RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2605
(D.c.3)

ICNAF Res.Doc.71/115

ANNUAL MEETING - JUNE 1971

Prediction of Yellowtail Flounder Population Size from Pre-recruit Catches

by

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Abstract

An index to population size of the southern New England stock of yellowtail flounder is developed utilizing the catch equation and the pre-recruit index (age I+) obtained from Albatross IV survey cruises. The estimated population size for 1971 and 1972 continues at the low 1970 level. To obtain a reduction in fishing rate to correct for overfishing and allow for recovery of the stock the 1972 quota for the southern New England population should be 8,000 MT (10,000 if Cape Cod stock is included in area west of 69°)

Introduction

Research vessel survey cruises (Grosslein 1969) conducted each autumn since 1963 provide an estimate of relative abundance of pre-recruit yellowtail flounder. These values may be used to construct an index of population size in following years. The relationship between this index and catch can be utilized to establish a catch quota one year in advance that would provide for the desired fishing rate. This procedure has been used to estimate a 1972 quota for yellowtail flounder in the southern New England area - west of 69° and south of 41°15' within Subarea 5.

Methods

It was possible to identify the fish of age group I with reasonable accuracy in the length frequencies of the autumn Albatross IV survey cruises. These are the youngest fish which are caught consistently in sufficient quantity to provide reasonable accuracy. The stratified mean numbers caught per tow of yellowtail flounder in age group I in the autumn survey cruises was estimated for the southern New England strata (Fig. 1). These estimates were taken to represent the relative abundance of age group II at the beginning of the year following the cruise made in October-November.

At present, yellowtail flounder first enter the commercial fishery in significant numbers at age II. Fish are almost completely recruited by age III. Most of the commercial catch is represented by age groups II through V (Brown and Hennemuth, 1971).

Let $n_{i,j}$ = Relative abundance of age group j in year i, where $j = 0,3; \ i = 1, 2, \ldots$

In other words, $n_{1,0}$ represents the relative abundance of age group II at the beginning of 1964, the initial observation.

The relative abundance of the available total population at the beginning of any year is,

$$N_i = n_{i,0} + e^{-Z_1}(n_{i-1,0} + n_{i-2,0}\, e^{-Z_2} + n_{i-3,0}\, e^{-2Z_2}). \qquad (1)$$

Z_1 = total mortality during the first year in the fishery (age group II)

Z_2 = total mortality during the second, third or fourth years in the fishery (age groups III-V).

The numbers caught,

$$C(N)_i = n_{i,0}(1-e^{-Z_1})E_1 + (1-e^{Z_2})E_2 e^{-Z_1}(n_{i-1,0} + n_{i-2,0}e^{-Z_2} \qquad (2)$$

$$n_{i-3,0}e^{-2Z_2}).$$

E = F/Z, the percent caught of total deaths during the year.

The indices in terms of weight, W_i, and the $C(W_i)$, may be obtained by multiplying the $n_{i,j}$ by the mean weight per fish in (1), adding the instantaneous growth rate, G, in the expomential of the catch equation (2), viz. $-Z + G$ and expressing E as $\frac{F}{Z-G}$. The average weights at age were calculated from the growth equation estimated by Lux and Nichy (1969) and the length weight equation estimated by Lux (1969).

Results

The catch per tow, in numbers, for age group II, $n_{i,0}$, is given in column one of Table 2 for the years 1964-1970. The calculated population index and catch index computed from equations (1) and (2) tabulated in Table 1 are plotted in Figure 2 for the years 1967-1971. The mortality rates were estimated by Brown and Hennemuth (1971). The average fishing rate obtained by dividing the average catch index by the average population index was 38 percent (top line, Fig. 2). Assessment studies of this population (Brown and Hennemuth, 1971) indicated at least a 20 percent reduction in fishing mortality would be required to achieve the maximum sustained yield. The line representing this reduced fishing mortality (a 33 percent fishing rate) is the bottom line on Figure 2.

The observed catch plotted against the catch index (Fig. 3) contains too few points to verify the accuracy or precision. It does appear that the catches during 1969 (and 1970 to a lesser degree) did produce much higher fishing intensities than in 1967-1968, assuming that the population index is valid.

Table 1.--Estimated population and catch indices (in numbers) for two fishing intensities with M = 0.2 and observed catch in numbers of fish

Year	Population[1/] Index	Catch[1/] Index	Observed Catch Nos. x 10^{-6}
1967	45.8	14.6	77
1968	52.9	18.6	75
1969	28.0	13.0	94
1970	17.9	7.9	54
1971	15.2	5.8	-

1/ Z_1 = 0.5, Z_2 = 1.2

To be useful in determining the quota for 1972, the relation between the catch and the population index in terms of weight and also the age II index for 1972 are required. The latter is, of course, not available until autumn, 1971, and we have used instead the average of the age II index for 1969-1971. The calculated population weight indices are given in Table 2 and are plotted against catch in Figure 4. The values used (including the variable mortality rates) to obtain these indices are presented in Table 3.

Table 2.--Indices of yellowtail flounder abundance in weight by calendar years for age groups II-V (west of 69°)

Year	Index
1967	101.1
1968	116.8
1969	89.7
1970	49.7
1971	36.4
1972	37.4

The points for 1967 and 1968 determine a line corresponding to the maximum sustained yield. The fact that those for 1969 and 1970 are above this line indicates overfishing. The point for 1971, assuming the entire catch quota of 13,000 MT is taken from the southern New England stock, falls between the two lines. Even if 2,000 MT of the quota is taken from the Cape Cod population, as is expected, the point is still above the line of 1967-1968, implying that the quota for 1971 is too high to produce the desired reduction in fishing mortality.

In order to correct for previous overfishing, and limit catch to a level providing for an increase in stock (assmming the 1972 recruitment index of two-year-olds is realized), a line representing a reduction of 20 percent in fishing from the 1967-1968 level was drawn (the lower line in Figure 4 labeled "desired level"). This intersects the ordinate through the 1972 population index at 8,000 MT.

Thus it seems advisable to set the 1972 quota for southern New England at 8,000 MT to achieve recovery of the stock. If the Cape Cod stock is included the quota for the area west of 69° could be set at 10,000 MT.

The development of prediction indices from the survey cruise studies is still in a preliminary stage. Considerable refinement is possible when aging studies of the survey collections are completed. Further development of models utilizing the survey catches to assess and predict harvestable surplus is proceeding

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Table 3.--Indices of yellowtail flounder abundance in southern New England populations (west of 69°)

Year Class	AGE 2		3		4		5	
	Nos.	Wt.	Nos.	Wt.	Nos.	Wt.	Nos.	Wt.
1962	16.3	25.9	9.9	32.0	3.0	15.3	0.9	6.1
1963	18.5	29.4	11.2	36.3	3.4	17.3	1.0	6.8
1964	11.7	18.6	7.1	23.0	2.1	10.7	0.6	4.1
1965	34.4	54.7	20.9	67.7	6.3	32.1	1.6	7.4
1966	19.9	31.6	12.1	39.2	3.0	15.3	0.7	4.8
1967	9.0	14.3	4.9	15.9	1.2	6.1	0.4	2.7
1968	7.0	11.1	3.8	12.3	1.1	5.6	0.3	2.0
1969	8.3	13.2	5.0	16.2	1.5	7.6	0.4	2.7
1970*	8.1	12.9						

M = .2
Age 2, F = .2, 1964-1968, 1971
Age 2, F = .3, 1969, 1970
Age 3, F = 1.0, 1964-1968, 1971-1974
Age 3, F = 1.2, 1969, 1970

* Average of 1967-1969 year classes

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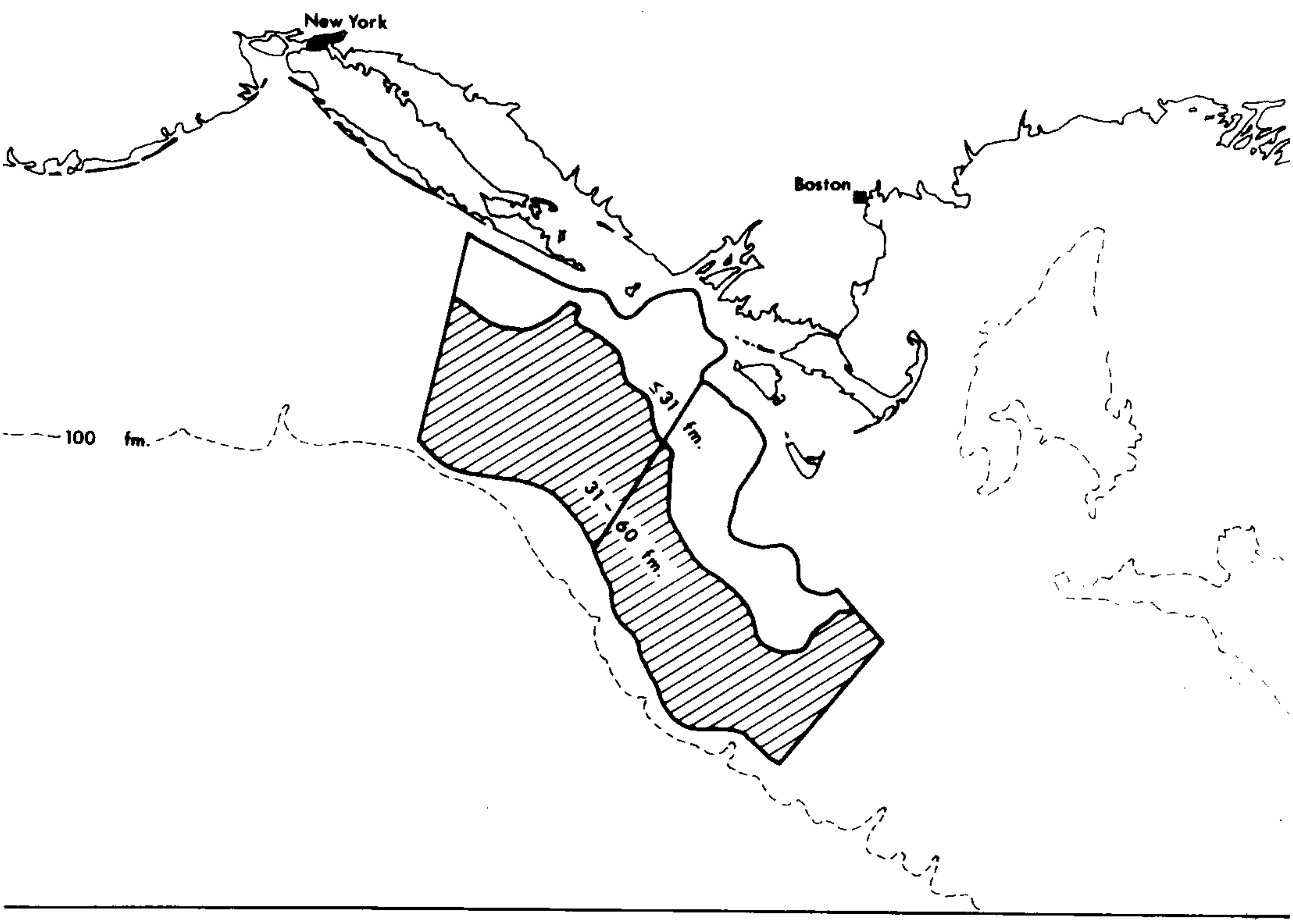

Figure 1.--Southern New England survey strata

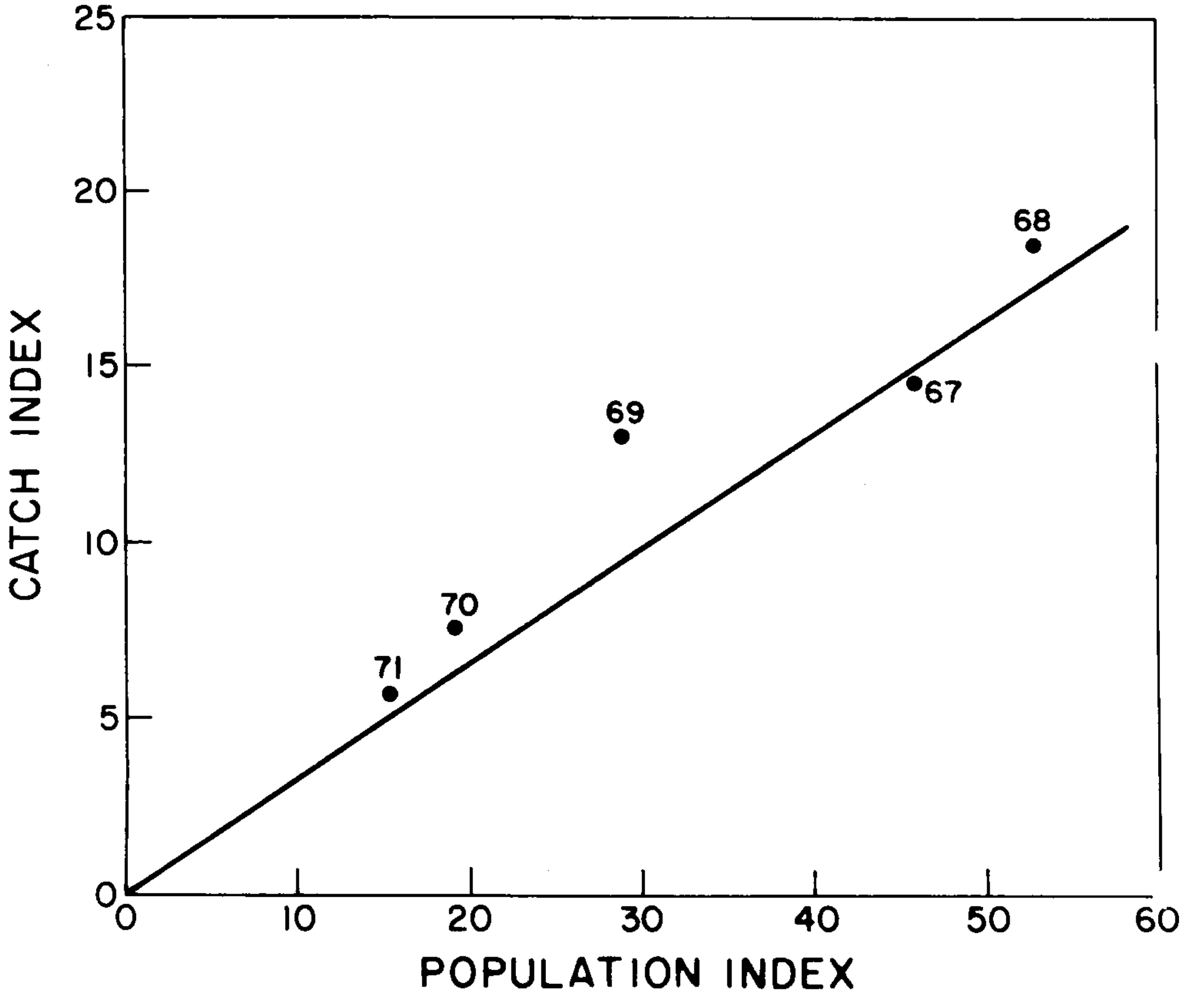

Figure 2.--Catch index as calculated from population index

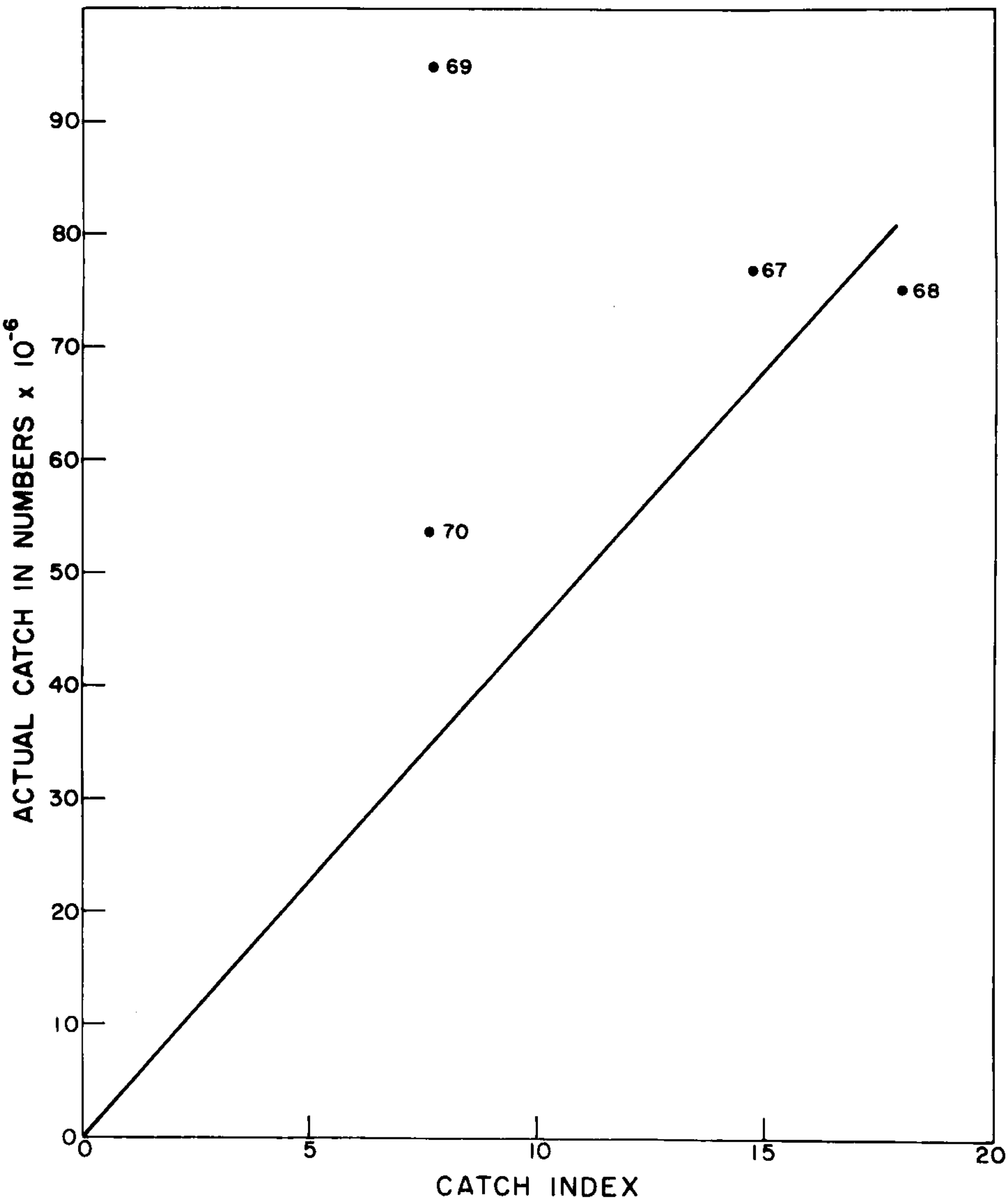

Figure 3.--Actual catch in numbers versus catch index

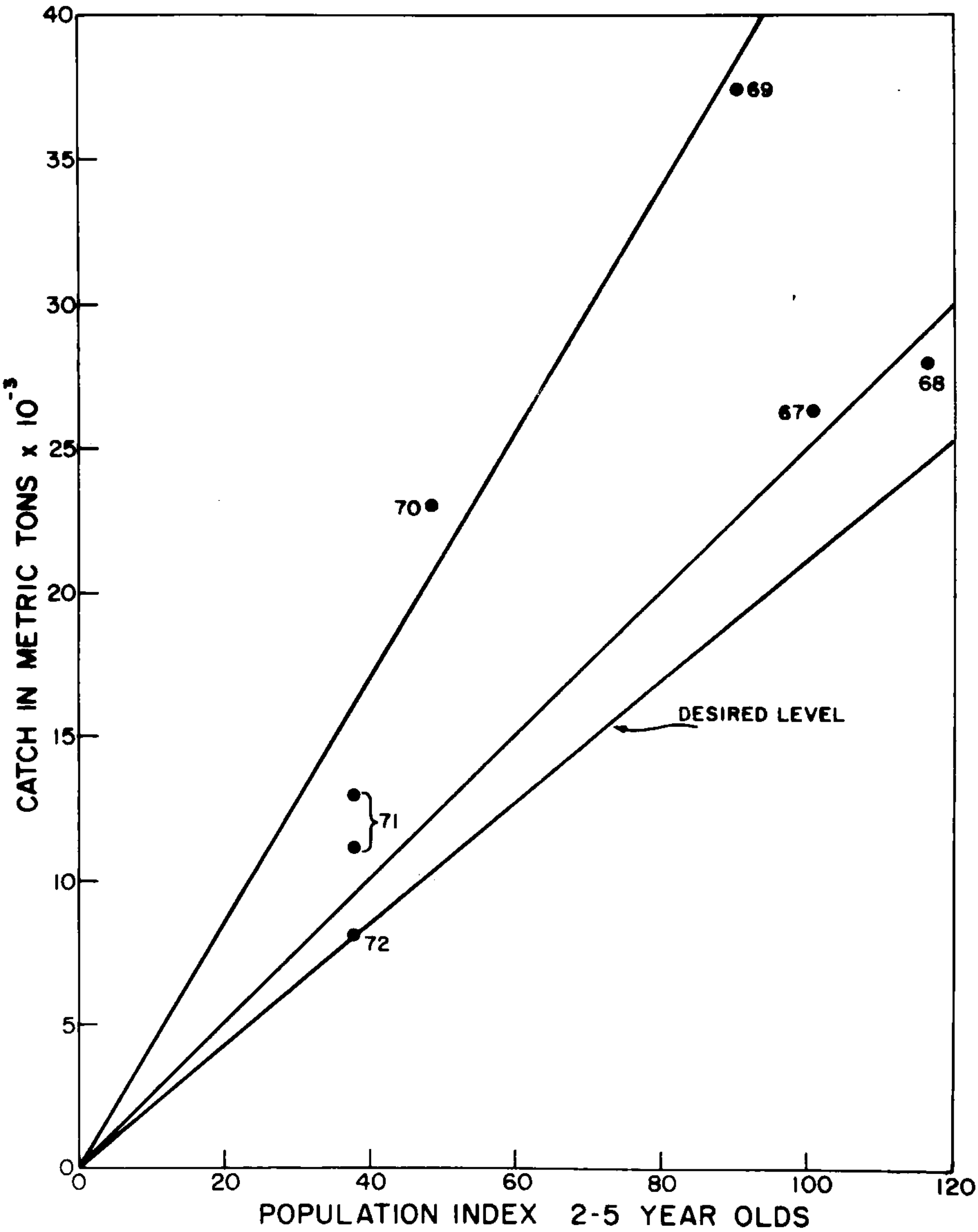

Figure 4.--Population weight index versus catch in weight