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NEW TAG-RECAPTURE GROWTH ANALYSIS FOR NORTH ATLANTIC ALBACORE DATA

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SUMMARY

An updated estimation of observed patterns in growth is presented, based on tag and recapture data analysis of Spanish tagging cruises carried out in the Bay of Biscay, the eastern area of the Cantabrian Sea, since 1976.

RESUME

Une estimation mise à jour du modèle de croissance observé, basé sur l'analyse des données de marquage/recapture obtenues au cours des campagnes de marquage espagnoles effectuées dans le golfe de Gascogne, la mer Cantabrique depuis 1976, est présentée.

RESUMEN

Se presenta una estimación actualizada del modelo de crecimiento observado, basado en el análisis de los datos de marcado/recaptura obtenidos a través de las campañas de marcado españolas efectuadas en el Golfo de Vizcaya, Mar Cantábrico, desde 1976.

INTRODUCTION

During 1976 tagging studies were initiated by IEO (Instituto Español de Oceanografía) in the Bay of Biscay, western area of Cantabrian Sea. Although the target species were not albacore (Cort and Mejuto, 1990), 1,009 thousands albacore were released up to 1987.

Between 1988 and 1991, annual tagging campaigns were carried out in this area directed to albacore (Ortiz de Zárate et al., 1991 ; Cort et al, 1992). The main purpose of the campaigns was to achieve a better knowledge of this species in the research framework of the Special Progamm of Albacore (PSG) sponsored by ICCAT (Anon. 1990, 1991). In particular the use of marking studies to determine patterns in the migration behaviour, growth, and differential capture rates between gears were identified ae research areas.

Earlier analyses of the recent tagging information considered the estimation of growth parameters using the Walford method (Ortiz de Zarate & Rodriguez-Cabello, 1993). This study emphasized the reviewing of all the release and recapture data and used the Fabens analytical method (Fabens, 1965) to estimates of the asymptotic size and growth rate parameters.

MATERIALS

The data, that were included in the growth analysis, comprised all recaptures reported by the surface fisheries fleets. These were baitboat, troll, mid-water trawl and driftnet vessels targetting albacore in the north east Atlantic Ocean and Bay of Biscay concerning the period 1976 - 1992.

All the tagging campaigns were isolated to the inner zone of Bay of Biscay between 44 and 46 degrees North and 2 and 6 degrees West, in the Cantabrian sea. Cort et al. (1992) provided the background for the location of the tagging experiments.

Recapture time period was from the months of June through October and November because this coincides with the main season on albacore by surface fleets.

The information recorded for each tag and recaptured fish used in the growth analysis included the date, location, length and the gear. Size was recorded in fork length to the nearest one centimeter.

The total data set included 405 recoveries which represent 3.1% of the total releases. Considered elegible for estimation of growth parameters were 228 recaptures or 56,3% of all recaptures and 1.7%, of all releases. Not all observations included size information thus the reason for the smaller number of recaptures in the growth analysis data set. The number of fish tagged by year and recaptured is shown in Table 1. The size distribution of fish released is shown in Figure 1.

The data analysis was restricted to include only those recaptures for which the time at liberty was greater than six months and those recaptures taken by expert personnel. Six months was used as the minimun time at liberty considering that fish would likely have mixed after this amount ot time and that some growth could be expected to have ocurred in this amount of time. The tag - recapture data used in the analysis of growth estimates are given in Table 2.

GROWTH ANALYSIS METHODS

We used the non-linear model of Fabens (Fabens, 1965) to derive growth parameter estimates from length increment and lapsed time observa-tions. The Marquardt-Levenberg algorithm (Levenberg, 1944; Marquardt, 1963) was used to find ordinary least squares (unweighted) of the growth rate parameter, k, and the asymptotic size, L infinity, for these direct observations of growth.

This model was chosen because of its general acceptance in many fisheries application for describing growth from size increment and time lapse data. The Fabens method allows for the incorporation of individuals at unequal time intervals into the analysis. The model is simple, the statistical properties and inherent problems of the model have been well studied and, moreover analytical software required to obtain the parameter estimates was readily available.

This growth model was also preferred over some of the other growth parameter estimation procedures that involve linear transformations of the data (e.g. Beverton, 1954; Walford, 1946; Gulland and Holt, 1959; Munro, 1982) because the fitting method is superior and provides more accurate results.

We recognized that the Fabens approach does not take into account individual variation in size at age in modelling growth as emphasized by Beverton and Holt (1957) and Sainsbury (1980) and recently by many authors. Although, this is of importance in modelling the growth pattern, it was considered more academic and was not the main concern in this study. We were more interested in being able to estimate the mean size (at age) of individuals from population.

Six months was used as the minimum time at liberty to select tag-recapture data for the analysis to be undertaken. That was decided to avoid the bias in annual growth rate due to diferential growth pattern along the year. Secondly, to not incorporate tag-recapture information that registers a negative growth when recaptured, caused by errors on mesaurements when released.

For comparison reasons several analyses of the complete albacore tag data were explored. It was of interest to examine the potential effects on parameter estimates of eliminating entire years of individuals points from the analysis set. It was also of interest to compare parameter estimates from the analyses of earlier tagging studies and with analyses of hard part samples (Anon, 1990) with those found from this study. Because we are mostly interested in modelling size at some specific age we made simple comparisons between studies by comparing estimated size at age across studies.

For this purpose we assumed a t_0 of -1.286, for making comparisons with the tag analysis parameter estimates. This value was estimated assuming a size of FL=55 cm for age =1 , as derived from observed mode in released individuals size distribution plotted in Figure 1.

These results were plotted and the differences and/or similarities between predicted points observed.

RESULTS

Non linear least squares parameter estimates of the growth rate, k, and asymptotic size, L infinity, were found to be 0.32 and 106 cm for our data set of 228 individuals. Results of the analysis are shown in Table 3.

The value of the L infinity parameter estimated in this study is smaller according to observed size in commercial catches (LF = 120 cm). That is due to lack of large fish recaptured in the data set analyzed and not to tag analytical method implemented.

These values are in reasonable agreement with estimates from other growth analyses of k and L infinity of albacore (see Anon. 1990) from hardpart samples and tag recapture analyses (Table 4). Direct comparison of the growth parameter estimates themselves across studies has several problems. First, parameter estimates derived from tagging data are not comparable with those from hardparts samples (Francis, 1988). Second, prior tagging studies estimates are also not directly comparable, due to different data sets used.

The usefulness of the parameter estimates derived in this study to accurately reflect albacore growth observed from these data and to demonstrate known from published work was determined by computing the predicted size at age as shown by the modeled estimates and comparing across studies, is given in Table 5 and Figure 2.

These results show that predicted size at age values are suitable when compared with those in the literature. It must be considered that the value of t_0 used as input in the computations is an important factor. The predicted values are quite similar to those of historycal studies.

We calculated the residual error in observed-expected growth and plotted against recapture size, as shown in Figure 3. The results suggest that the model did not account for the variation in the data in total. The pattern in residuals indicate a negative bias in predicted size with increasing recapture size. The bias is more pronounced for large fish above about 85 cm length, where fewer fish were represented in the data set. Moreover, it is not unexpected, since the data set did not account for observations from older and larger individuals.

Plots of the residual from observed and predicted recapture size againts time at liberty in Figure 4, showed no significant trends in the residuals of predicted size versus observed size with time.

DISCUSSION AND CONCLUSION

Results obtained through this analysis reflects the same overall pattern of growth as in previous analysis cited in the literature, when used to compute predicted size at age and assuming similar t_0 across studies. The model fit in this study, the von Bertalanffy, reasonably well described the observed size increment and time lapse observations.

Most of the releases comprised individuals of 1 or 2 years all. The recaptures are focussed on the capture of inmature albacores present in the fishing grounds and targetted by the surface fishery (1 to 4 years old, sizes 50-90 cm). Therefore, expected recoveries in this area would range from 2 to 4 age groups) and it would be rare to find older group fish, since they are not likely to be in the area, due to different behavioral pattern. The data included in this analysis of growth and the model von Bertalanffy well describes the growth of individuals that would be expected to be captured by the surface fisheries.

Results of residual distibution in Figure 3, suggest that models containing terms for individual variation in the growth pattern might be appropiate to apply when trying to control for individual variation in the obervations.

This study derived updated estimates for the two parameter growth model, k and L infinity. Traditional calculations of age nearly always employ the three parameter von Bertalanffy model , therefore attention should be given to the proper choice of values for t_0 . Future studies of tag recapture growth pattern for albacore could incorporate weighting of the individual observations into parameter estimation.

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Table 1.- Annual released albacore during tagging cruises in Bay of Biscay, western area in Cantabrian sea. (*) Campaigns targetting albacore.

Period 1976 - 1991		
Year	Tags	Recaptures
1976	228	4
1977	38	2
1978	138	12
1979	31	2
1980	222	5
1981	3	0
1982	4	0
1983	6	0
1984	0	0
1985	126	6
1986	213	5
1987	0	0
1988 (*)	406	38
1989 (*)	2969	94
1990 (*)	4481	88
1991 (*)	4219	149

Table 2. Tag recapture data used in the analysis

Release size mm	Tag		Recapture size mm	Days liberty	Growth mm
800	EM	7108	860	399	60
560	AT	3721	650	324	90
550	AT	3731	780	751	230
520	EM	8700	770	697	250
530	EM	8721	780	708	225
530	EM	8762	700	689	170
550	EM	8769	700	348	150
530	EM	8800	670	262	140
510	EM	8815	670	316	160
520	EM	8846	870	1395	350
540	EM	8866	670	285	130
540	EM	8878	740	361	200
560	TG	859	720	353	160
550	TG	861	720	687	170
540	TG	914	800	704	260
550	TG	963	660	305	110
580	YF	2116	680	380	100
560	YF	2190	720	364	160
560	YF	2370	690	371	130
560	YF	2395	710	390	150
560	YF	2586	830	723	270
570	YF	2696	660	300	90
560	YF	2849	840	741	280
540	YF	2963	730	359	190
560	YF	2979	750	338	190
530	YF	3032	720	369	190
570	YF	3040	730	359	160
560	YF	3075	800	1047	240
710	YF	3169	880	381	170
560	YF	3196	780	365	220
560	YF	3218	790	1115	230
560	YF	3238	630	343	70
590	YF	3277	730	329	140
610	YF	3285	730	351	120
580	YF	3287	740	376	160
580	YF	3345	760	383	180
620	YF	3365	760	360	140
720	YF	3450	840	407	120
750	YF	3471	780	361	30
740	YF	3476	890	382	150
700	YF	3505	850	364	150
460	YF	3551	650	303	190
490	YF	3576	720	594	230
590	YF	4009	710	398	120
550	YF	4209	710	405	160
590	YF	4278	840	743	250
590	YF	4296	710	404	120
570	YF	4297	710	354	140
560	YF	4322	700	399	140
550	YF	4334	630	343	80
550	YF	4341	710	361	160
550	YF	4350	650	297	100
580	YF	4369	870	742	290
570	YF	4402	700	363	130
550	YF	4441	720	737	170
610	YF	4448	720	365	110
560	YF	4570	680	367	120
580	YF	4592	770	390	190
580	YF	4621	770	375	190
570	YF	4651	920	1118	350
550	YF	4750	890	1170	340
840	YF	4796	940	365	100
530	YF	4874	870	1169	340
550	YF	4904	680	349	130
580	YF	4915	710	353	130
550	YF	4922	800	1068	250
910	YF	4933	1000	384	90
570	YF	4937	700	374	130
590	YF	5019	710	361	120
600	YF	5022	760	361	160
600	YF	5035	660	334	60
580	YF	5051	870	777	290
590	YF	5062	820	767	230
590	YF	5083	720	331	130
590	YF	5122	720	355	130
600	YF	5128	720	325	120
620	YF	5129	680	326	60
580	YF	5193	740	367	160
590	YF	5196	720	344	130
710	YF	5281	730	359	20
470	YF	5376	670	332	200
770	YF	5385	860	311	90
790	YF	5484	860	238	70
530	EM	8925	900	711	370
580	TG	7208	770	719	190
560	TG	7247	810	690	250
560	TG	7263	730	381	170
560	TG	7269	770	696	210
550	TG	7355	670	365	120
570	TG	7427	800	809	230
560	TG	7490	670	370	110
560	TG	7517	770	695	210
570	TG	7594	800	700	230
570	TG	7611	750	708	180
590	TG	8009	710	380	120
570	TG	8239	800	732	230
730	TG	8275	890	698	160
520	TG	8594	670	345	150
590	TN	46	710	356	120
590	TN	111	860	768	270
560	TN	161	730	356	170
540	TN	183	800	766	260
560	TN	211	700	364	140
530	TN	239	770	763	240
550	TN	256	770	712	220
540	YF	443	690	380	150
580	YF	569	750	710	170
540	YF	1065	780	690	240
610	YF	1119	820	698	210
770	YF	1205	860	388	90
570	YF	1229	740	369	170
510	YF	1259	760	731	250
550	YF	1261	690	329	140
590	YF	1605	770	795	180
710	YF	1798	820	373	110
600	YF	1817	770	349	170
610	YF	1835	810	683	200
550	YF	6036	840	708	290
550	YF	6056	630	370	80
540	YF	6261	830	747	290
560	YF	6297	720	710	160
540	YF	6310	720	389	180
540	YF	6344	750	702	210
560	YF	6346	660	322	100
540	YF	6351	870	710	330
530	YF	6360	720	715	190
550	YF	6452	690	282	140
560	YF	6467	820	708	260
600	YF	6470	710	715	110
550	YF	6514	680	376	130
540	YF	6553	650	372	110
590	YF	6610	860	722	270
550	YF	6685	810	716	260
550	YF	6713	845	706	295
540	YF	6717	740	771	200
560	YF	6794	720	391	160
530	YF	6810	760	720	230
530	YF	6841	700	727	170
690	YF	7046	880	746	190
700	YF	7146	830	329	130
680	YF	7171	740	342	60
540	ES	21	670	396	130
540	ES	54	620	315	80
660	ES	290	720	348	60
650	ES	298	700	339	50
570	ES	365	660	340	90
570	ES	497	680	332	110
700	NO	5422	780	355	80
650	NO	5431	800	341	150
680	NO	5432	770	374	90
650	NO	5438	790	357	140
690	NO	5442	910	430	220
640	NO	5458	770	344	130
640	NO	5532	790	403	150
670	NO	5555	750	337	80
670	NO	5623	820	360	150
660	NO	5638	790	382	130
640	NO	5655	830	365	190
670	NO	5671	770	390	100
680	NO	5683	760	427	80
620	NO	5713	720	387	100
650	NO	5720	760	408	110
710	NO	5738	810	335	100
650	NO	5783	840	348	190
640	NO	5785	750	367	110
660	NO	5816	740	344	80
660	NO	5834	790	367	130
650	NO	5853	760	370	110
610	NO	5854	700	347	90
650	NO	5889	760	364	110
600	NO	5898	750	363	150
590	NO	5976	740	333	150
580	NO	5990	690	347	110
610	NO	6006	790	337	180
640	NO	6057	800	332	160
670	NO	6080	830	381	160
570	NO	6242	630	340	60
580	NO	6248	710	335	130
670	NO	6260	730	354	60
680	NO	6345	770	342	90
680	NO	6347	800	383	120
700	NO	6374	790	362	90
650	NO	6399	840	349	190
600	NO	6444	820	338	220
630	NO	7131	680	323	50
690	NO	7243	810	366	120
670	NO	7247	695	395	25
680	NO	7290	770	343	90
660	NO	7292	740	335	80
650	NO	7305	720	353	70
600	NO	7378	650	344	50
670	NO	7543	830	402	160
690	NO	7559	820	337	130
570	NO	7579	710	346	140
660	NO	7630	680	354	20
540	TG	8676	600	340	60
590	TN	5111	670	354	80
550	TN	5120	680	384	130
600	TN	5141	730	352	130
550	TN	5225	700	356	150
570	TN	5280	720	368	150
620	TN	5331	710	340	90
640	TN	5334	720	337	80
660	TN	5384	880	429	220
550	TN	5395	720	361	170
650	TN	5415	770	398	120
650	TN	5434	820	398	170
660	TN	5447	810	372	150
550	TN	5449	640	289	90
620	TN	5454	720	371	100
660	TN	5460	780	361	120
590	TN	5464	750	400	160
540	TN	5507	650	389	110
510	TN	5539	600	316	90
550	TN	5557	630	387	80
550	TN	5683	720	369	170
520	TN	5778	640	295	120
540	TN	5790	670	377	130
590	TN	5802	750	379	160
590	TN	5828	680	371	90
600	TN	5969	710	386	110
560	TN	6083	670	347	110
570	YF	8213	830	403	260
560	YF	8319	700	348	140
520	YF	8667	610	327	90
520	YF	8771	680	347	160
560	YF	8886	700	399	140
550	YF	8929	660	361	110

Table 3. Results of Fabens analysis

Two parameters were estimated from 228 obervations.

Source	Sums of Squares	Mean Square
s2(i)	129580840.0000	568337.1000
s2(i)-average[s2]	1202976.0000	5276.2104
s2(i)-Model s2(i)	381739.7000	1681.6730

Variances and Covariances

Parameter	Weighted Estimate	S∞	k
S∞	1061.950	1.84982	-.00159
k	.320	-.00159	0.00000

Chi Square Statistic: 381739.6025
Pr[ChiSquare] = .0000

n = 229

$s2 = S\infty^{2} - (S\infty - s1)^{2} \cdot e^{(-2 \cdot k \cdot t)}$

$s = 1061.950 - 601.950 \cdot \exp(-.320 \cdot t)$

Table 4. Comparison of different growth parameters estimated for North Atlantic albacore.

	Author	Growth Parameters: L infinity	K	t_0
(1)	Bard, 1981	124.74	0.2284	-0.9892
(2)	WS 1989 *	114.17	0.2645	-0.9610
(3)	Present study **	106	0.32	-1.286

* It was calculated asuming FL = 62 cm at t=2 ages (Anon,1990)
** It was calculated asuming FL = 55 cm at t=1 ages
t= age in years

Table 5. Length (cm) at age predicted from comparison studies.

Age	Author		
	Bard, 1981	WS 1989 *	Present study **
1	45.5	46.2	55
2	61.7	62.0	69
3	74.5	74.1	79
4	84.8	83.4	86.5
5	92.9	90.6	91.8
6	99.5	96.1	95.7
7	104.6	100.3	98.5
8	108.7	103.5	100.6
9	111.9	105.9	102
10	114.6	107.7	103

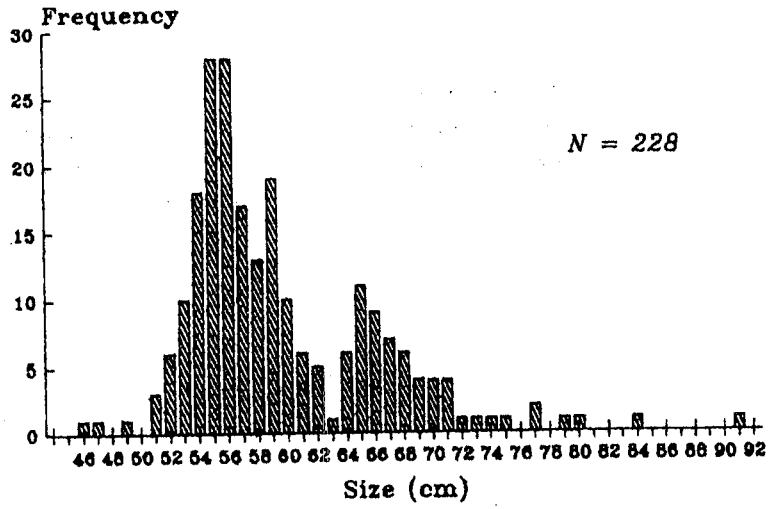

Figure 1.- Size data for released tagged fish used in the growth analysis.

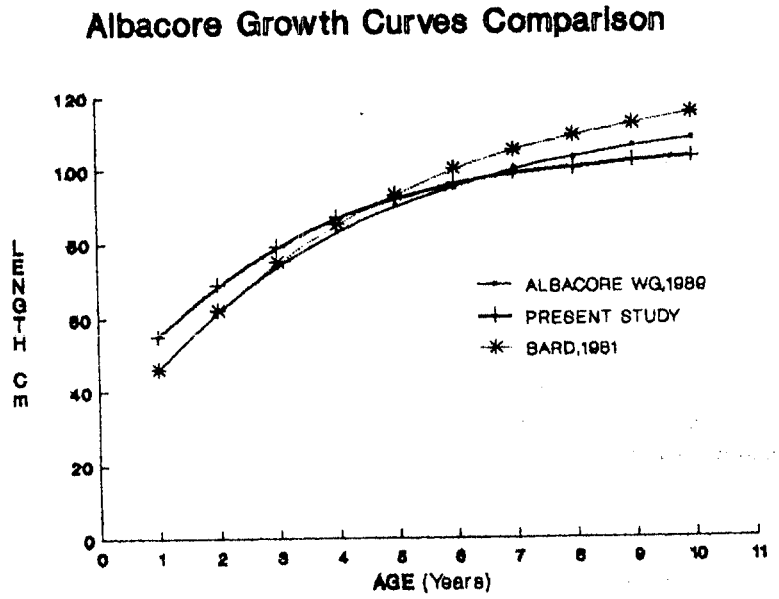

Figure 2.- Comparison of different growth curves.

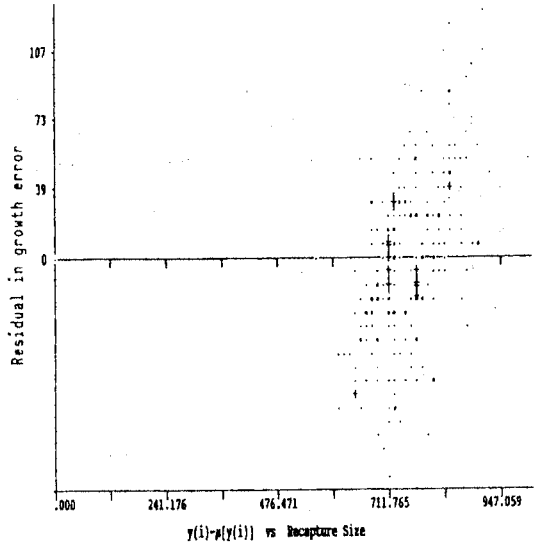

Figure 3.- Residual errors in observed-experted growth versus Recapture size.

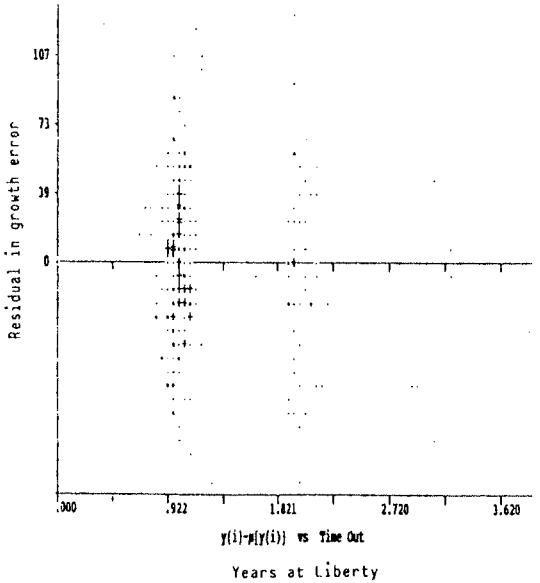

Figure 4.- Residual growth error versus time at liberty.