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Effects of increased vessel efficiency on effort regulation

by

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Catch and effort data of fleets operating in ICNAF Subareas 5 and 6 during 1961-1973 were analyzed according to the method outlined in ICNAF Res. Doc. 75/18 in order to determine standardized days fished for each year. The days fished were standardized among vessel, gear, and national fleets. Year to year changes in fishing operations were not taken into account except for a fixed term (two-year) adjustment for "learning". Halliday and Doubleday (ICNAF Res. Doc. 75/43) suggested a method for adjusting reported days fished for continuing temporal changes in efficiency. This method was applied to the standardized days fished unadjusted for learning in Subareas 5 and 6.

The standardized days fished in year t, f(t,adj), were calculated as:

$$f(t,adj) = f(t,rep) \times \exp(Kt),$$

where K = annual percent change in efficiency,
f(t,rep) = standardized days fished for year t,
where t takes on the values t = 0, 1,...12 (corresponding to the years 1973-1961). Data were generated using values of K = -.04, -.06, -.08, and -.10. The negative values of K allow the effort to be expressed in standardized units as of calendar year 1973. The linear equation of catch per unit effort on effort,

$$c/f(t,adj) = a + bf(t,adj),$$

was fit by least squares using a running average of three and five years for f(t,adj).

The results (Table 1) indicate little difference in the magnitude of the correlation coefficient, r, for K = -0.04 to -0.10. The fitted line for K = -0.08 with a three year running average (the greatest magnitude of r and F) is portrayed in Figure 1. The corresponding catch-effort parabola is portrayed in Figure 2.

A study by the US reported to the ICNAF Effort Working Group (Redbook, 1975) estimated changes in fishing efficiency between 1971 and 1973 based on changes in catch per unit effort of vessel gear categories relative to catch per unit effort of US 0-50 T side trawlers. This simulation gave an increase in efficiency of 17 percent; that is an annual percentage change, K, of -.09, which is similar to that determined from the above analysis.

With the relationship K = -.08, the estimated effort of 143,320 days fished related to the MSY was 65 percent of that actually expended in 1973. The 143,320 days fished, had they been expended in 1973 (i.e., multiplied by 5.27 tons per day) would have resulted in a catch of 755,296 tons, an estimate of the TAC for 1973 to achieve the goal of MSY effort.

[1] All ICNAF documents will now be numbered to include the month (in Roman numerals) of the meeting at which they were presented.

If, in fact, there is a constant, long-term, increasing efficiency, then the effort applied in future years must also be discounted in order to properly regulate fishing mortality. The question is how to account for this factor when setting future effort or catch regulations to achieve, say, MSY on the basis of prior assessment at a fixed point in time, viz. 1973.

The effort scale in Figure 1, f(t,adj), is such that it corresponds to f(t,rep) in 1973. The scale can be adjusted to previous years or projected to future ones by adjusting the scale, that is, multiplying the days fished on the X axis in Figures 1 and 2 by the relative efficiency to 1973. These relative values are given below based on K = -0.8 and t_o being 1973.

Year	Efficiency relative to 1973
1970	0.79
1971	0.85
1972	0.92
1973	1.00
1974	1.08
1975	1.17
1976	1.27

The days fish in 1976 units (1973 units X 1.27) are shown on the lower scale in Figures 1 and 2. The estimated (MSY) in these units is 112,850 days fished. Thus to achieve the objective of MSY the 34 percent reduction from 1973 is increased to a 49 percent reduction from the same 1973 effort base in order to discount hypothetical efficiency changes. Because this is in terms of total standardized effort, the percent reduction can be varied among vessel, gear, and national categories, of course, to achieve the overall objective.

The ICNAF Assessment Subcommittee in April 1975 (ICNAF Sum. Doc. 75/18) noted that the sum of the recommended TACs for 1976 was 76% of the sum for 1974 (in 1973 TACs were not recommended for all groups). This was considered by the committee to reflect a decline in biomass. If we assume a total decline of 24% between 1973 and 1976, the expected catch in 1976 would be 574,025 tons if the area were fished at MSY effort. This is an estimate of the 1976 TAC to achieve the goal. Clark and Brown (1975), ICNAF Res. Doc. 75/65, Appendix, calculated that the total stock was declining at an average rate of 27.5% per year in the period 1972-1974. If this decline continued through 1976, it would result in a stock of only 38% of that in 1973. This stock size would yield catch in 1976 of only 287,012 tons if fished at the MSY effort level.

Table 1. Total catch, standardized effort, catch per unit effort, standardized effort adjusted for increase in efficiency per year, and 3 and 5-year averages of the latter. Also, statistics associated with linear regressions $y_t = \hat{b}x_t + \hat{a}$ for y_t = CPUE of year t and x_t = effort of year t.

Year	Total catch	Standardized effort K=-.04	Catch per unit effort	3-year average effort	5-year average effort	Standardized effort K=-.06	Catch per unit effort	3-year average effort	5-year average effort	Standardized effort K = -.08	Catch per unit effort	3-year average effort	5-year average effort	Standardized effort K = -.10	Catch per unit effort	3-year average effort	5-year average effort
1961	344,286	64,385	39,840	8.64			31,339	10.98			24,653	13.96			19,392	17.75		
1962	472,263	116,020	74,721	6.32			59,965	7.87			48,123	9.81			38,620	12.23		
1963	650,825	112,195	75,207	8.65	63,256		61,574	10.57	50,959		50,412	12.91	41,063		41,274	15.77	33,095	
1964	786,346	133,233	92,954	8.46	80,961		77,641	10.13	66,393		64,365	12.22	54,300		53,762	14.63	44,552	
1965	954,808	138,405	100,503	9.50	89,555	76,645	85,643	11.15	74,953	63,232	72,990	13.08	62,589	52,109	62,198	15.35	52,445	43,049
1966	988,568	168,630	127,448	7.76	106,968	94,167	110,798	8.92	91,361	79,124	96,323	10.26	77,893	66,443	83,739	11.81	66,566	55,919
1967	759,881	127,660	100,421	7.57	109,457	99,307	89,065	8.53	95,167	84,944	78,994	9.62	82,769	72,617	70,061	10.85	71,999	62,227
1968	942,762	167,578	137,201	6.87	121,690	111,705	124,145	7.59	108,003	97,458	112,331	8.39	95,883	85,001	101,641	9.28	85,147	74,280
1969	1,029,391	235,939	201,054	5.12	146,225	133,325	185,596	5.55	132,935	119,049	171,325	6.01	120,883	106,393	158,153	6.51	109,952	95,158
1970	840,267	188,551	167,230	5.02	168,495	146,671	157,491	5.34	155,744	133,419	148,319	5.66	143,992	121,458	139,682	6.02	133,159	110,655
1971	1,124,872	226,545	209,127	5.38	192,470	163,007	200,927	5.60	181,338	151,445	193,049	5.83	170,898	140,804	185,479	6.06	161,105	131,003
1972	1,144,597	261,837	251,570	4.55	209,309	193,236	246,589	4.64	201,669	182,950	241,706	4.74	194,358	173,346	236,920	4.83	187,360	164,375
1973	1,153,946	218,934	218,934	5.27	226,544	188,607	218,934	5.27	222,150	201,907	218,934	5.27	217,896	194,667	218,934	5.27	213,778	187,834
$\hat{a}$					10.66	11.11			12.37	11.91			14.25	13.30			16.34	14.84
$\hat{b}$					-2.84×10^{-5}	-3.56×10^{-5}			-3.82×10^{-5}	-4.00×10^{-5}			-4.97×10^{-5}	-5.02×10^{-5}			-6.16×10^{-5}	-6.22×10^{-5}
r					-.90	-.89			-.91	-.87			-.92	-.87			-.91	-.87
F					37.21	27.74			46.29	21.58			47.46	22.01			43.49	21.35
MSY					997,783	867,024			1,000,838	885,418			1,021,224	880,894			1,083,586	885,155
effort (MSY)					187,201	156,121			161,858	148,700			143,320	132,419			132,670	119,293

= intercept r = correlation coefficient

= slope F = F-test

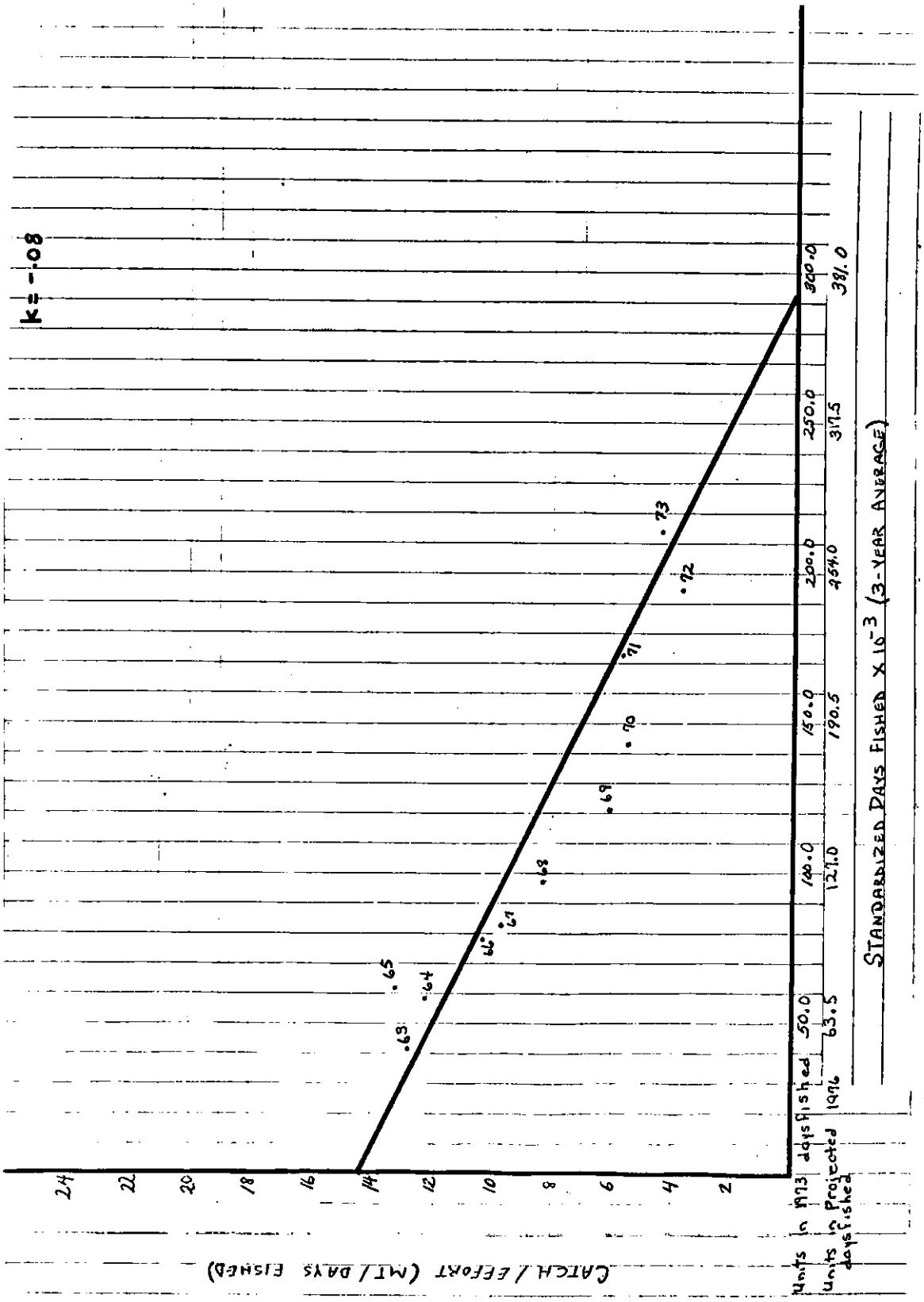

Figure 1. Total catch per day (finfish plus squid) vs. standardized days fished for Subarea 5 and Statistical Area 6, 1961-1973, using a three-year average over effort (days fished).

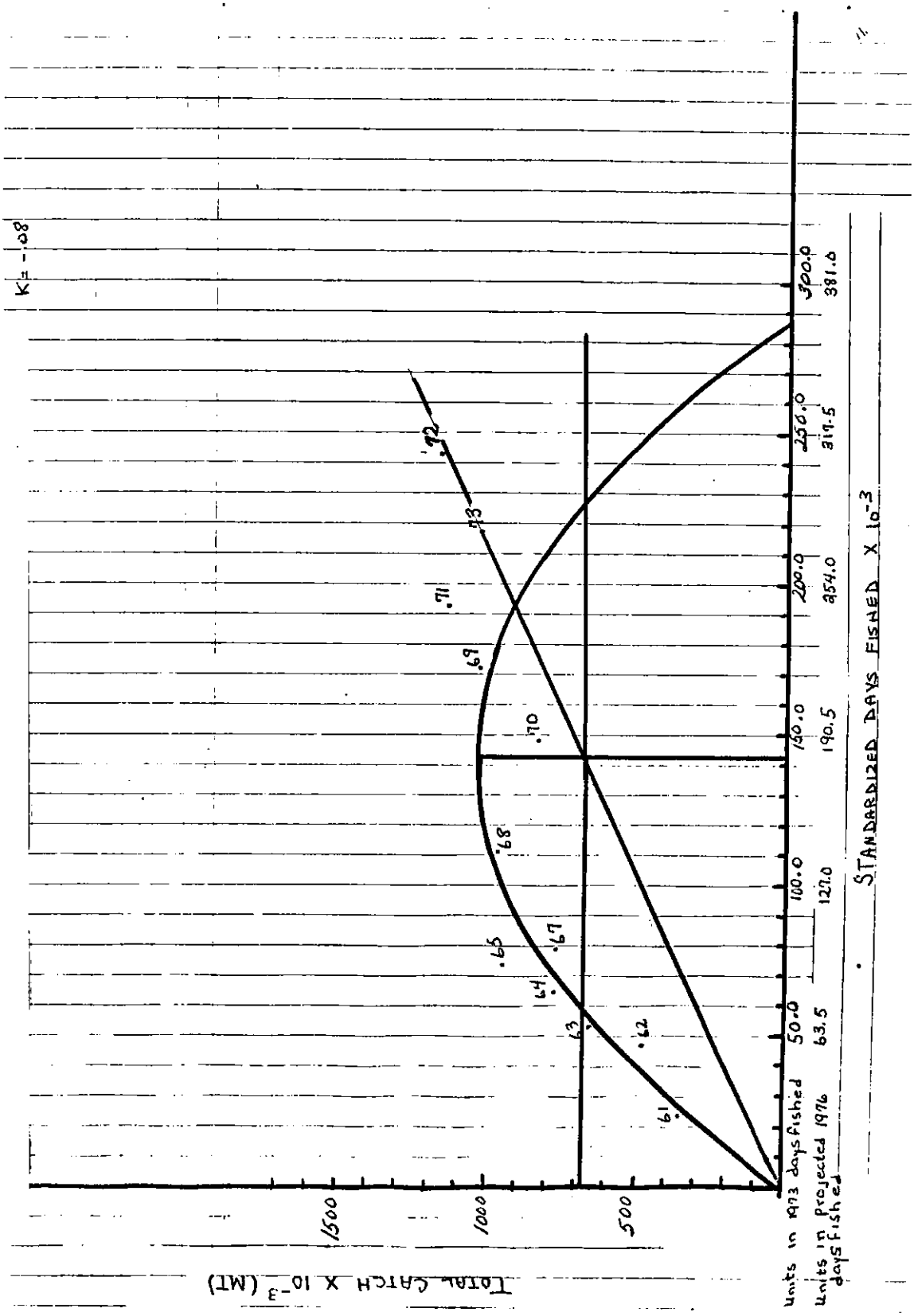

Figure 2. Total catch (finfish plus squid) vs. standardized days fished for Subarea 5 and Statistical Area 6, 1961-1973, using a three-year average over effort (days fished). Original data points (catch vs. standardized days fished) are plotted.

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ADDENDUM

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