Yellowtail Flounder (*Limanda ferruginea*): Status of the Stocks, January 1978

by

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78-02

Laboratory Reference No. 78-02

Summary

1. The most recent available commercial catch and effort data for yellowtail flounder on all three fishing grounds (Southern New England, Georges Bank and Cape Cod) indicates a level of relative abundance comparable to the lowest level ever observed.
2. Autumn bottom trawl survey data indicate that the current relative abundance of yellowtail flounder of all ages and of pre-recruits is similar to the relative abundance observed during the most recent few years for the Southern New England, Georges Bank and Mid Atlantic areas. The recent relative abundance for all three areas is the lowest ever observed.
3. Two simple models were applied to Georges Bank autumn bottom trawl survey data. Neither model is completely satisfactory. Nevertheless, they indicate a 1978 surplus yield of either 0 or 10480 tons.
4. Autumn bottom trawl survey data indicate that the 1978 Georges Bank catch at $F_{0.1}$, F_{max} and F = 0.8 is 3000, 4400 and 6200 tons respectively. The survey indicates that the 1978 Southern New England catch at $F_{0.1}$, F_{max} and F = 1.05 is 1100, 1700 and 2800 tons respectively.

Introduction

This document updates time-series of data that were considered during the development of past total allowable catches for yellowtail flounder along the Northeast coast of the USA. A section intended to provide a summary of useful background material on the fisheries for yellowtail flounder is also included.

A population size index, for the Southern New England ground, computed from the pre-recruit catch per tow of yellowtail flounder during autumn bottom trawl surveys was developed by Brown and Hennemuth (1971) by relating survey to commercial catches. The index corresponding to the autumn 1977 bottom trawl survey was calculated and reported in this document. Past observation of the (1) index, (2) annual catch, and (3) fishing mortality rate indicate the level of fishing mortality that is likely to be generated by a particular catch during 1978 for the current population size index.

Two models that attempt to relate fluctuations in abundance of yellowtail flounder on Georges Bank (as measured by USA autumn bottom trawl surveys) to the annual catch and recruitment of young fish to the stock are reported in this document for the first time. Neither model provides a satisfactory explanation of stock dynamics but they do provide some insight. By applying a method similar to Brown and Hennemuth's anlaysis for Southern New England, the abundance of yellowtail flounder on Georges Bank can also be used to indicate the level of fishing mortality that is likely to correspond to a particular catch in 1978.

Background on the Yellowtail Flounder Fisheries

The yellowtail flounder, Limanda ferruginea, is an important food fish. It is sought primarily by Massachusetts and Rhode Island otter trawlers from the ports of New Bedford, Provincetown, and Point Judith. During the late 1960's and early 1970's, there were significant catches by foreign vessels.

Yellowtail flounder are primarily sought on three fishing grounds along the east coast of the USA. These are the Southern New England, Georges Bank and Cape Cod grounds (Figure 1). There are smaller fisheries for yellowtail flounder in the Northern Gulf of Maine and Nova Scotia (Royce et al., 1959).

Yellowtail flounder were unexploited prior to 1935. With the decline in abundance of the thicker-bodied winter flounder, the yellowtail flounder fishery on the Southern New England ground developed rapidly. The peak domestic catch (38000 metric tons) occurred in 1942. The catch declined during the 1950's, recovered during the 1960's and once again declined during the 1970's (see the section on Catch and Fishing Effort Statistics). There was a significant foreign catch during the late 1960's and early 1970's. With the decline in catch from the Southern New England ground (ICNAF S.A. 5z west of 69^{o}W) during the early 1970's, significant catches were reported briefly (1970-1974) from SA 6.

The fishing on Georges Bank remained modest until 1962 when the total catch exceeded 10,000 tons for the first time. Reported foreign catches on Georges Bank have never exceeded 13% of the total. During the 1970's, the Georges Bank catch has been greater than the catch on the Southern New England ground.

The Cape Cod ground has produced the most steady yield of the three fishing areas. The catch has never exceeded 5,000 tons.

Tagging experiments and parasite studies performed by Lux (1963) indicated that there is little mixing between yellowtail flounder of the three grounds. The degree of mixing between the populations on the Southern New England ground and farther south in SA 6 is unknown.

In the past, otter trawls used to catch yellowtail flounder retained fish considerably smaller than the minimum acceptable market size, which was about 300 mm in length. Undersize fish sometimes made up as much as half the catch. These mostly 1 and 2 year old fish were discarded at sea. Their survival rate was probably low (Lux, 1964). Young yellowtail flounder are also taken as part of the industrial fishery. Available information indicates a sharp reduction in the proportion of the yellowtail flounder catch discarded at sea in recent years.

Catch and Fishing Effort Statistics

Total removals of yellowtail flounder can be categorized as domestic food landings, domestic discards, industrial catches and foreign catches. There are virtually no recreational catches. The weight of domestic food landings is determined at the time of sale. Past foreign catches were reported by individual nations.

When available, observers aboard commercial vessels determined the trip ratio of discards to total catch. The mean discard ratio during each quarter of the year was applied to the total food landings in order to estimate the amount discarded. Where direct observations aboard commercial vessels were not available, the quarterly discard ratio was estimated based on interviews of ship's officers. Industrial catches of yellowtail flounder are estimated by applying the proportion of this species (by weight) in samples to the total industrial catch.

Information obtained during interviews of commercial fishing vessel officers is used to calculate the average weight landed per 24 hours of fishing for trips landing at least 50% yellowtail flounder. Catch per effort information for each vessel class (by gross tonnage) is combined for each quarter of a year. These are then adjusted to correspond to a standard vessel class (26-50 gross tons) by applying fishing power coefficients. Finally, effort data for each vessel class is combined. Details of the method are described by Lux (1964).

Catch and fishing effort statistics for each fishing area are reported in Tables 1-4. The age composition of the catch from the Southern New England and Georges Bank fisheries is reported in Tables 5-6 for 1970-1976. The age composition is estimated using length and scale samples collected by port agents.

Application of USA Autumn Bottom Trawl Survey
Data to Yellowtail Flounder Assessments.

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 predict population size in following years assuming certain realistic mortality rates (Brown and Hennemuth 1971). The predicted population size is considered a population index. The ratio of annual catch to the population size index at the beginning of each year corresponds to a particular fishing mortality.

Table 7 contains the mean (1) number at age 1, (2) total number, (3) total weight and (4) the population size index for each autumn survey 1963-1977. The survey population size index should correspond to the size of the population at the start of the year following the survey. Annual catches and the corresponding population indexes are plotted in Figure 2. The vertical line in Figure 2 represents the locus of possible points for 1978 since a preliminary value from the autumn 1977 survey is already available. The slope of the line from any point through the origin indicates the fishing mortality relative to other years and relative to reference lines provided on the graph.

The total mortality rate of the Southern New England yellowtail flounder during 1963-1969 was estimated as 1.25 by Penttila and Brown (1973). Assuming that natural mortality equals 0.2, then the fishing mortality (F) was 1.05. By fitting a straight line through the origin to the data points in Figure 2 contained within this time interval, the line labelled as F = 1.05

was determined. The slope of the line corresponding to any other values of F can be calculated by substituting a point from the line of known F into an equation which relates catch to the survey population size index and solving for the unknown constant (q). A point which determines the line corresponding to any other F is then obtained by substituting F, q and any value of the survey population size index into the same equation and solving for catch. Lines corresponding to $F_{0.1}$ and F_{max} are also shown. F_{max} and $F_{0.1}$ were determined from the yield per recruit curve plotted in Figure 3.

In an effort to develop an analytical method for using survey data to predict the impact of future catches on a population, two models were considered. The first and simpler model was

$$\Delta P_i = a - b\, C_i + c\, R_i + \tilde{e}_i \qquad (1)$$

where ΔP_i is the change in survey catch (weight) per tow during year i, C is the total catch, R_i is the survey pre-recruit index (mean number per tow of age 1 fish) and $\tilde{e}$ is an error term with mean 0. Thus according to Equation (1) the size of a population would have a greater tendency to decrease the higher the annual catch and it would have a greater tendency to increase the greater the expected recruitment.

The second model, Equation (2), provides a more rigorous description of population dynamics.

$$\frac{\Delta P_i}{P_i} = a - b\,\frac{C_i}{P_i} + c\,\frac{R_i}{P_i} + \tilde{e}_i \qquad (2)$$

Here P_i is the survey catch (weight) per tow corresponding to the beginning of the year during which a catch of C_i is taken. For example, the autumn 1977 survey is assumed to correspond to the population size at the beginning of 1978. Equation (2) is an approximation of an equation in which the instantaneous rate of change in population biomass is (1) either directly or inversely proportioned to current biomass, (2) proportional to the instantaneous recruitment rate and (3) inversely proportioned to the instantaneous catch rate.

Values of the survey catch per tow (P_i), number of age 1 yellowtail flounder per tow (R_i), $\Delta P_i = P_{i+1} - P_i$, $\Delta P_i/P_i$, R_i/P_i, C_i and C_i/P_i for Georges Bank are given in Talbe 9. Both models described above were fit to the data from 1964-1976 prior to the preliminary analysis of the 1977 autumn survey data. For the second model

$$\frac{\Delta P}{P} = -0.14 + 1.09 \frac{R}{P} - 3.14 \times 10^{-4} \frac{C}{P} \qquad (3)$$

The multiple correlation coefficient is 0.74 which is statistically significant at the 5% level. The model provides a realistic explanation of the trends in catch per tow for 1964-1976. According to the model, for the low value of R/P and the high value of C/P during 1977, $\Delta P/P$ should have declined further, but just the opposite occurred. Variability not explained by the model could have led to this kind of result, but the observed deviation in 1977 is larger than would reasonably be expected based on past data. In fact, if this additional year of data is included in the analysis, the statistical fit is no longer significant. Clearly, model 2 cannot be applied with any degree of confidence until additonal observations are available at the extremely low recruitment levels indicated in 1976-1977, but since the model is intuitively reasonable, results based on it may be of interest. The percent change in population size on Georges Bank (as

measured by the autumn bottom trawl survey) according to Equation 3 for several levels of catch in 1978 is given in Table 10.

The fit of the first model to data was similar for 1964-1976 and 1964-1977. The results for the latter time period is:

$$\Delta P = 10.16 - 1.02 \times 10^{-3} C + 1.06 R \qquad (4)$$

The multiple correlation coefficient is 0.68 which is statistically significant at the 5% level. The percent change in population size on Georges Bank (as measured by the autumn bottom trawl survey) according to Equation (4) for several levels of catch in 1978 is also given in Table 10.

The annual Georges Bank catch and the autumn bottom trawl survey mean catch per tow in weight from the previous year is plotted for 1964-1977 in Figure 4. Penttila and Brown's estimate of total mortality for Georges Bank was used to determine lines through the origin corresponding to $F = 0.8$, F_{max} and $F_{0.1}$ using the same method as was described for Southern New England.

Autumn bottom trawl survey results for the Mid Atlantic area (SA 6) are given in Table 9. No further analysis of this data is now available.

Discussion

The status of the fishery west of 69°W is essentially the same as at the beginning of 1977. The population size index for the Southern New England ground remains at less than 10% of the peak level observed in 1968. The pre-recruit index has not exceeded 15% of the mean value prior to 1970 during the last five surveys. The current population size index indicates a 1978 catch of 2800, 1700 and 1100 tons for a fishing mortality of 1.05,

0.5 (F_{max}) and 0.3 ($F_{0.1}$) respectively. The relative abundance of yellowtail flounder in the Mid Atlantic area is less than 1% of the typical observed abundance prior to 1973.

The catch per standard day of fishing (U) for the Southern New England commercial fishery increased slightly during the first half of 1977. Nevertheless, it has remained less than 50% of the average level during the 1960's. U for the Cape Cod ground has continued to decline. In recent years, the Cape Cod ground has accounted for more than half of the total catch west of 69^{o}.

The commercial catch per standard day of fishing east of 69^{o}W (on Georges Bank) has been less than two tons since 1975. U ranged from 2 to 10 tons per standard day during 1943-1974 with an average of 4.2.

The mean weight per tow caught during each of the last four autumn bottom trawl surveys on Georges Bank was lower than in any of the previous 11 surveys. The mean catch per tow during 1974-1977 was about a third of the 1963-1973 level. The pre-recruit indexes during the last two surveys averaged only 8% of index during the previous 13 surveys.

Two models were applied to Georges Bank survey data. The more realistic of the two models (Equations 2 and 3) did not fit all of the available data satisfactorily. The model fit to data for 1964-1976 indicated no surplus production in 1978. This result probably has little predictive value, but surplus yield does depend on adequate recruitment and the evidence available at present indicates very poor recruitment.

The second model (Equations 1 and 4) fit to all available data indicated a surplus yield of 10480 tons in 1978. Clearly the second model is inadequate for predicting the affect of fishing during years of poor recruitment. A surplus yield of 9960 tons is indicated even during years of no recruitment.

Surplus yield during years of low recruitment is probably overestimated by this model.

The current autumn bottom trawl survey density index (mean weight/tow) for Georges Bank indicates a 1978 catch of 6200, 4400, and 3000 tons for a fishing mortality of 0.80, 0.5 (F_{max}) and 0.3 ($F_{0.1}$) respectively.

References

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Table 1. Yellowtail flounder catch statistics for Southern New England (catch in MT x 10^{-3}).

Year	Food landings	Discard	Industrial	Foreign	Total	Days fished in 1000's	Catch per day in MT
1935	6.0	2.4			8.4		
1936	6.8	2.7			9.5		
1937	7.6	3.0			10.6		
1938	7.7	3.1			10.8		
1939	9.5	3.8			13.3		
1940	14.2	5.7			19.9		
1941	19.3	7.7			27.0		
1942	28.4	9.9			38.3		
1943	18.0	7.3			25.3	5.75	4.4
1944	10.6	4.8			14.9	4.13	3.6
1945	10.4	4.2			14.6	2.86	5.1
1946	10.8	4.4			15.2	3.64	4.2
1947	12.1	4.9			17.0	4.59	3.7
1948	9.9	4.0			13.9	5.14	2.7
1949	4.7	1.9	0.2		6.8	3.40	2.0
1950	4.7	1.9	0.2		6.8	3.23	2.1
1951	2.8	1.1	0.1		4.0	2.00	2.0
1952	3.0	1.2	0.2		4.4	2.44	1.8
1953	2.0	0.8	0.3		3.1	1.63	1.9
1954	1.5	0.6	0.2		2.3	1.35	1.7
1955	2.2	0.9	0.3		3.4	1.70	2.0
1956	3.5	1.4	0.6		5.5	2.61	2.1
1957	5.5	2.2	0.7		8.4	2.62	3.2
1958	8.9	3.6	0.6		13.1	3.85	3.4
1959	7.7	3.1	0.5		11.3	5.13	2.2
1960	7.8	3.2	0.5		11.5	4.60	2.5
1961	11.6	4.7	0.7		17.0	4.85	3.5
1962	13.1	5.3	0.2		18.6	4.04	4.6
1963	22.0	5.4	0.3	0.2	27.9	5.47	5.1
1964	19.0	9.5	0.5	-	29.0	5.08	5.6
1965	18.9	7.0	1.0	1.4	27.8	6.61	4.2
1966	19.9	5.3	2.7	0.7	23.6	8.42	2.8
1967	10.8	7.7	4.5	2.8	25.8	6.51	4.0
1968	14.3	6.3	3.9	3.5	28.0	6.66	4.2
1969	11.4	2.4	4.2	17.6	35.6	10.78	3.3
1970	13.1	4.7	2.1	2.5	22.4	6.40	3.5
1971	8.2	3.3	0.4	0.3	12.2	3.81	3.2
1972	8.2	1.7	0.3	3.0	13.2	4.71	2.8
1973	7.2	0.1	0.3	0.2	7.8	4.11	1.9
1974	6.4	0.7	<0.1	0.1	7.1	3.74	1.9
1975	3.2	0.2	<0.1	0	3.4	2.43	1.4
1976	1.6	0.2	<0.1	<0.1	1.8	1.50	1.2
1977[1]	1.6	0.2	<0.1	<0.1	1.9	1.19	1.6

[1]Preliminary through June 1977. Preliminary New England landings through October 1977 = 2.4

Table 2. Yellowtail flounder catch statistics for Georges Bank (catch in MT x 10^{-3}).

Year	Food landings	Discard	Industrial	Foreign	Total	Days fished in 1000's	Catch per day in MT
1935	0.3	0.1			0.4		
1936	0.3	0.1			0.4		
1937	0.3	0.1			0.4		
1938	0.3	0.1			0.4		
1939	0.4	0.1			0.5		
1940	0.6	0.2			0.8		
1941	0.9	0.3			1.2		
1942	1.6	0.5			2.1		
1943	1.3	0.4			1.7	0.20	8.6
1944	1.7	0.6			2.2	0.22	10.0
1945	1.4	0.5			1.9	0.28	6.7
1946	0.9	0.3			1.2	0.23	5.2
1947	2.3	0.8			3.1	0.48	6.5
1948	5.7	2.0			7.7	1.12	6.8
1949	7.3	2.5			9.8	2.49	3.9
1950	3.9	1.4			5.3	1.64	3.2
1951	4.3	1.5			5.8	1.61	3.6
1952	3.7	1.3			5.0	1.60	3.1
1953	2.9	1.0			3.9	1.24	3.1
1954	2.9	1.0			3.9	1.38	2.8
1955	2.9	1.0			3.9	1.23	3.2
1956	1.6	0.6			2.1	0.79	2.7
1957	2.3	0.8			3.1	0.82	3.8
1958	4.5	1.6			6.1	1.40	4.4
1959	4.1	1.4			5.5	1.97	2.8
1960	4.4	1.5			5.9	2.02	2.9
1961	4.2	1.5			5.7	1.82	3.1
1962	7.7	2.7			10.3	2.35	4.4
1963	11.0	5.6		0.1	16.7	3.63	4.6
1964	14.9	4.9		-	19.8	3.53	5.6
1965	14.2	4.4		0.8	19.2	4.68	4.1
1966	11.3	2.1		0.3	13.7	5.71	2.4
1967	8.4	5.5		1.4	15.3	4.13	3.7
1968	12.8	3.6		1.8	18.2	4.66	3.9
1969	15.9	2.6		2.4	20.9	6.71	3.1
1970	15.5	5.5		0.3	21.3	6.26	3.4
1971	11.9	3.1		0.5	15.5	6.20	2.5
1972	14.2	1.2		2.2	17.6	8.00	2.2
1973	15.9	0.6		0.3	16.7	6.96	2.4
1974	14.6	1.2		1.0	16.8	8.40	2.0
1975	13.5	1.0		0.1	14.6	8.59	1.7
1976	11.3	0.7		<0.1	12.0	7.50	1.6
1977[1]	3.0	0.1		0	3.1	2.40	1.3

[1]Preliminary through June 1977. Preliminary New England landings through October 1977 = 8.5

Table 3. Yellowtail flounder catch statistics for Cape Cod Ground (catch in MT x 10^{-3}).

Year	Food landings	Discard	Industrial	Foreign	Total	Days fished in 1000's	Catch per day in MT
1935	0.4	0.1					
1936	0.4	0.1					
1937	0.5	0.2					
1938	0.5	0.2					
1939	0.6	0.2					
1940	0.9	0.3					
1941	1.3	0.4					
1942	1.5	0.5					
1943	1.3	0.4			1.7	0.53	3.2
1944	1.5	0.5			2.0	1.01	2.0
1945	1.2	0.4			1.6	0.61	2.6
1946	1.2	0.4			1.6	0.62	2.6
1947	1.1	0.3			1.4	0.75	1.9
1948	0.7	0.2			0.9	0.47	1.9
1949	1.2	0.4			1.6	0.68	2.4
1950	1.3	0.4			1.7	0.95	1.8
1951	0.8	0.2			1.0	0.79	1.3
1952	0.8	0.2			1.0	0.76	1.3
1953	0.8	0.2			1.0	0.78	1.3
1954	1.1	0.3			1.4	0.89	1.6
1955	1.3	0.4			1.7	1.00	1.7
1956	1.4	0.4			1.8	1.34	1.3
1957	2.4	0.7			3.1	1.44	2.2
1958	1.6	0.5			2.1	0.92	2.3
1959	1.5	0.5			2.0	0.76	2.6
1960	1.5	0.5			2.0	1.12	1.8
1961	1.8	0.6			2.4	0.91	2.6
1962	1.9	0.6			2.5	1.01	2.5
1963	3.6	1.0			4.6	1.00	4.6
1964	1.8	0.6			2.4	0.71	3.4
1965	1.5	0.5			2.0	0.70	2.8
1966	1.8	0.3			2.1	1.37	1.6
1967	1.5	0.8			2.3	1.69	1.4
1968	1.6	0.6			2.2	0.99	2.3
1969	1.3	0.3			1.6	0.68	2.5
1970	1.2	0.4			1.6	0.53	3.0
1971	1.7	0.7			2.3	0.79	2.9
1972	1.4	0.3			1.6	0.67	2.4
1973	1.7	<0.1			1.7	0.89	1.9
1974	2.1	0.2			2.3	1.21	1.9
1975	2.0	0			2.0	1.25	1.6
1976	3.6	0.1			3.7	2.31	1.6
1977[1]	1.6	0			1.6	1.14	1.4

[1]Preliminary through June, 1977. Preliminary New England landings through October 1977 = 2.7

Table 4. Yellowtail flounder catches in ICNAF statistical area 6 1964-1977, in metric tons.

Year	USA Landings	USA Discards	Foreign Catch	Total
1964	1809	*	0	1809
1965	2117	*	0	2117
1966	2240	*	0	2240
1967	5340	*	0	5340
1968	3272	*	0	3272
1969	3886	*	683	4569
1970	4050	*	118	4168
1971	6867	*	961	7828
1972	8774	*	117	8891
1973	4941	244	197	5382
1974	1884	32	16	1932
1975	633	17	3	653
1976	253	0	0	253
1977**	299			

* Unknown

**Preliminary landings through October, 1977.

Table 5. Age Composition of USA Yellowtail Flounder Landings from Southern New England Ground.

	Numbers x 10^{-3} Landed at Age														
	Age 1		Age 2		Age 3		Age 4		Age 5		Age 6		Age 7		Age 8+		
Year	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Total
1970	-	-	2557	10	7737	30	11211	43	3659	14	825	3	76	-	29	-	26091
1971	-	-	2556	14	3619	20	6878	39	3636	20	823	5	207	1	25	-	17744
1972	-	-	3006	15	5876	30	2788	14	6010	31	1361	7	321	2	122	1	19484
1973	-	-	2830	16	7437	41	4556	25	1641	9	1267	7	243	1	77	1	18051
1974	281	2	2009	15	3431	26	4126	31	1830	14	595	4	812	6	175	1	13259
1975	7	-	1221	20	1450	24	954	16	1326	22	617	10	372	6	183	3	6130
1976	129	3	914	25	1051	28	568	15	397	11	331	9	211	6	94	3	3695

Table 6. Age Composition of the USA Yellowtail Landings from Georges Bank (East of 69^{o} Longitude)

	Numbers x 10^{-3} Landed at Age														
	Age I		Age II		Age III		Age IV		Age V		Age VI		Age VII		Age VIII+		
Year	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Total
1970	-	-	4406	15	11792	40	8070	28	3247	11	1071	4	339	1	255	1	29810
1971	-	-	1961	9	8757	40	7026	32	2601	12	973	4	305	1	151	1	21774
1972	-	-	3427	13	11001	39	8622	31	3829	14	917	3	196	1	91	-	28083
1973	-	-	3222	10	12801	42	9227	30	3724	12	1334	4	275	1	157	-	30740
1974	500	2	5962	22	7968	29	7418	27	3743	14	770	3	643	2	117	1	27122
1975	348	1	17535	58	7066	23	2823	9	1500	5	516	2	235	1	130	1	30152
1976	30	-	18852	72	4716	18	1191	5	495	2	422	2	289	1	143	-	26136

Table 7. Autumn bottom trawl survey results for Southern New England yellowtail flounder.

Year of survey	No. per tow Age 1	Total No. per tow	Total weight per tow (lb)	Population size index *
1963	16.3	50.6	37.1	
1964	18.6	60.8	42.0	
1965	11.5	38.7	28.0	
1966	35.5	50.3	20.8	
1967	20.0	57.7	31.0	102.5
1968	10.0	40.2	22.2	119.2
1969	12.8	54.8	31.7	92.6
1970	7.3	39.8	24.2	71.9
1971	6.3	41.7	20.2	53.6
1972	4.3	73.3	44.3	40.0
1973	1.9	7.9	5.0	30.8
1974	1.1	7.3	4.7	20.1
1975	1.7	2.9	1.6	11.9
1976	2.6	10.7	6.5	8.3
1977	1.5**	4.8**	2.7**	9.2
1978				9.5**

*Calculations based on method described by Brown and Hennemuth (1971) using M = 0.2, F = 0.4 for 1969-1970 and F = 0.3 for all other years at age 2 and F = 1.2 for 1969-1970 and F = 1.0 for all other years at age 3 and greater.

**Preliminary

Table 8. Autumn bottom trawl survey results for Georges Bank yellowtail flounder. C_i, the catch in year i is also included. P_i is the survey mean catch per tow in the autumn of year i-1. R_i is the survey mean catch per tow in numbers of age 1 fish in year i-1.

Year of Catch(i)	P_i (lb/tow)	C_i (metric tons)	R_i (no. of 1's/tow)	ΔP_i $(P_{i+1}-P_i)$	$\Delta P_i/P_i$	R_i/P_i	C_i/P_i
1964	22.0	19800	11.6	1.4	0.064	0.53	900
1965	23.4	19200	2.6	-7.7	-0.329	0.11	820
1966	15.7	13700	1.3	-9.0	-0.573	0.08	873
1967	6.7	15300	9.8	6.3	0.940	1.46	2284
1968	13.0	18200	7.0	3.1	0.238	0.54	1400
1969	16.1	20900	10.6	-0.1	-0.006	0.66	1298
1970	16.0	21285	7.6	-7.4	-0.463	0.48	1330
1971	8.6	15511	4.8	2.4	0.279	0.56	1804
1972	11.0	17559	3.8	-0.1	-0.009	0.35	1596
1973	10.9	16731	2.4	0.3	0.028	0.22	1534
1974	11.2	16823	2.7	-4.9	-0.438	0.24	1502
1975	6.3	14576	3.5	-2.3	-0.365	0.56	2314
1976	4.0	12000	4.1	-1.4	-0.350	1.03	3000
1977	2.6	10000*	0.3	+3.0*	1.150*	0.12	3846
1978	5.6*		0.5*			0.09*	

*Preliminary

Table 9. Autumn bottom trawl survey results for the Mid Atlantic Area (ICNAF SA 6)

Year	mean number/tow	mean weight (lb)/tow	mean number age 1/tow
1963	28.8	19.7	11.1
1964	16.4	10.7	5.3
1965	49.1	12.8	19.2
1966	48.3	19.5	14.2
1967	55.6	20.5	12.5
1968	81.3	29.7	11.6
1969	45.4	21.9	0.6
1970	45.2	22.7	1.9
1971	27.0	8.3	11.0
1972	86.2	46.2	0.6
1973	8.2	4.1	0.69
1974	0.7	0.4	0.04
1975	0.9	0.3	0.46
1976	0.4	0.1	0.07
1977	1.44	0.15	1.41

Table 10. Percent change in population size of yellowtail flounder on Georges Bank (as measured by the autumn bottom trawl survey) according to Equation (3) and Equation (4) at various levels of catch in 1978. Input data is from Table 8.

Equation (4)

$$\Delta P = 10.16 - 1.02 \times 10^{-3} C + 1.06R$$

% Change	1978 Catch in tons
+92	5000
+37	8000
0.0	10480
-35	12000

Equation (3)

$$\frac{\Delta P}{P} = -0.14 + 1.09 \frac{R}{P} - 3.14 \times 10^{-4} \frac{C}{P}$$

0.0	0
-32	5000
-52	10000
-88	15000

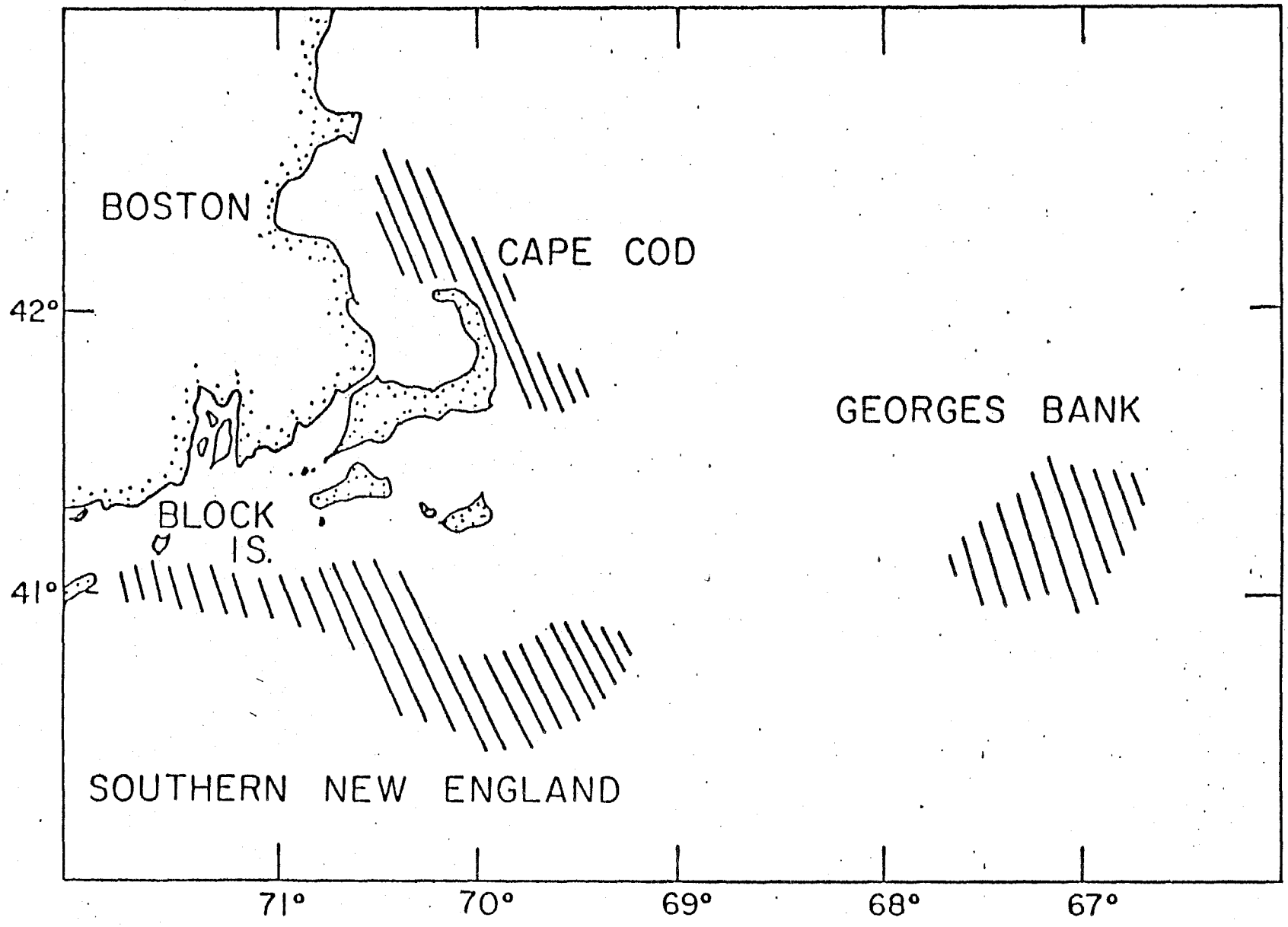


Figure 1. Yellowtail flounder fishing grounds.

Figure 2. Population size index based on USA autumn bottom trawl survey versus catch the following year for the Southern New England ground. Points are labelled by year of catch.

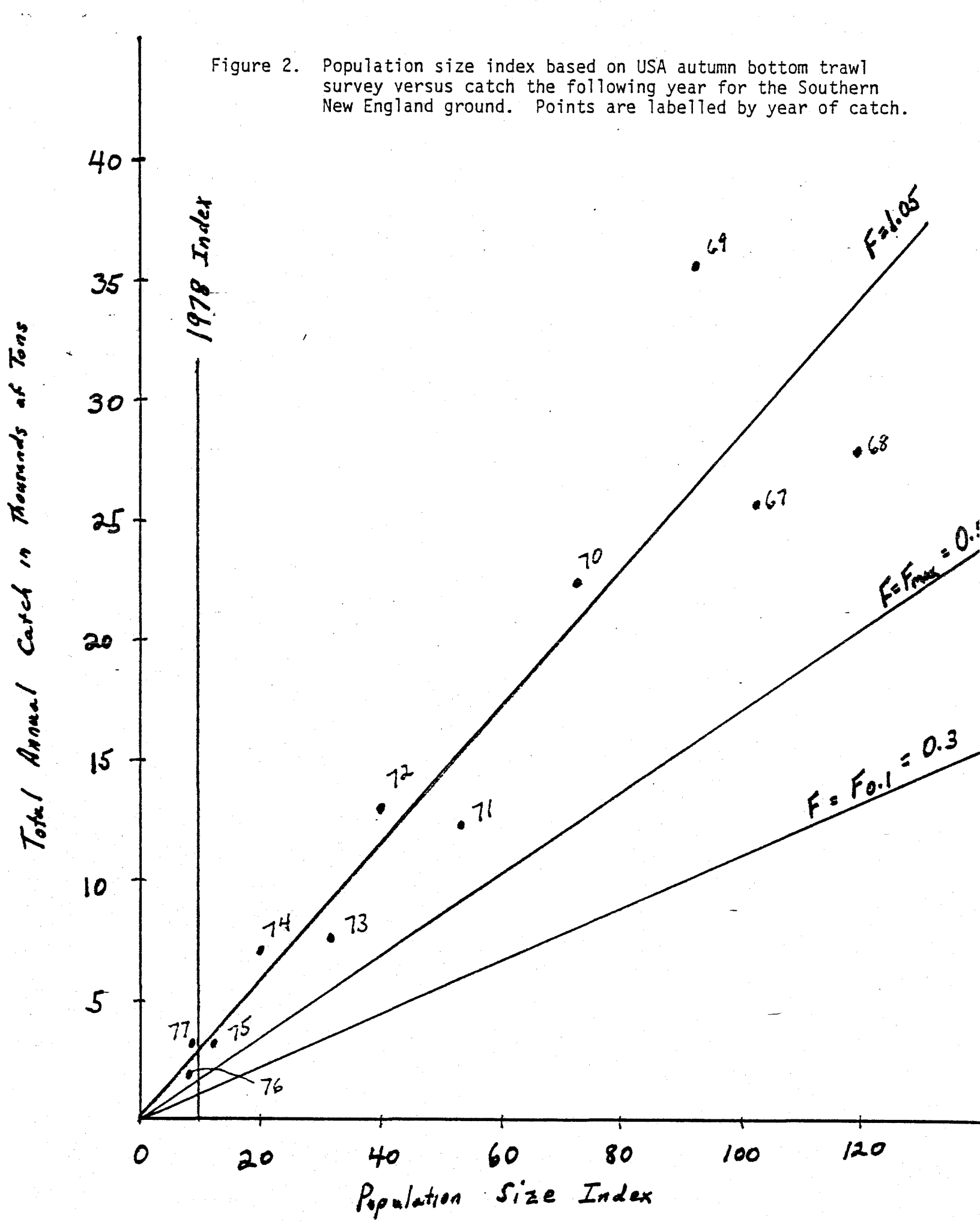
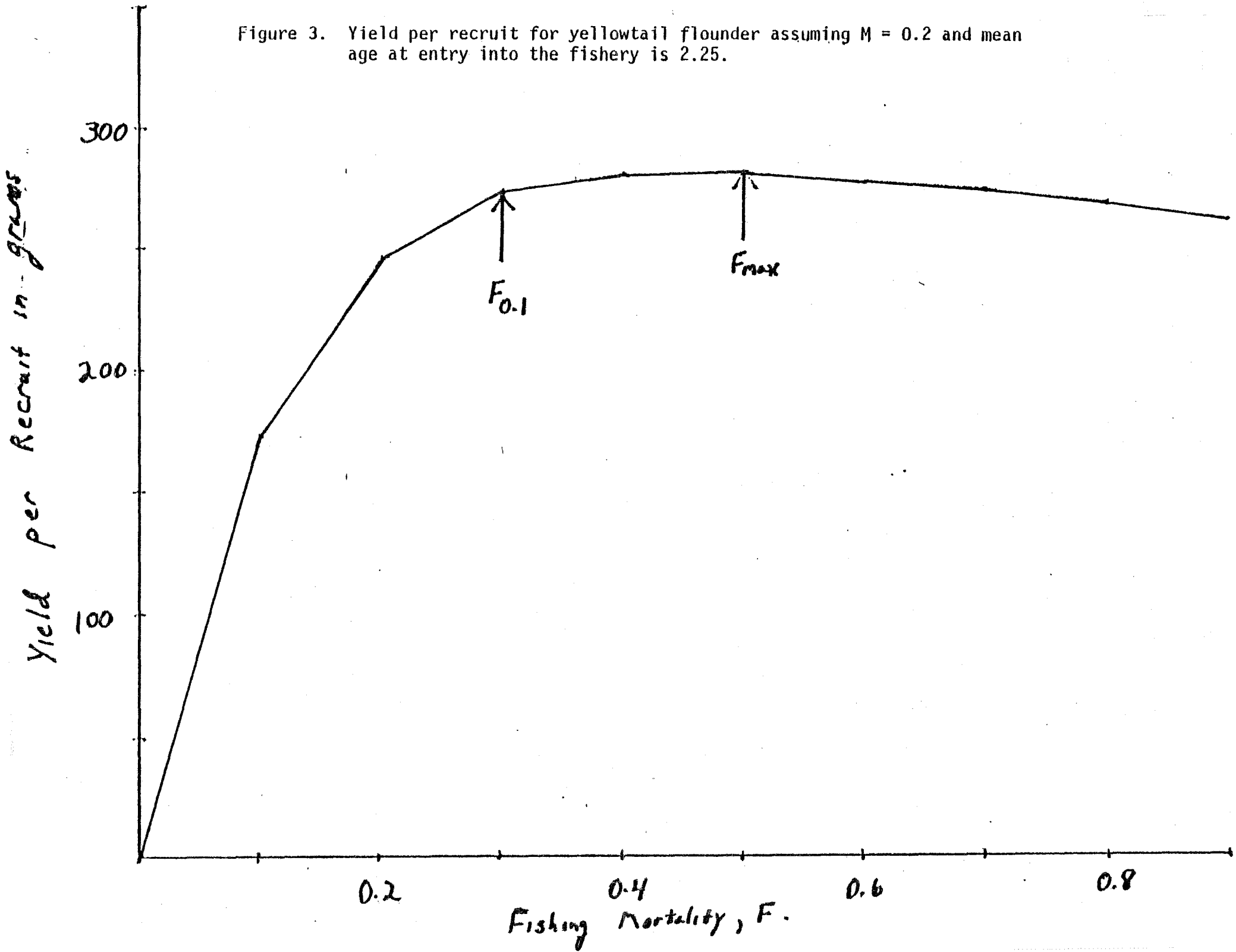


Figure 3. Yield per recruit for yellowtail flounder assuming M = 0.2 and mean age at entry into the fishery is 2.25.



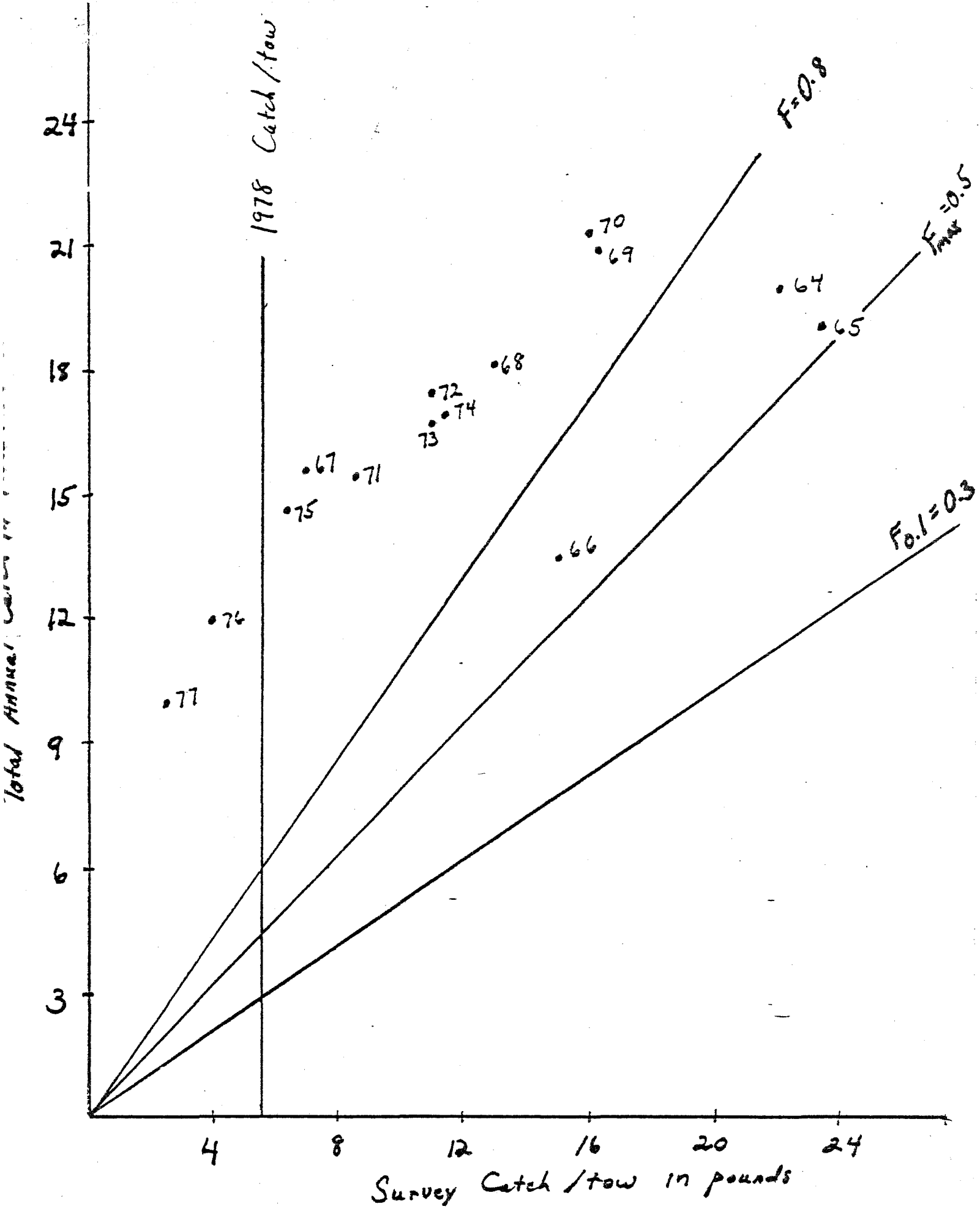


Figure 4. Survey mean catch/tow by autumn bottom trawl survey versus catch the following year for the Georges Bank ground. Points are labelled by year of catch.