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EXPLORATORY SURPLUS-PRODUCTION ANALYSIS OF BLUE AND WHITE MARLIN FISHERIES IN THE NORTH ATLANTIC

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SUMMARY

Variability in fishing methods between and within data series have made surplus-production analysis of blue and white marlin difficult. When only one set of parameters could be used in the model, the data had to be standardized to a single fishing method. In this paper, we explore the use of a non-equilibrium stock-production modeling approach (ASPIC) that can analyze several simultaneous data series with different catchability coefficients. Analysis of the blue marlin stock suggests that the stock biomass is somewhat higher than MSY level and that it could sustain a higher level of exploitation than at present. Analysis of the white marlin stock is more problematic, and conclusions are more tentative. The analysis strongly suggests that the stock is heavily overexploited, but the degree of overexploitation is not clear. The estimate of MSY for the white marlin is quite imprecise, indicating a poor match between the model and the available data. Possible causes of this are that the abundance index does not truly reflect abundance or that the catch data reflect an imprecise and varying proportion of the annual catch.

RESUME

Les variations des méthodes de pêche dans les séries de données et entre elles ont rendu difficiles les analyses de la production excédentaire du makaire bleu et du makaire blanc. Lorsqu'un seul jeu de paramètres pouvait être utilisé dans le modèle, il a fallu standardiser les données à une même méthode de pêche. Le présent document passe en revue l'utilisation d'une méthode de modélisation stock/production ne postulant pas de conditions d'équilibre (ASPIC) qui peut analyser plusieurs séries simultanées de données avec un coefficient de capturabilité différent. Le makaire bleu (Makaira nigricans) et le makaire blanc (Tetrapturus albidus) de l'Atlantique nord ont été analysés selon l'hypothèse d'un seul stock dans cette zone pour chacune de ces espèces. L'analyse du stock de makaire bleu suggère que la biomasse du stock dépasse le niveau capable d'alimenter la MSY, et que le stock pourrait supporter une exploitation accrue; néanmoins, le volume de production additionelle n'est pas clair. L'analyse du stock de makaire blanc est plus problématique, et les conclusions sont assez provisoires. L'analyse suggère que le stock est fortement surexploité, mais les estimations paramétriques sont très peu précises et semblent faussées, si bien qu'il est impossible d'estimer avec précision le degré d'exploitation, ni de se prononcer de façon conclusive quant à l'existence d'une surexploitation. Les difficultés de l'estimation semblent indiquer une concordance médiocre entre le modèle et les données disponibles. Une des raisons possibles de ce manque d'accord pourrait être des indices d'abondance qui n'estiment pas bien l'abondance, ou des données de capture qui ne reflètent pas de pourcentages cohérents de la prise annuelle.

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RESUMEN

La variación en los métodos de pesca entre series de datos y dentro de las mismas, dificultan el análisis del excedente de producción de aguja blanca y aguja azul. Cuando en el modelo se podía usar un solo conjunto de parámetros, los datos tenían que ser normalizados a un sólo método de pesca. En el presente documento, exploramos la aplicación de un enfoque de modelo de producción de stock de no-equilibrio (ASPIC) capaz de analizar varias series de datos simultáneas con diferentes coeficientes de capturabilidad. Se realizaron análisis de la aguja azul (Makaira nigricans) y aguja blanca (Tetrapturus albidus) en el Atlántico norte, bajo la hipótesis de que cada especie forma allí un único stock. El análisis de stock de aguja azul, sugiere que la biomasa del stock se encuentra por encima del nivel que soportaría un RMS y que el stock podría soportar una mayor explotación; sin embargo, el volumen de rendimiento adicional no queda claro. El análisis del stock de aguja blanca es mas problemático y las conclusiones totalmente provisionales. El análisis sugiere que el stock está muy sobreexplotado, pero las estimaciones de los parámetros son muy inconcretas y parecen estar sesgadas, por lo que el grado de sobreexplotación no se puede estimar con precisión, ni se puede llegar a la conclusión definitiva de que dicha sobreexplotación ha tenido lugar. La dificultad de la estimación parece indicar una escasa concordancia entre el modelo y los datos disponibles. Algunas de las posibles causas de esta falta de concordancia podrían ser índices de abundancia que no estiman bien la abundancia o datos de captura que no reflejan proporciones coherentes de la captura anual.

1. INTRODUCTION:

A non-equilibrium logistic (Schaefer) production model was used to assess the status of stocks of blue and white marlin in the North Atlantic. This type of model was chosen because of its simplicity and robustness. Although production models do not always produce sensible parameter estimates, Hilborn (1979) has shown that such cases are usually due not to model failures (such as lack of age structure or other realistic detail), but rather to data failures that would affect more complex models as well. It seems logical, then, to attempt to apply a relatively simple model successfully before introducing a more complex one.

Blue and white marlin are incidental catches in longline fisheries of many countries and are the directed species of many recreational and artisanal fisheries in the Caribbean, Gulf of Mexico and off the west African coast. Landings data have not been collected from all countries catching marlin, and even when estimates of catch are obtained, these fish are often either incorrectly identified or not identified to species . Effort data are often difficult to obtain, and a unit of effort in one fishery is generally not equivalent to a unit of effort in another fishery. In fact, a unit of effort may not be the same from year to year within one fishery (SCRS REPORT BILLFISHES, 1991).

Although it was not possible to fully meet some of the assumptions of the model, an attempt to assess the stocks was considered important because longline fisheries have recently expanded in areas of blue marlin abundance (Gulf of Mexico and Caribbean Sea), and new recreational and artisanal fisheries for blue marlin are developing in west Africa and the Caribbean. White marlin recreational CPUE's (U.S. and Venezuela) have been declining and Japanese longline CPUE's for white marlin have remained at low levels in the south Atlantic (SCRS REPORT BILLFISHES, 1991).

Improved methodology allowed better handling of some data base problems. General linear models (GLM) were used to standardize effort within fisheries for confounding effects such as gear changes and geographical inconsistencies. The dynamic non-equilibrium stock-production modeling approach (ASPIC) allowed two fisheries to be run in one model without standardizing units of effort. In addition ASPIC, being a "dynamic" model, does not use the equilibrium assumption. Models using the equilibrium assumption are known to overestimate MSY in fisheries with a declining stock size.

2. METHODS:

Due to uncertainties in life histories and population dynamics of the marlins, single Total Atlantic and separate North/South Atlantic stock hypothesis have been used for marlin. This paper used the separate North/South hypothesis and because the CPUE series available were both from the North Atlantic, only the North Atlantic region is explored.

Catch data from the SCRS Billfishes report 1991 were accepted as the best estimates of yearly catches (Table 1). CPUE's for Venezuelan recreational (Gaertner, 1992) and U.S. recreational (Farber et. al., 1992) fisheries were used to estimate effort. HPUE for the U.S. recreational fishery was used as an index of abundance (Farber et. al., 1992) in some models. These series are listed in Tables 2 and 3.

Each CPUE series was used separately to estimate total effort from total catch for single fishery models. In two-fishery models, U.S. recreational CPUE was used to estimate effort for all catch other than Venezuelan. Venezuelan CPUE was used to estimate effort for Venezuelan catch. U.S. recreational HPUE was used as an index of abundance in models using U.S CPUE.

Several models were bootstrapped (999 runs) in order to evaluate the variability of estimated and derived parameters. This allows making nonparametric confidence intervals on MSY and optimum effort.

Parameters estimated by the ASPIC model for this study were:

B_1	Biomass at the beginning of the first year (MT)
K	Biological carrying capacity, or maximum biomass (MT)
r	Biological intrinsic rate of increase of the stock, per year
qi	Catchability (one estimate for each fishery)

Additional quantities derived from estimated parameters;

MSY	Maximum sustainable yield (Kr/4)
B_{MSY}	Stock biomass at MSY (K/2)
F_{MSY}	Fishing Mortality rate at MSY (r/2)
f_i	Fishing effort rate at MSY in units of fishery (r/2qi)

The quantities estimated most precisely by production models are MSY, effort at MSY, and relative biomass and fishing mortality levels. Production models in general do not estimate the absolute abundance of the stock very precisely. For that reason, stock estimates presented here are normalized to the corresponding estimates of MSY.

3. RESULTS AND DISCUSSION

3.1 Blue Marlin

Graphs of observed and predicted yield, relative fishing mortality, relative biomass, and distribution of MSY bootstraps are presented for two blue marlin models. Figures 1 through 4 are graphs from a single-fishery model using U.S. recreational CPUE and the U.S. HPUE index. Results of a two-fishery model using U.S. and Venezuelan recreational CPUE are shown in figures 5 through 8.

Both of the blue marlin models suggest that relative fishing mortality is presently below fishing mortality at MSY and the relative biomass is presently (1.5 to 2 times) higher than MSY. Both models suggest that blue marlin could sustain a higher level of exploitation.

When U. S. recreational CPUE was used to estimate effort and U.S. HPUE was used as an index of abundance the nonparametric 90% confidence interval for MSY was 1,719 - 2,409 metric tons. In the model using Venezuelan recreational CPUE the 90% confidence internal for MSY was 2,203-3,072 metric tons. These estimates are similar to previously published estimates of MSY for blue marlin. When

Venezuelan and U. S. recreational CPUE's were used together to estimate effort and MSY was somewhat lower (1,296 -1,846 metric tons) than previous estimates (Table 4).

3.2 White Marlin

White Marlin estimates of MSY were highly variable. Although the R^2 for the model using the US recreational CPUE was reasonably high (0.78), the bootstrap showed that the results were highly imprecise (variable) (Figures 9-12). 90% confidence internals for MSY using U. S. recreational CPUE and U.S. HPUE as an index of abundance were 3.1210^8-$1.7*10^9$. When Venezuelan recreational CPUE was used the confidence internal for MSY was also very wide ($2.3*10^2$-$3.4*10^{9}$). All models had extremely poor fit when Venezuelan CPUE's were used. The lack of fit and high variability indicate a failure in the model, or more likely, in the data. One possible cause of such data failure might be that the abundance index does not truly reflect abundance. This would occur under several circumstances, such as varying catchability in different years, environmental effects on CPUE or HPUE, nonrandom errors in recording or computing indices, or computing the index on a varying fraction of an open population. The other data component is the total catch records. Difficulties in modeling would certainly be induced if the catch data reflected an imprecise and varying proportion of the annual catch. In this connection, we note that Farber and Conser (1982) stated that "stock assessment work on billfishes is plagued with shortcomings in the data base".

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Table 1 Total catch (metric tons) of blue and white marlin in the north Atlantic.

Year	Blue marlin	White marlin
1961	653	108
1962	3452	381
1963	5141	914
1964	4809	1694
1965	3682	2127
1966	2040	1798
1967	1173	588
1968	1344	692
1969	1601	1212
1970	1845	1048
1971	2115	1547
1972	1315	1208
1973	1616	995
1974	1916	1218
1975	2075	1088
1976	1364	1052
1977	1253	501
1978	971	428
1979	878	481
1980	1060	508
1981	1247	780
1982	1613	653
1983	1139	1381
1984	1188	701
1985	1293	842
1986	1030	927
1987	654	582
1988	884	301
1989	1471	267
1990	903	218

Table 2 U.S. recreational CPUE and HPUE, and Venezuelan CPUE for blue marlin.

Year	Blue marlin		
	U.S. HPUE	U.S. CPUE	Venezuelan CPUE
1961			0.170
1962			0.254
1963			0.112
1964			0.088
1965			0.065
1966			0.187
1967			0.129
1968			0.120
1969			0.137
1970			0.123
1971			0.066
1972			0.032
1973	1.000	1.000	0.024
1974	1.302	1.390	0.047
1975	1.166	1.002	0.018
1976	0.957	0.912	0.012
1977	1.050	1.033	0.021
1978	0.891	0.952	0.020
1979	1.234	1.228	0.047
1980	1.274	1.415	0.043
1981	1.380	1.599	0.068
1982	1.194	1.334	0.032
1983	1.212	1.464	0.073
1984	1.217	1.504	0.141
1985	1.270	1.656	0.061
1986	0.993	1.390	0.054
1987	1.385	1.806	0.064
1988	1.275	1.798	0.037
1989	1.259	1.606	0.066
1990	1.012	1.414	

Table 3 **U.S. recreational CPUE AND HPUE, and Venezuelan CPUE for white marlin.**

Year		White marlin	
	U.S. HPUE	U.S. CPUE	Venezuelan CPUE
1961			1.201602
1962			0.830013
1963			0.613840
1964			1.277708
1965			1.187028
1966			0.927410
1967			1.155924
1968			0.648755
1969			0.298924
1970			0.498394
1971			2.438986
1972			0.803269
1973	1.000	1.000	1.401348
1974	1.110	1.213	0.358834
1975	1.028	1.101	1.351347
1976	0.864	0.922	0.857526
1977	0.766	0.745	0.358679
1978	0.660	0.696	0.175161
1979	1.051	1.066	0.389604
1980	1.490	1.814	1.155753
1981	0.975	1.175	0.693366
1982	0.964	1.130	0.749110
1983	0.880	1.050	0.645733
1984	0.820	0.880	0.445068
1985	0.522	0.543	0.450880
1986	0.531	0.669	0.211003
1987	0.576	0.779	0.233624
1988	0.452	0.513	0.249563
1989	0.266	0.438	0.158951
1990	0.305	0.424	

Table 4 **Estimates of maximum sustainable yield (MSY) for blue and white marlin in the north Atlantic.**

	BLUE MARLIN	WHITE MARLIN
Kikawa & Honma 1978	2300	1700
Conser & Berdsley 1978	2,884-3,136	1,877-2,042
Farber & Conser 1982	2,347-3,388	1,729-2,423
This paper		
U.S. Rec.	1,719-2,509	3.1210^8-1.7*10^9
Venezuelan Rec.	2,203-3,072	2.3*10^2-3.4*10^9
Combined fisheries	1,296-1,846	NA

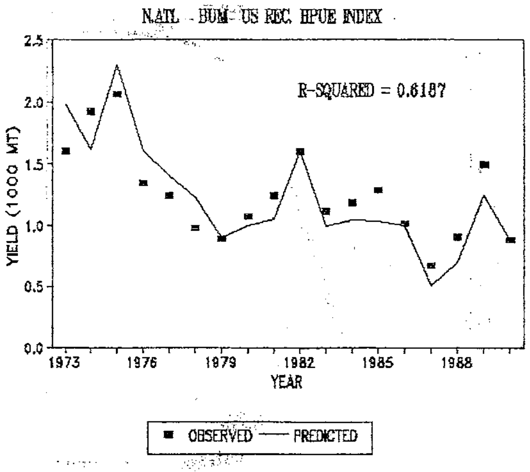

Figure 1. Observed and predicted north Atlantic blue marlin catch in metric tons.

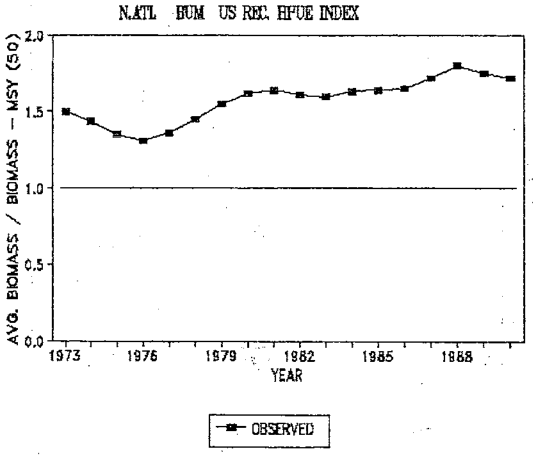

Figure 3. Average biomass of north Atlantic blue marlin divided by biomass at MSY. (Fishing effort is based on U.S. recreational CPUE and HPUE is used as an index of abundance.)

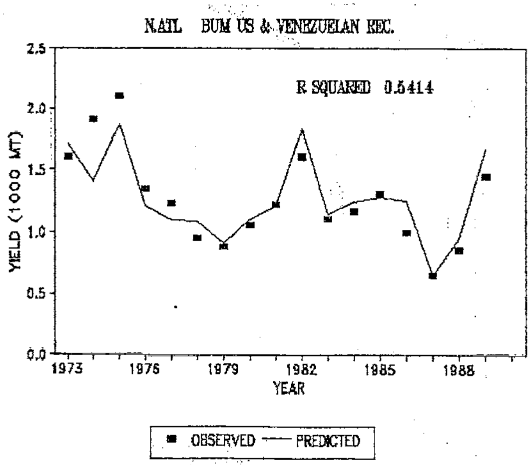

Figure 5. Observed and predicted north Atlantic blue marlin catch in metric tons.

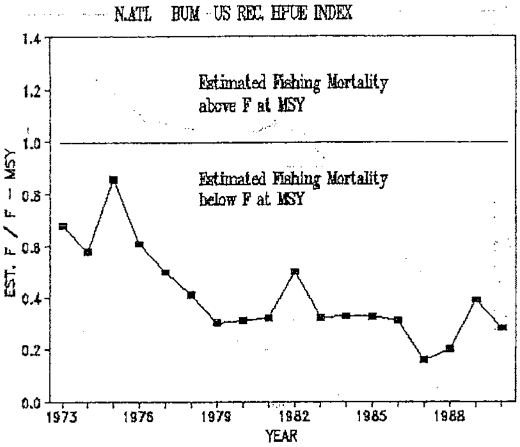

Figure 2. Estimated fishing mortality for north Atlantic blue marlin divided by fishing mortality at MSY. (Fishing effort is based on U.S. recreational CPUE and HPUE is used as an index of abundance.)

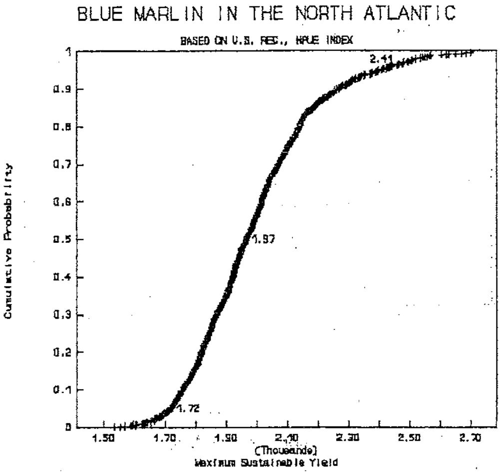

Figure 4. Distribution of 999 bootstraps of maximum sustainable yield for north Atlantic blue marlin. (Fishing effort is based on U.S. recreational CPUE and HPUE is used as an index of abundance.)

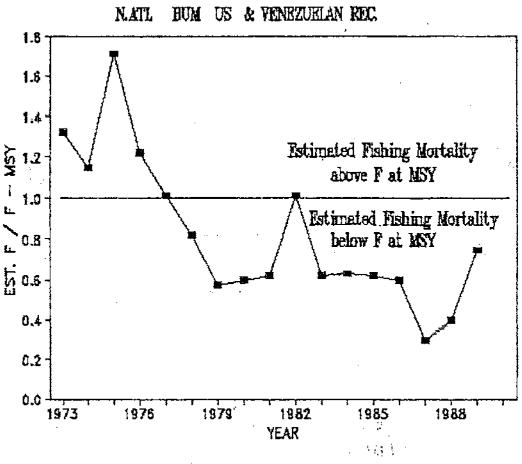

Figure 6. Estimated fishing mortality for north Atlantic blue marlin divided by fishing mortality at MSY. (Fishing effort is based on U.S. and Venezuelan recreational CPUE.)

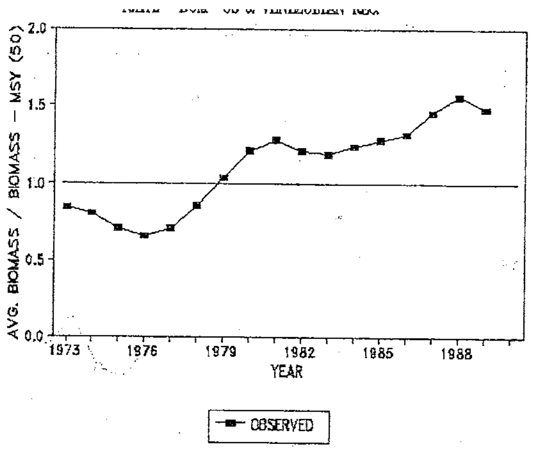

Figure 7. Average biomass of north Atlantic blue marlin divided by biomass at MSY. (Fishing effort is based on U.S. and Venezuelan recreational CPUE.)

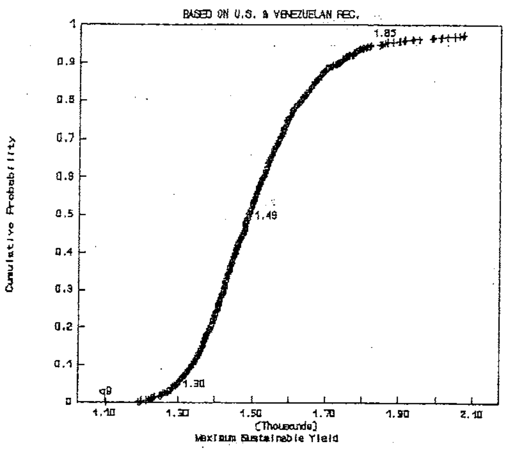

Figure 8. Distribution of 999 bootstraps of maximum sustainable yield for north Atlantic blue marlin. (Fishing effort is based on U.S. and Venezuelan recreational CPUE.)

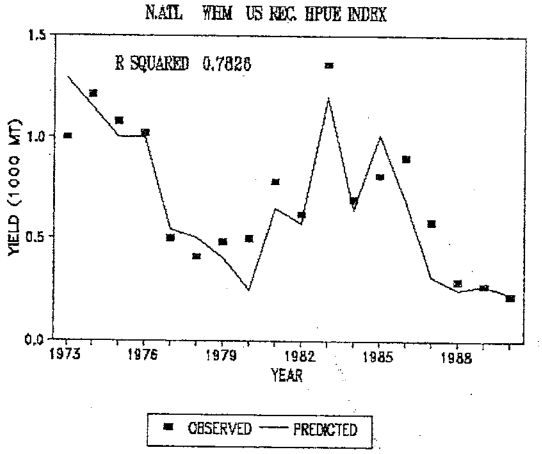

Figure 9. Observed and predicted north Atlantic white marlin catch in metric tons.

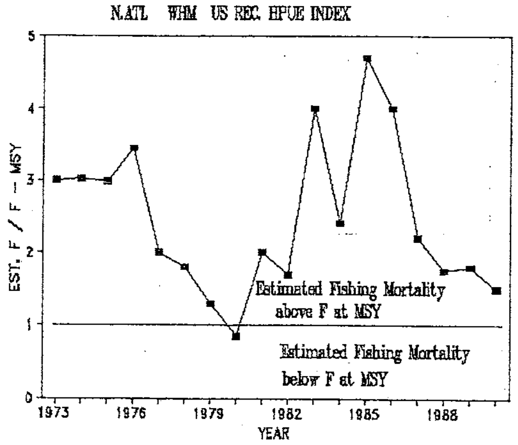

Figure 10. Estimated fishing mortality for north Atlantic white marlin divided by fishing mortality at MSY. (Fishing effort is based on U.S. recreational CPUE and HPUE is used as an index of abundance.)

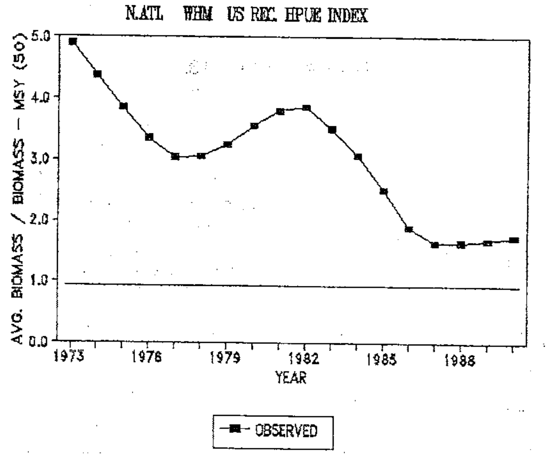

Figure 11. Average biomass of north Atlantic white marlin divided by biomass at MSY. (Fishing effort is based on U.S. recreational and HPUE is used as an index of abundance.)

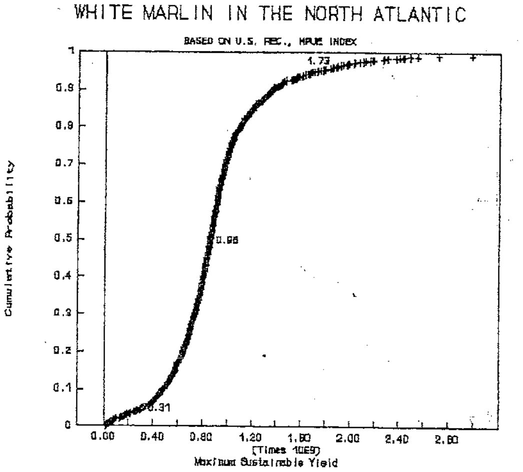

Figure 12. Distribution of 999 bootstraps of maximum sustainable yield for north Atlantic white marlin. (Fishing effort is based on U.S. recreational CPUE and HPUE is used as an index of abundance.)