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PRELIMINARY RESULTS OF ASPIC FOR NORTH ATLANTIC ALBACORE

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SUMMARY

The application of a relatively new approach for fitting production models to fisheries catch and fishing effort data is described for the north Atlantic albacore resource. The status of the north Atlantic albacore stock is investigated using ASPIC, a non-equilibrium surplus production model. Results from fitting ASPIC to catch and effort statistics from Spanish and French baitboat and troll fisheries and Japanese and Taiwanese longline fisheries are presented. Total variation in the CPUE is high and predicted trends in stock production are different between the separate CPUE data series. Results were not clearly defined from separate fits. The method may be useful but further exploration of the basic data input into the model should be conducted to better define the catch per effort information used in the model.

RESUME

L'application d'une méthode relativement nouvelle pour ajuster les modèles de production aux données de prise et effort des pêcheries est décrite pour le germon de l'Atlantique nord. L'état du stock du germon de l'Atlantique nord est étudié en utilisant l'ASPIC, un modèle de production additionnel ne postulant pas de conditions d'équilibre. Les résultats provenant de l'ajustement ASPIC aux statistiques de prise et effort des canneurs espagnols et français et des ligneurs et des pêcheries palangrières japonaise et taiwanaise ont été présentées. La variation globale de la CPUE est élevée et les tendances prédites de la production du stock sont différentes entre les séries séparées des données de CPUE. Les résultats n'ont pas été clairement définis pour les ajustements séparés. La méthode peut être utile mais des recherches plus poussées des données d'entrée de base dans le modèle devraient être menées à bien pour mieux définir l'information de prise par effort utilisée dans le modèle.

RESUMEN

Se describe la aplicación de un enfoque relativamente nuevo para el ajuste de modelos de producción a los datos de captura y esfuerzo de pesca de las pesquerías para el recurso de atún blanco del Atlántico Norte. El estado del atún blanco del Atlántico norte se investiga utilizando ASPIC, un modelo de producción excedente en condiciones de no equilibrio. Se presentan los resultados del ajuste de ASPIC a las estadísticas de captura y esfuerzo de las pesquerías españolas y francesas de cebo y curricán y las pesquerías de palangre japonesa y taiwanesa. La variación en la CPUE es alta y las tendencias previstas en la producción del stock son diferentes entre las series de datos de CPUE separadas. Los resultados no se definían claramente de los ajustes por separado. Este método puede ser útil, pero deberían llevarse a cabo importantes análisis adicionales para definir mejor la información de la captura por esfuerzo utilizada en el modelo.

Summary

The application of a relatively new approach for fitting production models to fisheries catch and fishing effort data is described for the North Atlantic Albacore resource. The status of the North Atlantic albacore stock is investigated using ASPIC, a non-equilibrium surplus production model. Results from fitting ASPIC to catch and effort statistics from Spanish and French baitboat and troll fisheries and Japanese and Taiwanese longline fisheries are presented. Total variation in the CPUE is high and predicted trends in stock production are different between the separate CPUE data series. Results were not clearly defined from separate fits. The method may be useful but further exploration of the basic data input into the model should be conducted to better define the catch per effort information used in the model.

Introduction

Surplus - production models have been used to assess the status of North Atlantic albacore by ICCAT since at least the early 1980's. Recent studies (Gonzalez - Garces and Mejuto (1984), SCRS 1984, and Bard (1990) have used the generalized production model as described by Fox (1975). The main differences between these studies were the length of the time series and the specific catch per unit of effort (CPUE) data sets selected for use in the analyses.

The analytical procedure explored in this study to investigate the catch per effort statistics of the North Atlantic albacore stock was ASPIC, A Stock-Production Model Incorporating Covariates (Prager 1991, 1992a, 1992b). The procedure has been used for a number of exploratory types of analyses to study the status of several fish stocks by the ICCAT scientific community. Some specific fisheries investigated recently with the method by this group, ICCAT, include the blue and white marlin stocks, Atlantic swordfish, and the west Atlantic bluefin tuna fisheries (SCRS 1992). Prager (1991) provides a general review of production models, a comprehensive background description of the model formulation for ASPIC, gives an application of the ASPIC model to the east Atlantic yellowfin tuna catch and effort data, and presents results for simulated data as well.

Model Background

The ASPIC procedure uses an analytically solvable population model based on the Graham-Schaefer logistic model (see Prager 1991). A major contrast from the model fitted with ASPIC and that of traditional surplus - production models is that the constant yield assumption of the traditional production

models is not imposed in parameter estimation. In this regard the method is similar to the approach used in the program GENPROD of Pella and Tomlinson (1969). ASPIC also offers other extensions to the usual surplus-production modelling methodology (Prager 1993). These are the flexibility to incorporate multiple time series of catch and effort data, the use of catch per effort indices or biomass indices or biomass estimates into parameter estimation, and the capability of handling missing data.

The ASPIC program has gained appeal recently among fisheries analysts because use of this method may be more applicable for many stocks because of the non -equilibrium yield assumption. For many fish stocks the resource is known to not be in an equilibrium condition and often sufficient statistics simply do not exist to apply other resource investigative methods such as age or length based virtual population analyses. Such a method as ASPIC then may offer promise for quantifying the resource status. The basic model is also simple and contains few parameters which must be interpreted by managers. In addition, the procedure as implemented by Prager (1991, 1992a, 1992b) offers analysts the ability to be curious with their data. The method incorporates terms for the variability between gears (fisheries) to into parameter estimation, changes in temporal catchability, and can make use of biomass indices into parameter estimation. Model results can be "tuned" to the observed data and auxillary information independent to the observations can be utilized for further weighting of each separate CPUE data series.

Data

The ASPIC method requires a time series of catch (yield) and fishing effort data. A time series The model provides direct estimates of r (the intrinsic rate of population increase), K (the carrying capacity), B_1 (ratio of beginning year biomass to biomass at which maximum sustainable yield (MSY) can be obtained) and q the catchability coefficient for each catch per effort data set. The procedure calculates values for other statistics that may be of interest to managers such as $F_{0.1}$ and F_{msy}.

Values of albacore catch (yield) documented in the ICCAT Statistical Bulletins for the Spanish baitboat and troll fisheries, the Japanese longline fishery, the Taiwanese longline fishery, and the French troll and baitboat fisheries were used in this analysis (Table 1). These data covered the years 1967 through 1991. Catch (yield) statistics are available for the albacore fisheries for years before 1967 however, fishing effort data were not available for all fisheries for these other years so analyses were begun with the 1967 year. In particular, Taiwanese longline nominal effort was available for early years however, adjusted effort derived from General Linear Models by Hsu and Chang (1992) and used in this study was available only since 1967.

There were two main sources of time fished (effort) for albacore. Several measures of directed effort existed for the Taiwanese longline fishery. Hsu and Chang provided albacore effort derived using the Honma (1974) method, from normalization, and also reported nominal effort that was directed to albacore. Trends were similar across methods and GLM and Honma derived effort more closely resembled nominal effort trends. The GLM adjusted measures of fishing effort were used in this study to maintain consistency with recent analyses of stock status. Adjusted catch per effort from GLM analyses was also used in the virtual population analyses performed with ADAPT during the 1992 Special Albacore Assessment Session (SCRS/92/104). To remain consistent with the data series selected by the 1992 albacore working group GLM adjusted effort was also used in this study.

Time series of standardized effort do not exist for the other major albacore fisheries. Standardized catch per effort indices of abundance in numbers exist for the Spanish troll and baitboat fisheries but are for the combined fisheries (i.e., gears were combined in the GLM analyses. These indices were not used to derive annual adjusted effort in these initial analyses with ASPIC. Changes in annual

average weight between the two fisheries was of concern and the variability between gears in catchability. In these preliminary explorations using ASPIC nominal effort directed to albacore (SCRS/92/22) was thus used for the Spanish surface fisheries as was the practice of earlier investigators. Japanese longline effort was taken from Uozumi (1992). Fishing effort for the French troll and baitboat fisheries was taken from SCRS/92/22. The complete time series of albacore catch (yield) and fishing effort data is presented in Table 2 of this paper.

The data series of catch (yield) data used in the ASPIC analyses performed in this study are a significant portion of the total catch since the beginning of the analysis period, 1967. For this reason in these first ASPIC runs no additional effort was made to apportion effort to the remaining catch although this might be a consideration for future analyses. The proportion of the annual total catch from these six fisheries (Spanish baitboat and troll, French baitboat and troll, Taiwanese and Japanese longline) represented in the analysis set investigated in this study ranged from 76 % (1990) to 97 % (1987).

Investigation Approach

A simple and tractable approach was used for the initial ASPIC fits to judge the potential of the method for studying the albacore stock status. This strategy was used since the method is relatively simple and is based upon a simple population model. Devising a complex scheme of selecting and/or combining CPUE time series at the onset of the ASPIC trials was not supported. The five integral points of the approach are described as follows.

The six sets of albacore CPUE statistics, Spanish baitboat and troll, French baitboat and troll, Japanese longline, and Taiwanese longline, were all included into the analysis. Variability between gears was of interest so the procedure was allowed to estimate separate q's for each fleet. During later runs, changes in catchability over time periods was examined. Time periods were chosen objectively using 1) patterns from initial results in the residuals and 2) historical patterns in the reported trends in yields and/or CPUE trends. The effect of each separate CPUE set in the total analysis was an unknown variable so the first runs were made without weighting of the individual CPUE datasets. Later runs incorporated weighting factors into the analysis. Although, not directly comparable for several reasons, final weighting factors from the ADAPT VPA's of the 1992 albacore workshop were used as initial scale factors. ASPIC also allows the user to tailor the parameter search such that the model minimization over the data may occur in terms of errors in effort or to errors in catch (yield). Errors were believed to be greater in effort than in yield and this seems a rational assumption since nominal effort measures were being used to index directed albacore fishing effort. Errors in yield resulting in under-reporting and under estimation of total catch are also most certain to exist.

ASPIC Results

Results of fitting ASPIC to the North ATlantic albacore CPUE data are shown in Table 3 for three cases. Final model values were similar for the weighted and un-weighted fits for each analysis data set so this did not appear to have a large impact of parameter estimates at least for these data. Model results are given for ASPIC fits to 1) the six sets of CPUE data, 2) to the Spanish and French baitboat and troll fisheries separately, and 3) for the Japanese and Taiwanese longline fisheries only. For each of these cases results from both un-weighted and weighted fits are given. Model results are disparate between cases and is not unexpected when the annual CPUE values are studied.

Annual trends in CPUE show large variations for the surface fisheries and are also very dis-similar from the longline fisheries (Figures 1 and 2). These fisheries are known to exploit different age groups of the population thus, the observed variation might be expected. The observed variation in CPUE

within the surface fisheries is also not unexpected because the importance of these gears to the total catch has varied largely over the time series included in the analysis. The component of the surface fisheries to the total has become much more important in the recent years.

The ASPIC fitting results from the total data set of six CPUE datasets gave MSY values from 68,440 MT to 68,930 MT (Table 3). Results from the surface fishery alone produced an MSY range of 36,650 MT to 42,210 MT. Model values of MSY from the surface fisheries and from the total CPUE data series are reasonably similar to results given by earlier authors for this stock (Table 4). The estimated population trajectories (Figure 3) indicate the resource has been above MSY since the early 1971 however it is likely that the a decline from the early 1960's level has occurred.

Model results from fitting to the Taiwanese and Japanese longline series alone produced quite very low and unrealistic MSY values on the order of near 10,000 MT much lower than the reported yields in recent years. The component of the total catch contributed by the longline fleet currently is much lower than the surface fleets and in 1991 averaged about 9 % by weight. The longline fishery CPUE data also contributed less to the total fitting than the surface fisheries. The results from the longline CPUE statistics appear less so than the surface fishery to index the current population. The longline fishery statistics are most representative of larger individuals based upon information from size composition samples from these fisheries. The ASPIC results for the longline fisheries thus most probably best index adult stock.

Discussion and Comments

Interpretation of these results is difficult for several reasons. The North Atlantic albacore resource is currently exploited by multiple fisheries, the segment of the population exploited by the individual fleets is variable as evidenced by the age or length composition of the separate fleet's catch, the total pattern of exploitation has varied over the time series of the analysis data set (1967-1992) as evidenced by large variation in annual CPUE trends, a large amount of disparity exists between the information sets available for use in the analysis (the CPUE data), and the degree of error present in the basic data used to compute CPUE is unknown.

The ASPIC method is flexible and can incorporate multiple information bases into parameter estimation. Final interpretation of results should consider the total package of information input into the model before using these results for management. For the ASPIC method to be of more value in interpreting current production of the North Atlantic albacore stock further reconciliation of the individual CPUE data series is needed. Standardized CPUE (in weight) directed to albacore is needed for the separate surface and longline fisheries. In this study standardized CPUE existed for only the Taiwanese longline fishery. Whether the nominal CPUE statistics were a reasonable representation of the population is unknown. Additional analyses then could objectively incorporate the multiple standardized CPUE sets into the total analysis by weighting each set according to the contribution to the total catch by age or size component.

References Cited

Anon, 1992. Documentation of Albacore stock assessment work carried out at the special session. ICCAT, Col. Vol. Sci. Pap., XL(2) (SCRS/92/22).

Bard, F.X. 1990. Modele de production applique au stock de germon nord Atlantique. Commentaires sur les CPUE disponibles. ICCAT, Col. Vol. Sci. Pap., XXXXIV: 128 - 134 (SCRS/90/50).

Fox W.W. 1975. Fitting the generalized stock production model by least squares and equilibrium approximation. Fish. Bull. 76(1): 23-37.

Gonzalez - Garces, A., 1981. A production model analysis of North Atlantic albacore (T. alalunga) 1957-1978. ICCAT Rec. Doc. Sci., 15(2):211-221.

Gonzalez - Garces, A. et Mejuto. J. 1984. Ajuste de un modelo de produccion a la poblacion de atun blanco (T. alalunga) del Atlantico norte 1967-1982. ICCAT. Rec. Doc. Sci., 18(2):294-306.

Hsu C.C. and S.K. Chang. 1992. The adjusted longline CPUE pf North and South Atlantic Albacore stock by three methods. ICCAT, Col. Vol. Sci. Pap., XL(2) (SCRS/92/104).

Hsu. C.C. and H.C. Liu. 1989. An considerable method of effort standardization as using in production analysis of the North Atlantic albacore stock. Submitted to the 39th World Tuna Conference, UCLA Conference Center, Lake Arrowhead, California, May 18-22, 1988.

ICCAT. 1992. Statistical Bulletin. 22 (1981-1991), Int. Comm. Conserv. Atlantic Tunas. Madrid, Spain, 187p.

ICCAT. 1990. Statistical Bulletin. 22 (1967-1980), Int. Comm. Conserv. Atlantic Tunas. Madrid, Spain, 187p.

Pella, J.J. and P.K. Tomlinson. 1969. A generalized stock production model. Bull. Inter-Am. Trop. Tuna Comm. 13:419-496.

Prager, M.H. 1993. A suite of extensions to a nonequilibrium surplus-production model. contrib. MIA-92/93-58, U.S. Dept. Commerce, NMFS, SEFSC, Miami Lab. Doc. MIA-92/93-58 46 p.

Prager, M.H. 1992a. ASPIC-A surplus-production model incorporating covariates. ICCAT, Col. Vol. Sci. Pap., XXXVI: 218-219.

Prager, M.H. 1992b. Recent developments in extending the ASPIC production model. ICCAT Coll. Vol. Sci. Pap. XL(2) (SCRS/092/127).

Prager, M.H. 1991. User's manual for ASPIC: A stock-production model iincorporating covariates. U.S. Dept. Commerce, NMFS, SEFSC, Miami Lab. Doc. MIA-91/92-20 46 p.

Uozumi, Y. 1992. Catch at size of Albacore caught by Japanese longline fishery in the Atlantic ocean from 1956 to 1990. ICCAT, Col. Vol. Sci. Pap., XL (2) (SCRS/92/106).

Table 1. Catch (yield Mt) and effort of major North Atlantic Albacore Fisheries used in ASPIC analyses.

	Catch (yield MT) Statistics					
	Longline		Spain		France	
Year	Taiwan	Japan	baitboat	troll	baitboat	troll
1968	1907	3306	11269	12963	2209	11030
1969	2352	4717	11980	10248	1710	7675
1970	4675	5875	12231	11250	1707	4456
1971	2871	6472	13494	16302	1483	7700
1972	4410	1319	6562	17834	475	8683
1973	9501	1467	6872	12927	1074	5785
1974	9538	2059	12207	13083	550	7875
1975	8130	1331	16247	4515	707	4959
1976	14837	1345	17846	8233	1590	5685
1977	13723	825	13889	10291	633	6190
1978	9324	531	10113	14131	386	8437
1979	6973	1219	14794	14232	220	7834
1980	7090	1036	15225	9459	355	3108
1981	6584	1740	11569	8241	392	2537
1982	10500	781	14823	10136	160	2695
1983	14254	1156	18190	10596	199	2192
1984	14923	576	6428	8242	10	2787
1985	14899	844	10307	8894	100	1760
1986	19646	470	14177	9767	130	1070
1987	6636	494	18015	10010	130	1441
1988	2117	723	16301	10966	0	359
1989	1294	764	14777	10479	290	70
1990	1512	737	15304	10342	0	0
1991	1574	737	8174	8955	0	0

	Fishing Effort Statistics					
	Longline		Spain		France	
Taiwan	Japan		baitboat	troll	baitboat	troll
65573.00	11484.00		16.10	37.60	3.00	31.80
51892.00	10552.00		20.90	20.00	2.90	9.90
94048.00	16553.00		14.90	27.50	2.00	11.00
82857.00	37699.00		21.60	33.40	2.30	15.80
125508.00	24897.00		11.60	30.40	0.80	14.80
219065.00	15383.00		13.60	24.40	1.80	18.90
196066.00	27126.00		11.60	23.70	0.50	12.10
177885.00	43360.00		17.20	15.40	0.70	9.00
166232.00	25596.00		21.60	20.00	1.20	9.90
248128.00	16602.00		10.00	20.10	0.40	9.70
142081.00	16571.00		10.00	22.50	0.40	12.00
115902.00	19249.00		10.20	17.00	0.10	10.00
114300.00	26841.00		10.40	16.70	0.30	11.20
177593.00	40653.00		11.50	17.20	0.40	5.30
248683.00	34923.00		10.90	17.20	0.10	6.00
254787.00	19773.00		16.10	16.10	0.20	3.30
365811.00	22036.00		7.20	12.40	0.09	4.20
401018.00	26287.00		9.90	23.40	0.10	4.70
662499.00	23514.00		12.80	20.70	0.10	2.30
244584.00	20519.00		10.30	24.70	0.10	3.50
55982.00	25335.00		12.00	19.70	0.09	0.70
46094.00	39862.00		9.50	21.90	0.20	0.20
76087.00	33643.00		9.00	18.90	0.10	0.10
74958.00	33000.00		7.90	14.00	0.00	0.00

Units: Surface effort 1000 fishing days
Taiwan LL 100 hooks
Japanese LL 1000 hooks

Table 2. Catch Per Effort of six major North Atlantic Albaore Fisheries.

	Longline		Spanish Surface		French Surface	
Year	Taiwan	Japan	Baitboat	Troll	Baitboat	Troll
68	.03	.29	699.94	344.76	736.33	346.86
69	.05	.45	573.21	512.40	589.66	775.25
70	.05	.35	820.87	409.09	853.50	405.09
71	.03	.17	624.72	488.08	644.78	487.34
72	.04	.05	565.69	586.64	593.75	586.69
73	.04	.10	505.29	529.80	596.67	306.08
74	.05	.08	1052.33	552.03	1100.00	650.83
75	.05	.03	944.59	293.18	1010.00	551.00
76	.09	.05	826.20	411.65	1325.00	574.24
77	.06	.05	1388.90	511.99	1582.50	638.14
78	.07	.03	1011.30	628.04	965.00	703.08
79	.06	.06	1450.39	837.18	2200.00	783.40
80	.06	.04	1463.94	566.41	1183.33	277.50
81	.04	.04	1006.00	479.13	980.00	478.68
82	.04	.02	1359.91	589.30	1600.00	449.17
83	.06	.06	1129.81	658.14	995.00	664.24
84	.04	.03	892.78	664.68	111.11	663.57
85	.04	.03	1041.11	380.09	1000.00	374.47
86	.03	.02	1107.58	471.84	1300.00	465.22
87	.03	.02	1749.03	405.26	1300.00	411.71
88	.04	.03	1358.42	556.65	.00	512.86
89	.03	.02	1555.47	478.49	1450.00	350.00
90	.02	.02	1700.44	547.20	.00	.00
91	.02	.02	1034.68	639.64	.00	.00

Units: Surface effort 1000 fishing days
Taiwan LL 100 hooks
Japanese LL 1000 hooks

Table 3. Results of Application of ASPIC in this study.

Data Set	MSY (MT)		$Biomass_{1992}/Biomass_{1968}$	
1967-1991	Unweighted	Weighted	Unweighted	Weighted
Surface	42,210	36,650	1.84	1.64
Longline	9,996	9,974	1.10	1.07
Combined	68,930	68,440	1.85	1.80

Table 4. Comparison Production Model Study Results.

Author	Years	MSY (MT)	Notes	
Bard 1990	1959-1988	56,800	Baitboat K=4	M=1
		58,400	K=4	M=0.4
		57,800	Troll K=3	M=0.5
		58,000	K=3	M=1.0
Gonzalez-Garces and Mejuto 1984	1957-1982	53,714	K=3	M=2
		127,121	K=4	M=0
		70,437	K=3	M=1
SCRS 1984	1967-1983	23,050	K=3	M=2
		59,800	K=4	M=0
		20,400	K=4	M=2
SCRS 1983		48,200-51,500	K=4	M=1

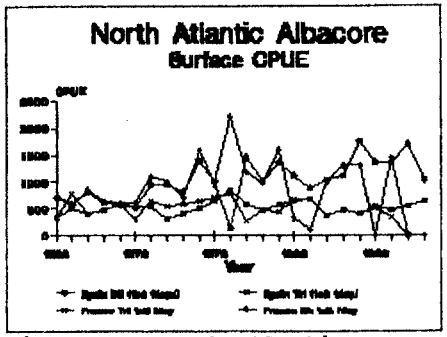

Figure 1. North Atlantic Surface CPUE

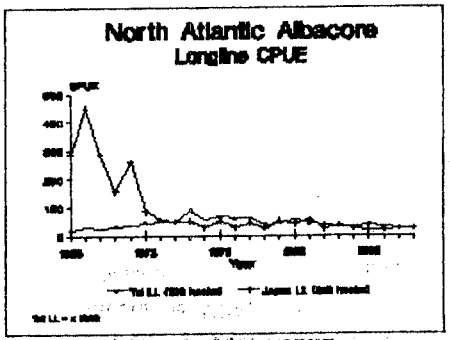

Figure 2. Longline CPUE

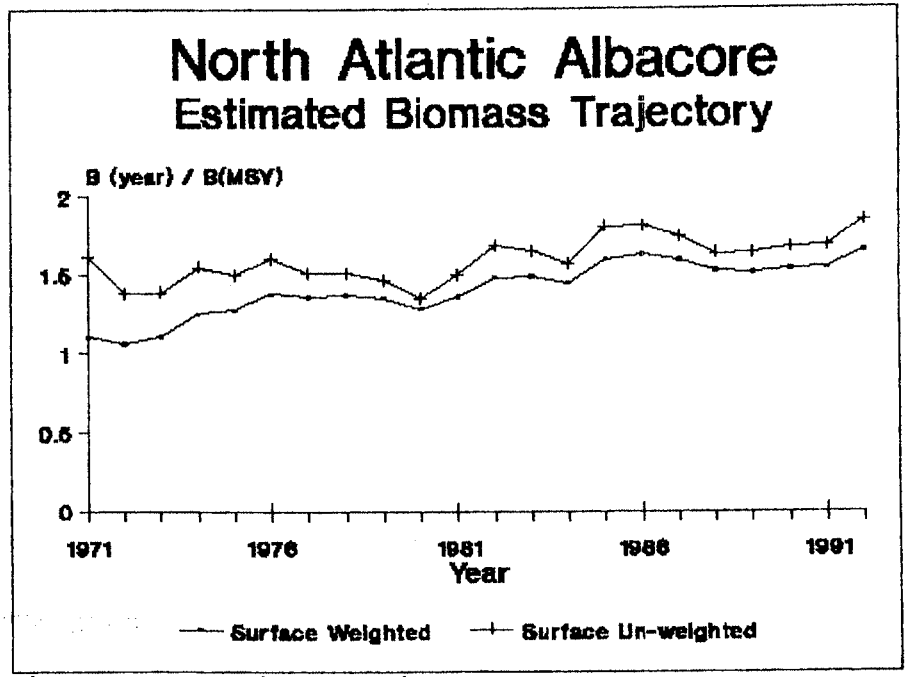

Figure 3. ASPIC Biomass Trajectory