Southwest Fisheries Center Administrative Report H-84-11

ASSESSMENT OF THE SOUTH PACIFIC ALBACORE STOCK BASED ON CHANGES IN CATCH RATES OF TAIWANESE LONGLINERS AND ESTIMATES OF TOTAL ANNUAL YIELD FROM 1964 THROUGH 1982

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July 1984

[NOT FOR PUBLICATION]

Table 1.--Estimated annual catches (metric tons) of South Pacific albacore, 1952-82.

Year	Japan	Taiwan	Korea	Other	Total
1952	210	--	--	--	210
1953	1,091	--	--	--	1,091
1954	10,200	--	--	--	10,200
1955	8,420	--	--	--	8,420
1956	6,220	--	--	--	6,220
1957	9,764	--	--	--	9,764
1958	21,558	--	146	--	21,704
1959	19,344	--	456	--	19,800
1960	23,756	--	610	--	24,366
1961	25,628	--	330	--	25,958
1962	38,880	0	599	--	39,479
1963	33,500	608	1,367	--	35,475
1964	21,435	629	2,911	--	24,975
1965	19,305	1,640	6,405	100	27,450
1966	23,401	6,669	10,817	500	41,387
1967	16,640	14,910	13,717	105	45,371
1968	7,707	14,496	10,138	14	32,355
1969	5,559	9,883	9,963	--	25,405
1970	6,560	12,463	11,599	50	30,672
1971	4,339	21,584	14,482	200	40,605
1972	2,796	23,050	14,439	468	40,753
1973	2,381	28,858	17,452	584	49,275
1974	1,847	19,980	12,194	890	34,911
1975	1,045	15,092	9,015	646	25,798
1976	1,906	19,954	12,212	25	34,097
1977	2,378	23,838	11,478	938	38,632
1978	2,744	22,027	11,891	1,617	38,279
1979	2,495	20,172	11,607	907	35,181
1980	2,667	19,224	11,046	843	33,780
1981	[1]2,500	17,705	11,046	1,768	33,019
1982	[1]2,500	17,682	14,504	4,715	39,401

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[1] Rough estimates.

Table 2.--Average annual catches of South Pacific albacore during 5-year periods, associated estimates of average catch per day by Taiwanese vessels, and total effective fishing effort.

5-year period	Average annual (mt)[1]	Annual catch per vessel-day (mt)[2]	Total effective annual effort (1,000 vessel-days)
1962-66	33,753	0.851	39.7
1967-71	34,882	0.815	42.8
1972-76	36,967	0.582	63.5
1977-81	35,785	0.606	59.1

[1] Derived from all vessels fishing in South Pacific.

[2] Derived from Taiwanese vessels landing catches at Pago Pago.

Table 3.--Average catches of South Pacific albacore per day of fishing by Taiwanese longliners based at Pago Pago, estimated total South Pacific albacore catches, and derived effective effort statistics, 1964-82.

Year	Catch rate (mt/day)	Total catch (10^3 mt)	Effective effort (10^3 days)
1964	0.826	24.975	30.236
1965	0.803	27.450	34.184
1966	0.923	41.387	44.840
1967	0.941	45.371	48.216
1968	0.782	32.355	41.375
1969	0.842	25.405	30.172
1970	0.808	30.672	37.960
1971	0.702	40.605	57.842
1972	0.643	40.753	63.379
1973	0.675	49.275	73.000
1974	0.452	34.911	77.237
1975	0.483	25.798	53.412
1976	0.659	34.097	51.741
1977	0.626	38.632	61.712
1978	0.771	38.280	49.650
1979	0.542	35.182	64.911
1980	0.529	33.811	63.915
1981	0.560	33.019	58.963
1982	0.778	39.401	50.644

The abundance index and the derived effective effort statistics (Table 3) were used to estimate the relationship between equilibrium yield and longlining effort. Because effort varied from year to year, the average abundance of exploitable albacore in any particular year probably differed from the equilibrium abundance expected had that year's effort, and other factors, been held constant. However, theory suggests that the average abundance in a particular year is approximately the same as the equilibrium abundance which would prevail if the fleet exerted a steady effort level equal to the average of that year's effort and the efforts applied in the preceding several years. Accordingly, following Gulland (1983), an adjusted effort statistic was computed for each year as a weighted average of the current effort and the efforts of the past 2 years. It is assumed here that a year class of albacore contributes significantly to the catch for 3 years.

A surplus production model was fit by least squares to the abundance index and the adjusted effective effort statistics (Fig. 1), providing estimates of the maximum sustainable yield (MSY) and the associated optimum level of longlining effort (FOPT). Also computed was a third parameter, m, which determines the shape of the production curve and, in particular, its behavior under high exploitation rates. The model equation is:

$$Y/F = (MSY/FOPT)\ [m + (1-m)\ (F/FOPT)]^{\frac{1}{m-1}}$$

where, Y/F = expected equilibrium abundance index (average tons of albacore per day of longlining by Taiwanese vessels), and

F = effective effort level.

Fitting this model to the 17 data points for the period 1966-82, the MSY was estimated to be 37.0 thousand mt, and the optimum effort level, FOPT, was calculated to be 56.9 thousand days of longlining (based on the "standard" effectiveness of Taiwanese vessels). The shape parameter, m, was estimated to be 2.4.

By inserting these parameter estimates into the model equation and multiplying by average effective effort, we obtained corresponding estimates of expected equilibrium yield. Values of "observed" equilibrium yield were computed by multiplying the observed abundance indices by their associated average effort. The results are plotted in Figure 2. The curve of predicted equilibrium yield is almost parabolic, but it is obvious from Figure 2 that curves with other shapes would "fit" the data almost as well. (Bear in mind that the curve shown in Figure 2 was not estimated by fitting to the plotted points.)

Sampling biases in the least squares parameter estimates were computed by Quenouille's jackknife procedure (Efron 1982). The resulting corrected ("jackknifed") estimates and associated 95% confidence intervals are:

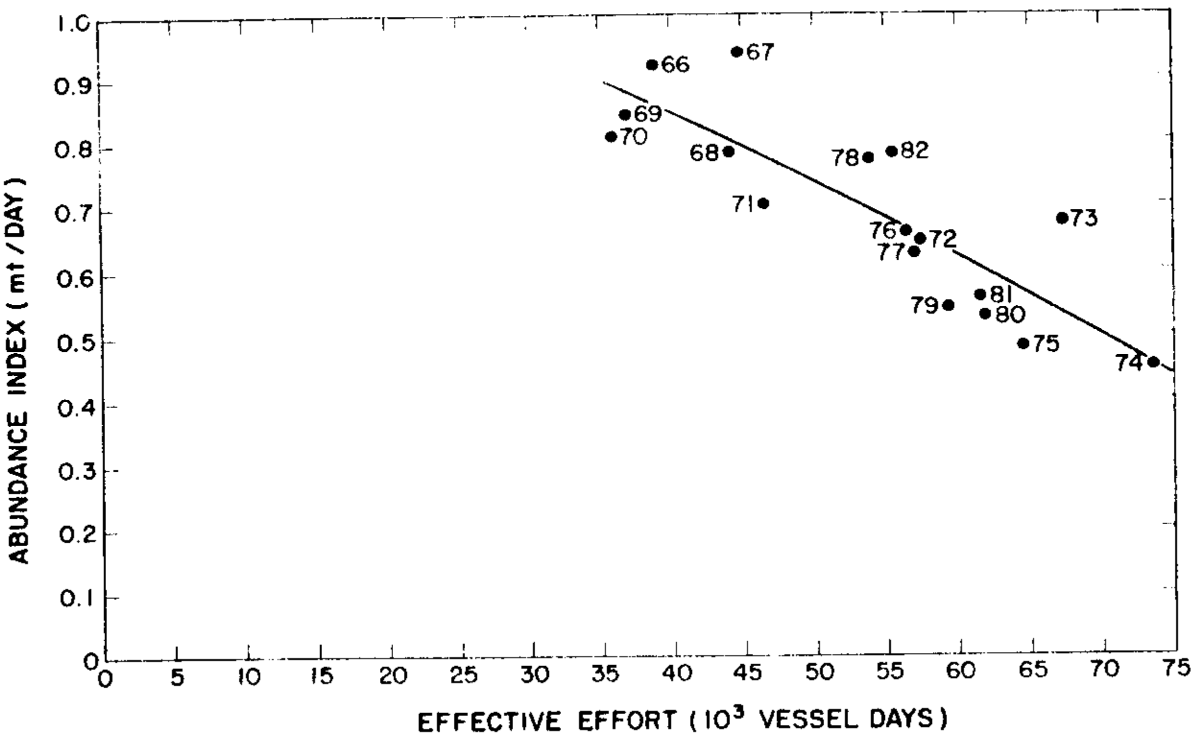

Figure 1.--Relationship between abundance index and estimated effective effort (points), and fitted production model (line).

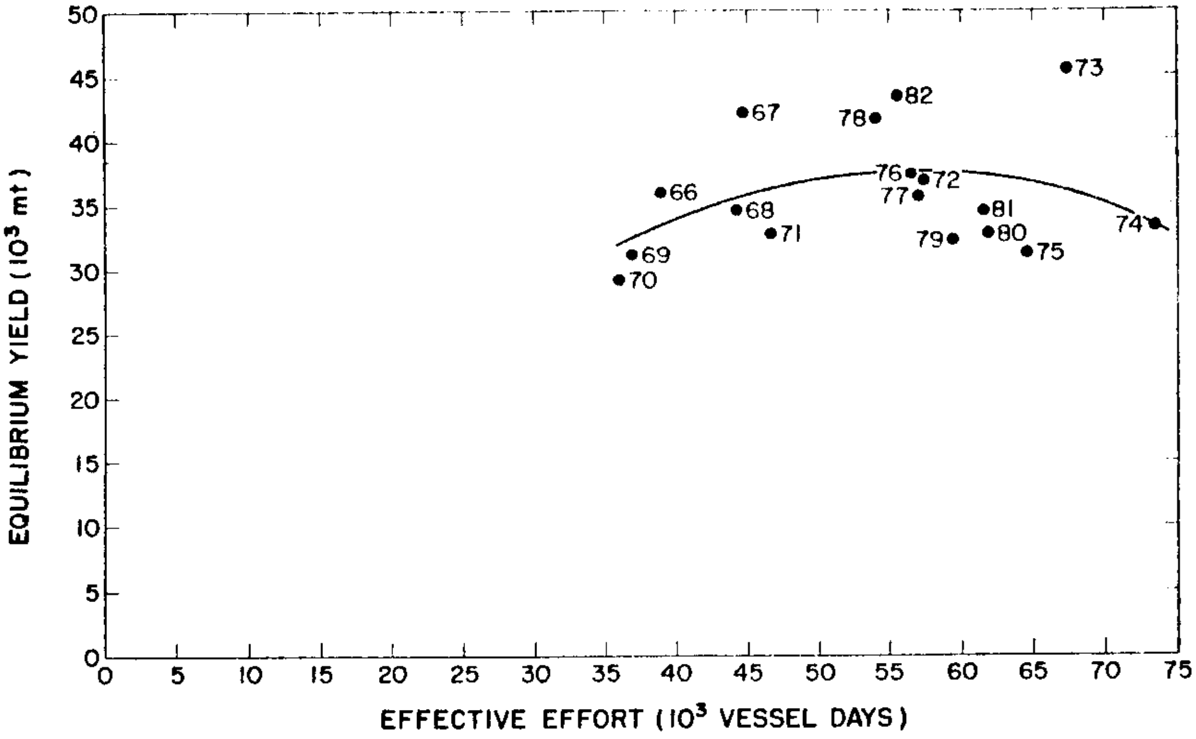

Figure 2.--"Observed" relationship between equilibrium yield and effort (points), and the corresponding equilibrium yield-effort curve implied by the fitted production model (line).

MSY = 37.542 (34.9 , 40.2)

FOPT = 58.215 (49.6 , 66.8)

$m = 0.215$ ($m \leq 2.4$)

Thus the least squares estimate of m is apparently seriously biased, and the implied shape of the surplus production curve in Figure 2 is open to question.

A provisional "unbiased" picture of the relationship between equilibrium yield and effort was computed by jackknifing the production curve around the full-sample least squares estimates of the parameters. Empirical estimates of standard error were also calculated and used to construct an approximate 95% confidence region for equilibrium yield, assuming normality of the jackknifed yield estimates at each effort level.

The resulting 95% confidence band and the "expected" equilibrium yield as a function of longlining effort are shown in Figure 3. While the considerable uncertainty about yield at higher effort levels is clearly indicated, the jackknifed production curve has an inadmissible inflection as effort exceeds the estimate of FOPT, suggesting that this simple jackknifing

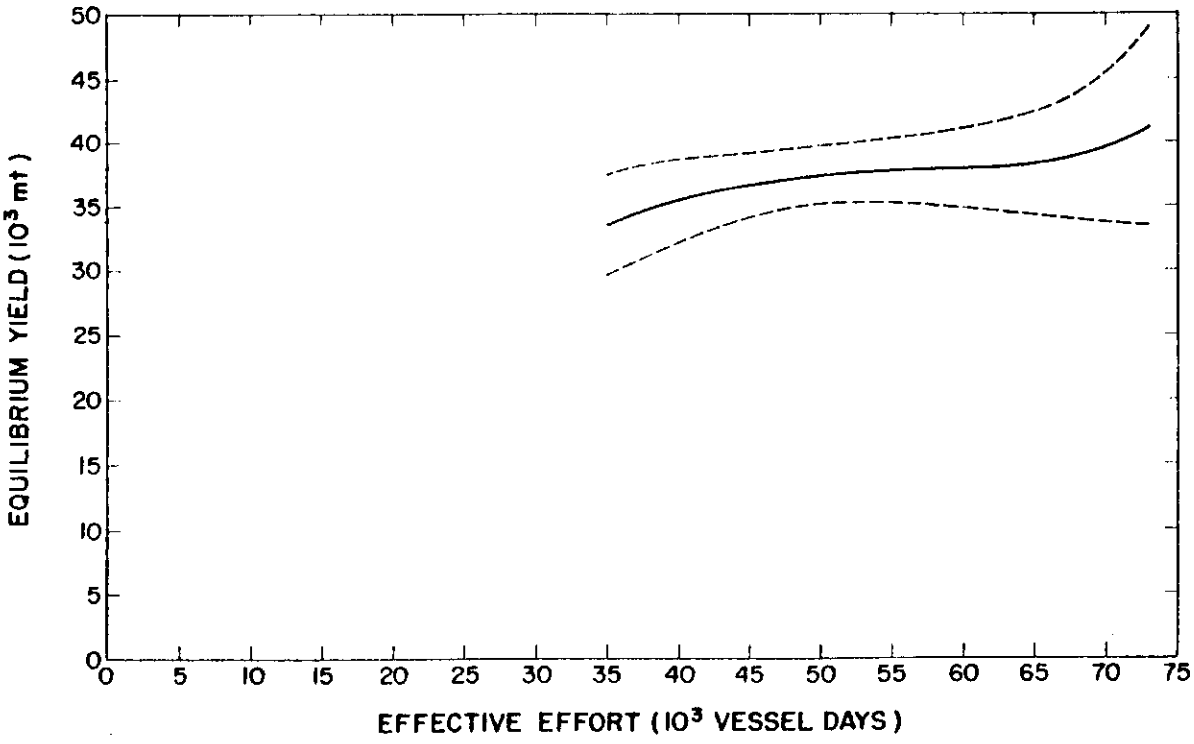

Figure 3.--Jackknifed equilibrium yield-effort curve and estimated 95% confidence region.

procedure is inadequate. Further study of this procedure and development of improved methods is necessary. Note also that the jackknifed production curve and associated 95% confidence band give different results than would be computed by simply inserting the jackknifed parameter estimates and the corresponding confidence limits into the equilibrium yield equation.

The results of this statistical analysis reaffirm the initial conclusion that little improvement in the sustainable yield to longliners can be realized by increasing their effort. Indeed, virtually the same yield could apparently be taken at substantially lower effort than has been exerted in recent years. Reduced effort would likely increase economic efficiency and provide a greater safety margin for the stock.

This assessment was based on several key assumptions which need verification. In particular, further work is needed to demonstrate the validity of the abundance index and to establish the accuracy of the total catch estimates.

Although prospects for increasing the longline catch may be slim, there is a possibility that the total yield of South Pacific albacore can be increased by expansion of effort in the surface fishery, which takes younger fish, on average. Thus an improvement in yield per recruit may be possible. However, on the assumption that the surface and longline fisheries are operating on the same stock, increased harvesting of smaller fish available to the surface fishery would reduce the potential yield to the longliners fishing the older segments of the stock. The degree of impact of a surface fishery on the longline catch rates cannot be predicted very reliably because growth and mortality rates are unknown. Further, the possibility also exists that the albacore available to the surface gear and those vulnerable to longlining are more or less independent groups of fish, in the sense that the surface fishery could be expanded with little harm to longlining. In view of the widespread interest in exploring potentials for a surface fishery, a delineation of stock structure and a study of the various interactions between surface and deepwater groups of albacore would be extremely beneficial.

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