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BIOLOGICAL VIEWS FOR THE CONSERVATION OF YELLOWFIN TUNA IN THE ATLANTIC OCEAN BASED ON INFORMATION OBTAINED UP TO OCTOBER 1972

by
S. Hayasi

SUMMARY

Rapid expansion of fishery in the Atlantic Ocean from 1968 to 1971 failed to increase the yield of yellowfin tuna. This phenomenon is well represented by models with parameter estimates presented at the recent meeting of the "Special Working Group on Stock Assessment of Yellowfin Tuna" held in Abidjan, 12-16 June 1972. Further study of available data is required to confirm the apparently maintained recruitment.

There is an optimum fishing intensity to maximize yield-per-recruit for fisheries into which yellowfin tuna enter with sizes of less than about 90 cm or 14 kgs, or younger than 2.2 years of age. A fishery aiming at immatures depletes egg production of the stock more severely than a fishery aimed merely at adults of the same fishing coefficient.

Recent changes in yield and effort warrant a limit of total yield of yellowfin tuna of around 70,000 tons until further evidence be obtained for a possible expansion of fisheries. The paper also covers a few considerations regarding technical problems inherent to regulation of yellowfin tuna fisheries in the Atlantic Ocean.

CONSIDERATIONS BIOLOGIQUES SUR LA CONSERVATION DE L'ALBACORE DANS L'ATLANTIQUE A PARTIR DE DONNEES ALLANT JUSQU'A OCTOBRE 1972

par
S. Hayasi

RESUME

L'expansion rapide de la pêcherie dans l'Atlantique de 1968 a 1971 n'a pas réussi à augmenter la production d'albacore. Ce phénomène est comparable à la situation actuelle d'après les modèles ayant recours à des paramètres estimés présentés à la réunion du Groupe de Travail Spécial pour l'Evaluation des Ressources d'Albacore tenue à Abidjan les 12-16 Juin 1972. Le recrutement apparemment soutenu rend nécessaire une analyse plus poussée des données disponibles.

Il existe un niveau optimum de l'intensité de la pêche qui permet de rendre maximum le rendement par recrue dans les pêcheries où l'albacore pénètre avec une taille inférieure à 90 cm ou 14 kgs, ou à moins de 2,2 ans. Une pêcherie visant les immatures réduit la production d'oeufs du stock plus gravement qu'une autre pêcherie de même coefficient de pêche ne portant que sur les adultes.

Des changements récents de rendement et d'effort fixent à 70.000 tonnes la limite pour la production d'albacore, tant que les possibilités d'expansion de la pêcherie ne sont pas confirmées. Ce travail contient également quelques remarques sur les problèmes techniques inhérents à la réglementation des pêcheries d'albacore dans l'Atlantique.

CRITERIOS BIOLOGICOS PARA LA CONSERVACION DE RABIL EN EL OCEANO ATLANTICO BASADOS EN INFORMACION OBTENIDA HASTA OCTUBRE DE 1972

por
S. Hayasi

RESUMEN

La rápida expansión de la pesquería en el Océano Atlantico desde 1968 a 1971 no consiguió un aumento de la producción de rabil. Este fenómeno se halla bién reflejado en los modelos obtenidos con parámetros estimados, presentados a la reunión del "Grupo de Trabajo Especial sobre Evaluación de Stocks de Rabil" que se celebró en Abidjan del 12 al 16 de Junio de 1972. Se requiere un estudio más detallado de los datos disponibles para confirmar el reclutamiento aparente mantenido.

Existe un nivel óptimo de la intensidad pesquera que permite llevar al máximo la producción-por-reclutamiento de aquellas pesquerías en las que los ejemplares de rabil se incorporan con tallas inferiores a los 90 cm o 14 kgs, o con una edad inferior a los 2,2 años. Una pesquería que tiene como objeto los ejemplares inmaduros merma la posibilidad de reproducción mucho más intensamente que otra pesquería que se lleva a cabo en ejemplares adultos con el mismo coeficiente pesquero.

Los cambios recientes de producción y esfuerzo fijan el límite de producción de rabil en unas 70.000 toneladas, hasta que se confirme la posibilidad de expansión de las pesquerías. El documento contiene, asimismo, unas cuantas consideraciones sobre problemas técnicos inherentes a la regulación de las pesquerías de rabil en el Oceano Atlántico.

Biological views for conservation of yellowfin tuna in the Atlantic Ocean, based on information obtained up to October 1972.

Sigeiti Hayasi

Introduction

At the Fourth Plenary Session of the Second Regular Meeting of the International Commission for the Conservation of Atlantic Tunas (ICCAT), a resolution was passed, in which (the Commission):

> "Authorizes the Council to recommend to the Contracting Parties that they prohibit landing of yellowfin weighing less than a minimum weight somewhere between 3.2 and 10 kg"(ICCAT 1971, p. 5).

Several days before the Session, the ICCAT Standing Committee on Research and Statistics (SCRS) and its Sub-Committee on Stock Assessment described that:

> "... 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" (ICCAT 1971, p. 5, Appendix 3 to Annex 6).

On the basis of the resolutions at the ICCAT Regular Meeting, biologists invited to the "Special Working Group on Stock Assessment of Yellowfin Tuna" met in Abidjan, 12-16 June 1972 --- simply called the Abidjan Meeting hereafter in this paper. Their conclusions in regard of stock assessment are summarized as:

(1) "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, p. 5), and,

(2) "... if fishing mortality is higher (for example, 1.0 and above), an increase in the size of recruitment to the optimum level ... would result in about a 10 % increase in yield-per-recruit. ... The Working Party discussed the difficulties in increasing the size of yellowfin caught. If the fishermen cannot distinguish sizes of tuna in the water and/or there is a wide variety of sizes within schools, it is likely that many fish below the minimum size will be captured and discarded. ... Fishing on mixed schools of skipjack and small yellowfin will result in additional wastage of undersized yellowfin that would be discarded under minimum size regulations. The losses from these effects following establishment of minimum size regulations may exceed the gains that may be expected from yield-per-recruit calculations. The Working Group strongly recommends that more effort be devoted to this problem in the Atlantic. ... The regulation of minimum landing size of 3.2 kg edicted in Senegal, the Ivory Coast and the Congo, should help prevent a decrease in the size of first capture"(ICCAT *loc. cit.* p. 6).

The present paper summarizes up-to-date biological information for formulating practical regulatory measures of yellowfin tuna fishery in the Atlantic Ocean.

1. Significance of regulations.

1.1. Growth of fisheries accompanying little increase of yield.

Yield of yellowfin tuna in the Atlantic Ocean did not substantially increase from 1968 to 1971 in spite of rapid growth of fishing activity in either separated or combined data from longline and surface fisheries. Especially, it is noted, for the last three years, that total yield decreased from 93,300 tons in 1969 to 69,000 tons in 1971 by 26 percent, and the surface yield from 61,700 tons to 44,000 tons by 29 percent (Fig. 1).

Yield-per-recruit models so far made available coincide with the observed relations between yield and effort. In a given model the relation between fishing activity and yield depends on the fishing coefficient and on average size or age of first capture. Among these two variables, recent fishing coefficients of surface fisheries seem to approach 1.0 (Table 1). Average entering size is estimated to be 32.5 cm by Joseph and Tomlinson (1972). Age composition compiled by Lenarz and Sakagawa (1972) indicates that the fish enter into surface fisheries at about 2 years after birth, or evidently less in 1970 and 1971 (Table 2).

According to Joseph and Tomlinson's model, the yield may decrease against increase of fishing coefficient over 2F or 0.5, if average size of first capture is less than 50 cm in body length as found at present (Fig. 2). If the fishing coefficient is 4F or 1.0 as estimated for the present data, further increase of fishing intensity may deplete the yield even if the entering size is rised to 60 cm, or 4.0 kg in body weight* (Fig. 2). A similar situation appears in comparable figures prepared by Lenarz and Sakagawa (1972) where increase of fishing coefficient beyond 1.0 curtails the yield, insofar as average age of first capture is below 1.7 to 1.9 years (Fig. 3). Hayasi *et al.*'s (ms) calculations show almost the same change of yield for fishery aiming at 1- to 3-year olds and, if natural mortality coefficient is 0.6, for that exploiting 2- to 5-year olds (Fig. 4). It is probable that total yield will be increased either by rising incoming size and age, or by reducing fishing intensity.

1.2. Apparently ~~retained~~ maintained recruitment.

There appears increasing trend in catch-per-unit-effort of newly recruited members, 1-age or less than 50 cm, into surface fisheries in Dakar and Pointe-Noire areas. However, the increasing trend is not always guaranttee for that the recruitment is ~~retained~~ maintained for recent increase of fishing intensity. The Abidjan Meeting noted:

> "... actual catches of these sizes of fish (of incoming year class) depend, possibly to a considerable extent, on the degree of the fishermen's interest in them and effort they concentrate on same. With the decline in large fish, such interest might grow and therefore the increasing trend in CPUE may be an artifact. Caution should be exercised in the interpretation of these data" (ICCAT 1972, p. 3).

2. Proposed regulatory measures.

Detailed models by Joseph and Tomlinson (1972) indicate that, if the fishing coefficient is 1.0 or 4F, rise of incoming size from 32.5 cm to 92.5 cm, or 15 kg, may increase the yield by 34.5 percent as far as no under-sized fish would be caught (Table 3). There are several difficulties in executing the size-limitation effectively, however. Especially, it is important that the fishermen may not be able to discriminate different sized yellowfin tuna nor to distinguish young yellowfin tuna and skipjack in the sea. Joseph and Tomlinson's calculation indicates that the size limitation will reduce the

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*Relation between body length and body weight is based on Lenarz (1971).

yield of yellowfin tuna by 47.1 percent, if all the under-sized fish are caught and damped (Table 3). The technical difficulty may also lead very strict execution of size limitation toward discouraging utilization of under-exploited species such as skipjack, frigate mackerels, little tunny and so forth. Of course, it is necessary to implement moderate size limitation incorporated with regulation of fishing effort, because exploitation of immatures is liable to deplete not only yield-per-recruit but also recruitment to the whole population. It may be realistic to regulate landing yellowfin tuna less than 3.2 kg (about 55 cm), but to allow boats fishing other species some incidental catch of the under-sized yellowfin tuna. Even such moderate regulation may work for keeping the entering size at around 60 cm or 4.2 kg.

As seen in Figs. 2 and 3, there is an optimum fishing intensity to maximize yield-per-recruit for fisheries to which yellowfin tuna enter at size less than about 90 cm or 14 kg, or at age younger than 2.2 years. Fisheries aiming at immatures as well as adults, e.g. 2- to 5-age fish, deplete indices of egg abundance by exploited stock or relative stock fecundity more heavily than others aiming at merely adults, e.g. 3- to 8-age fish, of the same fishing coefficient (Fig. 5). Therefore, difficulty of execution of size limitation requires regulation of fishing effort.

Unfortunately present biological information is not sufficient to determine the most probable fishing intensity. Furthermore, it may be very difficult task to distribute fishing intensity for various types of fisheries exploiting different segments of yellowfin tuna population in the Atlantic Ocean. The most practical measure may be obtained from examination of Fig. 1C in which total yield is plotted against index of total effort. It should be noted that the yield leveled off around 80,000 tons for peak of effort over 750 units. The yield in 1969 exceeds the sustainable yield because the effort increased up to that year. Taking into account that the yield was 69,000 tons in the third year or 1971 for fairly stabilized effort, it may be assumed that the sustainable yield fluctuates around 70,000 tons at most. Amount of quota, of course, must be modified on the basis of up-to-date information, and it is required to establish quick reporting system of information from contracting parties to ICCAT headquarter.

Quota system or limitation of yield also includes several problems. Reduction of yield-per-recruit due to decrease of average size of first capture might result in that actual yield does not reach the allowable quota in spite of growth of fishing intensity beyond permittable level.

There are several other problems that require political, social and economic examination. Free competition within quota is liable to cause over-investment that often shortens fishing season, and drives the excess effort to another stock and then brings about another over-exploitation problem. An operational difficulty in applying the quota system to the multigear fisheries is difference of fishing seasons for different types of gears. Major fishing season in the Gulf of Guinea and adjacent waters extends in January to April for longline fishery (Fig. 6), and June to October for surface fisheries (Fig. 7).

It is possible that reporting the yield and enforcement of regulation are not conducted at the same precision for all the types of fisheries. Namely bait boats and purse seiners operate at most around one month in fishing grounds aparting not very far from base ports. Furthermore, at present, they catch yellowfin tuna almost exclusively in the eastern tropical waters. On the other hand, longliners cruise for two months or even more over the whole Atlantic Ocean, and are liable to catch incidently yellowfin tuna even if they are aiming at bigeye tuna and albacore. Thus, regulations of longliners may be more difficult to execute than that of surface fisheries. Fortunately the examination of models indicates that change of fishing coefficient in longline fishery exerts less effects on yield-per-recruit and relative stock fecundity than the same amount of change in surface fishing intensity (Fig. 5).

3. Some additional comment.

Advance of researches forming basis of fishery management will make the regulatory measures more realistic. For instance, confirmation of isolation of eastern and western stocks would make it unnecessary to regulate operation in the western Atlantic for present conservation measures of yellowfin tuna. Moreover, studies in various fields conducted on national bases will contribute to explain any unpredictable change of stock and fishery due to introduction of fishery management.

Needed at present are continuous surveys on changes of fisheries and stock. And, the regulatory measures can be modified when new conclusions would be obtained in regard of conservation of the stock. It must be emphasized that control of fishing activities is indispensable for obtaining maximum benefit from the stock for long in future in the modern fisheries, technology of which often exceeds natural production of fish populations.

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Table 1. Estimates of recent fishing coefficient on yellowfin tuna in the Atlantic Ocean.

Author	Type of fisheries	Years	Average fishing coefficient
Fonteneau	Baitboat with iced well	) 1969-1971	0.9
	Baitboat with freezer		1.7
	Medium-sized purse seiner		0.4
	Average		1.0
Lenarz and Sakagawa	French Baitboat	) 1963-1967	0.85
	French purse seiners		0.66
	American purse seiner		1.73
	Average		1.08
Hayasi *et al.*	Surface fisheries	) 1970	1.0
	Longline fishery		2.0
Joseph and Tomlinson	Whole fisheries	1967-1971	0.25

Notes. 1. Natural mortality coefficient is assumed to be 0.8.
2. It is felt that 1.0 is an overestimate and 0.25 is an underestimate of surface fishing coefficient, and that the coefficient may be slightly less than 1.0.

Table 2. Catch of yellowfin tuna in terms of 1,000 fish by age in surface fisheries in the eastern tropical Atlantic Ocean, 1965-1971.

Age (years)	Length (cm)	Fishing season						
		1965	1966	1967	1968	1969	1970	1971
0	0- 29	0	0	0	0	9.5	1.0	0
1	30- 60	244.9	260.2	444.6	1,046.7	1,144.1	4,243.9	2,394.9
2	61-106	1,938.4	3,251.2	1,326.6	3,290.5	1,491.7	1,517.6	1,751.2
3	107-137	204.5	193.3	561.1	220.0	928.3	505.8	152.6
4	138-157	9.2	76.3	43.1	211.3	214.6	308.6	194.1
5	158-170	1.4	3.8	4.7	42.5	86.5	49.9	47.1
6+	171>	-	-	0.6	10.1	19.0	5.8	4.1
Total		2,398.4	3,784.8	2,380.7	4,821.1	3,893.7	6,632.6	4,544.0
Yield in 1,000 tons		23.5	34.4	34.4	47.6	62.9	46.8	41.9
Average weight in kg		9.8	9.1	14.0	9.9	16.2	7.1	9.2
Average age in years		2.5	2.5	2.6	2.5	2.6	2.1	2.1

After Lenarz and Sakagawa (1972), except average age that is calculated in the present study.

Table 3. Yield per recruit in Kg for 3 levels of fi-hing mortality and 3 entering sizes assuming (1) 100% success in avoiding the capture of fish less than the minimum allowable size and (2) complete inability to avoid fish less than the minimum allowable size. Also shown are percentage changes in yield under different conditions.

Body length	NO DUMPING Total	NO DUMPING SPS	NO DUMPING BB	NO DUMPING LPS	NO DUMPING LL	COMPLETE DUMPING Total	COMPLETE DUMPING SPS	COMPLETE DUMPING BB	COMPLETE DUMPING LPS	COMPLETE DUMPING LL	Relative fishing coefficient
32.5	3.502	.699	.845	.836	1.121	3.502	.699	8.45	.836	1.121	
52.5	3.565	.711	.842	.852	1.160	3.446	.687	8.14	.824	1.121	
%	1.79	1.71	-0.36	1.91	3.47	-1.60	1.72	-3.67	-1.44	0.0	
77.5	3.618	.728	.702	.868	1.320	3.064	.616	5.94	.735	1.118	1F
%	3.31	4.14	-16.93	3.82	17.75	-12.51	-11.88	-29.71	-12.09	-0.27	
67.5	3.637	.720	.784	.871	1.261	3.234	.641	.697	.774	1.121	
%	3.85	3.00	-7.22	4.18	12.48	-7.66	-8.30	-17.52	-7.42	0.0	
32.5	4.204	.842	1.304	.911	1.147	4.204	.842	1.304	.911	1.147	
52.5	4.380	.875	1.329	.949	1.227	4.093	.818	1.242	.886	1.147	
%	4.18	3.91	1.91	4.17	6.97	-2.65	-2.86	-4.26	-2.75	0.0	
77.5	4.748	.961	1.182	1.014	1.591	3.406	.690	.848	.727	1.141	2F
%	12.94	14.13	-9.36	11.30	38.70	-18.99	-18.06	-34.97	-20.20	-0.53	
82.5	4.751	.971	1.095	1.023	1.662	3.217	.634	.748	.699	1.136	
%	13.01	15.32	-16.03	12.29	44.89	-23.48	-24.71	-42.64	-23.28	-0.96	
32.5	4.126	.839	1.685	.820	.782	4.126	.839	1.685	.820	.782	
52.5	4.480	.907	1.792	.885	.896	3.912	.792	1.565	.773	.782	
%	8.57	8.10	6.35	7.92	14.57	-5.19	-5.61	-7.13	-5.74	0.0	
77.5	5.432	1.125	1.801	1.003	1.503	2.794	.579	.926	.516	.773	4F
%	31.65	34.08	6.88	22.31	92.19	-32.29	-30.99	-45.05	-37.08	-1.16	
92.5	5.551	1.193	1.425	1.044	1.890	2.182	.469	.560	.410	.743	
%	34.53	42.19	-15.44	27.31	41.68	-47.12	-44.11	-66.77	-50.00	-4.99	

After Joseph and Tomlinson (1972).

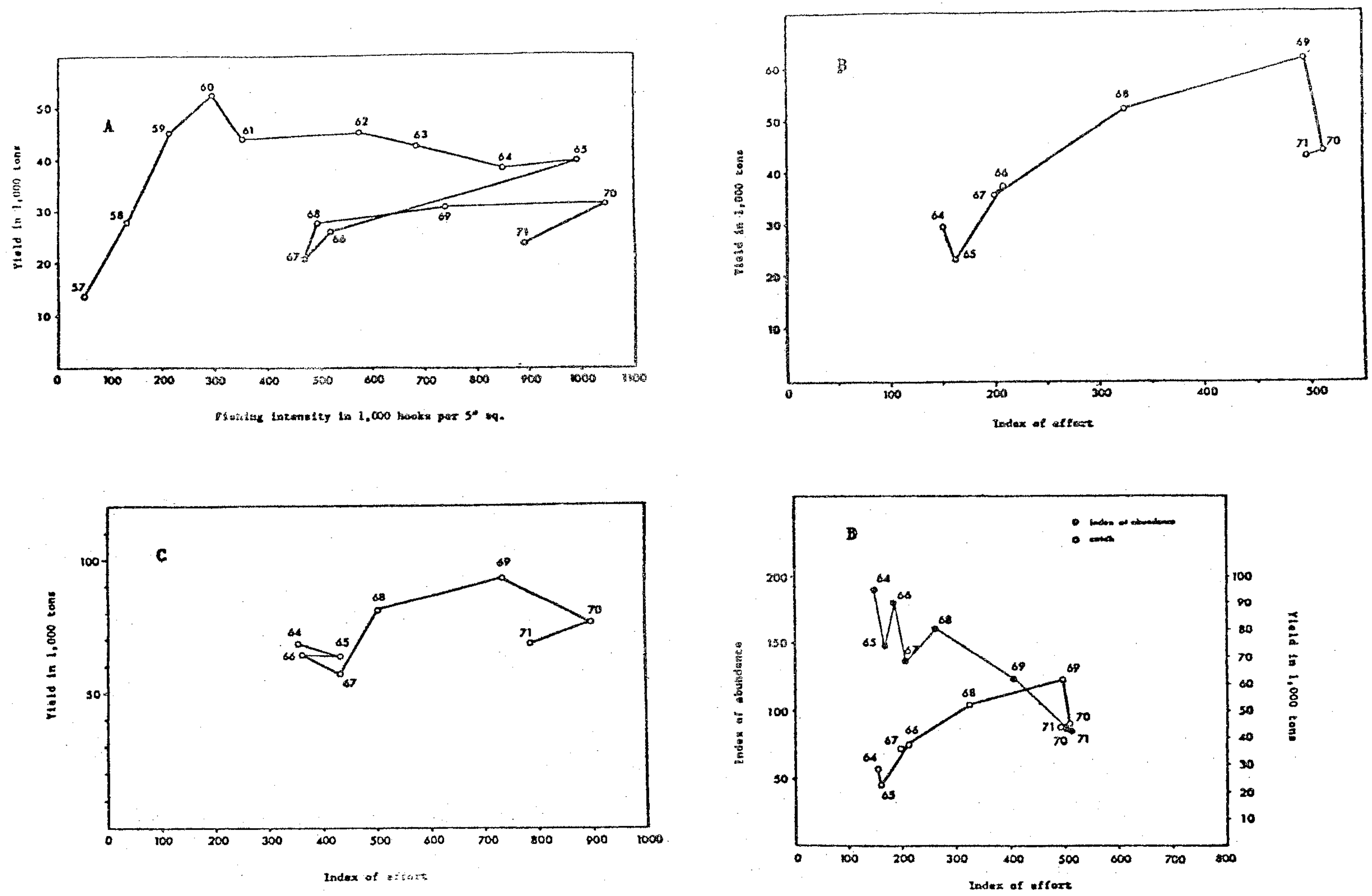


Fig. 1. Relationships between fishing intensity and yield of yellowfin tuna in Atlantic fisheries. After ICCAT (ms).

A: Fishing intensity in 1,000 hooks per 5° square and landing in 1,000 tons in the whole longline fishery, 1957-1971.

B: Index of effort and catch in 1,000 tons in the whole surface fisheries, 1964-1971.

C: Index of effort based on surface catch-per-unit-effort and yield in 1,000 tons in the whole Atlantic fisheries, 1964-1971.

D: Index of effort for two-year average, and yield in 1,000 tons and index of abundance in the whole surface fisheries, 1964-1971.

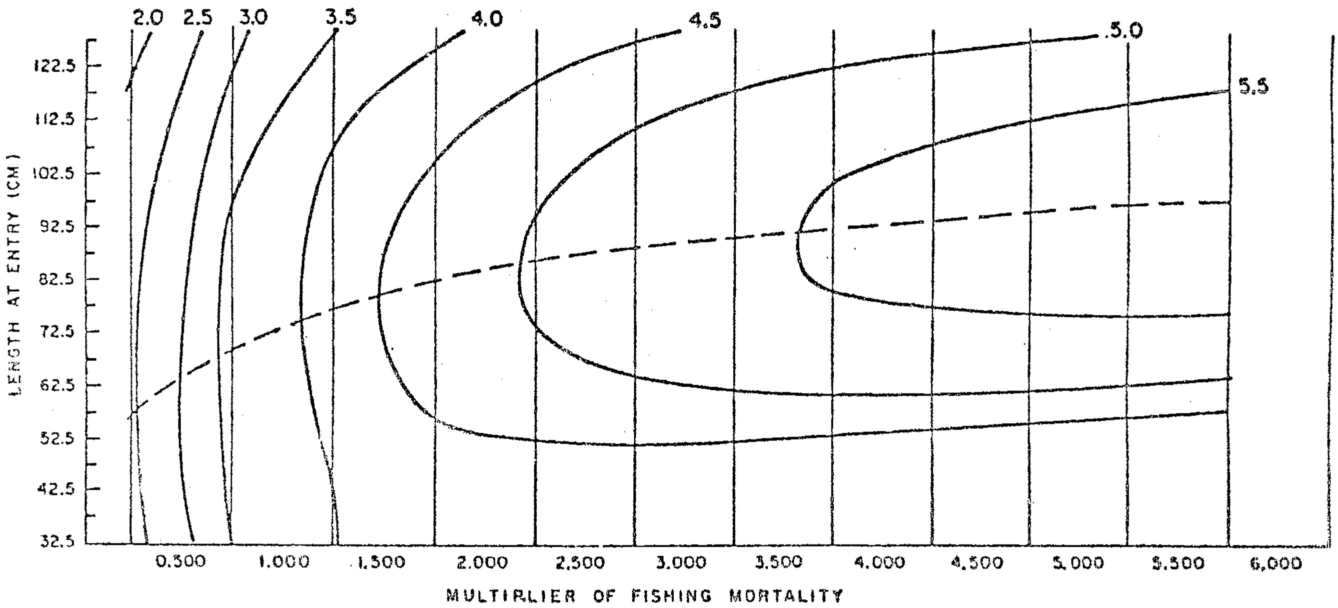
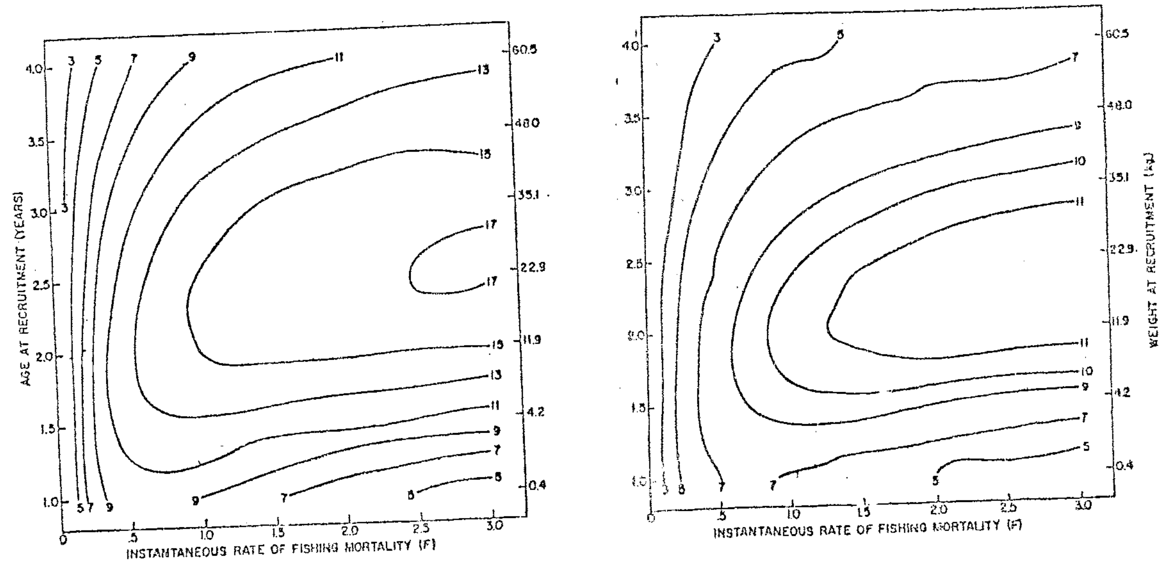


Fig. 2. Yield-per-recruit of yellowfin tuna against average body length of first capture in cm and index of fishing coefficient in that realized in 1970.
After Joseph and Tomlinson (1971).



M = 0.8

M = 1.0

Fig. 3. Yield-per-recruit of yellowfin tuna against average of age or weight at first capture and fishing coefficient.
Natural mortality coefficient is assumed to be 0.8 (left) or 1.0 (right).

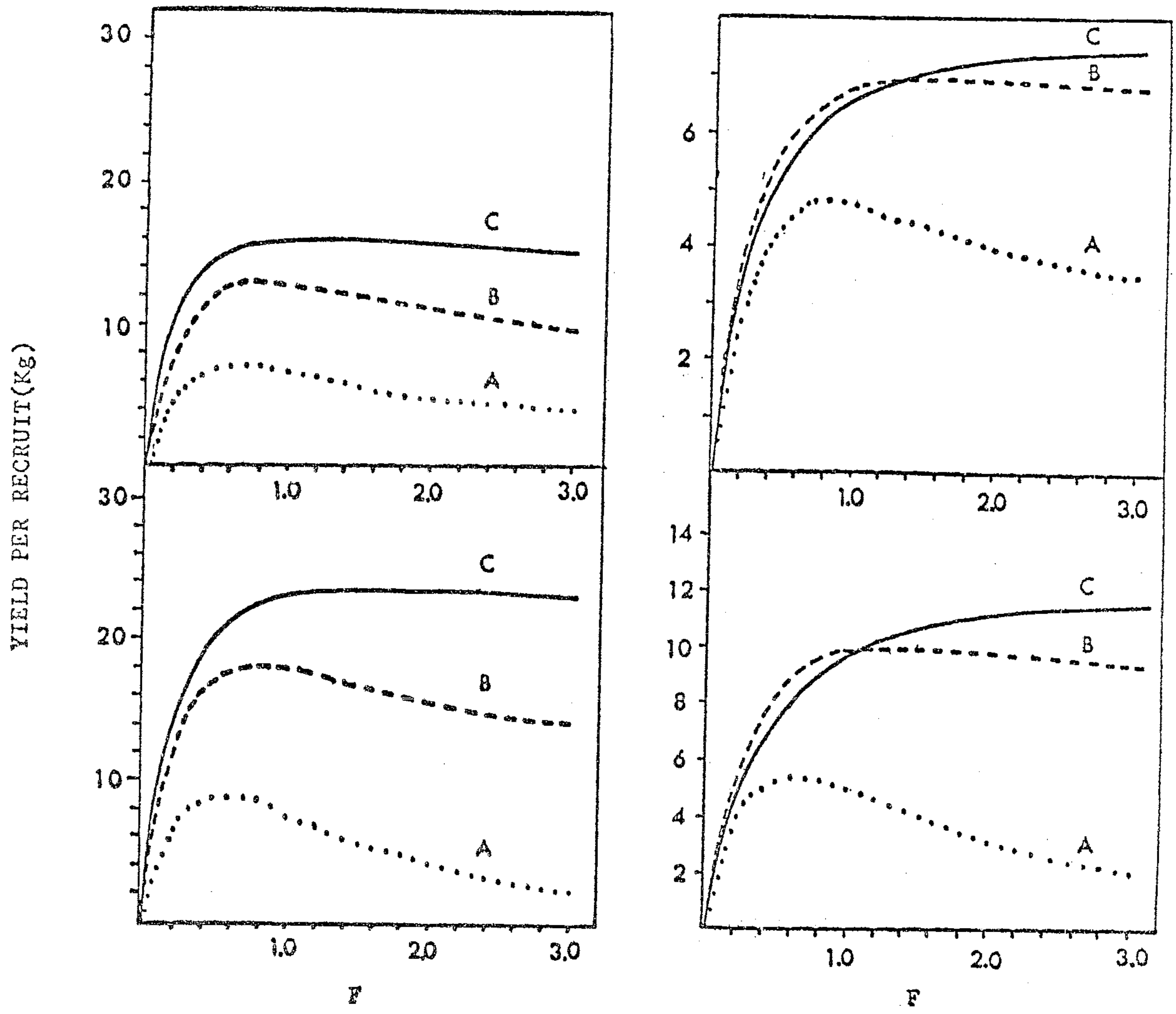


Fig. 4. Yield-per-recruit of yellowfin tuna expected for ~~by~~ either one of three types of fisheries, aiming at 1- to 3-age fish(A), at 2- to 5-age fish(B), at 3- to 8-age fish(C).

Natural mortality coefficient, $\underline{M}$, and growth parameters, $\underline{K}$, t_0 and W_∞ are assumed as follows:

$\underline{M}$: 0.3(left column) or 0.6(right column).
$\underline{K}$, t_0 and W_∞: 0.3, 0.0 and 122 kg(upper row) or 0.6, 0.86 and 99 kg(lower row).

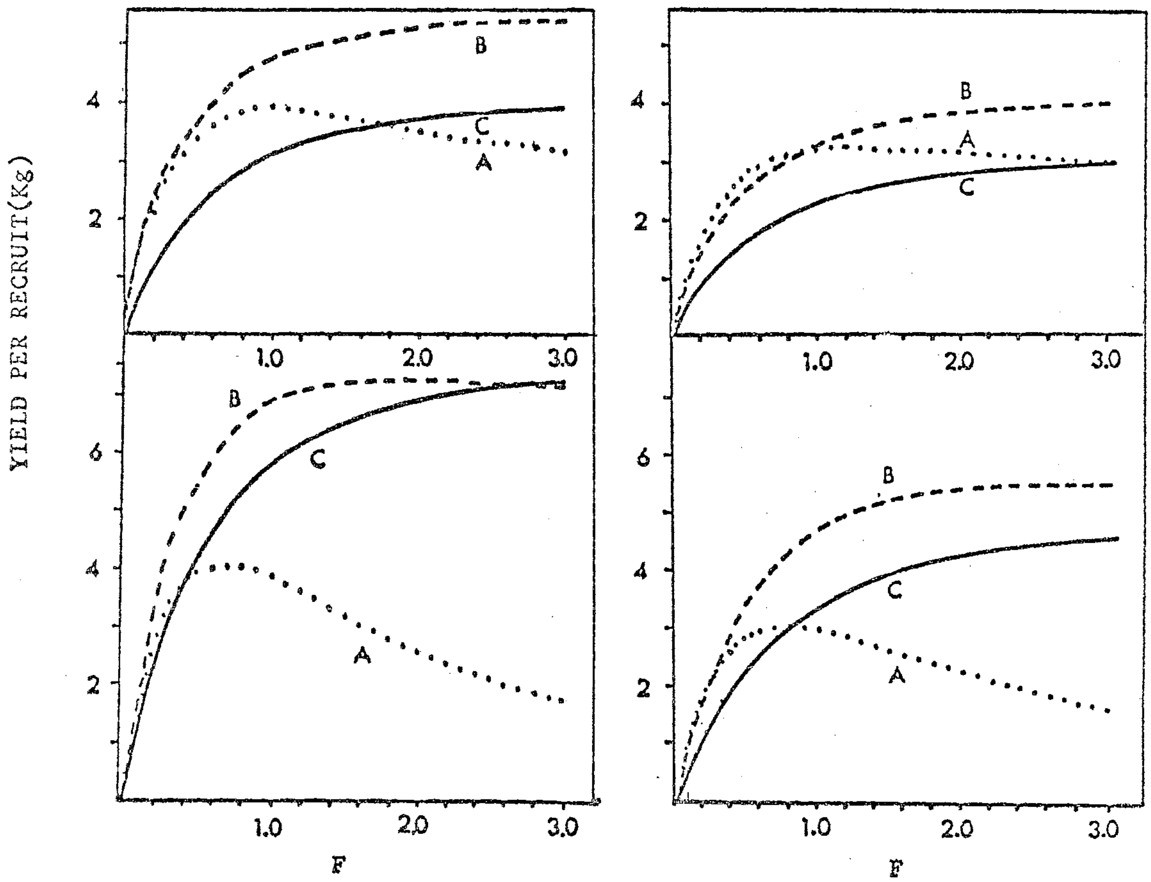


Fig. 4. Continued.

M; 0.8 (left column) or 1.0 (right column)

K; t_0 and W_∞: 0.3, 0.0 and 122 kg(upper row) or 0.6, 0.86 and 99 kg(lower row).

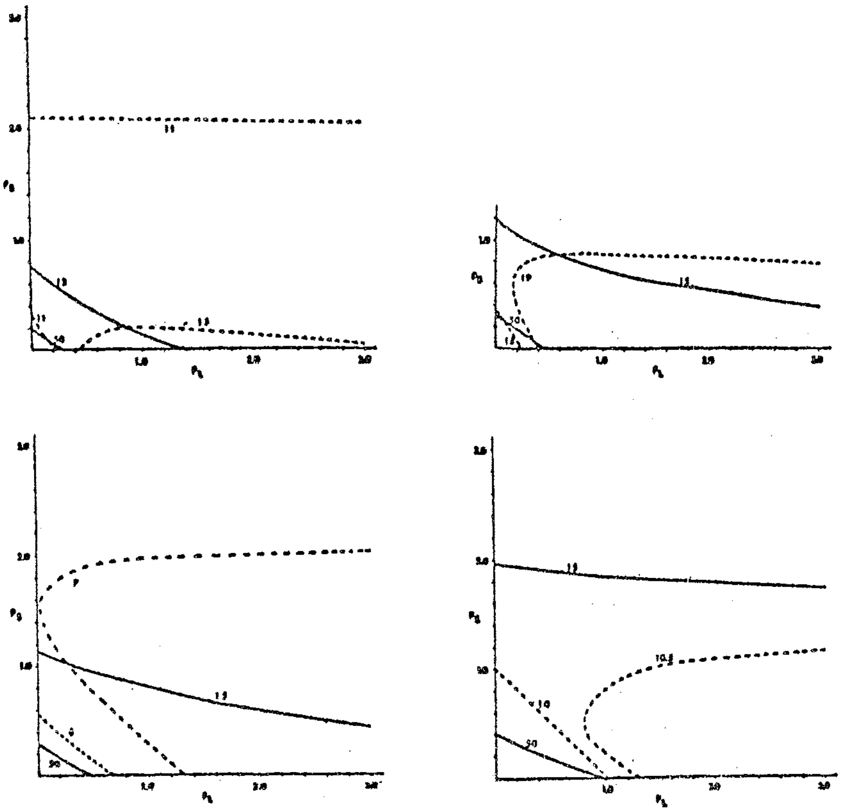


Fig. 5. Yield-per-recruit in kg(dotted line) and relative stock fecundity in percent(solid line) of yellowfin tuna taken by two types of fisheries aiming at 2- to 5-age fish, $\underline{F_S}$, and at 3- to 8-age After Hayasi et al. (ms).

Natural mortality coefficient, $\underline{M}$, growth parameters, $\underline{K}$, $\underline{t_0}$, and $\underline{W_{\infty}}$ and relative fecundity by age, $\underline{P_a}$, are assumed as follows:

$\underline{M}$: 0.3(upper row) or 0.6(lower row).

$\underline{K}$, $\underline{t_0}$ and $\underline{W_a}$ and $\underline{P_a}$: 0.3, 0.0, 122kg and as in Table 4(left column), or 0.6, 0.86, 99kg and as in Table 6(right column).

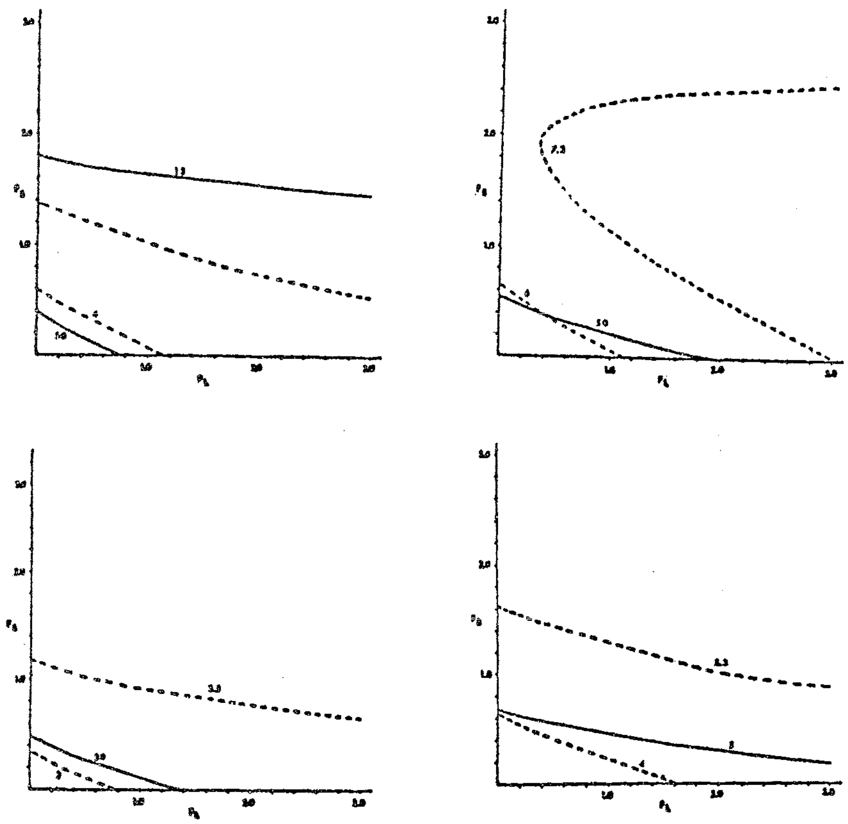


Fig. 5. Continued.

$\underline{M}$: 0.8(upper row) or 1.0(lower row).
$\underline{K}$, $\underline{t}_0$, $\underline{W}_a$ and $\underline{P}_a$: 0.3, 0.0, 122 kg and as in Table 4 (left column), 0.6, 0.86, 99 kg and as in Table 6 (right column).

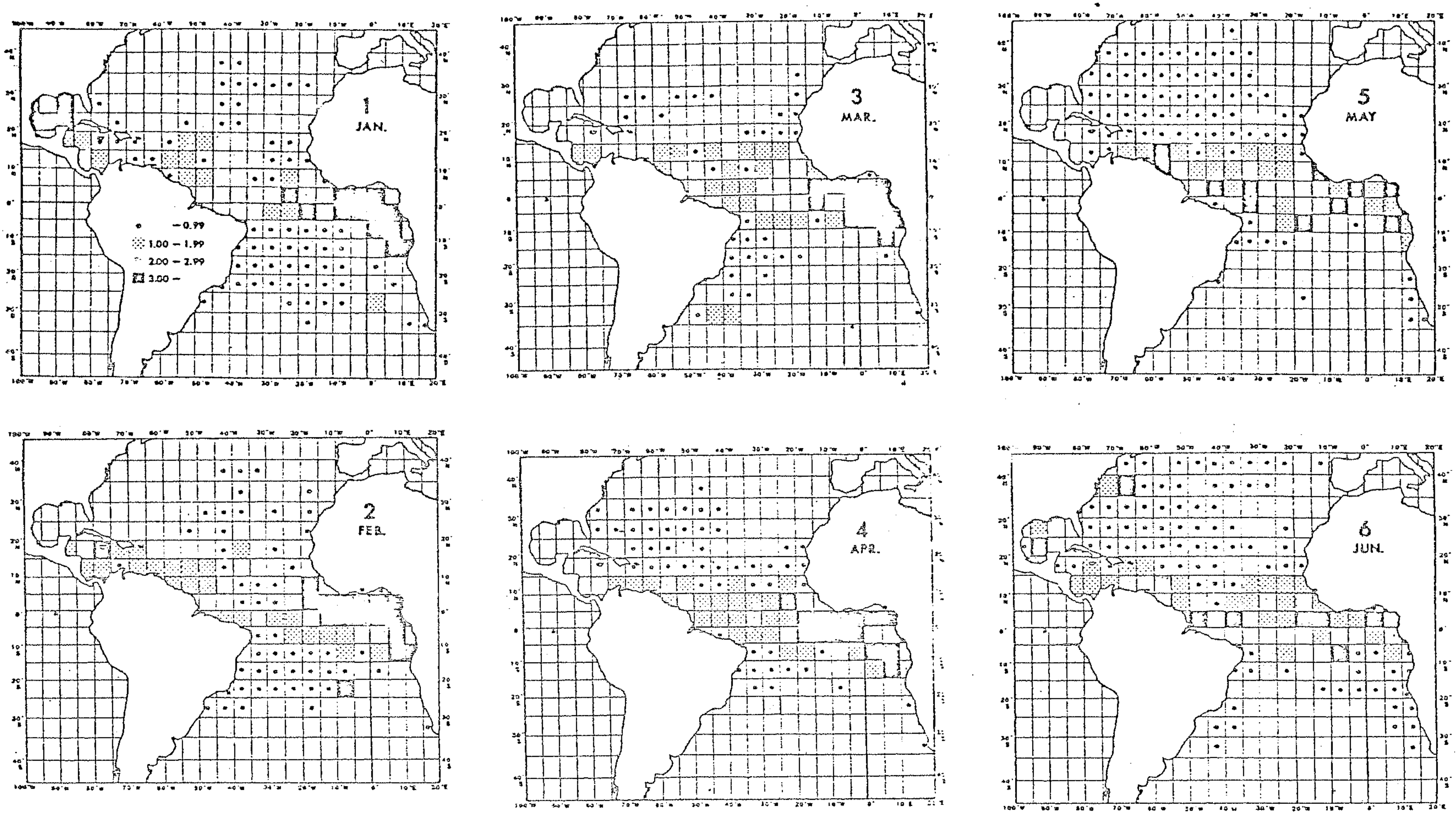


Fig. 6. Monthly average of relative abundance of yellowfin tuna for each 5° square exploited by Japanese longline fishery in the Atlantic Ocean, 1961-1965.

After Honma and Hisada (1971).

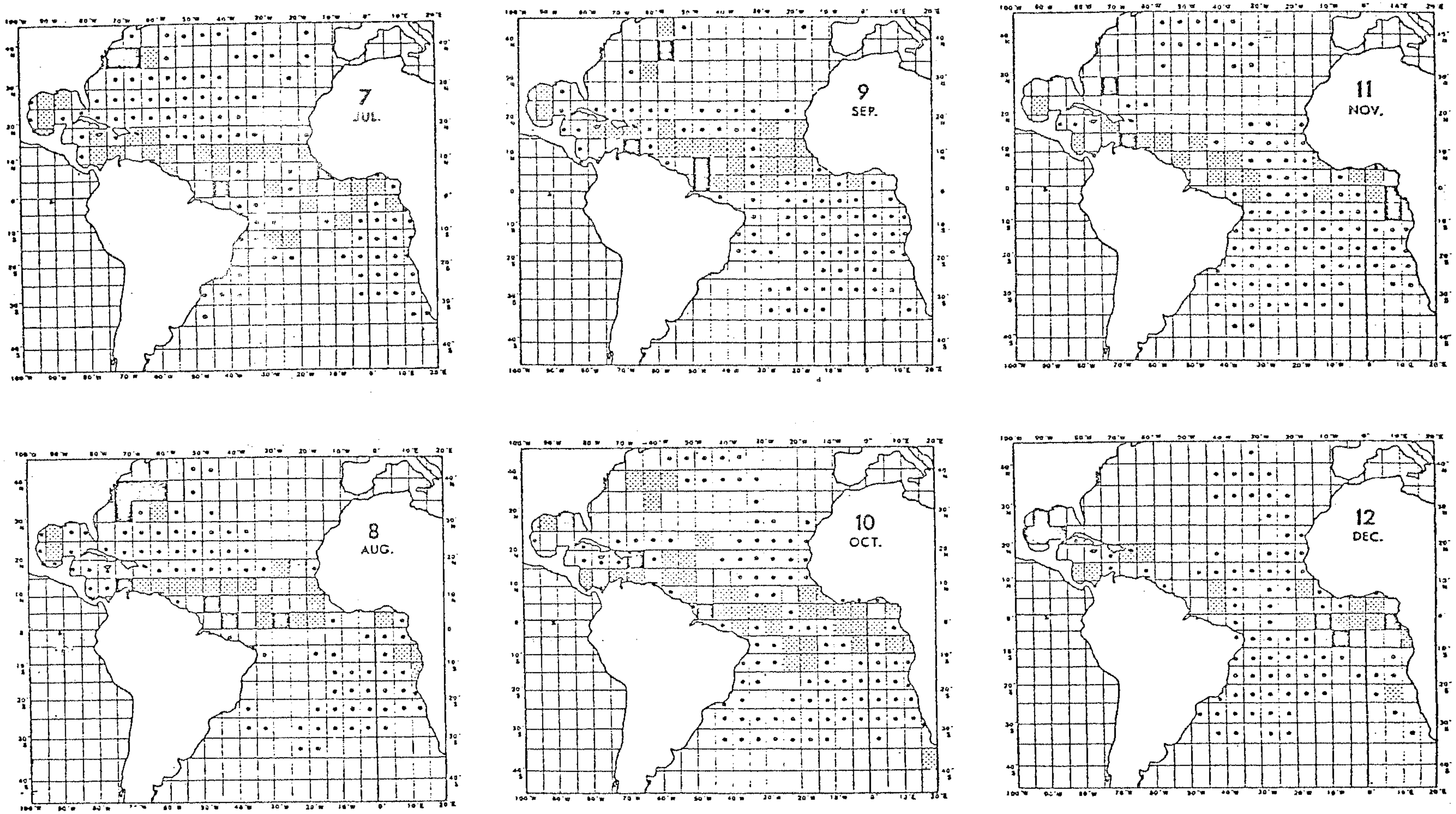


Fig. 6. Continued.

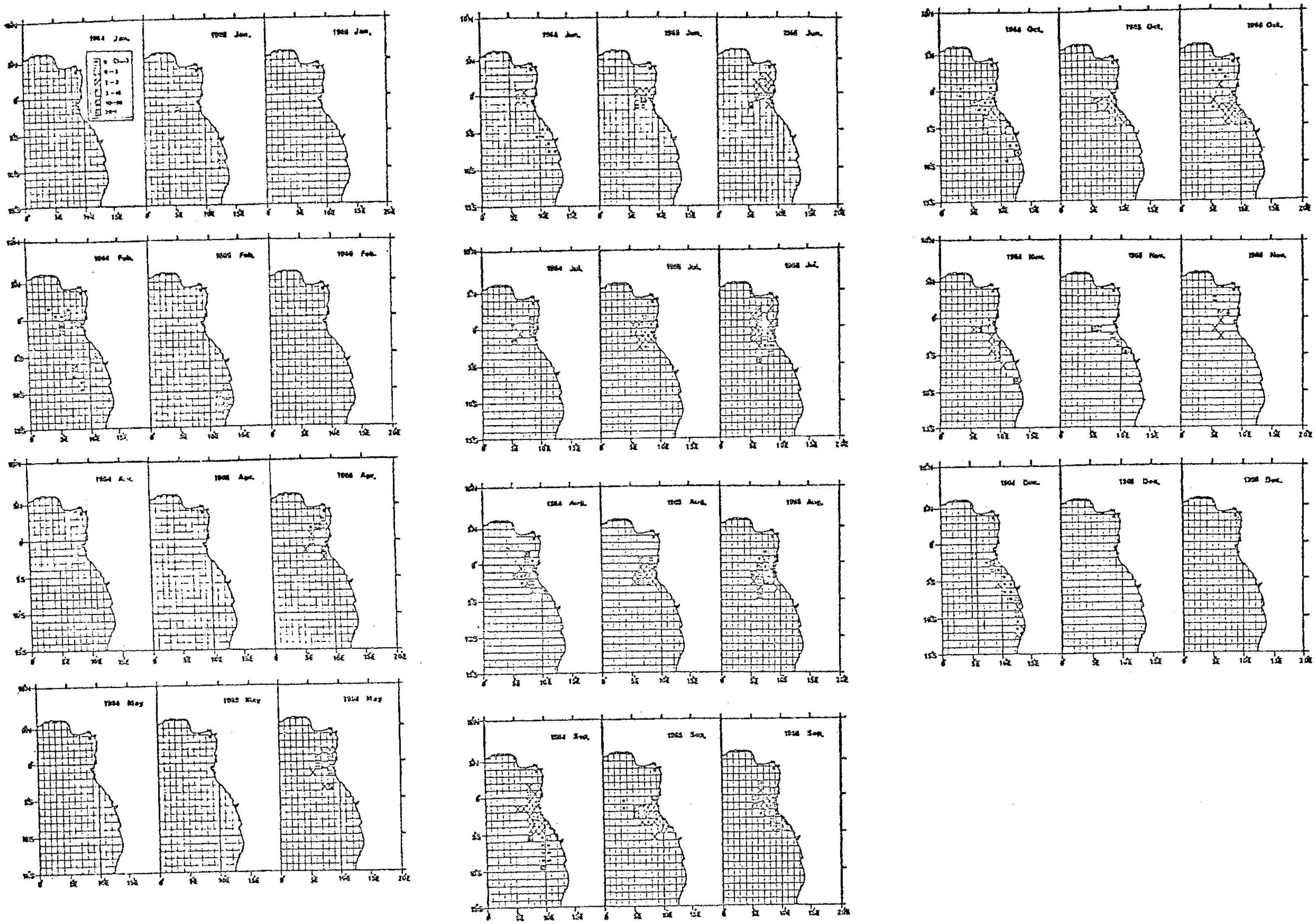


Fig. 7. Monthly distribution of catch-per-unit-effort of yellowfin tuna taken by pole-and-line fishery based on Pointe-Noire, 1964-1966.

After Le Guen *et al.* (1965), Le Guen and Poinsard (1966) and Poinsard (1967).