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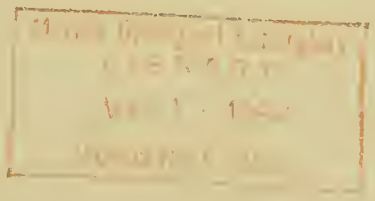

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ABSTRACT

Fishing effort reached nearly 100 million hooks in 1965, a level which is more than the yellowfin tuna stocks can support and remain commercially productive. As catch rates for yellowfin tuna decrease, more and more fishing will be directed toward albacore.

Data on catches and fishing effort by the Japanese Atlantic longline fleet have been published by Shiohama, Myojin, and Sakamoto (1965), and by the Fisheries Agency of Japan (1966, 1967a, 1967b). Analyses of part or all of the data have been carried out by Paiva (1961a, 1961b, 1962), Moraes (1962), Nakagome and Suzuki (1963), Lima and Wise (1963), Griffiths and Nemoto (1967), Le Guen and Wise (1967), Sakamoto (1967), Wise (1968), and Wise and Le Guen (in press).

The principal species (in numbers) in the fishery for the 10 years 1956-65 have been yellowfin tuna[1] (41 percent), albacore (39 percent), bigeye tuna (11 percent), and blue marlin (2 percent)--all other species make up only about 7 percent of the catch (table 1). These proportions have not been constant--the catch figures for the first 3 years of fishing on a commercial scale (1957-59) were: yellowfin tuna 77 percent, albacore 18 percent, bigeye tuna and blue marlin 2 percent each, all other species only 1 percent. The major reason for the change in species composition has been the decrease in catch rate of yellowfin tuna from nearly eight fish per 100 hooks in the whole Atlantic in 1957-59 to just under one fish per 100 hooks in 1965. (We have assumed throughout this study that the part of the fleet included in the logs available for tabulation is representative of the effort, catch, and geographical distribution of the whole fleet.)

Wise (1968) reviewed the development of the fishery from its beginning in 1956 through 1964, in the areas shown in figure 1. He pointed out that major changes took place in the fishery in 1964, and showed these changes as comparisons of percentages from 1963 to 1964. The same tendencies are apparent in the 1965 data compared with the 1963 data:

	1964 vs. 1963	1965 vs. 1963
Fishing effort	+54%	+ 77%
Yellowfin tuna catch	- 1%	+ 5%
Albacore catch	+88%	+ 59%
Bigeye tuna catch	+21%	+129%
Blue marlin catch	-13%	- 52%

The greatest percentage increases in fishing effort from 1963 to 1964 were in the Guianas, North Oceanic (West), Bahia, and Rio de Janeiro areas--all are western Atlantic areas and three of them are among the best regions for albacore. From 1963 to 1965 the largest percentage increases were in the areas of Benguela, North Oceanic (East), Gulf of Guinea, Guianas, and North Oceanic (West) (table 2). Fishing effort shifted from 1963 to 1964 to the western Atlantic and to good albacore areas, but the change from 1963 to 1965 was in the opposite direction, to the eastern Atlantic, slightly favoring better yellowfin tuna areas.

Note.--Estimates of catch, effort, and catch per unit effort in this paper are the best currently available. They supersede estimates in Le Guen and Wise (1967), Wise and Le Guen (in press), and Wise (1968). Corrections are minor, except for new estimates for 1961 and 1962 based on information received from A. Suda of the Far Seas Fisheries Research Laboratory of the Fisheries Agency of Japan (personal communication). Suda pointed out certain necessary corrections in the data for 1961 and 1962 as published by Shiohama, Myojin, and Sakamoto (1965).

[1] Common names only are given in the original Japanese reports.

Table 1.--Summary of catch and effort in the Japanese Atlantic longline fishery, 1956-65

[Estimates, adjusted for the whole fleet on the basis of sample in each year. Symbol Ø represents 500 fish or less.]

Year	Number of hooks	Species										Total fish
		Yellowfin tuna	Albacore	Bigeye tuna	Bluefin tuna	Blue marlin	White marlin	Black marlin	Other marlin	Sword-fish	Skipjack tuna	
	Thousand hooks	Thousand fish										
1956.....	131	12	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	0	13
1957.....	3,376	259	32	9	Ø	9	1	Ø	3	1	0	314
1958.....	8,001	746	100	15	Ø	10	1	Ø	4	1	0	877
1959.....	15,312	1,098	357	45	3	23	7	Ø	6	2	Ø	1,541
1960.....	20,727	1,159	452	71	7	27	11	Ø	12	3	Ø	1,742
1961.....	26,660	980	430	243	4	43	38	1	28	11	Ø	1,778
1962.....	54,921	991	1,102	367	54	112	113	3	68	20	0	2,829
1963.....	55,004	886	1,134	285	67	96	[1] 87	1	[2] 51	24	1	2,632
1964.....	84,998	876	2,134	344	63	84	[1] 163	Ø	[2] 118	31	2	3,815
1965.....	97,580	929	1,804	651	58	44	[1] 130	Ø	[2] 117	43	3	3,779
Totals.	366,710	7,936	7,546	2,030	256	448	551	5	407	136	6	19,320

[1] Includes striped marlin
[2] Includes spearfish and sailfish

Rank correlation between fishing effort and catch rates for 1965 shows that the fishermen directed their effort efficiently with respect to the total abundance of all species and to yellowfin tuna and albacore combined, but inefficiently with respect either to yellowfin tuna or to albacore. This relation is consistent with the partial move in fishing effort back to yellowfin tuna areas in 1965 after the distinct shift in 1964 to albacore areas.

Catches of yellowfin tuna and albacore by area are given in tables 3 and 4. Catch rates for yellowfin tuna, albacore, bigeye tuna, and blue marlin over the 10 years are shown in figure 2.

Mean catch rates, 1956-65, for yellowfin tuna, albacore, and blue marlin for the 11 areas are presented in tables 5 to 7. (Only these three species show clear declines in apparent abundance.) The mean rate was determined by adding the rates for all the months in which the area was fished and dividing by the number of months. The rate of decline in apparent abundance for each species in each area was calculated as the slope of a straight line fitted to logarithms of monthly catch rates, beginning with the first month of fishing in the best year. If the correlation coefficient (r) was significant at P = 0.05 level or less, the decline was accepted as real--otherwise it was rejected.

Declines are apparent for yellowfin tuna in all 11 areas, for albacore in 5 of the 11 areas, and for blue marlin in 7 of the 11 areas. The number of areas showing declines increased over the 1956-64 period (Wise, 1968), which itself showed an increased number of declines over the 1956-63 period (Wise and Le Guen, in press). In addition to the increased number of areas which show declines, the rates of decline themselves appear to be increasing for yellowfin tuna and blue marlin. We compared the decline rates calculated over 10 years of the fishery with the decline rates calculated over the first 8 years. Of the 20 comparisons possible for yellowfin tuna and blue marlin (fishing was negligible in the Gulf of Mexico before 1963), 11 show increases in declines or declines where none previously existed, 3 show no decline or equal decline, and only 6 have a decrease in rate of decline. In other words, the decline rates appear to be accelerating for these two species.

Le Guen and Wise (1967) estimated that an annual equilibrium yield of about 550,000 yellowfin tuna could be taken from the Gulf of Guinea, Guianas, North Oceanic (East), Cape Verde, Caribbean, and North Oceanic (West) areas (the best yellowfin tuna areas), with a total annual fishing effort of about 12 million hooks. They also estimated an annual equilibrium yield of about 165,000 yellowfin tuna from the rest of the Atlantic with an effort of about 3 million hooks.

The catch of yellowfin tuna in the best yellowfin tuna areas in 1965 was some 720,000 fish taken with almost 56 million hooks. These figures represent a yield only 31 percent over, despite a fishing effort more than 360 percent over, the estimated equilibrium figure.

The catch of yellowfin tuna in the rest of the Atlantic was about 213,000 fish in 1965, 29

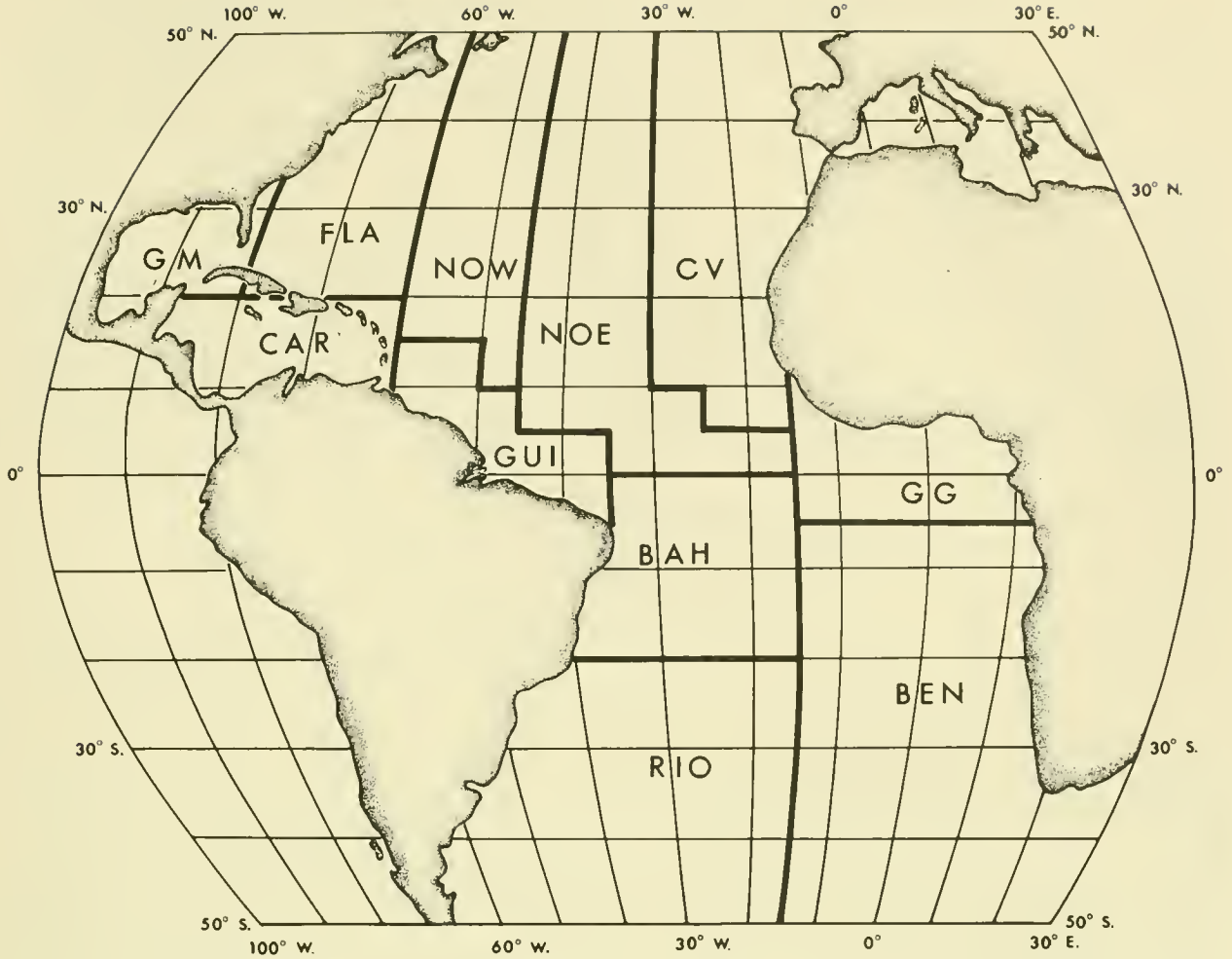

Figure 1.--Areas used in this study.

percent over the optimum, caught by about 42 million hooks, almost 1,300 percent above the equilibrium level. A large part of the effort in the Bahia, Rio de Janeiro, Florida, and Benguela areas must have been directed at albacore, since these are the best albacore fishing areas (table 4).

The widespread declines in catch rates and the apparent acceleration of decline rates for some species are consistent with constantly increasing fishing pressure. From a very modest beginning in 1956, the number of hooks fished in the Atlantic by the Japanese longliners rose to nearly 3 1/2 million in 1957. By 1962 this number had increased 16-fold, and in 1965 it was nearly 100 million hooks or more than 25 times the 1957 effort (table 1). These 100 million hooks were fished by approximately 150 Japanese longliners. Since then the number of Japanese longliners fishing in the Atlantic has decreased--in the first 3 months of 1968 about 75 Japanese longliners were fishing at any given time in the Atlantic.

In recent years, however, substantial numbers of longliners from other countries have entered the Atlantic tuna fisheries. The decrease in numbers of Japanese longliners has been made up by about 50 South Korean longliners, plus perhaps 20 or 30 longliners from other countries, including Cuba, Venezuela, and China (Taiwan). Reports are persistent that new vessels in addition to the longliners now fishing are being built or planned for Atlantic operations. Thus it seems likely that in 1968 the total level of fishing effort in the Atlantic by longline is comparable to the approximately 100 million hooks fished by the Japanese in 1965.

If decline rates for yellowfin tuna continue at the 1965 level (or accelerate), by mid-1970 the catch of yellowfin tuna per 100 hooks will be 0.5 fish or less in all areas, reducing what was a species of major importance to little more than an incidental catch. The result will be to focus nearly all of the fishing effort on albacore, the only other species sufficiently

Table 2.—Distribution of fishing effort in the Japanese Atlantic longline fishery by year and area

[Estimates, adjusted for the whole fleet on the basis of sample in each year.]

Year	GG	GUI	NOE	CV	BEN	CAR	NOW	BAH	RIO	FLA	GM	Total
	Thousand hooks											
1956.....	0	81	31	0	0	0	0	19	0	0	0	131
1957.....	1,328	515	1,218	234	0	5	0	74	0	0	2	3,376
1958.....	1,806	2,645	1,633	1,233	0	290	26	368	0	0	0	8,001
1959.....	2,999	2,836	3,380	3,311	15	258	92	2,404	17	0	0	15,312
1960.....	4,967	2,446	2,893	4,410	1,022	330	140	4,512	7	0	0	20,727
1961.....	7,603	478	2,136	4,305	6,685	92	91	5,186	84	0	0	26,660
1962.....	6,072	3,287	9,169	5,939	9,824	1,324	1,864	13,335	997	3,109	0	54,921
1963.....	6,475	3,304	8,059	5,729	7,756	2,560	3,135	8,195	2,803	6,555	433	55,004
1964.....	4,613	7,654	11,923	9,253	9,489	2,627	8,899	14,441	5,268	8,274	2,556	84,998
1965.....	13,809	6,588	18,433	9,004	21,239	1,909	6,231	8,311	5,258	6,279	519	97,580
Totals.	49,672	29,834	58,875	43,418	56,030	9,395	20,478	56,845	14,434	24,217	3,510	366,710

Table 3.--Catch of yellowfin tuna by the Japanese Atlantic longline fishery by year and area

[Estimates, adjusted for the whole fleet on the basis of sample in each year.
Symbol Ø represents 500 fish or less.]

Year	GG	GUI	NOE	CV	BEN	CAR	NOW	BAH	RIO	FLA	GM	Total
	Thousand fish											
1956.....	0	8	3	0	0	0	0	1	0	0	0	12
1957.....	114	33	89	19	0	Ø	0	3	0	0	Ø	259
1958.....	217	242	143	101	0	37	1	5	0	0	0	746
1959.....	366	167	209	313	1	19	5	17	Ø	0	0	1,098
1960.....	491	116	137	271	78	6	8	51	Ø	0	0	1,159
1961.....	486	16	61	116	264	2	1	34	Ø	0	0	980
1962.....	232	133	170	123	172	35	35	79	3	10	0	991
1963.....	214	64	131	132	92	99	14	60	3	50	25	886
1964.....	144	119	159	181	38	25	28	55	10	30	88	876
1965.....	279	109	197	101	137	20	15	53	4	6	8	929
Totals.	2,543	1,007	1,299	1,357	782	243	107	358	20	96	121	7,936

Table 4.--Catch of albacore by the Japanese Atlantic longline fishery by year and area

[Estimates, adjusted for the whole fleet on the basis of sample in each year. Symbol Ø represents 500 fish or less.]

Year	GG	GUI	NOE	CV	BEN	CAR	NOW	BAH	RIO	FLA	GM	Total
	Thousand fish											
1956.....	0	1	Ø	0	0	0	0	Ø	0	0	0	1
1957.....	6	7	15	2	0	Ø	0	2	0	0	Ø	32
1958.....	9	38	19	3	0	2	1	28	0	0	0	100
1959.....	27	41	31	4	Ø	6	2	245	1	0	0	357
1960.....	31	29	20	2	29	14	1	325	Ø	0	0	452
1961.....	50	7	8	3	73	2	3	281	4	0	0	430
1962.....	26	37	42	4	210	24	56	509	58	136	0	1,102
1963.....	21	30	34	9	194	32	136	219	134	324	1	1,134
1964.....	7	61	154	11	602	26	309	414	239	310	1	2,134
1965.....	19	42	240	19	799	10	156	172	209	138	Ø	1,804
Totals.	196	293	563	57	1,907	116	664	2,195	645	908	2	7,546

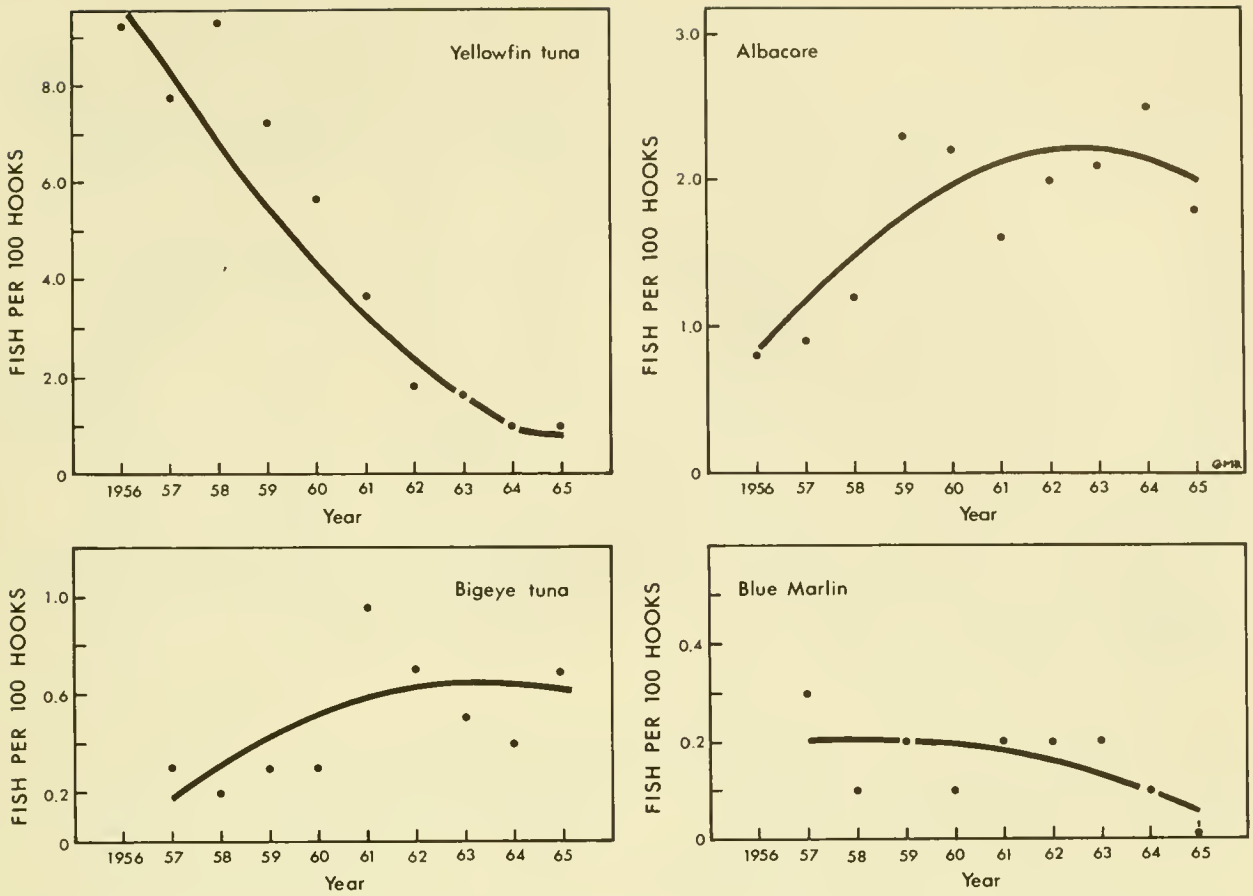

Figure 2.--Catch per 100 hooks, 4 principal species, whole Atlantic Ocean, Japanese Atlantic longline fishery, 1956-65.

Table 5.--Catch rates and rates of decline for yellowfin tuna, Japanese Atlantic longline fishery, 1956-65

Area	Mean catch rate	Catch rate, best year	Rate of decline[1]	Coeff. of correlation	Degrees of freedom
	Fish per 100 hooks				
GG.....	5.5	11.5 (1958)	0.011	-0.703**	73
GUI.....	4.5	9.5 (1956)	.009	-.840**	98
NOE.....	3.8	8.2 (1958)	.014	-.751**	80
CV.....	3.3	7.9 (1958)	.011	-.608**	73
CAR.....	2.9	9.3 (1958)	.010	-.627**	57
GM.....	2.8	3.8 (1963)	.030	-.662**	12
BEN.....	2.7	8.0 (1960)	.018	-.569**	62
NOW.....	1.5	4.8 (1959)	.017	-.761**	48
BAH.....	1.4	6.0 (1957)	.008	-.452**	80
FLA.....	0.9	2.6 (1963)	.033	-.600**	20
RIO.....	0.2	1.0 (1962)	.024	-.566**	19

[1] Rate of decline calculated as slope of a straight line (shown here as absolute value) fitted to logarithms of monthly catch rates, beginning with the first month of fishing in the best year.
**Highly significant (P = 0.01, or less).

Table 6.--Catch rates and rates of decline for albacore, Japanese Atlantic longline fishery, 1956-65

Area	Mean catch rate	Catch rate best year	Rate of decline[1]	Coeff. of correlation	Degrees of freedom
	Fish per 100 hooks				
RIO	3.7	4.2 (1963)	--	Positive slope	
BAH	3.5	7.1 (1958)	0.010	-0.519**	77
FLA	2.8	3.2 (1964)	--	-.455	15
BEN	2.7	5.0 (1964)	--	Positive slope	
NOW	2.4	2.9 (1965)	--	--	--
CAR	1.4	2.2 (1960,'62)	--(from '60)	-.238	45
GUI	1.2	1.6 (1957)	.003	-.399**	92
NOE	1.0	1.8 (1964,'65)	--	--	--
CV	0.6	1.7 (1960)	.012	-.283*	59
GG	0.5	0.6 (1961)	.015	-.374**	50
GM	0	0.1 (1963)	.034	-.563**	12

[1] Rate of decline calculated as slope of a straight line (shown here as absolute value) fitted to logarithms of monthly catch rates, beginning with the first month of fishing in the best year.
*Significant (P = 0.05, or less).
**Highly significant (P = 0.01, or less).

Table 7.--Catch rates and rates of decline for blue marlin, Japanese Atlantic longline fishery, 1956-65

Area	Mean catch rate	Catch rate, best year	Rate of decline[1]	Coeff. of correlation	Degrees of freedom
	Fish per 100 hooks				
BAH	0.4	0.9 (1958)	0.011	-0.521**	77
GM	.4	.5 (1965)	--	--	--
RIO	.2	1.1 (1959)	--	-.356	28
GUI	.2	.5 (1956)	.006	-.343**	98
CAR	.2	.4 (1964)	--	Positive slope	
FLA	.2	.3 (1963)	--	-.332	20
NOW	.2	.3 (1961)	.025	-.626**	38
NOE	.1	.3 (1957)	.009	-.492**	89
GG	.1	.2 (1957,'58)	.007(from '57)	-.376**	84
CV	.1	.2 (1957,'62, '63)	.007(from '57)	-.342**	79
BEN	.1	.1 (1960,'63)	.009(from '60)	-.328**	62

[1] Rate of decline calculated as slope of a straight line (shown here as absolute value) fitted to logarithms of monthly catch rates, beginning with the first month of fishing in the best year.
**Highly significant (P = 0.01, or less).

abundant to support a longline fishery. The question is whether the albacore stocks can bear such intense fishing. Of the major albacore areas, only Bahia shows a decline in albacore catch rate--Rio de Janeiro, Florida, Benguela, and North Oceanic (West) do not (although there is a hint in the data that the Florida area may begin to show a decline rate in 1966). It is hard to imagine, however, that a marked increase in fishing in these areas will not be reflected in declines in catch rates for albacore. A substantial lowering of the albacore catch rate combined with an already extremely low catch rate for yellowfin tuna will make a continuing viable Atlantic longline fishery extremely doubtful.

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