

TRENDS IN CATCH, FISHING EFFORT, CATCH RATE AND LENGTH DATA FOR THE JAPANESE LONGLINE FISHERY IN THE ATLANTIC OCEAN, 1955-1989

Z. Suzuki

National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu-shi, Shizuoka 424, Japan

SUMMARY

Historical trends of the basic statistics from the Japanese longline fishery were described focusing on the west Atlantic yellowfin tuna for the years 1955-1988. The catch, fishing effort, catch rate and size data were compiled for the western and eastern areas divided along 30°W as well as the entire Atlantic. A brief comparison of these statistics between the west and east areas was made to obtain information on the stock unit.

RESUME

La tendance historique des statistiques de base de la pêche palangrière japonaise est décrite en étudiant l'albacore de l'Atlantique ouest pour les années 1955-88. Les données de prise, d'effort, de taux de capture et de taille ont été rassemblées pour les secteurs est et ouest, délimités à 30°W, ainsi que pour l'ensemble de l'Atlantique. Une brève comparaison de ces statistiques entre est et ouest visait à obtenir une information sur l'unité de stock.

RESUMEN

Se describen las tendencias históricas de las estadísticas básicas de la pesquería de palangre japonesa, centrándose en la pesca de rabil en el Atlántico oeste durante el período 1955-1988. Se recopilieron datos de captura, esfuerzo de pesca, tasa de captura y datos de talla, de las zonas este y oeste, cuya división se encuentra a 30°W, así como de todo el Atlántico. Se hizo una breve comparación de las estadísticas de las zonas este y oeste para obtener información sobre la unidad de stock.

1) Introduction

This paper deals with trends of basic statistics for yellowfin tuna taken by the Japanese longline fishery in the Atlantic Ocean. Exploitation of the Atlantic yellowfin tuna by pelagic industrial fishery has been initiated by the Japanese longline fishery from the mid-1950's in the Caribbean Sea (Suzuki 1988). The Japanese longline fishery aimed at yellowfin tuna in the tropical waters at the beginning of the exploitation and covered the whole main distribution areas of yellowfin by the early 1960s. Then, the fishery shifted the target species to bigeye both in the tropical and the higher latitudes as well as southern bluefin and northern bluefin tunas in the higher latitudes.

Presently, yellowfin tuna are not the target species in the fishery, rather they are secondary target species like swordfish. This is one of a disadvantage for the data from this fishery to be used in the stock assessment. However, this fishery has some unique characteristics, i.e., it has the widest areal coverage with the longest time series among the major yellowfin fisheries in the Atlantic Ocean. The analysis of the data on this fishery will be informative, especially to stock structure, ecological aspects and gear interaction with other fishery on yellowfin tuna.

Trends of the basic statistics, catch, effort, CPUE and size of the catch, on the Japanese longline fishery for yellowfin tuna are described by western, eastern and entire Atlantic Oceans.

2) Materials and methods

2.1) Materials

All materials used in the present paper have been compiled routinely by the National Research Institute of Far Seas Fisheries from the beginning of the fishery in the Atlantic in 1955 to 1988.

Task II catch and effort statistics for the Japanese longline fishery, compiled 5° squares by month, were used to calculate effective effort and standardized CPUE for the years from 1956 to 1988. Similar statistics but with the additional information on the number of branch lines between the two adjacent floats, hereafter referred to as branch line statistics, were also used to check the possible effect of gear structure, with

respect to fishing depth from the surface, on CPUE. This branch line statistics cover the period from 1975 to 1988. The use of deep longline which set the hooks as deep as about 250 m from the surface compared with about 150 m by regular type of the longline started from 1977 in the Atlantic Ocean (Suzuki and Kume 1982).

Catch in weight, average weight of the catch and catch by length of yellowfin tuna caught by the Japanese longline fishery were calculated from size measurement data of the Japanese longline fleet in combination with the Task II catch and effort statistics previously mentioned. Sample length measurement data have been compiled by latitude 5°x longitude 10° area and month for yellowfin tuna. The length data covers from 1955 to 1988.

2.2) Method

The trends of catch, effort, CPUE, average length of the catch and catch by length were calculated by hypothetical three stocks in western, eastern and entire Atlantic Oceans.

2.2.1) Standardization of the fishing effort

Effective fishing effort or standardized CPUE for yellowfin tuna was calculated by Honma method (Honma 1974) and general linear model (GLM) with the use of software "SAS". The period for calculation of the average year hook rates (HR: number of yellowfin tuna /100 hooks) in the Honma method covers the years from 1965 to 1975 and the Task II catch and effort data of the Japanese longline fishery for the years 1956-1988 were used. The stock areas for calculating the effective effort are south of 50°N and north of 40°S divided west and east by the 30°W line.

In case of applying the GLM, the branch line statistics of the Japanese longline fishery for the years 1975-1988 were used to see the effect of the deep longlining over the HR(CPUE) more explicitly as well as to compare the results with that of the Honma method. Areal division used in the GLM is shown in Fig. 1. The model used was as follows:

$$\log(\text{HR} \cdot 10 + 1.0) = \text{Mean} + \text{Year} + \text{Quarter} + \text{Area} + \text{Gear} + \text{Quarter} \cdot \text{Area} + e$$

Hook rates (HR) were multiplied 10 after the several trials by various constants to see the results of multiplication on residual. A constant 1.0 was added to the hook rates so that zero catch records can be used for the GLM. Month was regarded as repetition of quarter. Gear was classified into two categories, regular longline with the number of branch lines between the adjacent floats from 4 to 6, deep longline from 10 and over.

2.2.2) Estimation of catch by size

There are two kinds of size measurements for yellowfin tuna

caught by the Japanese longliners, one is fork length measurement and the other is gilled-and-gutted weight measurement. The weight measurements have been routinely converted to the length with the length-weight equation (Kamirura and Honma 1959):

$$W = 0.00000664L^{3.1878}$$

where W and L denote gilled-and-gutted weight in kg and fork length in cm.

This equation was estimated for the Pacific yellowfin tuna caught by the Japanese longline fishery. Usually the gilled-and-gutted weight is converted to the corresponding whole weight by multiplying a constant of 1.15 derived from the study by Morita (1973). As a matter of fact, it is appropriate to use the comparable relationship estimated for the Atlantic stock such as Davis (1989). However, since no length-weight relationships were available other than the one for the Pacific in the early period and the conversion from weight to length was made in the early steps of the size data compilation and summed up later on for making the basic statistics used for the routine analyses, it was not possible to re-compile the whole original size measurement data with the use of the Atlantic equation in this paper due to time constraint. Fortunately, the difference between the two equations is negligibly small for the range of the sizes used mostly:

	10	15	20	25	30	35	40	45	50	(Kg)
a)	83	94	103	111	117	123	128	133	137	(cm)
b)	81	93	102	110	117	123	128	133	138	
	55	60	65	70	75	80	85	90	95	
a)	142	146	149	153	156	159	162	165	168	
b)	142	147	151	154	158	161	164	168	171	

a) Kamimura and Honma (1959), b) Davis (1989)

Extensive substitutions were necessary to match the catches with the sample length measurements. Only the Japanese size measurement data were used for the substitution of the measurement data. This is because of time constraint of data manipulation and poor length measurement data for the longline countries other than Japan. The matching of the catches with the length measurement data were done by a area and time stratum of latitude 10° x longitude 20° area and quarter of the year considering availability of the length data in a given area-time stratum. This causes some problem for the area 20°W-40°W due to overlapping the area between the western and eastern stocks separated along the 30°W line. In this case, the same length data were used for both stock but the number of catch was assigned by stock splitting the catch into the area 20°W-30°W and 30°W-40°W. There

are small numbers of strata with the measurement data but without the catches. The sample measurement data were regarded as the catch in such cases. General rules of the substitution of length measurement data employed are as follows:

- 1) Longitudinal substitution was given higher priority than latitudinal substitution.
- 2) Substitution across years was not made.

However, the general rules were not applicable to the data in the early period due to scarcity of the size measurement samples as shown below.

Table 1 summarizes the result of the substitution. In the most cases of the early period before 1975, more than 50 % of the catch strata were matched to the substituted length measurement data in terms of the time area stratum previously mentioned. Ratio of the total number of the catches to that of the length measured was less than 5 % in most cases. Since 1975 the size samples increased significantly with less than 50% of the substitution and with about 10-30 % of the catch were sized. This improvement is due to implementation of on-board measurements by the Japanese longline fishermen.

3) Results and discussion

3.1) Results

Trend of fishing effort

Figure 2. shows the trend of the effective fishing effort for yellowfin tuna exploited by the Japanese longline fishery calculated by Honma method for western, eastern and entire stocks. The trends can be classified into the three period: 1) the early period from the beginning of the fishery to the end of the 1960s during which time the longline fleet remained in the tropical areas, mainly in the eastern Atlantic, 2) the middle period in the 1970s when time the fishing effort begun to leave from the tropical areas to the higher latitudes, for bluefin and bigeye tunas in the west Atlantic, 3) from the beginning of the 1980s to the present time with re-directed fishing effort to the eastern tropical areas for bigeye tuna after the implementation of harsh fishing regulations on western Atlantic bluefin tuna.

Trends of catch and average weight

Table 2 shows the estimated average weight and catch in weight by western, eastern and entire stocks from 1955 to 1988. The catch trends for the three assumed stocks resemble with the respective fishing effort trends. Average weight was more or less the same between the western and eastern stocks for the early period till the end of the 1960s. Afterwards, however, the eastern stock has been having larger average weight than that of the western counterpart. This reflects the separation of the

fishing grounds for the Japanese longline fishery within the western and eastern Atlantic, and not necessarily indicates the change in average weight of the populations, i. e., localized fishing effort in the higher latitudes of the coastal areas for bigeye and bluefin tunas in the western Atlantic where the size of non-targeted yellowfin tuna caught rather incidentally is the smallest throughout the Atlantic in comparison of major fishing ground in the tropical eastern Atlantic for bigeye tuna.

Trend of CPUE

A remarkably steep decline in the CPUE till the early 1960s characterizes the early period of the yellowfin exploitation, both in the western and eastern Atlantic Ocean (Fig. 3). Then, the decline became very moderate with steeper decrease for the eastern stock till the early 1980s. The declining trend between the eastern and western stocks appears to be similar from the beginning phase of the exploitation to the early 1980s. However, it tends to diverge afterward, i. e., more or less stable CPUE for the eastern stock in contrast to a increasing trend for the western stock.

Another CPUE series was computed by the GLM for the period from 1975 to 1988. After trials with several multiplying constants and areal divisions, the final selection of model as described in the previous section was made on the basis of the value of R square and residual pattern. As anticipated from the Pacific (Suzuki et al 1978) and Indian (Koido 1985) cases, the discrimination of gear construction, the regular and the deep longline, has little effect on variation of CPUE for the assumed all three stocks although statistically significant for the eastern and entire stocks (Table 3). Frequency distribution of residuals, not shown here, usually skewed somewhat to negative residual side. R square was lowest for the western stock.

The trends of CPUE estimated by the GLM are different from that calculated by Honma method in a varying degree for each stock (Fig. 4). As for the western stock, there appears to be a low CPUE period in the two methods from 1980 to 1983 and from 1980 to 1981 for the Honma estimates and the GLM estimates, respectively. However, relative value of CPUE in the late 1980s to that in the late 1970s is higher for the Honma estimates and the opposite is true for the GLM estimates. The trend of annual CPUE is quite different between the Honma and GLM estimates for the eastern stock, the Honma estimates show downward trend to 1980 with relatively stable or slightly upward period afterward while the GLM estimates tend to be stable to 1981 with a increasing trend afterward. For the entire stock, the difference appears not to be so large as in the case of the eastern stock. However, the relative value of CPUE in the late 1980s to that in the late 1970s is lower for the Honma estimates whereas about the same for the GLM estimates.

3.2) Discussion

As is already mentioned, the estimation of the catch in weight and average weight of yellowfin tuna taken by the Japanese longline fishery made in this paper (Table 2) is probably unreliable for the early period till the end of 1960s due to insufficient size measurement data available. There are considerable difference in total catch in weight between the official catches of yellowfin tuna by the Japanese longline fishery during this period. The catch estimated in the present paper is consistently higher, as much as about 50 % or more in some cases, than the official catch (ICCAT 1982a, 1982b, 1988). This appears to be caused by a very high average weight based on a small number of measurements applied for this period. For example, the average weight in 1962 for the catch from the entire Atlantic compares 40 kg in gilled-and-gutted condition (equivalent to 46 kg for whole weight) estimated from independent survey (Anonymous 1965) with 56 kg in the present paper.

It is difficult to judge which CPUE series, either the Honma or GLM series, reflects a situation close to reality because both method have advantages and disadvantages as Conser (1985) pointed out. However, it may be pertinent to note that, for the eastern stock, the trend of population biomass for ages 5 and 6 fish normally taken by the longline estimated from VPA (Fonteneau and Diouf 1989) seems to be somewhat similar, to a series based on "low catchability hypothesis", to that by the GLM. More detail studies on the GLM approach to obtain standardized CPUE should be attempted.

There seems to be difference in the CPUE trends during 1975-1988 period between the western and eastern stocks both within the Honma and GLM estimates although the trends for specific stock is different between the two methods. On the other hand, the CPUE trend calculated by the Honma method shows similarity for the period before the 1980s. This may infer either two separate stocks in the Atlantic with a significant mixture between them or one stock but with two different fractions which have different migratory routes in the western and eastern Atlantic. Transatlantic movements of yellowfin recently reported (Bard and Scott 1989) indicate that the movement of adult yellowfin tuna is much more extensive than previously believed, although Honma and Hisada (1971) anticipated such transatlantic recoveries of the tagged yellowfin in their hypothesis on the stock structure of the Atlantic yellowfin. The extent of the mixture between the western and eastern yellowfin should be quantified in the future followup studies.

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Table 1 Summary table of Atlantic yellowfin size substitution for the Japanese longline fishery

Year	No. of catch stratum(a)	No. of size stratum	No. of substitution (b) and b/a with parentheses	No. of sized fish and its ratio to No. of catch with parentheses
1955	1	1	0(.00)	84(1.00)
1956	13	4	9(.69)	4534(.28)
1957	26	14	12(.46)	10497(.04)
1958	28	0	28(1.00)	0(.00)
1959	43	3	40(.93)	357(.00)
1960	47	9	38(.81)	250(.00)
1961	56	0	56(1.00)	0(.00)
1962	62	4	58(.94)	359(.00)
1963	71	21	50(.70)	5327(.01)
1964	95	23	72(.76)	3208(.00)
1965	123	44	79(.64)	6737(.01)
1966	103	31	72(.70)	4399(.01)
1967	86	17	69(.80)	1887(.01)
1968	91	24	67(.74)	6281(.02)
1969	96	7	79(.92)	1190(.00)
1970	102	14	88(.86)	997(.01)
1971	97	21	76(.78)	14441(.05)
1972	95	17	78(.82)	6722(.04)
1973	73	24	49(.67)	13058(.12)
1974	61	20	41(.67)	4426(.05)
1975	84	44	40(.48)	11579(.10)
1976	67	34	33(.49)	31812(.31)
1977	61	37	24(.39)	9571(.23)
1978	52	28	24(.46)	9405(.17)
1979	55	27	28(.51)	16792(.27)
1980	81	41	40(.49)	15058(.22)
1981	87	47	40(.46)	15143(.14)
1982	94	46	48(.51)	8360(.06)
1983	81	40	41(.51)	8393(.16)
1984	87	46	41(.47)	10556(.12)
1985	108	61	47(.44)	14317(.11)
1986	94	37	57(.61)	4670(.06)
1987	85	40	45(.53)	7218(.09)
1988	97	54	43(.44)	17706(.12)

Table 2 Catch in tons and average weight of the catch in kg of the Atlantic yellowfin caught by the Japanese longline fishery

	Average w.			Catch		
	west	east	total	west	east	total
1955	44.2	.0	44.2	3.7	.0	3.7
1956	83.2	81.2	64.4	952.8	93.8	1046.6
1957	67.0	72.1	71.0	3991.1	14650.9	18642.0
1958	62.3	64.3	63.3	22555.1	24726.2	47281.3
1959	61.1	67.8	66.1	17211.0	55336.9	72547.9
1960	55.5	58.4	57.8	12925.1	54047.0	66972.1
1961	56.5	59.9	59.7	2965.3	55561.0	58526.4
1962	52.3	57.9	55.8	19569.4	35695.7	55265.1
1963	56.1	58.6	57.6	19259.2	31797.7	51056.9
1964	54.0	43.7	48.6	22636.4	20113.0	42749.4
1965	54.9	54.3	54.5	15118.3	35433.6	50551.8
1966	59.3	59.3	59.3	12922.7	10475.7	23398.4
1967	46.9	56.3	53.9	4256.1	15475.0	19731.1
1968	44.1	51.6	48.9	4370.3	9034.1	13404.4
1969	39.1	41.6	40.4	4511.8	5270.6	9782.4
1970	39.2	46.5	40.7	5030.9	2697.8	7728.7
1971	38.3	59.6	41.1	9726.8	2271.8	11998.6
1972	38.3	52.5	42.2	4407.9	2306.0	6713.9
1973	32.8	44.1	36.5	2387.9	1584.6	3972.5
1974	33.2	55.4	36.1	2735.0	689.2	3424.2
1975	41.7	59.6	47.8	3191.1	2347.5	5538.6
1976	34.9	58.5	36.3	3419.6	357.8	3777.4
1977	39.5	46.0	39.9	1544.8	110.2	1655.0
1978	37.1	51.4	38.8	1847.0	336.2	2183.1
1979	36.2	41.6	36.7	2043.2	265.0	2308.2
1980	47.9	57.7	51.1	2243.2	1324.5	3567.7
1981	39.3	51.5	42.0	3439.3	1258.0	4697.3
1982	49.3	54.5	51.5	3866.8	3238.7	7105.5
1983	42.2	56.0	47.0	1455.1	1036.3	2491.4
1984	40.2	44.3	42.6	1508.9	2393.1	3902.0
1985	42.2	45.6	44.1	2269.8	3248.1	5517.9
1986	45.9	49.1	47.0	2522.5	1398.8	3921.3
1987	40.8	51.4	45.4	1929.7	1883.8	3813.5
1988	43.1	49.0	46.3	2976.8	3876.3	6853.1

Table 3-1 Summary table of the GLM analysis of CPUE for the western stock

Number of observations in data set = 1923

Dependent Variable: LCPUE

R-Square	C.V.	Root MSE	LCPUE Mean
0.207192	49.80528	0.811700	1.62974644

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	13	61.04058533	4.69542864	7.13	0.0001
QUARTER	3	87.72555202	29.24185094	44.38	0.0001
AREA	5	93.43547043	18.68709409	28.36	0.0001
GEAR	1	0.29809673	0.29809673	0.45	0.5013
QUARTER*AREA	15	82.04923910	5.46994927	8.30	0.0001

OBS	_NAME_	YEAR	QUARTER	AREA	GEAR	LSMEAN	STDERR	CPUE_P
						1=regular	2=deep	
1	LCPUE	75	.	.	.	1.53852	0.09960	0.36577
2	LCPUE	76	.	.	.	1.77160	0.09765	0.48803
3	LCPUE	77	.	.	.	1.85842	0.10100	0.54136
4	LCPUE	78	.	.	.	1.77008	0.10343	0.48713
5	LCPUE	79	.	.	.	1.96365	0.08812	0.61253
6	LCPUE	80	.	.	.	1.29893	0.08204	0.26654
7	LCPUE	81	.	.	.	1.45247	0.06029	0.32737
8	LCPUE	82	.	.	.	1.57548	0.06208	0.38330
9	LCPUE	83	.	.	.	1.55859	0.08442	0.37521
10	LCPUE	84	.	.	.	1.60971	0.08096	0.40014
11	LCPUE	85	.	.	.	1.50851	0.06712	0.35200
12	LCPUE	86	.	.	.	1.54729	0.08783	0.36987
13	LCPUE	87	.	.	.	1.44950	0.09912	0.32510
14	LCPUE	88	.	.	.	1.67966	0.10948	0.43637
15	LCPUE	.	1	.	.	1.32669	0.07016	0.27685
16	LCPUE	.	2	.	.	1.60882	0.06981	0.39969
17	LCPUE	.	3	.	.	1.78139	0.07195	0.49380
18	LCPUE	.	4	.	.	1.73523	0.11084	0.46702
19	LCPUE	.	.	2	.	1.43721	0.03746	0.32099
20	LCPUE	.	.	3	.	1.44174	0.16345	0.32281
21	LCPUE	.	.	4	.	2.05957	0.05653	0.68426
22	LCPUE	.	.	5	.	1.97990	0.06451	0.62420
23	LCPUE	.	.	6	.	1.60749	0.03934	0.39903
24	LCPUE	.	.	8	.	1.15227	0.16208	0.21654
25	LCPUE	.	.	.	1	1.60028	0.04526	0.39544
26	LCPUE	.	.	.	2	1.62578	0.05542	0.40824

Table 3-2 Summary table of the GLM analysis of CPUE for the eastern stock

Number of observations in data set = 5465

Dependent Variable: LCPUE

R-Square	C.V.	Root MSE	LCPUE Mean
0.354593	74.27591	0.599950	0.20773203

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	13	94.2970049	7.2536158	20.15	0.0001
QUARTER	3	23.5162057	7.8387352	21.78	0.0001
AREA	4	673.3051699	168.3262925	467.65	0.0
GEAR	1	1.4714052	1.4714052	4.09	0.0432
QUARTER*AREA	12	281.4153097	23.4512758	65.15	0.0001

OBS	_NAME_	YEAR	QUARTER	AREA	GEAR	LSMEAN	STDERR	CPUE_P
						1=regular	2=deep	
1	LCPUE	75	.	.	.	0.91948	0.045472	0.15080
2	LCPUE	76	.	.	.	0.79781	0.064308	0.12207
3	LCPUE	77	.	.	.	0.72158	0.067527	0.10579
4	LCPUE	78	.	.	.	0.77193	0.056532	0.11639
5	LCPUE	79	.	.	.	0.86425	0.051212	0.13732
6	LCPUE	80	.	.	.	0.78807	0.031735	0.11992
7	LCPUE	81	.	.	.	0.72614	0.033849	0.10671
8	LCPUE	82	.	.	.	0.90268	0.027494	0.14662
9	LCPUE	83	.	.	.	0.72019	0.034821	0.10548
10	LCPUE	84	.	.	.	1.01046	0.028327	0.17469
11	LCPUE	85	.	.	.	0.97432	0.024967	0.16494
12	LCPUE	86	.	.	.	0.85225	0.029984	0.13449
13	LCPUE	87	.	.	.	1.08303	0.035188	0.19536
14	LCPUE	88	.	.	.	1.03370	0.025761	0.18115
15	LCPUE	.	1	.	.	0.86434	0.019662	0.13734
16	LCPUE	.	2	.	.	0.76805	0.024890	0.11556
17	LCPUE	.	3	.	.	1.03067	0.028166	0.18030
18	LCPUE	.	4	.	.	0.81293	0.024985	0.12545
19	LCPUE	.	.	9	.	0.97299	0.018090	0.16459
20	LCPUE	.	.	10	.	1.54099	0.031223	0.36692
21	LCPUE	.	.	11	.	0.88401	0.041895	0.14206
22	LCPUE	.	.	12	.	0.59960	0.017860	0.08214
23	LCPUE	.	.	13	.	0.34740	0.019364	0.04154
24	LCPUE	.	.	.	1	0.82098	0.020296	0.12727
25	LCPUE	.	.	.	2	0.91702	0.018106	0.15018

Table 3-3 Summary of the GLM analysis of CPUE for the entire stock

Number of observations in data set = 7398

Dependent Variable: LCPUE

R-Square	C.V.	Root MSE	LCPUE Mean
0.415542	65.14873	0.665619	1.02169166

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	13	128.632991	9.894845	22.33	0.0001
QUARTER	3	61.489424	20.496475	46.26	0.0001
AREA	10	1707.849957	170.784996	385.48	0.0
GEAR	1	4.861662	4.861662	10.87	0.0009
QUARTER*AREA	30	406.125827	13.537528	30.56	0.0001

OBS	_NAME_	YEAR	QUARTER	AREA	GEAR	LSMEAN	STDERR	CPUE_P
					1=regular 2=deep			
1	LCPUE	75	.	.	.	1.29271	0.04341	0.26426
2	LCPUE	76	.	.	.	1.35850	0.05001	0.28904
3	LCPUE	77	.	.	.	1.34152	0.05572	0.28249
4	LCPUE	78	.	.	.	1.29407	0.05173	0.26476
5	LCPUE	79	.	.	.	1.42758	0.04596	0.31696
6	LCPUE	80	.	.	.	1.12682	0.03411	0.20858
7	LCPUE	81	.	.	.	1.12045	0.03312	0.20662
8	LCPUE	82	.	.	.	1.27291	0.02900	0.25712
9	LCPUE	83	.	.	.	1.12998	0.03613	0.20922
10	LCPUE	84	.	.	.	1.36831	0.03137	0.29287
11	LCPUE	85	.	.	.	1.31356	0.02799	0.27194
12	LCPUE	86	.	.	.	1.22359	0.03281	0.23994
13	LCPUE	87	.	.	.	1.39377	0.03748	0.30300
14	LCPUE	88	.	.	.	1.40080	0.03068	0.30585
15	LCPUE	.	1	.	.	1.12347	0.03251	0.20755
16	LCPUE	.	2	.	.	1.24453	0.03310	0.24713
17	LCPUE	.	3	.	.	1.45923	0.03473	0.33026
18	LCPUE	.	4	.	.	1.33377	0.05072	0.27953
19	LCPUE	.	.	2	.	1.45665	0.02897	0.32916
20	LCPUE	.	.	3	.	1.44007	0.13277	0.32210
21	LCPUE	.	.	4	.	2.04977	0.04504	0.67661
22	LCPUE	.	.	5	.	1.95921	0.05018	0.60937
23	LCPUE	.	.	6	.	1.56776	0.03017	0.37959
24	LCPUE	.	.	8	.	1.14310	0.12905	0.21365
25	LCPUE	.	.	9	.	0.99924	0.01980	0.17162
26	LCPUE	.	.	10	.	1.59198	0.03411	0.39135
27	LCPUE	.	.	11	.	0.94221	0.04592	0.15656
28	LCPUE	.	.	12	.	0.65394	0.01877	0.09231
29	LCPUE	.	.	13	.	0.38882	0.02085	0.04752
30	LCPUE	.	.	.	1	1.23925	0.02232	0.24530
31	LCPUE	.	.	.	2	1.34125	0.02380	0.28238

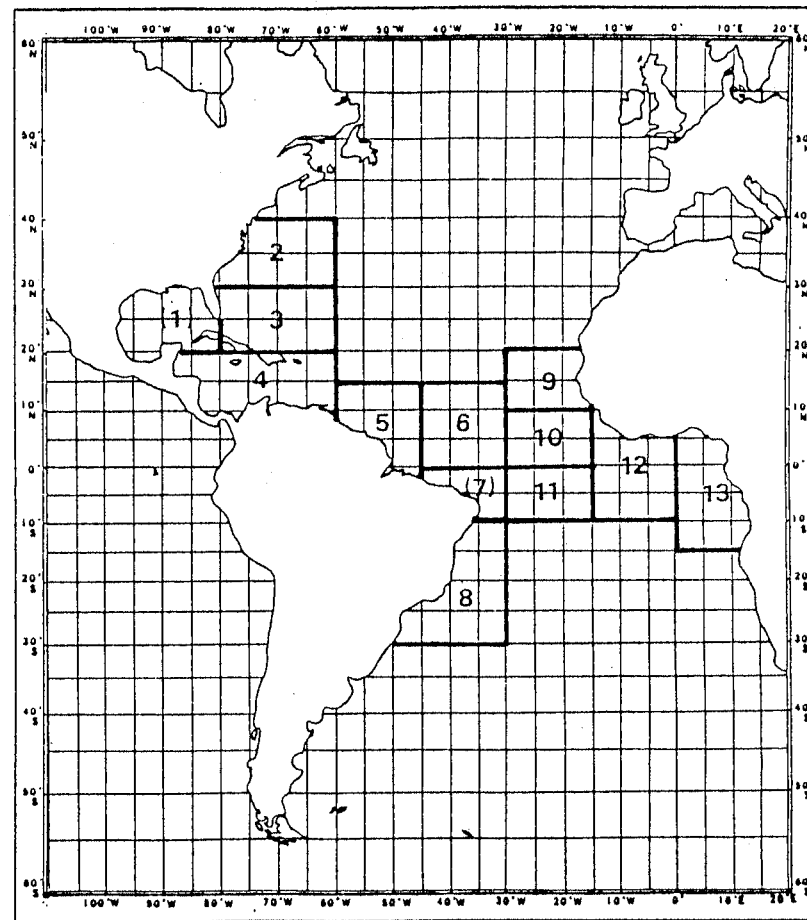


Fig. 1. Division of areas for the GLM estimation of yellowfin CPUE by the Japanese longline fishery
Areas 1 and 7 were not used in the final calculations.

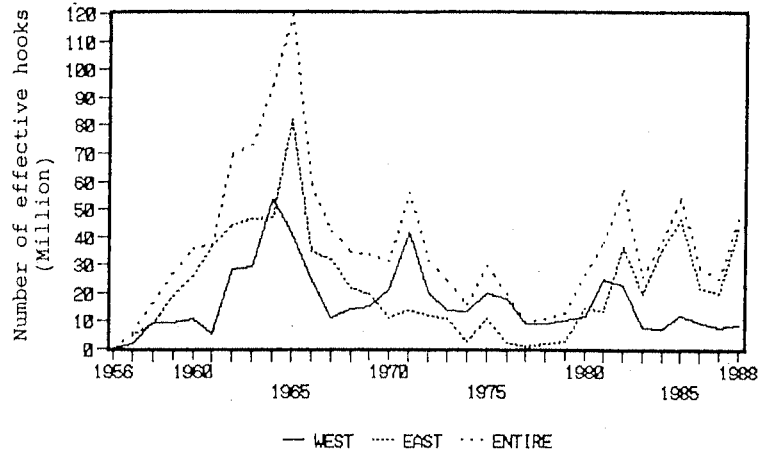


Fig. 2. Trends of effective effort based on the Honma method on yellowfin tuna caught by the Japanese longline fishery

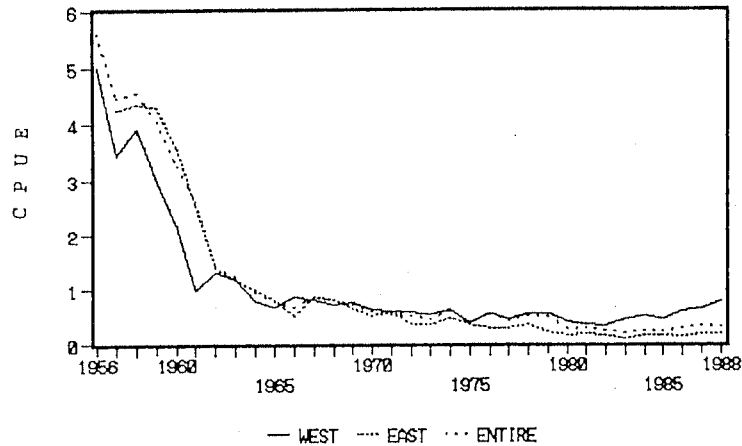


Fig. 3. CPUE trends for yellowfin, taken by the Japanese longline fishery, derived from effective effort calculated with the use of the Honma method

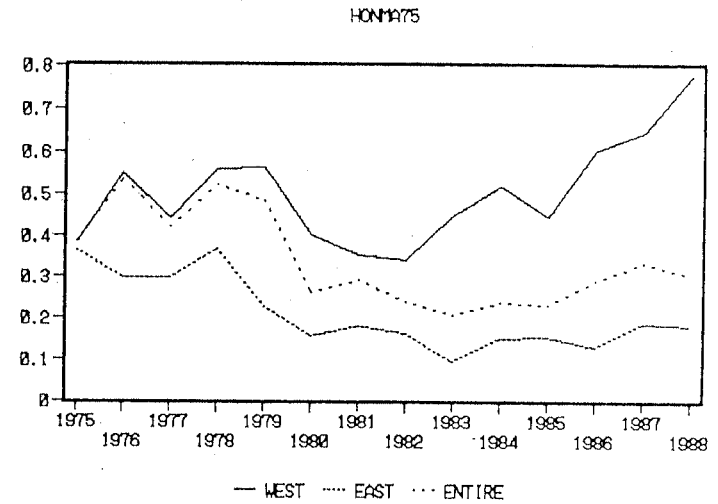
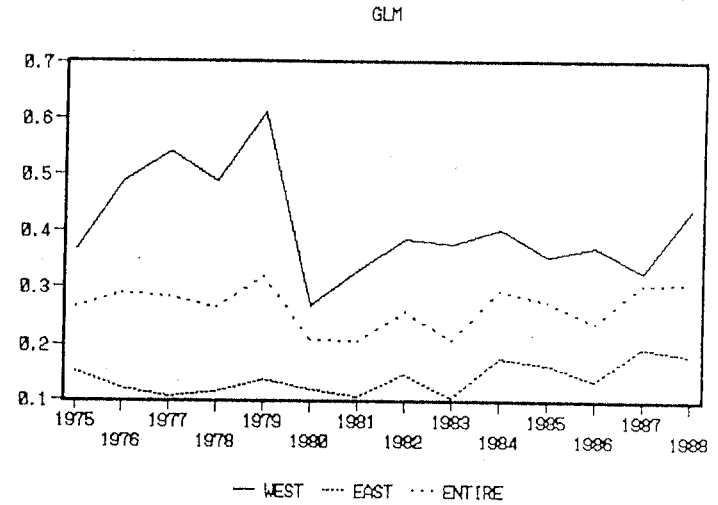


Fig. 4. Comparison of CPUE trends estimated by the GLM(upper) and Honma method(lower) for yellowfin taken by the Japanese longline fishery.