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INTRODUCTION

SUMMARY

The assessment of north Atlantic swordfish was carried out by the 1991 ICCAT SCRS using the ADAPT procedures (Anon., 1992). Sensitivity analysis and retrospective analysis were also conducted to evaluate the reliability of this assessment. The particular concern that has arisen from the retrospective analysis is that there is a tendency to underestimate F 's on younger fish (ages 1-3) and to overestimate F 's on ages 4-5+ fish in the current year relative to the F levels that become apparent after additional years are added to the time series (Anon., 1992). The reasons for this retrospective pattern were not clear. In this paper, which focuses on ages 5+, this retrospective pattern is reviewed and possible causes of and solutions for this pattern are discussed.

RESUME

Les résultats des analyses rétrospectives obtenus en 1991 lors de la réunion du SCRS de l'ICCAT sur l'évaluation de l'espadon indiquaient qu'il existait une tendance à sous-estimer les tailles de la population des âges 5+ de l'année en cours. Ce document examine à nouveau cette rétrospective et en discute les causes. Les résultats indiquent une spécification erronée à certains égards: par exemple, les indices de CPUE ne sont pas liés à l'abondance telle que postulée, ou bien les données de prise par âge sont erronées.

RESUMEN

Los resultados de los análisis retrospectivos llevados a cabo sobre la evaluación de pez espada durante el SCRS de ICCAT en 1991, indicaban que había una tendencia a subestimar la talla de las edades 5+ de la población en el año en curso. Este documento vuelve a examinar esta pauta retrospectiva y discute sus causas. Los resultados indican una especificación errónea del modelo en algunos aspectos: por ejemplo, los índices de CPUE no están relacionados con la abundancia, como se asume, o los datos de captura por clases de edad están equivocados.

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In this paper, focusing on ages 5+, I reexamine this retrospective pattern and discuss the possible causes and solutions of this pattern.

MATERIALS AND METHODS

The data used in this paper such as catch-at-age data and eleven CPUE indices and the other input values required for ADAPT are the same as the data and values used in SCRS Swordfish Assessment Group (Anon., 1992).

Although the method used in this paper is essentially the same as the method used in SCRS Swordfish Assessment Group (Anon., 1992), only weighting of CPUE indices is changed. Equal weight is used instead of iterative reweighting, because reweighting procedure may converge to a local minimum (Butterworth and Punt, 1992), and equal weighting reveals the retrospective pattern more clearly. Details of method used in this paper are shown in Appendix.

Retrospective analysis is the process of stepping back through the years of available data and conducting VPA tuning at each step, ignoring all data in the subsequent year. This exercise was carried out until 1986.

For comparative purposes, a VPA was also run using only the CPUE indices for the period of 1987-1990.

In the present SCRS swordfish assessment, CPUE indices are assumed to be linearly related to the population size. In this paper, an alternative assumption that CPUE indices are related to the population size through a power function (Parrack, 1986), which is used in the assessment of southern

bluefin tuna (Ishizuka and Tsuji,1991), is also applied. This nonlinear relation is given by

$$CPUE = q N^b \quad (1)$$

where CPUE is CPUE index, N is the population size, q is the catchability coefficient, and b is the parameter to be estimated.

RESULTS AND DISCUSSION

The results of retrospective analysis, the base case (equal weight, using 1978-1990 data), two alternative assumptions (using 1987-1990 data and nonlinear model), and the 1991 ICCAT base case assessment (iterative reweighting) are shown in Table 1 for the period of 1986 onward. Fig.1 shows the population estimates of ages 5+ obtained from these eight analyses.

The population estimates of ages 5+ of base case in this paper are less than that of ICCAT base case. The reason for this difference is that in the ICCAT assessment, there was little weight on US4 (CPUE index of U.S.A. age 4), US5+ (CPUE index of U.S.A. ages 5+), and JLL5+ (CPUE index of Japan ages 5+). It should be noted that there are the strong declining trends of the US4, US5+, and JLL5+ indices in the early 1980's and declining trends of the ES4 (CPUE index of Spain age 4) and ES5+ (CPUE index of Spain ages 5+) indices in the middle of 1980's.

The results of retrospective analysis show that there is a tendency to underestimate population sizes of ages 5+ in the current year (Fig.1). Since actual catch in number at ages 5+ in the year 1987, 1988, 1989, and 1990 are 78195, 63585, 57868, and 52414, respectively, the estimates of population sizes in the current year of retrospective VPA's are less than or equal to the actual catches, and hence they are strongly underestimated.

Fig.1 also indicates that there is a distinctive difference in the population estimates between using 1978-1986 data and 1987-1990 data.

This dichotomy and underestimation would seem to indicate model misspecification in some respects: for example, the CPUE indices are not related to abundance as assumed, or the catch-at-age data are in error. The causes of these problems seem to be that the declining trends of the CPUE indices of ages 4-5+ in early 1980's are not consistent with actual changes of population sizes (at least population sizes estimated from catch data).

The parameter b in nonlinear model (equation (1)) is estimated to be 1.853. This indicates that the CPUE indices are not linearly related to abundance as assumed. It should be pointed out that the estimate of b is similar to that of southern bluefin tuna (b=1.6892; Ishizuka and Tsuji,1991). The result is consistent with above interpretation, but it is not conclusive.

Until a more definitive study is completed, it will be difficult to resolve this problem. Tentative approaches suggested at this stage are as follows:

1) Introduction of nonlinear relationship between CPUE and population size: Judging of introduction of parameter b can be done by the likelihood ratio test or using AIC (Akaike Information Criterion).

2) Iterative reweighting:

The retrospective pattern of the 1991 SCRS assessment where iterative reweighting was applied is not stronger than that of this analysis (Anon.,1992). The reason is that there was little weight on US4, US5+, and JLL5+ in retrospective VPA runs of ICCAT assessment. Hence, if iterative reweighting procedure performs well, it could correct this retrospective pattern to some extent.

3) Using CPUE indices only on and after 1987:

Since CPUE indices until 1986 are ignored, this is an extreme assumption. If CPUE indices before 1987 are unreliable, however, this might be the best way. At least, this analysis should be done for the sensitivity test.

REFERENCES

- Anonymous. 1992. Reference Paper on 1991 Swordfish Stock Assessments by SCRS Swordfish Assessment Group. ICCAT Coll. Vol. Sci. Pap., 39(2):397-476.
- Butterworth, D.S. and A.E. Punt. 1992. A Review of Some Aspects of the Assessment of the Western North Atlantic Bluefin Tuna. ICCAT Coll. Vol. Sci. Pap., 39(3):731-757.
- Hiramatsu, K. 1992. Possible Biases in the VPA Estimates of Population Sizes of the Plus Group. ICCAT Coll. Vol. Sci. Pap., 39(2):497-502.
- Ishizuka, Y. and S. Tsuji. 1991. Assessment of the Southern Bluefin Tuna Stock. Document Submitted to the Tenth Trilateral Scientific Meeting on SBT. SBFWS/91/8, pp.20.
- Parrack, M.L. 1986. A Method of Analyzing Catches and Abundance Indices from Fishery. ICCAT Coll. Vol. Sci. Pap., 24:209-221.
- Pope, J.G. 1972. An Investigation of the Accuracy of Virtual Population Using Cohort Analysis. Res. Bull. int. Comm. Northw. Atlant. Fish., 9:65-74.
- Powers, J.E. and V.R. Restrepo. 1992. Additional Options for Age-Sequenced Analysis. ICCAT Coll. Vol. Sci. Pap., 39(2):541-553.

Table 1. Results of population size estimates. Base case, four retrospective VPA's, two alternative assumptions, and the 1991 ICCAT assessment. Only results after 1986 are listed.

Application	Year	1	2	Age 3	4	5+
Base case	1986	611673	470204	300296	175931	190314
Equal weight	1987	594871	459335	302465	168334	172844
	1988	719344	420760	270585	150673	142576
	1989	819951	511886	225464	129024	124319
	1990	498270	603699	317613	103710	103007
	1991	--	366688	389515	177179	73082
Retro.-1989	1986	558988	444122	288119	169924	183816
	1987	684672	416200	281111	158364	162607
	1988	785962	494284	235269	133190	126032
	1989	896588	566428	285660	100111	96460
	1990	--	666444	362268	152995	56525
Retro.-1988	1986	634917	395295	265295	158680	171653
	1987	787502	478366	241134	139700	143443
	1988	852078	578473	286166	100460	95061
	1989	--	620560	354589	141781	44306
Retro.-1987	1986	700712	409299	222890	137751	149013
	1987	880819	532234	252600	104959	107772
	1988	--	654875	330269	109847	37412
Retro.-1986	1986	732143	401956	210475	108098	116936
	1987	--	557968	246588	94795	57231
1987-90 data	1986	673420	500773	314568	182970	197929
	1987	694813	509889	327493	180019	184842
	1988	727612	502587	311975	171164	161966
	1989	752425	518655	292458	162912	156971
	1990	433938	548413	323155	158560	157484
1991	--	314017	344251	181716	165591	
CPUE ~ N ^b b=1.853	1986	642650	485540	307456	179462	194134
	1987	645010	484697	315021	174196	178863
	1988	702645	461811	291349	160953	152304
	1989	738929	498214	259074	146025	140700
	1990	554103	537364	306419	131228	130337
1991	--	412399	335205	168014	120987	
ICCAT SCRS Reweighting	1986	619940	472559	300263	175741	190103
	1987	611898	466231	304855	168916	173864
	1988	728718	434967	276965	153567	145586
	1989	838132	519865	238084	135189	130539
	1990	504303	618813	324769	114880	114420
1991	--	371767	402464	183682	95753	

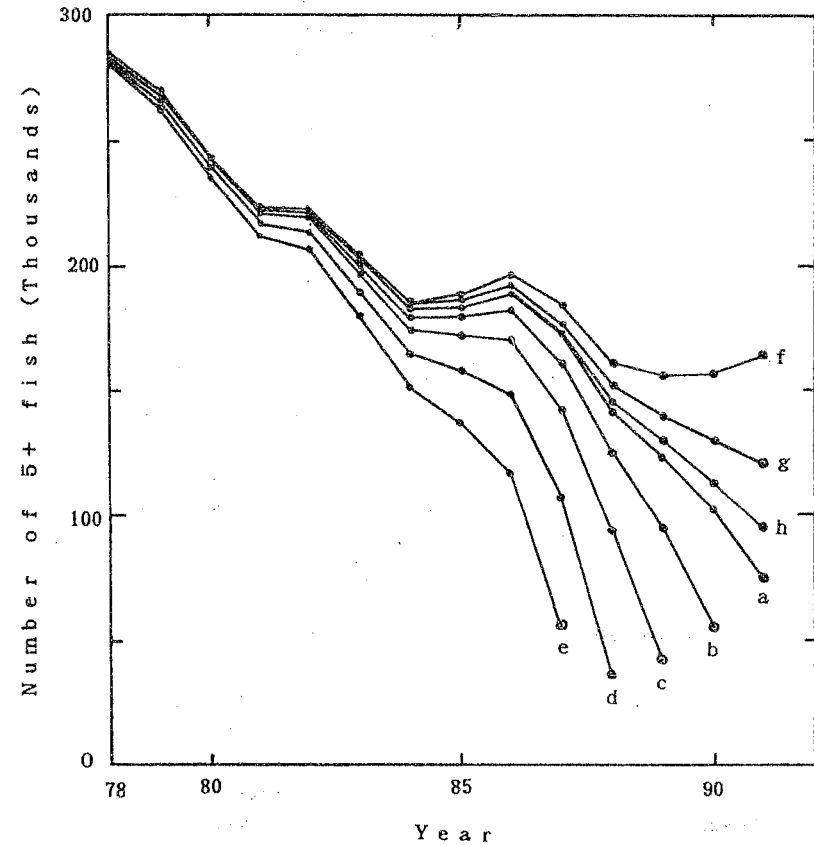


Fig.1 Comparison of population size estimates for ages 5+. Base case (a), four retrospective VPA's (b:-1989, c:-1988, d:-1987, e:-1986), two alternative assumptions (f:1987-1990 data, g:nonlinear model), and the 1991 ICCAT assessment (h).

APPENDIX

POPULATION EQUATIONS

Population size of age a ($a=1,2,3$) at the beginning of year y , $N_{a,y}$, is calculated using Pope's equation (Pope,1972):

$$N_{a,y} = N_{a+1,y+1} \exp(M) + C_{a,y} \exp(M/2) \quad (A1)$$

where M is the natural mortality rate and $C_{a,y}$ is the catch of fish age a during year y .

For ages 4 and 5+, following equations are used (Hiramatsu,1992):

$$N_{4,y} = \frac{\beta_y C_{4,y}}{C_{5+,y} + \beta_y C_{4,y}} \{ N_{5+,y+1} \exp(M) + (C_{5+,y} + C_{4,y}) \exp(M/2) \} \quad (A2)$$

$$N_{5+,y} = \frac{C_{5+,y}}{C_{5+,y} + \beta_y C_{4,y}} \{ N_{5+,y+1} \exp(M) + (C_{5+,y} + C_{4,y}) \exp(M/2) \} \quad (A3)$$

where

$$\beta_y = 1 + (1 - F_{4,y}/2)(F_{5+,y}/F_{4,y} - 1). \quad (A4)$$

$F_{a,y}$ is the fishing mortality rate on fish age a during year y . For simplicity, β is fixed at 1.044 in this paper. This approximation corresponds to fixing $F_{5+}/F_4 = 1.0582$ and $F_4 = 0.5$ in equation (A4).

TUNING

Objecting function is given by

$$SS = \sum_{i,y} W_i (CPUE_{i,y} - q_i \bar{N}_{a,y})^2 \quad (A5)$$

where W_i is the weight and supplied external to the analysis, and $CPUE_{i,y}$ is the standardized CPUE for year y series i . $\bar{N}_{a,y}$ is the average of $N_{a,y}$ and given by

$$\bar{N}_{a,y} = N_{a,y} (1 - \exp\{-Z_{a,y}\}) / Z_{a,y} \quad (A6)$$

where $Z_{a,y}$ is the total mortality rate on fish age a during year y .

ESTIMATION

The unknown parameters are $N_{2,1991}$, $N_{3,1991}$, $N_{4,1991}$, $N_{5+,1991}$, and q_i 's (and b when nonlinear relationship in equation (1) is assumed). q_i can be estimated by (Powers and Restrepo,1992)

$$q_i = \frac{\sum_y CPUE_{i,y} \times \bar{N}_{a,y}}{\sum_y N_{a,y} \times \bar{N}_{a,y}} \quad (A7)$$

The other parameters were estimated using the simplex search method.

COMPARISON

In order to evaluate this simple model, I compared the results of this model with that of the ICCAT assessment. Giving the weight which used in the base case of 1991 ICCAT assessment, population sizes are calculated using this model. The results of this model and the base case of ICCAT assessment are listed below. The differences between them are around 1%.

Comparison of population size estimates

Model	Year	Age				
		1	2	3	4	5+
This model	1978	396267	286600	206843	158502	284204
	1991	--	372667	403757	185521	95784
1991 ICCAT	1978	393691	284459	205375	157298	280379
	1991	--	371767	402464	183682	95753