Pacific Billfish Angler Catch Rates for Key Area Stock Assessments

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Introduction

The catch per unit effort (CPUE) or other statistical measures of fishing effort and success are not well known for most Pacific big-game fisheries for billfishes (and also tunas). Nevertheless, assessments of the stocks involved concern both anglers and fishery managers confronted with interactions arising from commercial and recreational interests in these fisheries.

Fisheries agencies have long attempted to obtain data on billfish catch, effort, and biology from recreational fisheries. Data have been obtained from tournaments, voluntary logbooks programs, club records, observations of charterboat catches, individual angler records, and from special government monitoring programs. Some of this sampling has been successful, but in most cases quality of the statistics or sampling bias has been a problem (Abramson, 1963; Calhoun, 1950).

ABSTRACT—The Pacific Billfish Angler Survey was initiated in 1969 to measure the trend of angler CPUE annually. Survey respondents (1969-84) have reported 145,661 angler days catching 59,460 billfish, resulting in an average CPUE of 0.41 fish/day or 2.45 days of fishing per billfish. Annual totals of catch, effort, and resulting CPUE are given for many of the important recreational billfish fishing areas. A comparison of CPUE trends between the commercial longline and the recreational angler is made for the area about the southern tip of Baja California where high CPUE rates are common to both fisheries. The correlation between recreational and commercial CPUE is reasonable (Y_2 = 0.82), and the recreational angler CPUE is negatively affected by the nearby commercial longline fishery.

The sport fishery consists of many small and mobile units that may or may not land their billfish catches at locations where the record of the landing was made. The total annual recreational billfish catch and the effort expended in making this catch in the Pacific is unknown. The commercial longline, harpoon, and gillnet fleets of Japan, Korea, and Taiwan account for the major portion of billfish taken in the Pacific, and extensive data on landings in weight and numbers of fish, and locations of catch and hook effort expended are maintained by the fishing vessels for government agencies.

The purpose of this paper is to show that catch rates derived from localized recreational fisheries can be used to monitor stocks that are distributed widely and also commercially exploited. The center of distribution of such stocks, however, must be near the recreational fishery. Catch rates of billfish from recreational fisheries will be described and then compared with those from commercial fisheries.

The Angler Survey

Early west coast marine sport fishery surveys to determine total catch were conducted by the U.S. Fish and Wildlife Service through contract to the U.S. Department of Commerce, Census Bureau (Clark, 1960). They were inaccurate relative to billfish catch, as indicated by comparisons of the number of billfish aught off southern California with records from various billfish clubs. The Pacific Billfish Angler Survey was initiated to obtain a better measure of both catch and angler effort from California and from other major billfish fishing areas in the Pacific Ocean. In recent years, angler response has been received from recreational fishing areas in the Indian Ocean and the survey has been expanded to include this area.

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The U.S. Fish and Wildlife Service's Tiburon Marine Laboratory began the Pacific Billfish Angler Survey in 1969, and the survey was later transferred to the U.S. Department of Commerce's National Marine Fisheries Service (NMFS) in the National Oceanic and Atmospheric Administration. In an attempt to sample economically a large number of Pacific billfish anglers, the postcard type survey method was adopted. G. B. Talbot was the original designer of the postcard-type Pacific Billfish Angler Survey.

The postcard survey method of obtaining recreational fishery data has certain problems as reviewed by Abramson (1963) and Calhoun (1950). One problem is that it may be difficult for a fisherman to remember precisely the catch from the previous year. However, since the average billfish angler does not participate in the sport frequently, and since his catch is small and billfish are "trophy fish," his recall should be better than might be expected. The survey postcard format has changed considerably since 1969 (Squire, 1974). It has been simplified to encourage accurate and complete response (Fig. 1). Anglers are requested to give an honest answer and are told that information on zero catches was important. Despite its simple format, billfish anglers frequently make mistakes in completing the survey form.

The Pacific Billfish Angler Survey form is mailed annually with the NMFS Southwest Fisheries Center's *Billfish Newsletter*. The newsletter and angler survey form are sent to all anglers who have either tagged and released billfish, or who have returned an angler survey form for the preceding year. Billfish angler survey forms are distributed during the spring months of the year following the year surveyed. Survey forms are collected for the preceding surveyed year through September. The forms are coded and the catch and effort data are placed in the SWFC computer facility, and are analyzed to determine the catch rates of the various fishing areas in the Pacific.

Estimates of catch and effort were made annually for the total Pacific and for specific fishing areas. Approximate fishing days reported by the billfish angler (f) are summed and divided into the total billfish catch reported (C):

$$\frac{C}{f} = \text{CPUE (catch per angler day).}$$

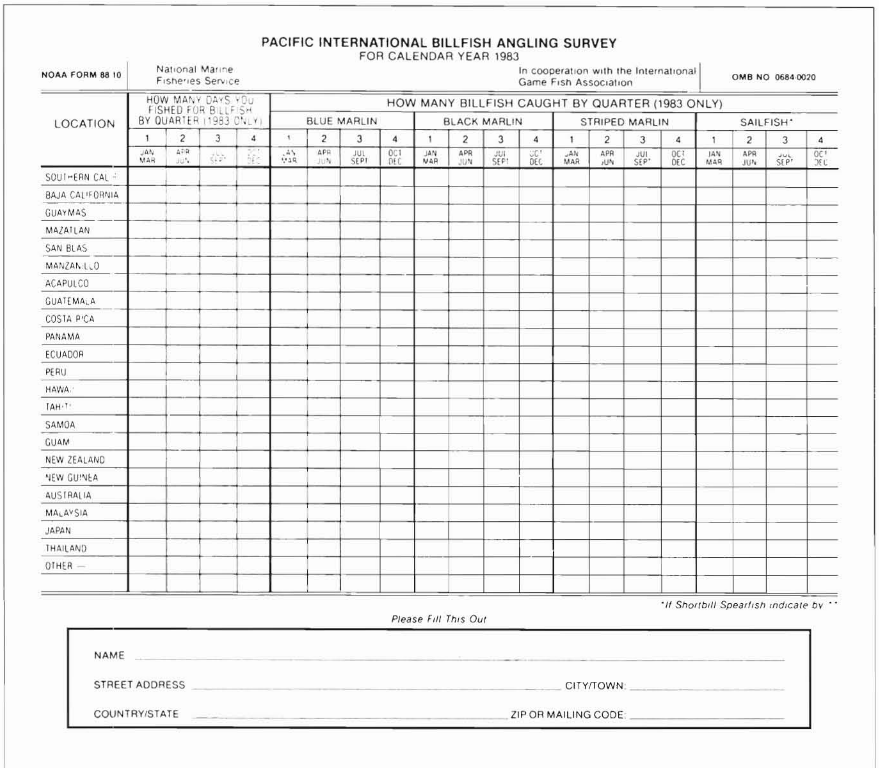
Also, to determine the average amount of effort required by an angler to catch a billfish is calculated:

$$\frac{f}{C} = \text{EPUC (days fishing per billfish).}$$

Additional analyses are made for each species and major fishing area using approximate fishing effort and catch by species.

Angler response to the survey has been high for southern California. Analysis indicates that at least 33 percent of the anglers catching striped marlin have reported. This estimate is based on the number of striped marlin reported by respondents compared to the total annual striped marlin catch off southern California as reported by the big-game angling clubs. Response level is also high for fishing off Baja California Sur, Mex. and around the Hawaiian Islands, but less so for other ports along the west coast of Mexico, Central and South America, and many other important billfish fishing areas in the Pacific. Anglers have responded with survey cards from 35 different fishing areas in the Pacific. The distribution of the fishing locations is shown in Figure 2.

Figure 1.—Pacific Billfish Angler Survey form.



PACIFIC INTERNATIONAL BILLFISH ANGLING SURVEY
FOR CALENDAR YEAR 1983

NOAA FORM 88 10 | National Marine Fisheries Service | In cooperation with the International Game Fish Association | OMB NO 0684-0020

LOCATION	HOW MANY DAYS YOU FISHED FOR BILLFISH BY QUARTER (1983 ONLY)				HOW MANY BILLFISH CAUGHT BY QUARTER (1983 ONLY)															
					BLUE MARLIN				BLACK MARLIN				STRIPED MARLIN				SAILFISH*			
	1 JAN MAR	2 APR JUN	3 JUL SEPT	4 OCT DEC	1 JAN MAR	2 APR JUN	3 JUL SEPT	4 OCT DEC	1 JAN MAR	2 APR JUN	3 JUL SEPT	4 OCT DEC	1 JAN MAR	2 APR JUN	3 JUL SEPT	4 OCT DEC	1 JAN MAR	2 APR JUN	3 JUL SEPT	4 OCT DEC
SOUTHERN CALIF.																				
BAJA CALIFORNIA																				
GUAYMAS																				
MAZATLAN																				
SAN BLAS																				
MANZANILLO																				
ACAPULCO																				
GUATEMALA																				
COSTA RICA																				
PANAMA																				
ECUADOR																				
PERU																				
HAWAII																				
TAHITI																				
SAMOA																				
GUAM																				
NEW ZEALAND																				
NEW GUINEA																				
AUSTRALIA																				
MALAYSIA																				
JAPAN																				
THAILAND																				
OTHER —																				

*If Shortbill Spearfish indicate by "

Please Fill This Out

NAME ______

STREET ADDRESS ______ CITY/TOWN: ______

COUNTRY/STATE ______ ZIP OR MAILING CODE: ______

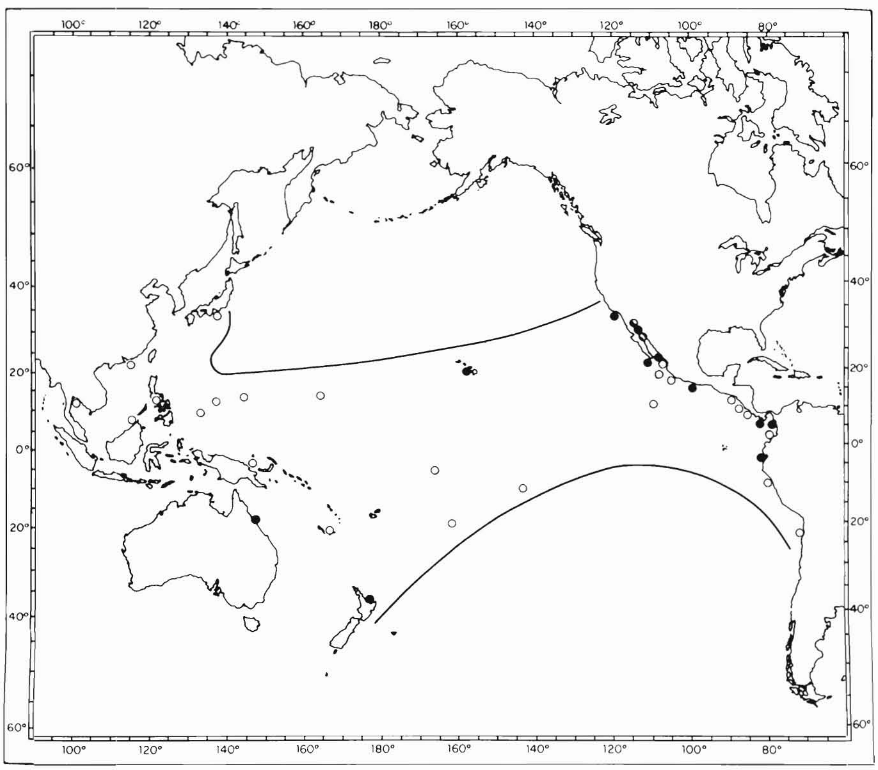


Figure 2.—Locations of billfish angler effort as indicated by survey response. Locations with 1,000 or more angler-days reported are indicated by a circle.

Table 1.—Angler catch rates for the total Pacific Ocean, 1969-83, all billfish species.

Year	Effort (in angler days)	Catch: No. of fish	Catch: Fish per day
1969	6,481	3,502	0.54
1970	6,569	3,779	0.58
1971	5,622	3,449	0.61
1972	6,899	3,511	0.51
1973	4,788	1,882	0.39
1974	9,635	3,475	0.36
1975	7,305	2,761	0.38
1976	8,591	2,918	0.34
1977	11,125	3,953	0.36
1978	14,453	3,906	0.27
1979	12,058	3,786	0.31
1980	14,100	5,506	0.39
1981	11,075	4,555	0.41
1982	8,782	4,418	0.50
1983	9,070	4,017	0.44
1984	9,108	4,024	0.41
Total	145,661	59,460	

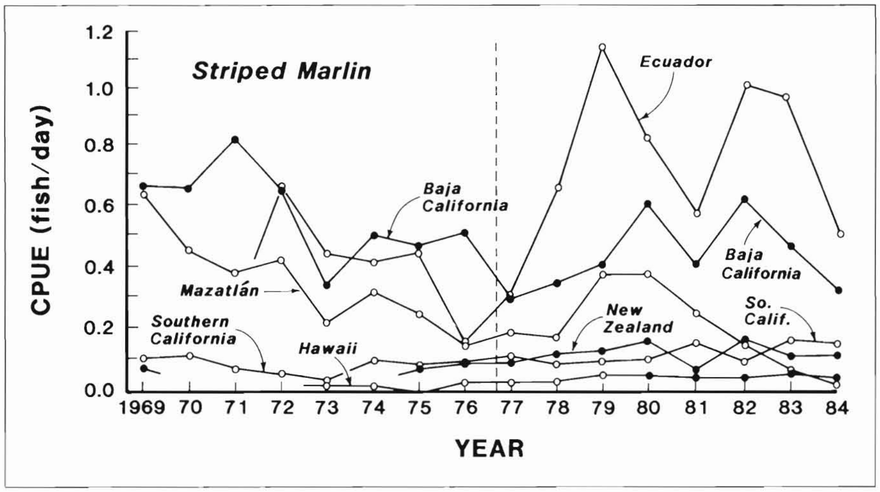


Figure 3.—Catch rates for striped marlin in areas having greater than 2,000 angler days.

Results of the Survey

About 80 percent of the survey cards sent with the SWFC's annual *Billfish Newsletter* were returned. The mailing list for the *Billfish Newsletter* is composed of anglers who have tagged and released billfish or who have participated in previous angler surveys. Some of the anglers who had not fished for billfish during the previous year return their cards so that they can remain on the newsletter mailing list. The combined totals of the catch and effort sample for billfish fishing in the Pacific Ocean for the period 1969-84 is 145,661 angler days (average 9,103 days/year) reporting a catch of 59,460 billfish (all species combined). This is a CPUE of about 0.41 fish per day or 2.45 days per billfish. The highest CPUE, 0.58 fish/day, was recorded in 1970, and the lowest, 0.27 fish/day, was recorded in 1979.

The annual totals of catch, effort, and CPUE are given by year in Table 1. For fishing areas having 1,000 angler days reported, the angler effort, catch by species, and CPUE are given for 1969-83 in Table 2. These areas are southern California (U.S.); Baja California Sur, Guaymas/Pta. Penasco/Kino, Mazatlán, and Acapulco/Zihuatanejo/Ixtapa (Mex.); Australia; Hawaiian Islands; Panama; Ecuador; Costa Rica; and New Zealand. Statistics for locations having a respondent level of less than 1,000 angler days are summarized in Table 3.

Striped Marlin

Some of the more productive recreational fishing grounds for striped marlin, *Tetrapturus audax*, in the Pacific Ocean are the areas around the southern tip of Baja California and off the coast of Ecuador. These waters are also fished for blue marlin, *Makaira nigricans*; black marlin, *M. indica*; and sailfish, *Istiophorus platypterus*. A commercial longline fishery targets on striped marlin and swordfish, *Xiphias gladius*; off Baja California Sur near the recreational fishery area. This commercial fishery has produced some of the highest catch rates for striped marlin recorded in the Pacific or Indian Oceans.

Striped marlin catch rates for recreational fisheries off Baja California Sur and Mazatlán, Mex. and off Ecuador, New Zealand, southern California, and the Hawaiian Islands are shown in Figure 3. These areas had effort rates greater than 2,000 angler days during 1969-83.

The recreational fishing area around the southern tip of Baja California Sur is located near a center of high striped marlin availability in the northeast Pacific, an area that accounts for most of the recreational catch of striped marlin in the eastern Pacific. For that reason, changes in catch rate in this area are of interest to recreational anglers, and to charterboat, fishing boat, and fishing resort operators. Catch rates declined in this area from about 0.66 fish per angler day observed during 1969-70 to 0.29 fish per day in 1977. This downward trend was reversed after 1977, and catch rates increased during 1978, 1979, and 1980 to 0.61, and then fluctuated between 0.41 and 0.62 from 1981 to 1983, declining to 0.32 in 1984 (Fig. 3).

Before the start of the Billfish Angler Survey in 1969, historical catch data obtained from the fishing resort of Rancho Buena Vista, located on Las Palmas Bay off the east coast of the southern tip of Baja California Sur, indicated a catch rate in the early 1960's of 0.6 to 0.9 striped marlin per angler day; the decline in the catch rate there from an estimated average of 0.75 in the early mid 1960's to about 0.30 fish per day in 1977 was substantial.

The average CPUE for striped marlin catches off Ecuador for 1978-84 was 0.83 fish per day, close to twice the rate of 0.46 fish per day recorded for Baja California Sur for the same period. The peak CPUE rates were also much higher, near 1.20 fish per day in 1978. However, the number of angler days reported was only 5 percent of that reported for Baja California Sur, making the Ecuador data less precise.

Striped marlin is the major billfish species reported from off Japan, and survey data were recently obtained from that

Table 2.—Reported catch, effort, and resulting CPUE rates for all locations in the Pacific having more than 1,000 angler days reported.

Location and year	Angler days	No. of billfish	Fish/ day	Days/ fish	Major species	Catch: Blue marlin	Catch: Striped marlin	Catch: Black marlin	Catch: Sailfish
Southern California									
1969	2,297	220	0.095	10.44	SM		220		
1970	2,068	232	0.11	8.91	SM		221		11
1971	2,093	192	0.90	10.90	SM		152		40
1972	2,212	119	0.05	18.59	SM		119		
1973	1,900	56	0.03	33.93	SM	10	46		
1974	4,409	460	0.10	9.58	SM	2	450		8
1975	2,678	247	0.09	10.80	SM	3	238		6
1976	2,848	275	0.10	10.36	SM		265		10
1977	3,383	381	0.11	8.88	SM	6	358		17
1978	5,684	429	0.08	13.25	SM	25	398	4	2
1979	4,921	438	0.09	11.24	SM	7	399	17	15
1980	3,900	429	0.11	9.09	SM	18	403	1	7
1981	2,997	453	0.15	6.62	SM	16	428	2	7
1982	2,666	296	0.11	9.01	SM	9	279		8
1983	2,696	485	0.18	5,56	SM	27	450		8
1984	2,874	397	0.14	7.49	SM	10	377		6
Total	49,626	5,109	0.10	9.71	SM	133	4,803	25	145
Hawaii									
1969									
1970	77	30	0.39	2.57	BLM	30			
1971									
1972	186	78	0.42	2.38	BLM	76			2
1973	84	12	0.14	7.00	BLM	10	1	1	
1974	1,003	100	0.10	10.03	BLM	88	12		
1975	677	77	0.11	8 79	BLM	76			1
1976	1,826	201	0.11	9 08	BLM	146	35	5	15
1977	1,984	432	0.22	4.59	BLM	345	33	8	46
1978	2,926	598	0 20	4.89	BLM	465	57	13	63
1979	2,017	441	0.22	4 57	BLM	315	76	20	30
1980	3,652	721	0.20	5.07	BLM	483	148	6	84
1981	1,448	327	0.23	4.43	BLM	248	44	2	48
1982	953	248	0.26	3.84	BLM	180	31	4	33
1983	1,377	361	0.26	3.81	BLM	264	62	6	29
1984	1,435	357	0.25	4.02	BLM	250	63	11	33
Total	19,645	3,983	0.20	4.93	BLM	2,976	562	6	384
Panama									
1969	26	24	0.92	1.08	SF				18
1970	115	76	0.66	1.51	SF				40
1971									
1972	193	131	0.68	1.47	SF				72
1973	157	159	1.05	0.96	SF		60	28	71
1974	304	348	1.14	0.87	SF		14	87	247
1975	167	279	1.31	0.76	SF		11	45	163
1976	293	235	0.80	1.25	SF		5	45	185
1977	377	288	0.76	1.31	SF	2	25	32	229
1978	340	325	0.96	1.05	SF	1	2	10	312
1979	347	265	0.76	1.31	SF	7	1	39	218
1980	418	353	0.84	1.18	SF	8	1	59	285
1981	455	457	1.00	1.00	SF	7	6	67	377
1982	417	554	1.33	0.75	SF	15	1	76	462
1983	178	82	0.46	2.17	SF	2		10	70
1984	243	364	1.50	0.67	SF	6	3	80	275
Total	4,025	3,880	1.04	0.96	SF	48	129	578	3,024

Location and year	Angler days	No. of billfish	Fish/ day	Days/ fish	Major species	Catch: Blue marlin	Catch: Striped marlin	Catch: Black marlin	Catch: Sailfish
Baja California									
1969	2,519	1,971	0.78	1.28	SM		1,657		314
1970	3,398	2,615	0.77	1.30	SM		2,258		357
1971	2,793	2,546	0.91	1.10	SM		2,253		293
1972	3,436	2,454	0.71	1.40	SM		2,207		244
1973	1,800	790	0.44	2.28	SM	67	600	31	92
1974	2,647	1,585	0.60	1.67	SM	66	1,307	6	206
1975	2,239	1,243	0.56	1.80	SM	35	1,058	21	129
1976	1,785	1,198	0.67	1.49	SM	47	897	14	240
1977	2,186	880	0.40	2.48	SM	39	643	10	188
1978	2,551	1,099	0.43	2.32	SM	58	855	6	180
1979	2,838	1,399	0.49	2.03	SM	88	1,175	8	128
1980	3,525	2,432	0.69	1.45	SM	91	2,143	20	178
1981	4,215	2,000	0.47	2.11	SM	94	1,722	25	159
1982	2,805	2,215	0.79	1.27	SM	129	1,735	22	329
1983	2,797	2,049	0.73	1.37	SM	500	1,307	31	211
1984	2,039	1,044	0.51	1.95	SM	203	659	7	170
Total	43,573	27,520	0.63	1.58	SM	1,417	22,476	201	3,418
Australia									
1969	755	398	0.53	1.90	BKLM			236	162
1970	262	69	0.30	3.32	BKLM			59	10
1971	357	157	0.44	2.27	BKLM			157	
1972	414	347	0.84	1.19	BKLM			347	
1973	357	543	1.52	0.66	BKLM		1	540	2
1974	558	493	0.88	1.33	BKLM	17	1	472	3
1975	540	327	0.61	1.65	BKLM			326	1
1976	689	423	0.61	1.23	BKLM	4	25	387	7
1977	706	621	0 88	1.14	BKLM	4	1	611	5
1978	1,036	539	0.52	1.92	BKLM	13	2	501	23
1979	574	319	0.56	1.80	BKLM	4	2	296	17
1980	1,119	601	0.54	1.86	BKLM	3	5	540	53
1981	503	215	0.43	2.34	BKLM	9	52	135	19
1982	662	381	0.58	1.74	BKLM	3	5	310	63
1983	560	353	0.63	1.59	BKLM		1	310	42
1984	886	471	0.53	1.88	BKLM	2	1	407	61
Total	9,978	6,257	0.63	1.59	BKLM	59	96	5,634	468
Mazatlan									
1969	583	704	1.21	0.83	SM		382		322
1970	461	588	1.28	0.78	SF		214		374
1971	272	305	1.12	0.89	SF		101		204
1972	290	300	1.03	0.97	SF		123		177
1973	294	188	0.64	1.56	SF	6	61		121
1974	190	184	0.97	1.03	SF	7	58	1	118
1975	115	125	1.09	0.92	SF	1	29	1	94
1976	150	140	0.93	1.07	SF	5	19	2	114
1977	149	118	0.79	1.26	SF	1	29	2	86
1978	218	111	0.51	1.96	SF	3	38		70
1979	125	104	0.83	1.20	SM	17	48	1	38
1980	144	141	0.98	1.02	SF	3	54	1	83
1981	136	113	0.83	1.20	SF		34	2	77
1982	99	63	0.64	1.57	SF	3	15		45
1983	110	64	0.58	1.72		8	8	2	46
1984	90	64	0.71	1.41	SF	10	1	1	52
Total	3,426	3,312	0.97	1.03	SF	64	1,214	13	2,021

Continued on next page.

Table 2.—Continued. Reported catch, effort, and resulting CPUE rates for all locations in the Pacific having more than 1,000 angler days reported.

Location and year	Angler days	No. of billfish	Fish/day	Days/fish	Major species	Catch: Blue marlin	Catch: Striped marlin	Catch: Black marlin	Catch: Sailfish
New Zealand									
1969									
1970	41	3	0.07	13.67	SF		3		
1971									
1972	15	1	0.07	15.00	BKLM			1	
1973	8	0							
1974	5	2	0.40	2.50	BLM	2			
1975	146	74	0.51	1.97	BKLM	4	10	60	
1976	36	3	0.08	12.00	SM		3		
1977	191	17	0.09	11.24	SM		16		1
1978	320	35	0.11	9.14	SM		35		
1979	169	21	0.12	8.05	SM		19	2	
1980	273	42	0.15	6.50	SM	1	40	1	
1981	457	39	0.09	11.72	SM	6	30	2	1
1982	297	46	0.15	6.46	SM	1	45		
1983	631	79	0.13	7.99	SM	6	68	2	3
1984	473	50	0.11	9.46		7	38	4	1
Total	3,062	412	0.13	7.43	SM	27	307	72	6
Ecuador									
1969	51	68	1.33	0.75	M		56		12
1970	41	79	1.93	0.52	M		75		4
1971									
1972	25	20	0.80	1.25	SM		16		4
1973	65	48	0.74	1.35	SM	1	28		19
1974	192	122	0.64	1.57	SM		79	1	42
1975	111	126	1.14	0.88	SF	2	48	1	75
1976	217	179	0.82	1.21	SF	2	35	3	139
1977	238	104	0.48	2.09	SM	1	69	2	42
1978	180	127	0.71	1.42	SF		61	2	64
1979	180	205	1.14	0.88	SM	1	192		12
1980	250	294	1.18	0.85	SM	5	248	8	33
1981	239	145	0.61	1.65	SM	4	137		7
1982	187	189	0.99	1.01	SM	13	163	6	7
1983	94	88	0.94	1.07	SM	19	49	4	16
1984	292	200	0.68	1.46	SM	17	144	15	24
Total	2,362	2,004	0.85	1.18	SM	65	1,322	42	500
Acapulco/Zihautanejo/Ixtapa									
1969	112	111	0.94	1.05	SF		5		106
1970	97	84	0.87	1.15	SF		9		75
1971	40	42	1.05	0.95	SF		2		40
1972	64	44	0.69	1.45	SF		3		41
1973	30	35	1.17	0.86	SF		10		25
1974	42	53	1.26	0.79	SF		1		52
1975	106	71	0.67	1.49	SF		12		59
1976	96	150	1.56	0.64	SF		3	1	146
1977	314	456	1.45	0.69	SF		6	1	449
1978	114	100	0.88	1.14	SF			1	99
1979	227	218	0.96	1.04	SF		5		213
1980	69	81	1.17	0.85	SF		5		76
1981	105	122	1.12	0.89	SF		1		121
1982	46	44	0.96	1.05	SF				44
1983	100	87	0.87	1.15	SF	1	2	1	83
1984	78	62	1.26	0.79	SF	4		1	57
Total	1,644	1,760	1.07	0.93	SF	5	64	5	1,686
Costa Rica									
1969									
1970	7	0							
1971									
1972									
1973	1	1	1.00	1.00	SF				1
1974									
1975	30	85	1.83	0.35	SF				85
1976	78	100	1.28	0.78	SF				100
1977	537	462	0.86	1.16	SF	1	1	3	457
1978	58	63	1.09	0.92	SF			1	62
1979	120	138	1.15	0.87	SF	3	5	1	129
1980	183	199	1.09	0.92	SF	5	5	4	185
1981	228	184	0.81	1.24	SF	2	29	4	149
1982	196	247	1.26	0.79	SF	4	5	15	223
1983	199	254	1.28	0.78	SF	6	2	8	238
1984	140	303	2.16	0.44	SF	4	3	17	279
Total	1,777	2,036	1.15	0.87	SF	25	50	53	1,908
Guaymas/Kino/Pta. Penasco									
1969									
1970									
1971	67	50	0.75	1.34	SF				50
1972	64	17	0.27	3.76	SF				17
1973	38	20	0.53	1.90	SF				20
1974	53	24	0.02	2.21	SF		2		21
1975	143	34	0.24	4.21	SF				34
1976	100	42	0.42	2.38	SF	1	4		37
1977	86	16	0.19	5.38	SF				16
Guaymas/Kino/Pta. Penasco									
1978	105	16	0.15	6.56	SF				16
1979	175	37	0.21	4.73	SF				37
1980	106	11	0.01	9.64	SF		4		7
1981	127	27	0.21	4.70	SF	1	12		14
1982	112	5	0.04	22.40	SF		2		3
1983	67	10	0.15	6.70	SF		1	2	7
1984	191	30	0.16	6.37					30
Total	1,434	339	0.24	4.23	SF	2	25	3	309

Table 3.—Reported catch, effort and resulting CPUE rates for locations having a response level of less than 1,000 angler days.

Location	Angler days	No. of billfish	Fish/day	Days/fish	Major species
Manzanillo, Mex.	928	595	0.64	1.56	SF
Thailand	522	243	0.47	2.15	BKLM
Guatemala	435	178	0.41	2.44	SF
Tahiti	434	124	0.29	3.50	BLM
New Guinea	386	92	0.24	4.20	SF
San Blas, Mex.	320	224	0.70	1.43	SF
Guam	265	45	0.17	5.89	BLM
Fiji	159	9	0.06	17.67	SF
Philippine Islands	122	37	0.30	3.30	SF
Samoa	93	10	0.11	9.30	BLM
Puerto Vallarta, Mex.	90	52	0.58	1.73	SF
Peru	38	9	0.28	4.22	SM
Japan	78	38	0.43	2.05	SM
Clipperton Island	23	1	0.04	23.00	SF
Columbia	34	33	0.97	1.03	SF
Marshall Islands	18	4	0.22	4.50	BLM
Revillagigedo Islands	18	3	0.17	6.00	SM
New Caladonia	12	0			
Nicaragua	2	8	4.00	0.25	SF
Yap Island	7	1	0.14	7.00	BLM
Topolobampo, Mex.	7	3	0.43	2.33	SF
El Salvador	6	6	1.00	1.00	SF
Palau	6	2	0.33	3.00	BKLM/SF
Borneo	4	1	0.25	4.00	BKLM
Chile	3	0			
Cook Island	4	0			
China	3	0			

fishery. From data obtained in 1982 and 1983, the catch rate was 0.49 striped marlin per angler day, only slightly less than the 1981-83 average of about 0.53 fish per day for Baja California Sur.

Environmental changes can have a significant impact on CPUE rates by modifying the distribution and behavior of the fish. The years of 1982-83 was an El Niño period of warmer sea surface temperature in the eastern Pacific. The effect of this environmental change was evident from the change in abundance/availability of several billfish species around the southern tip of the Baja California peninsula. Striped marlin CPUE dropped from the 1982 level of 0.62 fish per day to 0.47 in 1983 and to 0.32 fish per day in 1984. Though striped marlin had become less abundant around the tip of Baja California, a joint-venture Mexican/Japanese commercial longliner operation working to the west and southwest of the southern tip of Baja California (Cabo San Lucas) did obtain CPUE rates comparable to those of previous years. Blue marlin CPUE increased substantially during the El Niño of 1983 from an average of 0.03 fish per day (1973-82) to 0.18 fish per day in 1983 and continued at a rate of 0.10 in 1984. In 1983 and 1984 the center of the California catch correspondingly shifted to the northwest between San Nicolas Island and the Santa Barbara Channel Islands. This area is northwest of the normal catch areas around Catalina Island, between Catalina Island and the mainland, and off San Diego. Sea surface temperatures were very warm off southern California during the 1983 El Niño and were higher in 1984; catches of striped marlin increased with a record of CPUE rate of 0.16 fish per day in 1983 and 0.13 fish per day in 1984. These increases were related to above average sea surface temperatures off the northwest coast of Baja California and southern California (Squire, 1974).

Blue Marlin

Blue marlin is common to tropical oceans and is a dominant billfish species in the central Pacific area from the Tuamotu Islands in the southeast to the Marianas Islands in the northwest. These areas appear to be the major habitat of blue marlin. Commercial longline catches of this species declined in the Pacific to about 12,500 metric tons (t) in 1975, but since 1975 catches have increased.

Angler catch rates for blue marlin are normally lower than those observed for striped marlin and sailfish (Fig. 4). However, the size of this species (up to 2,000 pounds-plus) makes it an attractive sportfish. Limited survey data from Tahiti and Guam show CPUE rates that are not substantially different from those of Hawaii. CPUE rates ranged from 0.16 to 0.28 fish per day in 1984.

Angler response from Hawaii was high compared with that of other island areas in the central Pacific. In 1970 and 1972 Hawaiian catch rates for blue marlin were considerably higher than in 1973-83; however, the sample size in the early 1970's was small compared with that of later years. Blue marlin catch rates have increased from about 0.10 fish per day during 1973-76 to nearly 0.25 fish per day in 1984.

Although the angler response rate is low for the Tahiti areas, data collected since 1976 indicate an average CPUE rate of 0.23 fish per day. This is above the Hawaiian Islands average of 0.18 fish per day for the same period. The CPUE

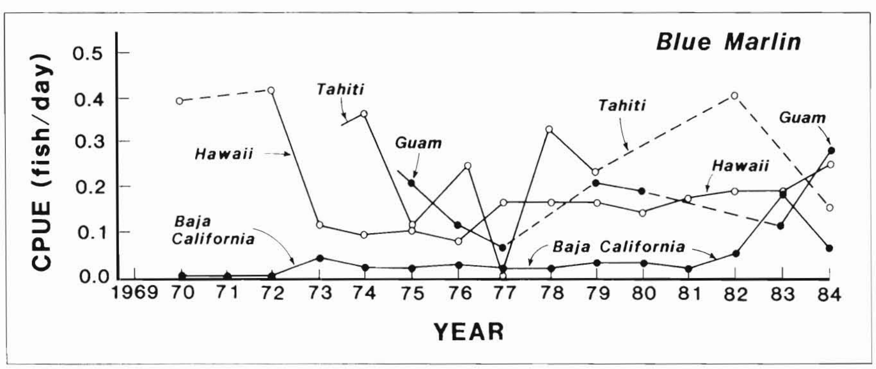


Figure 4.—Catch rates for blue marlin in areas having a response rate of greater than 200 angler days.

rate for blue marlin caught off Baja California Sur is usually very low (0.03 fish per day average), except for the El Niño years of 1982-83 when the CPUE rate increased to 0.18 fish per day, a CPUE similar to that observed for the central Pacific Ocean.

Black Marlin

The center of black marlin distribution is in the southwest Pacific and Indo-Pacific area. High angler CPUE rates were recorded for the area along the Great Barrier Reef, Queensland, Australia, located on the western edge of the Coral Sea. Angler catch rates for black marlin in areas having a response rate greater than 200 angler days are shown in Figure 5.

Large fluctuations in catch rates for black marlin were observed off Queensland during the early years of the survey (Fig. 5). High catch rates of up to 1.5 fish per angler day were observed in 1971 and 1973. The rates declined to a level of about 0.5 fish per day in 1978 and since then remained near that level. The average CPUE for 1976-84 is 0.54. This fishery produces large fish and many of the catches are in excess of 300-400 pounds. Considering that the CPUE is about 0.5 fish per day, the catch per angler in weight is one of the highest in the world. Thailand reported an angler CPUE rate of 0.44 fish per day, only slightly less than that observed for the Queensland area; however, the fish caught off Thailand were not as large as those caught off Queensland, Australia (pers. commun.). In the eastern Pacific Ocean some black marlin are landed in the tropics off Central and South America, and billfish anglers fishing in Panama report an average CPUE rate of 0.11 fish per day.

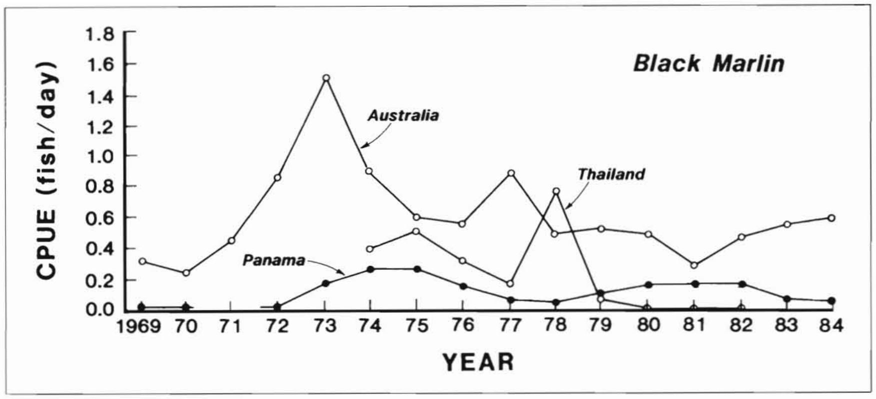


Figure 5.—Catch rates for black marlin in areas having a response rate of greater than 500 angler days.

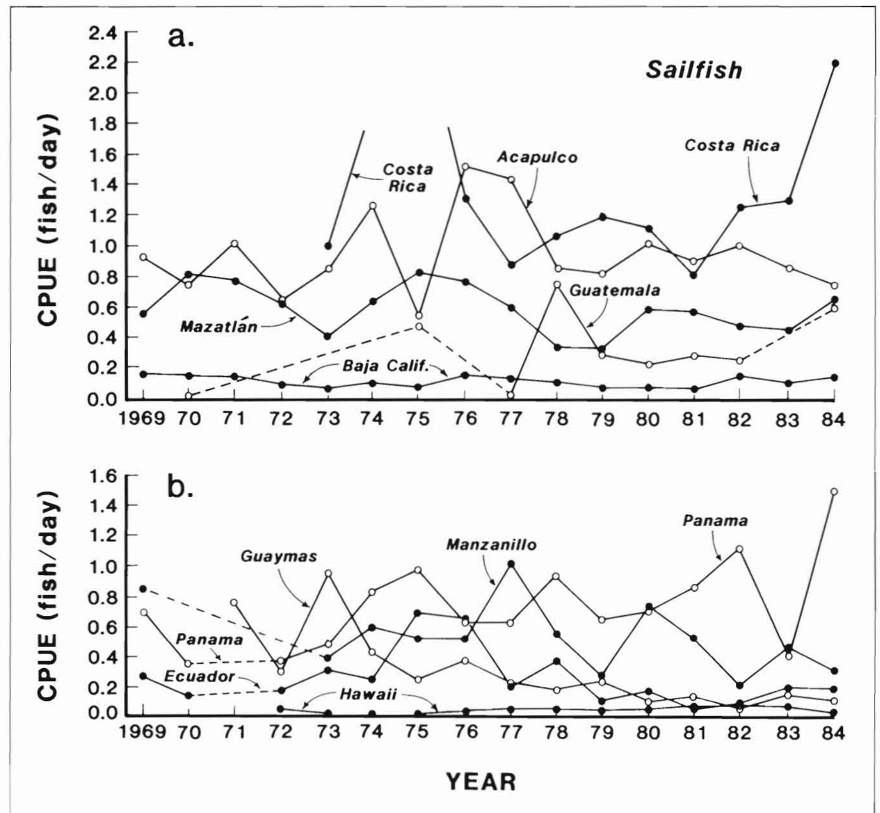


Figure 6.—Sailfish catch rates for areas (a and b) having a response of greater than 400 angler days.

Sailfish

High commercial and recreational CPUE rates for sailfish are observed along the eastern Pacific coast from Panama to the Gulf of California, Mex. This area has the highest abundance of sailfish in the eastern Pacific. Abundance is highest along the coast from near Acapulco, Mex., south to off Costa Rica and Panama during the winter. In the spring and summer, sailfish move northward and have been recorded in the northern part of the Gulf of California (lat. 31°N). The number of survey responses is low for anglers fishing in areas of high sailfish catches. Catch rates for Costa Rica, Guatemala, Mexico (Baja California Sur, Mazatlán, Manzanillo, Guaymas/Pta. Penasco/Kino, and a Acapulco/Ixtapa), Ecuador, and Hawaiian areas as well are given in Figure 6a-b. These areas have substantial catches of sailfish and an angler response rate of 400 or more angler days. The CPUE rate for fishing off Acapulco/Ixtapa, Mex., an area near the center of Pacific sailfish distribution, averages about 1.0 fish per day. Costa Rica appears to have the highest sailfish CPUE in Central America; its CPUE reached 2.17 fish per angler day in 1984. Mazatlán, Mex., to the northwest has a catch rate that fluctuates around 0.5 fish per day with highs of 0.81-0.82 fish per day observed in 1970 and 1975. The ranges for sailfish catch rates for the southern tip of Baja California Sur are lower than those for Mazatláns and appear to be relatively stable at 0.08 fish per day. To the southwest, Manzanillo, Mex., and Panama have sailfish CPUE rates of 0.50-0.80 fish per angler day. CPUE rates below 0.50 were recorded from Guatemala, Ecuador, Baja California, Guaymas/Pta. Penasco/Kino, and the Hawaiian Islands.

The sailfish was one of the target species for the Japanese longline fleet operating off Mexico in the early years of that fishery (1960-65). In the eastern Pacific Ocean, catches were recorded in excess of 9,000 t in 1965. Catches then declined to about 3,500 t in 1975, increased to over 10,000 t in 1976, and then declined to a record low of less than 1,000 t in 1981. Annual CPUE rates of 90 fish per 1,000 hooks fished were recorded for some 5° long. × 5° lat. areas off Central America during the early years of the longline fishery.

Summary and Discussion

CPUE Trends From Billfish Survey and Recreational Fishery Data

Data on catch and effort for most recreational billfish fisheries in the Pacific Ocean are very limited. Therefore, the opportunities to compare the results of the postcard survey method with catch rates developed by other methods are few. Although some fishing resort operations maintain fishing records, these records are in most cases insufficient for generating CPUE values comparable to the records of the Billfish Angler Survey. Records for the resorts are maintained in "numbers of boat days," which poses the problem of the number of angler days actually represented. Charter boats may at times fish for species other than billfish, and this could result in CPUE error. In some areas (Baja California), a substantial amount of angler response to the Billfish Survey is from U.S. fishermen who fish off private boats, and the catch rate for this private fleet may have a higher CPUE rate than the public charter boat fleet. Bias may also result if respondents to this survey are the more successful anglers.

Eastern Pacific

Some data suitable for comparison with the Survey CPUE rates off the Americas are available. From March 1978 to February 1979, biologist Hector Zurita Brito of Mexico's Departmento de Pesca conducted a comprehensive sampling study of the recreational billfish fishery in the Acapulco/Zihuatanejo area. About 30,000 sailfish were caught in this area annually and the catch rate was found to be 1.0 fish per day (Zurita Brito 1980, 1985). From the Billfish Angler Survey for the same area in 1978 the catch rate for sailfish was 0.87 sailfish per day. There was thus a 13 percent difference, or 0.13 fish per day less for Billfish Angler Survey data.

A field sampling program for billfish was conducted in 1968 and 1969 by the U.S. Fish and Wildlife Service in the Las Palmas Bay area of Baja California Sur (Rancho Buena Vista), and at Mazatlán. Results of this study are given in graphs in a paper by Talbot and Wares (1975). The following results were determined from the graphs to indicate the angler CPUE rates for striped marlin and sailfish off Bahia de Palmas (Baja California Sur) and Mazatlán.

Billfish Angler Survey, 1969 (first year of Survey).

	Talbot and Wares (1975)	Billfish Angler Survey
Striped marlin		
Mazatlán	0.45	0.66
Baja Calif.	0.60	0.66
Sailfish		
Mazatlán	0.60	0.55
Baja Calif.	0.10	0.12

A limited amount of catch/effort data from a leading fishing resort in the East Cape area of Baja California, located on Bahia de Palmas, was made available; analysis of these data indicate a striped marlin CPUE rate much lower than that recorded by the Survey:

Year	Billfish Angler Survey CPUE	Fishing Resort CPUE
1981	0.41	0.13
1982	0.62	0.16
1983	0.47	0.22 (first half year)

For Ecuador, fishing resort data had boat days only. The CPUE calculated using an estimated angler days effort (boat days multiplied by two) appeared more compatible with data from the Billfish Angler Survey than were sample data from Baja California:

Year	Billfish Angler Survey CPUE	Fishing Resort CPUE
1972	0.53	0.64
1973	0.35	0.43
1974	0.29	0.41

Angler catch rates for strpied marlin at both locations appear not to be comparable with catch rates from the Billfish Angler Survey. Ecuador resort data, even though they were from a much smaller sample than the Baja California survey data (2,070 angler days vs. 41,534 angler days), were in better agreement with the Survey than the Baja California resort data.

Central and Western Pacific

Recent studies of the Hawaiian Island billfish fisheries provide a source of comparative data. Holland (1985) reported that by examining the number of marlin flags on charterboats entering Kewalo Basin, Honolulu, Hawaii, he was able to determine the number of marlin caught by this fleet. A measure of effort for full-day charters from the Kewalo Basin fleet indicated that the CPUE rate was one marlin per 6.25 days of fishing or 0.16 fish per boat day. On the other hand, Samples et al.[1], from economic survey data, reported that the 119 charterboats around the Hawaiian Islands fished an average of 155 trips per year catching an average of 47 billfish (striped, blue, and black marlin, sailfish, swordfish, and shortbill spearfish, *Tetrapturus angustirostris*). From this figure the total

[1]Samples, K. C., J. Kusakabe, and J. Sproul. 1984. A description and economic appraisal of charterboat fishing in Hawaii. NMFS Honolulu Lab. Admin. Rep. H-84-6C, 130 p.

catch would be 5,593 billfish, reported to be taken by a total of 73,780 anglers, given a statewide CPUE of 0.08 billfish per angler day.

These surveys, however, do not indicate the charterboat trips that fished marlin as one of 13 groups of targeted fishes. From Samples et al.[1] data for the island of Hawaii, which has a higher percentage (14.8 percent) of billfish in the charterboat catch than the data from the islands of Oahu or Maui, the billfish CPUE rate (based on 128 days fishing per charterboat, a catch of 58 billfish, and an estimated three anglers per trip) is calculated to be 0.15 billfish per angler day. The Pacific Billfish Angler Survey CPUE for the Hawaiian Islands for 1978-84 is 0.13-0.19 fish per angler day with an overall average of 0.16 fish per angler day, which is comparable to the rates reported by Holland (1985) (though the Survey rates were higher than his during 1982-83) and by Samples et al.[1] The Billfish Angler Survey form does not separate response data by island.

Sample heterogeneity must account for much of the CPUE differences during comparable years. The Samples et al.[1] data represent findings from a statewide questionnaire; Holland's data are from the fishing grounds off the island of Oahu, not the best marlin fishing area in the Hawaiian Islands (Holland, 1985). The highest catch rates are recorded off the Kona coast of the island of Hawaii (Samples et al.[1]), and the CPUE rates there are most like to those determined by the Billfish Angler Survey. The Billfish Angler Survey should be biased toward higher CPUE values because the respondent base is made up of anglers who are active in billfish fishing and who fish the higher density areas of billfish; it is possible that the better billfish anglers are primarily responding. Hawaiian angler catch rates of blue marlin, the major target species in the Hawaiian Islands area, are not as high as those observed for striped marlin and black marlin in other important recreational fishing areas. This is probably because the Hawaiian Islands are not geographically near the center of distribution for blue marlin while that is the case for the recreational fisheries for striped marlin about the tip of Baja California Sur and for black marlin near the Great Barrier Reef off Queensland (Suzuki and Honma[2]). The distribution of blue marlin in the Pacific Ocean is centered in the south central Pacific Ocean (lat. 10°-20°S × long. 140°-160°N) from December to February and in the northwest central Pacific (long. 120°E) from June to August.

Catch rates for recreational billfish fisheries in most areas of the Pacific Ocean are relatively stable compared with the trend of catch rates observed for striped marlin about the southern tip of Baja California Sur, and for black marlin off the Queensland coast. Both of these productive recreational fishing areas are located near commercial longline fisheries that targets on these species. In summary, it appears that CPUE's derived from the Billfish Angler Survey are comparable to other angler surveys unless there are sampling errors.

Comparison of CPUE Trends Between the Commercial Longline and Recreational Fisheries

I compared the trends in CPUE's between geographical areas, such as off Baja California Sur and Queensland, which have both an intensive recreational fishing (high angler response) and a commercial longline fishery (high CPUE) for billfish species.

Black Marlin

Black marlin have been fished in the Coral Sea and other areas in the southwest Pacific by longline fleets from Japan since the early 1950's. The total number of black marlin caught by the Japanese commercial longline fleet in the southwest Pacific ranged from 4,000 to 14,000 fish per year during 1969-80. During this same period, CPUE rates calculated by 3-year periods indicate a decline from an average of 0.17 fish per 1,000 hooks (1969-71) to 0.07 fish per 1,000 hooks (1978-80) a 57 percent decline in CPUE (Anonymous, 1980).

Angler catch rates for black marlin off Australia peaked in 1973 at about 1.5 fish per angler day. This peak may have been due to fleet expansion to new grounds and increased efficiency of the charter fleet during the early 1970's when the recreational black marlin fishery was developing rapidly off the Cairns area and also north of that area. The angler CPUE average for the 1971-75 period, 0.83, declined to 0.46 fish per angler day for 1979-1984, a 45 percent decline in angler CPUE. The commercial longline CPUE for the southwestern Pacific for 1972-74 was 0.11 fish per 1,000 hooks. This declined to 0.07 fish per 1,000 hooks in 1978-80, a 36 percent CPUE decline. Thus, for a comparable time period the CPUE for the commercial fishery declined 36 percent for the southwest Pacific, and the CPUE for the recreational black marlin fishery declined 45 percent.

Striped Marlin

The 1969-76 catch of striped marlin per 1,000 hooks fished by the Japanese commercial longline fleet off the southern tip of the Baja California peninsula correlated positively with the CPUE of the recreational fleet as determined by the Survey (Fig. 7; Squire, 1982). Regression of the 1969-76 CPUE's for striped marlin attained by the Japanese longline fleet with that of recreationally caught striped marlin for the same period and in the same general area off Baja California Sur (5° areas, lat. 20°N by long. 105°W and lat. 20°N by long. 110°W) produced a reasonable correlation ($r = 0.81$). The CPUE of the Japanese longline fleet was much higher in the early and middle 1960's, before the start of the billfish angler survey in 1969, and it is reasonable to assume, based on historical data, that the angler CPUE was also higher. The limited amount of recreational fishery data available would support this.

Decline in the commercial longline catch rate of striped marlin off Baja California Sur appeared to be greater than that observed for recreational billfish anglers (Fig. 7). If CPUE rate is related to stock size, then the Survey could be measuring changes in stock size for a major area of fishing in the eastern Pacific. This is plausible because the area around the southern tip of Baja California Sur ac-

[2]Suzuki, Z., and M. Honma. 1977 Stock assessment of billfishes in the Pacific. Draft working paper, Billfish Stock Assessment Workshop, NMFS Honolulu Laboratory, Hawaii, 5-16 December 1974.

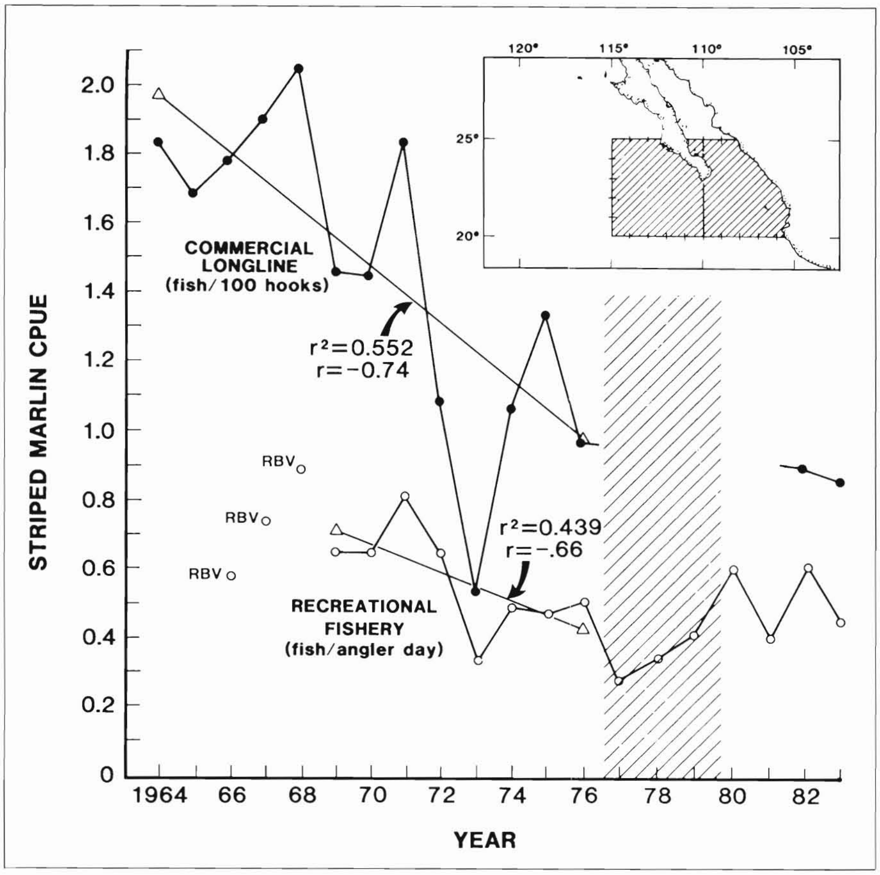


Figure 7.—Striped marlin CPUE and its regression for the commerical longline fleet 1964-76, two 5° long. by 5° lat. areas, and the Billfish Angler Survey for the southern portion of Baja California. The hatched area represents a period when longline operations were negligible within Mexico's 200-mile economic zone.

counts for about 25 percent of the commercial striped marlin catch in the eastern Pacific (east of long. 130°W). Downward CPUE trends in both sport and commercial fisheries indicate that the commerical longline fishing may have had an impact on the lower recreational billfish catch rates.

Longline fishing by foreign fishermen off Mexico for striped marlin, sailfish, and swordfish was interrupted in the spring of 1977 due to the enforcement of Mexico's 200-mile economic zone, which prohibited fishing by foreign fishermen except by permit from the government. In 1977 and 1978 no longline effort and catches of striped marlin were reported by the Japanese Fishery Agency from around the tip of Baja California Sur, an area that produces some of the highest catch rates for striped marlin in the Pacific (Anonymous, 1956-80). As part of joint ventures between Mexico, Japan, Taiwan, and Korea, commercial longline fishing targeting on striped marlin, swordfish, and to a lesser extent on sailfish, was resumed in 1980. Effort and catch increased in 1981 and 1982. Longline catch data on the number of striped marlin per 1,000 hooks fished from portions of the joint venture longline operations about the southern tip of Baja California Sur are available for 1982 and 1983 (personal commun.). Striped marlin CPUE was calculated based on a 1982 catch of 13,489 fish using 1,494,610 hooks to give a CPUE of 9.03 fish per 1,000 hooks. The 1983 CPUE was 8.71 fish per 1,000 hooks fished based on a catch of 18,931 striped marlin using 2,104,716 hooks. The CPUE rate for 1982-83 is only slightly less than the CPUE rate the Japanese longliners experienced in 1976, before elimination of foreign longline fishing within Mexico's 200-mile economic zone.

The Billfish Angler Surveys in 1978, 1979, and 1980 show an increase in angler catch rate for Baja California Sur, reversing the downward trend of angler CPUE from 1969 to 1976 (Fig. 3, 7). The CPUE subsequently declined in 1983 to 1984.

The relaxation of commercial fishing effort in a local area (200 n.mi. zone) appears to have had a positive impact on billfish angler catch rates. Although recreational and commercial CPUE's noted in this paper and by Pristas (1980) appear to be positively correlated, the CPUE's may be following changes in local availability—that is, the fishing may not be noticeably affecting the total stock.

The economic value of recreational fishing for the large pelagics such as tunas and billfishes is substantial (Radonski, 1984; Herrick[3]). High catch rates of black marlin off Queensland, Australia, attract anglers from throughout the world, as does the high catch rates of billfish off Baja California Sur, Mexico. In some areas, such as about the tip of Baja California Sur, the recreational fishery is very important to the local economy.

It is important for fishery managers to know the economic value of the fishery and the level and trend of billfish angler catch rates as well. In southern California about 3,000 private boats are equipped with billfish fishing gear (Anonymous, 1979), yet the angler catch rate for striped marlin there is low—0.1 ± fish per day. Even at this low CPUE level, anticipation of a catch is great enough to warrant substantial expense and effort by

[3]Herrick, Samuel F., Jr. 1984. Socio-economic profile of the southern California billfish angler. NMFS Southwest Fish. Cent. Admin. Rep. LJ-84-12.

mostly local marine anglers. However, if the catch rates for striped marlin about the southern tip of Baja California Sur were to decline to such low levels (0.2-0.3 fish/angler day), foreign billfish anglers would be reluctant to undergo the expense and time to travel there and experience what would be rated as poor fishing for that area.

Summary

Data presented in this paper showing declines in commercial longline CPUE in relation to changes in angler CPUE for striped marlin off Baja California Sur and black marlin off Queensland suggest that recreational billfish fisheries are being affected by the commercial longline fisheries. The same was suggested by Pristas (1980) for billfish species in the Gulf of Mexico. When commercial longline fishing was curtailed within Mexico's 200 n.mi. economic zone in 1977-80, the recreational CPUE for striped marlin increased, which would be expected if the commercial fishery were having an effect.

However, in evaluating the relationship between the oceanic longline and localized, coastal recreational fisheries, it should be kept in mind that billfish are highly migratory and not likely to form local, vulnerable populations; the difference in total catch between most recreational and commercial fisheries is usually several orders of magnitude in favor of the commercial longline fishery; the magnitude of the effect of longline fishing on a localized recreational fishery may only be accurately measured by angler catch rate in geographical areas where density and availability of a particular billfish stock are increased especially for the recreational fishery. In the eastern Pacific the mechanism by which the abundance of striped marlin is reflected in the localized recreational catch from off Baja California Sur may be high mobility of the fish throughout the eastern Pacific commercial fishing grounds coupled with increased availability when the fish nears the recreational fishing area.

Results from the Billfish Angler Survey indicate that management of pelagic billfish resources, where both commercial and recreational fisheries are participants, may require a determination of the minimum allowable angler catch rate based on socioeconomic analysis. This catch rate can be used as a bench mark when considering regulations that affect the interests of both the commercial and recreational fisheries.

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