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RECENT STATUS OF THE BIGEYE TUNA STOCKS IN THE ATLANTIC OCEAN

by

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SUMMARY

Recent exploitation of bigeye tuna in the Atlantic seems to have reached to the level of full utilization of the stock(s). This report presents, on the basis of revised data, the results of (1) production model analyses, (2) cohort analysis and (3) examination of interaction between gears on Y/R basis. Some comments are extended to the case of two possible stocks in the North and South Atlantic separately.

RESUME

L'exploitation du thon obèse dans l'Atlantique semble avoir atteint récemment le niveau d'exploitation totale du stock (des stocks). Ce rapport présente, à partir de données révisées, les résultats obtenus par (1) les analyses de modèle global, (2) l'analyse de cohortes, et (3) l'étude de l'interaction entre engins à partir des analyses de rendement par recrue. Quelques commentaires sont également formulés quant à l'existence éventuelle de deux stocks séparés pour l'Atlantique Nord et Sud.

RESUMEN

La explotación del stock(s) de patudo en el Atlántico parece haber alcanzado un nivel de plena utilización. El informe presenta, en base a datos revisados, los resultados de (1) análisis del modelo de producción (2) análisis de cohortes, y (3) examen de la interacción entre los diferentes artes basado en análisis del rendimiento por recluta. Se formulan algunos comentarios sobre la posible existencia de dos stocks separados al Norte y al Sur del Atlántico.

1. Bigeye tuna fisheries in the Atlantic.

Annual catch of Atlantic bigeye tuna has been increasing until recently. In 1974 and 1975, the catches reached to the highest peaks of a little more than 50 thousand tons. The preliminary 1976 catch indicates remarkable decline, about 35 thousand tons. The main gear capturing bigeye tuna has been longline fishery, while recent catch of baitboat fishery is becoming significant (Fig. 1).

1.1. Longline fishery.

Since 1971 until 1975, bigeye catch by longline gear has stayed at relatively high level between 30 and 35 thousand tons. Main longline fishing countries are Japan, Taiwan, Korea and Cuba. As displayed in another study by Kume MSa, recent longline bigeye fishing grounds of Japan and Taiwan locate in temperate waters, while Korean and Cuban longline fisheries are taking more bigeye in tropical waters. Brazilian and Argentine longline fisheries are operating in the offshore waters of their coasts. It appears that bigeye tuna in the Atlantic are completely covered by tuna longline fisheries of such nations as above.

In Figure 2, shown are the size composition of Atlantic bigeye tuna caught by Japanese longline fishery, 1965-1975 data combined, and by north and south Atlantic separately. Since the Japanese longline fishery used to operate in tropical waters in 1960's, the figure represents a typical size composition of longline catch. The longline fishery captures mainly medium- and large-sized bigeye, larger than 100 cm or 3 years old and older.

1.2. Baitboat fisheries.

Bigeye catch by baitboat fishery is encountered in two local areas of the eastern Atlantic. More than 10 thousand tons of bigeye are annually caught by Spanish and Portuguese baitboat fleets in recent years. In the Gulf of Guinea, the baitboat fleet based at Tema recorded increased catch of bigeye tuna after 1974.

(a) Spanish and Portuguese bigeye bait boat fishery (S-P BB fishery)

Spanish and Portuguese baitboat fisheries are capturing bigeye tuna in the waters around Canarian Islands and Madeira-Azores Islands, respectively. Monthly change in bigeye landings of these fleet shows peak months of April to June, the combined catch accounting for more than 70% of the annual catch (Fig. 3). Bigeye baitboat fishery by Canarian fleet was described in detail by Santos (1976 and 1977), in which during months of March to June the size compositions of catch are dominated by fish ranging 70-120 cm or 2 and 3 years old fish. According to the age data in 1975 and 1976 by Santos (pers. comm.), more than 50% of the bigeye caught by Canarian fleet are mainly comprised of 2 years olds (Fig. 4).

(b) Baitboat fisheries in the Gulf of Guinea (GG BB fishery)

In the Gulf of Guinea, bigeye tuna are caught by baitboat fishery mixed with skipjack and yellowfin tuna. The amount of catch was very minor until recently, but from 1974 and onward the annual catch has become fairly large. It is reportedly said that there have been some confusions in identfying two species between young bigeye and yellowfin tunas. As shown in Fig. 5, baitboat catch of bigeye tuna in the Gulf of Guinea is composed predominantly of 1 year olds.

1.3. Purse seine fishery.

Purse seine fleet in the Atlantic captures bigeye tuna sporadically around the Gulf of Guinea, and the catch amount has been very little. The largest catch of bigeye tuna was experienced in 1974, about 1,800 tons. Size of bigeye by purse seine fishery ranges rather widely (Fig. 6), but major constituents are 1-3 years old fish.

1.4. Other fisheries.

Catch statistics of Atlantic bigeye tuna indicate some amount of catch by unknown gear during years 1963-1971. In 1974 and onward, handlining bigeye catch by Portuguese and the catch by unknown gear of Spain are tabulated. These catches are relatively minor in amount compared to the total annual catch.

1.5. Recent catches and dominant ages by gear.

According to recent catch statistics and size data, bigeye catch by gear with dominant age groups of each gear may be outlined, as an average of 1974-1976, as follows:

Gear	Annual catch	Dominant age groups
Longline	30,367 tons	3 years and older
S-P BB fishery	10,107	2 and 3 years olds
GG BB fishery	3,366	1 year olds
Purse seine	804	1-3 years olds
Other fisheries	1,455	unknown

2. Population parameters used in the assessment analyses.

Growth equation: $L_t = L_\infty(1-e^{-0.2066t-0.0249})$ $L_\infty = 214.8$ cm

This growth equation is estimated for Pacific bigeye tuna by Yukunawa and Yabuta (1963), but it is well comparable to the growth of Atlantic bigeye estimated by Champgnat and Pianet (1974).

Natural mortality coefficient (M)

Although there has been no definite value for M of Atlantic bigeye tuna, Murphy and Sakagawa (1977) evaluated that M of bigeye tuna probably lies in the lower portion of the range, 0.35 to 0.73, based on a comparative study on M's of various tuna species. Other values of M recently estimated by Kume (1977) using a technique by Suda (1970) in which the relationship between effort and reciprocal of cpue is utilized, are 0.452 and 0.432 that are well within the range of M quoted above. In this study, two values of M, 0.45 and 0.55, are adopted in the calculation when necessary.

3. Assessment of the status of the bigeye stock(s).

3.1. Production model analyses.

Historical catch and effort data of the Atlantic bigeye fisheries are available for the longline fishery for north and south Atlantic separately as well as for whole Atlantic (Kume, MSa). Because no effort data are available other than those of the longline fishery, total effort is estimated by extrapolating the longline effort data with the ratio of the amounts between longline catch and total catch. In the case of two stocks assumption, the catches of surface fisheries are allocated to the north Atlantic except those of purse seine and baitboat fisheries in the Gulf of Guinea. Among the catch and effort data thus obtained, the data prior to 1960 were excluded from the analysis due to the incompleteness of catch records of bigeye tuna which were by-product in earlier stages of the Japanese longline fishery. The imput data prepared for the production model are tabulated in Table 1. Three cases (M=0, 1.001 and 2) of the generalized production model, the computor program PRODFIT by Fox (1975), were fitted to three sets of data with 4 and 5 significant year classes in the catch. The estimated equilibrium curves in the case of 4 year classes with plottings of observed data are shown in Figs. 7-9. The calculated maximum sustainable yiled (Ymax), optimum fishing effort (fopt), degree of fit index and 1975 and 1976 catches are indicated in Table 2. The values of degree of fit index are quite high compared to those obtained by Sakagawa (1977).

It seems that in all three cases the recent utilization of the bigeye stocks in the Atlantic is judged to have been on the high level of exploitation. Preliminary 1976 catch is about 35 thousand tons, remarkably lower than those of two preceding years. The corresponding effort data are yet unavailable, but as far as Japanese longline fishery is concerned, the fleet size in 1976 reduced to 2/3 of that in 1975. The interpretation of a decline of bigeye catch in 1976 should be accompanied at least by the total amount of the corresponding effort.

3.2. Cohort analysis.

Revised catch history by age of the Atlantic bigeye caught by the longline fishery is obtained for the years of 1965 to 1975 by Kume (MS b). Based on this data three cohorts were applied to cohort analysis of Murphy's method (the computor program by Tomlinson 1970). They are 1965-1 (from 1 age of 1965 to 10 age of 1974), 1966-1 (1 age of 1966 - 10 age of 1975) and 1967-1 (1 age of 1967 - 9 age of 1975) cohorts. It is considered that the influence of recent expansion of surface fishery that captures younger ages may not have extended or may have been very small, if any, on the catch of older ages of the recent longline fishery. There have not been obtained any age-specific fishing mortality coefficient (F) for three cohorts, so that under this section a point is directed to estimating amount of recruitment at age 1.0 (N_1). In the backward calculation of the cohort, four values of initial F were arbitrarily chosen; 0.1, 0.3, 0.5 and 0.7. The results of the calculation are shown in Table 3 for two cases of M=0.45 and 0.55. The range of N_1, number of fish at the beginning of age 1, is 270×10^4 - 700×10^4 for high initial F's. Although N_1 fluctuates depending upon the supposed M, it is suggested that annual recruit of Atlantic bigeye tuna varies fairly large.

3.3. Interaction of catches among gears.

When the average age at first capture varies, the change in Y/R of bigeye tuna was calculated under such assumptions as F=non-age-specific, M=0.45 and the entry age to the fishing ground as 1.0. The largest Y/R is attainable at about 3.5 age at first capture. However, as already shown in section 1.5., Atlantic bigeye are now exploited by multi-gear fisheries.

An attempt was made to evaluate the interaction of catches among gears on Y/R basis. Considering recent status of bigeye fisheries, postulated are three types of gears as follows:

	Catch	Range of dominant age
Gear-1 (longline)	30,000 tons	3 years and older
Gear-2 (GG-BB)	3,400 tons	1 year olds
Gear-3 (SP-BB and purse seine)	11,000 tons	1.5 to 4.0 years olds

Recent value of F of Gear-1 may be in the range of 0.35-0.52, according to catchability coefficient (0.22×10^{-8}) estimated by Kume (1977) and the overall longline effort (Kume, MSa). The F of Gear-2 was estimated to be 0.27, assuming that $N_1 = 500 \times 10^4$, M=0.45 and catch in number of Gear-2 = about 97×10^4 fish estimated by taking mean weight of catch as 3.5 kg. Without Gear-3, number of fish at age 2.0 (N_2) will become 243×10^4. To estimate F of Gear-3, N_2 is set at 230×10^4. In the same manner of the case of Gear-2, by solving the catch equation F of Gear-3 was calculated to be 0.31, if the mean weight of Gear-3 catch is taken as 15 kg. With gear-specific F's of 0.4, 0.3 and 0.3 for Gear-1, Gear-2 and Gear-3, respectively as above estimated and when one of three gears varies its effort, changes in Y/R of each gear were computed (Table 4).

It is pointed out that under the assumed bigeye fisheries the increased catch of Gear-2 is almost equivalent to the decreased catch of Gear-1 or Gear-3. However, it is obvious that increase in F of small fish fishery results in the decrease of the catch of large fish fishery and total yield.

When it is desired to recover or increase total Y/R, firstly investigated is the availability of recruiting small-sized fish to Gear-2 fishery. In the above calculation, all recruiting fish are supposed to pass through Gear-2. If not, the imput parameters as well as the model should be reconstructed. In addition, it should be investigated if the bigeye taken by baitboat fleet in the Gulf of Guinea can be separately captured from other species, especially from skipjack. Unless this is possible, then the exploitation of skipjack that will accept further exploitation will be hampered by some limitation on taking small bigeye, if imposed.

In conclusion, it is unquestionable that the effect of recent expansion of surface catch of bigeye on longline fishery should be carefully monitored and that pertinent features of fishery biology of bigeye tuna as above noted should be further investigated.

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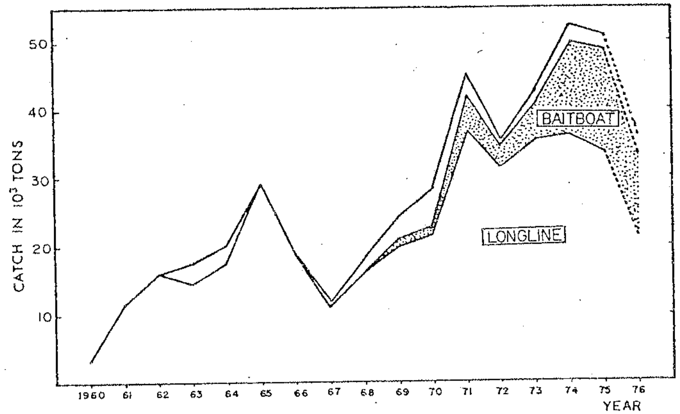

Fig. 1. Annual change in total catch of bigeye tuna in the Atlantic Ocean, 1960-1976. 1976 catch is preliminary.

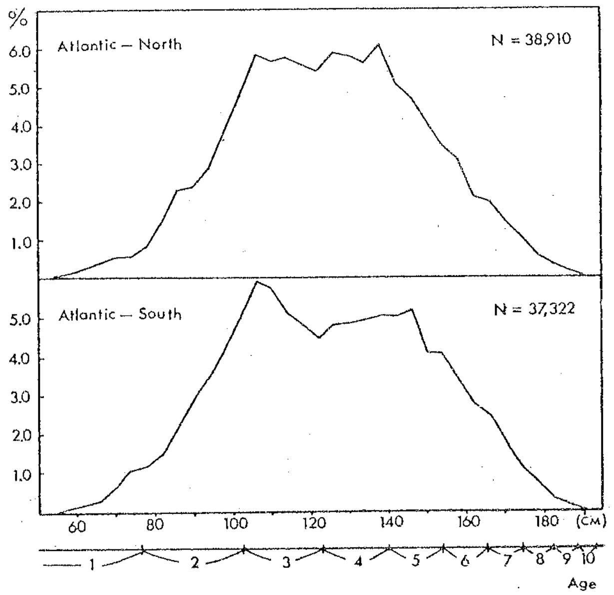

Fig. 2. Size composition of Atlantic bigeye tuna caught by Japanese longline fishery, 1965-1974 data combined. Age scale is calculated from the growth equation by Yukinawa and Yabuta (1963).

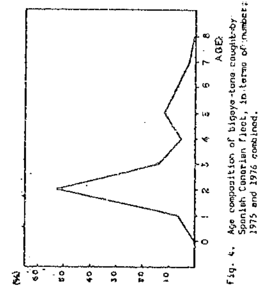

Fig. 4. Age composition of bigeye tuna caught by Spanish Canarian fleet, in terms of number; 1975 and 1976 combined.

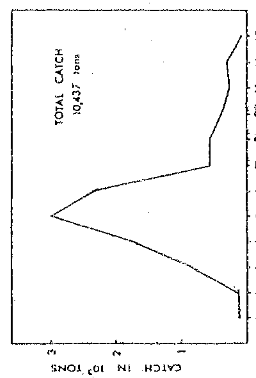

Fig. 3. Monthly change in the bigeye catch by Spanish Canarian and Portuguese baitboat fleets in 1975. Data from ICCAT Data Record Vol. 9 and Santos (1977).

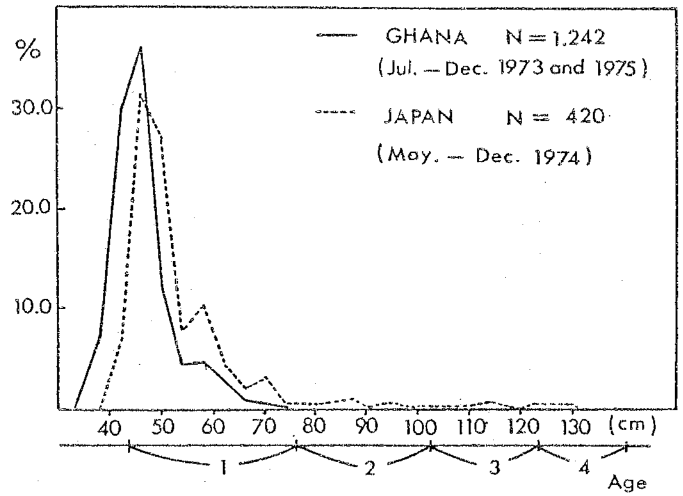

Fig. 5. Size composition of bigeye tuna caught by baitboat fleet in the Gulf of Guinea. Data from ICCAT Data Record Vol. 2, 3, 7 and 9.

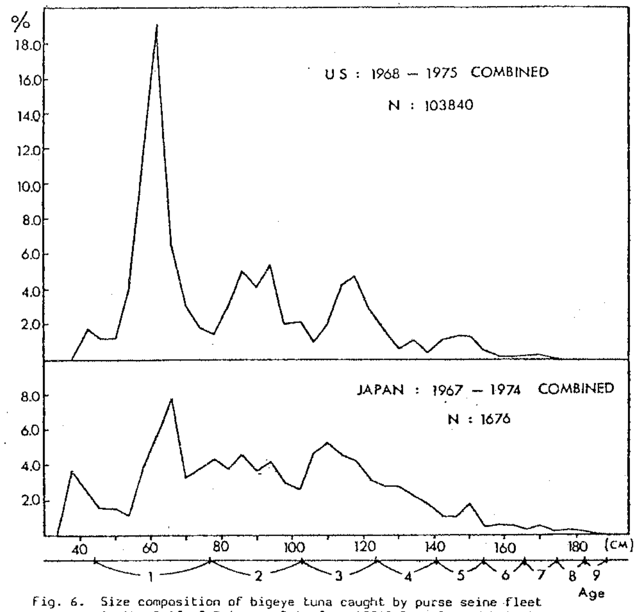

Fig. 6. Size composition of bigeye tuna caught by purse seine fleet in the Gulf of Guinea. Data from ICCAT Data Record Vol. 1, 5, 6 and 9.

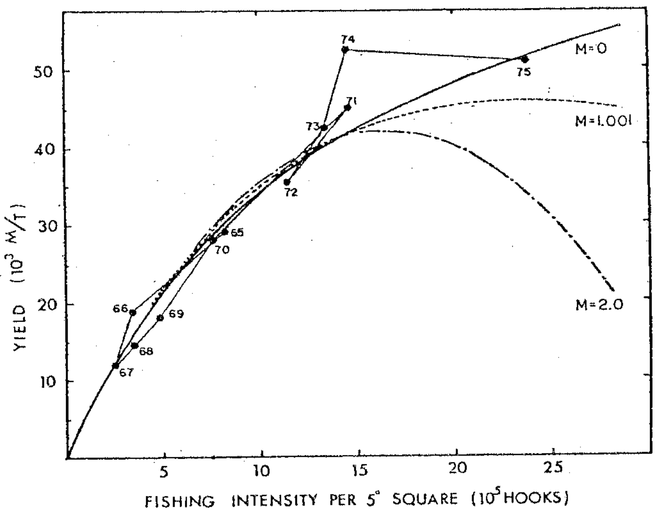

Fig. 7. Fitting the catch and effort data, 1960–1975, of bigeye tuna to the generalized production model, for the whole Atlantic Ocean. Observed data for the years of 1965 to 1975 are indicated in the figure.

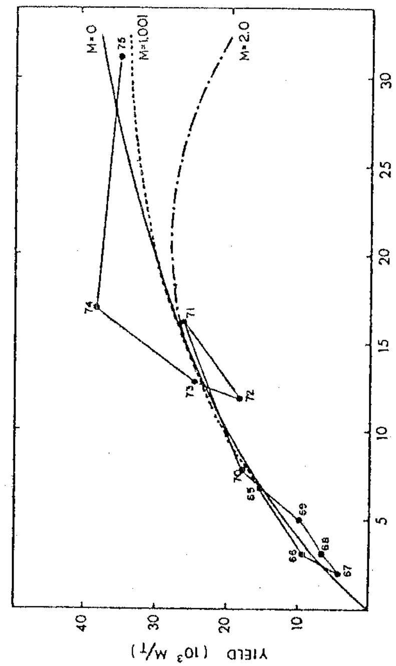

Fig. 8. Fitting the catch and effort data, 1960–1975, of bigeye tuna to the generalized production model, for the north Atlantic. Observed data for the years 1965 to 1975 are indicated in the figure.

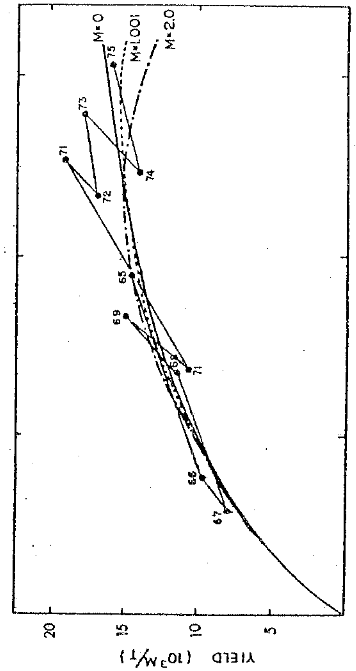

Fig. 9. Fitting the catch and effort data, 1960–1975, of bigeye tuna to the generalized production model, for the south Atlantic. Observed data for the years 1965 to 1975 are indicated in the figure.

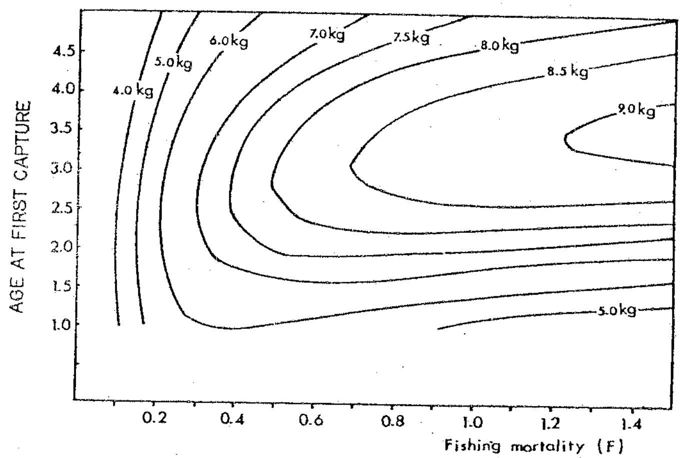

Fig. 10. Isopleths of Y/R (kg) of bigeye tuna with the change in average age at first capture.

Table 1. Annual catch and relative effort of Atlantic bigeye tuna fishery, 1960-1975, in three areas; whole Atlantic, north and south Atlantic.

year	Whole Atlantic catch (10^3 tons)	Whole Atlantic relative effort*	North Atlantic catch (10^3 tons)	North Atlantic relative effort	South Atlantic catch (10^3 tons)	South Atlantic relative effort
1960	3.0	105.8	2.1	115.6	0.9	97.7
1961	11.2	199.8	3.1	100.5	8.2	315.1
1962	16.0	364.2	8.5	325.5	7.5	410.6
1963	17.4	379.6	11.1	395.6	6.3	346.9
1964	20.4	478.7	13.7	570.4	6.7	367.0
1965	29.2	807.2	14.8	688.6	14.4	941.0
1966	19.0	349.6	9.2	318.3	9.7	382.0
1967	12.0	241.9	4.1	199.4	7.9	291.6
1968	18.2	483.6	6.5	311.1	11.6	671.7
1969	24.1	644.1	9.5	506.3	15.0	832.6
1970	28.2	746.0	17.5	792.4	10.7	683.7
1971	45.1	1459.1	26.1	1632.7	19.0	1266.1
1972	35.2	1156.7	18.1	1188.0	17.1	1160.8
1973	42.5	1357.2	24.4	1288.7	18.1	1396.5
1974	52.4	1460.0	38.3	1713.0	14.1	1231.4
1975	51.0	2384.5	35.0	3114.0	16.0	1531.0

* relative effort is expressed in terms of fishing intensity, namely 10^3 hooks per 5^o square.

Table 2. Some parameters estimated in the generalized production model (Fox 1975) applied to Atlantic bigeye tuna fishery, 1960-1975, under the assumption of two different stock structures. Number of significant year classes was chosen as 4.

	m	degree of fit index	fopt (10^3 hooks)	Ymax (10^3 tons)	catch (10^3 tons) 1975	catch (10^3 tons) 1976
whole Atlantic	0	0.621	∞	83.5		
	1.001	0.941	2,346	45.7	51.0	35.1
	2	0.977	1,656	41.8		
north Atlantic	0	0.986	∞	65.6		
	1.001	0.990	3,517	34.1	35.0	-
	2	0.993	2,117	27.8		
south Atlantic	0	0.994	∞	24.0		
	1.001	0.995	1,465	15.5	16.0	-
	2	0.996	1,165	15.2		

Table 3 Estimated number of fish at age 1.0 (N_1) for the years 1965-1967 by cohort analysis.

M	initial F	N_1 (in 10^3 fish) 1965	1966	1967
0.45	0.1	3,067	3,935	6,258
	0.3	2,746	3,335	4,447
	0.5	2,681	3,213	4,088
	0.7	2,653	3,162	3,933
0.55	0.1	5,539	7,401	12,189
	0.3	4,717	5,863	8,002
	0.5	4,549	5,549	7,161
	0.7	4,478	5,414	6,802

Table 4. Change in Y/R (kg), when F's of Gear-1 and Gear-3 are fixed at 0.40 and 0.30, respectively, and F of Gear-2 varies.

F of Gear-2	Yield per recruit (kg) Gear-2	Gear-3	Gear-1	Total
0	0	3.43	3.81	7.24
0.10	0.32	3.12	3.45	6.89
0.15	0.47	2.97	3.28	6.72
0.20	0.60	2.83	3.12	6.55
0.30	0.86	2.58	2.83	6.27
0.45	1.18	2.23	2.43	5.84
0.60	1.46	1.94	2.09	5.49
0.90	1.87	1.46	1.55	4.88