ON TARGETING PROBLEM, PARTITIONING FISHING EFFORT AND ESTIMATING ABUNDANCE INDEX OF BIGEYE TUNA FOR TAIWANESE LONGLINE FISHERY IN THE INDIAN OCEAN

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ABSTRACT

Bigeye tuna, Thunnus obesus, is a valuable species distributing in tropical and temperate waters around the world. Taiwan is one of the leading nation fishing bigeye tuna in the three Oceans. In 1999, the catch of bigeye tuna amounted to 38,000 mt by Taiwanese longline fleets in the Indian Ocean. In this study, daily logbooks with set by set catch information were used, a partitioning of fishing effort made by different fishing types, say deep and regular types, was pursued before some discussion of spatial and catch composition distributions of different hooks usd between floats. Then the new catch information was used to standardize catch per unit effort by general linear model, applied as the estimated abundance index of bigeye tuna for Taiwanese longline fishery in the Indian Ocean. The results showed that most years of the standardized time series trend were similar with Japanese trend, however, the trend after 1991 was opposite. This discrepancy needs to be in further investigated.

INTRODUCTION

Bigeye tuna, Thunnus obesus, is one of the most valuable and cosmopolitan scombridae, distributing in the tropical and temperate waters between 45 ^{o}N and 45^{o}S. In the Indian Ocean, bigeye tuna is exploited in the waters northerly 15^{o}S and the southwestern Indian Ocean. From the fishery initiated till the recent, more than 84% in weight of the total Indian catch had been made by longline gear (Anon., 1997), especially by Korean, Japanese and Taiwanese longline fleets, and Taiwan longline fishery has begun the leading fishery for bigeye tuna in the Indian Ocean since 1999. The production made by surface gears increased abruptly in the recent year, and the percentage of longline catch decreased to about 65% in 1999. And Taiwan fishermen have made about 50% of those longline catches in 1999.

Using standardized historical longline catch and effort data as the abundance index, a few studies to estimate maximum sustainable yield (MSY) have been done by production models (e.g. Miyabe, 1988; Chang and Hsu, 1993) and by virtual population analysis (Nishida and Takeuchi, 1999). The MSY derived from the latest production model analysis (Yeh et al., 2001) was estimated at about 45,000 metric tons by age-structured production model based on Taiwanese, Japanese and Korean longline catch and effort series. More recently, Nishida and Takeuchi (1999) have pointed out that the spawning stock biomass has dramatically declined since 1993. Nonetheless, a high uncertainty is concluded in analyzing the status of the bigeye tuna stock (Anon., 1999) during the First Working Parties on Tropical Tunas (1-4 September, 1999, Seychelles) sponsored by Indian Ocean Tuna Commission.

The catch and effort data of Taiwanese longline fishery have become important in using to assess the stock. But, since

1986, the fishing types have become much complicate in order to effectively target bigeye tuna in the Indian Ocean. One of the most important tasks in deriving an eligible abundance index is how to segregate fishing efforts directed to bigeye tuna. This work has been done in the Indian Ocean (Lin., 1998), and only a preliminary investigation has been pursued in the Atlantic Ocean (Hsu and Liu, 2000). Further, the previous standardized catch per unit effort derived from nominal catch and effort for Taiwanese longline fishery (Yeh et al., 2001) shows a great variation among seasons and sub-areas for bigeye tuna. Moreover, in the early 1990s no homogeneous distributions of logbooks were recovered from central bigeye tuna fishing area in space and time (Hsu and Liu, 2000). Therefore, since the day of the stock status was evaluated, the mixture and unidentified fishing effort directed to bigeye tuna has been used in standardizing catch per unit effort as the abundance index for the species. Even the generalized linear models (GLM and GENMOD) are applied to standardize nominal catch per unit effort with NHBF factor (O'Brien et al., 1997; Okamoto and Miyabe, 1998). The result has obviously been misleading the interpretation of abundance index, and the derived standardized catch per unit effort may not be the most appropriate representative of the bigeye tuna stock abundance.

On the estimation of abundance index using fishery catch and effort data, some criteria are necessary to be verified in priori, in the case of Taiwanese longline fishery, the most important criteria is how to partition fishing efforts of different fishing types made by different vessels in different time and space. Since 1986, Taiwanese longline fleets use two fishing types to target different tuna species. And very often, the fishermen exchanged fishing types for their targets from day to day. Therefore, the objectives of the present study are to partition fishing effort from different fishing types and to estimate abundance indices for assessment of the Indian bigeye stock..

MATERIALS AND METHODS

For the fishery data availability, three kinds of time series catch and effort are used in the present analysis, the first series is a 5x5 degree block aggregated catch and effort from 1967 to 1978; the second series is daily logbooks data for catch and effort of fishing by each day-set -vessel from 1979 to 1999; and the third is catch and effort series obtained from partitioning from logbooks data by fishing type from 1979 to 1999. In which logbook data, there are recording hooks between floats (HBF) information that is useful to partition fishing types.

1. Targeting problem

To study the targeting problem with different fishing types for Taiwanese longline fishery, the third kind data were used. Daily sets of vessels submitting the logbooks with HBF were selected, and then, catch per unit effort of bigeye tuna for the corresponding 5x5 block were estimated in aggregation from 1995 to 1000 by each HBF.

2. Partitioning fishing effort

Due to the targeting problem of different HBF used by Taiwanese longline fleets, an appropriate partitioning fishing effort seemed necessary before estimating abundance index. Two articles, Lin (1998) and Yeh et al.(unpublished) are present for this situation in the Indian and Atlantic Oceans, respectively. Herein with the Lin's criteria for partitioning fishing efforts from different fishing types (say deep and regular fishing types) was adopted in the present study.

3. Estimating abundance index

Four GLM models with different factors were used to standardizing catch per unit effort obtained from the partitioned data files from 1979 to 1999; and two GLM models were used to standardize catch per unit effort with files from 1967 to 1978.

RESULTS

As the classification of subarea (Figure 1) and 5x5 square block design, the species compositions of albacore, bigeye tuna and yellowfin tuna caught by different HBF were mapped in Figures 2 to 15.

HBF information with more area coverage was found for that HBF was from 8 to 10 and from 12 to 17. The latter illustrated that HBF from 12 to 17 was deployed in the subareas from 1 to 6 excluding 5, and high percentage yellowfin tuna catch was found in subarea 1, and bigeye tuna catch in subareas 2, 3, 4 and 6, even deployed in subarea 5, the catch was mostly bigeye tuna (see HBF=14). The former group of HBF (8-10) showed that if deployed in subarea 1, the catch was mostly yellowfin tuna; if in subarea 2, 3, 4 and 6, the catch was mostly bigeye tuna, and; if in subarea 5, the catch was mostly, or say, all the catch were albacore.

Furthermore, ignoring HBFs and combining and estimating the catch composition for the three species from 1995 to 1999 with HBF in logbooks, the results showed that the three species has spatial tendency in catch (Figures 16 –20). The results obtained are very obvious to classify that subareas 2, 3, 4 and 6 are bigeye tuna areas, subarea 5 is albacore area except the northwestern Australian waters (100^{o}E eastward and 35^{o}S northward).

Therefore, based on Lin's criteria (Table 1) for partitioning fishing effort from different fishing types (Lin, 1998), the new nominal catch per unit effort of bigeye tuna were shown in Figure 21 for Taiwanese longline fishery in the Indian Ocean.

And based on the partitioned fishing effort and subarea division (Figure 1), four GLM models with different factors are resulted in Table 2 with their ANOVA tests (Tables 3 – 6 for each GLM model, respectively), standardized catch per unit effort in Figures 22-25. Tested by AIC showed model 3 had the smallest AIC value (Table2), then the model 3 was selected and the residual analysis for fitting model 3 GLM was illustrated in Figure 26; two GLM models are resulted in Table 7 with ANOVA tests (Tables 8 and 9), and model 1 had the lower AIC value than model 2 (Table 7), then model 1 was selected and standardized catch per unit effort in Figures 27and 28, respectively, and the residual analysis was in Figure 29.

Accordingly, Figure 30 showed the standardized catch per unit effort of bigeye tuna for Taiwanese longline fishery in the Indian Ocean. The abundance index trend indicated a high fluctuated decreasing trend from 1967 to 1990, and an increasing trend from 1991 then after.

DISCUSSION

There are several abundance index estimated and standardized from catch per unit effort of bigeye tuna for Taiwanese, Japanese and Korean longline fishery in the Indian Ocean (Chang and Hsu, 1993; Okamoto et al., 2000, Hsu and Liu, 2000; Yeh et al., 2001). All of those abundance indices used long-term series of catch and effort data. Of those, Japanese index (Okamoto et al., 2000) and Taiwanese index (Hsu and Liu, 2000; Yeh et al., 2001) are very similar trend from the early time to 1990, and then, Taiwanese index showed very clear increasing trend other than Japanese trend showing decreasing trend. This increasing trend is very obvious in the present study. Though the data process is not different with those of Hsu and Liu (2000) and Yeh et al. (2001), the different tendency should be re-clarified with Japanese decreasing trend.

The CPUE is one of the characteristics to assess the resource condition of tuna. By the number and the location of fishing area that used in the CPUE standardization, the estimate of CPUE was different (Tsou, 1990). And then, the more appropriate division of fishing subarea, the more unbiased CPUE series will obtain (Allen, 1980; Hsu, 1996, 1998). The separation of fishing subarea in this study were only depend on the nominal CPUE and fishing effort in geographical distribution of Taiwanese longline fishery during the periods from 1979 to 1996. The small fishing area stratification may obtain better-standardized CPUE series than used in the present study.

The deep and regular longline data by reference value proposed by Lin (1998) was used in the present study. However, according the report of Mohri et al (1997), the different fishing types showed that there were no marked differences in the vertical distribution of Indian bigeye tuna by depth, in the south of 25°S of the Indian Ocean. According to their investigation (Mohri et al., 1997), the Indian bigeye tuna were caught between the hook depth 61m - 280m and the CPUE were obtained similarly. And the hook depth of deep longline gear, on the whole, is really between 100m - 250m. Thus we can suggest that the gear which take Indian bigeye tuna as target species can either deep or regular longline gear in the south of lat.25°S, and perhaps in the west Indian Ocean. Our illustration of catch composition and hooks between floats distribution also showed a similar result (Figures 2-20).

The CPUE trends between countries are different from 1991 to 1999. This perhaps indicated that the catchability between Japanese and Taiwanese longline factors are not consistent with each other. These situations might result from the difference fishing gear, fishing strategy, the variables that used in the standardization procedure and the geographical zone of higher fishing effort. For example, the fishing ground in the surrounding of west Austria and Cape Town of South Africa were the mass operation area of Japanese longline vessel during the time period from 1955 to 1995. But in contrast, those areas were not the major operation zone of Taiwanese and Korean longline vessels. As a result, the more sufficient and correct information we collect (e.g. sea temperature, gear type, bait type and so on), the more realizable of resource condition we will realize.

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Table 1 The ratio used to partitioning fishing effort deployed by different fishing types for Taiwanese longline fishery in the Indian Ocean, where the values are adapted from Lin (1998) and albacore ratio is defined as the number of albacore catch divided by the numbers of albacore and the number of bigeye tuna caught. If the albacore ratio for a 5x5 square block for each daily deployed set, the fishing type is classified as regular type, otherwise the deep type.

I. For the area V (Figure 1)

Month	Albacore ratio
June	0.89
thJuly	0.95
August	0.91
September	0.82
November - May	0.97

II. For areas I, II, III and IV (Figure 1)

Month	Albacore ratio
January – December	0.02

III. For area VI (figures)

Ratio is above 0.38 for all month.

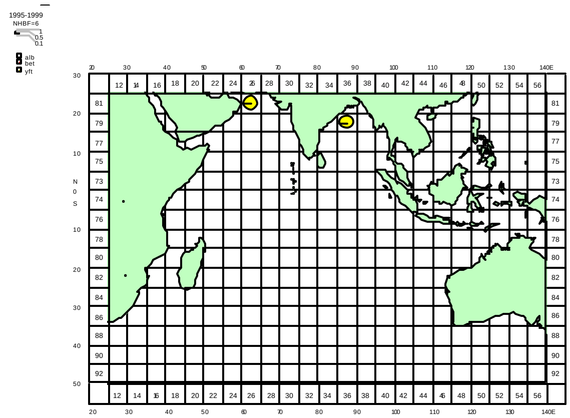


Figure 2. Distribution of catch composition of albacore, bigeye tuna and yellowfin tuna caught by 6 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

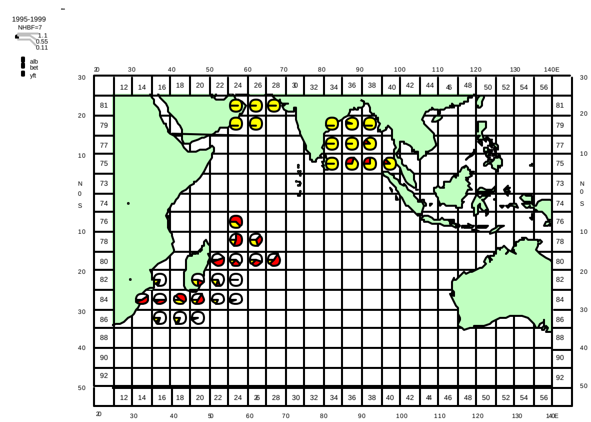


Figure 3. Distribution of catch composition of albacore, bigeye tuna and yellowfin tuna caught by 7 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

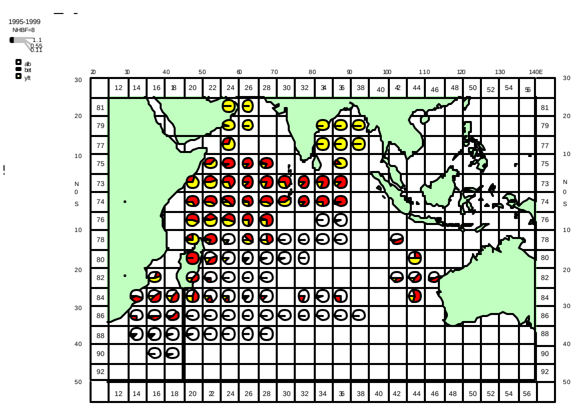


Figure 4. Distribution of catch composition of albacore,bigeye tuna and yellowfin tuna caught by 8 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

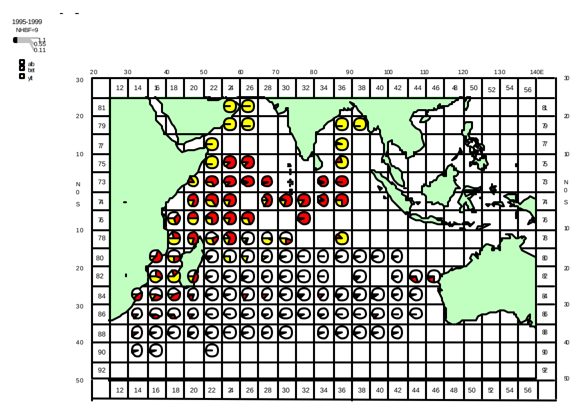


Figure 5. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 9 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

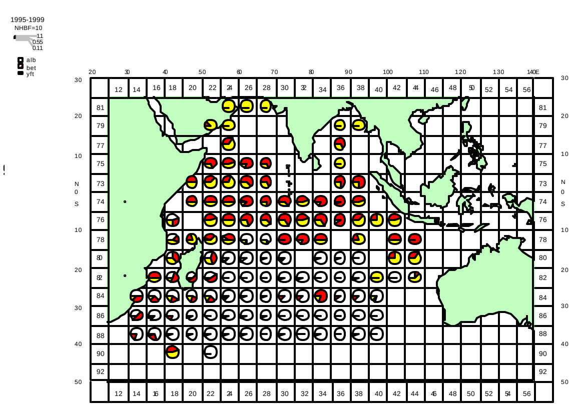


Figure 6. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 10 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

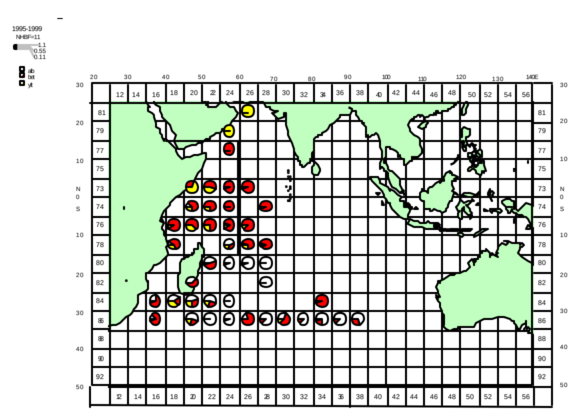


Figure 7. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 11 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

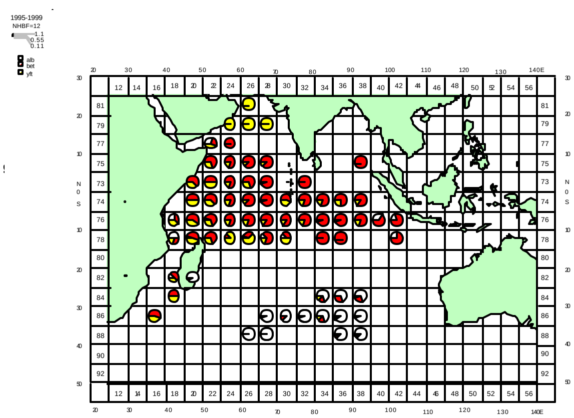


Figure 8. Distribution of catch composition of albacore, bigeye tuna and yellowfin tuna caught by 12 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

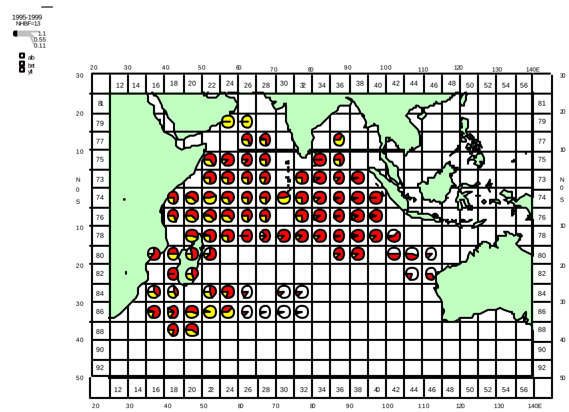


Figure 9. Distribution of catch composition of albacore, bigeye tuna and yellowfin tuna caught by 13 hooks between floats by Taiwanese longlinefishery in the Indian Ocean.

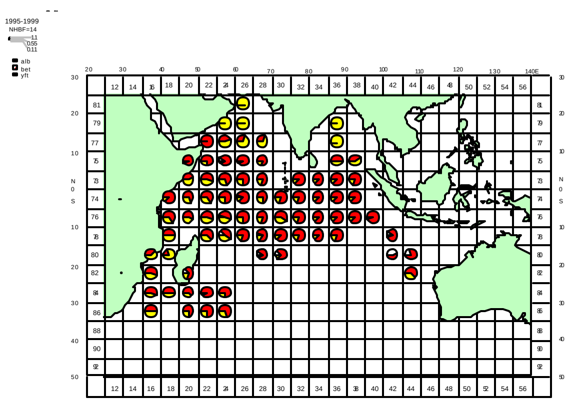


Figure 10. Distribution of catch composition of albacore,bigeye tuna and yellowfin tuna caught by 14 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

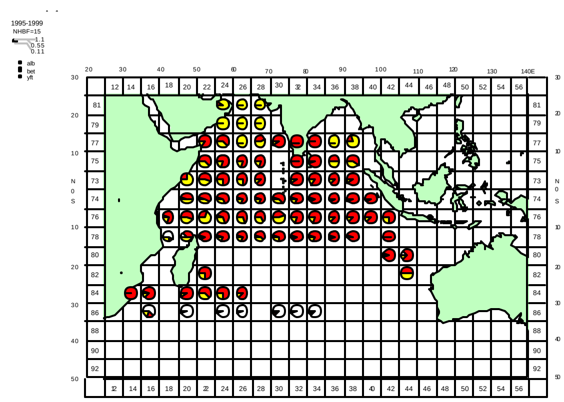


Figure 11. Distribution of catch composition of albacore,bigeye tuna and yellowfin tuna caught by 15 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

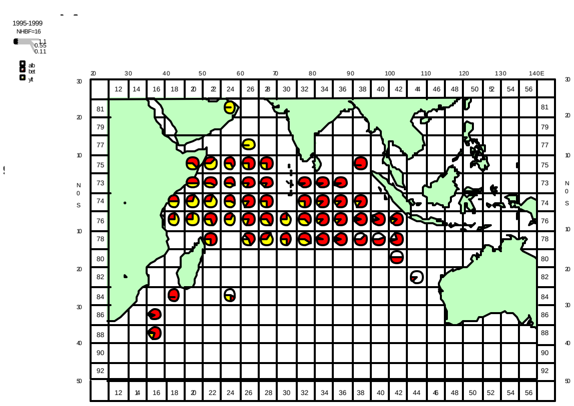


Figure 12. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 16 hooks between floats by Taiwanese longlinefishery in the Indian Ocean.

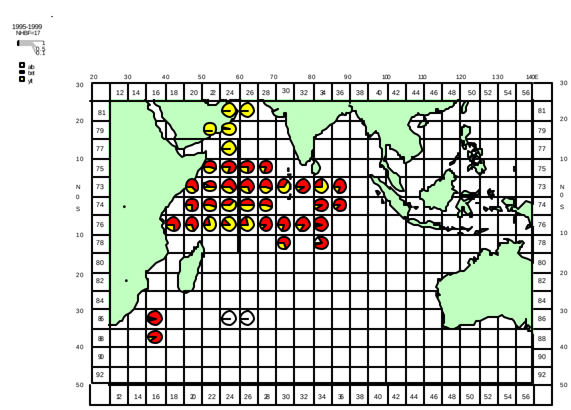


Figure 13. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 17 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

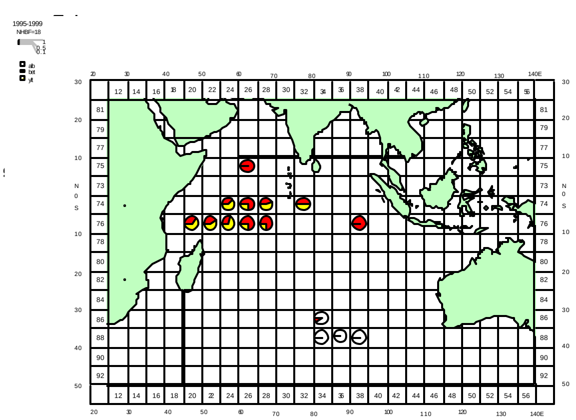


Figure 14. Distribution of catch composition of albacore, bigeye tuna and yellowfin tuna caught by 18 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

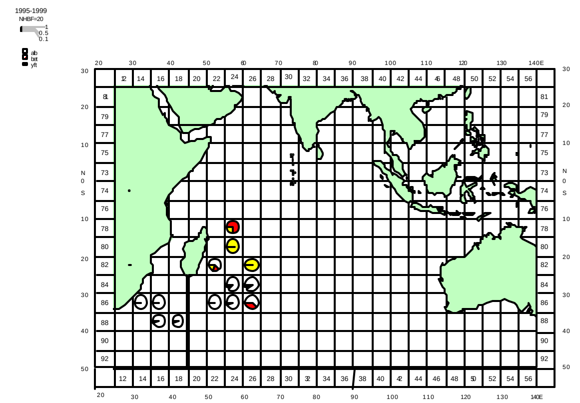


Figure 15. Distribution of catch composition of albacore, bigeyetuna and yellowfin tuna caught by 20 hooks between floats by Taiwanese longline fishery in the Indian Ocean.

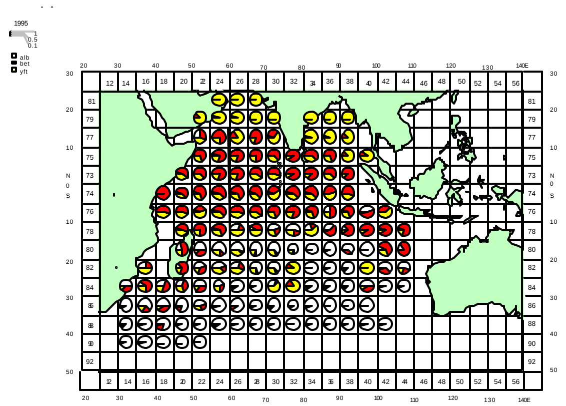


Figure 16. Catch distribution of three species (albacore,bigeye tuna and yellowfin tuna) aggregated by month and by 5x5 square block in 1995.

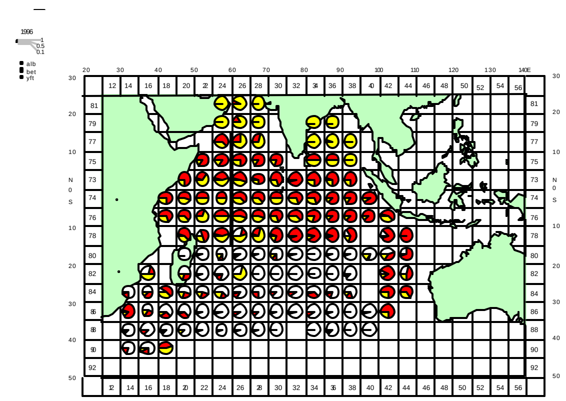


Figure 17. Catch distribution of three species (albacore, bigeye tuna and yellowfin tuna) aggregated by month and

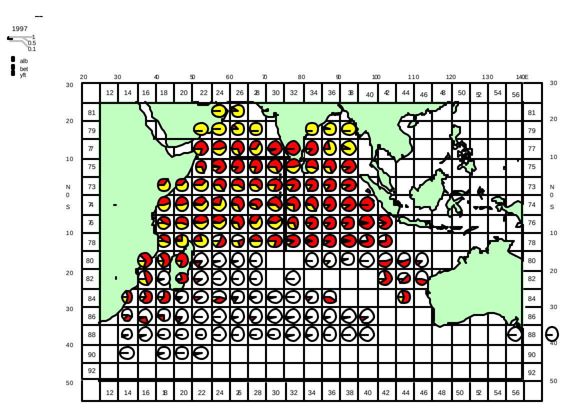


Figure 18. Catch distribution of three species (albacore,bigeye tuna and yellowfin tuna) aggregated by month and by 5x5 square block in 1997.

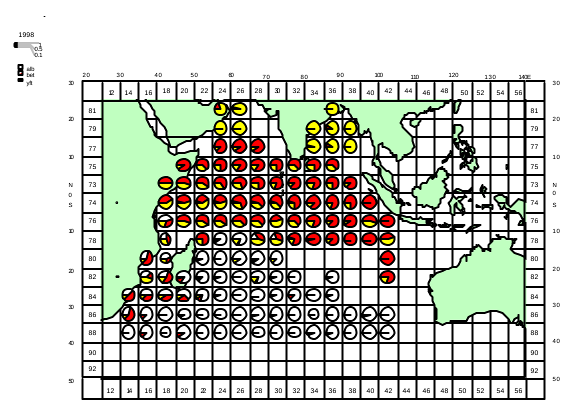


Figure 19. Catch distribution of three species (albacore, bigeye tuna and yellowfin tuna) aggregated by month and by 5x5 square block in 1998.

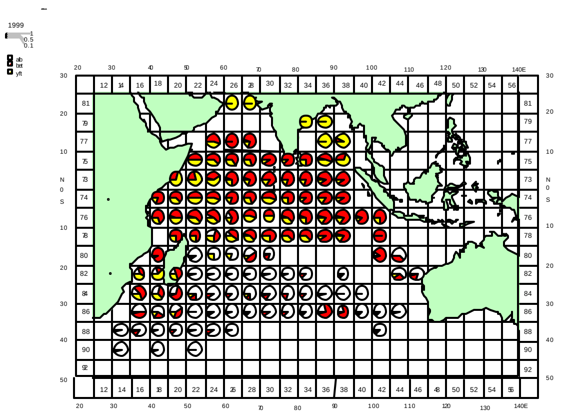


Figure 20. Catch distribution of three species (albacore, bigeyetuna and yellowfin tuna) aggregated by month and by 5x5 square block in 1999.

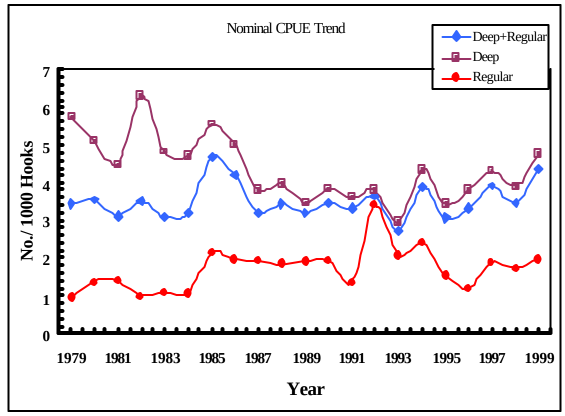
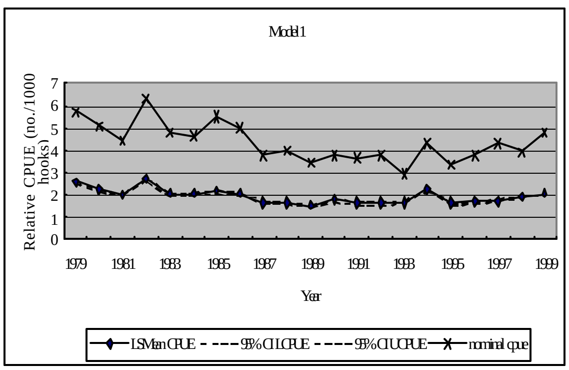


Figure 21.



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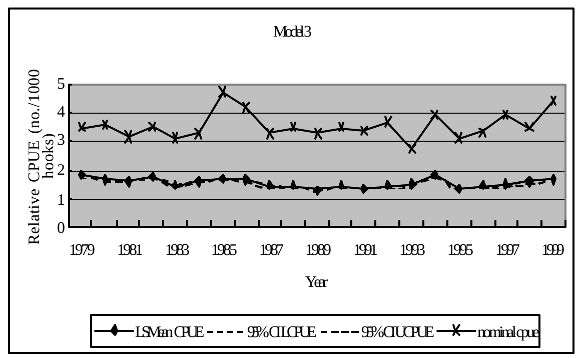

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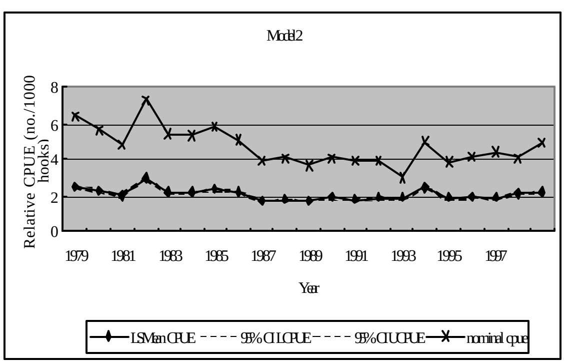

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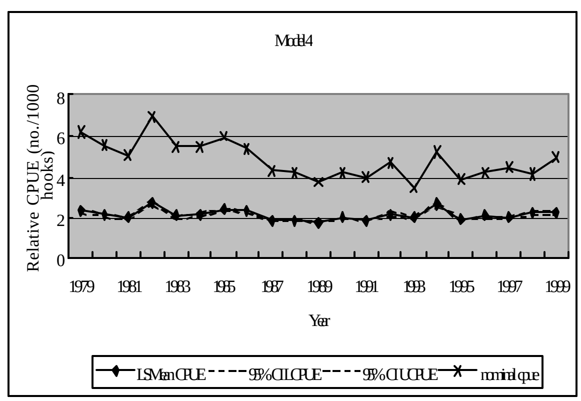


Figure 25.

Residual Analysis

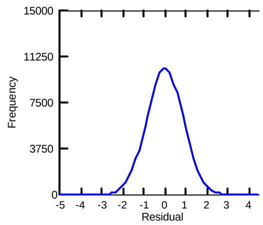
Moments

N	216344	Sum Weights	216344
Mean	0	Sum Observations	0
Std Deviation	0.87236471	Variance	0.76102018
Skewness	-0.3352809	Kurtosis	0.57058512
Uncorrected SS	164641.389	Corrected SS	164641.389
Coeff Variation	.	Std Error Mean	0.00187554

Tests for Normality

Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.059248	Pr > D	< 0.0100
Cramer-von Mises	W-Sq	120.7996	Pr > W-Sq	< 0.0050
Anderson-Darling	A-Sq	908.0261	Pr > A-Sq	< 0.0050

Figure 26.



Residual Analysis

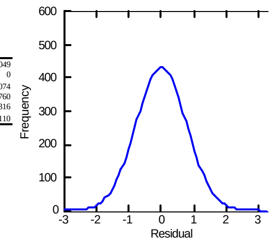
Moments

N	5049	Sum Weights	5049
Mean	0	Sum Observations	0
Std Deviation	0.7794	Variance	0.6074
Skewness	-0.2924	Kurtosis	0.7760
Uncorrected SS	3066.1316	Corrected SS	3066.1316
Coeff Variation	.	Std Error Mean	0.0110

Tests for Normality

Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.027556	Pr > D	< 0.0100
Cramer-von Mises	W-Sq	1.458159	Pr > W-Sq	< 0.0050
Anderson-Darling	A-Sq	10.80678	Pr > A-Sq	< 0.0050

Figure 29.



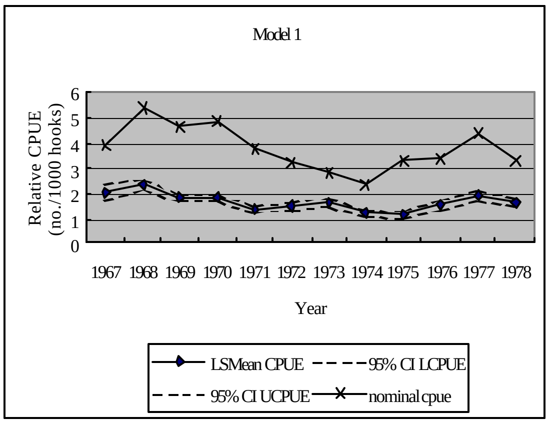


Figure 27.

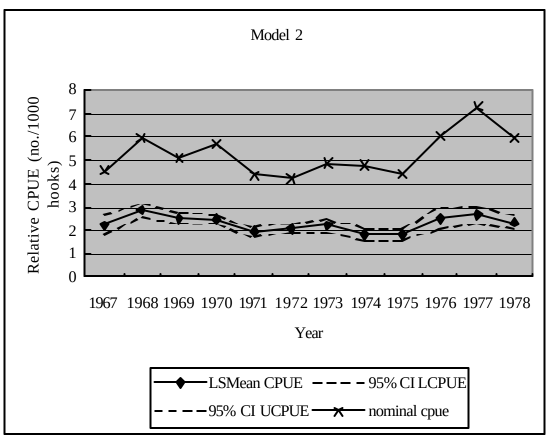


Figure 28

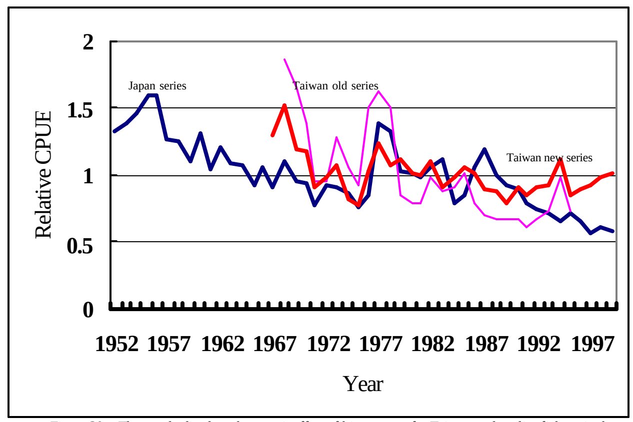


Figure 30. The standardized catch per unit effort of bigeye tuna for Taiwanese longlinefishery in the Indian Ocean from 1967 to 1999.

Table 2

model	No. of observations	No. of parameters	R-square	C.V.	MSE	F Value	AIC
model 1: deep longline in allarea ln(cpue+10%cpue)=year+loc+quar+quar*loc	227764	55	0.350003	83.82910	0.7906	2851.63	-53406.142
model 2: deep longline in betarea ln(cpue+10%cpue)=year+loc+quar+quar*loc	183914	45	0.375167	78.86557	0.7954	3154.44	-42009.781
model 3: regular and deep longline in allarea ln(cpue+10%cpue)=year+loc+quar+type+quar*loc+loc*type+quar*type	332103	77	0.509018	141.9103	0.7889	6620.16	-78592.838
model 4: regular and deep longline in betarea ln(cpue+10%cpue)=year+loc+quar+type+quar*loc+loc*type+quar*type	202406	63	0.354603	78.18326	0.8118	2647.26	-42075.909

Table 3

model 1: deep longline in allarea
ln(cpue+10%cpue)=year+loc+quar+quar*loc

Class	Levels	Values
year	21	1979-1999
loc	6	1 2 3 4 5 6
quar	4	1 2 3 4

Number of observations 227764

The GLM Procedure
Dependent Variable: ln(cpue+10%cpue)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	96942.4445	2254.4755	2851.63	<.0001
Error	227720	180033.6227	0.7906		
Corrected Total	227763	276976.0672			

R-Square	0.350003	RootMSE	0.889152
Coeff Var	83.8291	ln(cpue+10%cpue) Mean	1.060673

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	2874.8757	143.7438	181.82	<.0001
loc	5	60096.3812	12019.2762	15202.90	<.0001
quar	3	1575.8531	525.2844	664.42	<.0001
loc*quar	15	2836.5600	189.1040	239.19	<.0001

Table 4

model 2: deep longline in betarea
ln(cpue+10%cpue)=year+loc+quar+quar*loc

Class	Levels	Values
year	21	1979-1999
loc	4	1 2 3 4
quar	4	1 2 3 4

Number of observations 183914

The GLM Procedure
Dependent Variable: ln(cpue+10%cpue)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	87814.3782	2508.9822	3154.44	<.0001
Error	183878	146252.8719	0.7954		
Corrected Total	183913	234067.2501			

R-Square	0.375167	RootMSE	0.891841
Coeff Var	78.86557	ln(cpue+10%cpue) Mean	1.130837

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	1912.5213	95.6261	120.23	<.0001
loc	3	50915.9340	16971.9780	21338.20	<.0001
quar	3	941.0060	313.6687	394.36	<.0001
loc*quar	9	1330.0562	147.7840	185.80	<.0001

Table 5

model 3: regular and deep longline in allarea
ln(cpue+10%cpue)=year+loc+quar+type+quar*loc+loc*type+quar*type

Class	Levels	Values
year	21	1979-1999
loc	6	1 2 3 4 5 6
quar	4	1 2 3 4
type	2	R D
Number of observations	332103	

The GLM Procedure
Dependent Variable: ln(cpue+10%cpue)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	52	271583.1769	5222.7534	6620.16	<.0001
Error	332050	261959.7148	0.7889		
Corrected Total	332102	533542.8916			

R-Square	Coeff Var	RootMSE	ln(cpue+10%cpue) Mean
0.509018	141.9103	0.88821	0.625895

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	20	14834.2968	741.7148	940.17	<.0001
loc	5	198062.5052	39612.5010	50211.30	<.0001
quar	3	8575.1891	2858.3964	3623.19	<.0001
type	1	28141.4696	28141.4696	35671.00	<.0001
loc*quar	15	7256.4490	483.7633	613.20	<.0001
loc*type	5	14297.6724	2859.5345	3624.64	<.0001
quar*type	3	415.5947	138.5316	175.60	<.0001

Source	DF	Type II SS	Mean Square	F Value	Pr > F
year	20	1788.4532	89.4227	113.35	<.0001
loc	5	131587.0877	26317.4175	33358.90	<.0001
quar	3	5174.7407	1724.9136	2186.43	<.0001
type	1	26061.0176	26061.0176	33033.90	<.0001
loc*quar	15	4161.6568	277.4438	351.68	<.0001
loc*type	5	13206.3424	2641.2685	3347.97	<.0001
quar*type	3	415.5947	138.5316	175.60	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	1788.4532	89.4227	113.35	<.0001
loc	5	58991.7492	11798.3498	14955.10	<.0001
quar	3	2982.0086	994.0029	1259.96	<.0001
type	1	1065.3720	1065.3720	1350.42	<.0001
loc*quar	15	4161.6568	277.4438	351.68	<.0001
loc*type	5	13206.3424	2641.2685	3347.97	<.0001
quar*type	3	415.5947	138.5316	175.60	<.0001

Table 6

model 4: regular and deep longline in betarea
ln(cpue+10%cpue)=year+loc+quar+type+year*loc+year*type+quar*loc+loc*type+quar*type

Class	Levels	Values
year	21	1979-1999
loc	4	1 2 3 4
quar	4	1 2 3 4
type	2	R D
Number of observations	202406	

The GLM Procedure
Dependent Variable: ln(cpue+10%cpue)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	42	90258.2503	2149.0060	2647.26	<.0001
Error	202363	164275.0072	0.8118		
Corrected Total	202405	254533.2575			

R-Square	Coeff Var	RootMSE	ln(cpue+10%cpue) Mean
0.354603	78.18326	0.90099	1.152408

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	20	8767.9248	438.3962	540.04	<.0001
loc	3	77496.9875	25832.3292	31821.70	<.0001
quar	3	972.4253	324.1418	399.3	<.0001
type	1	92.2262	92.2262	113.61	<.0001
loc*quar	9	2023.1537	224.7949	276.91	<.0001
loc*type	3	600.5077	200.1692	246.58	<.0001
quar*type	3	305.0251	101.6750	125.25	<.0001

Source	DF	Type II SS	Mean Square	F Value	Pr > F
year	20	1497.3405	74.8670	92.23	<.0001
loc	3	73576.1771	24525.3924	30211.70	<.0001
quar	3	947.3837	315.7946	389.01	<.0001
type	1	70.4678	70.4678	86.81	<.0001
loc*quar	9	1751.0731	194.5637	239.67	<.0001
loc*type	3	540.6097	180.2032	221.98	<.0001
quar*type	3	305.0251	101.6750	125.25	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	1497.3405	74.8670	92.23	<.0001
loc	3	5378.9846	1792.9949	2208.71	<.0001
quar	3	485.6448	161.8816	199.41	<.0001
type	1	14.7002	14.7002	18.11	<.0001
loc*quar	9	1751.0731	194.5637	239.67	<.0001
loc*type	3	540.6097	180.2032	221.98	<.0001
quar*type	3	305.0250	101.6750	125.25	<.0001

Table 7

model	No. of observations	No. of parameters	R-square	C.V.	MSE	F Value	AIC
model 1: in allarea ln(cpue+10%cpue)=year+loc+quar+quar*loc	5049	46	0.433185	82.77754	0.611514	112.7	-2391.186202
model 2: in betarea ln(cpue+10%cpue)=year+loc+quar+quar*loc	3362	36	0.25236	53.26791	0.526233	43.3	-2086.4416

model 1: in allarea
ln(cpue+10%cpue)=year+loc+quar+quar*loc

Class	Levels	Values
year	12	1967-1978
loc	6	1 2 3 4 5 6
quar	4	1 2 3 4
Number of observations	5049	

The GLM Procedure
Dependent Variable: ln(cpue+10%cpue)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	34	2343.2753	68.9196	112.70	<.0001
Error	5014	3066.1316	0.6115		
Corrected Total	5048	5409.4070			

R-Square	0.433185	RootMSE	0.781994
Coeff Var	82.77754	ln(cpue+10%cpue) Mean	0.944693

Table 8

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	11	309.4676	28.1334	46.01	<.0001
loc	5	1771.8662	354.3732	579.50	<.0001
quar	3	103.1349	34.3783	56.22	<.0001
loc*quar	15	158.8067	10.5871	17.31	<.0001

Source	DF	Type II SS	Mean Square	F Value	Pr > F
year	11	105.9796	9.6345	15.76	<.0001
loc	5	1801.1118	360.2224	589.07	<.0001
quar	3	103.1349	34.3783	56.22	<.0001
loc*quar	15	158.8067	10.5871	17.31	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	11	105.9796	9.6345	15.76	<.0001
loc	5	1551.3859	310.2772	507.39	<.0001
quar	3	16.6109	5.5370	9.05	<.0001
loc*quar	15	158.8067	10.5871	17.31	<.0001