A STOCK-PRODUCTION MODEL ANALYSIS OF SAILFISH *(ISTIOPHORUS PLATYPTERUS)* IN THE EASTERN ATLANTIC OCEAN USING STANDARDIZED INDICES OF ABUNDANCE

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SUMMARY

Sailfish catch and effort data were analyzed using a non-equilibrium stock-production model under an eastern Atlantic Ocean stock structure hypothesis. The landings database consists of yields from artisanal, longline, and recreational based fisheries. A single standardized catch rate series (SCRS/97/68-REV.) was used to index abundance for the eastern Atlantic stock from 1976 to 1995. This series was constructed based on catch and effort statistics from: the artisanal drift gillnet fisheries of Ghana (1975-1994) and Côte d'Ivoire (1987-1995), three artisanal fisheries of Senegal (1982-1995), and the rod and reel (sport) fishery of Senegal (1986-1995). Estimates of annual relative biomass levels, annual relative fishing mortality levels, along with bias-corrected estimates of maximum sustainable yield (MSY) and F_{MSY} were derived. Many of the problems outlined in the previous analysis were addressed with the standardization of catch rates and a truncated time series. The results of this analysis indicate that sailfish in the eastern Atlantic Ocean are likely (1996) fully exploited, and levels of relative biomass and fishing mortality have remained relatively stable over the past decade.

RÉSUMÉ

Les données de prise et d'effort du voilier ont été analysées en utilisant un modèle de production du stock en condition de non équilibre dans le cadre d'une hypothèse de structure du stock est-atlantique. La base de données des débarquements se compose des productions des pêcheries artisanale, palangrière et sportive. Une seule série de taux de capture standardisé (SCRS/97/68-Rev.) a été utilisée pour établir l'indice d'abondance du stock est-atlantique de 1976 à 1995. Cette série a été élaborée sur le fondement de statistiques de prise et d'effort provenant : des pêcheries artisanales au filet maillant dérivant du Ghana (1975-1994) et de la Côte d'Ivoire (1987-1995), de trois pêcheries artisanales du Sénégal (1982-1995), et de la pêcherie (sportive) à la canne/moulinet du Sénégal (1986-1995). Les estimations des niveaux annuels de la biomasse relative, des niveaux annuels de la mortalité par pêche relative, parallèlement aux estimations, dont les biais ont été corrigés, de la production maximum équilibrée (PME) et de la F_{PME} ont été dérivées. Un grand nombre des problèmes ébauchés dans les analyses préliminaires antérieures ont été traités avec la standardisation des taux de capture et une série temporelle tronquée. Les résultats de cette analyse indique que le voilier, dans l'Océan Atlantique Est, est probablement (1996) pleinement exploité, et que les niveaux de la biomasse et de la mortalité par pêche relatives sont demeurés relativement stables au cours de la dernière décennie.

RESUMEN

Se analizaron los datos de captura y esfuerzo de pez vela usando un modelo de no equilibrio de producción del stock bajo una hipótesis de estructura del stock del Atlántico este. La base de datos de desembarques consiste en rendimientos de las pesquerías artesanal, de palangre y de recreo. Se usó una sola serie de tasas de captura estandarizada (SCRS/97/68-REV) como índice de abundancia para el stock del Atlántico este de 1976 a 1995. Esta serie se construyó en base a las estadísticas de captura y esfuerzo de: las pesquerías artesanales de red de enmalle a la deriva de Ghana (1975-1994) y Côte d'Ivoire (1987-1995), tres pesquerías artesanales de Senegal (1982-1995) y la pesquería (deportiva) de caña y carrete de Senegal (1986-1995). Se derivaron estimaciones de niveles de biomasa relativa anual, niveles anuales de mortalidad por pesca relativa, junto con estimaciones con sesgo corregido de rendimiento máximo sostenible (RMS) y F_{RMS}. Muchos de los problemas esbozados en análisis preliminares previos se trataron con la estandarización de las tasas de captura y una serie temporal truncada. Los resultados de este análisis indican que el pez vela del Atlántico este, está siendo (1996) probablemente explotado al máximo, y que los niveles de biomasa relativa y de mortalidad por pesca han permanecido relativamente estables a lo largo de la última década.

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1. INTRODUCTION

The historical evolution of sailfish (Istiophorus platypterus) database development and stock assessment for the eastern Atlantic Ocean is documented by Farber et al. (1995, 1996). Although there was a Japanese longline standardized catch rate time series representing the off-shore abundance of eastern Atlantic sailfish/spearfish (1961-1992), the greatest short-coming of the most recent past assessment was that there were no standardized indices to represent the other components of the fishery (Farber et al., 1996). These included the Ghanaian artisanal fishery (1974-1993), which based on catches is the most abundant segment of the sailfish distribution in the East Atlantic. Further, the methodology used to standardize the Senegalese nominal CPUE series was not a general linear model (GLM) analysis. Rather, the indices of abundance were calculated using $CPUE_i = \Sigma U_i f_i / \Sigma f_i$, where U = individual CPUE for years i = 1982, ..., 1992, with effort f, for the three artisanal canoe fisheries (handline, trolling, and nets). Additionally, the Senegalese recreational (rod and reel) CPUE data were not standardized.

Following the recommendations of Farber et al. (1996), and further revisions and updating of the artisanal and recreational sailfish catch and effort data from Ghana, Senegal, and Côte d'Ivoire, Jones et al. (1997) generated several series of standardized catch rates (by country/fishery, combined etc...) using a GLM analysis. The detailed data from Senegal were made available by personal communication with Taib Diouf during a two week collaboration in Miami in July, 1997. Additional data for Côte d'Ivoire were made available by personal communication with A. Herve and from Kothias et al. (1995). Many of the problems outlined in the previous preliminary analysis were addressed with the standardization of catch rates, adoption of different assumptions pertaining to indices of abundance, and a truncated landings time series.

2. DATA AND METHODS

Landings data for east Atlantic sailfish (Figure 1) used in this analysis were reported to ICCAT by 19 different fisheries, including artisanal, longline, and recreational sources (ICCAT 1997, SAI-Table 1). The magnitude of the catch from the longline fleets dominated the total catch until the mid 1970's and was followed by a strong reversal in the mid 1970's with the artisanal fishery dominating landings through 1995. Although landings for this stock were available for the years 1961-1996, only landings data from 1976 to 1995 have been used in this assessment, in part because of a more than 50 fold increase in the reported artisanal fisheries in the early 1970's. In addition, the reported landings by the offshore Japanese longline fishery and CPUE measures constructed therefrom, included spearfish until recently. Since the Japanese proportion of the total reported sailfish catch declined with the growing dominance of the more coastal artisanal fishery, this truncated time series allowed better estimates of the sailfish catch, and the catch rates to better reflect sailfish abundance.

The non-equilibrium stock-production model, ASPIC (Prager 1992, 1994, 1995), was applied to the landings and catch rate series. This model requires time series of catches. and estimates of relative stock abundance (CPUE). Initially, all longline landings were combined and associated with the updated and revised standardized and adjusted (to base year 1975) Japanese longline CPUEs for sailfish/spearfish combined (Yokawa and Uozumi, 1997) across the entire time series. Similarly, the standardized and adjusted catch rate series from the artisanal and recreational West African fisheries was applied to the combined landings for the available years. Based on examination of the catch and CPUE data sets available and their performance in model fits, the Japanese longline CPUE was subsequently dropped from the analysis, and the artisanal/recreational West African catch rate series was used to index abundance for the years 1976-1995.

The remaining CPUE data were integrated into a model of standardized catch rates from the east African artisanal and recreational fisheries (Figure 1). Details of the standardization procedure for this catch rate series are presented in Jones et al. (1997). A more comprehensive historical background of west African sailfish fisheries is presented in Farber et al. (1996). All nominal catch rate statistics were in units of kg/trip. The artisanal drift gillnet fishery catch and effort data from Ghana were available for 1975-1994 by month and area (western, central, Greater Accra, and Volta). Because data were very limited in three of these locations, only the western region catch and effort statistics were used. Catch and effort data for Senegal from the artisanal and recreational fishery from 1982-1995 were available by gear (handline, trolling, nets, and rod and reel) and month. The Côte d'Ivoire artisanal drift gillnet catch and effort data for 1987-1995 were available by month. These data were standardized by time, area, and gear to generate the single catch rate (1975-1995) for the combined artisanal and recreational sailfish fisheries from Senegal, Côte d'Ivoire, and Ghana, that are used in this analysis.

The analysis regarded landings (i.e., catch) as exact, and accumulated model residuals in effort under the assumption that errors are multiplicative with constant variance. This was the procedure used in previous assessments when applying the ASPIC model, and is considered statistically preferable because effort is generally known less precisely than yield. Bias corrected estimates and approximate 80% confidence limits for management benchmarks and relative trajectories were constructed based on 1000 bootstrapped trials.

3. RESULTS

The initial analyses using the entire time series with the Japanese longline and West African catch rate series resulted in difficulties in model fits, unreasonable parameter estimates and a flat solution surface. Many attempts were then made using various model constraints, fixing parameter values, regenerating new indices of abundance for the artisanal and recreational database, and applying an overall 5% tail trim of the normalized residuals in order to reduce the affect of outliers. The working group considered these assessment approaches unreasonable, and these analyses were abandoned. Thus, only the combined artisanal and recreational West African catch rate series was used to index abundance for the years 1976-1995 (Figure 1). Using this approach, the model was successfully fit to the data. The model appeared to adequately capture the dynamics of the standardized effort series (Figure 2, Appendix 1).

The bias corrected point estimate of MSY (Table 1) was 1,390 mt, with an approximate 80% confidence interval of 647-1,741 mt. The trajectory of the bias-corrected point estimates of relative biomass, B/B_{MSY}, was at a maximum in the beginning of the time series, declined to a fully exploited level in the mid 1980's (1.0 reference line), and has been generally stable for the last decade, with a slight decline (Figure 3). The most recent year (1996) bias corrected level of relative biomass is 88% of the optimum biomass (Table 1, Appendix 1). The approximate nonparametric 80% confidence interval from the bootstrapping procedure for B/B_{MSY} indicates that the relative biomass is likely at a fully exploited level since the mid 1980's, with a terminal year relative biomass between 65% and 110% of optimum levels (Table 1).

The trajectory of the bias-corrected point estimates of relative fishing mortality, F/F_{MSY}, exhibits general stability across most of the time series at an optimum level, with some variability (Figure 4). The 80% approximate confidence interval trajectory throughout most of the late 1980's and 1990's, with the exception of 1993, when there a somewhat higher yield (Figure 1), is at or near the optimum reference level of 1.0. The relative fishing mortality level in the terminal year (1995) is 126% of the optimum level, with an 80% confidence interval of 96-172%.

4. DISCUSSION and CONCLUSION

A detailed discussion of the many problems associated with sailfish/spearfish database and the assessment of the eastern Atlantic Ocean stock is presented by Farber et al. (1996). Some of the data problems had been resolved before this assessment, including data that had been reported as "unclassified region" or the lumping of sailfish/spearfish into the "billfish unclassified" category. In addition, fitting the model to a truncated time series likely removed most of the problems of the sailfish/spearfish data aggregation, which was associated most severely with the dominance of the offshore longline fishery in the 1960's and early 1970s. The omission of the Japanese longline CPUE as an index of abundance contributed significantly to the overall improved fit of the model. This can be attributed to the changes in gear, deployment locations, target species, and reduced reports of sailfish landings in the most recent part of this time series. The species working group felt that these effects, including the more coastal distribution of sailfish and offshore distribution of spearfish, reduced the viability of using the Japanese longline catch rates as an index of abundance, and justified omitting this series from the analysis.

Although these changes in modeling strategies have greatly improved the east Atlantic sailfish analysis, there are continued problems with the overall database. In particular, eastern Atlantic sailfish landings may continue to reflect significant omissions of sailfish (as well as marlin) bycatch mortality from longline fisheries operating off West Africa. Large longline fishery fleets target swordfish and tuna off West Africa but do not report landing (or mortalities) of significant numbers of sailfish and spearfish. Further, sailfish are known to be used for bait, eaten by crews, and/or cut off the longline and discarded dead. These omissions to the landing reports likely represent an important source of mortality in the population. The continued lack of reporting of billfish bycatch by the Spanish longline fleet, the nation producing the highest annual reported landings of swordfish over the past 30+ years, and the highest annual landings of yellowfin tuna in the Atlantic Ocean since the early 1980s (Farber et al. 1996) continues to make the total landings table incomplete. In addition, some uncertainties also exist in recent landing reports from Gabon, as well as other east Atlantic fisheries.

Nonetheless, it appears that the general results of this assessment are reasonable and that the status of the stock of the eastern Atlantic sailfish/spearfish is likely fully exploited. The most recent 5 year average of landings is about 1,606 mt. This is higher than the current replacement yield of estimate of 1,473 mt, though is less than the upper 80% confidence limit of 1,759 mt. (Table 1). Hence, although the population at present appears to be fully exploited, consistent harvest at these levels will probably reduce the future level of relative biomass.

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Table 1. Estimated management benchmarks from the non-equilibrium production model for the eastern Atlantic sailfish stock. Confidence limits, based on 1,000 bootstrapped trials, are shown in parenthesis. More detailed information is contained in Appendix 1.

Benchmark	Bias Corrected Estimate	
MSY (mt)	1,390	(647-1,741)
B_{MSY} (mt)	11,600	(6,602-26,647)
Current (1995) Observed Yield	1,703	
Current (1996) Replacement Yield	1,473	(1,092-1,759)
Relative Biomass (B_{1996}/B_{MSY})	0.88	(0.65-1.10)
Relative Fishing mortality (F_{1995}/F_{MSY})	1.26	(0.98-1.72)

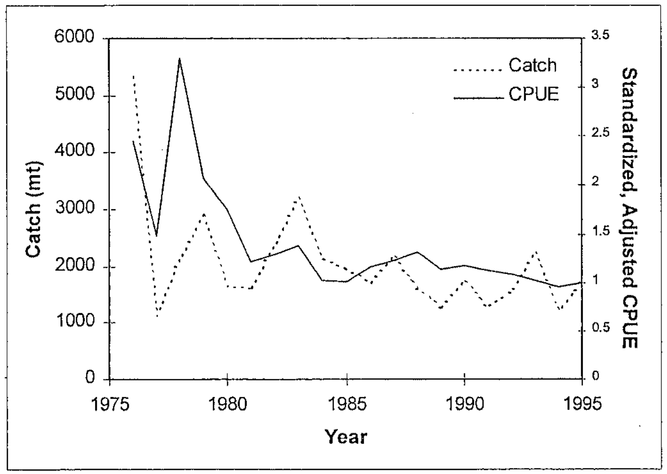

Figure 1. Total landings (mt) and catch rates for East Atlantic sailfish/spearfish used in this analysis. Landings are from all gears combined, catch rates are based on the combined artisanal/recreational model.

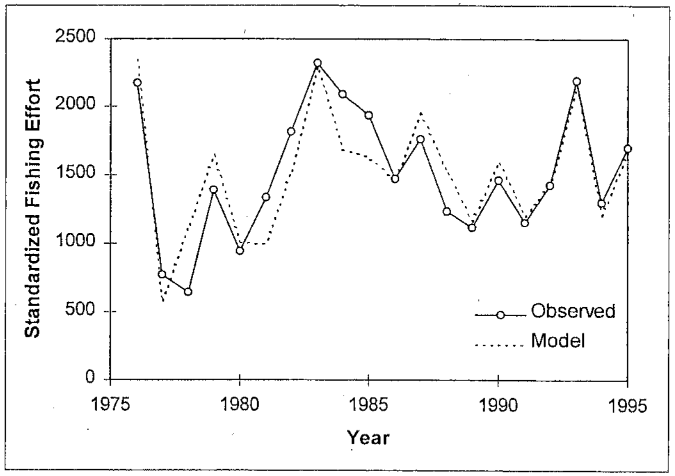

Figure 2. Observed vs. estimated West African artisanal/recreational effort from the non-equilibrium production model. Standardized effort series is calculated as CPUE/landings, were landings are regarded as exact by the model.

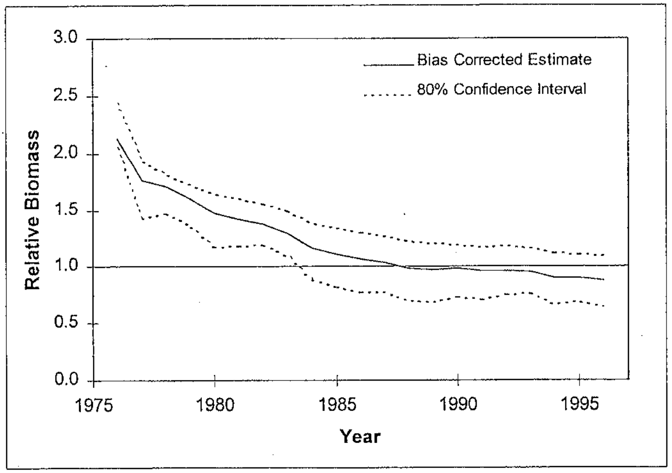

Figure 3. Bias-corrected trajectory of relative biomass (B/B_{MSY}) with approximate 80% confidence limits for the East Atlantic sailfish stock, 1976-1996.

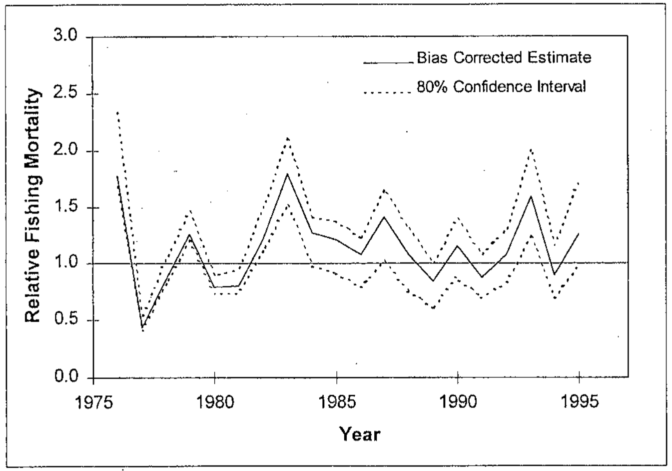

Figure 4. Bias-corrected trajectory of relative fishing mortality (F/F_{MSY}) with approximate 80% confidence limits for the East Atlantic sailfish stock, 1976-1995.

Appendix 1. Production model output.

East Atlantic Sailfish

18 Oct 1997 at 12:26
BOT Mode

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.64)

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CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	20	Number of bootstrap trials:	1000
Number of data series:	1	Lower bound on MSY:	1.000E+00
Objective function computed:	in EFFORT	Upper bound on MSY:	1.500E+05
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-02
Relative conv. criterion (restart):	5.000E-08	Upper bound on r:	5.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964185
Maximum F allowed in fitting:	8.000	Monte Carlo search trials:	3000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	2.369E-03	1	N/A	2.000E+00	N/A	
Loss(1) Combined Art&Rec	6.734E-01	20	3.741E-02	1.000E+00	1.000E+00	0.583

TOTAL OBJECTIVE FUNCTION:	6.75729514E-01
Number of restarts required for convergence:	4
Est. B-ratio coverage index (0 worst, 2 best):	1.1971
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	2.126E+00	2.070E+00	-2.65%	2.039E+00	2.437E+00	2.086E+00	2.280E+00	1.938E-01	0.091
K	2.321E+04	2.081E+04	-10.32%	1.320E+04	5.293E+04	1.760E+04	3.468E+04	1.708E+04	0.736
r	2.176E-01	2.964E-01	36.21%	6.009E-02	4.981E-01	1.223E-01	3.406E-01	2.183E-01	1.003
q(1)	7.819E-05	1.202E-04	53.75%	3.773E-05	2.014E-04	5.677E-05	1.357E-04	7.893E-05	1.009
MSY	1.390E+03	1.542E+03	10.93%	6.466E+02	1.741E+03	1.055E+03	1.588E+03	5.330E+02	0.383
Ye(1996)	1.473E+03	1.484E+03	0.75%	1.092E+03	1.759E+03	1.287E+03	1.636E+03	3.492E+02	0.237
Bmsy	1.160E+04	1.041E+04	-10.32%	6.602E+03	2.647E+04	8.799E+03	1.734E+04	8.542E+03	0.736
Fmsy	1.088E-01	1.482E-01	36.21%	3.004E-02	2.490E-01	6.114E-02	1.703E-01	1.091E-01	1.003
fmsy(1)	1.316E+03	1.233E+03	-6.30%	1.122E+03	1.536E+03	1.213E+03	1.432E+03	2.185E+02	0.166
F(0.1)	9.791E-02	1.334E-01	32.59%	2.704E-02	2.241E-01	5.503E-02	1.532E-01	9.822E-02	1.003
Y(0.1)	1.376E+03	1.527E+03	10.82%	6.401E+02	1.723E+03	1.044E+03	1.572E+03	5.276E+02	0.383
B-ratio	8.775E-01	8.066E-01	-8.08%	6.540E-01	1.100E+00	7.616E-01	9.812E-01	2.196E-01	0.250
F-ratio	1.259E+00	1.352E+00	7.44%	9.750E-01	1.724E+00	1.080E+00	1.474E+00	3.940E-01	0.313
Y-ratio	9.954E-01	9.626E-01	-3.29%	8.838E-01	9.999E-01	9.447E-01	9.970E-01	5.235E-02	0.053
f0.1(1)	1.184E+03	1.109E+03	-5.67%	1.009E+03	1.383E+03	1.092E+03	1.289E+03	1.966E+02	0.166

Appendix 1. Continued...

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1976	0.281	2.154E+04	1.891E+04	5.319E+03	5.319E+03	4.840E+02	1.898E+00	2.070E+00
2	1977	0.069	1.671E+04	1.663E+04	1.144E+03	1.144E+03	9.910E+02	4.643E-01	1.606E+00
3	1978	0.134	1.655E+04	1.600E+04	2.142E+03	2.142E+03	1.095E+03	9.032E-01	1.591E+00
4	1979	0.196	1.551E+04	1.466E+04	2.881E+03	2.881E+03	1.281E+03	1.326E+00	1.490E+00
5	1980	0.121	1.391E+04	1.376E+04	1.667E+03	1.667E+03	1.382E+03	8.177E-01	1.336E+00
6	1981	0.120	1.362E+04	1.351E+04	1.627E+03	1.627E+03	1.405E+03	8.130E-01	1.309E+00
7	1982	0.182	1.340E+04	1.293E+04	2.355E+03	2.355E+03	1.450E+03	1.229E+00	1.288E+00
8	1983	0.274	1.249E+04	1.162E+04	3.188E+03	3.188E+03	1.518E+03	1.852E+00	1.201E+00
9	1984	0.203	1.082E+04	1.051E+04	2.138E+03	2.138E+03	1.541E+03	1.372E+00	1.040E+00
10	1985	0.196	1.023E+04	1.001E+04	1.964E+03	1.964E+03	1.539E+03	1.324E+00	9.828E-01
11	1986	0.175	9.802E+03	9.717E+03	1.702E+03	1.702E+03	1.535E+03	1.182E+00	9.420E-01
12	1987	0.234	9.635E+03	9.301E+03	2.172E+03	2.172E+03	1.524E+03	1.576E+00	9.260E-01
13	1988	0.182	8.987E+03	8.927E+03	1.629E+03	1.629E+03	1.511E+03	1.231E+00	8.637E-01
14	1989	0.140	8.869E+03	8.997E+03	1.262E+03	1.262E+03	1.514E+03	9.465E-01	8.524E-01
15	1990	0.191	9.121E+03	9.014E+03	1.722E+03	1.722E+03	1.514E+03	1.289E+00	8.766E-01
16	1991	0.144	8.913E+03	9.022E+03	1.300E+03	1.300E+03	1.515E+03	9.723E-01	8.566E-01
17	1992	0.170	9.128E+03	9.111E+03	1.551E+03	1.551E+03	1.518E+03	1.149E+00	8.772E-01
18	1993	0.257	9.095E+03	8.712E+03	2.241E+03	2.241E+03	1.500E+03	1.736E+00	8.741E-01
19	1994	0.146	8.354E+03	8.482E+03	1.237E+03	1.237E+03	1.489E+03	9.841E-01	8.029E-01
20	1995	0.200	8.606E+03	8.497E+03	1.703E+03	1.703E+03	1.490E+03	1.352E+00	8.271E-01
21	1996		8.393E+03						8.066E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Combined Art&Rec

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1976	2.172E+03	2.340E+03	0.2812	5.319E+03	5.319E+03	-0.07450	0.000E+00
2	1977	7.746E+02	5.724E+02	0.0688	1.144E+03	1.144E+03	0.30250	0.000E+00
3	1978	6.498E+02	1.114E+03	0.1338	2.142E+03	2.142E+03	-0.53861	0.000E+00
4	1979	1.395E+03	1.635E+03	0.1965	2.881E+03	2.881E+03	-0.15833	0.000E+00
5	1980	9.496E+02	1.008E+03	0.1212	1.667E+03	1.667E+03	-0.05976	0.000E+00
6	1981	1.338E+03	1.002E+03	0.1205	1.627E+03	1.627E+03	0.28863	0.000E+00
7	1982	1.819E+03	1.516E+03	0.1822	2.355E+03	2.355E+03	0.18269	0.000E+00
8	1983	2.321E+03	2.283E+03	0.2745	3.188E+03	3.188E+03	0.01619	0.000E+00
9	1984	2.087E+03	1.692E+03	0.2033	2.138E+03	2.138E+03	0.21001	0.000E+00
10	1985	1.937E+03	1.633E+03	0.1962	1.964E+03	1.964E+03	0.17084	0.000E+00
11	1986	1.470E+03	1.457E+03	0.1752	1.702E+03	1.702E+03	0.00859	0.000E+00
12	1987	1.768E+03	1.943E+03	0.2335	2.172E+03	2.172E+03	-0.09406	0.000E+00
13	1988	1.234E+03	1.518E+03	0.1825	1.629E+03	1.629E+03	-0.20747	0.000E+00
14	1989	1.115E+03	1.167E+03	0.1403	1.262E+03	1.262E+03	-0.04550	0.000E+00
15	1990	1.467E+03	1.589E+03	0.1910	1.722E+03	1.722E+03	-0.07971	0.000E+00
16	1991	1.153E+03	1.199E+03	0.1441	1.300E+03	1.300E+03	-0.03880	0.000E+00
17	1992	1.427E+03	1.416E+03	0.1702	1.551E+03	1.551E+03	0.00733	0.000E+00
18	1993	2.187E+03	2.140E+03	0.2572	2.241E+03	2.241E+03	0.02186	0.000E+00
19	1994	1.297E+03	1.213E+03	0.1458	1.237E+03	1.237E+03	0.06672	0.000E+00
20	1995	1.703E+03	1.667E+03	0.2004	1.703E+03	1.703E+03	0.02116	0.000E+00

Appendix 1. Continued...

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 1000 trials.

TRAJECTORY OF RELATIVE BIOMASS (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1976	2.127E+00	2.070E+00	-2.66%	2.039E+00	2.437E+00	2.086E+00	2.280E+00	1.938E-01	0.091
1977	1.761E+00	1.606E+00	-8.82%	1.435E+00	1.944E+00	1.595E+00	1.846E+00	1.888E-01	0.107
1978	1.707E+00	1.591E+00	-6.83%	1.472E+00	1.813E+00	1.587E+00	1.756E+00	1.621E-01	0.095
1979	1.600E+00	1.490E+00	-6.86%	1.372E+00	1.734E+00	1.485E+00	1.671E+00	1.862E-01	0.116
1980	1.469E+00	1.336E+00	-9.01%	1.178E+00	1.641E+00	1.323E+00	1.559E+00	2.358E-01	0.161
1981	1.418E+00	1.309E+00	-7.69%	1.182E+00	1.598E+00	1.295E+00	1.510E+00	2.148E-01	0.151
1982	1.372E+00	1.288E+00	-6.15%	1.192E+00	1.555E+00	1.275E+00	1.471E+00	1.955E-01	0.142
1983	1.290E+00	1.201E+00	-6.92%	1.097E+00	1.490E+00	1.188E+00	1.396E+00	2.084E-01	0.162
1984	1.163E+00	1.040E+00	-10.54%	8.843E-01	1.390E+00	1.018E+00	1.278E+00	2.604E-01	0.224
1985	1.106E+00	9.828E-01	-11.13%	8.254E-01	1.342E+00	9.637E-01	1.223E+00	2.596E-01	0.235
1986	1.064E+00	9.420E-01	-11.43%	7.815E-01	1.299E+00	9.202E-01	1.177E+00	2.569E-01	0.241
1987	1.039E+00	9.260E-01	-10.89%	7.828E-01	1.273E+00	9.130E-01	1.155E+00	2.421E-01	0.233
1988	9.863E-01	8.637E-01	-12.43%	7.038E-01	1.227E+00	8.474E-01	1.103E+00	2.554E-01	0.259
1989	9.738E-01	8.524E-01	-12.47%	6.930E-01	1.205E+00	8.287E-01	1.075E+00	2.466E-01	0.253
1990	9.820E-01	8.766E-01	-10.74%	7.354E-01	1.198E+00	8.532E-01	1.071E+00	2.174E-01	0.221
1991	9.590E-01	8.566E-01	-10.68%	7.140E-01	1.173E+00	8.268E-01	1.041E+00	2.146E-01	0.224
1992	9.654E-01	8.772E-01	-9.13%	7.589E-01	1.182E+00	8.554E-01	1.053E+00	1.974E-01	0.205
1993	9.519E-01	8.741E-01	-8.17%	7.663E-01	1.165E+00	8.581E-01	1.061E+00	2.028E-01	0.213
1994	8.923E-01	8.029E-01	-10.02%	6.754E-01	1.117E+00	7.771E-01	9.960E-01	2.189E-01	0.245
1995	8.995E-01	8.271E-01	-8.04%	6.943E-01	1.113E+00	8.017E-01	1.013E+00	2.109E-01	0.234
1996	8.775E-01	8.066E-01	-8.08%	6.540E-01	1.100E+00	7.616E-01	9.812E-01	2.196E-01	0.250

East Atlantic Sailfish Output from ASPIC-P.EXE
CTL file for ASPIC-P

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1976	1.774E+00	1.898E+00	6.99%	1.679E+00	2.323E+00	1.751E+00	2.007E+00	2.566E-01	0.145
1977	4.335E-01	4.643E-01	7.10%	4.184E-01	5.209E-01	4.272E-01	4.692E-01	3.587E-02	0.083
1978	8.636E-01	9.032E-01	4.59%	8.239E-01	1.050E+00	8.495E-01	9.372E-01	8.773E-02	0.102
1979	1.264E+00	1.326E+00	4.90%	1.201E+00	1.455E+00	1.249E+00	1.341E+00	9.169E-02	0.073
1980	7.851E-01	8.177E-01	4.14%	7.365E-01	8.937E-01	7.644E-01	8.274E-01	5.498E-02	0.070
1981	7.977E-01	8.130E-01	1.91%	7.371E-01	9.537E-01	7.648E-01	8.566E-01	9.180E-02	0.115
1982	1.220E+00	1.229E+00	0.75%	1.115E+00	1.498E+00	1.162E+00	1.324E+00	1.623E-01	0.133
1983	1.794E+00	1.852E+00	3.26%	1.512E+00	2.095E+00	1.638E+00	1.910E+00	1.483E-01	0.083
1984	1.274E+00	1.372E+00	7.73%	9.839E-01	1.412E+00	1.115E+00	1.332E+00	2.170E-01	0.170
1985	1.210E+00	1.324E+00	9.46%	9.171E-01	1.373E+00	1.055E+00	1.284E+00	2.287E-01	0.189
1986	1.077E+00	1.182E+00	9.73%	7.897E-01	1.227E+00	9.339E-01	1.144E+00	2.100E-01	0.195
1987	1.412E+00	1.576E+00	11.62%	1.013E+00	1.649E+00	1.223E+00	1.524E+00	3.016E-01	0.214
1988	1.081E+00	1.231E+00	13.90%	7.590E-01	1.303E+00	9.327E-01	1.194E+00	2.611E-01	0.241
1989	8.388E-01	9.465E-01	12.84%	6.104E-01	1.000E+00	7.179E-01	9.216E-01	2.036E-01	0.243
1990	1.151E+00	1.289E+00	11.99%	8.761E-01	1.390E+00	1.002E+00	1.279E+00	2.766E-01	0.240
1991	8.770E-01	9.723E-01	10.86%	6.959E-01	1.076E+00	7.753E-01	9.811E-01	2.058E-01	0.235
1992	1.078E+00	1.149E+00	6.54%	8.327E-01	1.294E+00	9.551E-01	1.188E+00	2.330E-01	0.216
1993	1.594E+00	1.736E+00	8.93%	1.227E+00	1.997E+00	1.415E+00	1.812E+00	3.970E-01	0.249
1994	9.010E-01	9.841E-01	9.22%	6.887E-01	1.168E+00	7.914E-01	1.041E+00	2.493E-01	0.277
1995	1.259E+00	1.352E+00	7.44%	9.750E-01	1.724E+00	1.080E+00	1.474E+00	3.940E-01	0.313