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SENSIVITY OF PROJECTIONS OF WEST ATLANTIC BLUEFIN STOCK SIZE TO CATCHES IN THE CENTRAL ATLANTIC REGION AND TO RETROSPECTIVE PATTERNS IN HISTORICAL STOCK SIZE ESTIMATES

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SUMMARY

The sensitivity of projected west Atlantic bluefin spawning stock sizes to alternative initial conditions and future yields were examined. The inclusion of information from the Japanese longline fishery in the central north Atlantic resulted in projections of SSB below the September working group's base case projections, while adjustment for retrospective patterns resulted in projected SSB higher than the base case. None of the sensitivity treatments resulted in estimates markedly different from the base case relative to levels of SSB in the mid-1970's nor relative to the working group's estimates of MSY.

RESUME

La sensibilité de l'ampleur du stock reproducteur du thon rouge de l'Atlantique ouest projetée aux conditions alternatives de départ et aux rendements futurs a été examinée. L'incorporation de l'information provenant de la pêcherie palangrière japonaise de l'Atlantique nord central a donné des projections de SSB en-dessous des projections du cas de base du groupe de travail de septembre alors que l'ajustement pour les schémas rétrospectifs ont donné des SSB projetés plus élevés que le cas de base. Aucun des traitements de sensibilité n'a donné d'estimations très différentes du cas de base relatif aux niveaux de SSB dans le milieu des années soixante-dix et ni relatif aux estimations de la PME des groupes de travail.

RESUMEN

Se examinaron la sensibilidad de los tamaños de stock reproductores previstos para el atún rojo del Atlántico oeste frente a condiciones iniciales alternativas, y los rendimientos futuros. La inclusión de información de la pesquería de palangre de Japón en el Atlántico norte central se tradujo en previsiones de SSB por debajo de las previsiones del caso base del grupo de trabajo de septiembre, mientras que el ajuste de esquemas retrospectivos se tradujo en previsiones de SSB superiores al caso base. Ninguno de los tratamientos de sensibilidad se tradujo en estimaciones marcadamente diferentes del caso base relativo a los niveles de SSB a mediados de los años 70 ni relativos a las estimaciones de RMS de los grupos de trabajo.

Introduction

At its meeting in Madrid from 24 September through 2 October 1993, the bluefin tuna working group examined the status of the stock using a wide variety of population models and considered different options with respect to stock structure as well as the boundary between the hypothesized east and west stocks. The working group used virtual population analysis (VPA) and non-equilibrium production models to provide advice to the Commission on the effects of future catch levels. The purpose of this paper is to examine the sensitivity of the projected stock sizes from VPA to alternative assumptions about the west Atlantic stock.

The working group used non-equilibrium production model analyses to examine the effects of an alternative boundary between east and west Atlantic stocks, because of concern about recent relatively large catches by Japanese longliners in the central North Atlantic. Historical yields from that fishery were added to the SCRS's west Atlantic yield and the analyses were rerun using the same index of abundance as in the west only analysis. The working group reported that there was little change in estimates of MSY and 1992 replacement yield between the base case and alternative boundary analyses.

In this paper we investigate the sensitivity of the VPA projections to the addition of recent catches by the Japanese longline fishery in the central North Atlantic area to the west Atlantic catch under several future catch scenarios.

The working group also examined the base case west Atlantic VPA for retrospective patterns in estimates of abundance of various age groups. Those analyses showed inconsistent patterns for the more recent estimates; as the model was applied to fewer and fewer years of data (ie as the model used fewer and fewer observations for fitting), some of the estimates for an age range in a year were higher than the base case estimate for that age range and some were lower. In general the retrospective analysis showed a convergence in the estimates of abundance of older ages to larger stock sizes with more years included in the analysis. There is generally a high degree of uncertainty about estimates of abundance in the terminal years of a VPA, and it is not clear that the retrospective estimates would be statistically different. The reason for retrospective patterns is unclear, though misaging, misreporting, catchability changes, and mis-specification of M could be possible sources (ICES 1991). Also it should be noted that retrospective patterns do not provide insight into the degree or direction of departure from the true status of the stock; therefore it is not clear whether VPA estimates or such estimates adjusted for retrospective pattern are closer to the true abundance. Retrospective patterns are a symptom indicative of inconsistencies in the analysis (ICES 1991).

In this paper we also investigate the effects of the estimated retrospective patterns on projected spawning stock size under various future catch scenarios and we compare them, as sensitivity tests, to the base case projections.

Methods

VPA Including Japanese Central North Atlantic Catches

Miyabe (SCRS/93/49) described the Japanese central North Atlantic longline fishery as extending from 35°W to 50°W. The catch at age from that fishery and east of the hypothesized stock boundary (30-55°N 30-45°W) was calculated from the historical yield developed by the working group (Table 1). That catch at age was restricted to 1987-1992 to characterize the recently developed fishery. The size and age composition of that catch was assumed to be the same as that of the entire Japanese longline fishery. The estimated catch at age was added to the base case catch at age.

A figure of nominal catch rates from that fishery in last quarter of 1985-1992 was presented by Miyabe (SCRS/93/49), and approximate values were used as an additional index of abundance in tuning the VPA which included the central North Atlantic catch at age (Table 2). Only 1987-1992 catch rates were used in the VPA, because only 1987-1992 catches from that fishery were incorporated in the VPA. The catch rates were calculated as simple averages of the last quarter of a year and the first quarter of the next. In the VPA those catch rates were considered representative of all ages in the Japanese longline age composition, which was dominated by ages 6-7 in those years.

Retrospective Pattern Adjustment

The matrix of stock size estimates from the retrospective analysis by the working group was used to calculate possible retrospective pattern ratios of estimated stock sizes for a year class at age from analyses with n years of data and n-1 years of data so that estimates of adjustments for the base case VPA could be estimated (Table 3). To evaluate the sensitivity of the base case projections to the effects indicated by the retrospective analysis, the mean retrospective pattern ratios for each age were used to estimate alternative stock size estimates which were used in projections as described below. Uncertainty about the estimated retrospective pattern ratios was incorporated in the estimates of uncertainty about estimates of stock size used for the projections. The CV of the adjusted stock size estimate was estimated assuming that CV of the VPA estimate of stock size and the CV of the mean retrospective pattern ratios were independent, so that could simply be summed such that the adjusted CV was

$$CV_{Adj} = SQRT\ (\ CV_N^2 + CV_R^2\ ),$$

where CV_{Adj} is the coefficient of variation for the adjusted stock sizes, SQRT is the square root operator, CV_N is the coefficient of variation of the unadjusted stock size estimates, and CV_R is the coefficient of variation of the mean retrospective pattern ratio.

Projections

The general procedure used to project stock size was similar for both the analysis based on the VPA which included the Japanese central North Atlantic information and the estimates of terminal stock size adjusted for retrospective patterns. The procedures to obtain initial stock sizes differed from those used by the working group in September 1993 for the base case projections; therefore the base case projection was recalculated using the alternative procedure for comparison.

The 1992 abundance at age was assumed to be lognormally distributed with mean and variance equal to the corresponding age-specific estimates from the VPA. (The VPA estimates of variance were obtained using the delta method.) The initial (1992) abundances for each of five hundred independent projections were determined by drawing at random from the age-specific lognormal distributions. As the working group did in September 1993, future abundances were calculated from the catch equation assuming a natural mortality rate of 0.14 and a fully-selected fishing mortality rate that was either sufficient to achieve the total allowable catch or ten times the natural mortality rate. The age-specific selectivities were calculated from the geometric mean of the VPA estimates of F at age in 1989-1991 and multiplied by 0 for age 1, 0.28 for ages 2 and 3, and 1.0 for ages 3 and up. The modification factors (0 and 0.28 for ages 1-3) assume that the regulations implemented in 1992 reduce the catch by the percentage specified by the Commission. These procedures were used for the alternative calculations for the base case and for the projections derived from the VPA including the information form the Japanese longline central Atlantic fishery.

The retrospective analysis differed from the other projections in the treatment of initial stock sizes and in the calculation of selectivity pattern. Both the 1992 and 1993 abundance at age vectors were determined by retrospective adjustments of the base case VPA (except 1993 recruits, which were obtained from the stock-recruitment curve). The same random drawing procedure described above for the 1992 abundance at age was applied to the 1993 abundance at age. The 1992 data were treated randomly, as opposed to just the 1993 data, so that the sensitivity of 1992 estimate of spawning stock biomass (midyear) to the retrospective pattern adjustment could be examined. The projected selectivity pattern was calculated from the mean of the 1989-1991 base case selectivities, rather than geometric mean of the base case F's, because the adjusted F's would have been different from the base case F's and were not available. For those calculations the annual selectivities were rescaled to their means, then averaged and then multiplied by the modification factors given above.

The future recruits, from 1993 on, were computed from a stock-recruitment curve fitted to the VPA. Variability was included in the recruitment process by drawing from the lognormal distribution generated from the expected recruitment and the residual mean-square error. The stock-recruitment curve for the projections based on the VPA including the Japanese central North Atlantic fishery was obtained by fitting the Beverton and Holt formula to the abundance data. The curve used for the retrospective analysis was obtained by fitting Beverton and Holt's formula to the base case VPA from the bluefin tuna working group. Spawning stock biomass (SSB) was computed from the abundances of ages 8 to 10+ multiplied by the age-specific weights used in the base VPA. The fitting procedure is described in Restrepo et al. (SCRS/93/72).

Results

The effect of using the delta distribution estimates of variance in terminal stock size had little impact on the projected spawning stock biomass (SSB) compared to the projected SSB derived from the 500 bootstrapped VPA's (Figure 1).

The estimated catch at age for the analysis including the Japanese longline central North Atlantic catch is shown in Table 3 and the estimated abundances and F's are shown in Tables 4 and 5.

The sensitivity of the base case projected SSB at a catch limit of 2394 mt in 1993 and 1200 MT thereafter to the inclusion of the information from the Japanese longline central North Atlantic fishery is shown in Figure 2; for that analysis it was assumed that all west Atlantic and Japanese central North Atlantic catches were restricted to 1200 mt. The projected SSB was lower than in the west Atlantic base case. Three additional alternative projected catch scenarios were investigated; one restricted total catches (west Atlantic and Japanese central North Atlantic) to 1995 MT starting in 1994, another assumed that west Atlantic catches after 1993 were restricted to 1200 MT while the Japanese central North Atlantic fishery continued at its 1990-1992 mean (1040 MT) for a total catch of 2240 MT, and another assumed catches after 1993 of 1995 MT from the west Atlantic while the Japanese fishery continued at 1040 MT in the central North Atlantic for a total of 3035 MT. All three indicated sharp declines in SSB after 1995 (Figure 3).

The mean ratios, calculated from the estimated stock sizes at age in Table 3, and their CV's are shown in Table 4. The mean ratios at each age all exceeded 1.00; larger ratios were observed for the younger ages, but they also had much higher CV's. The variability in these estimates is such that few, if any, would be considered significantly different from 1.0. This method does not take into account time trends in these ratios which can be seen in the plots of retrospective stock trajectories in the draft report, where estimates from retrospective VPA's with more years of data are closer to the base case than estimates from VPAs with fewer years of data. As a result the averages in Table 4 are larger than one would obtain with just 2-3 years of retrospective information. The estimated CV's of the base case stock sizes at age (calculated with the delta method), are shown in Table 5; also shown are the stock sizes at age and the associated CV's after the adjustment for retrospective pattern.

The projected SSB derived from the stock sizes adjusted for retrospective pattern are shown for two future catch scenarios in Figure 4. At catches of 1200 MT after 1993, median SSB was projected to be higher than for the base case, but with a catch of 1500 MT in those years the median projected SSB eventually declined to the base case level.

These analyses indicate that there is some sensitivity of the base case projections of SSB to alternative assumptions about the boundary line between the east and west stocks and about the estimated abundance in 1993 as calculated through one approach to adjustment for possible retrospective patterns. However, the amount of change in SSB indicated by these sensitivity analyses is small relative to the historical levels of SSB and small relative to the SSB that which would produce MSY and well within the confidence intervals as estimated by the working group.

In conducting these analyses we are simply examining the effects of alternative assumptions; in no way do we consider these assumptions more reasonable than those made by the working group.

Literature Cited

International Council for the Exploration of the Sea (ICES). 1991. Report of the working group on methods of fish stock assessments. C.M. 1991/Assess:25. St. John's, Newfoundland, Canada, June 1991.

Table 1. Japanese longline yield from the central North Atlantic (50-50°N, 30-45°W) in 1987-1992 from the working group meeting in September 1993; only 1987-1992 were used for VPA analyses including catches from that region.

Year	Yield (kg)
1987	16,464
1988	24,528
1989	124,268
1990	660,527
1991	1,389,625
1992	1,068,700

Table 2. Approximate nominal catch rates from the Japanese longline fishery in the central North Atlantic used in tuning the VPA which included catches from that area.

Year	Index
1987	0.30
1988	0.65
1989	0.65
1990	0.95
1991	1.00
1992	1.50

Table 3. Retrospective estimates of stock size at age calculated by the working group in September 1993.

N at Age 1

	89	90	91	92	93
T=Catch through 88	0	0	0	0	0
T=Catch through 89	23510	0	0	0	0
T=Catch through 90	17116	36227	0	0	0
T=Catch through 91	76315	96428	91367	0	0
T=Catch through 92	40248	42314	69204	20283	0

N at Age 2

	89	90	91	92	93
T=Catch through 88	53180	0	0	0	0
T=Catch through 89	78162	19706	0	0	0
T=Catch through 90	75055	14147	29290	0	0
T=Catch through 91	73366	65612	81625	76332	0
T=Catch through 92	78114	34257	34582	57065	17242

N at Age 3

	89	90	91	92	93
T=Catch through 88	15680	0	0	0	0
T=Catch through 89	8936	55980	0	0	0
T=Catch through 90	18222	53280	8369	0	0
T=Catch through 91	25394	51813	53095	57456	0
T=Catch through 92	21590	55938	25840	16617	44042

N at Age 4

	89	90	91	92	93
T=Catch through 88	16777	0	0	0	0
T=Catch through 89	33236	6209	0	0	0
T=Catch through 90	27252	14280	29678	0	0
T=Catch through 91	26917	20515	28406	36162	0
T=Catch through 92	49769	17208	31984	12507	12589

N at Age 5

	89	90	91	92	93
T=Catch through 88	8725	0	0	0	0
T=Catch through 89	14928	25344	0	0	0
T=Catch through 90	12667	20143	10605	0	0
T=Catch through 91	25162	19853	16024	21974	0
T=Catch through 92	15681	39715	13150	25084	10211

N at Age 6

	89	90	91	92	93
T=Catch through 88	9190	0	0	0	0
T=Catch through 89	7308	11384	0	0	0
T=Catch through 90	11918	9419	14959	0	0
T=Catch through 91	12591	20279	14706	12395	0
T=Catch through 92	12279	12038	31972	9897	20479

N at Age 7

	89	90	91	92	93
T=Catch through 88	8016	0	0	0	0
T=Catch through 89	9397	4422	0	0	0
T=Catch through 90	10614	8426	6496	0	0
T=Catch through 91	13285	9011	15935	10771	0
T=Catch through 92	13689	8740	8773	25779	7919

N at Age 8

	89	90	91	92	93
T=Catch through 88	4288	0	0	0	0
T=Catch through 89	4954	5686	0	0	0
T=Catch through 90	6483	6743	5811	0	0
T=Catch through 91	8369	9063	6320	11671	0
T=Catch through 92	8626	9413	6084	5448	20627

N at Age 9

	89	90	91	92	93
T=Catch through 88	2752	0	0	0	0
T=Catch through 89	3546	2579	0	0	0
T=Catch through 90	4197	3905	3651	0	0
T=Catch through 91	5378	5543	5664	3690	0
T=Catch through 92	5539	5766	5969	3485	3003

N at Age 10

	89	90	91	92	93
T=Catch through 88	10385	0	0	0	0
T=Catch through 89	14851	9576	0	0	0
T=Catch through 90	17703	12615	8945	0	0
T=Catch through 91	22866	18122	15147	12150	0
T=Catch through 92	23566	18870	15989	13145	9166

Table 4. Ratios of age-specific stock sizes estimated in successive years of the retrospective analysis, the mean ratios at age and the coefficients of variation about those rations (CV_R). Rows of ratios are labeled as to the stock sizes (N) by year and the terminal year (T_{year}) used in each analysis.

	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10+
$N_{89,T89}/N_{89,T88}$	-	1.470	0.570	1.981	1.711	0.795	1.172	1.155	1.289	1.430
$N_{89,T90}/N_{89,T89}$	0.728	0.960	2.039	0.820	0.849	1.631	1.130	1.309	1.184	1.192
$N_{89,T91}/N_{89,T90}$	4.459	0.978	1.394	0.988	1.986	1.056	1.252	1.291	1.281	1.292
$N_{89,T92}/N_{89,T91}$	0.527	1.065	0.850	1.849	0.623	0.975	1.030	1.031	1.030	1.031
$N_{90,T90}/N_{90,T89}$	-	0.718	0.952	2.300	0.795	0.827	1.905	1.186	1.514	1.317
$N_{90,T91}/N_{90,T90}$	2.662	4.638	0.973	1.437	0.986	2.153	1.069	1.344	1.419	1.437
$N_{90,T92}/N_{90,T91}$	0.439	0.522	1.080	0.839	2.000	0.594	0.970	1.039	1.040	1.041
$N_{91,T91}/N_{91,T90}$	-	2.787	6.344	0.957	1.511	0.983	2.453	1.088	1.551	1.693
$N_{91,T92}/N_{91,T91}$	0.757	0.424	0.487	1.126	0.821	2.174	0.551	0.963	1.054	1.056
$N_{92,T92}/N_{92,T91}$	-	0.748	0.289	0.346	1.142	0.799	2.393	0.467	0.944	1.082
Mean R	1.595	1.431	1.498	1.264	1.242	1.199	1.392	1.087	1.231	1.257
CV_R	1.021	0.917	1.184	0.484	0.417	0.481	0.457	0.233	0.175	0.174

Table 5. Base case and adjusted stock size estimates (1992, Jan 1) with associated estimates of variability (CV, coefficient of variation.

AGE	Base N	CV_N	Adj N	CV_{Adj}
1	20283	0.703	32360	1.240
2	57065	0.703	81654	1.156
3	16617	0.703	24888	1.377
4	12507	0.670	15812	0.827
5	25084	0.670	31161	0.789
6	9897	0.470	11863	0.672
7	25779	0.470	35896	0.656
8	5448	0.649	5923	0.690
9	3485	0.649	4289	0.672
10+	13145	0.649	16525	0.672

Table 6. Catch at age for west Atlantic bluefin with the catches from the Japanese central North Atlantic fishery included.

	70	71	72	73	74	75	76	77	78	79	80	81
1	64886	62999	45404	5105	55957	43556	5411	1275	5132	2745	3161	6086
2	105064	153363	98578	74310	20054	148027	19780	22420	10864	10553	16184	9615
3	127518	38360	33762	30480	21093	8328	72393	9717	20015	16288	11068	16539
4	21455	46075	3729	7162	6506	11963	2909	32140	6315	14917	8882	5244
5	3677	672	3858	2132	3170	821	2898	4947	10530	3448	2866	6023
6	914	1674	119	1451	684	546	344	3634	4061	3494	2981	3721
7	176	2109	567	953	916	317	205	958	655	2612	5532	2884
8	172	1350	576	1544	913	670	1167	513	472	599	3454	3211
9	535	1134	262	556	1081	1651	556	1111	341	558	1061	2765
10+	3725	5956	5519	4444	12505	9472	14036	13533	11980	12286	12216	10619
Totl	328122	313692	192374	128137	122879	225351	119699	90248	70365	67500	67405	66707
2-5	257714	238470	139927	114084	50823	169139	97980	69224	47724	45206	39000	37421
6-7	1090	3783	686	2404	1600	863	549	4592	4716	6106	8513	6605
8-9	707	2484	838	2100	1994	2321	1723	1624	813	1157	4515	5976
8-10+	4432	8440	6357	6544	14499	11793	15759	15157	12793	13443	16731	16595

	82	83	84	85	86	87	88	89	90	91	92
1	3528	4173	868	568	563	1512	4851	787	2368	3327	435
2	3729	2439	7504	5523	5939	13346	9157	12926	4299	14835	6021
3	1655	3268	1848	12310	7136	9164	11844	1722	18841	12082	2635
4	498	894	2073	2814	3442	5537	4008	4002	2554	5507	1562
5	342	866	2078	4329	1128	4449	4209	1912	4777	4493	3888
6	751	911	1671	4019	1726	2353	4295	2370	3042	5603	2027
7	478	1402	593	1024	931	1587	2296	2957	2567	4984	4116
8	518	1354	760	614	520	1266	1649	1984	3347	2701	3609
9	897	1040	1090	695	346	1024	1607	1526	1953	2775	1764
10+	3078	5631	4573	5605	5335	3862	4564	5533	4633	5219	5112
Totl	15474	21978	23058	37501	27066	44100	48480	35719	48381	61526	31169
2-5	6224	7467	13503	24976	17645	32496	29218	20562	30471	36917	14106
6-7	1229	2313	2264	5043	2657	3940	6591	5327	5609	10587	6143
8-9	1415	2394	1850	1309	866	2290	3256	3510	5300	5476	5373
8-10+	4493	8025	6423	6914	6201	6152	7820	9043	9933	10695	10485

Table 7. Estimated abundance at age from the analysis including the information from the Japanese central North Atlantic information.

	70	71	72	73	74	75	76	77	78	79	80	81
1	333987	259714	224551	126523	485514	142215	134062	85204	54702	76226	61787	57071
2	202205	230068	167296	153035	105240	370035	83244	111510	72885	42780	63711	50772
3	217508	78807	59095	54625	64390	72858	184669	54004	76113	53262	27395	40366
4	88393	71605	33073	20255	19383	36425	55593	93521	37918	47594	31199	13571
5	39315	56927	19879	25283	10973	10821	20577	45622	51519	27095	27545	18883
6	75050	30758	48864	13698	19996	6599	8643	15194	35059	35006	20348	21280
7	27132	64394	25181	42369	10558	16747	5229	7194	9835	26702	27182	14918
8	77278	23424	54017	21363	35947	8327	14264	4355	5363	7940	20783	18492
9	46972	67022	19107	46424	17135	30400	6615	11314	3309	4223	6345	14857
10+	175803	189704	216583	199515	209152	184077	176102	145267	122499	97908	76843	59978
2-5	547421	437408	279344	253199	199986	490138	344082	304656	238435	170732	149850	123592
6-7	102182	95152	74045	56067	30555	23346	13872	22387	44894	61708	47530	36198
8-9	124249	90445	73124	67787	53082	38727	20879	15669	8671	12163	27128	33349
8-10+	300053	280149	289708	267302	262234	222804	196981	160936	131170	110071	103971	93327

Table 4 continued.

	82	83	84	85	86	87	88	89	90	91	92	93
1	54023	94919	66723	75030	114231	50526	114284	43264	46812	62914	18777	0
2	43954	43681	78633	57198	64699	98783	42517	94837	36879	38492	51597	15919
3	35205	34741	35704	61378	44587	50720	73467	28458	70427	28062	19727	39256
4	19786	29065	27162	29319	41923	32128	35578	52859	23137	43742	13220	14699
5	6943	16737	24435	21684	22871	33243	22785	27201	42229	17738	32905	10040
6	10832	5717	13744	19309	14829	18833	24763	15897	21868	32268	11251	24990
7	15042	8718	4124	10395	13053	11286	14184	17536	11616	16183	22845	7897
8	10290	12631	6276	3033	8084	10481	8336	10196	12496	7715	9447	16036
9	13092	8463	9722	4749	2067	6544	7934	5715	7021	7758	4204	4870
10+	52621	53427	47599	44563	37011	28690	26087	23843	19142	16632	13794	9279
2-5	105887	124224	165934	169579	174079	214874	174347	203355	172672	128035	17449	79913
6-7	25874	14435	17868	29704	27882	30119	38946	33433	33485	48451	34096	32887
8-9	23381	21095	15997	7782	10151	17025	16271	15912	19518	15473	13651	20906
8-10+	76002	74522	63596	52345	47161	45715	42358	39754	38660	32105	27444	30186

Table 8. Estimated fishing mortality rate at age from the analysis including the information from the Japanese central North Atlantic information.

	70	71	72	73	74	75	76	77	78	79	80	81
1	0.2327	0.2998	0.2434	0.0442	0.1316	0.3956	0.0442	0.0162	0.1058	0.0393	0.0563	0.1212
2	0.8023	1.2192	0.9793	0.7257	0.2277	0.5550	0.2927	0.2419	0.1737	0.3057	0.3164	0.2262
3	0.9711	0.7283	0.9308	0.8961	0.4297	0.1305	0.5404	0.2136	0.3295	0.3948	0.5624	0.5730
4	0.3000	1.1415	0.1286	0.4730	0.4429	0.4311	0.0577	0.4562	0.1961	0.4069	0.3621	0.5303
5	0.1055	0.0127	0.2324	0.0946	0.3686	0.0847	0.1633	0.1233	0.2464	0.1463	0.1180	0.4158
6	0.0131	0.0601	0.0026	0.1203	0.0373	0.0927	0.0436	0.2950	0.1323	0.1130	0.1704	0.2069
7	0.0070	0.0357	0.0244	0.0244	0.0975	0.0205	0.0429	0.1537	0.0740	0.1106	0.2452	0.2314
8	0.0024	0.0637	0.0115	0.0805	0.0276	0.0901	0.0917	0.1347	0.0989	0.0842	0.1956	0.2054
9	0.0123	0.0183	0.0148	0.0129	0.0699	0.0599	0.0943	0.1110	0.1169	0.1524	0.1970	0.2218
10+	0.0230	0.0342	0.0277	0.0242	0.0662	0.0567	0.0892	0.1050	0.1106	0.1442	0.1863	0.2098
2-5	0.6925	0.8600	0.7575	0.6515	0.3164	0.4582	0.3617	0.2778	0.2406	0.3321	0.3253	0.3897
6-7	0.0115	0.0435	0.0100	0.0470	0.0577	0.0404	0.0433	0.2473	0.1192	0.1119	0.2125	0.2170
8-9	0.0061	0.0299	0.0124	0.0337	0.0411	0.0663	0.0925	0.1176	0.1057	0.1074	0.1959	0.2126
8-10+	0.0160	0.0328	0.0238	0.0266	0.0610	0.0584	0.0895	0.1063	0.1102	0.1400	0.1888	0.2108
F10+/F9	1.8700	1.8700	1.8700	1.8700	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460	0.9460

	82	83	84	85	86	87	88	89	90	91	92
1	0.0725	0.0482	0.0140	0.0081	0.0053	0.0326	0.0465	0.0197	0.0557	0.0583	0.0251
2	0.0952	0.0617	0.1077	0.1091	0.1034	0.1561	0.2615	0.1576	0.1332	0.5285	0.1334
3	0.0517	0.1061	0.0570	0.2412	0.1877	0.2146	0.1892	0.0670	0.3363	0.6127	0.1542
4	0.0273	0.0335	0.0852	0.1084	0.0920	0.2036	0.1285	0.0845	0.1257	0.1447	0.1352
5	0.0542	0.0570	0.0954	0.2400	0.0543	0.1545	0.2200	0.0782	0.1290	0.3153	0.1352
6	0.0771	0.1868	0.1393	0.2515	0.1330	0.1435	0.2051	0.1737	0.1611	0.2053	0.2139
7	0.0346	0.1887	0.1670	0.1114	0.0794	0.1630	0.1901	0.1988	0.2693	0.3983	0.2139
8	0.0554	0.1218	0.1388	0.2437	0.0714	0.1384	0.2375	0.2331	0.3367	0.4671	0.5225
9	0.0762	0.1410	0.1278	0.1702	0.1972	0.1831	0.2439	0.3355	0.3522	0.4800	0.5916
10+	0.0647	0.1197	0.1085	0.1445	0.1674	0.1555	0.2071	0.2848	0.2990	0.4075	0.5023
2-5	0.0650	0.0665	0.0911	0.1713	0.1148	0.1764	0.1974	0.1145	0.2089	0.3672	0.1375
6-7	0.0522	0.1879	0.1457	0.2002	0.1076	0.1508	0.1996	0.1868	0.1973	0.2657	0.2139
8-9	0.0670	0.1295	0.1321	0.1982	0.0957	0.1553	0.2406	0.2687	0.3423	0.4735	0.5433
8-10+	0.0654	0.1224	0.1144	0.1523	0.1516	0.1554	0.2198	0.2784	0.3206	0.4388	0.5224
F10+/F9	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490	0.8490

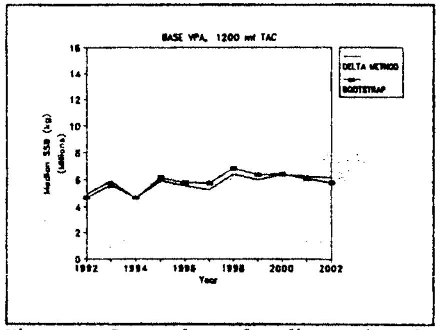

Figure 1. Comparison of median projected SSB calculated from 1992 stock sizes estimated from bootstrapped VPAs and from estimates assuming the base case mean with variance calculated by the delta method.

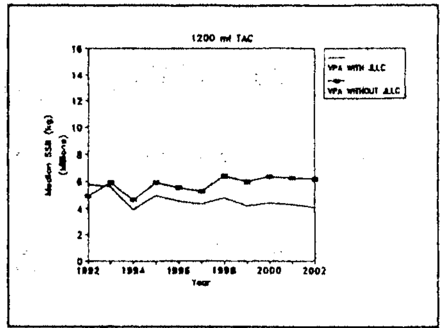

Figure 2. Projected SSB from the west Atlantic base case VPA and the VPA including Japanese longline central North Atlantic information assuming catches of 2394 MT in 1993 and 1200 MT thereafter from the entire area.

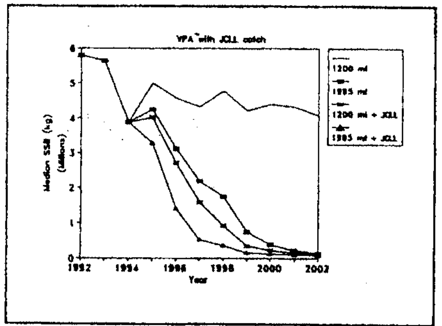

Figure 3. Projected SSB based on the VPA including the Japanese longline central North Atlantic information with assumed catches of 2394 MT in 1993 followed by 1200 MT, 1995 MT, 2240 (1200+JCLL), and 3035 MT (1995+JCLL).

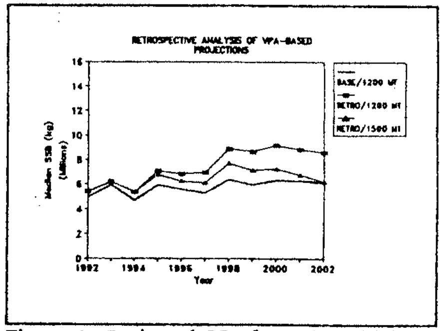

Figure 4. Projected SSB from the initial stock sizes from the base case VPA and from initial stock sizes adjusted for retrospective patterns.