

**A REVIEW OF THE GROWTH RATE OF WEST ATLANTIC BLUEFIN TUNA, *THUNNUS THYNNUS*,
ESTIMATED FROM MARKED AND RECAPTURED FISH**

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SUMMARY

Estimates of growth rates of west Atlantic bluefin from recaptured fish are reviewed to examine the sensitivity of estimates to the exclusion of observations from recaptures of large fish which had been at liberty for many years.

RESUME

Les estimations du taux de capture du thon rouge ouest-atlantique effectuées à partir de poissons recapturés sont examinées pour déterminer le degré de sensibilité des estimations au fait d'exclure les observations provenant de recaptures de grands poissons qui ont passé plusieurs années en liberté.

RESUMEN

Se examinan estimaciones de tasas de crecimiento de atún rojo del Atlántico oeste, obtenidas en peces recapturados, con el fin de estudiar la sensibilidad de las estimaciones a la exclusión de observaciones de recapturas de peces grandes que habían estado en libertad durante muchos años.

During a review of the information used by Turner et al. (1991) to estimate the growth curve currently used by the SCRS for west Atlantic bluefin, *Thunnus thynnus*, some duplication of observations, one error in time at large, and one erroneous entry were found. The impact of these problems on the estimated growth curve and the estimated catch at age is examined.

Methods

The duplicated observations (Table 1) were removed from the data set used by Turner et al., the error in the time at liberty (released at 51 cm and recaptured at 85 cm with an actual time at liberty of 0.47 yr, rather than 0.74 yr) was corrected, and the erroneous entry (80cm at release, 267 cm at recapture and 10.2 years at liberty) was removed.

Turner et al. (1991) calculated several growth curves using various types of size data, but recommended the growth curve based on fish with estimated or measured fork length at release and recapture. For this review only the curve based on fork lengths was recalculated.

Kirkwood's method of estimating growth from mark-recapture data (Kirkwood 1983) was used as in Turner et al. (1991). Additionally the original and the revised data sets were bootstrapped 1000 times each.

Results

Turner et al. (1991) estimated L_{∞} at 380.1, K at 0.079, and t_0 at -0.731; with the revised data those estimates were L_{∞} of 382.0, K of 0.079, and t_0 of -0.707. Plots of the two curves were indistinguishable at normal scales. Figure 1 shows the revised estimate of the growth curve with the raw data under the assumption that the release age was exactly as predicted by the model from the size at release.

The bootstrap results indicated a broader range of estimates of size at age with the revised data than with that used by Turner et al. (Figure 2). The estimated catches at age using the original growth curve (Table 2) were compared with those estimated from the revised curve; both relative and absolute differences are shown in Table 3. Relative differences ranged from +/- 0. to about +/-20%; most of the differences of about +/-5% occurred at ages 4 and older.

Turner and Restrepo (1992) investigated the effects of uncertainty in various components of the virtual population analysis and projections for west Atlantic bluefin including uncertainty in the catch at age due to both uncertainty about growth equation used for age slicing and some uncertainty about the recorded catch. They used the 1000 estimated growth curves from the original data used by Turner et al. (1991) and from which the 95% empirical confidence intervals are shown in Figure 2. They showed that uncertainty about the estimated catch at age had comparatively little impact on the range of the relative estimates of abundance of large bluefin, and more important effects on the range of relative estimates for small and medium fish in the earlier part of the time series.

Kirkwood, G.P. 1983. Estimation of von Bertalanffy growth curve parameters using both length increment and age-length data. *Can. J. Fish. Aquat. Sc.* 40 (9): 1405-1411.

Turner, S.C. and V.R. Restrepo. 1992. Sensitivity of bluefin tuna virtual population analysis and projections to uncertainty in inputs. *ICCAT. Col Vol. Sci. Pap.* 39(3): 793-802

Turner, S.C., V.R. Restrepo, and A.M. Eklund. 1991. A review of the growth of Atlantic bluefin tuna, *Thunnus thynnus*. *ICCAT. Col Vol. Sci. Pap.* 35(2): 271-293.

Table 1. Fork length at release and recapture, time at liberty, year of release of duplicated observations used by Turner et al. (1970).

Fork Length (cm)		Time at Liberty (years)	Year of Release
Release	Recapture		
80 *	267	15.9	*
80	262	12.0	78
102	297	14.0	76
106	292	14.0	76
71	246	10.2	77

* This fish is assumed to be Canadian tag 01171 (released in 1965 at 80 cm, recaptured 257 cm, at liberty 15.9 years).

Table 2. Estimated catch at age using the Turner et al. (1991) growth curve.

YEAR	AGE										total
	1	2	3	4	5	6	7	8	9	10+	
1970	64869	105064	127518	20998	4062	979	182	115	542	3777	328106
1971	62998	153364	38359	46021	704	1595	2000	1480	1146	6022	313689
1972	45402	98577	33762	3554	4031	117	514	601	263	5549	192370
1973	5102	74304	30485	7115	2010	1594	825	1625	586	4489	128135
1974	55958	19846	21291	6487	3137	712	919	879	1076	12580	122885
1975	43556	148026	8329	11850	899	569	311	565	1680	9568	225353
1976	5412	19643	72511	2754	3035	372	187	1166	514	14109	119703
1977	1273	22395	9481	32093	5171	3560	1080	483	1089	13615	90240
1978	5133	10848	19831	6409	10424	4213	655	509	314	12030	70366
1979	2745	10537	16179	14993	3415	3407	2715	633	521	12351	67496
1980	3160	16160	10855	8881	3033	2869	5306	3790	1022	12323	67399
1981	6087	9606	16550	4962	6194	3602	2833	3332	2676	10867	66709
1982	3528	3710	1648	519	336	730	484	482	823	3171	15431
1983	4173	2438	3253	909	816	912	1388	1310	1012	5761	21972
1984	868	7495	1855	1989	2110	1709	585	719	1014	4715	23059
1985	568	5510	12311	2714	4216	4173	1014	656	661	5652	37475
1986	563	5895	7176	3383	1162	1669	994	518	334	5370	27064
1987	1513	13268	9104	5508	4334	2421	1421	1341	1053	3908	43871
1988	4850	8995	11843	3814	4182	4138	2408	1592	1553	4709	48084
1989	786	12864	1675	3624	1841	2017	2644	1861	1429	5509	34250
1990	2363	4216	17917	1844	2712	1915	1538	2303	1605	4319	40732

Table 3. Relative and absolute differences in estimated catches at age estimated using the growth curve estimated by Turner et al. (1991) and the curve from this paper. Relative differences are relative to the catch at age estimated from the Turner et al (1991).

year	age										total
	1	2	3	4	5	6	7	8	9	10+	
1970	0.0000 0	0.0000 0	0.0000 8	-0.0218 -457	0.0803 326	0.1216 119	0.0659 12	-0.5826 -67	-0.0129 -7	0.0199 75	1
1971	0.0000 0	0.0000 0	0.0000 -1	-0.0012 -53	-0.0241 -17	-0.0614 -98	-0.0445 -89	0.0959 142	-0.0079 -9	0.0206 124	-1
1972	0.0000 0	-0.0001 -9	0.0001 2	-0.0476 -169	0.0422 170	0.0342 4	-0.1167 -60	0.0399 24	-0.1065 -28	0.0119 66	0
1973	0.0000 0	-0.0001 -8	-0.0008 -24	-0.0048 -34	-0.0905 -182	0.1336 213	-0.1576 -130	0.0363 59	0.0768 45	0.0138 62	1
1974	-0.0004 -25	-0.0093 -185	0.0084 179	-0.0003 -2	-0.0175 -55	0.0253 18	0.0305 28	-0.0330 -29	-0.0279 -30	0.0081 102	1
1975	0.0000 0	-0.0001 -14	-0.0652 -543	0.0374 443	0.0578 52	0.0844 48	-0.0193 -6	-0.1912 -108	0.0143 24	0.0109 104	0
1976	-0.0011 -6	-0.0067 -132	0.0011 88	-0.0454 -125	0.0428 130	0.0995 37	-0.0802 -15	-0.0017 -2	-0.1128 -58	0.0065 92	1
1977	-0.0149 -19	-0.0008 -17	-0.0457 -433	-0.0021 -66	0.0851 440	-0.0222 -79	0.1306 141	-0.0787 -38	-0.0964 -105	0.0129 176	0
1978	-0.0146 -75	-0.0037 -40	-0.0077 -152	-0.0339 -217	0.0043 45	0.0885 373	0.0076 5	0.0629 32	-0.0987 -31	0.0050 60	0
1979	0.0000 0	-0.0129 -136	-0.0012 -20	-0.0374 -560	0.1751 598	-0.0326 -111	0.0556 151	0.0553 35	-0.0653 -34	0.0062 76	-1
1980	-0.0016 -5	-0.0011 -18	-0.0431 -468	0.0097 86	0.0887 269	-0.0356 -102	-0.0388 -206	0.0913 346	-0.0372 -38	0.0110 135	-1
1981	-0.0010 -6	-0.0034 -33	0.0025 38	-0.1046 -519	0.0581 360	-0.0297 -107	-0.0092 -26	0.0267 89	-0.0430 -115	0.0293 318	-1
1982	-0.0048 -17	-0.0129 -48	0.0146 24	0.0578 30	-0.0685 -23	-0.0055 -4	0.0227 11	-0.0871 -42	-0.0960 -79	0.0464 147	-1
1983	0.0000 0	-0.0103 -25	-0.0058 -19	0.0132 12	-0.0221 -18	-0.0055 -5	-0.0072 -10	-0.0420 -55	-0.0227 -23	0.0246 142	-1
1984	-0.0426 -37	0.0021 16	0.0086 16	-0.0508 -101	0.0156 33	0.0234 40	0.0171 10	-0.1001 -72	-0.1085 -110	0.0437 206	1
1985	0.0000 0	-0.0160 -88	0.0031 38	-0.0324 -88	-0.0209 -88	0.0304 127	0.0148 15	0.0549 36	-0.1059 -70	0.0209 118	0
1986	0.0000 0	-0.0758 -447	0.0605 434	-0.0254 -86	0.0275 32	-0.0258 -43	0.0734 73	-0.0019 -1	0.0030 1	0.0069 37	0
1987	0.0000 0	-0.0121 -160	0.0057 52	-0.0015 -8	-0.0261 -113	0.0764 185	-0.1006 -143	0.0626 84	-0.0038 -4	0.0274 107	0
1988	0.0000 0	-0.0295 -265	0.0172 204	-0.0336 -128	-0.0368 -154	0.0101 42	0.0963 232	-0.0352 -56	-0.0670 -104	0.0484 228	-1
1989	-0.0025 -2	-0.0013 -17	0.0084 14	-0.0480 -174	0.0505 93	-0.0377 -76	0.0091 24	0.0043 8	-0.0812 -116	0.0448 247	1
1990	-0.0042 -10	-0.0050 -21	0.0083 6	-0.0553 -102	-0.0077 -21	0.0611 117	-0.0540 -83	-0.0491 -113	0.0461 74	0.0352 152	-1

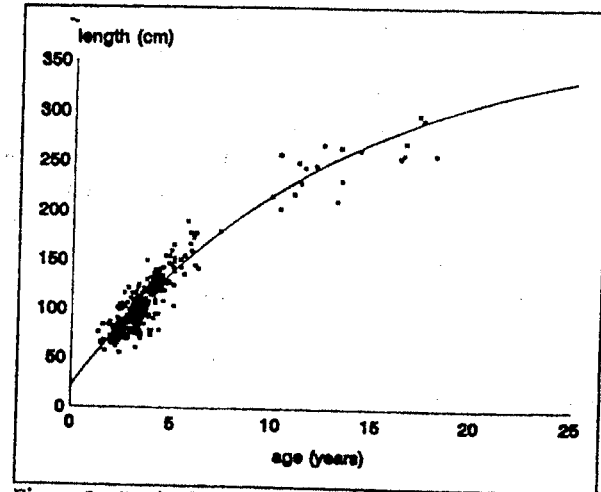


Figure 1. Revised estimate of west Atlantic bluefin tuna growth with the raw data shown under the assumption that age at release was exactly as estimated from the model and the size at release.

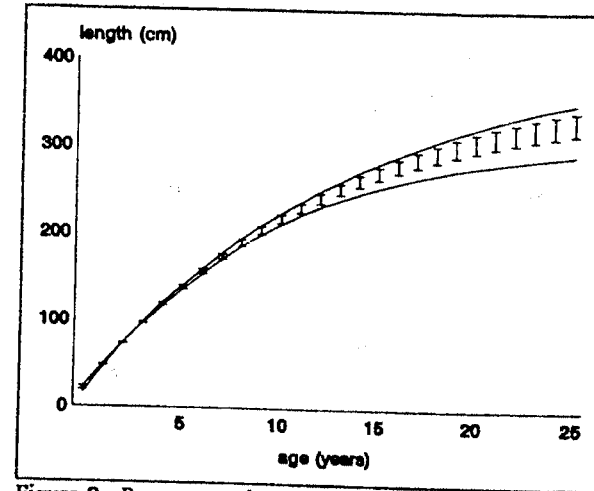


Figure 2. Bootstrapped 95% confidence intervals about estimated growth curves for west Atlantic bluefin tuna from Turner et al. (1991, error bars) and this paper (lines).