.9	88014	0.06	66.3	250.3	23647	0.16	115.6	567.4	69326	0.07
4	116.0	423.2	413.8	39542	41894	0.12	126.3	653.2	85455	0.06	66.5	249.2	22848	0.16	124.2	565.9	67028	0.07
5	84.0	398.0	388.9	38635	40949	0.12	120.6	633.9	82827	0.07	62.7	242.3	22369	0.16	104.3	544.2	65121	0.08
6	106.0	400.9	392.4	37658	39826	0.13	121.4	618.4	80168	0.07	65.8	239.7	21868	0.17	115.3	536.6	63212	0.08
7	79.0	374.2	366.4	36659	38657	0.13	112.9	598.6	77525	0.08	61.1	232.7	21296	0.18	100.1	515.1	61233	0.08
8	124.0	387.9	380.6	35760	37594	0.14	129.0	595.4	75077	0.08	69.1	235.2	20770	0.18	128.2	525.5	59063	0.08
9	100.0	383.2	366.5	35436	37153	0.14	118.3	582.7	72939	0.08	66.2	234.0	20402	0.19	110.9	516.6	58182	0.09
10	82.0	370.6	364.3	35125	36768	0.15	107.4	560.8	70854	0.09	58.9	225.0	20014	0.20	96.8	492.3	57106	0.10
11	84.0	363.7	357.4	34256	35852	0.15	112.3	547.0	68744	0.09	60.9	219.3	19435	0.21	100.9	477.0	55169	0.10
12	77.0	341.2	335.3	33072	34594	0.16	97.9	521.5	66439	0.09	53.2	207.1	18896	0.23	89.2	453.6	53431	0.10
13	84.0	330.6	324.0	31397	33096	0.16	102.3	505.4	63994	0.09	55.0	199.5	17610	0.23	92.7	437.7	51266	0.11
14	78.0	315.9	311.3	30187	31372	0.17	95.7	485.8	61536	0.09	51.3	190.3	16947	0.23	87.3	419.6	48881	0.11
15	96.0	323.9	318.2	28798	30264	0.17	117.6	482.5	58449	0.10	63.1	196.2	16228	0.24	107.5	425.9	47062	0.11

Table 4. Results for Low Contrast Blurred Modes data.

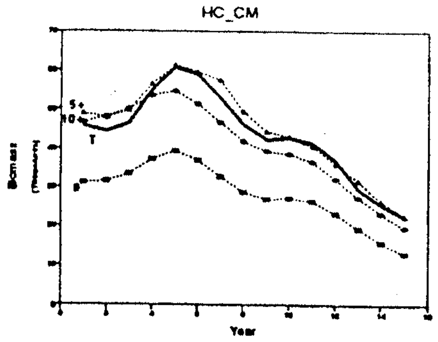
Analysis: Year	True N1	True N1-10	True N1-9	True Bio1-9	True Bio	True F	Plus10 N1	Plus10 N1-10	Plus10 Bio	Plus10 F	Age 9 N1	Age 9 N1-9	Age 9 Bio1-9	Age 9 F	Plus5 N1	Plus5 N1-5+	Plus5 Bio	Plus5 F
1	100.0	430.0	421.0	43309	45608	0.10	286.0	1763.6	242809	0.02	58.7	224.0	21643	0.17	94.1	488.8	58875	0.08
2	101.0	422.2	412.6	41957	44417	0.11	275.5	1699.1	236041	0.02	56.6	217.0	20691	0.18	96.6	474.7	57046	0.08
3	100.0	414.1	404.6	40673	43043	0.11	270.4	1641.3	233089	0.02	57.3	212.4	19798	0.18	102.2	468.5	55334	0.08
4	116.0	423.4	414.2	39591	41943	0.12	268.5	1581.4	226004	0.02	58.3	209.7	19016	0.19	103.1	464.3	54008	0.09
5	84.0	398.4	389.3	38716	41031	0.12	256.5	1538.2	218607	0.03	55.5	204.8	18418	0.19	96.1	453.2	52724	0.09
6	106.0	401.4	392.9	37766	39934	0.13	248.7	1496.2	211104	0.03	56.2	201.0	17644	0.19	96.1	445.3	51340	0.10
7	79.0	374.9	367.1	36605	38802	0.13	237.1	1431.6	203639	0.03	54.4	196.1	17279	0.20	96.3	436.4	50020	0.10
8	124.0	388.6	381.4	35910	37746	0.14	258.6	1406.9	196536	0.03	57.9	195.9	16616	0.21	109.4	442.4	48978	0.11
9	100.0	394.0	387.2	35600	37327	0.14	244.9	1375.4	190191	0.03	57.4	194.9	16443	0.22	96.2	432.6	47937	0.10
10	82.0	371.5	365.0	35262	36937	0.15	226.4	1326.9	184424	0.03	52.7	186.5	16043	0.23	88.8	417.1	47050	0.11
11	84.0	364.5	358.2	34426	36035	0.15	227.5	1291.3	178707	0.04	52.6	182.8	15472	0.25	89.3	402.9	45578	0.11
12	77.0	342.1	336.1	33252	34768	0.16	213.0	1246.2	173060	0.04	46.3	174.3	14654	0.27	81.6	385.6	44333	0.12
13	84.0	331.5	324.8	31567	33261	0.16	216.1	1212.6	167510	0.04	48.2	167.6	14145	0.27	82.2	371.3	42482	0.13
14	78.0	318.8	312.1	30365	31560	0.17	204.6	1174.0	162203	0.04	45.3	160.0	13466	0.27	77.8	355.5	40451	0.13
15	96.0	324.7	319.0	28963	30441	0.17	246.3	1184.7	157550	0.04	54.4	163.3	12903	0.28	84.0	350.9	38915	0.13

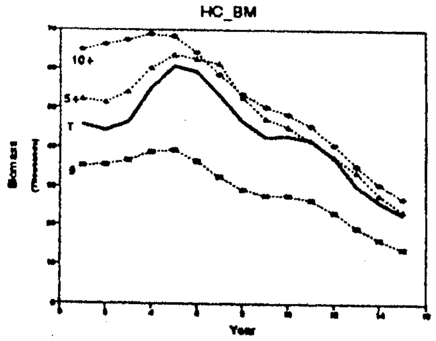
Table 1. Results for High Contrast Clear Modes data.

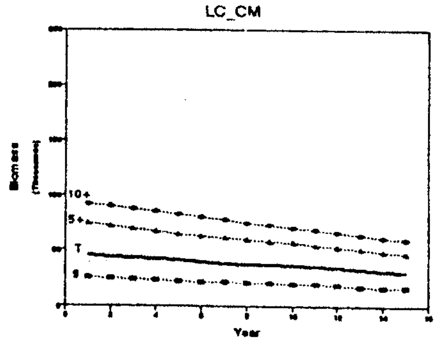
Analysis: Year	True N1	True N1-10	True N1-9	True Bio1-9	True Bio	True F	Plus10 N1	Plus10 N1-10	Plus10 Bio	Plus10 F	Age 9 N1	Age 9 N1-9	Age 9 Bio1-9	Age 9 F	Plus5 N1	Plus5 N1-5+	Plus5 Bio	Plus5 F
1	100.0	430.0	421.0	43309	45608	0.10	105.3	439.9	46701	0.09	92.4	334.4	31181	0.12	86.6	423.4	46855	0.09
2	101.0	422.2	412.6	41955	44415	0.12	123.1	463.0	47979	0.10	115.7	363.9	31582	0.14	126.8	451.1	47966	0.11
3	500.0	810.8	801.6	44019	46356	0.14	218.1	573.9	50019	0.11	213.4	463.5	33465	0.15	370.1	714.0	49782	0.12
4	116.0	734.2	725.4	52593	54844	0.16	123.0	560.2	53345	0.11	119.1	478.3	37252	0.15	143.5	693.0	56367	0.12
5	84.0	623.5	615.2	58381	60496	0.18	97.9	510.6	54534	0.19	86.5	426.4	39187	0.16	91.2	610.0	61161	0.16
6	106.0	545.1	537.6	56871	58738	0.20	98.0	459.6	51429	0.25	86.7	376.0	36900	0.25	93.4	533.7	59303	0.19
7	79.0	457.3	451.0	51388	52984	0.22	88.1	411.8	46814	0.28	79.7	334.0	32804	0.32	76.9	464.4	57333	0.21
8	124.0	437.1	431.6	44871	46209	0.24	114.4	404.0	41922	0.27	104.7	328.2	28757	0.32	118.4	440.5	49479	0.23
9	300.0	600.7	596.3	41249	42378	0.26	182.1	468.1	39162	0.25	171.9	395.0	26899	0.32	221.3	530.5	44406	0.23
10	82.0	511.9	508.1	41781	42726	0.28	90.4	424.3	38556	0.23	65.9	360.1	27316	0.30	95.4	476.0	43020	0.24
11	94.0	442.5	439.3	40676	41514	0.30	76.5	367.0	36682	0.29	72.3	310.9	26563	0.31	82.8	411.5	40628	0.27
12	77.0	366.6	352.7	33390	36943	0.32	61.2	302.8	32327	0.34	57.6	253.6	23250	0.39	69.7	344.8	35999	0.27
13	84.0	314.9	312.1	29105	29812	0.34	61.4	258.5	27408	0.36	57.1	214.7	19351	0.44	70.9	301.6	31801	0.33
14	76.0	262.2	260.4	25175	25615	0.36	55.7	223.9	23152	0.39	51.8	184.1	15833	0.46	65.3	261.9	26457	0.32
15	96.0	278.8	276.9	21987	22472	0.38	66.7	210.7	19574	0.44	62.1	173.9	13078	0.48	79.5	250.8	22621	0.35

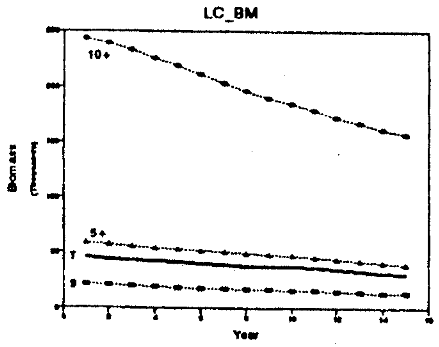
Table 2. Results for High Contrast Blurred Modes data.

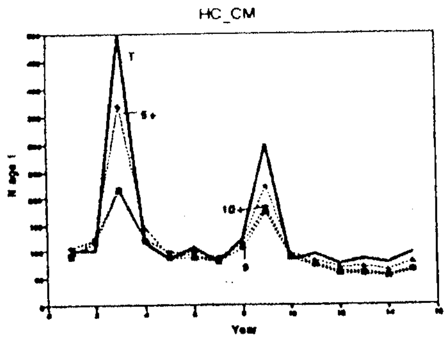
Analysis: Year	True N1	True N1-10	True N1-9	True Bio1-9	True Bio	True F	Plus10 N1	Plus10 N1-10	Plus10 Bio	Plus10 F	Age 9 N1	Age 9 N1-9	Age 9 Bio1-9	Age 9 F	Plus5 N1	Plus5 N1-5+	Plus5 Bio	Plus5 F
1	100.0	430.0	421.0	43309	45608	0.10	120.4	570.3	64756	0.06	96.1	365.3	35288	0.10	89.0	444.2	52168	0.08
2	101.0	422.2	412.6	41957	44417	0.12	139.6	586.4	66224	0.07	120.9	393.5	35533	0.12	161.3	522.9	515[illegible]	0.10
3	500.0	810.9	801.7	44044	46381	0.14	186.7	643.6	67431	0.08	170.3	463.3	36690	0.13	303.8	706.6	54160	0.11
4	116.0	734.3	725.5	52647	54697	0.16	140.9	635.1	66855	0.10	120.6	462.2	38853	0.13	142.8	696.7	60276	0.12
5	84.0	623.2	615.0	58415	60530	0.18	119.4	593.2	68154	0.18	94.4	422.0	39271	0.17	105.0	618.4	63435	0.15
6	106.0	547.1	539.8	57190	59058	0.20	110.2	541.1	64051	0.22	89.6	376.8	36431	0.25	95.9	546.0	62533	0.16
7	79.0	459.4	453.2	51793	53389	0.22	104.4	495.2	58621	0.21	87.3	340.9	32390	0.28	89.6	488.0	61246	0.22
8	124.0	438.9	433.6	45251	46589	0.24	126.5	484.4	53570	0.20	107.6	338.5	29064	0.27	141.6	481.5	52669	0.23
9	300.0	602.4	597.9	41596	42733	0.26	161.0	512.8	50251	0.18	141.6	374.6	27625	0.26	184.9	525.8	47374	0.23
10	82.0	513.1	509.3	42055	43031	0.28	105.3	475.6	48480	0.19	92.1	350.2	27665	0.25	102.6	478.0	45226	0.23
11	94.0	443.4	440.1	40914	41762	0.30	86.0	418.4	45481	0.26	74.7	305.7	26392	0.30	84.3	413.6	41362	0.26
12	77.0	369.0	354.9	33767	37368	0.32	72.5	357.7	40601	0.29	62.8	256.3	23058	0.36	72.7	351.5	37724	0.26
13	84.0	316.9	314.0	29478	30196	0.34	69.1	311.0	35216	0.28	59.1	218.3	19352	0.39	73.8	310.9	33682	0.33
14	76.0	283.8	282.1	25513	25960	0.36	62.3	273.7	30715	0.28	53.0	190.2	16306	0.39	66.7	269.7	27762	0.33
15	96.0	280.1	278.2	22272	22765	0.38	73.0	257.6	26832	0.31	61.9	179.7	13919	0.40	78.9	255.7	23649	0.34







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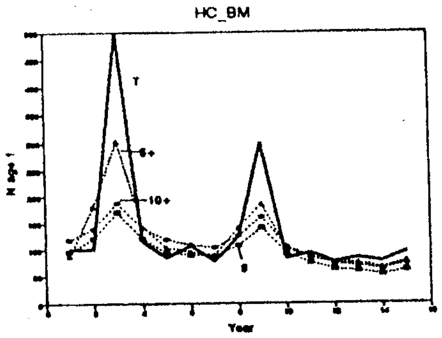
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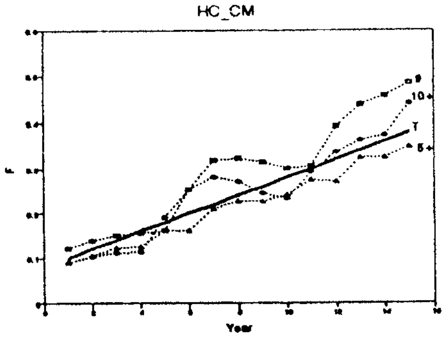
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T
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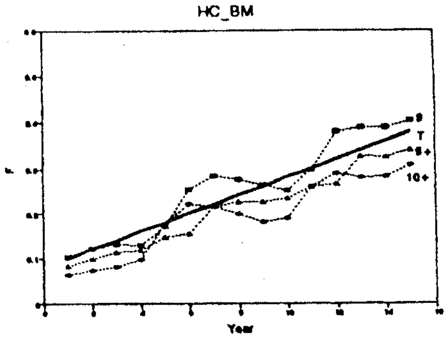
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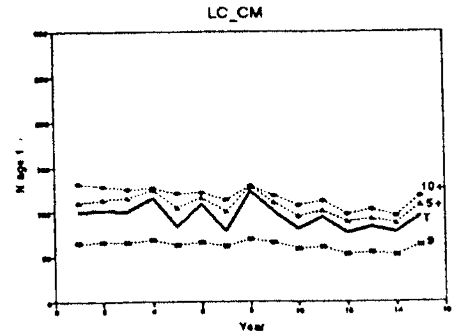
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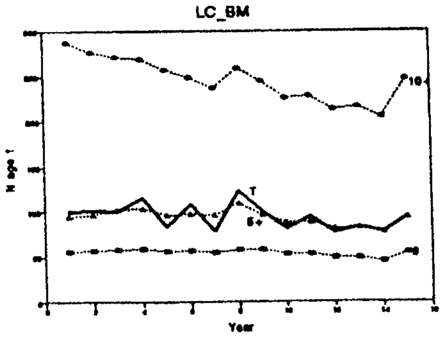
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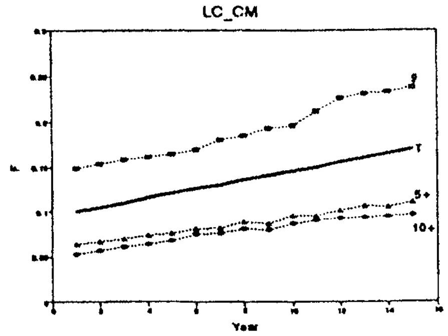
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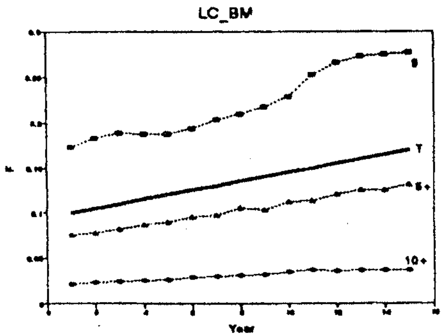
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