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ASSESSMENT OF THE CONDITION OF THE NORTH ATLANTIC ALBACORE FISHERY

William H. Lenarz
and
Atilio Coan

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center
La Jolla, California 92037

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INTRODUCTION

Bard (1974) reviewed the development of the North Atlantic albacore fishery. Briefly a commercial fishery has existed in the Bay of Biscay since at least 1880. The fishery started as a troll fishery which was pursued by French and Spanish fishermen in the Bay of Biscay east of 10°W. After the second world war baitboats entered the fishery and fished as far west as 15°W. The trollers also began fishing further to the west and by 1964 had moved offshore to 30°W. Japanese longliners began harvesting Atlantic albacore in a significant fashion in 1962 and in 1966 were joined by longliners from Taiwan and South Korea. The Asian longliners have captured albacore in most temperate and tropical areas of the Atlantic. Minor amounts of albacore have also been caught by several other nations in their local waters. Total catches in recent years (1967-71) averaged about 45,000 tons in the North Atlantic (Table 1).

Fishery scientists have raised concern about the status of the Atlantic stocks of albacore. For example, the report of the 1973 SCRS meeting states, "The 1972 data are still incomplete, but there appears to have been a general decline in total catch since 1964-1965. This decline has occurred in both longline and surface fisheries. In the surface fishery in the Bay of Biscay there has been a particularly clear decline in the catches and catch-per-unit-effort, in the traditional areas, which have been only partly balanced by a shift in effort to the west."

Several stock assessments in recent years have been based on the assumption of two stocks. Although a definitive study on the stock structure of Atlantic albacore has not been made, it is generally thought that separate stocks inhabit the northern and southern hemispheres, e.g., Beardsley (1969) and Le Gall (1974).

Beardsley (1971) used the production model approach on catches in terms of numbers of fish and concluded that up to 1968 there was room for expansion by the longline fishery in both hemispheres. Shiohama (1974) plotted longline catches in terms of weight and against fishing effort and concluded that by 1971 the longline fishery had reached the state of full exploitation in both hemispheres. Bard (1974), in a preliminary analysis, using the production model approach concluded that the MSAY (maximum sustainable average yield) for the north Atlantic surface fishery is 11-12 million fish at a fishing effort of 200,000-300,000 troller days at sea. During recent years surface effort has been less than 100,000 days at sea. Thus his results indicate that the stock is being considerably underexploited by surface gear. He also concluded that since 1968 fishing by longliners has reduced the stock of mature fish to the extent that recruitment has been reduced to the surface fleet. Assuming that class II (age 3) and class III (age 4) fish were exploited at the same rate, Bard estimated F to be 1.0 and M to be 0.2 on an annual basis. He also assumed that Beardsley's (1971) estimate of F (0.6) for the ages caught by the longline fleet was valid. Bard used the estimates of mortality to calculate yield per recruit isopleths which indicated that an increase of minimum age of capture from 2 to 3 years would increase yield per recruit by about 10%, a substantial increase in fishing effort without an increase in size at recruitment would reduce yield per recruit, and optimum age at recruitment for a longline fishery in the absence of a surface fishery would be about 6 years.

While these studies on stock assessment of Atlantic albacore have considerable merit we believed that some of the assumptions of these studies may be invalid and that further analysis is warranted.

1) We believe that the significance of trends in catch and effort noted by the SCRS needs verification.

2) We believe that the production model approach should be applied to catches in terms of weight rather than numbers.

3) We believe that since it has been assumed that the longline and surface fisheries exploit a common stock, the production model approach should also be applied to the combined fisheries rather than to only each fishery separately as has been done in the past.

4) We also believe that the assumption that the rate of exploitation for ages 3 and 4 fish and age 6-13 fish are the same needs to be examined.

With these thoughts in mind we examined 1) the significance of trends in catch and effort and used the data of Bard (1974) and Shiohama (1973 and 1974) for a 2) production model and 3) cohort analysis of the fishery.

Examination of Trends in the Fishery

We used the test of runs (Dixon and Massey, 1969) to test for significant trends in time series of 1) total catch of albacore in the Atlantic, Table 2, 2) catch of albacore by France, Table 1, 3) catches of Spain, Table 1, 4) CPUE of Japanese longliners in the north Atlantic, Table 1, 5) CPUE of French trollers, Table 1, and 6) average weight of albacore caught by longliners, Table 3. Significant trends at the 95% level of confidence were not detected for any of the time series except the French catch which deviated from random fluctuations about the median at the 99% level of confidence. The decline in the French catch must be at least partially explained by the decrease in effort by the French fleet in recent years, Letaconnoux (1973). The Japanese CPUE declined significantly at the 88% level of confidence. The lack of significant fluctuations in average weight of fish, Table 3; in their catch suggests that the fluctuation in the CPUE may not have been completely caused by changes in the status of the stock unless recruitment to the longline fishery had been reduced in a fashion that caused the age composition of the catch to remain constant.

However, we note that the average weight for 1969 is extremely high (32 kg) which suggests a possible error. Data are not available from the longline fishery after 1971. Inclusion of 1972 and 1973 data from the surface fishery does not change the results. The above results suggest that the status of the fishery has not significantly changed between 1959 and 1971, but short-term changes in the status of the stock caused by the fishery would not be detectable by the test of runs if fishing effort varied in a random fashion. Thus a production model analysis could result in additional information on the status of the stock.

Production Model Analysis

The age composition of catches of north Atlantic albacore by surface and longline gears, Table 4, shows that the surface fishery captures only young fish and the longliners tend to capture older fish. The modal age for surface gear is 3 years, while the modal age for longline gear is 5 years. Surface gear captures relatively few fish older than 4 years (0.9%), while the longliners capture relatively few fish younger than 5 years (12.6%).

In the strict sense, the production model approach assumes that observed changes in the age composition of the catch have no significant impact on net biomass production. Under this assumption we fitted the production model to the combined catch and effort data of the two gears. However, it has been shown that the age composition of the catch of yellowfin tuna can be important (Lenarz et al., 1974; Fox, MS). With this in mind we also fit the model to the surface fishery alone. This approach assumes that either 1) the catch by longliners of small amounts of young fish does not siginificantly affect the population and that the total catch by longliners does not affect the catch of young fish by the surface gear through density-dependent mechanisms or that 2) the longline rate of exploitation has remained constant over the period of analysis. Since the catch of older fish by longliners should be effected by the catch of young fish by surface gear under the assumption of a common stock, we do not believe that meaningful results would be obtained from examination of the catch of longliners separately.

The age composition of the total catch in terms of weight, figure 1, reveals that the catch is heavily dominated by fish of two year classes (presumably ages 3 and 4 years). Thus using the equilibrium approximation method of estimating the parameters of the production model, we averaged effort over 2 years (Fox, in press).

We first examined the longline and surface fisheries together for the 1959-71 period. French and Japanese estimates of CPUE were "standardized" by dividing each by their 1959-71 average. "Standard" effort was then calculated for the two components of the fishery by dividing catches by the corresponding CPUE and then summing over the two gears, table 5. We used PRODFIT (Fox, In press) to estimate the parameters of the production model using fixed values of m equal to 0.0, 1.001 and 2.0. The results indicate that the stock is considerably underfished, figure 2. An examination of the surface fishery separately also indicates only moderate fishing, figure 3.

The models explain very little of the variation in CPUE ($r^2 \leq 0.05$). Thus we hesitate to put any faith in the estimates of maximum sustainable yield or optimum fishing effort as shown in figures 2 and 3. However, the results agree with our examinations of trends in the fishery, viz, there is no evidence of the stock being overfished, in a biological sense.

Cohort Analysis

While the fishery appears to be in a healthy state, in a biological sense, a cohort analysis was conducted to evaluate the possibility that increases in yield per recruit could be obtained by changing age (size) selection by the fishery. The age composition data shown in table 4 were calculated from the 1968-72 average age composition of catches by the French troller fleet (Bard, 1974) and the 1967-71 average age composition from the Japanese longline fleet (Shiohama, 1973 and 1974). It would have been desirable to look at each year separately or to at least use the same years for calculating the averages. We decided not to examine each year separately because the time series were too short to conduct a meaningful individual cohort analysis of a longlived species such as albacore (maximum age in the fishery about 10 years) and there was insufficient data from the longline fishery for such an examination. Age composition data are not available from the 1967 French fishery or the 1972 Japanese fishery. We decided to use 5 years of not completely concurrent data rather than 3 years of completely concurrent data.

Age composition of fish caught by the French troller fleet was taken from table 11 of Bard (1974). These estimates were obtained from logbooks of fishermen. Class III in Bard's data is composed of 4 and 5 year old fish. We used estimates of the proportion of 4 and 5 year fish obtained from samples by Bard and Dao (1973) and Bard, Dao, and Laurec (1974) for 1971 and 1972 to divide the fishermen's logged catch of Class III albacore into catches of 4 and 5 year old fish. Bard (1974) felt that, although baitboats tended to catch large albacore late in the season, fish caught by the two surface gears (troll and baitboats) were essentially the same.

The longline length frequency data were divided into age groups by quarter using the growth curve of Bard (1974). We also used Bard's estimate of apparent modal size for age 2 and 5 fish which are apparently not caught in a random fashion with respect to size by the surface fishery. The length-weight relationship of Beardsley (1971) was employed in converting length to weight.

We estimated age specific F for each quarter with the Gulland (1965)-Murphy (1965) method. We assumed that M is 0.2 following Bard (1974) and Beardsley (1971), but also allowed M to be 0.4 because the coefficient of growth (K) of the van Bertalanffy growth model is estimated to be 0.183 by Bard (1974), 0.19 by Yang (1970) and 0.14 by Beardsley (1971), and M/K is throught to be about 2.0 for another tuna, yellowfin (Lenarz et al., 1974). The computer program COHORT (written by W.W. Fox, Jr.) was used to calculate F by the reverse solution. Estimates of F for younger fish did not converge for a reasonable range of F for the older fish. Consequently, we used both high and low estimates of F (hereafter referred to as high and low input F respectively). Yield-per-recruit calculations were made by the computer program MGEAR (written by Lenarz).

In all cases, F was estimated to be considerably higher for ages 3 and 4 than for fish of other ages, figure 4. High input F results in single-season rates of exploitation of about 0.40 for ages 3 and 4. This seems too high in view of the very low (<3.0%) rate of tag returns reported by Letaconnoux (1973). Low input F still produced estimates of exploitation that appear to be high in view of the low rate of tag return, but the extremely low estimate of F for older fish that are pursued by longliners seems too low to us. We concluded that the two sets of estimates provide reasonable bounds to the actual values.

Estimates of yield per recruit as a function of age at recruitment at the present level of fishing effort indicate that there would be no benefit obtained from raising the age at recruitment, figure 5. However, at high F and substantially higher fishing effort modest increases in yield per recruit would be obtained by increasing the age at recruitment. Plots of yield per recruit as a function of fishing effort by the two gears gives no indication of overfishing in the yield per recruit sense, figure 6. The results suggest that substantial gains through increases in F of either fishery over the 1967-72 average could be made under low input F and modest gains under high input F. In most cases increases in effort by surface gear appear to be more rewarding in a yield per recruit sense than increases by longline gear. When the two gears are treated separately, figure 7, the results reveal that the surface fishery has a considerable impact on yield per recruit to the longline fishery. The analysis shown in figure 7 assumed that, when both gears are in the fishery, effort is changed proportionally for both gears. If longline effort remains constant when surface effort is increased, yield per recruit to the longliners would be less than shown in figure 7. Consequently, analyses of the longline fishery alone does not appear prudent.

Discussion

All available data on the population biology indicate that the northern Atlantic albacore fishery is healthy in a biological sense. The production model analysis indicated that the stock is capable of producing a considerably greater yield than is presently being taken. This is in agreement with the production model analyses of Bard (1974) and Beardsley (1971). The very low rate of return of tagged albacore is also suggestive of potentially higher yield.

The low rate of tag returns could be caused by tagging mortality, shedding, low reporting, and/or changes in behavior. Clemens (1961) and Laurs and Associates (1973) obtained low tag return rates for north Pacific albacore. Clemens believed that tagging mortality is low and stated "after having tagged several tons of albacore, yellowfin tuna, and skipjack, and a few bluefin and bigeye tuna, I believe that albacore are the hardiest of the five followed by bluefin, bigeye, yellowfin, and skipjack." Laurs[1], who has tagged albacore, held live albacore aboard ship, and followed albacore bearing sonic tags, also believes that at least immediate tagging mortality is low. Returns from a double tagging study indicate that tag shedding is on the order of 25% per year (Laurs, pers. comm.). Relatively high returns of fish at liberty for more than one fishing season suggests that long-term tag shedding and mortality is not excessive. In summary, while some tagging mortality and shedding undoubtedly occurs it appears unlikely that they are sufficiently high (on the order of 90%) that when accounted for would produce a high apparent rate of exploitation, high enough to indicate over-fishing in a yield-per-recruit sense. We have no estimate of the reporting rate of tag recoveries or whether or not behavior changes occur that would reduce the likelihood of tag returns. Laurs (pers. comm.) reported that a very low proportion of the tag returns come from trollers. Since trollers take about 75% of the catch in the eastern Pacific and most of the tagged fish were released by trollers, Laurs' results suggest the possibility of avoidance of trolled lures by albacore once they have been captured by trolling. On the other hand, Clemens (1961) reported that most of his tag returns came from trollers. We believe that a careful analysis of the tagging data from the eastern Atlantic fishery may shed some light on the problem.

[1] R. Michael Laurs, SWFC

It is thought by some investigators that more than one group of albacore contributes to the eastern Atlantic fishery (Aloncle and Delaporte, MS). If these groups represent separate stocks, then the stocks should be analyzed separately. At present data is not available for this type of analysis. We recommend that an attempt be made to separate the catch and effort statistics by groups of fish.

Acknowledgements

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Table 1 Catch and effort statistics from North Atlantic albacore fishery

Year	Surface catch (1000 tons)[1]			Longline catch (1000 tons)[2]			Surface[1]		Longline[2]	
	Spain	France	Total	Japan	Others	Total	Effort days at sea of French trollers	CPUE (tons/day)	Effort 1000 hooks per 5° square	CPUE (kg/100 hooks)
1959	30.1	24.1	54.2	0.6	0.0	0.6	123,204	.440	26.7	22.5
1960	47.8	20.4	68.2	1.1	0.0	1.1	149,239	.457	21.6	50.9
1961	25.3	18.1	43.4	0.4	0.0	0.4	95,006	.457	10.4	38.5
1962	30.2	21.6	51.8	5.7	0.0	5.7	95,245	.544	178.0	32.0
1963	27.6	17.3	44.9	14.5	0.0	14.5	106,967	.420	330.9	43.8
1964	27.6	20.4	48.0	15.8	0.0	15.8	114,228	.420	509.1	26.8
1965	27.3	16.6	43.9	14.3	0.0	14.3	74,315	.591	531.9	26.9
1966	27.7	14.3	42.0	5.9	2.1	8.0	104,178	.403	371.7	21.5
1967	31.4	16.1	47.5	4.8	7.5	12.3	98,938	.480	632.7	23.1
1968	23.6	13.8	37.4	3.3	2.4	5.7	98,278	.381	261.7	21.8
1969	22.5	10.0	32.5	4.7	2.7	7.4	88,203	.368	211.5	35.0
1970	23.6	6.4	30.0	5.9	4.0	9.9	79,344	.378	540.8	18.3
1971	29.0	9.8	38.8	6.5	5.3	11.8	77,100	.503	765.2	15.4

[1] Bard (1974)
[2] Shiohama (1974)

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Table 2. Total catch of albacore in the Atlantic Ocean, 1963-72. Data from report of 1973 SCRS meeting

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Catch (1000 m tons)	74.4	87.7	87.8	75.4	76.1	71.9	75.3	68.4	79.9	74.1

Table 3. Average weight of albacore caught by Japanese longliners in the north Atlantic, Shiohoma (1974)

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Average weight (kg)	10	21	22	20	27	19	26	19	19	19	32	17	20

Table 4. Average catch in numbers by North Atlantic surface and longline fisheries Surface data is 1968-72 average from Bard (1974). Longline data is 1967-71 average from Shiohama (1973 & 74)

	Surface	Longline					
	July-Sept.	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Total	Grand Total
Age (Years)							
1	0		33	0		33	33
2	944,000	289	212	19	10	530	944,530
3	4,269,000	1,712	3,746	1,066	336	6,860	4,275,860
4	1,231,000	30,487	9,443	10,141	4,065	54,136	1,285,136
5	61,000	61,224	27,027	16,277	60,401	164,929	225,929
6		20,844	60,020	19,126	12,548	112,538	112,538
7		9,864	28,008	39,508	8,116	85,496	85,496
8		3,154	15,387	26,064	3,053	47,658	47,658
9		543	2,461	7,862	614	11,480	11,480
10		94	108	1,239	66	1,507	1,507
Total	6,505,000	128,211	146,445	121,302	89,209	485,167	6,990,167

Table 5. Catch of albacore in north Atlantic and "standardized" effort

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Catch (1000 m tons)	54.8	69.3	43.8	57.5	59.4	63.8	58.2	50.0	59.8	43.1	39.9	39.9	50.6
Effort	54.6	65.0	41.9	46.3	55.4	65.3	46.3	55.2	57.2	49.7	44.4	49.1	54.3

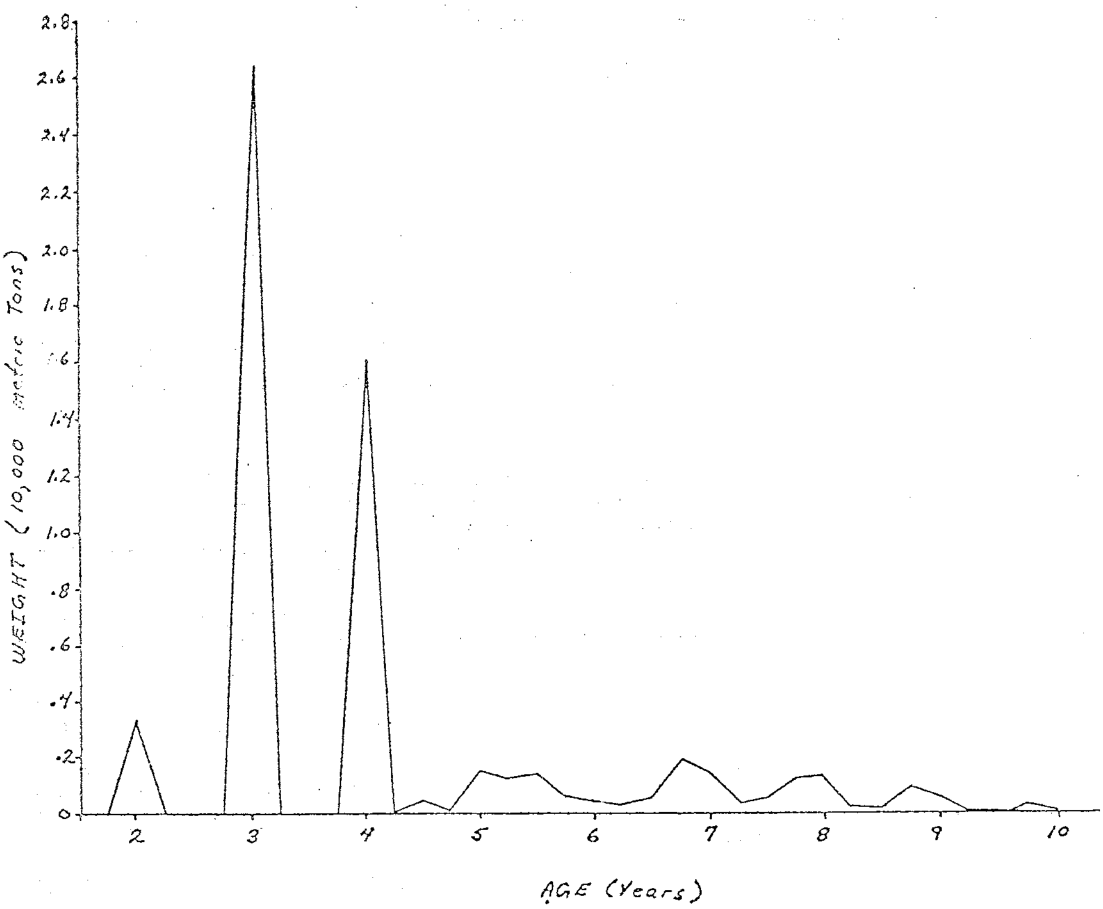


Figure 1. Average age composition of North Atlantic albacore fishery in terms of weight (1967-1972).

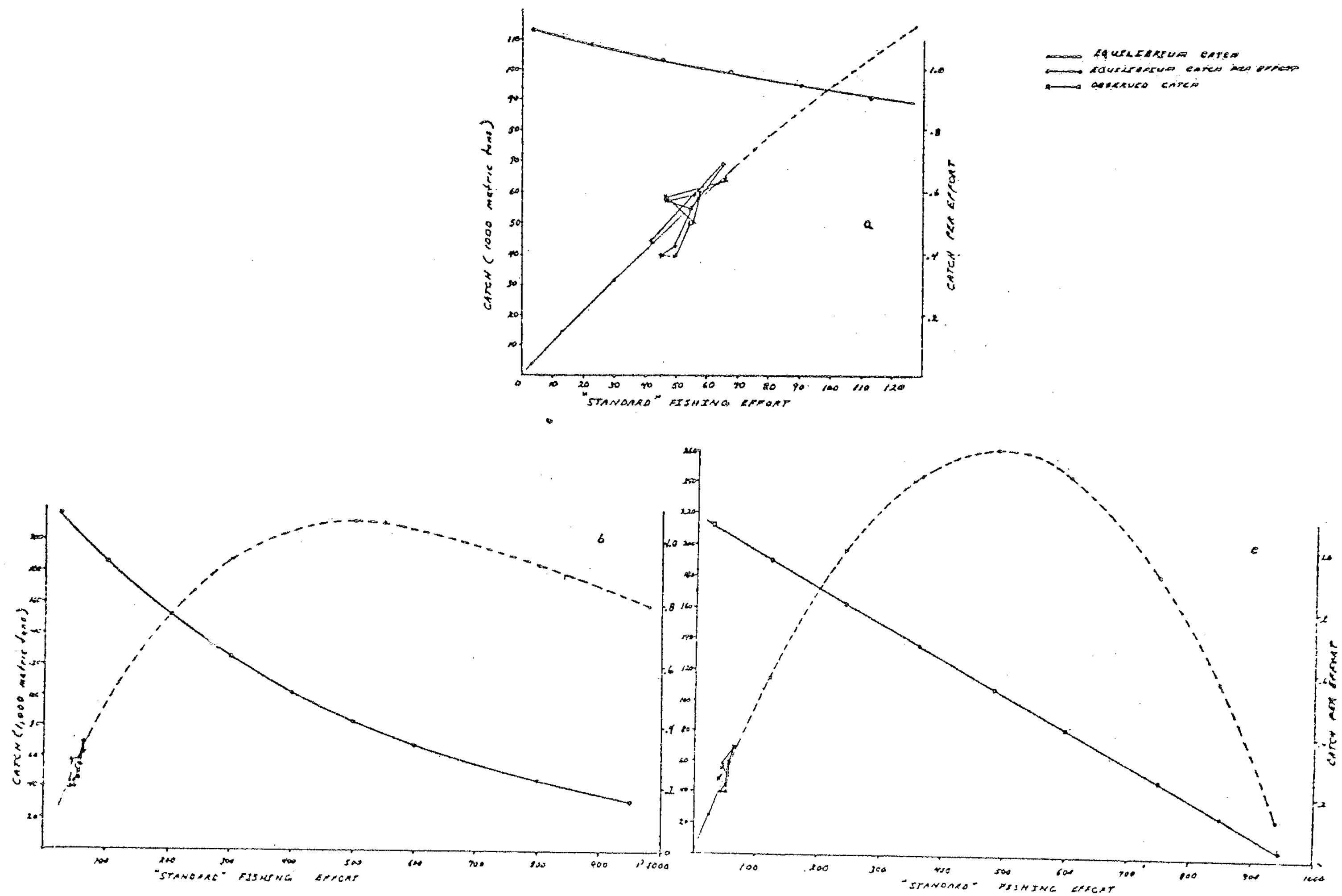


Figure 2. Production model estimates of equilibrium catch and catch per effort for combined north Atlantic albacore fisheries, 1959-71. a) m = 0 b) m = 1.001 c) m = 2.

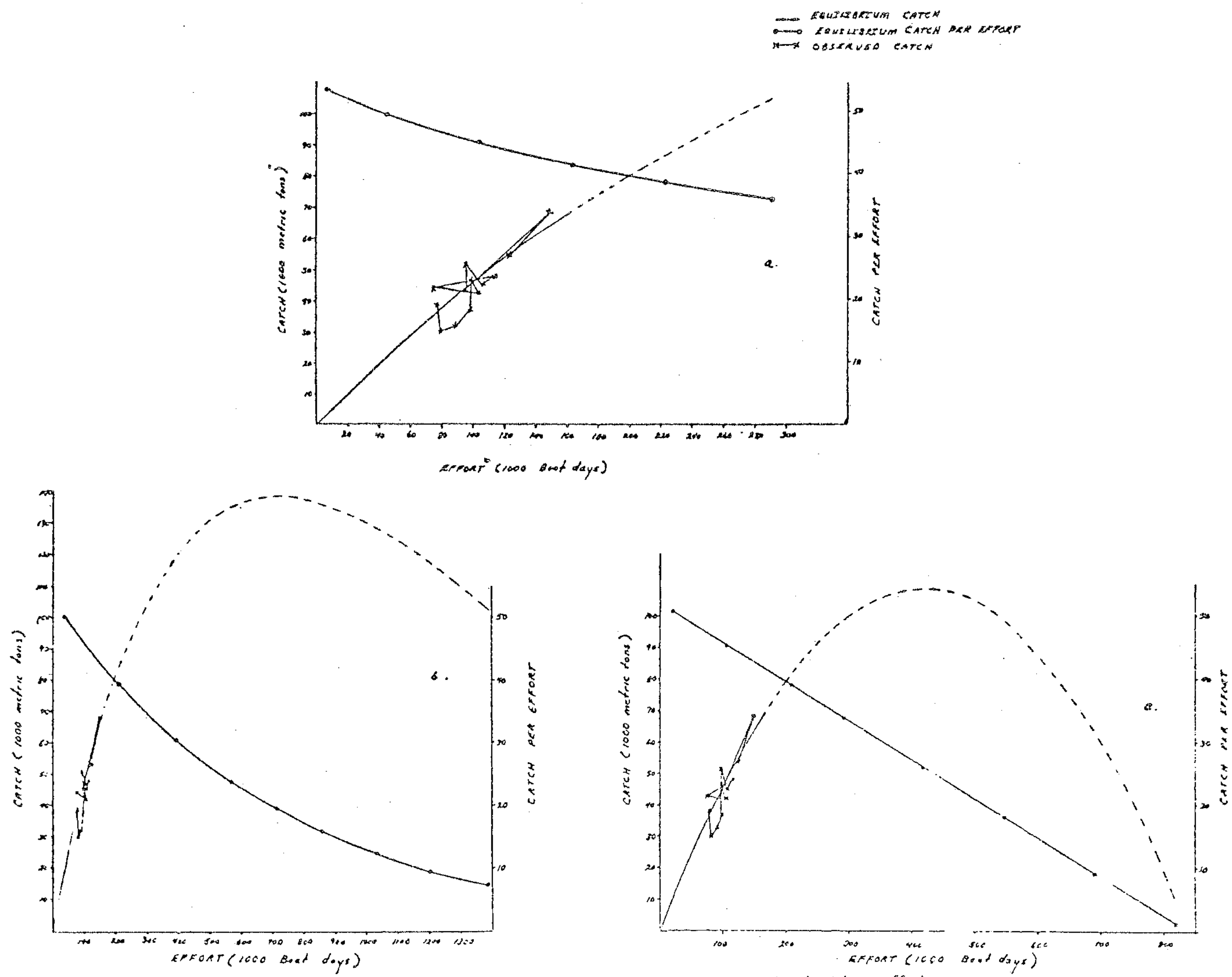
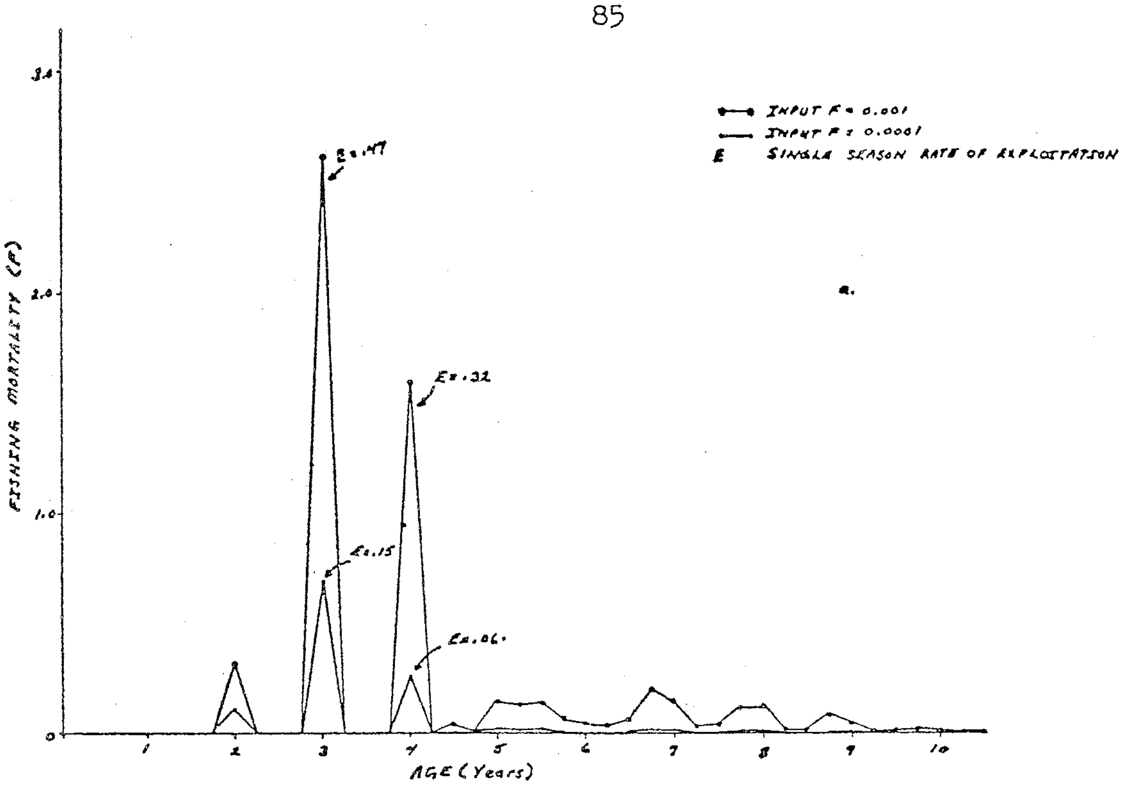


Figure 3. Production model estimates of equilibrium catch and catch per effort for north Atlantic albacore surface fishery, 1959-71.



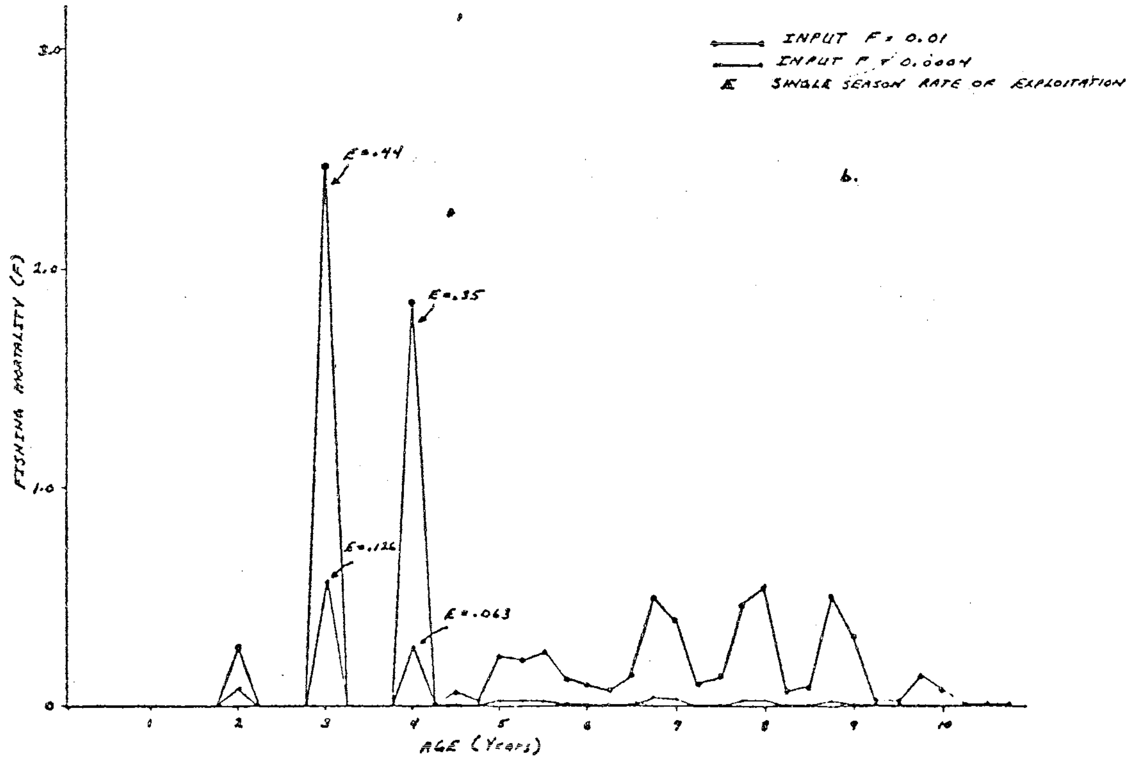


Figure 4. Estimates of age specific F by quarter on an annual basis for north Atlantic albacore fishery, 1967-72. a) M = 0.2 b) M = 0.4

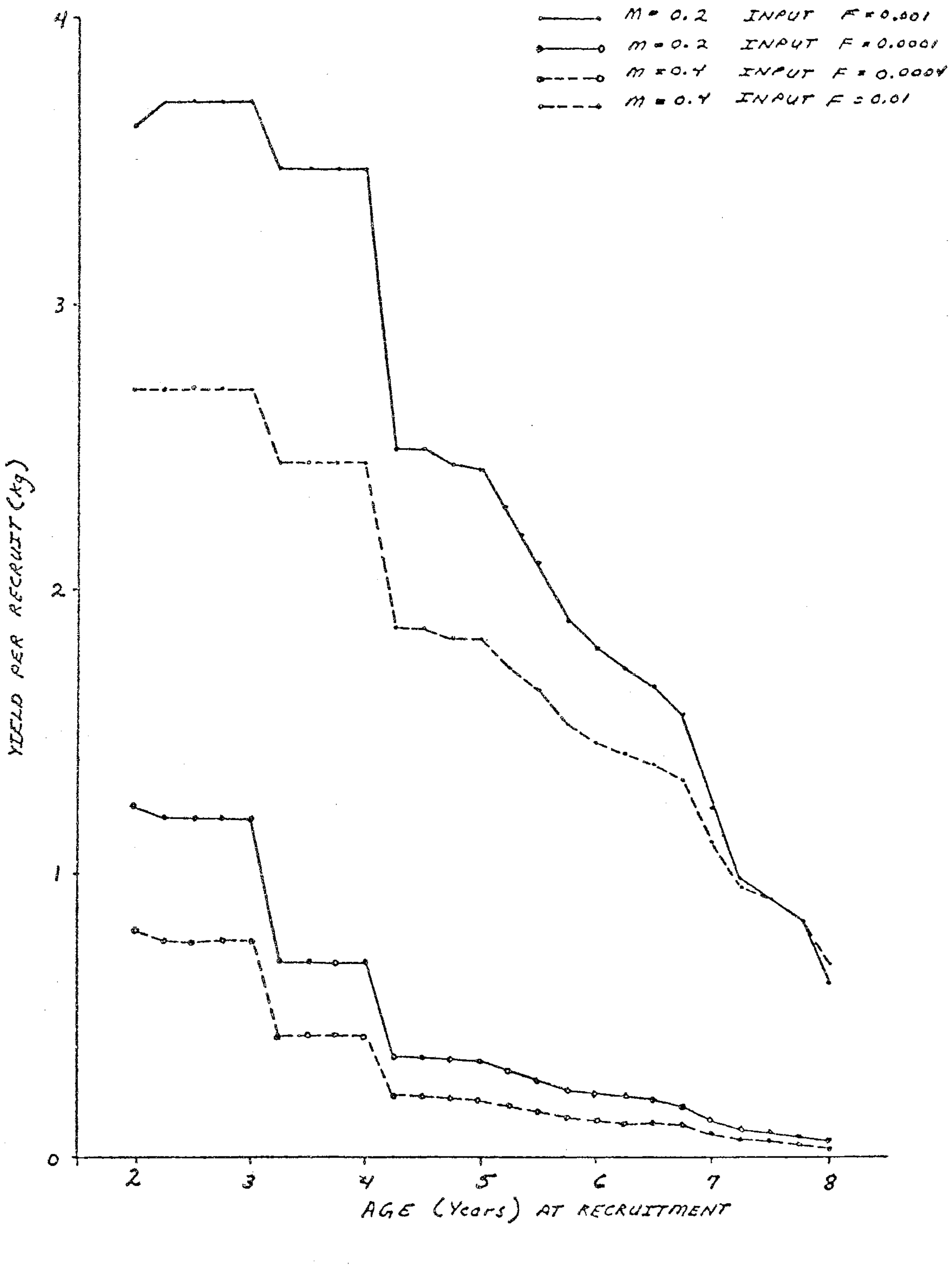


Figure 5. Estimates of yield per recruit of north Atlantic albacore fisery as a function of age at recruitment at present (1967-72) level of fishing effort.

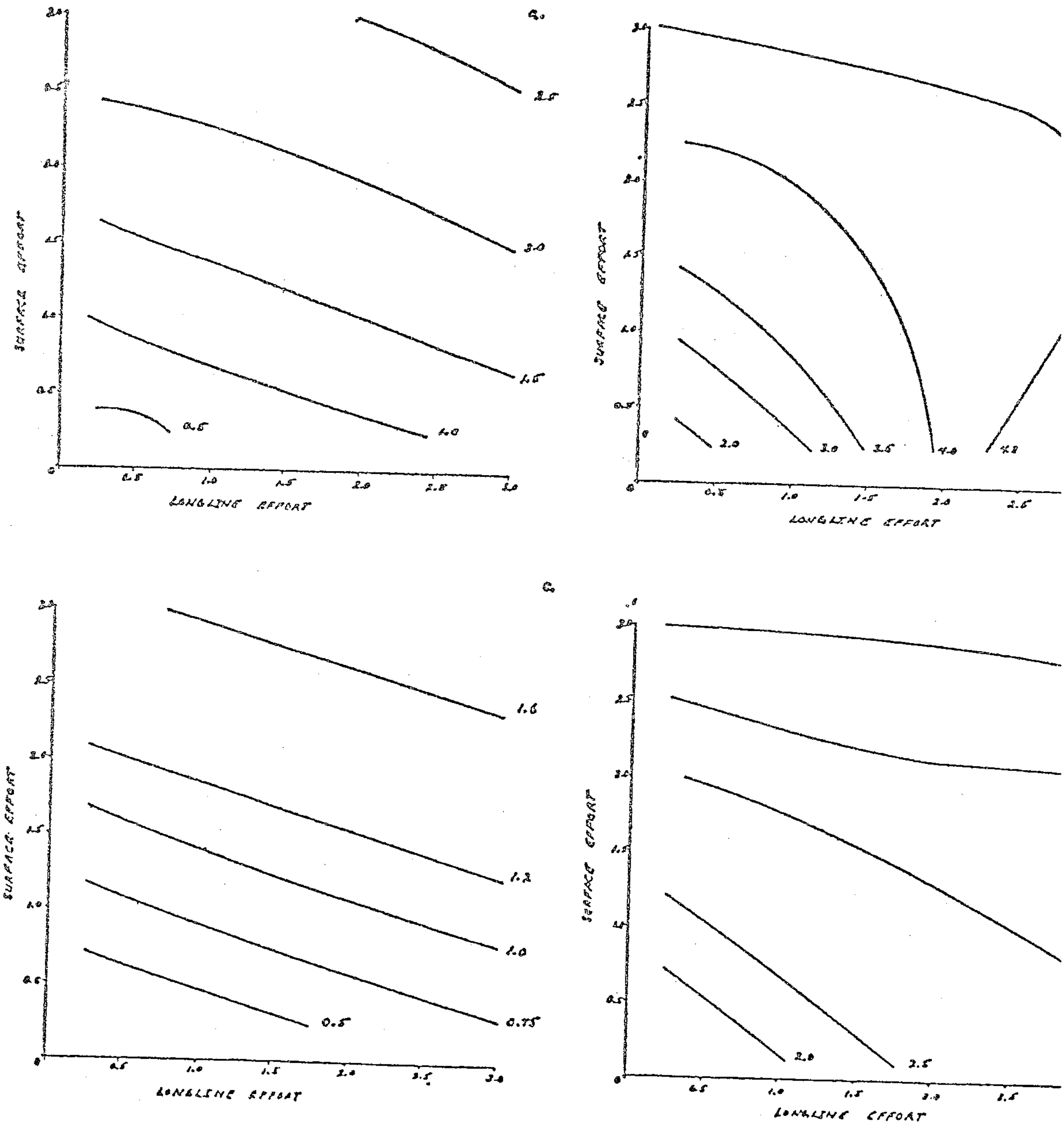


Figure 6. Estimates of yield per recruit (kg) of north Atlantic albacore fishery as a function of fishing effort by surface and longline gears at present (1967-72) age of recruitment. a) M = 0.2 and input F = 0.0001, b) M = 0.2 and input F = 0.001, c) M = 0.4 and input F = 0.0004, d) M = 0.4 and input f = 0.01.

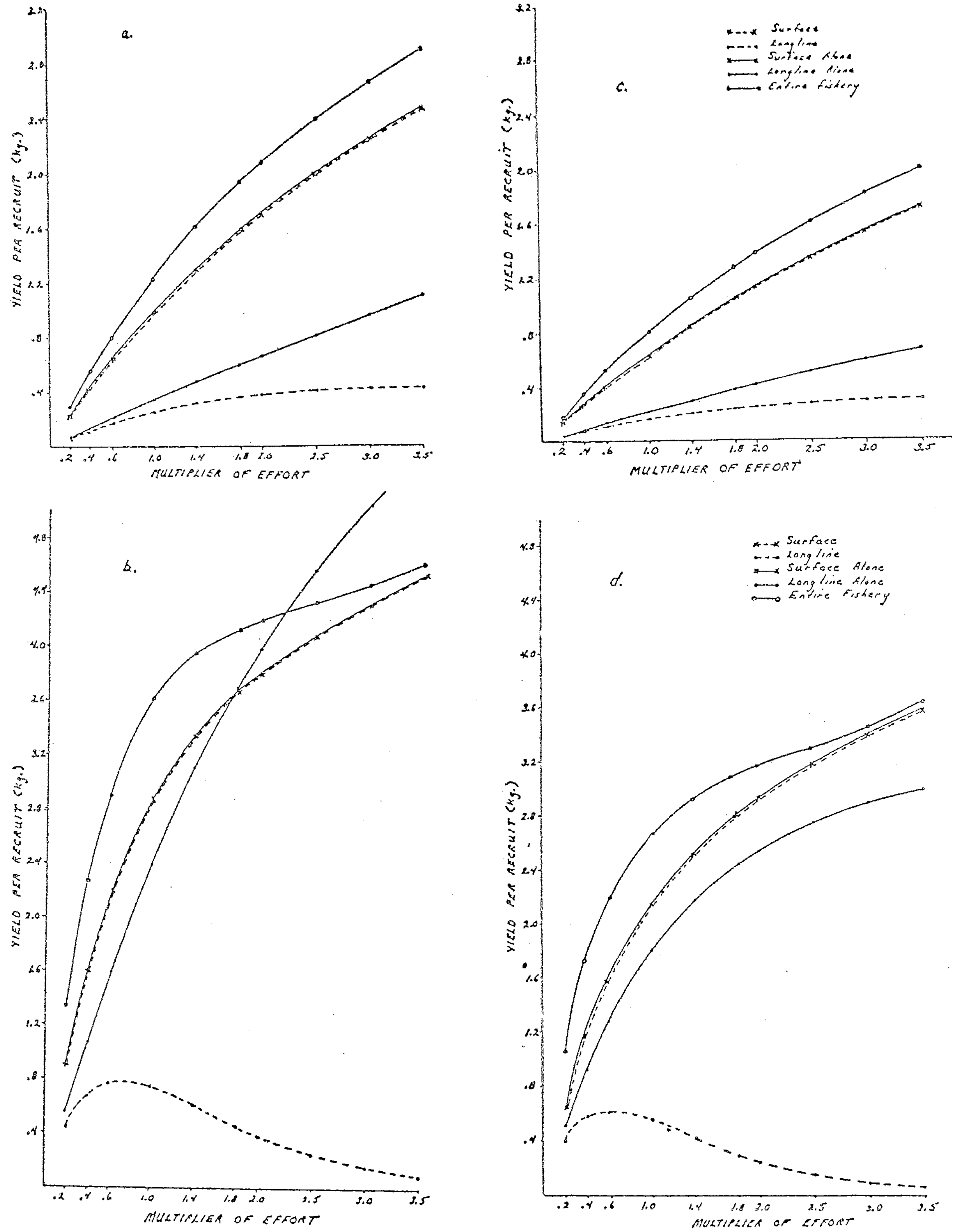


figure 7. Estimates of yield per recruit (kg) of north Atlantic albacore fishery to each gear at present (1967-72) age of recruitment as a function of fishing effort and in presence or absence of each gear. a) M = 0.2 and input F = 0.0001, b) M = 0.2 and input F = 0.001, c) M = 0.4 and input F = 0.0004, d) M = 0.4 and input F = 0.01.