

OVERALL FISHING INTENSITY AND YIELD BY THE ATLANTIC  
LOGLINE FISHERY FOR ALBACORE, 1956-1975

by

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SUMMARY

In this paper, the standardization of effort of the longline albacore fishery was made for sub-areas (N-1, N-2, S-1 and S-2) on a quarterly basis. The relationship between the effective effort and catch was analyzed on the stocks in the North and South Atlantic Oceans. In addition, a production model analysis was attempted on both stocks, especially utilizing the data of the surface fishery for the northern stock.

RESUME

Le présent document fait état d'une normalisation de l'effort palangrier portant sur le germon, par trimestre, pour les sous-secteurs N-1, N-2, S-1 et S-2. La relation entre l'effort effectif et la prise a été analysée pour les stocks de l'Atlantique Nord et Sud. En outre, on a tenté l'analyse de ces deux stocks au moyen du modèle global, en utilisant en particulier les données de surface du stock nord.

RESUMEN

En este documento, la normalización del esfuerzo de la pesquería de palangre de atún blanco, se hace por subzonas (N-1, N-2, S-1 y S-2) y por trimestre. Se analiza la relación entre el esfuerzo efectivo y la captura, respecto a los stocks al Norte y al Sur del Atlántico. Por otra parte, se intentó efectuar un análisis del modelo de producción sobre ambos stocks, especialmente por medio de los datos de la pesquería de superficie del stock norte.

Appendix tables reproduced in Data Record Vol. 11.

Appendice tableaux reproduits dans la Vol. 11 du Recueil de Données.

Appendice cuadros reproducidos en Vol. 11 de la Colección de Datos

Estadísticos.

In this manuscript of a series of overall fishing intensity and yield papers on the Atlantic albacore, the method estimating effective effort was modified as follows;

Sub-area of the adult and young fish for both the North and South stocks were delineated by quarter of year (App. Fig. 1). Efficiency index of fishing effort was calculated by unit area ( $5^\circ \times 5^\circ$ ) and by quarter, with sub-areas for both stocks treated independent.

$$f_{ijk} = r_{ij} \cdot h_{ijk}$$

$h_{ijk}$  : Crude number of hooks for i-th unit area, i-th quarter and k-th year

$r_{ij}$  : efficiency index of fishing effort

$$r_{ij} = d_{ij} \cdot A_{ij} / \frac{\sum_j \sum_i d_{ij} \cdot A_{ij}}{\sum_j \sum_i A_{ij}}$$

$d_{ij}$  : Average hook rate for 1961-1974 (App. Fig. 1)

$A_{ij}$  : Area index

$$d_{ij} = 100 \cdot \sum_k C_{ijk} / \sum_k h_{ijk}$$

$C_{ijk}$  : Catch in number for 1961-1974

$h_{ijk}$  : Crude number of hooks for 1961-1974

For Japan and Taiwan, effective fishing effort was first obtained by sub-areas. Then, the values were expanded into estimates for whole longline fleets with the ratio of total yields to combined yields by Japanese and Taiwanese fleets.

Procedures to have the reported yields by countries assigned to sub-areas were as follows :

- 1) Japan and Taiwan: Catch in number by sub-areas, obtained from the Japanese and Taiwanese statistical data by area, was converted to yields using the average weight of fish from the age composition by Morita (1977). Average fish weights of 22 kg for the North and South adults, 14 kg for the North young, and 13 kg for the South young were used. The reported yields were, then, assigned to sub-areas with the ratio of yields thus estimated by these sub-areas. The Taiwanese reported yields for 1962-1966 were assigned to sub-area of the North adults according to Shiohama (1977), as the statistical data by area was no available for this period.
- 2) Korea: For the 1964-1973 yields, approximate estimates in Shiohama's last report (1977) were used. For the 1974 and 1975 yields, the reported figures were assigned to sub-areas in the same procedures as given above, based on data available for this period (Korea 1976, 1977).
- 3) Other countries: The reported yields of Panama, Venezuela and Cuba were treated as those removed from sub-area of the northern adults and yields of Argentina and Brazil as those from sub-area of the South adults.

Effective effort, fishing intensity, catch in number and yields for whole longline fleets estimated by sub-areas were given in App. Tables 1 and 2. Comparing CPUE's in Shiohama's last report (1977) with CPUE's estimated in this manuscript, as shown in Figs. 1 and 2, there is a similar trend between these two series of CPUE estimates for sub-area of the North and South adults, except for the South stock in 1957. A similar trend is also seen for sub-areas of the North and South young, although considerable difference in CPUE is noted for the South stock in 1962-1964 and for the North stock in 1973.

#### 1 North stock

The 1975 total albacore yields by whole longline fleets are estimated roughly as 12,000 tons, that is, 6,600 tons by Taiwan, 4,000 tons by Korea and 1,400 tons by Japan. Japanese and Taiwanese fleets mostly depend on the young and Korean fleet especially on the adults. During the recent years, degree of efficiency of fishing effort, as shown in Fig. 3, has been very low at about 0.2 for Japanese fleet, while, it has been very high around 2.0 for Taiwanese fleet. This would mean that albacore of the North stock has been harvested more efficiently by Taiwanese and Korean fleets than by Japanese fleet.

1) Relationship between fishing effort and yields for whole longline fisheries. As shown in Fig. 4, the total yields and catches in number removed from the North stock have increased with increasing fishing intensity, attaining to be the highest of 18,000 tons and 850,000 fish, respectively, in 1973. The yields, however, appear to become nearly level at about 15,000 tons. The CPUE for the young fish has been in a little upward trend after 1973, while the CPUE for the adults has been generally in a decreasing trend (App. Table 1).

2) Result of production model analysis

Available data including French and Spanish yield and effort data presented at the SCRS in 1976 (Bard, 1977) were analyzed using the PRODFIT program (Fox, 1975). Standardization of fishing effort through different fisheries, that is, the Spanish live bait, French trolling, longline in sub-area of the adults and longline sub-area of young, was made as follows;

$$S_{ik} = R_{ik} / \frac{1}{n} \sum_{k=1}^n R_{ik}$$

$R_{ik}$  : CPUE for the i-th fishery in k-th year

$S_{ik}$  : Index of standardized effort for i-th fishery

$$E_k = \sum_{i=1}^m \frac{W_{ik}}{S_{ik}}$$

$W_{ik}$  : Yield by i-th fishery

$E_k$  : Standardized effort in k-th year

Standardized effort and input data are given in Table 1. With the number of age groups fished to be the S-Y curves were obtained for each of 4 cases where m is variable or fixed at 0.0, 1.001 and 2.0, respectively. The result is shown in Table 2 and Fig. 5. Whichever the case, the MSY for the North stock is roughly between 58,000 tons and 69,000 tons, which is achieved at effort level of  $93 \times 10^3$  for  $m=1.26$ ,  $82 \times 10^3$  for  $m=2.0$  and  $133 \times 10^3$  for  $m=1.001$ . The 1975 yield estimate of 31,000 tons and effort estimate of  $43 \times 10^3$  nearly correspond to a half of Y max., and a half of  $f_{opt.}$ , respectively. In 1975, the lowest yield after 1957 was recorded for the North stock, due to small catches by the surface fisheries, although CPUE was not low (Table 1).

## 2 South stock

The South stock has been harvested exclusively by the longline fisheries. Longline countries included Taiwan, Korea, Japan, Argentina and Brazil. Of the 1975 yields of about 18,000 tons from this stock, 15,000 tons were shared by Taiwan, 2,000 tons by Korea, 400 tons by Japan and 100 tons each by Argentina and Brazil. In all, 6,600 tons were removed from sub-area of the adults and 11,000 tons from sub-area of the young (App. Table 2). Young albacore was fished only by Taiwanese and Japanese fleets and the adult fish was exploited mostly by Taiwanese and Korean fleets.

1) relationship between fishing effort and yields for whole longline fleets. Generally, the yields from the South stock had been in an increasing trend until 1972 with increasing fishing intensity. After 1973, both yield and fishing intensity have been decreased. The CPUE was down to as low as 1.53 in 1973 and again up to 1.75 in 1975. The yields appear to become nearly level at about 30,000 tons. It seems that no substantial increase in total yields be expected with increasing effort of the longline fishery over the recent level (Fig. 6).

### 2) Result of production model analysis

For standardization of fishing effort, the same procedure as in the case of the North stock were employed. Relative fishing effort and input data for the analysis are given in Table 3. The number of age groups fished in Table 3 are given from the age composition by Morita (1977). The MSY for the South stock is around 29,000 tons for each of  $m=0.770$  (variable),  $m=1.001$  or  $m=2.0$  (Table 4). The S-Y curves are shown in Fig. 7. Taking into account the status of 1974 and 1975 as shown in Figs. 6 and 7, careful observation should be needed in future.

## References

- Bard, F. X., 1977 Commentaires sur l'etat du stock de germon (*Thunnus alalunga*) Nord Atlantique. ICCAT/SCRS/76/59, Coll. Vol. of Sci. Pap. Vol. VI, 215-232.
- Fox, W. W. Jr., 1975 Fitting the generalized stock production model by least-squares and equilibrium approximation. Fish. Bull. Vol. 73, No 1.
- Korea, 1976 Catch and effort, catch/effort, LL-Korea & Panama-1974-5x5<sup>2</sup> by month. ICCAT Data Rec., Vol. 7, 46-53.
- Korea, 1977 Catch and effort, catch/effort, LL-Korea-1975-5x5<sup>2</sup> by month & summary, ICCAT Data Rec. Vol. 9, 12-18.
- Morita, S., 1977 Estimated age compositions of albacore harvests by Japanese and Taiwanese longline fisheries in the Atlantic Ocean. ICCAT/SCRS/76/32, Coll. Vol. of Sci. Pap. Vol. VI, 190-194.
- Shiohama, T. and S. Morita, 1975 Overall fishing intensity and catch by length class of albacore in Japanese Atlantic longline fishery, 1956-1972. ICCAT/SCRS/74/25, Coll. Vol. of Sci. Pap. Vol. IV, 89-108.
- Shiohama, T. 1977 Overall fishing intensity and yield by the Atlantic longline fishery for albacore, 1956-1976. ICCAT/SCRS/76/30, Coll. Vol. of Sci. Pap. Vol. VI, 181-183.

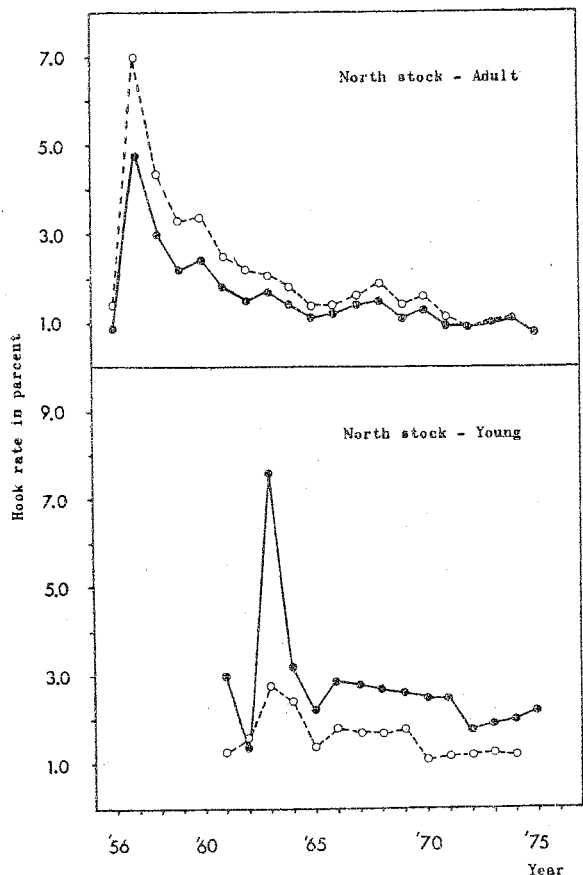


Fig. 1. CPUE of adult and young albacore for the longline fishery in the North Atlantic Ocean (Solid line). Broken lines indicate the value of CPUE by calculating method which was used in the previous issue of this series.

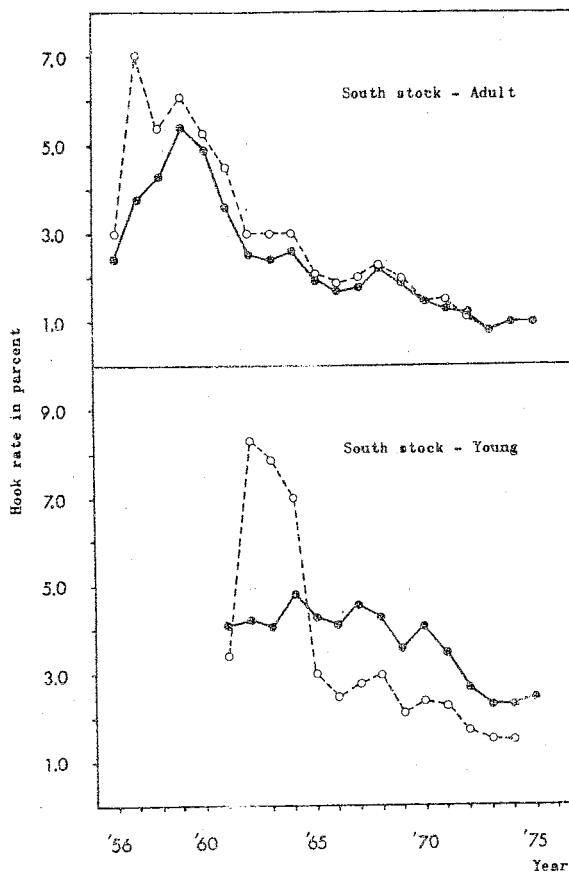


Fig. 2. CPUE of adult and young albacore for the longline fishery in the South Atlantic Ocean (Solid line). Broken lines indicate the value of CPUE by calculating method which was used in the previous issue of this series.

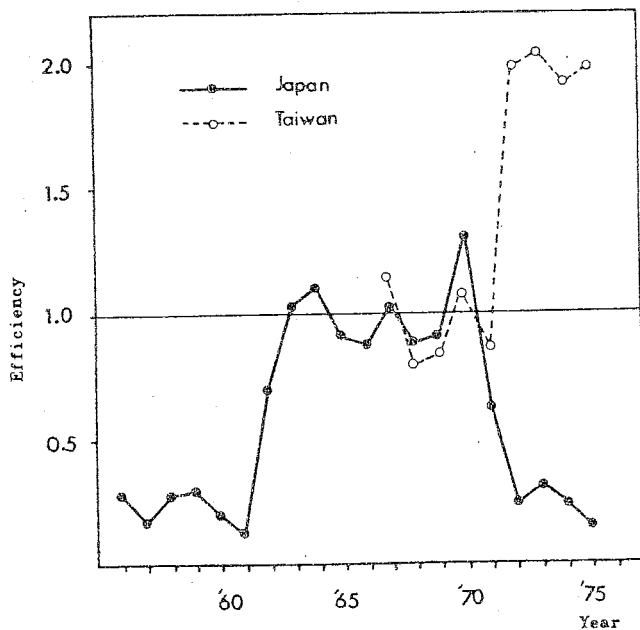


Fig. 3. The efficiency of fishing effort for Japanese and Taiwanese longline fishery of the North Atlantic albacore, 1956-1975.

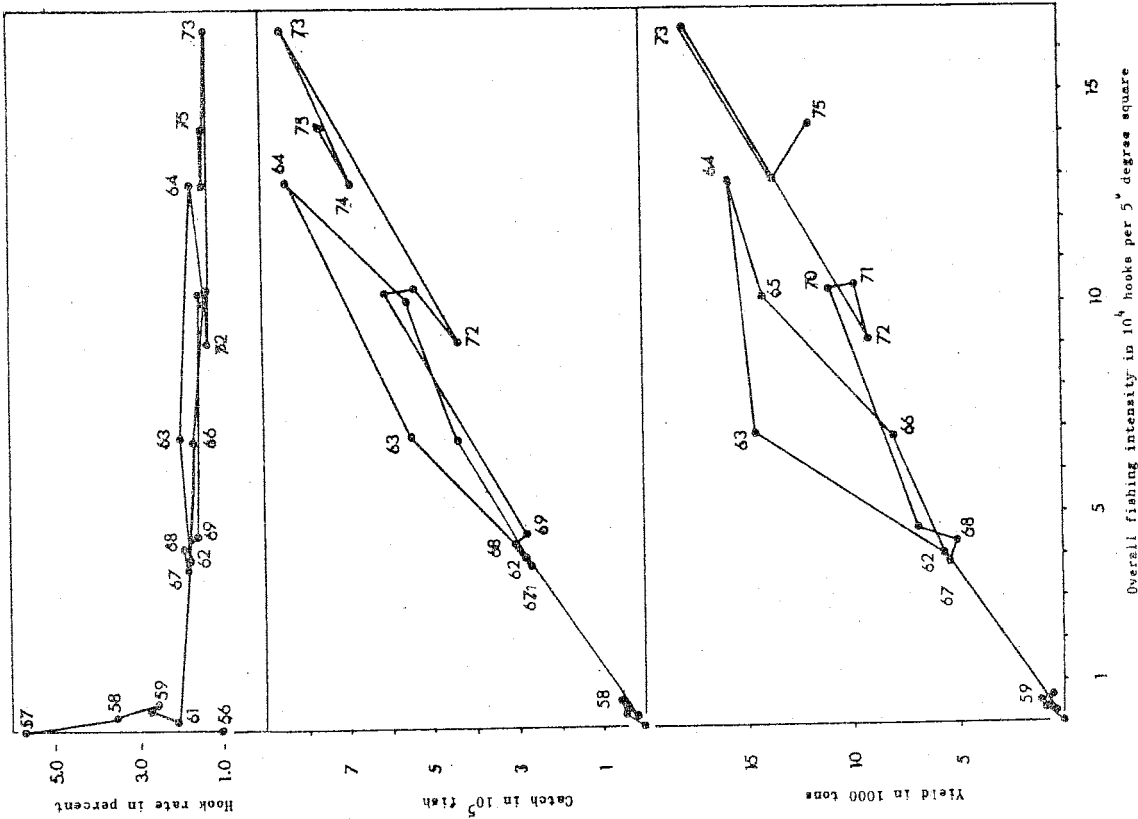


Fig. 4. Hook rate, catch and yield of albacore against overall fishing intensity in the North Atlantic longline fishery, 1956-1975.

Table 1. Annual yield, CPUE and relative standardized effort for the adult and young albacore in the North Atlantic Ocean, 1957-1975.

Year	Longline (Adult)				Longline (Young)				Surface (Spain)				Surface (France)				Data for production model analysis		
	Yield in tons	R <sub>ik</sub> 1)	S <sub>ik</sub> 2)	E <sub>ik</sub> 3)	Yield in tons	R <sub>ik</sub> 1)	S <sub>ik</sub> 2)	E <sub>ik</sub> 3)	Yield in tons	R <sub>ik</sub> 1)	S <sub>ik</sub> 2)	R <sub>ik</sub> 3)	Yield in tons	R <sub>ik</sub> 1)	S <sub>ik</sub> 2)	E <sub>ik</sub> 3)	Y <sub>k</sub>	Number of age	
1957	135	1.301	3.4509	.39	-	-	-	-	21,924	1.425	0.9059	24,201	20,064	0.386	1.4866	13,515	37,755	42,123	3
1958	945	0.603	1.5995	591	-	-	-	-	33,924	1.450	0.9218	36,802	17,279	0.244	0.9385	18,411	55,804	52,148	3
1959	599	0.224	0.5942	1,008	-	-	-	-	30,140	1.760	1.1062	27,246	18,922	0.294	1.1308	16,733	44,987	49,661	3
1960	1,131	0.514	1.3634	830	-	-	-	-	30,697	1.757	1.1170	27,482	19,597	0.346	1.3308	14,726	43,038	51,425	3
1961	380	0.387	1.0265	370	-	-	-	-	24,335	1.104	0.7018	34,675	17,092	0.421	1.6192	10,556	45,601	41,807	3
1962	5,727	0.313	0.8302	6,898	b	0.176	0.4190	14	31,500	1.666	1.0210	30,852	20,293	0.369	1.4192	14,290	52,063	57,526	3
1963	14,533	0.468	1.2414	11,707	96	1.288	3.0667	31	28,155	1.497	0.9517	29,584	16,239	0.257	0.9885	16,428	57,750	59,023	3
1964	14,331	0.273	0.7241	19,791	1,485	0.400	0.9524	1,559	28,500	1.567	0.9562	28,609	19,486	0.325	1.2500	15,589	65,548	63,802	3
1965	8,063	0.341	0.9045	10,683	4,512	0.421	1.0024	4,501	29,025	1.189	0.7559	38,398	15,549	0.333	1.2800	12,140	65,722	58,749	3
1966	5,365	0.272	0.7215	7,436	2,780	0.425	1.0119	2,747	25,511	1.392	0.8849	28,829	13,414	0.193	0.7423	18,071	57,083	47,070	3
1967	1,258	0.363	0.9629	3,384	2,184	0.419	0.9976	2,189	32,429	2.031	1.2912	25,115	15,534	0.207	0.7962	19,510	50,198	53,405	3
1968	3,489	0.270	0.7162	4,872	1,622	0.376	0.8952	1,812	23,632	1.274	0.8099	29,179	13,239	0.191	0.7346	18,022	53,885	41,982	3
1969	4,121	0.338	0.8966	4,596	2,745	0.501	1.1929	2,301	22,229	0.994	0.6319	35,178	9,385	0.179	0.6885	13,531	50,916	40,745	3
1970	7,477	0.298	0.7905	9,459	3,625	0.273	0.6500	5,577	23,480	1.428	0.9078	23,865	6,163	0.160	0.6354	10,015	55,706	38,480	3
1971	4,548	0.223	0.5915	7,689	5,393	0.315	0.7500	7,191	29,796	1.305	0.8296	35,916	9,210	0.179	0.6885	11,229	41,086	42,783	3
1972	4,509	0.258	0.6844	6,588	4,720	0.329	0.7833	6,026	24,396	2.292	1.4571	16,743	8,558	0.187	0.7192	12,806	45,602	44,947	3
1973	10,751	0.280	0.7427	14,476	7,131	0.330	0.7857	9,076	19,322	1.695	1.0776	17,931	8,425	0.235	0.9038	9,322	41,158	40,393	3
1974	7,820	0.271	0.7188	10,879	5,908	0.327	0.7786	7,588	24,240	2.852	1.8131	13,369	8,425	0.249	0.9577	6,343	45,232	31,186	3
1975	5,457	0.173	0.4589	11,891	6,592	0.304	0.7238	9,107	13,062	1.293	0.8220	15,891	6,075	0.249	0.9577	6,343	45,232	31,186	3
Mean		0.377				0.420				1.573				0.260					

1) R<sub>ik</sub> ; CPUE(Yield in tons / Effective effort)

2) S<sub>ik</sub> ; CPUE index

3) E<sub>ik</sub> , E<sub>k</sub> ; Relative fishing effort

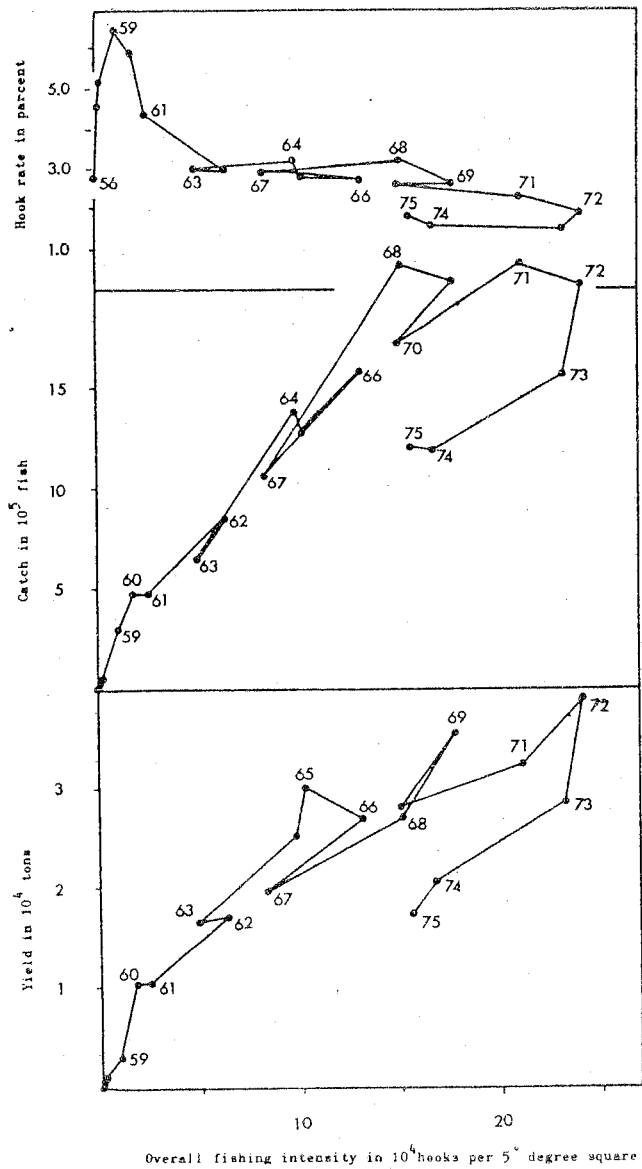


Fig. 4. Hook rate, catch and yield of albacore against overall fishing intensity in the South Atlantic longline fishery, 1959-1975.

Table 2. Result of production model analysis for the North Atlantic albacore, 1957-1975.

m	Residual sum of squares	Optimum cpue	Optimum relative fishing effort	M.S.Y. (10 <sup>3</sup> tons)
Variable (1.260)	0.3839	0.63	92,613	58.5
0.0	0.3844	-	-	110.0
1.001	0.3876	0.52	133,121	69.1
2.0	0.3851	0.70	82,308	57.7

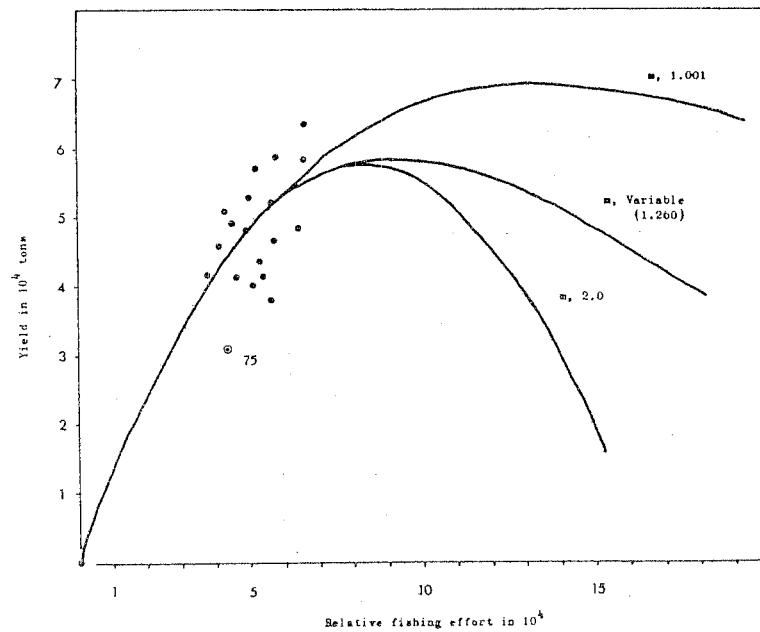


Fig. 5. Relation between yield and relative fishing effort obtained from production model analysis on the surface and longline fisheries for the North Atlantic albacore, 1957-1975.

Table 3. Annual yield, CPUE and relative standardized effort for the adult and young albacore in the South Atlantic Ocean, 1956-1975.

Year	Adult			Young			Data for production model analysis				
	Yield in tons	1) $R_{ik}$	2) $S_{ik}$	3) $E_{ik}$	Yield in tons	1) $R_{ik}$	2) $S_{ik}$	3) $E_{ik}$	$E_k$	Yield in tons	Number of age
1956	21	0.510	0.9714	22					22	21	3
1957	725	1.044	1.9886	365					365	725	3
1958	1,047	0.855	1.6286	643					643	1,047	3
1959	3,015	0.550	1.0476	2,878					2,878	3,015	3
1960	10,473	1.060	2.0190	5,187					5,187	10,473	3
1961	10,346	0.783	1.4914	6,937	47	0.519	1.0000	47	6,984	10,393	3
1962	16,480	0.507	0.9657	17,065	642	0.509	0.9807	655	17,720	17,122	3
1963	15,447	0.654	1.2457	12,400	1,134	0.655	1.2620	899	15,299	16,581	4
1964	22,552	0.505	0.9619	23,445	2,853	0.565	1.0886	2,621	26,066	25,405	4
1965	18,835	0.605	1.1524	16,344	11,338	0.762	1.4682	7,722	24,066	30,173	5
1966	13,486	0.405	0.7714	17,482	13,002	0.561	1.0809	12,029	29,511	26,488	4
1967	11,737	0.436	0.8305	14,132	8,110	0.719	1.3854	5,854	19,986	19,847	4
1968	14,749	0.451	0.8590	17,170	12,487	0.467	0.8998	13,878	31,048	27,236	4
1969	21,333	0.467	0.8895	23,983	14,177	0.535	1.0308	13,753	37,736	35,510	4
1970	15,303	0.359	0.6838	22,379	12,809	0.538	1.0366	12,357	34,736	28,112	4
1971	16,252	0.281	0.5352	30,366	16,321	0.458	0.8825	18,494	48,860	32,573	4
1972	17,780	0.340	0.6476	27,455	21,368	0.454	0.8748	24,426	51,881	39,148	4
1973	11,935	0.219	0.4171	28,614	16,849	0.366	0.7052	23,893	52,507	28,784	4
1974	8,881	0.252	0.4800	18,502	11,859	0.352	0.6782	17,486	35,988	20,740	4
1975	6,552	0.219	0.4171	15,708	11,045	0.324	0.6243	17,692	33,400	17,597	4
Mean		0.525				0.519					

1)  $R_{ik}$ ; CPUE (Yield in tons / Effective effort)

2)  $S_{ik}$ ; CPUE index

3)  $E_{ik}, E_k$ ; Relative fishing effort

Table 4. Result of production model analysis for the South Atlantic albacore, 1956-1975.

m	Residual sum of squares	Optimum cpue	Optimum relative fishing effort	M.S.Y. ( $10^3$ tons)
Variable (0.770)	0.4661	0.55	52,841	28.9
0.0	0.4909	-	-	47.5
1.001	0.4686	0.61	46,854	28.6
2.0	0.5335	0.76	38,181	29.2

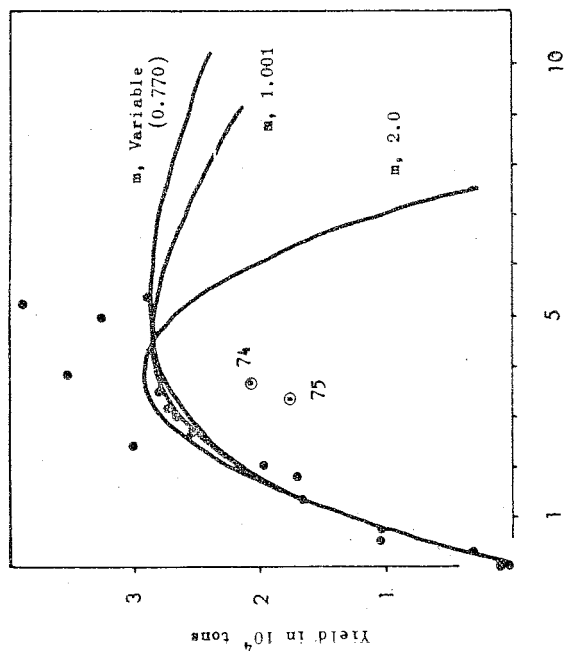
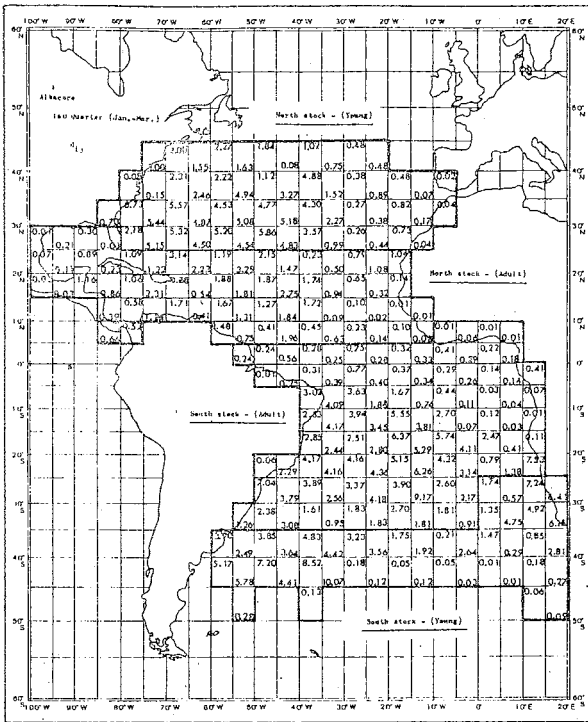
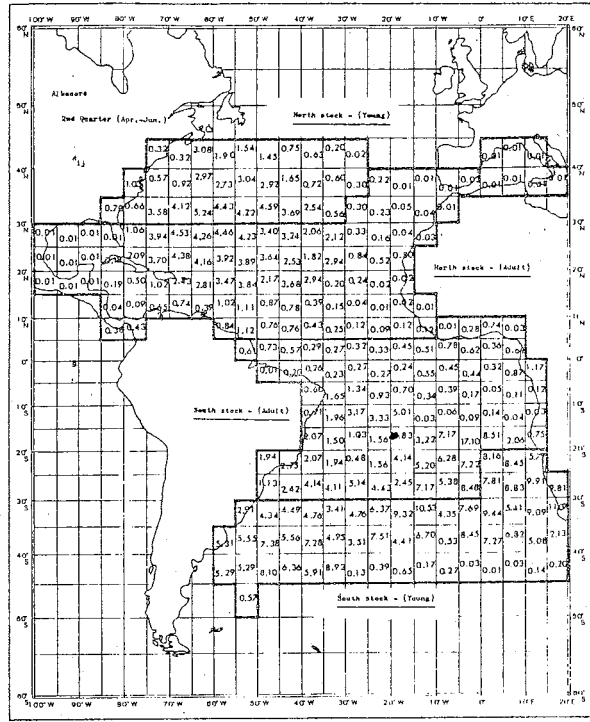


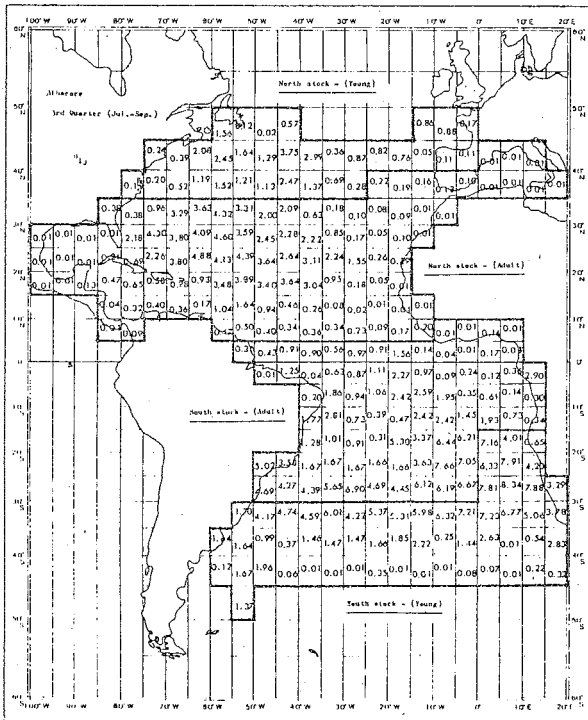
Fig. 7. Relation between yield and relative fishing effort obtained from production model analysis on the longline fishery for the South Atlantic albacore, 1956-1975.



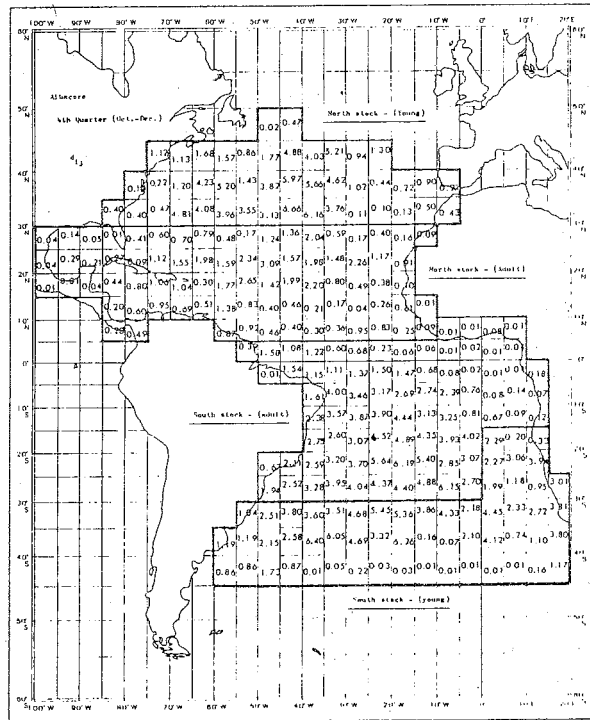
Appendix Figure 1-1.



Appendix Figure 1-2.



Appendix Figure 1-3.



Appendix Figure 1-4.

Appendix Figure 1. Distribution of hook rate by Quarter and by 5° degree square( $d_{ij}$ ), and sub-area for the adult and young of the North and South Atlantic albacore stocks.