AN EXAMINATION OF THE BASIS FOR A CATCH QUOTA REGULATION ON ATLANTIC YELLOWFIN TUNA

by

W. W. Fox, Jr. and W. H. Lenarz

SUMMARY

The production model approach (both the logistic and the generalized models) was used to estimate the maximum sustainable average yield (MSAY) of Atlantic yellowfin tuna from French-Ivory Coast-Senegalese catch-per-unit-effort data, 1964-71. Our estimate, based on the current constitution of the fishery, is about 75,000-80,000 metric tons for the total Atlantic and lies in the interval of 38,000-122,000 metric tons. The MSAY was estimated to be obtained with a fishing mortality coefficient, F, of about 0.6 - 0.7.

The seasonal catch-per-unit-effort of various segments of the fleet and the whole fleet combined were computed to aid in establishing an opening date should a quota system be instituted. The catch-per-unit-effort was highest, for those segments of the surface fleet considered, during the months of June through September. The highest catches-per-unit-effort were obtained by the Japanese longline fleet, however, in January through April. Taking an average weighted by the amount of catch between the surface and longline fleets, little difference is obtained for the season average catch-per-unit-effort unless the season is very short.

Three alternatives for management were discussed which are: (1) no quota because of inadequate data, a projected catch for 1972 greater than 1970 or 1971, and a changing constitution of the fishery; (2) the establishment of a quota of 75,000 - 80,000 metric tons; or (3) a closely monitored program of allowing fishing to continue above the estimated MSAY. The latter two alternatives require the implementation of a monitoring system not currently embodied in ICCAT.

EXAMEN DES FONDEMENTS D'UNE REGLEMENTATION DE LA PECHE DE L'ALBACORE DANS L'ATLANTIQUE PAR UN SYSTEME DE QUOTA DE CAPTURES

par

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RESUME

Le rendement maximal soutenu moyen (MSAY) de l'albacore dans l'Atlantique a été estimé par la méthode du modèle de production (modèle logistique et modèle généralisé) à partir des données de captures par unité d'effort (CPUE) de la flottille franco-sénégalo-ivoirienne, de 1964 à 1971. Notre estimation, qui se base sur les structures actuelles de la pêcherie, est d'environ 75.000 à 80.000 tonnes pour l'ensemble de l'Atlantique compris dans l'intervalle de 38.000 à 122.000 tonnes. Un coefficient F de mortalité due à la pêche d'environ 0,6-0,7 a été utilisé pour le calcul du MSAY.

Les CPUE saisonniers de divers secteurs de la flottille et ceux de la flottille dans son ensemble ont été calculés afin de permettre de fixer une date d ouverture au cas où un système de quota serait établi. Les CPUE les plus élevés dans les secteurs de la pêche de surface considérés se trouvent de Juin à Septembre. Cependant, dans le cas des palangriers japonais, les plus forts CPUE ont été obtenus de Janvier à Avril. A partir d une moyenne pondérée par le volume des prises de la flottille de surface et de la flottille palangrière, on n'observe que des différences minimes de CPUE saisonnier, à moins que la saison ne soit très courte.

Trois possibilités de contrôle ont été traitées: (1) pas de quota en raison des données incomplètes, de l'augmentation prévue des prises de 1972 par rapport à 1970 et 1971, et des structures changeantes de la pêcherie, (2) entrée en vigueur d un quota de 75.000 à 80.000 tonnes, (3) programme contrôlé de très près permettant à la pêche de progresser au-delà du MSAY estimé. Les deux dernières possibilités exigent la mise en place d'un système de contrôle dont l'ICCAT ne dispose pas à l'heure actuelle.

EXAMEN DE UNA BASE PARA LA REGULACION DE CUPOS DE CAPTURAS DEL RABIL EN EL OCEANO ATLANTICO

por

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RESUMEN

Se utilizó el método del modelo de producción (tanto el modelo logístico como el generalizado), para estimar el promedio de rendimiento máximo continuado (MSAY) de rabil en el Atlántico a partir de los datos de capturas-por-unidad-esfuerzo procedentes de la flota de Francia-Costa de Marfil-Senegal, correspondientes a 1964-71. Nuestra estimación, basada en la actual constitución de la pesquería, es aproximadamente de 75.000-80.000 toneladas métricas para todo el Atlántico y se halla en el intervalo de las 38.000-122.000 toneladas métricas. Se estimó que el MSAY se obtenía empleando un coeficiente de mortalidad, F, de unos 0,6-0,7.

Se calculó la captura-por-unidad-esfuerzo estacional de diversos sectores de la flota y de toda la flota combinada a fin de tratar de establecer una fecha de comienzo si hubiera de instituirse un sistema de cupos. Las capturas-por-unidad-esfuerzo más altas para aquellos sectores de la flota de superficie considerados tuvo lugar durante los meses de Junio a Septiembre. Sin embargo, las capturas-por-unidad-esfuerzo más elevadas fueron obtenidas por la flota japonesa de palangre, de Enero a Abril. Tomando una media ponderada por el volumen de pesca entre las flotas de superficie y de palangre, se obtiene poca diferencia en el promedio de capturas-por-unidad-esfuerzo estacional a menos que la temporada sea muy corta.

Se discutieron tres posibles alternativas de ordenación que son las siguientes: (1) no establecer cuota por falta de datos adecuados, una captura prevista para 1972 más elevada que la de 1970 o 1971, y la variabilidad de la estructura de la pesquería; (2) establecimiento de un cupo de 75.000-80.000 toneladas métricas; (3) un programa seguido muy de cerca que permita continuar la pesquería por encima del MSAY estimado. Las dos últimas alternativas requieren un sistema que permita seguir muy de cerca la pesquería y que todavía no está establecido en ICCAT.

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BACKGROUND

Fishery scientists, at several meetings, have concluded that increases in fishing effort in at least some of the Atlantic yellowfin tuna fisheries would not result in increased catch. FAO (1968) concluded that ". . .any increased longline fishing would at best increase the longline catch marginally, and might decrease it," but ". . .if the size of fish caught in the surface fishery does not decrease, then the presence of this fishery will probably tend to increase the total catch." The International Commission for the Conservation of Atlantic Tunas (ICCAT) Sub-Committee on Stock Assessment (ICCAT, 1971) concluded in its 1971 meeting that:

> "While the data available to the Sub-Committee gave a much poorer coverage of the fisheries than is desirable, and there was not time at the meeting to analyze the available data in detail, it appears fairly clear that the yellowfin fishery in the Atlantic is approaching or may even have reached, the point where control of the amount of fishing and/or sizes of fish caught is desirable. The Sub-Committee therefore strongly recommends that the SCRS take early steps to give detailed consideration to the practical action that would be required to control the amount of fishing, or the minimum sizes of fish caught. In making these recommendations the Sub-Committee recognizes that even if immediate action is initiated by the Committee it will require some considerable effort to develop and implement actual control on the fishery. By that time much better assessments of the state of yellowfin stocks will be available, including reasonable quantitative estimates of the annual catch that should be taken to achieve the prescribed objectives of the Commission."

The 1971 Commission meeting of ICCAT authorized the Council to recommend size regulations and to take other necessary conservation measures on yellowfin and bluefin tunas. The report of the June 1972 ICCAT Special Working Group on Stock Assessment of Yellowfin Tuna concluded that ". . .Since increasing effort will not give much increase in catch-per-recruit, and may cause a reduction in recruitment and therefore in total catch, the group believes it would be desirable to discourage any rapid increase in fishing beyond the present level, particularly in the existing geographical boundaries of the surface fishery of the eastern Atlantic" (ICCAT, 1972). The Japanese government has distributed a proposal to member governments of ICCAT which recommends a 70,000 metric ton catch quota for yellowfin tuna in the Atlantic. Under the proposal the fishing season would start in January. This paper was assembled in response to the above recommendations and proposals.

INTRODUCTION

A catch quota regulation is usually employed to ensure that fishing effort does not exceed that level which will produce the maximum sustainable average yield (MSAY).[1] There are basically three components to a catch quota regulation system similar to that employed by the Inter-American Tropical Tuna Commission (IATTC) and the International Pacific Halibut Commission (IPHC): (1) the estimation of the magnitude of the MSAY, (2) the setting of an opening date for fishing for the quota, and (3) the projection of a date for closing the season when the quota will be attained. There are many other possible ramifications of a quota-type regulatory system such as individual country quotas and special allocations for certain groups

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[1]The word "average" is inserted in the usual connotation MSY, because the "sustainable" yield will fluctuate even if fishing effort and the catchability coefficient remain constant. IATTC (1972) used the term, average maximum sustainable yield (AMSY), to denote a similar concept.

within the fishery, but these will not be dealt with in this paper. We will be concerned, therefore, only with the estimation of the MSAY and the establishment of an opening date.

ESTIMATION OF THE MSAY

The production model approach has been employed by IATTC and IPHC, for example, to estimate the maximum sustainable average yield (MSAY). This approach is simply an extension of the Lotka-Volterra equations into the situation of a population exploited by man. The production model makes use of only catch and fishing effort data, but the approach is such an over-simplification of the dynamic processes involved that the assumptions need to be made explicit. The basic assumptions about the population processes are: (1) there are no age-specific effects on population productivity, (2) the population is either closed or fortuitously behaves as if closed, and (3) the concept of equilibrium obtains for the population under study. Also, additional population assumptions must be made for particular estimation procedures. The assumptions about the data used in estimation are: (1) a sufficient amount of data is available covering reasonably large changes in population size due to fishing, (2) there has been no unaccounted change in the selective quality of the fishing gear, and (3) there has been no unaccounted change in fishing efficiency or population availability so that the coefficient of catchability remains constant.

The Model

The generalized production model (Pella and Tomlinson, 1969) is defined by three parameters--m, U_{max}, and Y_{max}. The parameter m defines the symmetry of the curve relating fishing effort to equilibrium yield (e.g., when m = 2 then the yield curve is a symmetrical parabola and is commonly known as the Schaefer or logistic model). U_{max} is the catch-per-unit-effort obtained as fishing starts on a virgin population. Y_{max} is the estimate of MSAY. Other useful parameters for management implications which can be derived or estimated from the first three are f_{opt}, the level of fishing effort to produce Y_{max}; U_{opt}, the catch-per-unit-effort at f_{opt}; and q, the catchability coefficient.

Currently, the two best procedures for estimating m, U_{max}, and Y_{max} are due to Gulland (1961) and Pella and Tomlinson (1969). With the Pella-Tomlinson procedure, however, it is necessary to make the additional assumption of an instantaneous response of the population processes to changes in population size. Gulland's procedure circumvents, at least in part, this assumption by estimating equilibrium conditions through averaging the fishing effort over some mean time period, $\bar{T}$, that a year class contributes significantly to the catch (see Gulland, 1969, p. 120). Fox (1972) designed a computer program, PRØDFIT, which uses a least-squares non-linear regression procedure and Gulland's equilibrium approximation technique to obtain estimates of the parameters of the generalized production model and estimates of the variability in the parameters. We utilized the program PRØDFIT in this study.

The Data

ICCAT (1972, Tables 1 and 5) presented the best available catch and effort data for the Atlantic yellowfin tuna fishery 1964-1971. Most of the data contributing to the index of abundance (see footnote Table 1) represented only 3 years, 1969-1971. Three sets of data, however, covered 6 years, 1966-1971--Point Noire purse seiners, Point Noire bait boats, and Dakar bait boats--and the Point Noire bait boats covered the period 1964-1971. Figure 1 is a scatter diagram indicating the degree of correlation among the three major data sources and their relation to the final index of abundance. The 8 years of data are shown in Table 1, along with the computed effective fishing effort, for the surface catch alone and the total Atlantic catch combined. It is worth noting that while these data are the best currently available, they may not be comparable to the standardized data available for the yellowfin tuna fishery of the eastern Pacific. That is to say, that there have been no comprehensive studies on the reliability of the Atlantic catch and effort data similar to those undertaken by IATTC for the Pacific. Nonetheless, the indices of abundance, derived solely from the surface fishery, indicate an apparent 54% reduction in stock size from 1964-1971 which may be related to both the over two-fold increase in effective fishing for the surface fishery or the little over 100% increase in effective effort for the total fishery (Table 1).

The Results

The data from Table 1 were fit to both the logistic production model (m = 2) and the generalized production model for both the surface and total data with the

Table 1.--Catch and effort data for the Atlantic yellowfin tuna fishery 1964-71[1]

Year	(a) Index of abundance	(b) Surface catch (thousand metric tons)	(c) Effective surface effort (b)/(a)	(d) Total Atlantic catch (thousand metric tons)	(e) Effective total effort (d)/(a)
1964	0.191	29.5	154.	68.0	356.
1965	0.147	23.7	161.	64.1	436.
1966	0.180	37.7	209.	64.7	359.
1967	0.136	36.4	268.	58.0	426
1968	0.161	52.8	328.	81.1	504.
1969	0.125	61.8	494.	93.4	747.
1970	0.087	44.8	515.	76.9	884.
1971	0.088	43.9	499	68.6	780.

[1] Data source ICCAT (1972, Tables 1 and 5). The index of abundance was obtained in ICCAT (1972) by (i) normalizing the catch-per-unit effort of each gear type through dividing the yearly catch/effort by the mean value for the years in which data were available, (ii) an area mean index of abundance was computed over gear types, and (iii) the total index of abundance [column (a) above] was obtained by averaging over the three area indices and dividing by 10.

computer program PRØDFIT (Tables 2 and 3). Several averaging times (1-4 years) were used, but based on the weight-frequency diagrams of ICCAT (1972, Figure 11) and the growth equation of Le Guen and Sakagawa (in press) a year-class apparently contributes significantly to the catch for about 4 years. We, therefore, selected $\bar{T} = 2$ as the appropriate averaging time.

For the surface fishery alone, the logistic production model estimates the MSAY at 47.3 thousand metric tons (tmt) with a confidence region[2] of ± 19 tmt (Table 2). The estimated fishing mortality coefficient $\hat{F}$, to obtain the MSAY is 0.48 ($\hat{f}_{opt} \times \hat{q}$). Figure 2 shows the data and the fitted logistic production model--the fit is reasonably good. The minimum sum of squares was not found for the generalized production model (Table 2), but the likely estimate of the MSAY is in the range of 50-55 tmt. Using the surface fishery data alone, however, additionally assumes either that the longline fishery operates on a different population than the surface fishery or that the longline fishery's effective effort has remained and will continue to remain constant. ICCAT (1972, Table 2) indicates that there has been a sharp decline in the nominal Japanese longline fishing effort 1964-1966, but it appears to have stabilized 1967-1971. ICCAT (1972, Table 1), however, shows that Korean and Taiwanese longline catches have increased sharply 1967-1971 such that the total effective effort of the longline fishery may have remained near the level in the Japanese longline fishery 1964-1966.

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[2]The confidence region was established with delta method variance estimates and Chebyschev's Inequality. It is approximately a 95% confidence interval; it would be exact if the production model were linear, if the fishing effort were measured without error, and if the usual assumptions about the error terms were fulfilled.

Table 2.--Atlantic yellowfin tuna surface fishery alone production model parameters estimated with PRODFIT

$\bar{T}$ (years)	$\hat{m}$	$\hat{U}_{max}$	$\hat{U}_{opt}$	$\hat{Y}_{max}$ (thousand metric tons)	$\hat{f}_{opt}$	$\hat{q}$	$\hat{F}$
Logistic Model							
1	2.0 [1]	0.216	0.108	52.0 (± 22)	482.	0.000645	0.311
2	2.0 [1]	0.213	0.106	47.3 (± 19)	444.	0.001069	0.475
3	2.0 [1]	0.219	0.110	44.6 (± 19)	407.	0.001018	0.414
4	2.0 [1]	0.209	0.105	40.2 (± 21)	384.	0.000697	0.268
Generalized Model							
1	5.65 [2]	0.189 [2]	----	56.9 [2]	--	----	----
2	4.64 [2]	0.183 [2]	----	51.2 [2]	--	----	----
3	1.77	0.226	0.108	44.2 (± 19)	411.	0.001370	0.563
4	1.97	0.210	0.104	40.1 (± 21)	384.	0.000648	0.249

[1] Defined.

[2] Minimum sum of squares not located.

Table 3.--Total Atlantic yellowfin tuna fishery production model parameters estimated with PRØDFIT

$\bar{T}$ (years)	$\hat{m}$	$\hat{U}_{max}$	$\hat{U}_{opt}$	$\hat{Y}_{max}$ (thousand metric tons)	$\hat{f}_{opt}$	$\hat{q}$	$\hat{F}$
Logistic Model							
1	2.0[1]	0.235	0.118	82.4 (± 36)	700.	0.000800	0.560
2	2.0[1]	0.229	0.115	76.8 (± 38)	670.	0.001036	0.694
3	2.0[1]	0.235	0.118	72.5 (± 36)	617.	0.000648	0.400
4	2.0[1]	0.228	0.114	65.3 (± 37)	572.	0.001395	0.798
Generalized Model							
1	2.14	0.231	0.119	82.8 (± 36)	698.	0.000778	0.543
2	3.13	0.203	0.119	80.0 (± 42)	674.	0.000890	0.600
3	0.00	2.26	0.000	70.6 (± ∞)	∞	0.000984	∞
4	0.70	0.380	0.116	63.0 (± 34)	544.	0.001220	0.664

[1] Defined.

For the total Atlantic yellowfin tuna fishery, the logistic production model (Table 3) estimates the MSAY at 76.8 tmt, with a confidence region of ± 38 tmt and an F of 0.69. The generalized production model (Table 3) estimates the MSAY at 80.0 tmt, with a confidence region of ± 42 tmt and an F of 0.60. The data are plotted in Figure 3 along with both of the fitted production models. The generalized production model (dashed line Figure 2B) predicts a somewhat alarmingly rapid decline in catch with overfishing even at the 1971 level. We believe that the true yield curve does not fall off as rapidly as the generalized production model estimates; however, fishing beyond the 1971 level should be closely monitored to be prudent.

ESTIMATION OF THE OPTIMAL OPENING DATE

The opening date of the fishing season is an important factor because if a date is chosen that allows fishing to occur when yellowfin are most available and vulnerable to the fishery then the resources allocated to fishing will be used efficiently. On the other hand, if the opening date of the fishing season is chosen such that fishing occurs when yellowfin are not most available and vulnerable to the fishery then the resources allocated to fishing will be used inefficiently.

Estimates of monthly catch-per-effort of yellowfin tuna by four fleets in the Atlantic, averaged over 3 years, were examined to determine the optimum opening date of a fishing season for yellowfin, if the fishery were regulated. Catch-per-effort for each fleet were normalized by dividing monthly values by the annual average of the fleet. Unweighted fleet averages were then calculated by summing over years and dividing by three. Averages for the combined France-Ivory Coast-Senegal (FIS) fleets were calculated using catches by each fleet as weights. Averages for the combined surface and longline fleets were calculated using catches by total surface and longline fleets during 1969-1971 period as weights. Estimates of unweighted average catch-per-effort for a fishing season of a specified length and opening date were also made.

Data for the FIS ice boat, bait boat, and average seiner fleets were obtained from Fonteneau[2] (personal communication) for the 1969-1971 period. These fleets operate close to the coast of western Africa. Data for the Japanese longline fleet for the 1968-1970 period were obtained from the Fisheries Agency of Japan (1970, 1971, 1972). All catch and effort data in the area defined by Hayasi et al. (1970) were used for the catch-per-effort calculations. This area roughly includes all of the Atlantic Ocean bounded by 20° N and 15° S. Since longline vessels pursue a number of species other than yellowfin tuna in the area used for this study, it is possible that the effort data is not a good measure of effort for yellowfin only.

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[2]Fishery scientist, ORSTOM, Ivory Coast.

Monthly averages for each fleet and combined fleet are presented in Table 4. Figure 4 illustrates monthly indices of catch-per-effort of yellowfin tuna by the FIS surface fleets. There is some variability among fleets, but there is a general trend for a peak in January and June. The combined indices for the FIS surface fleets have a definite peak in June (Figure 4B). Average indices of catch-per-effort by the FIS surface fleet for season of 2-11 months duration starting in each month of the year are shown in Figure 5. When the season length is long there is almost no relation between opening date and the index of catch-per-effort. When the season length shortens (e.g., 5 months) there is a marked advantage in starting the fishing season in June rather than in January or December. Indeed, when the season is only 5 months long the average index is 27% higher when the season is opened in June instead of January.

Monthly averages of the indices of catch per effort for the surface (FIS) and longline fleets are compared in Figure 6A. The peak for the longline fleet occurs in March while the peak for the surface fleet occurs in June. The monthly averages of indices of catch per effort for the combined fleets shows a peak in June (Figure 6B). Average indices of catch per effort by all Atlantic fleets for season of 2-11 months duration starting in each month are shown in Figure 7. The results are similar to those shown in Figure 5 in that when the season is long there is little relation between opening date and the indices of catch per effort. As the season shortens differences increase and June becomes the best month to open the season. Differences among opening dates are not as great as when only the surface fishery is considered.

Table 4.--Three-year averages of normalized monthly values of catch-per-effort for yellowfin tuna

	FIS (1969-71)				Japan (1968-70) longline	Weighted average of FIS and Japan
	Ice boat	Bait boat	Average seiners	Weighted average		
January	1.355	1.056	1.080	1.118	1.157	1.132
February	1.263	0.862	0.723	0.852	1.421	1.058
March	0.724	0.825	0.963	0.883	1.525	1.115
April	1.043	0.961	0.816	0.896	1.350	1.060
May	1.083	0.747	0.864	0.865	0.828	0.852
June	2.003	0.783	1.850	1.558	0.929	1.330
July	1.599	1.121	1.137	1.208	0.866	1.084
August	0.721	0.964	1.142	1.020	1.085	1.044
September	0.694	1.297	1.306	1.204	0.806	1.060
October	0.432	1.253	0.808	0.879	0.843	0.866
November	0.464	1.151	0.610	0.747	0.565	0.681
December	0.617	0.981	0.701	0.771	0.626	0.719

DISCUSSION AND RECOMMENDATIONS

Both a maximum sustainable average yield (MSAY) and an optimal opening date for the Atlantic yellowfin tuna fishery have been estimated. It is necessary, however, to recount our reservations and to formulate a set of recommendations to ICCAT.

Catch Quota

Our point estimate of the MSAY for the total Atlantic yellowfin tuna fishery lies between 75-80 thousand metric tons (tmt) and in the interval of 38-122 tmt as the fishery is now constituted. The constitution of the fishery (i.e., distribution of effort geographically, seasonally, and among gear types) is very important and any changes should be closely monitored. The data used in this analysis are somewhat crude relative to those available to IATTC. The confidence region of about ± 50% of the estimated MSAY for the Atlantic is very high compared to a similarly estimated confidence region on the order of ± 10% for the eastern Pacific bait boat data, 1934-1967, due partly to the crudeness of the data, but due also to the few years for which data are available. Nevertheless, the fact that the total yellowfin tuna catch has not substantially increased in the face of rapidly mounting fishing effort is evidence that some plateau as the fishery is now constituted may have been reached.

There are several alternatives that ICCAT could follow: (1) Since the data are relatively poor in quality and short in length, the Commission may wish to wait until more data are available before enacting a quota system. This alternative could lead to the establishment of an entirely different production model. If, on the other hand, the present parameter estimates and the logistic model are reasonably accurate, then continued fishing at a level 50% above that for 1971, for example, would result in a sustainable average yield 55% less than the maximum. (2) The Commission could set a rigid quota of 75-80 tmt. This alternative could impair reasonable development of the fishery if indeed the true MSAY were higher. (3) The Commission, realizing that the fishery may have attained some plateau, could enact an experimental program of "overfishing" (i.e., relative to the estimate of the MSAY) to determine the MSAY empirically. This third alternative has been adopted by IATTC for determining the MSAY of the eastern Pacific yellowfin tuna fishery. Since the model predicts an MSAY of 75-80 tmt (± 50%), a reasonable base for "overfishing" would be 95-100 tmt.[3] Provisions would be needed (a) to provide substantial incremental increases in the quota should the population remain in a productive condition, and (b) to curtail fishing should the population show any signs of substantial true overfishing.

In order to implement an overall catch quota regulation, a competent system for near real-time monitoring of the status of the population and the fishing fleet would have to be established. This would involve (1) the compilation of accurate and complete catch statistics from all countries involved and with less than a 6-month time delay, (2) a uniform logbook system covering a majority of the

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[3]IATTC established its experimental program of overfishing with a quota of 120,000 short tons, 25% above the MSAY estimate of 95,000 short tons.

international fishing fleet, and (3) a reporting system such that the total landings plus catch still at sea and the number and capacities of vessels from all countries at sea are known on a weekly basis. Also, a reliable system for enforcing the regulation would be needed.

Opening Date

While there appears to be little reason to choose a given opening date when the open season is long, as the season shortens there is a definite advantage for choosing June as the opening date. Experience in the eastern tropical Pacific yellowfin fishery suggests that if a catch quota regulation is imposed on the Atlantic fishery, the season will become progressively shorter. For practical purposes the open season in the eastern tropical Pacific fishery is now less than 5 months. Since it would be difficult to shift opening dates once the season is shortened, June appears to be the best month for opening the season if a catch quota regulation is imposed on the Atlantic yellowfin tuna fishery. However, we have ignored the effect of fishing and season length on the catch rate of subsequent months. This study, therefore, should be considered as only a first attempt.

Regulatory Area

The report of the ICCAT Special Working Group on Stock Assessment of Yellowfin Tuna (ICCAT, 1972) recommended that ". . . rapid increase in fishing effort beyond the present level should be discouraged particularly in the existing geographical boundaries of the surface fishery of the eastern Atlantic." The above consideration of the existing boundaries of the fishery is an important one because if there is not rapid mixing of yellowfin among areas of the Atlantic, an expansion of the fishing grounds could result in an increase in the amount of yellowfin available to the fishery and then an increase in the potential yield to the fishery.

The history of the yellowfin fishery of the eastern tropical Pacific reveals that an expansion in the area fished for yellowfin is associated with an increase in apparent sustainable yield of the fishery (IATTC, 1972). Figure 8 of this paper (IATTC, 1972; Figure 1) illustrates the area fished in the eastern tropical Pacific prior to the expansion of the fishing grounds subsequent to 1960. Figure 9 (IATTC, 1972; Figure 3) shows the distribution of catches in 1971 and demonstrates that large amounts of yellowfin were captured in 1971 in areas that had not been exploited before 1961. Figure 10 (IATTC, 1972; Figure 24) illustrates the relationship between sustainable average yield and fishing effort for the historical fishing grounds (solid circles connected by line and curve A), new fishing grounds (open circles and curve B), and combined fishing grounds (X's and curve C). It is apparent that the expansion of the fishing grounds is associated with an increase in yield of the fishery, but the actual causes have not yet been demonstrated.

Figures 11 and 12 illustrate the distribution of total fishing effort and yellowfin catch of the American fleet by 1° x 1° areas in the Atlantic for the period 1967-1971.

Almost all areas of high effort are within 120 miles (2°) of the coast, but several areas of high yellowfin catches occur considerably further offshore. For example, in the 1° area bounded by 0° N, 1° W and 1° N, 2° W, 1,135 tons of yellowfin have been captured by the American fleet between 1967 and 1971 with 32.5 days of fishing effort. All of the yellowfin were captured in November 1969 when 27.5 days of effort occurred. Three days of fishing effort occurred in July 1970, 1 day in September 1970, and 1 day in July 1971. Although this area has produced very good fishing it has barely been explored by the American fleet. On the other hand, only 639 tons have been captured in the 1° area bounded by 4° N, 0° W and 5° N, 1° W even though 184 days of fishing effort have been expended there covering 14 of the 25 months that have been fished by the American fleet.

Figures 13 and 14 illustrate fishing effort and yellowfin catches of the FIS fleet by 1° areas in 1970 (ORSTOM, 1971). Almost all areas receiving high amounts of effort occurred fairly close to the coast or near offshore islands.

It appears that the surface fishery for yellowfin in the eastern tropical Atlantic has concentrated most of its effort near shore even though the offshore region appears to have a potential for producing large catches of yellowfin. The proximity to shore of the surface fishery for yellowfin in the Atlantic is reminiscent of the early history of the eastern tropical Pacific. If regulations are not imposed in the Atlantic fishery, the offshore areas will probably be explored eventually and the potential MSAY realized. If regulations are imposed which encourage exploration of offshore areas (for example a catch quota within the present boundary of the surface fishery), then the potential MSAY should be realized earlier. If regulations are imposed which discourage exploration of offshore areas (for example, a catch quota for the entire Atlantic), then realization of the potential MSAY will likely be delayed. Since there are many nations involved in the fishery, it would probably be difficult to enforce a catch quota for a specified area because of the difficulty in determining where catches are made. An alternative regulation that would be simpler to enforce and still encourage offshore fishing would be to close the nearshore area(s) to fishing when the catch of yellowfin in the entire Atlantic reaches a specified level.

This paper presents some of the scientific aspects of the results of possible decisions made by ICCAT concerning regulation of the Atlantic yellowfin tuna fishery. We are not specifically recommending that a catch quota system be imposed on the fishery. We feel that the decision makers should carefully weigh the possible benefits and liabilities discussed in this paper as well as the problems involved in enforcing regulations and obtaining the necessary improvements in the data collection system before making the final decisions.

STATUS OF THE FISHERY, 1972, AND ITS RELATION TO A CATCH QUOTA

The 3-year decline in yellowfin catches, 1969-71 (Table 1), does not appear to be a continuing general decline in the fishery. Preliminary projections for 1972 indicate that the 1972 catch will likely equal or perhaps exceed the 1970 level. The cumulative catch by the French-Ivory Coast-Senegal fleet reported in "La Peche Maritime" through August is greater than either 1970 or 1971. The yellowfin catch of the American fleet is likely to be much greater than 1971 and even larger than 1970; about 22,000 short tons of tuna have been landed through mid-October which early samples indicate could be more than 50% yellowfin tuna.

While it appears that catch may be up, there are also indications that fishing effort is also up--at least in the American fleet. Fishing in the Atlantic by the American fleet began earlier than usual in 1972. In addition, the number of vessels currently in the eastern Atlantic is in the mid-30's, whereas the previous high was 25 vessels in 1969.

This very preliminary information indicates that the 1972 data point will likely fall above either equilibrium line in Figure 3A and to the right of the other points. The actual place where 1972 will be located is impossible to determine at this time, but it likely will not alter the parameters of the logistic production model drastically. On the other hand, the shape of the generalized production model likely will be changed significantly. The net result of a point falling in this location would be to increase the estimate of the MSAY and cause it to occur at a higher level of fishing effort.

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FIGURES

Figure 1.--Scatter diagrams of indices of abundance of Atlantic yellowfin tuna for three gear types, 1966-71, among themselves (A-C) and against the final index of abundance (D-F). The dashed line is a 45° bisector.

Figure 2.--Plots of catch and fishing effort data for the Atlantic yellowfin tuna surface fishery with (A) the equilibrium relationship between the index of abundance and fishing effort, and (B) the relationship between sustainable average yield and fishing effort.

Figure 3.--Plots of catch and fishing effort data for the entire Atlantic yellowfin tuna fishery with (A) the equilibrium relationship between the index of abundance and fishing effort, and (B) the relationship between sustainable average yield and fishing effort.

Figure 4.--(A) Monthly indices of catch-per-effort of yellowfin tuna for the three FIS surface fleets. (B) Monthly indices of catch-per-effort of yellowfin tuna for the combined FIS surface fleets.

Figure 5.--Average index of catch-per-effort of yellowfin tuna for combined FIS surface fleets for seasons of 2-11 months starting in each month of the year.

Figure 6.--(A) Monthly indices of catch-per-effort of yellowfin tuna for the combined FIS fleets (surface) and Japanese longline fleet. (B) Monthly indices of catch-per-effort of yellowfin tuna for the entire Atlantic fishery.

Figure 7.--Average index of catch-per-effort of yellowfin tuna for the entire Atlantic fishery for seasons of 2-11 months starting in each month of the year.

Figure 8.--The eastern Pacific Ocean showing the historic area, A1, of the fishery for yellowfin tuna (striated) and more recently fished region within the Commission Yellowfin Tuna Regulatory Area (CYRA) referred to as Area A2 (shaded), and area outside of CYRA which is referred to as Area A3. The numbers within the blocked area represent sampling locations for length-frequency samples (IATTC, 1972, Figure 1).

Figure 9.--Distribution (5° areas) of yellowfin tuna catches by purse seiners during 1971, non-regulated trips only (IATTC, 1972, Figure 3).

Figure 10.--Relationships between effort and catch for the yellowfin tuna fishery within the CYRA. Curve B represents the outer area within the CYRA (A2), curve A represents the inner area of the CYRA (A1), curve C represents the best fit to the combined data of areas A1 and A2, and curve A + B represents an addition of curves A and B.

Figure 11.--Percent of total effort by 1° square for American fleet (1967-1971) in the eastern tropical Atlantic.

Figure 12.--Percent of yellowfin tuna catch by 1° square for American fleet (1967-1971) in the eastern tropical Atlantic.

Figure 13.--Effort of FIS fleet by 1° square (1970) in the eastern tropical Atlantic (ORSTOM, 1971).

Figure 14.--Catch of yellowfin tuna by FIS fleet by 1° square (1970) in the eastern tropical Atlantic (ORSTOM, 1971).

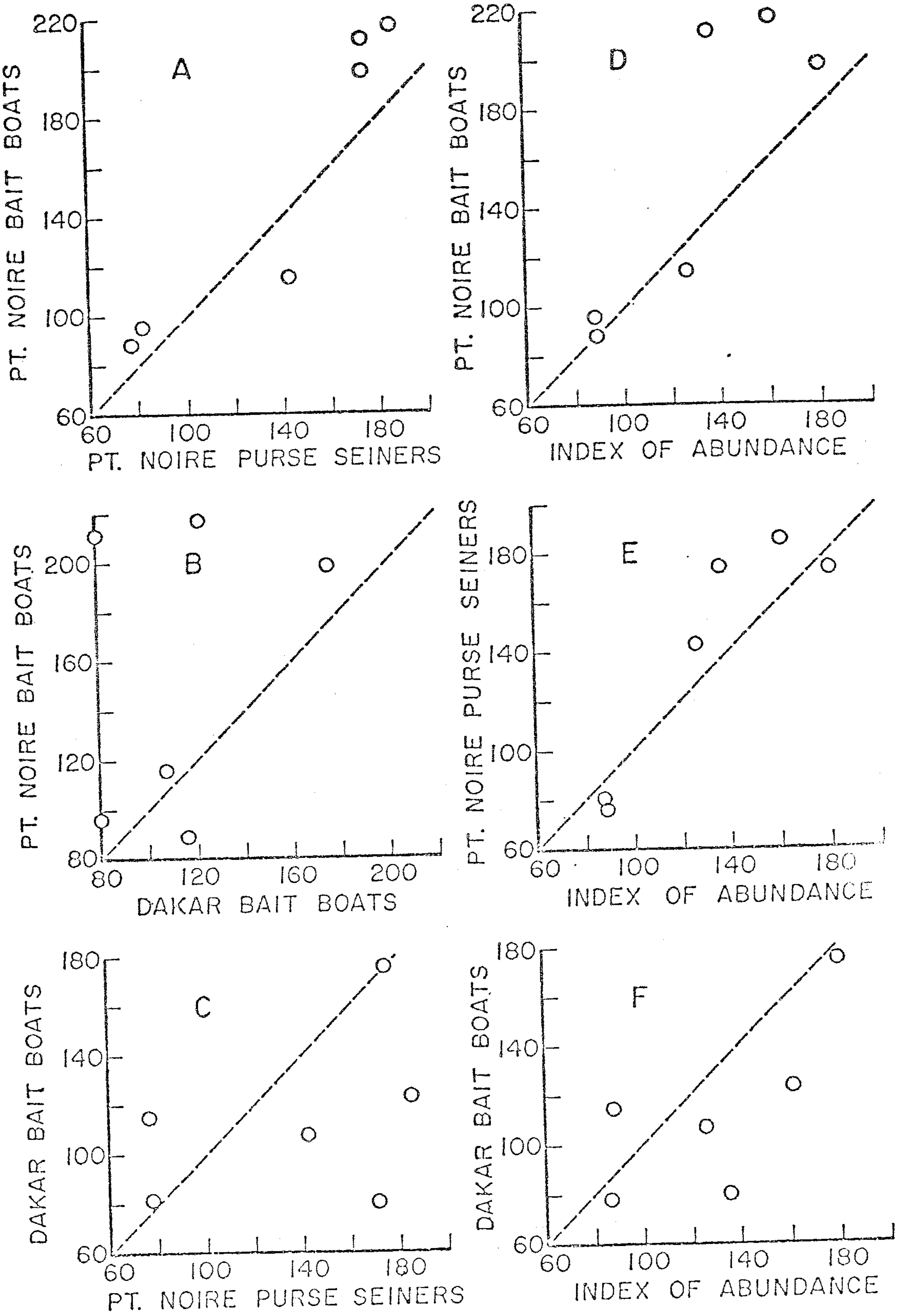

A
PT. NOIRE BAIT BOATS
PT. NOIRE PURSE SEINERS
220 180 140 100 60
60 100 140 180
D
PT. NOIRE BAIT BOATS
INDEX OF ABUNDANCE
220 180 140 100 60
60 100 140 180
B
PT. NOIRE BAIT BOATS
DAKAR BAIT BOATS
200 160 120 80
80 120 160 200
E
PT. NOIRE PURSE SEINERS
INDEX OF ABUNDANCE
180 140 100 60
60 100 140 180
C
DAKAR BAIT BOATS
PT. NOIRE PURSE SEINERS
180 140 100 60
60 100 140 180
F
DAKAR BAIT BOATS
INDEX OF ABUNDANCE
180 140 100 60
60 100 140 180

Figure 1

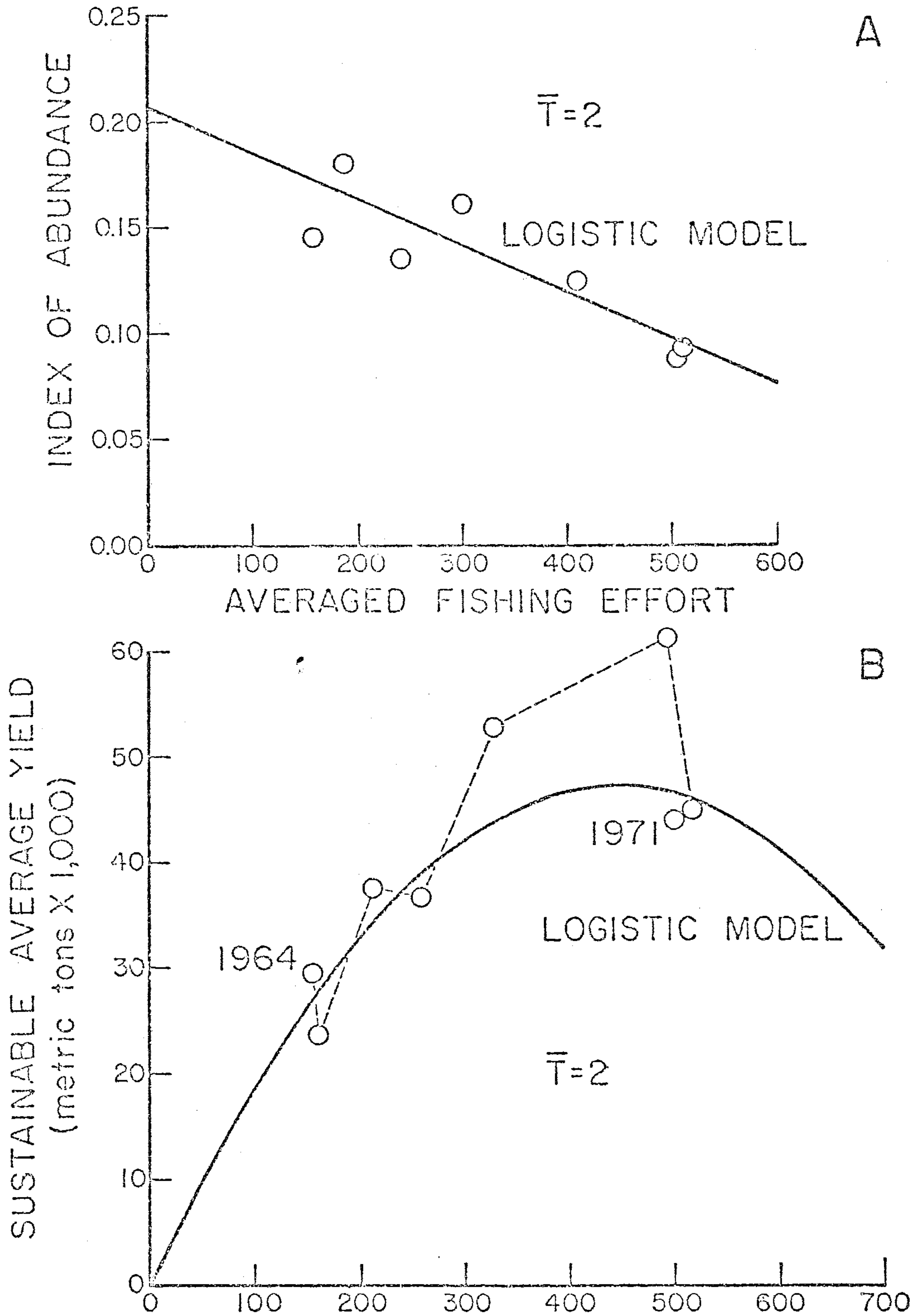

A
T̄=2
LOGISTIC MODEL
INDEX OF ABUNDANCE
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
600
AVERAGED FISHING EFFORT
B
1971
LOGISTIC MODEL
1964
T̄=2
SUSTAINABLE AVERAGE YIELD
(metric tons X 1,000)
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
FISHING EFFORT

Figure 2

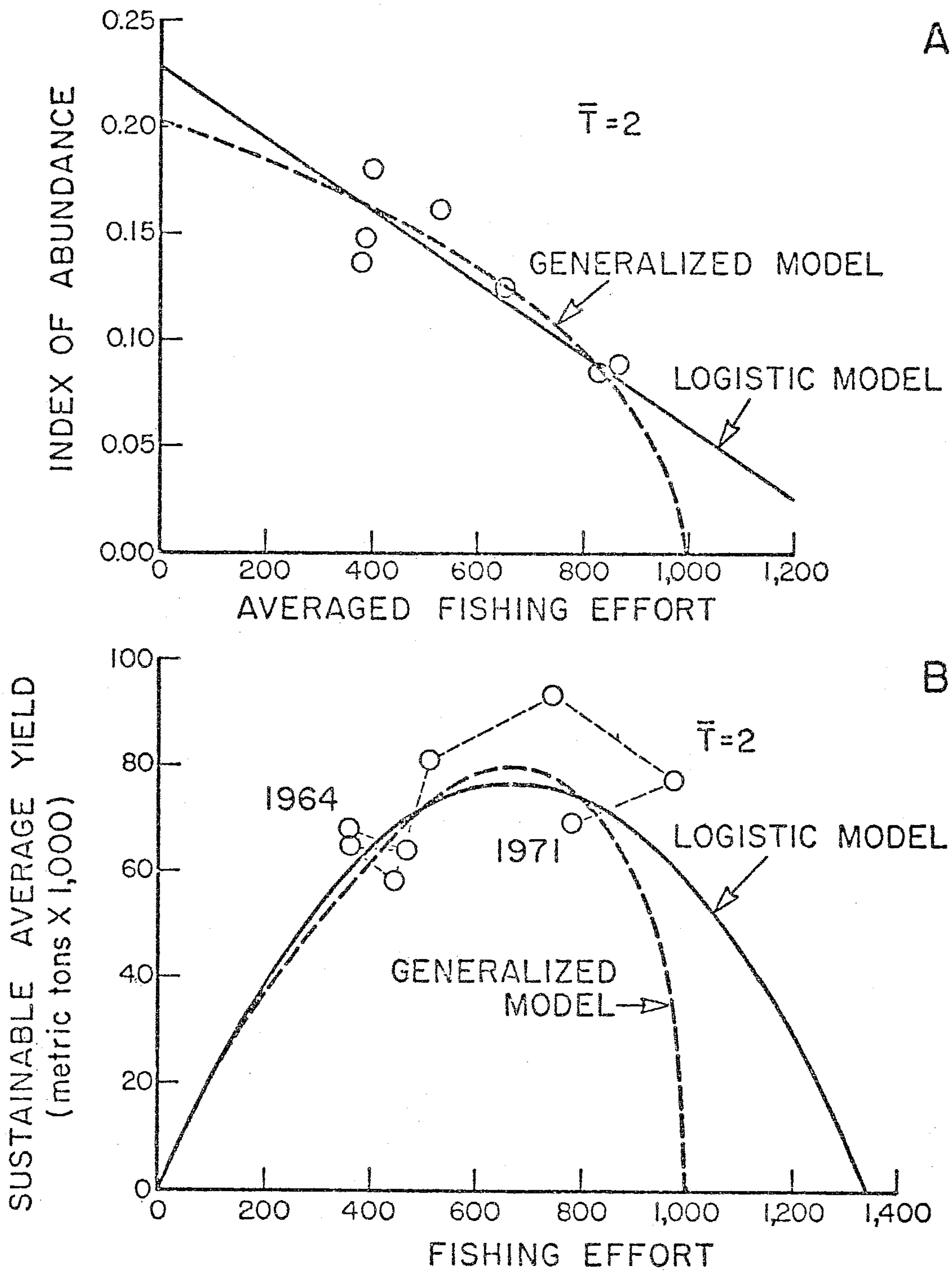

A
T̄=2
INDEX OF ABUNDANCE
0.25
0.20
0.15
0.10
0.05
0.00
GENERALIZED MODEL
LOGISTIC MODEL
0
200
400
600
800
1,000
1,200
AVERAGED FISHING EFFORT
B
T̄=2
SUSTAINABLE AVERAGE YIELD
(metric tons X 1,000)
100
80
60
40
20
0
1964
1971
LOGISTIC MODEL
GENERALIZED
MODEL
0
200
400
600
800
1,000
1,200
1,400
FISHING EFFORT

Figure 3

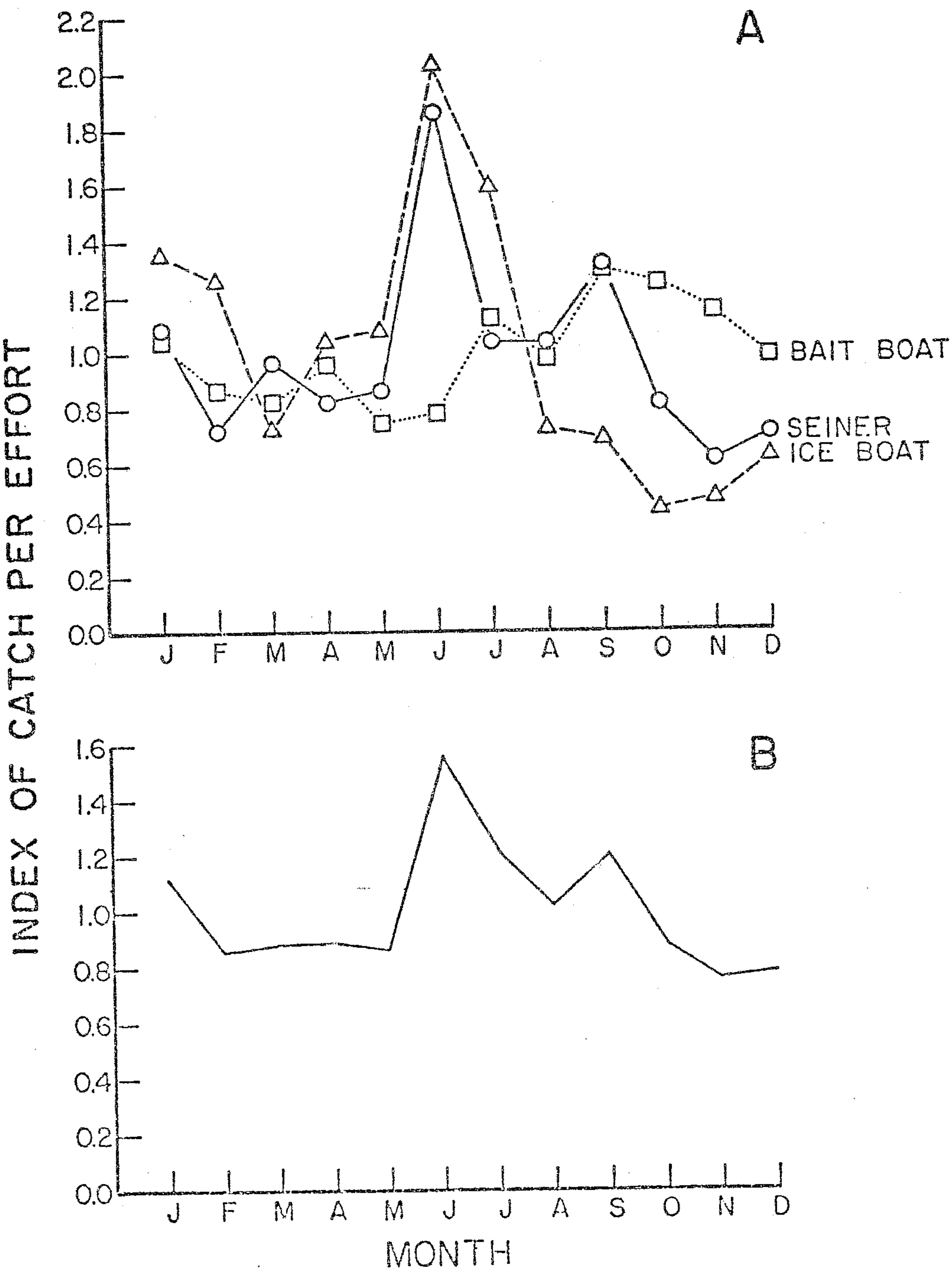

A
B
INDEX OF CATCH PER EFFORT
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J F M A M J J A S O N D
BAIT BOAT
SEINER
ICE BOAT
MONTH

Figure 4

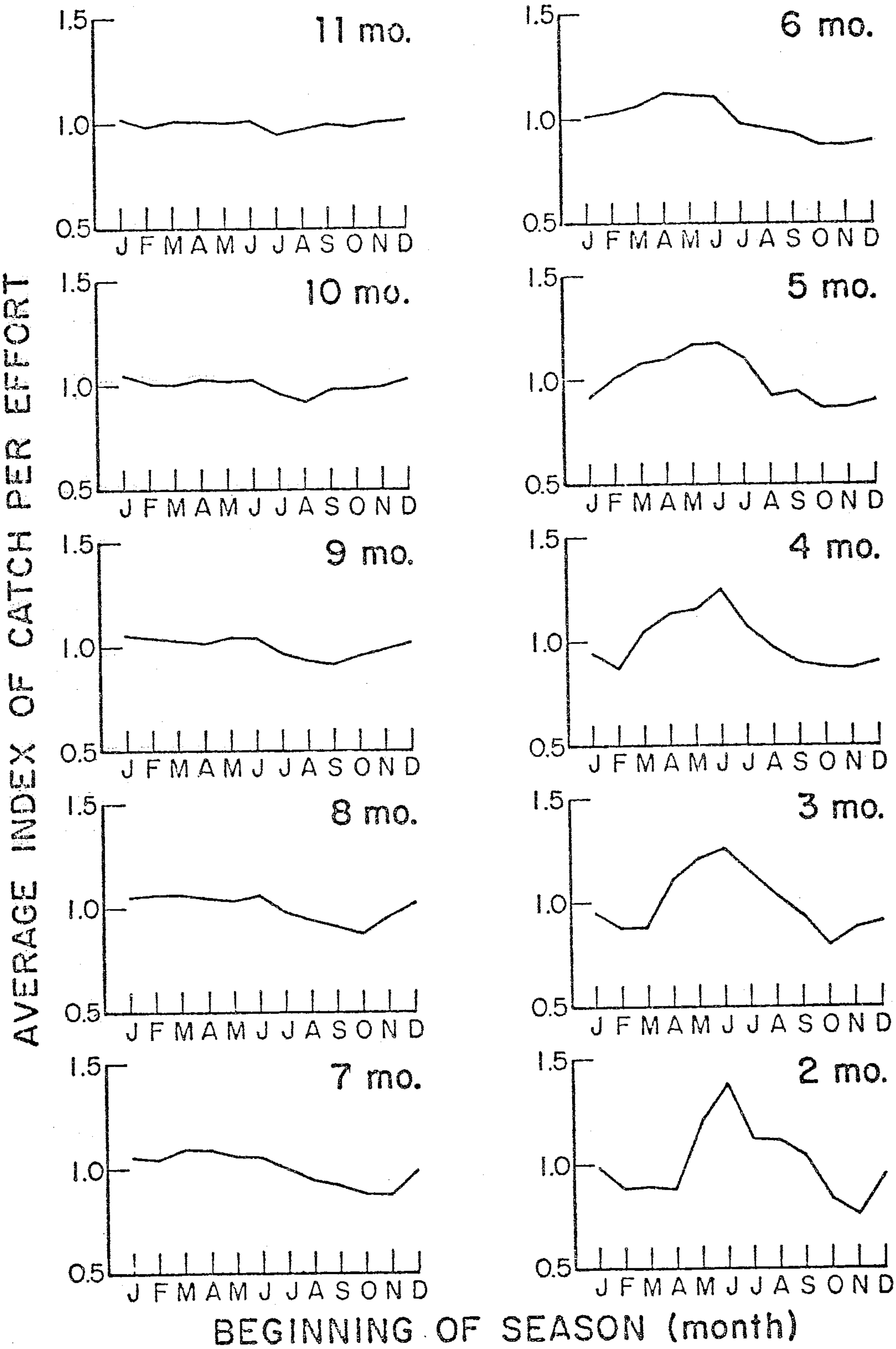

AVERAGE INDEX OF CATCH PER EFFORT
11 mo.
10 mo.
9 mo.
8 mo.
7 mo.
6 mo.
5 mo.
4 mo.
3 mo.
2 mo.
1.5
1.0
0.5
J F M A M J J A S O N D
BEGINNING OF SEASON (month)

Figure 5

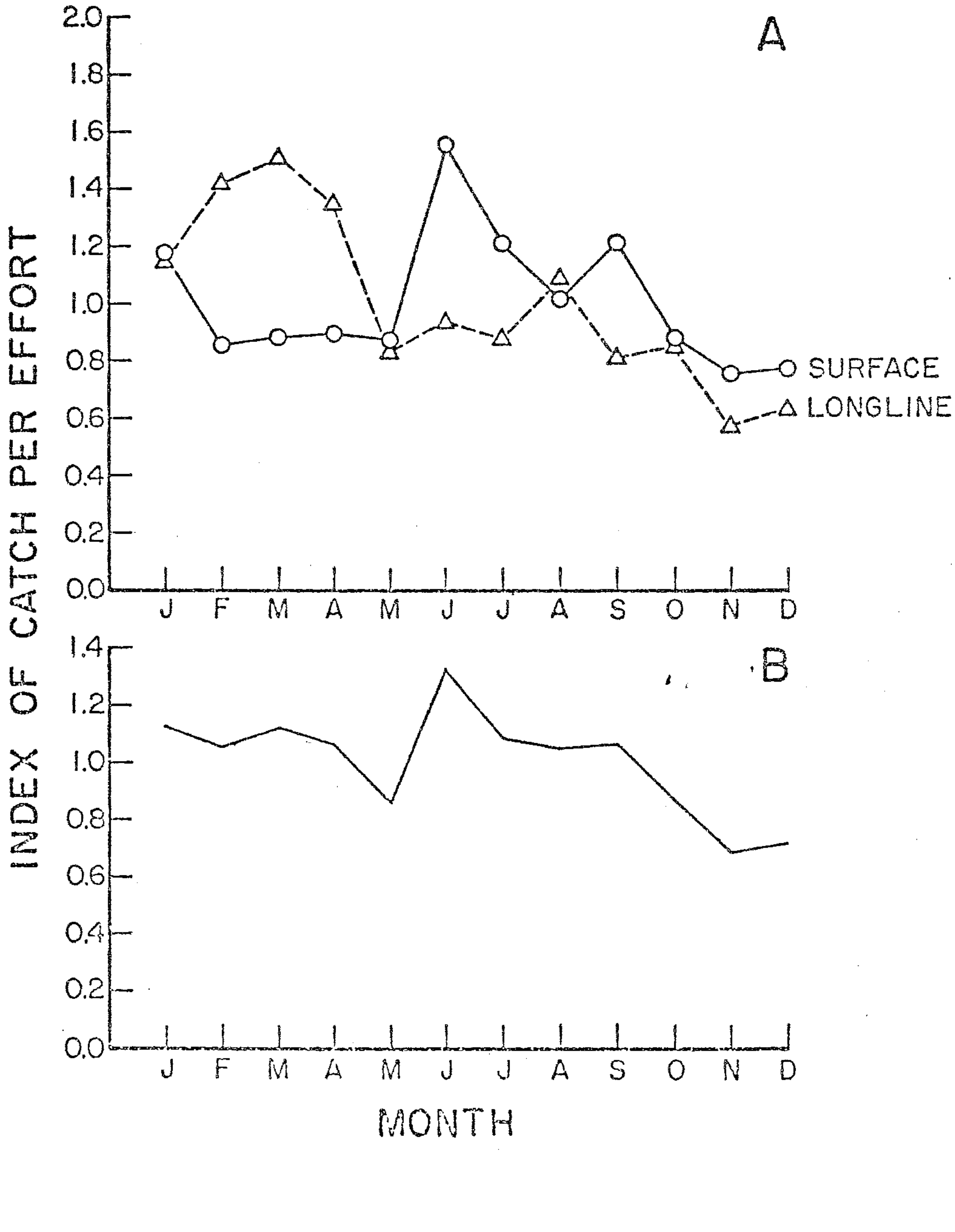

A
SURFACE
LONGLINE
B
INDEX OF CATCH PER EFFORT
MONTH
J F M A M J J A S O N D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

Figure 6

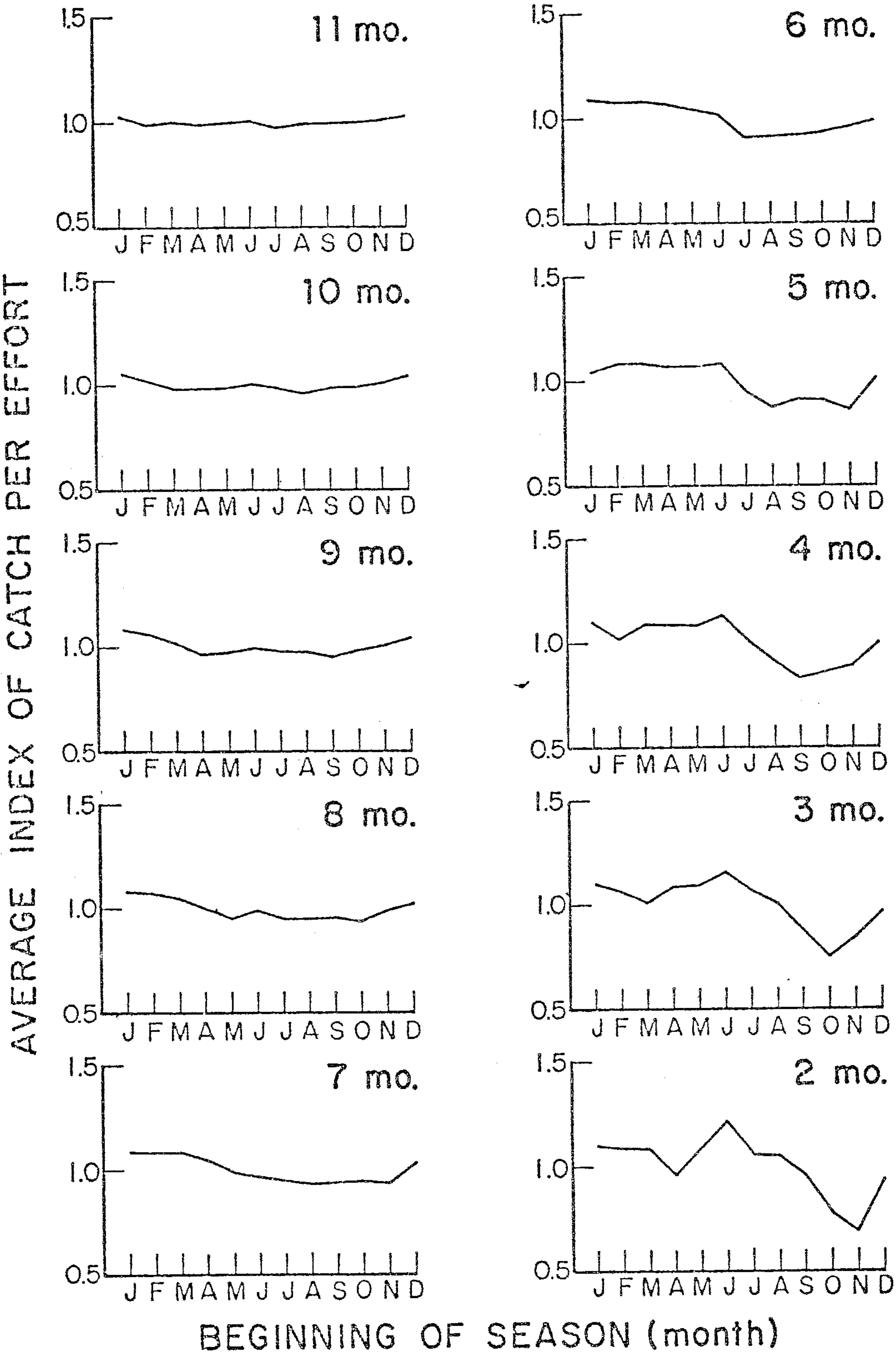
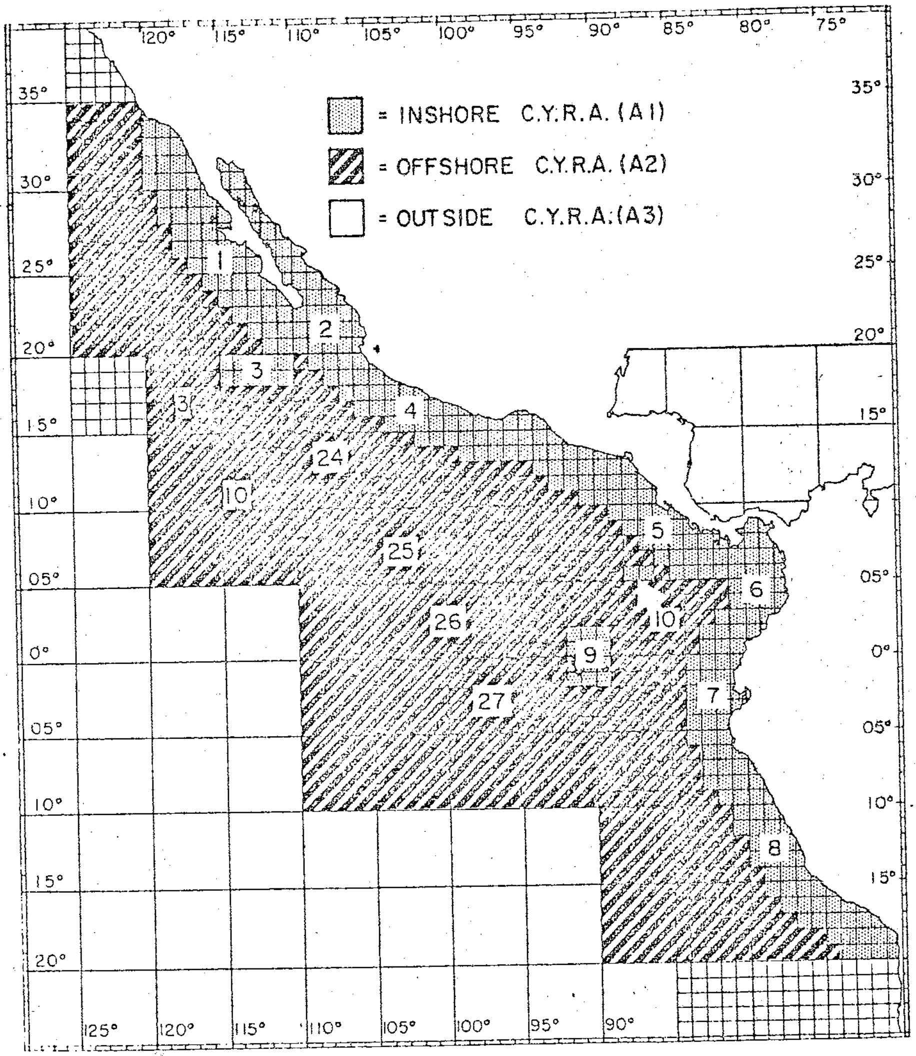

11 mo.
10 mo.
9 mo.
8 mo.
7 mo.
6 mo.
5 mo.
4 mo.
3 mo.
2 mo.
1.5
1.0
0.5
J F M A M J J A S O N D
AVERAGE INDEX OF CATCH PER EFFORT
BEGINNING OF SEASON (month)

Figure 7



= INSHORE C.Y.R.A. (A1)
= OFFSHORE C.Y.R.A. (A2)
= OUTSIDE C.Y.R.A. (A3)
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
35°
30°
25°
20°
15°
10°
05°
0°
125°
1
2
3
4
5
6
7
8
9
10
13
24
25
26
27

Figure 8

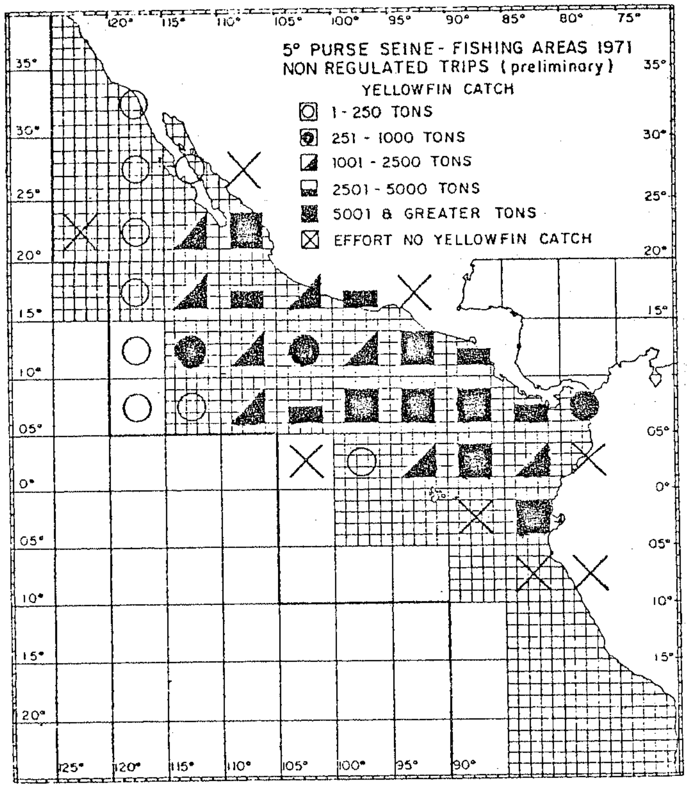


Figure 9

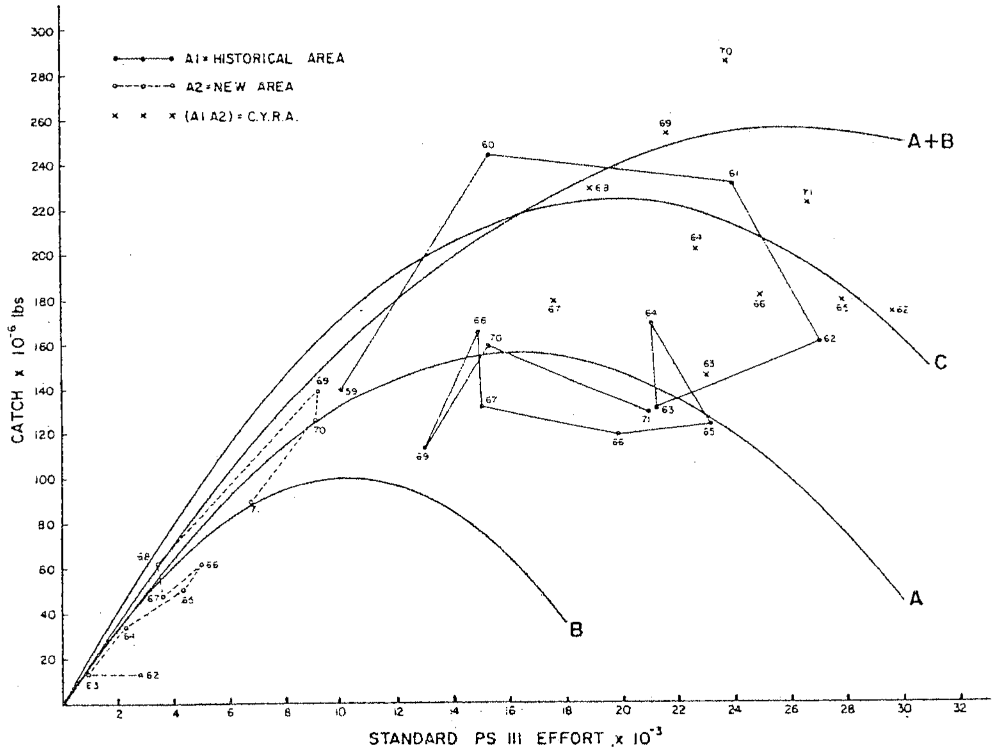


Figure 10

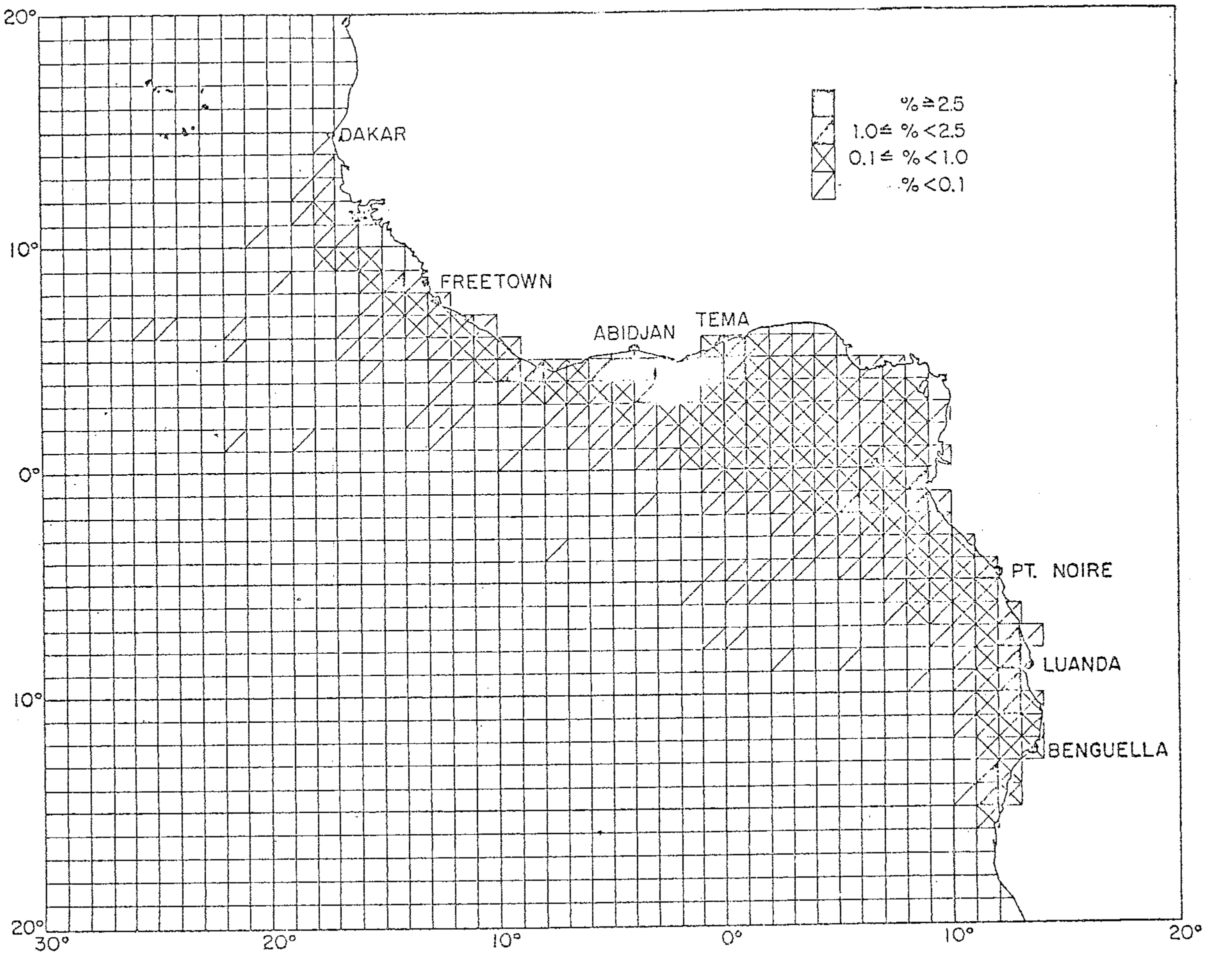


Figure 11

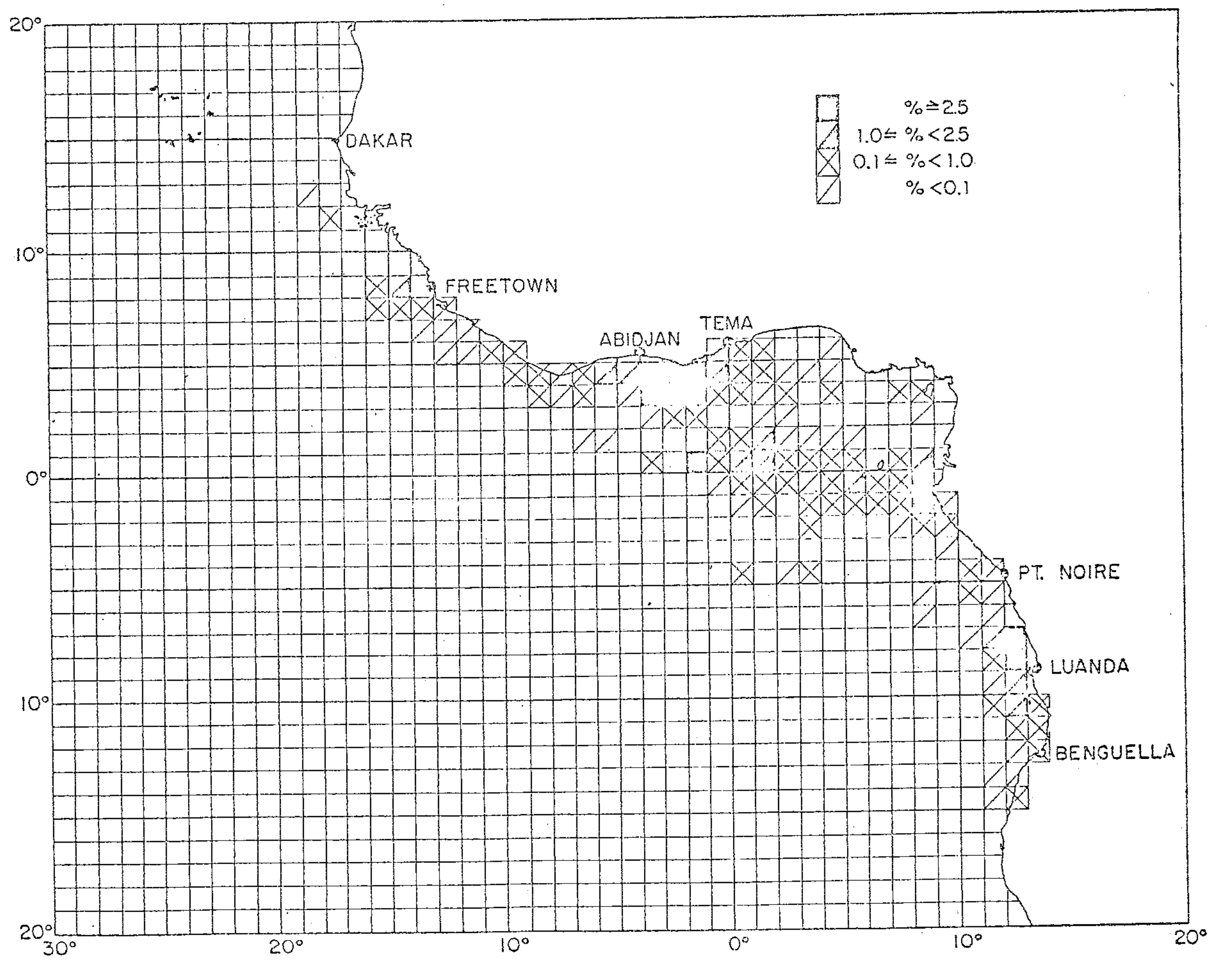


Figure 12

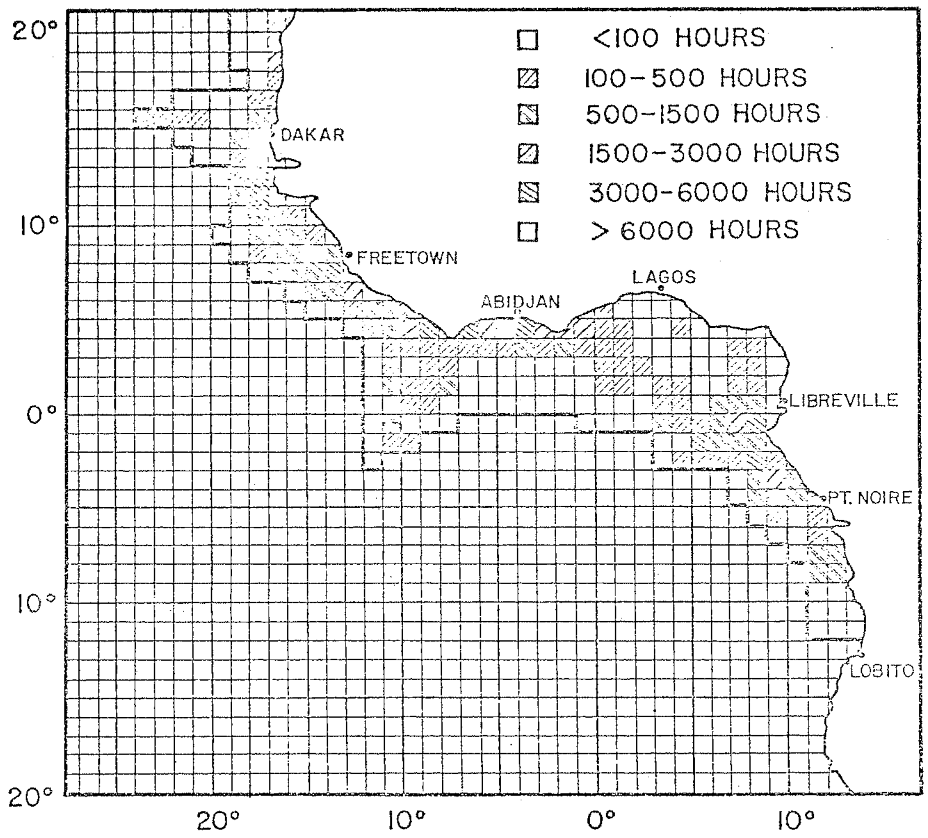


Figure 13

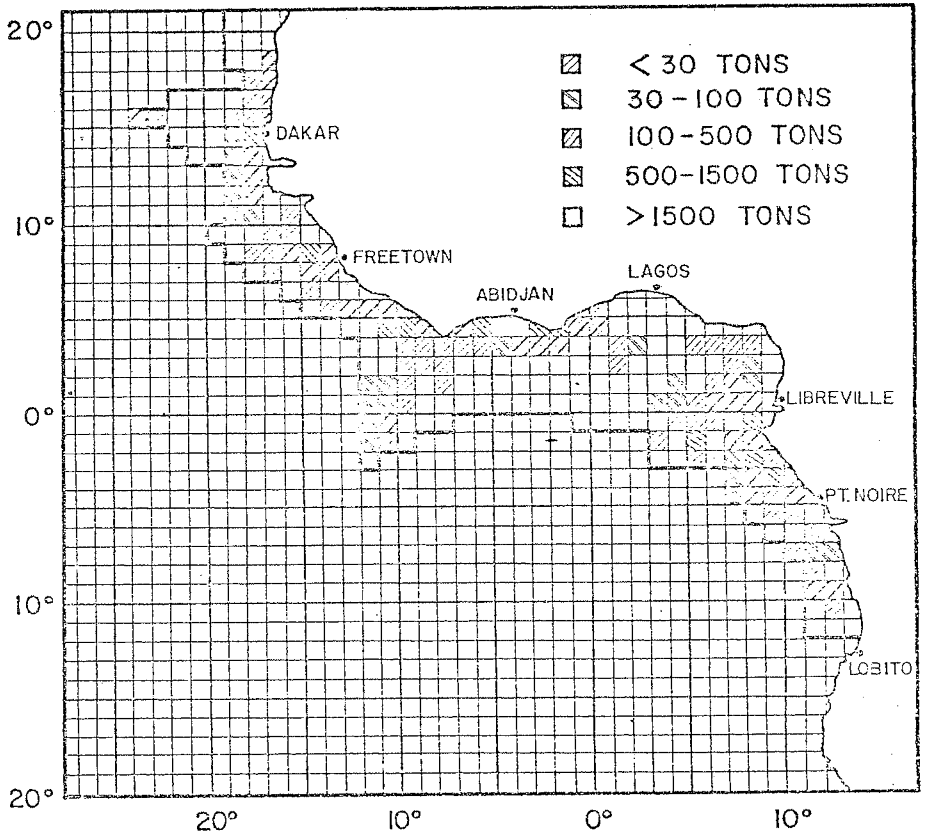


Figure 14

STUDY OF FRENCH TROLLER YIELD OF ALBACORE IN 1971

by

F.X. Bard and J.C. Dao

SUMMARY

In 1971, 8,200 tons of albacore were caught by the French fleet, 6,600 tons by 250 trollers, and 1,600 tons by 50 baitboats.

The sampling program (6,300 albacores were measured)and logbook surveys (20% of the fleet), under way since 1967, make it possible to determine the nature and distribution of the troller fleet contribution. Calculations, based on data obtained from different sources, show the following results:

		Measurements (1)	Measurements & Overall Sampling (2)	Fishermen's Calculations (3)	
Class I	(2 years)	217,700	186,300	247,360	"bonites" (small)
Class II	(3 years)	1,044,370	1,095,800	1,100,800	medium-sized
Class III	(4 years)	160,100	141,250	128,050	large
Class IV	and over	12,470	10,400		
Fishing Effort (no. of days fishing)			14,735	15,815	

(1) Measurements related to quantities landed

(2) Measurements correlated bi-monthly with catches (this fishery is registered in the logbooks by number of fish per day fishing).

The calculations (3) come from one source only - the logbooks given to boat masters, who also note the number of fish per size class and per day fishing. This method is very reliable and, above all, enables a detailed table of composition of catch throughout the campaign to be drawn up, using the 300,000 albacores registered in the logbooks.

ESTIMATION DE LA PRODUCTION DE THON BLANC DES THONIERS-LIGNEURS FRANÇAIS EN 1971

par

F.X. Bard et J.C. Dao

RESUME

En 1971, 8.200 tonnes de thon blanc ont été pêchées par la flottille française, dont 6.600 par les 250 thoniers pêchant à la ligne traînante et 1.600 par les 50 thoniers pêchant à l'appât vivant.

Le programme d'échantillonnage (6.300 germons mesurés) et d'enquêtes par carnets de pêche (20% de la flottille), qui se poursuit depuis 1967 permet de préciser la nature et la répartition des apports pour la flottille des ligneurs. Le calcul a été effectué à partir de différentes sources et donne:

	Mensurations (1)	Mensurations et Echantillonnage Global (2)	Evaluation des Pêcheurs (3)	
Classe I (2 ans)	217.700	186.300	247.360	"bonites"
Classe II (3 ans)	1.044.370	1.095.800	1.100.800	"demis"
Classe III (4 ans)	160.100	141.250	128.050	"gros"
Classe IV et plus	12.470	10.400		
Effort de pêche (nombre de jours de pêche)		14.735	15.815	

(1) Mensurations rapportées aux quantités débarquées
(2) Mensurations combinées aux pêches quinzaine par quinzaine (ces pêches sont répertoriées en nombre de poisson par jour de pêche dans les carnets).

L'évaluation (3) a pour origine les seuls carnets de pêche remis aux patrons, lesquels consignent aussi le nombre de poisson par classe de taille et par jour de pêche. Cette méthode, très fiable, permet notamment de donner un tableau détaillé de la composition des captures tout au long de la campagne, en utilisant les 300.000 thons blancs répertoriés dans les carnets de pêche.

ESTIMACION DE LA PRODUCCION DE ATUN BLANCO (ALBACORA) DE LOS ATUNEROS FRANCESES EN 1971

por

F.X. Bard y J.C. Dao

RESUMEN

En 1971, fueron pescadas 8.200 toneladas de atún blanco por la flotilla francesa, de las cuales 6.600 correspondieron a los 250 atuneros que pescan al curricán y 1.600 a los 50 atuneros que capturan con cebo vivo.

El programa de muestreo (medición de 6.300 albacoras) y de encuestas por medio de los libros de bitácora (20% de la flotilla), que está teniendo lugar desde 1967, permite precisar la naturaleza y reparto de las aportaciones de la flotilla que pesca al curricán. El cálculo ha sido efectuado basándose en diferentes fuentes y arroja las siguientes cifras:

	Mediciones (1)	Mediciones y Muestreo Global (2)	Evaluación de los pescadores (3)
Clase I (2 años)	217.700	186.300	247.360 ("bonites")
Clase II (3 años)	1.044.370	1.095.800	1.100.800 ("demis")
Clase III (4 años)	160.100	141.250	128.050 ("gros")
Clase IV y superiores	12.470	10.400	
Esfuerzo pesquero (número de días de pesca)		14.735	15.815

(1) Mediciones relacionadas con las cantidades desembarcadas
(2) Mediciones combinadas con las pescas quincena por quincena (dichas pescas se encuentran registradas en los libros de bitácora en número de peces por día de pesca).

La evaluación (3) tiene por fuente únicamente los libros de bitácora entregados a los patronos de embarcación, quienes consignan también el número de peces por clase de talla y por día de pesca. Este método, que es muy seguro, permite especialmente ofrecer un cuadro detallado de la composición de las capturas a lo largo de la campaña, utilizando las 300.000 albacoras registradas en los libros de bitácora.