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Status review of ICNAF Subarea 5 and Statistical Area 6 yellowtail flounder stocks

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ABSTRACT

Abundance of yellowtail flounder in Subarea 6 and in 5Z West of 69° has significantly decreased since 1970 due to successive years of failing recruitment. The pre-recruit stock abundance model previously used to set yellowtail quotas West of 69° indicates that removals in excess of 2500 MT from Southern New England grounds will further deplete the stock. Allowing for 1500 MT to be taken from Cape Cod grounds, the removals West of 69° should be limited to 4000 MT.

An analysis of yellowtail in SA6 indicates that successive years of failing recruitment concomitant with an increase in fishing mortality has brought abundance to a very low level. Assuming 1976 recruitment at least at the 1974 level, the analyses indicate that less than 500 MT can be removed in 1975 if abundance levels are not to be decreased further.

A pooled assessment of the total southwest area (Subarea 5 West of 69° and Subarea 6), indicates that a 4000 MT removal limit during 1974 will stabilize abundance if 1976 recruitment is at least at the 1974 level.

Catch, effort, and survival rates based on USA landings per day at age data for Georges Bank indicate that the 16000 MT quota presently in effect has decreased mortality and stabilized abundance East of 69° . The measure is adequate if 1971-1973 recruitment levels are maintained.

INTRODUCTION

The basic assessment of the SA5 yellowtail flounder stocks (Figure 1) have been reported by Brown (1970) and Brown and Hennemuth (1971a). This document reports current catch and effort statistics, updates the assessment of SA5 stocks, and presents an assessment of the stock in SA6 using a pre-recruit catch model developed by Brown and Hennemuth (1971b).

SUBAREA 5 STOCKS

Southern New England. Although quota regulations greatly decreased removals since 1970 (Table 1), U.S.A. commercial catch per day decreased significantly (46%) during the period. Age compositions of the U.S.A. landings (Table 2) show an increase in the proportion of age II and III fish and a decrease in older fish from 1970 to 1973.

U.S.A. Albatross IV fall research cruise-catch per tow indices from Southern New England cruise strata (Figure 2) indicate a drastic decrease in abundance in 1973. The total weight of yellowtail caught per tow has decreased from 32 pounds per tow in 1970 to 5 pounds in 1973 (Table 3). Age-length keys were developed for each cruise so that the number of pre-recruits (age I) caught per tow could be determined. The catch per tow in numbers of pre-recruits has decreased 87% since 1969.

A procedure using pre-recruit catch per tow data from fall research cruises to predict subsequent year class abundance and the desired catch level has been previously developed and used to estimate TAC values for a given fishing mortality rate (Brown and Hennemuth, 1971b; Brown, 1972; Parrack, 1973). Indices of year class abundance, as estimated from pre-recruit catch per tow values, are summed over the four year classes in the fishery to compute a stock abundance index each year (Table 4). The annual indices are assumed to be linearly related to catch for each fishing rate (Figure 3). The 1975 abundance index can only be computed if a 1974 pre-recruit catch per tow value is available. Since the parameter will not be measured until autumn 1974, the 1974 pre-recruit value is assumed to be the 1973 value. At the 1975 abundance level a catch of 2500 MT is estimated to stabilize the stock assuming 1975 recruitment is at least at the 1974 level.

Cape Cod Stock. An increase in effort from 540 standard days in 1970 to 890 in 1973 has been accompanied by a 37% decrease in catch per day (Table 1). Although techniques to estimate abundance from research cruise pre-recruit data have not been developed for this stock, a further decline in abundance, as evidenced by decreasing catch per day values during 1970 to 1973 might be expected in 1975. Therefore catches will likely decrease slightly from the 1600-1700 MT level unless effort is increased.

Management Area West of 69° Longitude. Removals limitations have reduced the catch from 5Z West of 69° (Southern New England and Cape Cod stocks) from 24103 MT in 1970 (the last year of unrestricted fishing) to 9510 MT in 1973. Commercial catch per standard day, however, decreased from 3.5 to 1.9 during that period. Several successive years of poor recruitment have resulted in even the reduced harvest being in excess of stock production.

Allowing for 1500 MT to be taken from the Cape Cod stock and 2500 MT from Southern New England, a 4000 MT TAC West of 69° in 1975 would stabilize abundance if recruitment levels do not decrease further.

East of 69° . The relation between stock abundance indices and fishing intensities have not as yet been developed for the Georges Bank stock. However, removals and catch-per-effort values (Table 5) have stabilized under quota management as has the research cruise catch-per-tow abundance index values (Table 6). Although age compositions of the USA landings (Table 7) exhibit no trends, landings per day at age values indicate a slight decrease in Z (Table 8) under removal restrictions (full recruitment is assumed to be at age IV to the landings and at age III to the catch which includes discards of younger fish). The 16000 MT quota presently in effect has, therefore, served to maintain current yields at past recruitment levels. The measure seems adequate if successive years of poor recruitment do not occur.

SUBAREA 6

Estimate of Mortality Rates. Albatross IV fall data for cruise strata south of 5Zw (Figure 2) were analyzed to estimate mortality rates. Age-length keys for each year based on an analysis of scale samples were computed for 1963-1971. Age data were not available for 1972 and 1973. 1970 and 1971 data were therefore pooled to compute the age-length key used for 1972 and 1973 so that catch per tow at age and mortality rates could be calculated for all fall cruises, 1963-1973 (Table 9).

Estimates of total mortality coefficients (Z) for fish fully recruited to the commercial fishery (age III and older) indicate that mortality increased after 1970. The average coefficient for age III and older was 1.2 for the seven-year period 1963-1970 and 1.8 for the period 1970-1973. The natural mortality coefficient (M) has been estimated at .2 for 5Z yellowtail (Lux, 1969). If this value is assumed for SA 6 yellowtail, F for the two periods was 1.0 and 1.6. The average Z for age II fish, the age at entry into the fishery, was 0.6 thus estimating F at .4 during the year of recruitment.

POPULATION ABUNDANCE INDICES

Yearly stock abundance indexes were developed by the method of Brown and Hennemuth (1971b) based on annual fall cruise pre-recruit (age I+) catch-per-tow values. Abundance in numbers of a given year-class at time of entry into the fishery (age II) is assumed to be measured by the pre-recruit catch per tow for that year-class as monitored the preceding fall. The abundance index of the year-class in the beginning of its second year in the fishery is calculated by multiplying the pre-recruit index by the survival rate during the first year of exploitation, in this case s = .55 (i.e. $.55 = e^{-Z}$, Z = .6 for age II). The index at the beginning of the fourth and fifth years are each computed by finding the product of survival and abundance the preceding year. For example, the abundance at the beginning of the third year in the fishery is the abundance at the beginning of the second year times survival, in this case s = .30 before 1970 ($s = e^{-1.2}$) and s = .165 after 1970 ($s = e^{-1.8}$). The abundance index for each year-class each year in terms of weight was calculated by finding the product of the abundance index in numbers and weight at age. Weight at age data for SA 6 was not available so length at age at the beginning of the year was determined by a Bertalanffy growth equation for SA 5 (Lux and Nichy, 1969) and weight at age was then calculated from a length-weight equation (Lux, 1969b). The total abundance index for each year was then found by summing the abundance indexes for all year classes in the fishery (age II-V) that year. The abundance index for a given year requires the pre-recruit catch-per-tow for the four preceding years. Therefore, in order to calculate the 1975 abundance index, the pre-recruit value for the 1974 cruise (1973 year-class) was assumed to be the same as the 1973 value.

These stock abundance indices as calculated above (Table 11) show a general decrease since 1970 as do fall research cruise total catch-per-tow data (Table 12).

The plot of nominal catches and the weight abundance indices (Figure 4) give two clusters of points, one for the period 1967-69 and one for 1971-1973. Lines, which reflect the average fishing mortality coefficients during the periods as previously estimated, were fit by the least squares method which sets the ordinate intercept at zero. The lines show the relation between abundance and catch for the two levels of fishing that existed during the period 1967-1973.

The 1975 abundance index is extremely low, and, although the relation between parent stock size and recruitment are not known, it is reasonable to assume that further reductions in abundance are not desirable if stock recovery is expected. A catch that would halt further decreases may be determined by computing the change in the weight abundance index that would occur during 1975 for year-classes in the fishery for different survival rates:

$$A = A' \, e^{g-(M+F)}$$

where A is the weight abundance index at the end of 1975 for a given year-class, A' is the index at the beginning of 1975 for a given year-class, and M, F, and g are mortality and growth coefficients applying to the year-class during 1975. Growth rates at age (Brown and Hennemuth, 1971a) were computed from the growth and length-weight equations previously used.

Assuming no fishing mortality to exist and the 1974 year class to be equal to the 1973 year class, the stock is estimated to approximately double by the beginning of 1976 (Table 13). If fishing is set at the 1971-1973 level, stock abundance will decrease 50% by the end of 1975 and 20% after 1976 recruitment (if 1976 recruitment is at the 1974 level). Stock abundance will decrease 38% during 1975 and will be 10% less than the initial 1975 stock after recruitment in 1976 if fishing is set at the 1967-1969 level.

The plot of abundance indices and catch (Figure 4) indicate that in order to achieve a fishing rate equivalent to the 1967-1969 level a removal of less than 500 MT is necessary. Therefore, if the 1973 and 1974 year-classes are assumed to be of the same abundance as the 1972 year-class, no directed yellowtail fishery can exist if the extremely low current stock size is to be maintained or increased.

TOTAL AREA SOUTHWEST (SA 6 AND 5Z WEST OF 69° COMBINED)

Since no distinct geographical or abundance density boundaries are known to exist between the Southern New England stock and populations in SA 6, it is unlikely that the stocks are distributed discretely. A single management regime for the total area West of 69° longitude from 38° to 42° latitude would account for the overlap of distributions between SA 5 and SA 6.

The pre-recruit stock abundance model previously used on Southern New England and SA 6 separately was fit to the total southwest area. Mortality coefficients for Southern New England and SA 6 were combined as were pre-recruit catch-per-tow values from both areas (Figure 2). The results of the model (Table 14) indicates that abundance (as catch) has decreased as do total catch-per-tow indexes of fall research cruises (Table 15). Plots of catch and abundance indexes (Figure 5) indicate two levels of fishing. The lower line represents an F of 1.0 which existed in Southern New England (Brown, 1971b) and in SA 6 (estimated from research cruise catch-per-tow at age data, above) during 1969-68, and the upper line the somewhat higher fishing level which has occurred in later years (between an F of 1.2 on Southern New England and 1.6 in SA 6).

Abundance at the end of 1975 (before 1976 recruitment) was computed for all year-classes recruited to the fishery assuming the 1967-68 fishing level and assuming no fishing (Table 16). The percentage increase in abundance under both conditions was calculated for the end of 1975 and after 1976 recruitment assuming 1976 recruitment to be at the 1974 level. Abundance is estimated to remain relatively stable (a 10% decrease) if fishing is at the 1967-68 level during 1975. The plot of abundance and catch (Figure 5) indicates a removals limit of 2500 MT at that fishing level. Allowing for 1500 MT to be caught from Cape Cod grounds, removal should then be limited to 4000 MT over the entire area if abundance is to remain relatively stable from 1975 to 1976. If no fish are removed during 1975, the stock is estimated to increase by 50% after 1976 recruitment if that recruitment is at the 1974 level.

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Table 1. 5Z yellowtail flounder catch and effort values west of 69° longitude.

	Southern New England						Cape Cod Grounds			Total Area West of 69° Nominal Catch
	U.S.A. CATCH				Other Nations Catch[1]	Total Catch	USA Food			
	Food									
	Landings	Discards	Total	Industrial			Landings	Discard	Total	
1970										
Metric tons	13139	4730	17869	2095	2529	22493	1184	426	1610	24103
[2]STD. D.F.	5053	5053	5053	599	723	6375	538	538	538	6913
MT/day	2.6		3.5			3.5	2.2		3.0	3.5
1971										
Metric tons	8157	3337	11494	397	308	12199	1662	660	2322	14815
[2]STD. D.F.	3547	3547	3547	124	96	3767	791	791	791	4558
MT/Day	2.3		3.2			3.2	2.1		2.9	3.2
1972										
Metric tons	8226	1661	9887	329	3024	13240	1364	280	1644	14884
[2]STD. D.F.	3577	3577	3577	119	1080	4776	682	682	682	5458
MT/Day	2.3		2.8			2.8	2.0		2.4	2.7
1973										
[3]Metric tons	7150	146	7295	343	175	7813	1662	35	1697	9510
[2]STD. D.F.	3789	3789	3789	178	92	4059	893	893	893	4952
MT/Day	1.9		1.9	1.9		1.9	1.9		1.9	1.9

1) The USSR reported 2761 MT caught west of 69° (1973 Redbook, Part I, p. 81). For other countries, 1970-1973 and the USSR 1970-71, and 1973, that catch reported in ICNAF Statistical Bulletins caught from 5Zw are assumed to be the total catch west of 69°.

2) USA food landings were divided by the landings per standard day fished (Lux, 1964) to calculate the U.S.A. days fished in the Food Fishery. The USA catch (landings plus discard) was then divided by the standard days fished to calculate the catch per day so that total days fished could be determined.

3) 1973 catches were taken from ICNAF Summ. Doc. 74/7.

Table 2. Age composition of the USA yellowtail landings[1] from Southern New England.

	NUMBERS X 10^{-3} LANDED AT AGE														
	AGE II		AGE III		AGE IV		AGE V		AGE VI		AGE VII		AGE VIII+		TOTAL
YEAR	NOS.	%	NOS.	%	NOS.	%	NOS.	%	NOS.	%	NOS.	%	NOS.	%	NOS.
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	--	18051

1) Excludes Industrial Landings.

Table 3. Albatross IV fall research cruise catch per tow indexes for Southern New England yellowtail flounder.

YEAR	Nos. per tow age I+	Total Nos. per tow	Total pounds per tow
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
1968	10.0	40.2	22.2
1969	12.8	54.8	31.7
1970	7.3	39.8	24.2
1971	6.3	41.7	20.2
1972	4.3	73.3	44.3
1973	1.7	7.9	5.0

Table 4. Stock abundance indexes and catches for Southern New England.

YEAR	STOCK ABUNDANCE INDEX*	TOTAL CATCH (MT)
1967	102.5	25800
1968	119.2	28000
1969	92.6	35600
1970	71.9	22493
1971	53.6	12199
1972	40.0	13240
1973	30.8	7813
1974	20.1	
1975	13.2	

*Indices in terms of weight based on fall research cruise pre-recruit catch per tow data (see text for explanation).

Table 5. Georges Bank yellowtail flounder catch and effort statistics (east of 69° longitude).

		U.S.A. Food Catch			Other Nations	
		Landings	Discards	Total	Catch	Total Removals
1970	MT	15502	5533	21035	4) 250	21285
	3) STD. Days Fished	6201	6201	6201	74	6275
	MT/STD. Day	2.5		3.4		3.4
1971	MT	11881	3127	15008	4) 503	15511
	3) STD. Days Fished	5941	5941	5941	201	6142
	MT/STD. Day	2.0		2.5		2.5
1972	MT	14157	1159	15316	1) 2243	17559
	3) STD. Days Fished	7079	7079	7079	1020	8099
	MT/STD. Day	2.0		2.2		2.2
1973	MT	15899	571	16471	2) 186	16657
	3) STD. Days Fished	6725	6725	6725	155	6880
	MT/STD. Day	2.4		2.4		2.4

1) ICNAF Redbook, Part I, p. 81.
2) ICNAF Summ. Doc. 74/7.
3) USA Landings were divided by the landings per standard day fished (Lux, 1954) to calculate the USA days fished in the food fishery. The USA catch (landings plus discard) was then divided by the standard days fished to calculate the catch per day so that the total standard days fished could be determined.
4) 5Ze nominal landings, ICNAF Stat. Bull. Vol. 20, Vol. 21.

Table 6. Fall research cruise mean catch per tow indexes for Georges Bank yellowtail flounder.

Year	No. per tow	Weight per tow
1963	30.1	22.0
1964	23.0	23.4
1965	15.0	15.7
1966	14.8	6.7
1967	19.2	13.0
1968	25.6	16.1
1969	23.1	16.0
1970	13.4	8.6
1971	15.2	11.0
1972	14.6	10.9
1973	13.1	9.5

Table 7. Age composition of the USA yellowtail landings from Georges Bank (East of 69° longitude).

	Numbers X 10^{-3} Landed at Age														
	AGE II		AGE III		AGE IV		AGE V		AGE VI		AGE VII		AGE VIII+		
Year	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Total
1970	4406	15	11792	40	8070	28	3247	11	1071	04	339	01	255	01	29180
1971	1961	09	8757	40	7026	32	2601	12	973	04	305	01	151	01	21774
1972	3427	12	11001	39	8622	31	3829	14	917	03	196	01	91	--	28083
1973	3222	10	12801	42	9227	30	3724	12	1334	04	275	01	157	--	30740

Table 8. Total rates of instantaneous rates of mortaltiy (Z) computed form USA numbers landed per standard day fished for Georges Bank yellowtail.

YEAR	SURVIVAL*	z
1970-71	.33	1.12
1971-72	.38	.96
1972-73	.42	.87

$$^{*}S = \frac{(c/f)_V + \ldots + (c/f)_{VIII}}{(c/f)_{IV} + \ldots + (c/f)_{VIII}}$$

Table 9. Albatross IV fall research cruise catch per tow at age for S.A.6 yellowtail flounder.

Year	Mean Number Caught Per Tow at Age						
	I	II	III	IV	V	VI	VII
1963	11.08	7.35	3.42	5.42	.89	---	---
1964	5.33	5.64	1.11	2.08	1.22	---	---
1965	19.02	5.49	.81	.61	----	---	---
1966	14.02	11.28	3.43	.50	----	---	---
1967	12.53	29.95	7.12	.56	----	---	.05
1968	11.58	42.45	21.39	.76	.06	.02	---
1969	.56	16.95	22.64	2.63	.16	---	---
1970	1.94	5.25	22.04	14.33	1.57	---	---
1971	11.01	8.21	3.60	3.05	.21	---	---
1972	.63	15.67	33.11	32.34	4.49	---	---
1973	.69	1.51	2.90	2.78	.33	---	---

Table 10. Total mortality coefficients (Z) computed from fall Albatross IV catch per tow data for S.A.6 yellowtail flounder.

Year	Z, Age II- III	Mean Z, Age III and Older
63-64	1.9	1.0
64-65	1.9	0.6
65-66	.5	0.5
66-67	.5	1.8
67-68	.3	2.2
68-69	.6	1.8
69-70	+.3	0.5
70-71	.4	3.1
71-72	+1.4	+1.3
72-73	1.7	3.6

Table 11. Stock abundance indexes computed from fall research cruise pre-recruit catch per tow data, 1963-1973, and nominal catches for that period for SA6 yellowtail flounder.

Year	Abundance Index*		Catch (MT)
	Number	Weight	
1967	25.9	64.4	5340
1968	24.3	67.3	3272
1969	21.7	59.0	3886
1970	9.7	36.8	4168
1971	3.6	11.7	7828
1972	12.3	22.4	8891
1973	6.9	21.6	** 6024
1974	2.1	7.5	
1975	1.3	3.8	

* Z age 2 = .6
  Z age ≥3, 1963-1970 = 1.2
  Z age ≥3, 1970-1973 = 1.8

** ICNAF Summ. Doc. 74/7

Table 12. Fall research cruise average total catch per tow for SA 6 yellowtail flounder.

Year	Total Nos./tow	Total Weight/tow
1963	28.8	19.7
1964	16.4	10.7
1965	49.1	12.8
1966	48.3	19.5
1967	55.6	20.5
1968	81.3	29.7
1969	45.4	21.9
1970	45.2	22.7
1971	27.0	8.3
1972	86.2	46.2
1973	8.2	4.1

Table 13. Initial and terminal abundance indexes for different levels of fishing during 1975 for SA 6 yellowtail flounder.

Year class	Initial weight abundance index, 1975	Weight abundance index at end of 1975, M = .2		
		No Fishing	Fishing at 1967-1969 level	Fishing at 1971-1973 level
1973	110	183	123	123
1972	123	158	58	32
1971	31	34	12	7
1970	115	114	42	23
Total of recruited year classes	379	489	235	185
% Gain in abundance at the end of 1975 before 1976 recruitment		29%	-38%	-51%
Gain in abundance after 1976 recruitment assuming the 1974 year class strength equal to the 1972 year class. (i.e. total of recruited year classes ÷ 110 ÷ 379.)		58%	- 9%	-22%

Table 14. Estimated abundance and catches for yellowtail flounder West of 69° longitude from 38 to 42° latitude.

Year	Stock Abundance Index		Total Catch (MT)
	Numbers Index	Weight Index	
1967	39.3	8886	31140
1968	32.8	8906	31272
1969	24.9	7306	39486
1970	15.9	5151	26661
1971	9.7	2925	20027
1972	12.9	2976	22131
1973	8.2	2542	13837
1974	3.8	1278	
1975	2.8	772	

Table 15. Albatross IV fall survey cruise catch per tow values for yellowtail flounder West of 69° longitude from 38° to 42° latitude.

Year	Catch per tow Nos. Age I+	Total Nos.	Total Weight
1963	14.4	42.8	30.9
1964	13.9	45.0	30.8
1965	14.2	42.4	22.6
1966	27.8	49.6	20.3
1967	15.6	56.4	24.9
1968	10.9	64.1	26.6
1969	5.7	49.3	26.0
1970	4.2	42.9	23.3
1971	9.0	33.2	13.3
1972	2.2	80.8	45.4
1973	1.1	8.1	4.5

Table 16. Percent Changes in Abundance from the initial 1975 level before and after 1976 recruitment for yellowtail west of 69° between 38° and 42° latitude.

Year Class	Stock abundance indexes at the end of 1975, M = .2 Initial 1975 Index	No. Fishing	1967-1968 Fishing Level (F = 1.0)
1973	190	316	259
1972	228	293	107
1971	187	205	75
1970	167	165	61
Recruited Total-	772	979	-34
% change before 1976 Recruitment		+27	-34
5 change after 1976 Recruitment assuming 1976 Recruitment Level to be equal to the 1974 level (i.e. recruited total at the end of 1975 plus 190 + 772)		+51	-10

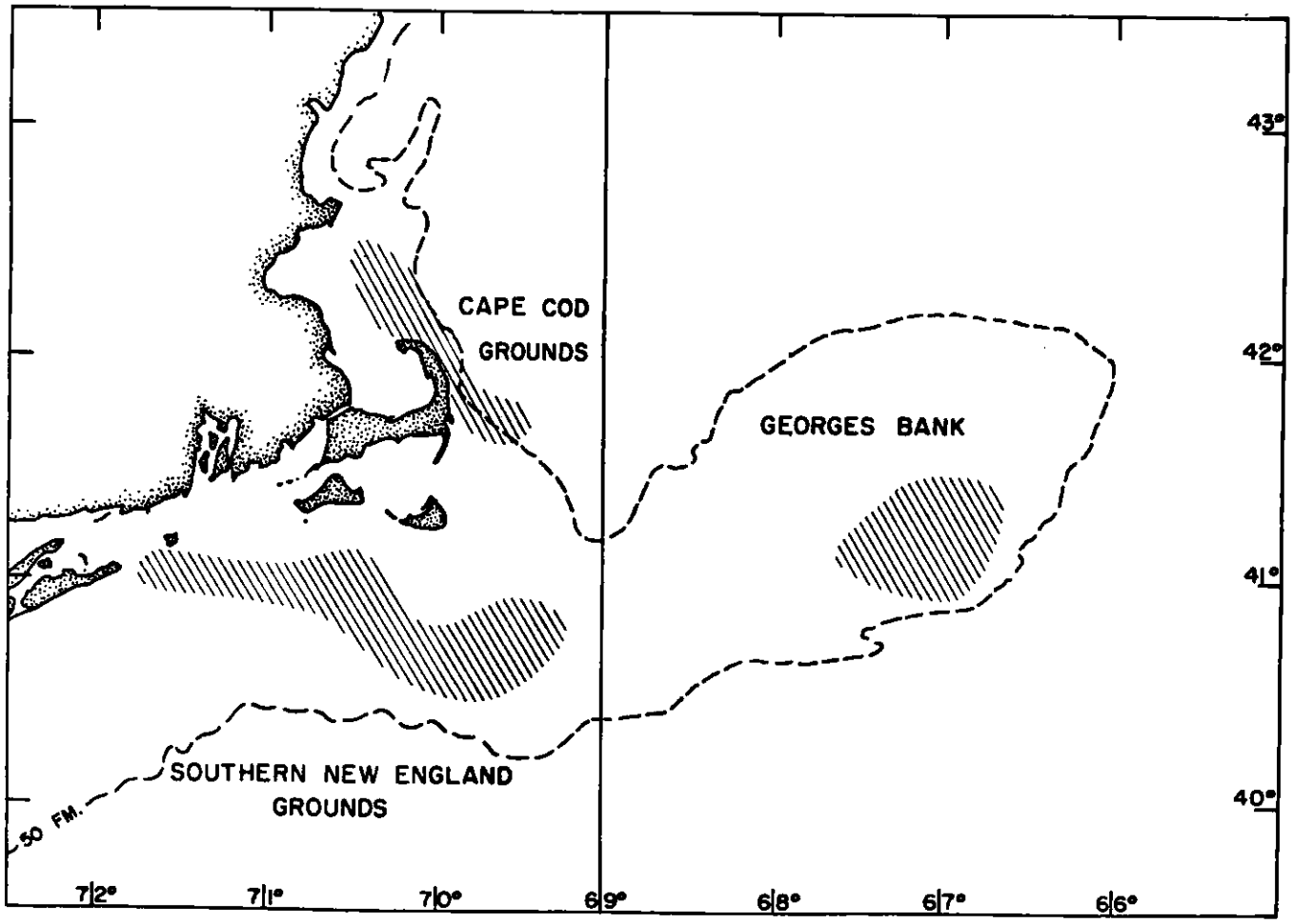

Fig. 1. ICNAF Subarea 5 yellowtail stocks.

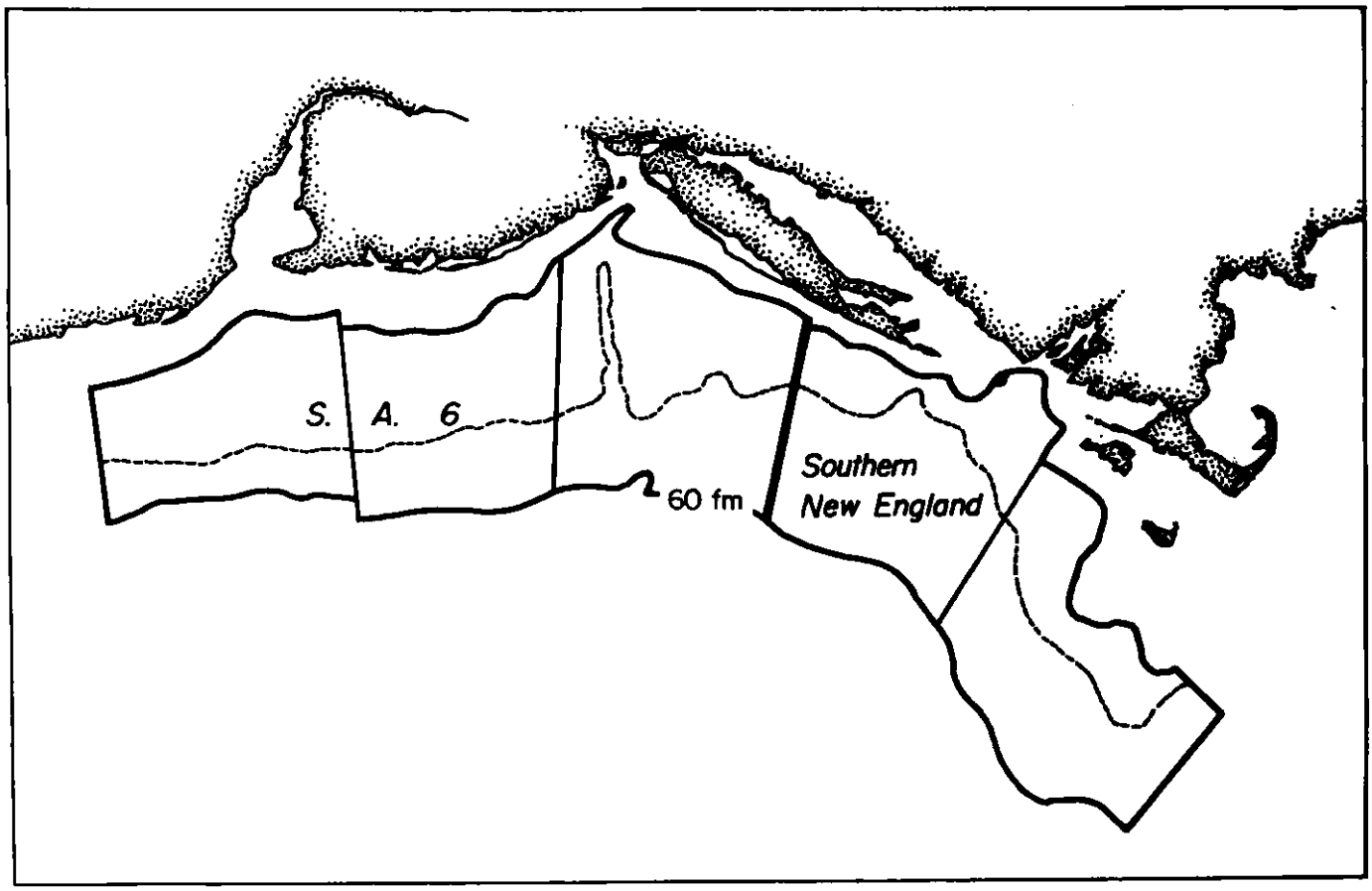

Fig. 2. Southern New England and Statistical Area 6 Research Cruise Survey Strata.

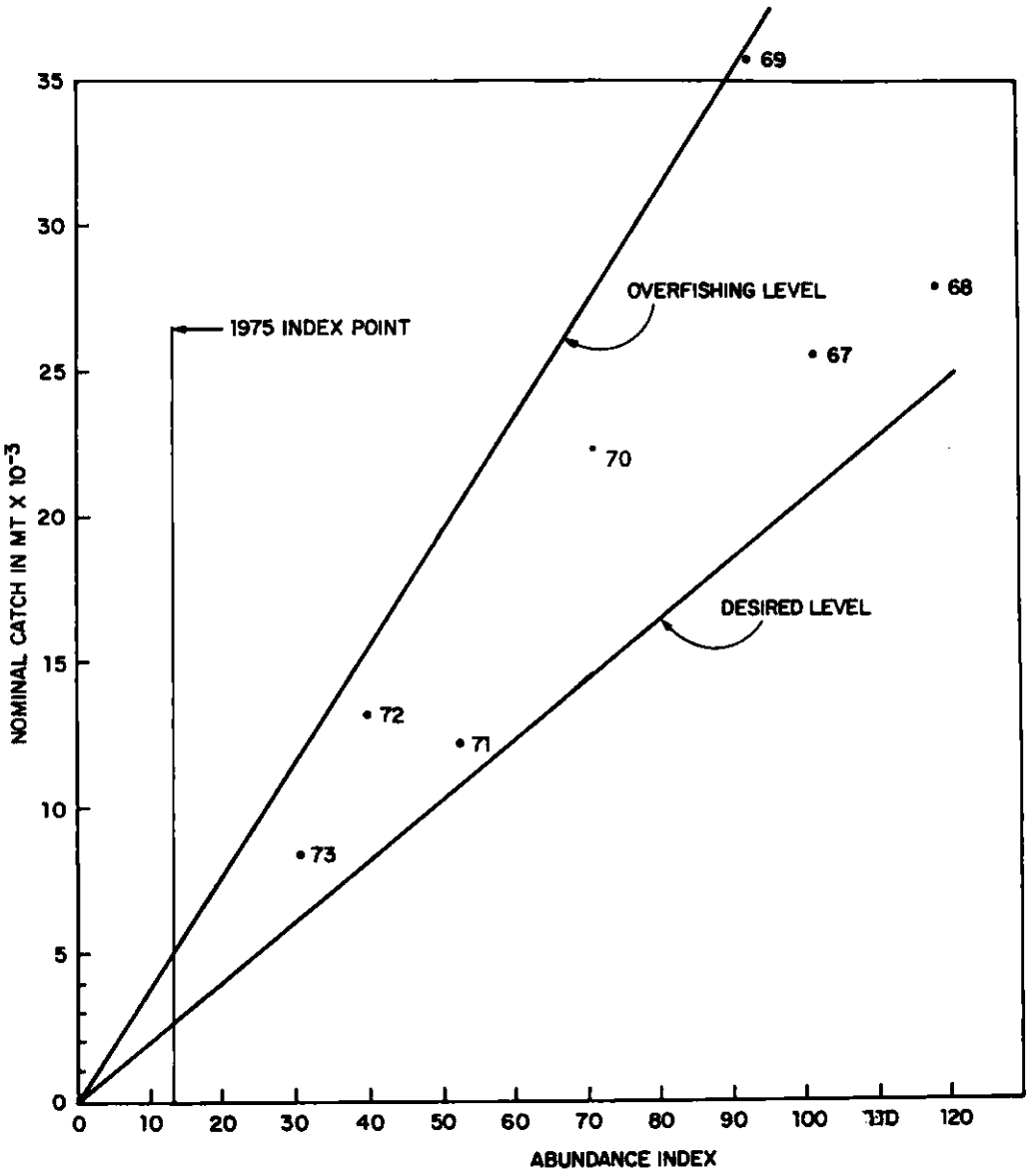

Fig. 3. Relationship between catch and an index of stock abundance for Southern New England yellowtail flounder showing a desired level of catch (F = 0.6), a level of overfishing (F = 1.2), and the 1975 stock abundance index.

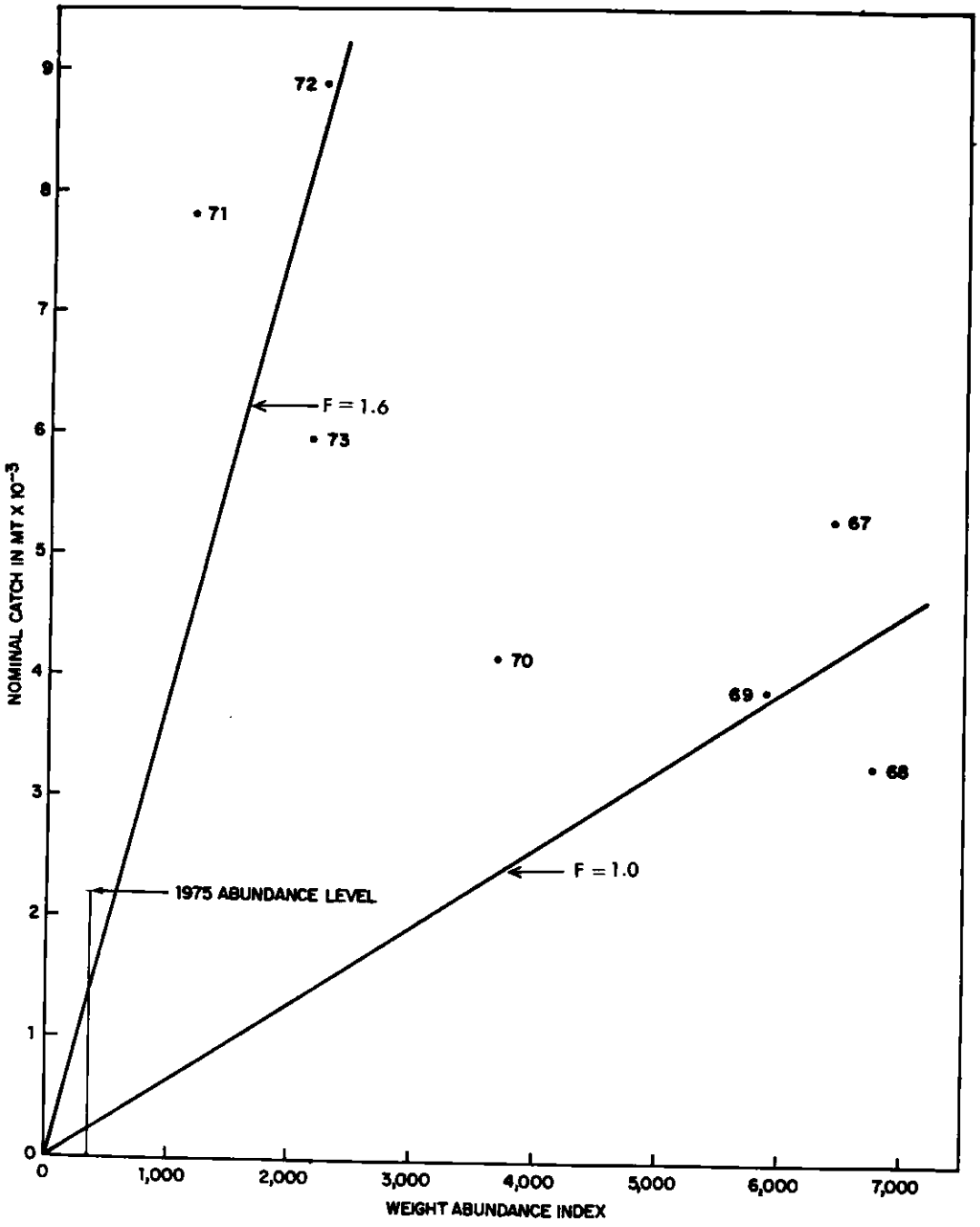

Fig. 4. The relationship between catches and abundance indexes for Statistical Area 6 yellowtail flounder at two levels of fishing mortality and the 1975 abundance index point.

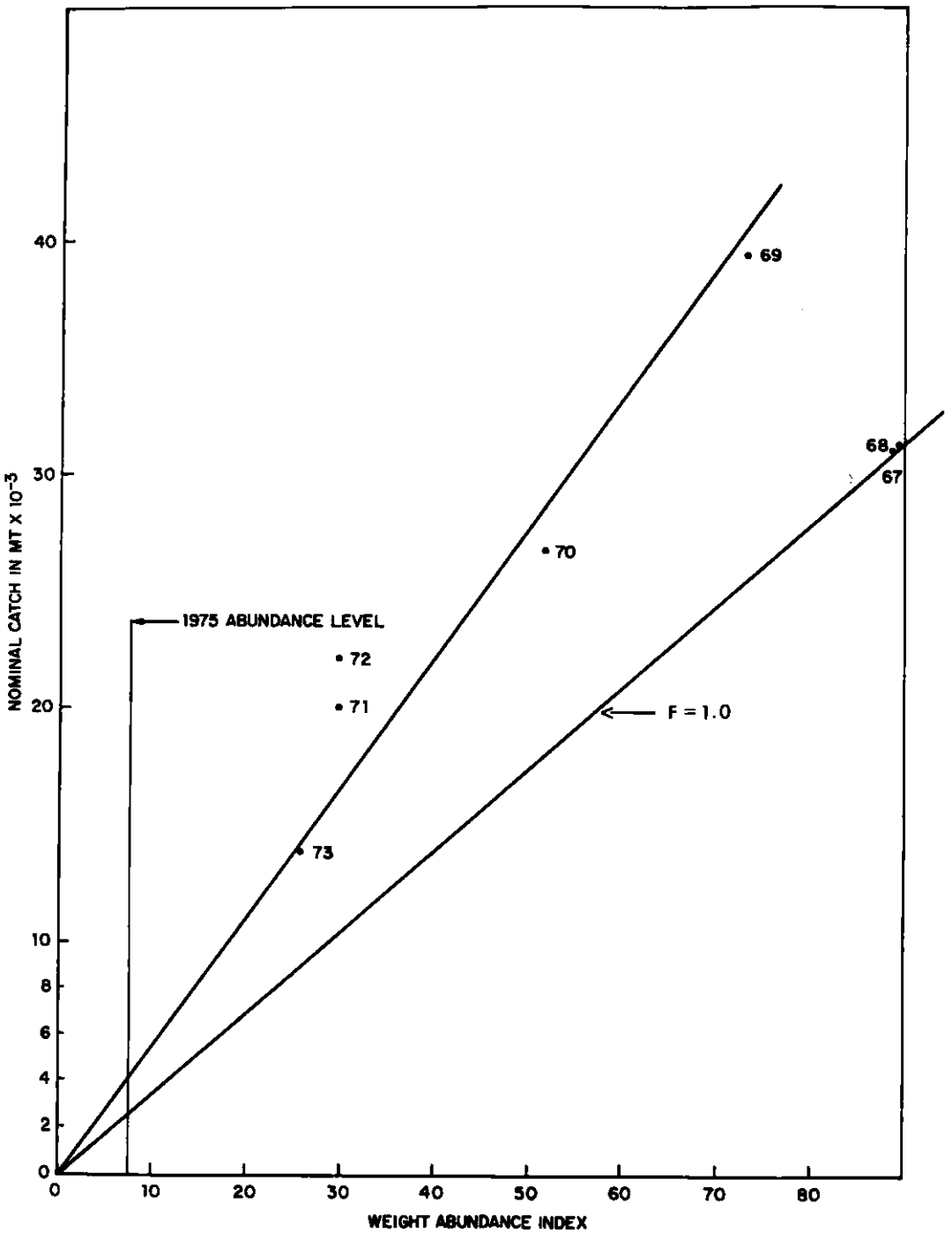

Fig. 5. Relationship between catches and abundance indexes at two levels of fishing and the 1975 abundance level for yellowtail flounder west of 69° in Subarea 5 plus Statistical Area 6.