STATE OF THE SKIPJACK TUNA STOCKS OF THE ATLANTIC OCEAN FROM PRODUCTION MODEL ANALYSIS, 1969-1975

by

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SUMMARY

Nominal fishing effort for FIS ice baitboats, FIS freezer baitboats, FIS small seiners, FIS large seiners, Japanese single seiners, Japanese double seiners, Japanese baitboats and United States seiners were standardized to estimate the total fishing effort on skipjack tuna. The Annobon region was used as the index area because skipjack is a major tuna species caught in that region. Catch and effort by flag-gear and month were calculated for this region and then the effort standardized by,

$$P_k = \text{antilog} \sum_{i=1}^{n} \left[\log \left(\frac{CPSY_{ik}}{CPSY_{is}} \right) \right] \Big/ n$$

$$f = \sum_{i=1}^{n} \sum_{k=1}^{m} X_{ik} P_k$$

where $OSPY_{ik}$ is the combined catch of yellowfin and skipjack tuna per unit of effort of the ith month and kth flag-gear; $CPSY_{is}$ is the catch per unit effort of the ith month of the standard flag-gear (s = FIS small seiners); X_{ik} is fishing effort of the ith month and kth flag-gear type; and f is the total standardized fishing effort.

The generalized stock production model was fitted to data of total skipjack tuna catch from the eastern Atlantic and f for 1969-1975. The model did not fit the data very well. Estimates of the maximum average sustainable yield varied between 89,300 tons and 118,400 tons. The best fit of the data was obtained with a flat-topped yield curve.

RESUME

L'effort nominal de pêche des canneurs glaciers, canneurs congélateurs et petits et grands senneurs FIS, des senneurs simples, senneurs en paire et canneurs japonais, ainsi que des senneurs américains, a été normalisé pour estimer l'effort de pêche total portant sur le listao. La région d'Annobon a été choisie comme indice, du fait que le listao est l'une des principales espèces qui y sont capturées. La prise et l'effort par pavillon-engin et par mois ont été calculés pour cette zone. L'effort a ensuite été standardisé par l'équation:

$$P_k = \text{antilog} \sum_{i=1}^{n} \left[\log \left(\frac{CPSY_{ik}}{CPSY_{is}} \right) \right] \Big/ n$$

$$f = \sum_{i=1}^{n} \sum_{k=1}^{m} X_{ik} P_k$$

dans laquelle $CPSY_{ik}$ est la prise combinée d'albacore et de listao par unité d'effort du i-ième mois et du k-ième pavillon-engin. $CPSY_{is}$ est la prise par unité d'effort du i-ième mois du pavillon-engin standard (s = petits senneurs FIS). X_{ik} est l'effort de pêche du i-ième mois et

du k-ième pavillon-type d'engin, et f est l'effort de pêche total normalisé.

Le modèle global a été appliqué aux données sur la capture totale de listao dans l'Atlantique Oriental et la valeur de f pour 1969-75, mais ne s'est pas ajusté de façon satisfaisante. Les estimations de la moyenne de production maximale soutenue varient de 89.300 à 118.400 tonnes. Le meilleur ajustement a été obtenu au moyen d'une courbe de production aplanie.

RESUMEN

Con el fin de evaluar el total del esfuerzo de pesca aplicado al patudo, se normaliza el esfuerzo nominal de los barcos cebo con depósito de hielo y congeladores, grandes y pequeños cerqueros, todos ellos pertenecientes a la flota FIS, así como de los cerqueros simples, dobles y barcos cebo, de la flota japonesa, y de los cerqueros norteamericanos. La región de Annobon se toma como zona de referencia, ya que allí se pesca el listado, uno de los túnidos más importantes. Se calculan la captura y el esfuerzo en dicha región, por bandera, arte y mes, y se normaliza el esfuerzo como sigue:

$$P_k = \text{antilog} \sum_{i=1}^{n} \left[\log \left(\frac{CPSY_{ik}}{CPSY_{is}} \right) \right] \Big/ n$$

$$f = \sum_{i=1}^{n} \sum_{k=1}^{m} X_{ik} P_k$$

donde $CPSY_{ik}$ es la captura combinada de rabil y listado, por unidad de esfuerzo del i-ésimo mes y k-ésimo bandera/arte; $CPSY_{is}$ es la captura por unidad de esfuerzo del i-ésimo mes de bandera/arte standard (s = pequeños cerqueros FIS); X_{ik} es el esfuerzo de pesca del i-ésimo mes y k-ésimo tipo de bandera/arte; y f es el esfuerzo de pesca total normalizado.

El modelo de producción generalizado, ha sido ajustado a los datos del total de captura de listado, procedentes del Atlántico oriental y a f del período 1969-1975, aunque no se logró un ajuste muy preciso. Las estimaciones de la media de rendimiento máximo sostenible oscilan entre 89.300 y 118.400 toneladas. El mejor ajuste de los datos se obtuvo por medio de una curva de rendimiento aplanada.

INTRODUCTION

The catch of Atlantic skipjack tuna fluctuated upwards at a rate of about 10,000 metric tons (MT) annually until it reached a record high of 115,000 MT in 1974 (Figure 1). The following year, it declined sharply to 59,000 MT, and scientists voiced concern about the state of the stocks (ICCAT, 1976).

Evidence presented at the 1975 meeting of the International Commission for the Conservation of Atlantic Tunas (ICCAT) showed that over 90% of the total Atlantic skipjack tuna catch was taken in the eastern Atlantic and the 1974 catch was approaching the range of rough estimates of potential yield for the stocks (Sakagawa and Murphy, 1976). These same conclusions were reached by participants of a Working Group on Atlantic Skipjack Tuna which was convened by the Institut Sénégalais de Recherches Agricoles in March 1976 (ISRA, 1976). Furthermore, the participants concluded that the maximum sustainable yield from production model analysis range between 90,000 to 125,000 MT for the eastern Atlantic skipjack fishery.

In this report we assess the state of the Atlantic skipjack tuna stocks using the generalized production model and data from the 1969-1975 eastern Atlantic surface yellowfin-skipjack tuna fishery. The procedures we use are different from those used by the Working Group in that more up-to-date fishery statistics and a different standardization procedure for fishing effort are used.

DATA AND ANALYTICAL PROCEDURES

ICCAT Statistical Bulletin (ICCAT, 1975a) served as the source for Atlantic skipjack tuna catches, 1969-1974, and the ICCAT Secretariat provided preliminary statistics for 1975. The catches were partitioned and assigned to the eastern or western Atlantic according to information on the operations of the fleet. Approximately 99% of the total Atlantic catch of skipjack tuna in 1969-1975 was caught in the eastern Atlantic.

Nominal catch and fishing effort by 1° area-month for the FIS (French-Ivory Coast-Senegalese) baitboat and purse seine fleets, Japanese baitboat and purse seine fleets and the United States purse seine fleet of the Atlantic were tabulated from various sources (Table 1). These fleets annually participate in the eastern tropical Atlantic tuna fishery. The data were separated by flag and gear and pooled over 1° areas within the Annobon region (Figure 2) by month. Fishing effort of the different flag-gears was then standardized using the procedure:

$$\rho_k = \text{antilog} \left[\sum_{i=1}^{m} \log\left(\frac{CPSY_{ik}}{CPSY_{is}}\right) \right] \Bigg/ m$$

$$f = \sum_{i=1}^{m} \sum_{k=1}^{m} X_{ik}\, \rho_k .$$

Where $CPSY_{ik}$ is the combined yellowfin and skipjack tuna nominal catch per unit of effort of the ith month and kth flag-gear, X_{ik} is the nominal fishing effort of the ith month and kth flag-gear, s is the standard flag-gear (FIS small seiner), f is the total standardized fishing effort, and ρ_k is the standardization factor for the kth flag-gear. The ρ_k's for 1969-1975 are shown in Table 2 and the standardized fishing efforts are shown in Table 3.

We chose the Annobon region for indexing skipjack abundance simply because catches from that region have been consistently high from year to year and all fleets fish in that region (ISRA, 1976).

Catch per standard day's fishing of skipjack tuna (CPSDF) were calculated for each year and divided into total catch from the eastern Atlantic to estimate total standardized fishing effort by year for the fishery (Table 4). The data on total catch and total standardized fishing effort were then used in analyses with the generalized production model (Pella and Tomlinson, 1969). One and two significant year classes are assumed in our analyses.

STANDARDIZED FISHING EFFORT

Various procedures have been used to standardize fishing effort for Atlantic skipjack tuna (ISRA, 1976; Sakagawa and Murphy, 1976). None have so far proven to be satisfactory primarily because fishing effort in the Atlantic skipjack tuna fishery is not only directed to skipjack tuna but to yellowfin tuna too. The procedure used in this report attempts to account for this by including the catch of yellowfin tuna in the estimation of ρ_k's. However, our estimated CPSDF is quite similar to previous estimates (ISRA, 1976) calculated with a cruder procedure (Figure 3).

PRODUCTION MODEL ANALYSIS

The computer program, PRODFIT (Fox, 1975) was used to fit the generalized production model to the data in Table 3. Three special cases ($m = 0$; $m \to 1$; $m = 2$) of the model were fitted (Figure 3). None of the models fitted the data very well (Table 5). Estimates of maximum average sustainable yield (MASY) ranged from 89,300 to 118,400 MT. The best fit was obtained with the flat-topped model ($m = 0$) and with two significant year classes contributing to the catch. MASY with this model is 118,400 MT.

Because of the poor fit of the models to the data, we are not confident that the results reflect true equilibrium MASY levels for the eastern Atlantic fishery. We suspect that much of the variation is caused by the estimation procedure for standardized fishing effort, which does not fully account for the multiple species characteristic of the fishery, and by variation in availability of skipjack tuna to the fishery.

Furthermore, the fishery is dependent on one or two incoming year classes for virtually the entire catch (Coan, 1976; ISRA, 1976) and consequently the failure of one year class, due to either changes in abundance or in distribution, is disasterous to the fishery. Whether the decline in catch of 1975 is due to changes in abundance or to distribution of skipjack tuna is not clear. However, the influencing factor apparently affected availability of skipjack tuna in all regions of the eastern Atlantic but particularly in the Angola region, where catches in the 1970's have been exceptionally large (ISRA, 1976).

Table 1. Sources of catch and effort data by country and gear-type, 1969-1975.

Country	Gear Type	1969	1970	1971	1972	1973	1974	1975
FIS	Ice baitboat Freezer baitboat Small purse seiner Large purse seiner	1	1	1	1	1	2	1
Japan	Double purse seiner Single purse seiner	4	5	4	4	3	2	2
	Baitboat	6				6	6	6
United States	Purse seiner	7	7	7	7	7	7	7

[1] ICCAT (pers. comm., Madrid, Spain)
[2] ICCAT (1975 b)
[3] ICCAT (1975 c)
[4] ICCAT (1973 b)
[5] ICCAT (1973 a)
[6] Kume (pers. comm., Far Seas Laboratory, Shimizu, Japan)
[7] NMFS, La Jolla, California

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Table 2. Standardization factors by flag-gear for tuna fishing vessels that fished in the Annobon region of the eastern Atlantic Ocean, 1969-1975.

Year	French-Ivory Coast - Senegalese				Japanese			U.S.A.
	Ice baitboat	Freezer baitboat	Small seiner	Large seiner	Single seiner	Double seiner	Baitboat	Large seiner
1969	0.25	0.57	1.00	1.64	1.09	1.89	0.79	3.29
1970	0.80	0.76	1.00	1.55	1.05	2.59	-	0.79
1971	0.15	0.42	1.00	1.02	0.81	1.75	-	1.43
1972	0.03	0.76	1.00	1.14	1.01	1.57	-	0.92
1973	0.11	0.77	1.00	3.30	1.66	3.60	1.10	1.66
1974	-	0.61	1.00	1.87	1.24	-	1.00	0.82
1975	-	0.56	1.00	1.73	0.74	-	0.61	1.69

Table 3. Standard days fishing by flag-gear and total catch for all 8 flag-gears that fished in the Annobon region of the eastern Atlantic Ocean, 1969-1975.

Year	French-Ivory Coast - Senegalese				Japanese			U.S.A.		
	Ice baitboat	Freezer baitboat	Small seiner	Large seiner	Single seiner	Double seiner	Baitboat	Large seiner	Effort	Total catch
1969	45.73	1643.40	2405.40	633.10	253.80	957.21	956.26	5373.44	12268.34	14184.64
1970	79.14	1541.97	1831.50	959.76	139.18	1087.05	-	1221.10	6859.70	17105.16
1971	3.68	742.61	1440.60	1031.90	203.76	927.42	-	746.17	5096.14	15341.32
1972	0.53	1294.18	2827.90	1276.60	359.47	690.94	-	1531.30	7880.92	19912.77
1973	3.70	749.21	3677.70	3721.95	518.26	107.92	5977.48	456.16	15212.38	19509.64
1974	0	403.49	2720.60	4991.80	242.68	0	5607.00	651.22	14616.79	30033.41
1975	0	23.79	1862.70	8103.33	31.14	0	616.22	3104.94	13742.12	16665.05

Table 4. Skipjack tuna catch per standard day's fishing (CPSDF), skipjack tuna catch (metric tons) and total fishing effort (standard day's fishing) for the eastern Atlantic skipjack tuna fishery.

Year	CPSDF	Catch	Effort
1969	1.156	43142	37320
1970	2.494	63834	25595
1971	3.010	83922	27881
1972	2.495	75525	30270
1973	1.282	78186	60988
1974	2.055	113794	55374
1975	1.213	55564	45807

Table 5. Estimates of some parameters of the production model for the skipjack tuna fishery of the Atlantic Ocean.

m	Y_{max} ($x10^3$ tons)	f_{op} ($x10^3$ day's fishing)	U_{op} (tons/day's fishing)	Degree of fit index
1 significant year class				
0	115.0	∞	-	0.473
1.001	89.3	61.2	1.46	0.455
2.0	90.3	53.7	1.68	0.440
2 significant year class				
0	118.4	∞	-	0.538
1.001	93.4	61.5	1.52	0.505
2.0	95.1	54.9	1.73	0.471

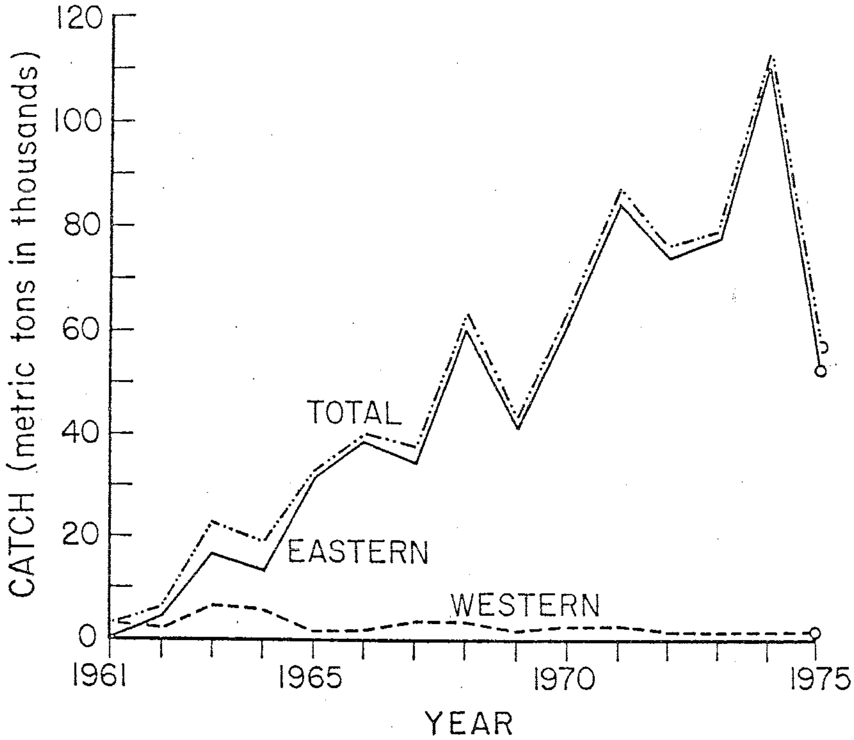

Figure 1. Catch of skipjack tuna from the Atlantic Ocean by region. Estimates for 1975 are preliminary.

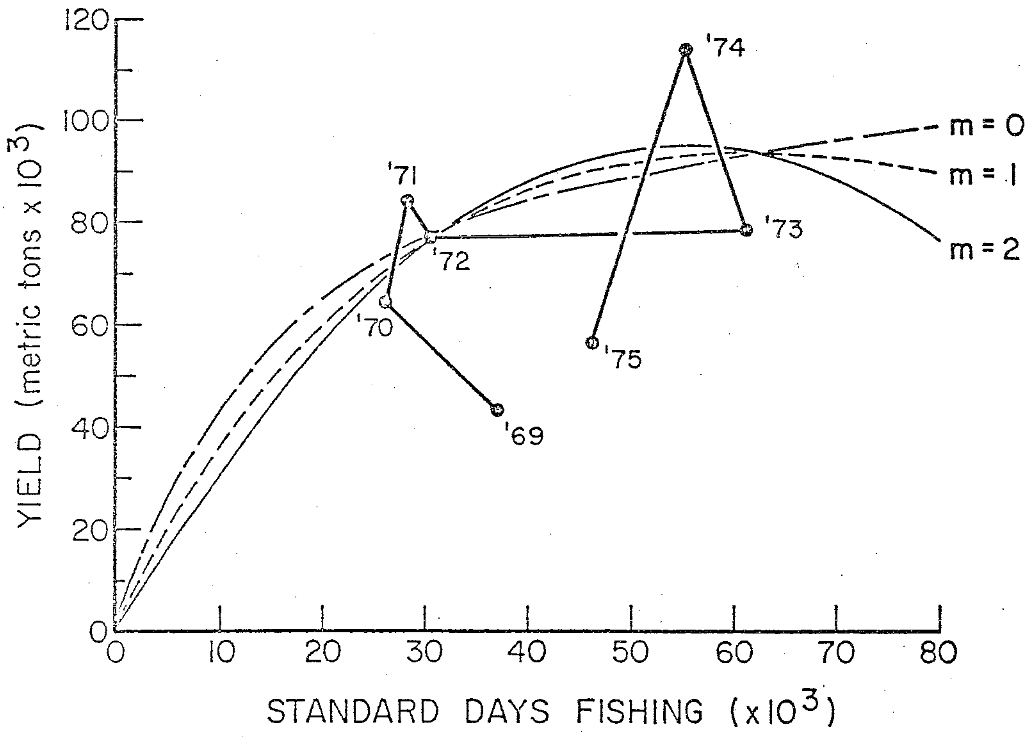

Figure 4. Relation between catch and standardized fishing effort for skipjack tuna of the eastern Atlantic Ocean. Average sustainable yield curves for three special cases of the production model with the assumption of two significant year classes are shown.

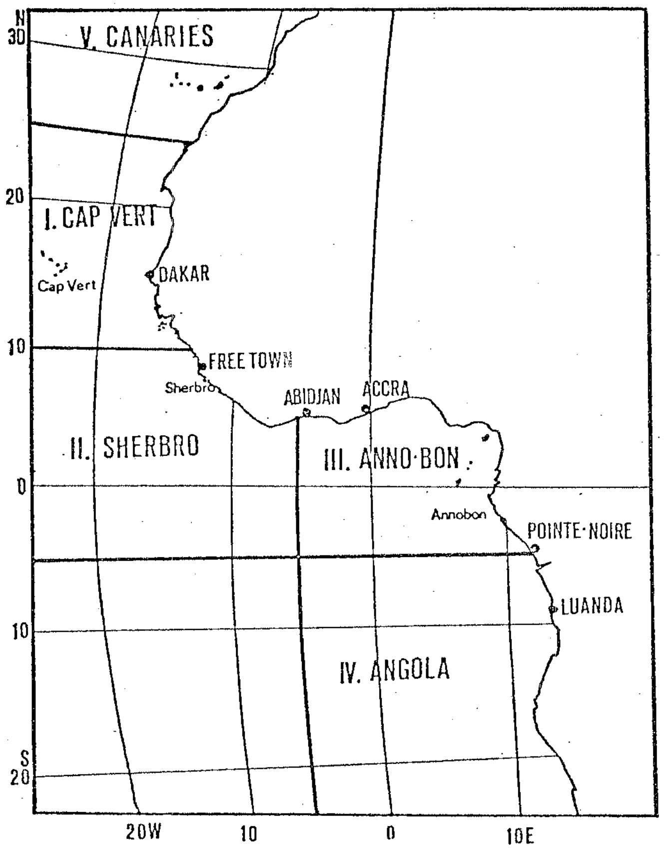

Figure 2. ICCAT statistical areas for skipjack tuna fishery data

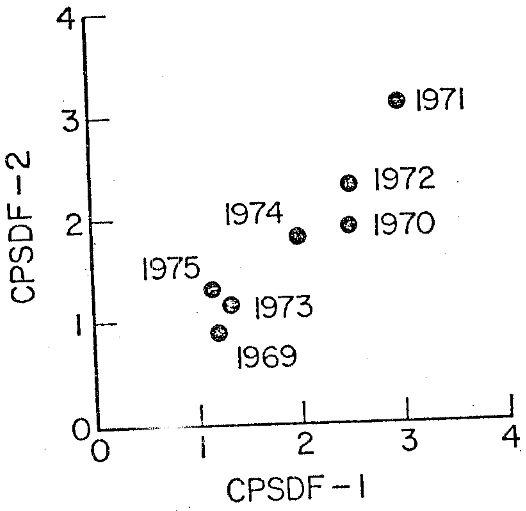

Figure 3. Correlation between catch per standard day's fishing of skipjack tuna estimated in this study (CPSDF-1) and by the ISRA Working Group (CPSDF-2)