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Sources of Variation in Catch Per Unit Effort of Yellowtail Flounder on Georges Bank, Southern New England and Cape Cod Grounds

by

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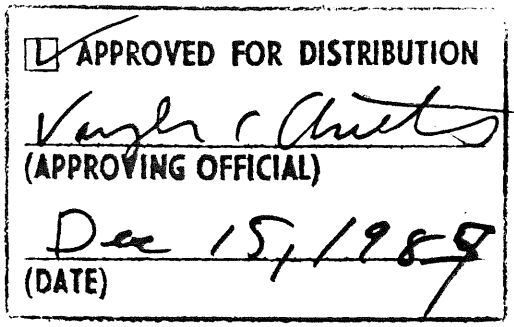

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INTRODUCTION

The yellowtail flounder, Limanda ferruginea, inhabits coastal waters in 10-100 m depths from Labrador to the Chesapeake Bay in the Northwest Atlantic (Lux and Livingstone, 1982). Commercial harvesting of this species is conducted on three major fishing grounds off the New England coast in 50-100 m depths; intermingling of yellowtail flounder between Georges Bank, Cape Cod, and Southern New England grounds (Figure 1) is insignificant, therefore these grounds are considered to support separate stocks (Royce et al., 1959; Lux, 1963).

Commercial exploitation of yellowtail flounder began in the late 1930's following the decline of the winter flounder fishery (Royce et al., 1959). Landings, excluding discard, for the three grounds combined peaked at 31,500 metric tons (MT) in 1942 and subsequently declined to 5,500 MT in 1954. Domestic landings then increased gradually to a record high of 36,900 MT in 1963, followed by a decline to a low of 10,500 MT in 1978 (Figure 2). The distant water fleet took an additional 20,700 MT in 1969. Landings from these fishing grounds have recently increased to 24,000 MT in 1982 and 30,800 MT in 1983. Landings for 1984, however, declined to 15,500 MT (Clark et al., 1984).

The decline in landings during the 1940's, which occurred primarily on the Southern New England grounds, was not due to overfishing (Royce et al., 1959), and has been attributed to a warming trend in the region which affected recruitment (Sissenwine, 1974). The more recent decline between 1969 and 1978, however, has been attributed to increased fishing effort (Brown et al., 1980). Relative abundance, as measured by commercial catch-per-unit effort (CPUE), has fluctuated since 1942, coincident with landings, and CPUE trends among the three grounds have been similar (McBride and Clark, 1983).

Royce et al. (1959) calculated CPUE for the years 1942-1949 as landings divided by a 24-hour fishing day for vessels landing 75% or more yellowtail flounder by weight. Vessels between 5-25 gross registered tons (GRT) were standardized against 26-50 GRT vessels, and vessels larger than 50 GRT were excluded. During 1942-1949, CPUE calculations indicated a decline in abundance reflecting the same trends as landings.

Lux (1964) calculated CPUE as landings per standard day fished for the years 1942-1961. Calculations were based on trips in which 50% or more of the landings consisted of yellowtail. The 26-50 GRT vessel size was chosen as a standard from a range of <26, 26-50, 51-75, and 76-100 GRT categories. Ratios of CPUE of each category to the standard were computed and the resulting fishing power coefficients used to estimate standard days fished. Trends in adjusted CPUE during 1942-1961 coincided with landings from Georges Bank and Southern New England; however, the Cape Cod data were not sufficient for comparisons.

Since 1964 Lux's method has been used routinely to determine yellowtail CPUE for the three fishing grounds, and is employed annually to evaluate yellowtail flounder abundance. Over the years, the traditional side trawlers have been almost entirely replaced by more modern stern trawlers, many of which are larger than 100 GRT, with the maximum being 310 GRT. Although the size composition of the fleet has changed, procedures for calculating relative fishing power have not been updated to reflect the current fishery. Accordingly, updated standardization procedures are required to account for the presence of these larger vessels.

In this paper variation in CPUE from 1964 to 1983 is examined by statistical area, vessel size (GRT), depth, and time, to provide a basis for computing fishing power coefficients which better represent the present vessel composition of the yellowtail fleet.

DISTRIBUTION OF VESSELS IN THE FISHERY

The three major yellowtail flounder fishing grounds off the coast of New England are defined by statistical areas used for reporting of commercial landings. Cape Cod grounds are identified by areas 514 and 521, Georges Bank by 522-525, and Southern New England grounds by 526 and 537-539 (Figure 3). Since 1964, vessel GRT's have been categorized by tonnage class (TC) as given in Table 1. Data from recent years indicate an increase in the size range of vessels fishing for yellowtail flounder, as well as shifts in the predominant vessel class in the fishery.

Between 1942 and 1949, the Southern New England grounds were exploited by vessels ranging from 5-75 GRT; most of these were in the 26-50 GRT range (Royce et al., 1959). During 1949-1961, vessels ranged from 26 to 100 GRT with the predominant vessels still in the 26-50 GRT range (Lux, 1964). The dominant vessel size shifted between 1961 and 1983 from 51-72 GRT (TC 31) in 1964 to 73-104 GRT (TC 32) in 1972, and most recently to 105-150 GRT (TC 33) in 1982.

Although the size range of vessels fishing on Georges Bank remained similar to Southern New England, the dominant vessel group varied over time. In the early 1940's, vessels in the 51-75 GRT range predominated, but a shift

to the smaller 5-50 GRT range occurred during 1950-1957. The 51-75 GRT category was again dominant from 1958 until the early 1960's. A gradual shift to larger vessels began in the mid-1960's so that by 1968 TC 32 vessels were dominant. By 1976 another shift to TC 33 vessels commenced as larger vessels continued to enter the fishery. This tonnage class has remained dominant through 1983.

Cape Cod grounds have always contributed the least to the total yield from the three grounds. Lux (1964) considered the 26-50 GRT range to be dominant from 1943-1961, when the only other vessels fishing were smaller than 26 GRT. Recent data from 1976-1983 indicate a predominance of tonnage classes 24 and 25 except in 1983, when class 33 vessels were dominant.

A review of Lux's (1964) data from 1942-1961 and the distribution of yellowtail landings from 1964-1983 (Figures 4-6) reveal that vessels of similar size have continually fished the same general areas over the past 40 years. The TC 21-24 vessels fish primarily on Southern New England and Cape Cod grounds (Figure 4), although TC 24 vessels occasionally enter the southwest part of Georges Bank. The TC 25-33 vessels fish on both Georges Bank and Southern New England grounds (Figure 5), while TC 41-43 vessels concentrate on Georges Bank (Figure 6). Although tonnage class 41 vessels operate at times on the eastern part of the Southern New England grounds, the TC 42 and 43 vessels fish exclusively on Georges Bank.

The distribution plots (Figures 4-6) reveal a gradual phaseout of smaller (TC 21-24) vessels on the inshore Southern New England and Cape Cod grounds and a concurrent increase in the activity of large (TC 41-43) vessels on Georges Bank, Southern New England, and, to a lesser extent, on the Cape Cod grounds. In evaluating trends in CPUE we must ask whether these changes in the yellowtail fishery over the past 20 years (i.e., the shift in the

predominant vessel size on two of the three grounds and the addition of larger GRT vessels to the fleet on all three grounds) affect CPUE as calculated by the traditional method (Lux, 1964). If the same size range of vessels (5-100 GRT) had fished for yellowtail flounder throughout the years, a shift in the dominant vessel class would not affect CPUE estimates since effort is standardized against the same class and is, therefore, relative. However, the maximum vessel size has increased and the predominant tonnage class now represents vessels larger than 100 GRT. Since landings and effort data contributed by these larger vessels were not incorporated into previous CPUE calculations, CPUE estimates may not necessarily be representative for recent years. The following procedures, therefore, were developed to calculate new fishing power coefficients that encompass the entire size range of vessels now in the fishery.

METHODS OF ANALYSIS

Data were obtained from Northeast Fisheries Center (NEFC) detailed commercial landings files containing landings and effort recorded by trip. Fishing effort or days fished (df) is defined on a 24-hour basis as number of hours fished divided by 24. Only trips landing 50% or more of yellowtail flounder were analyzed. Catch per day fished (CPUE) was computed for each trip and transformed to ln CPUE[1] since preliminary analysis indicated a lognormal distribution and a positive correlation of the arithmetic mean CPUE with the variance.

Trips landing between 1964 and 1983 were classified by vessel tonnage class, statistical area, and depth zone fished. Vessels ranging in size from 5 to 310 GRT (Table 1a) and statistical areas corresponding to the three major

[1] ln CPUE = $\log_e$ (landings/days fished).

stocks were selected for analysis: Georges Bank (522-525), Southern New England (526; 537-539), and Cape Cod (514 and 521) (Figure 3). Because of their sporadic representation, TC 21-23 vessels have been excluded from the Georges Bank analyses and have been combined as one category on the Southern New England grounds. Depth zones 1, 2, and 3 (Table 1b) were also selected from six possible zones based on the availability of yellowtail flounder.

Trip data were aggregated at different levels of spatial resolution to examine variability in CPUE over the entire region and within each of the three established stocks. Two-way analyses of variance (ANOVA) with interacation were performed on annual data sets using the BMDP statistical software program P4V (Dixon, 1981). The ANOVA was performed initially to test for differences in CPUE among all tonnage classes and statistical areas and to determine the overall extent of tonnage class-area interactions. Based on the results of these analyses, all subsequent tests for significance of tonnage class, area, and depth main effects were also performed with the interaction effects removed from the error sum of squares. The secondary analyses examined the effect of tonnage class-area and depth-area interactions among and within each of the stocks. Estimates of annual geometric mean CPUE were also obtained by combinations of tonnage class, stock area, and depth from the row and column means provided by the P4V software (Tables 2 and 3).

A standard vessel class was selected for each of the three stocks for use in calculation of fishing power coefficients based on the prevalence of the vessel class in the fishery and its relative contribution to the landings over the 20 years. The TC 32 category was chosen as the standard for both Georges Bank and Southern New England stocks, and the TC 25 class was chosen as the standard for the Cape Cod stock. Within each stock annual fishing power coefficients were derived for each tonnage class relative to the standard

using the General Linear Model (GLM) Procedure of the Statistical Analysis System (SAS Institute, 1982). Coefficients were computed by retransforming the tonnage class parameter estimates obtained by fitting ln CPUE data to the model:

$$Y_i = \alpha + \beta_i X_i + \varepsilon_i$$

where:

Y_i = ln CPUE,

X_i = tonnage class,

α and β = intercept and parameter estimates, respectively, of the linear model,

ε_i = error term.

Annual deviations of the coefficients from the 20-year mean were tested for first order autocorrelation using the Durbin-Watson test statistic (Neter and Wasserman, 1974). Overall fishing power coefficients were subsequently computed for each stock by incorporating year and tonnage class effects in the GLM procedure using the data from 1964 through 1983.

Annual standardized fishing effort for each tonnage class was derived by multiplying unadjusted days fished (df) by the corresponding fishing power coefficient (fpc). Annual catch and adjusted df for each stock were summed over all tonnage classes and annual standardized CPUE calculated as $[\Sigma\ \text{CATCH}/(\text{df} \times \text{fpc})]$. Calculation procedures are illustrated in detail in Appendix A. A FORTRAN 77 computer program, YTLPD, has been written to perform the standardization calculations on a quarterly basis.

RESULTS

The initial ANOVAS performed over all statistical areas revealed highly significant ($P<0.01$) differences in CPUE for tonnage class and area main effects in each of the 20 years (Table 4). The interaction of tonnage class and area was also highly significant in all years, suggesting that relative fishing power of the individual vessel classes varies according to area. ANOVA results for the comparison of CPUE among stocks were highly significant for area main effects in 19 out of 20 years, and the tonnage class by stock area interaction term was highly significant in all years (Table 4). Grouping the data according to stock tended to reduce the amount of significant tonnage class x area interaction within each stock, although differences among tonnage classes remained highly significant.

On Georges Bank the differences in CPUE were highly significant for statistical area and tonnage class main effects in 80 and 100% of the years, respectively. The tonnage class x area interaction was highly significant in only 40% of the years. Differences due to area on Southern New England grounds were highly significant in all years except 1978, and differences due to tonnage class were highly significant in all years. The interaction term was highly significant in 70% of the years. Differences due to area on the Cape Cod grounds were highly significant in all years except 1975 and differences due to tonnage class were highly significant for all years. The interaction was highly significant in only 35% of the years (Table 4).

The smaller vessels (TC 21-24) generally exhibited the lowest CPUE indices in all three areas, although class 21-23 vessels were represented only on Southern New England and Cape Cod grounds (Table 2). Catch rates of medium vessels (TC 25; 31-33) were similar to each other, but were generally greater than those for class 21-24 vessels. Annual CPUE indices for the largest

vessels (TC 41 and 42) were more variable, but generally were equal to or greater than those corresponding to medium and small vessels, particularly in the later years (Table 2).

Differences in mean CPUE due to depth zone were generally not significant. Depth main effects yielded highly significant differences in only 50, 35, and 15% of the years for Georges Bank, Southern New England, and Cape Cod grounds, respectively (Table 4), while the tonnage class x depth interaction was highly significant in not more than 20% of the years on each of the three grounds.

ANOVA results clearly suggest a high degree of variability in yellowtail flounder CPUE among vessel sizes and geographic areas. Interactions between tonnage classes and all statistical areas throughout the region were highly significant in all cases. Further analyses yielded highly significant differences in CPUE among the three stocks and highly significant tonnage class x stock interactions. Differences in mean CPUE among statistical areas within each stock were also significant in many cases, although the tonnage class x area interaction was generally not significant. The highly significant interaction between tonnage classes and stocks suggests that relative fishing power among vessel classes is not consistent from stock to stock, implying a need for computing a separate set of fishing power coefficients for each stock.

Standardization of CPUE

Annual fishing power coefficients obtained from the linear model parameter estimates for each tonnage class by stock are presented in Table 5. Cursory examination of the coefficients reveals distinct trends throughout the 20-year series. On Georges Bank and Southern New England grounds, fishing

power coefficients for the smaller vessels (TC 23-25) relative to the standard declined over time, whereas coefficients for the larger vessels increased over time. On Cape Cod grounds the coefficients increased for the smaller vessels (TC 23-24) although trends were less pronounced. These trends are illustrated graphically by plotting annual deviations from the 20-year average in Figures 7-9. A Durbin-Watson test for first order autocorrelation (Neter and Wasserman, 1974) of the annual deviations was significant for most tonnage classes within each of the stocks. These results indicate the presence of a substantial time effect in the data and illustrate the need for incorporating year in the estimation procedure in order to obtain a set of coefficients to represent the entire 1964-1983 period.

Results of two-way ANOVAs incorporating year and tonnage class were highly significant for both main effects for each of the three stocks. Fishing power coefficients derived from the parameter estimates of the linear model for the combined 1964-1983 period are presented in Table 6. The calculated standard CPUE estimates based on these coefficients are given in Appendix B, Tables 1-3 for the Georges Bank, Southern New England, and Cape Cod stocks, respectively.

Despite annual differences between the revised standardized CPUE index and the traditional index (McBride and Clark, 1983), each index has tracked the same general trends (Figure 10). Although differences are minor, the revised standardized CPUE for Georges Bank and Southern New England has remained slightly higher than the traditional index since the early 1970's. Prior to this, the traditional CPUE index was slightly greater than the revised index. On Cape Cod grounds, the differences between the two indices are consistently greater, particularly in the early years, but still follow the same general trend.

DISCUSSION

The analytical approach adopted in this paper is based on the hypothesis that catch-per-unit effort of yellowtail flounder differs among the various tonnage classes of vessels and geographic regions associated with the fishery. The results obtained from the initial ANOVA, where CPUE data from all statistical areas encompassing the three stocks were pooled, supported this hypothesis. In each of the 20 years analyzed, the main effects of tonnage class and statistical area represented highly significant ($P<.01$) sources of variation. The tonnage class by area interaction term was also highly significant in all cases, implying that vessels of various tonnage classes exhibit different CPUE trends relative to each other in different areas. Given the large number of observations in each analysis, the more rigorous 99% significance level was chosen to test the null hypothesis (no significant differences) since relatively small differences in mean CPUE can result in statistically significant differences.

The initial results established the basis for further investigations. In subsequent analyses, the data were grouped to test the null hypothesis that no significant differences in CPUE existed among the three traditionally accepted stock definitions (Georges Bank, Southern New England, and Cape Cod). The highly significant differences obtained in 19 out of 20 years indicate that catch rates are different among the stocks and support Lux's (1963) earlier hypothesis. The resulting highly significant tonnage class by stock area interaction term obtained from the ANOVAs in all years suggests that standardization of CPUE among tonnage classes should be performed separately for each stock.

Analysis of variance within each stock provided the final basis for performing the standardized CPUE calculations. In these tests, the rejection of the null hypothesis for tonnage class main effects in all years for each stock suggests that separate fishing power coefficients must be calculated for each tonnage class. The ANOVA results also indicated that differences in mean CPUE among statistical areas within each stock were highly significant in 80% or more of the years implying that, within each stock region, yellowtail abundance is not homogeneous. This is not surprising since yellowtail are prevalent only on certain grounds within each geographic region. Further analyses of the data by depth indicated no overall significant differences in CPUE between the two primary depth zones (1-55 m and 56-110 m) where yellowtail flounder are consistently caught.

Interactions between tonnage class and statistical area within each stock were highly significant in only 35 and 40% of the years analyzed for the Cape Cod and Georges Bank stocks, respectively. In Southern New England, however, the interaction term was highly significant in 70% of the years. The infrequent number of significant interactions on Georges Bank and Cape Cod grounds relative to Southern New England suggests a greater independence of the tonnage class and area main effects with respect to CPUE; i.e., both large and small vessels exhibited relatively similar changes in mean CPUE among statistical areas within each stock. This may be explained by the relatively homogeneous grouping of vessels on the Cape Cod and Georges Bank fishing grounds. Although Georges Bank is fished by vessels in the tonnage class 24 to 42 range, the 25 and 31 class vessels have similar catch rates and class 41 vessels consistently exhibit relatively high catch rates. On Cape Cod grounds a wider range of vessels fish throughout the area, but they consistently have stable catch rates across all vessel classes. On the Southern New England

grounds, which are fished by all vessel classes, area effects tended to significantly alter the relative CPUE trends among the tonnage classes to a greater degree than on Georges Bank or Cape Cod grounds.

In choosing data sets for computing fishing power coefficients we sought to minimize the amount of interaction among the vessel tonnage classes and geographic areas involved. This criterion was met to a greater extent for the Cape Cod and Georges Bank stocks than for the Southern New England stocks. It appears that yellowtail flounder inhabiting this region, are subject to a more complex set of interactions perhaps due to temperature and bottom type. We decided, however, to accept the results and proceed with the calculations of fishing power coefficients for each of the three stocks.

Annual coefficients computed for each vessel tonnage class fishing on Georges Bank, Southern New England, and Cape Cod grounds provided a basis for examining the consistency in relative fishing power of individual tonnage classes over time. Annual deviations for Georges Bank and Southern New England grounds indicated a gradual change in relative fishing power of most tonnage classes between 1964 and 1983. On Georges Bank and Southern New England grounds, larger vessels exhibited higher catch rates relative to the standard in the later years as compared to the earlier years. Since many of these vessels are relatively recent additions, one can postulate that a period of learning occurred in the years prior to 1975. Also, the larger, newer vessels which are, presumably, equipped with more sophisticated electronics would be better able to capitalize on the slowly recovering stocks in the late 1970's and early 1980's.

Results of the tests for autocorrelation of annual deviations indicated substantial year effects; therefore, a two-way ANOVA was appropriate to account for year and tonnage class variation. Although the standardized CPUE estimates obtained from this procedure are similar to those obtained by previous methods, the revised procedures described in this paper insure adequate representation of all vessel classes engaged in the yellowtail fishery in the CPUE calculations. Differences in estimated CPUE between the two procedures result primarily from shifts in the vessel composition of the fleet over the past 20 years, and a change in the designated standard. The revised fishing power coefficients thus reflect current relationships among the individual vessel classes, and are more appropriate for use in future calculations.

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Table 1a. Definition of vessel tonnage classes included in analysis of variance of yellowtail flounder CPUE.

Gross Registered Tonnage (Range)	Vessel Tonnage Class
5 - 10	21
11 - 15	22
16 - 22	23
23 - 33	24
34 - 50	25
51 - 72	31
73 - 104	32
105 - 150	33
151 - 215	41
216 - 310	42
311 - 400	43

Table 1b. Depth ranges and corresponding zones included in the analysis of variance of yellowtail flounder CPUE.

Depth Range (meters)	Depth Zone
1-55	1
56-110	2
111-183	3

Table 2. Geometric mean CPUE[1/] (landings per day fished, metric tons) for Georges Bank, Southern New England and Cape Cod yellowtail flounder trips by vessel tonnage class, 1964-1983.

	Vessel Tonnage Class									
Year	21	22	23	24	25	31	32	33	41	42
					Georges Bank					
1964	--	--	--	3.65	4.17	4.88	5.04	4.58	4.52	2.14
1965	--	--	--	2.41	3.06	3.62	3.55	3.39	4.97	--
1966	--	--	1.18	1.25	2.27	2.76	2.78	2.76	2.71	--
1967	--	--	--	--	2.20	2.74	2.96	2.78	2.65	--
1968	--	--	--	3.88	2.99	3.47	3.55	3.84	3.53	2.66
1969	--	--	--	3.28	2.82	3.06	3.30	3.02	2.81	3.88
1970	--	--	--	3.74	2.40	2.88	3.08	2.81	2.70	--
1971	--	--	--	1.66	2.07	2.70	2.52	2.24	2.35	--
1972	--	--	--	--	1.96	2.24	2.39	2.29	1.96	--
1973	--	--	--	1.38	2.64	2.61	2.81	3.05	2.76	3.20
1974	--	2.52	--	--	2.79	2.13	2.23	2.19	1.30	3.42
1975	--	--	--	1.93	1.91	1.64	1.93	2.04	1.72	3.19
1976	--	--	--	1.35	1.69	1.77	1.84	2.16	2.06	--
1977	--	--	--	--	1.17	1.66	1.77	2.26	1.81	--
1978	--	--	--	--	1.67	1.50	1.72	2.03	2.82	--
1979	--	2.69	--	1.31	1.80	2.41	2.37	2.82	3.64	--
1980	--	0.30	--	1.09	0.90	2.88	2.62	3.27	3.00	--
1981	--	--	--	1.12	1.24	1.98	2.48	2.61	2.23	--
1982	--	--	1.88	0.48	2.02	1.71	2.10	2.53	3.97	2.07
1983	--	--	--	--	0.79	2.46	1.97	2.21	3.79	--
					Southern New England					
1964	2.34	1.94	6.15	4.88	4.66	4.44	5.04	4.59	4.09	--
1965	1.77	1.55	3.87	3.62	3.12	3.56	3.81	4.05	1.50	--
1966	1.21	3.06	3.19	2.93	2.52	2.61	2.56	2.35	3.03	--
1967	1.80	1.14	2.94	3.38	3.23	2.67	2.66	2.31	1.80	--
1968	2.24	4.15	4.69	4.42	4.02	3.41	3.62	3.63	3.53	--
1969	2.65	3.72	5.17	3.81	4.10	3.39	3.43	4.01	2.81	--
1970	7.74	3.28	4.76	3.77	3.96	3.08	3.64	2.87	2.70	--
1971	11.72	1.60	4.06	3.14	3.32	2.85	2.87	3.16	2.35	--
1972	--	1.96	3.19	2.62	3.30	3.01	2.96	3.04	1.96	--
1973	--	1.01	1.05	2.26	2.66	2.29	2.22	2.12	2.76	--
1974	--	1.08	1.62	2.31	2.14	2.07	2.07	2.64	1.30	--
1975	--	0.57	1.57	1.13	1.29	1.33	1.55	1.55	1.72	--
1976	--	0.72	0.90	0.53	0.86	1.13	1.32	1.69	2.06	--
1977	--	0.93	1.73	1.44	1.77	1.61	1.82	1.98	1.81	--
1978	--	--	2.72	1.15	1.58	1.52	2.04	2.26	2.82	--
1979	0.79	1.74	2.28	1.59	2.17	2.32	2.93	2.88	3.64	--
1980	--	1.02	2.46	1.91	2.54	2.68	2.81	3.07	3.00	--
1981	--	1.88	2.50	1.43	2.58	2.76	2.61	3.28	2.23	--
1982	2.49	1.96	2.42	2.29	3.10	3.20	3.72	3.98	3.97	--
1983	8.81	1.74	2.51	3.35	3.43	3.27	3.65	3.57	3.79	--
					Cape Cod Grounds					
1964	--	1.65	1.38	1.94	2.64	2.85	2.76	--	--	--
1965	--	1.45	1.20	1.59	2.16	3.56	2.12	2.07	--	--
1966	1.13	1.07	1.23	1.48	2.55	3.64	1.76	--	--	--
1967	--	0.78	0.90	1.56	2.46	3.21	1.95	2.62	--	--
1968	--	1.16	0.99	1.89	2.65	4.11	2.42	--	1.13	--
1969	--	1.66	1.33	2.02	2.77	3.64	2.47	--	--	--
1970	--	1.03	1.05	2.34	2.33	3.64	6.96[2/]	34.18[2/]	2.91	--
1971	--	1.17	1.89	2.43	2.04	2.24	1.90	2.45	3.36	--
1972	1.71	1.63	1.16	2.02	1.85	2.02	1.46	1.79	1.93	--
1973	1.02	1.32	1.06	1.87	1.99	1.90	1.91	1.63	2.84	--
1974	0.83	1.15	0.90	1.59	2.08	1.74	1.82	1.87	1.37	--
1975	0.77	1.13	1.23	1.42	1.92	1.45	1.64	1.09	1.19	--
1976	0.34	1.31	1.38	1.69	1.93	1.42	1.54	1.88	2.15	--
1977	0.28	0.86	1.25	1.50	2.03	1.45	1.42	2.19	2.57	--
1978	--	0.84	1.59	1.90	2.11	1.96	1.53	1.92	5.99	--
1979	0.98	0.91	1.42	1.83	2.10	2.24	1.74	2.23	3.12	--
1980	0.26	0.58	1.30	1.73	2.18	2.24	2.07	2.19	3.34	--
1981	0.70	0.76	1.17	1.69	2.24	2.40	1.22	1.85	2.99	--
1982	0.54	0.71	1.22	1.79	2.02	2.41	1.57	1.94	2.37	--
1983	0.69	1.51	1.23	1.96	1.91	1.29	1.53	1.46	0.83	--

1/ Calculated as: $e^{(1/n \cdot \Sigma \ln(\frac{\text{landings}}{\text{effort}}))}$

2/ Only one trip by tonnage classes 32 and 33 in 1970 on Cape Cod grounds.

Table 3. Geometric mean CPUE[/1.] (landings per day fished, metric tons) for Georges Bank, Southern New England, and Cape Cod yellowtail flounder trips by depth zone, 1964-1983.

	Georges Bank				Southern New England				Cape Cod Grounds			
	Depth Zone				Depth Zone				Depth Zone			
Year	1	2	3	Combined	1	2	3	Combined	1	2	3	Combined
1964	3.92	4.91	2.74	4.80	5.05	4.96	4.71	5.03	2.13	2.36	-	2.25
1965	3.76	3.48	-	3.55	3.61	3.88	2.28	3.66	1.61	1.80	2.36	1.71
1966	3.02	2.62	1.29	2.71	2.71	2.66	0.71	2.71	1.99	2.13	1.70	2.07
1967	3.19	2.69	2.81	2.79	2.97	2.77	1.14	2.91	1.52	2.16	-	1.80
1968	3.38	3.51	-	3.49	3.70	3.97	3.24	3.76	2.15	2.31	-	2.24
1969	3.36	3.11	-	3.16	3.62	3.93	1.58	3.66	2.16	2.66	-	2.27
1970	2.81	2.99	1.00	2.93	3.44	3.68	1.62	3.49	1.10	2.24	34.18[/2.]	1.40
1971	2.20	2.30	2.75	2.28	3.26	2.96	-	3.14	1.03	1.94	-	1.46
1972	2.28	2.37	1.34	2.35	3.28	3.25	2.74	3.27	1.56	1.88	-	1.82
1973	2.30	3.06	2.85	2.91	2.41	2.55	4.40	2.47	1.75	1.83	2.27	1.81
1974	2.10	2.32	2.90	2.30	2.31	2.02	-	2.19	1.86	1.78	-	1.82
1975	1.85	1.99	1.29	1.98	1.59	1.63	-	1.60	1.53	1.38	1.32	1.46
1976	1.75	2.06	-	2.03	1.34	1.56	-	1.43	1.54	1.88	2.93	1.70
1977	1.92	2.15	1.67	2.14	1.92	1.97	-	1.94	1.70	1.89	1.27	1.77
1978	1.78	2.09	1.98	2.07	2.45	2.17	-	2.32	1.90	1.71	3.49	1.86
1979	2.47	2.79	2.04	2.74	2.88	2.39	-	2.76	2.03	2.03	2.47	2.03
1980	2.58	3.50	1.53	3.37	2.71	3.51	1.13	3.04	2.06	2.31	2.38	2.16
1981	2.26	2.88	1.54	2.76	2.46	2.78	-	2.58	1.74	1.96	5.67	1.79
1982	2.34	2.66	2.53	2.62	3.20	3.54	4.53	3.31	1.81	1.44	0.91	1.67
1983	1.98	2.28	3.04	2.26	3.08	3.13	5.91	3.10	1.70	1.41	-	1.62

/1. Calculated as: $e^{[1/n \cdot \Sigma \ln (\frac{\text{landings}}{\text{effort}})]}$

/2. Only one trip in depth zone 3 in 1970 on Cape Cod grounds.

Table 4. Frequency with which highly significant (P<.01) results were obtained from analysis of variance (ANOVA) tests of yellowtail flounder annual CPUE data. (Total number of years tested = 20).

	Main Effects		
	Area	Tonnage Class	Depth
All Areas	20/20	20/20	N/A
Among Stocks	19/20	N/A	N/A
Georges Bank	16/20	20/20	10/20
So. New England	19/20	20/20	7/20
Cape Cod	19/20	20/20	3/20

	Interactions	
	Tonnage Class x Area	Tonnage Class x Depth
All Areas	20/20	N/A
Among Stocks	20/20	N/A
Georges Bank	8/20	4/20
So. New England	14/20	2/20
Cape Cod	7/20	1/20

N/A - Not Applicable (Tests not performed)

Table 5. Annual fishing power coefficients calculated by vessel tonnage class relative to a standard class vessel fishing for yellowtail flounder on Georges Bank, Southern New England, and Cape Cod grounds, 1964-1983.

Year	Vessel Tonnage Class[1]									
	21	22	23	24	25	31	32	33	41	42
Georges Bank										
1964				0.73	0.83	0.97		0.91	0.90	0.43
1965				0.68	0.86	1.02		0.95	1.40	-
1966				0.45	0.81	0.99		0.99	0.97	-
1967				-	0.74	0.93		0.94	0.89	-
1968				1.09	0.84	0.98		1.08	0.88	0.75
1969				0.99	0.85	0.93		0.92	0.95	1.17
1970				1.21	0.78	0.94		0.91	0.94	0.92
1971				0.66	0.82	1.07		0.89	1.12	-
1972				-	0.82	0.94		0.96	0.93	-
1973		not		0.49	0.94	0.93	1.00	1.09	1.09	1.14
1974		calculated		-	1.25	0.96		0.98	0.97	1.53
1975				1.00	0.99	0.85		1.06	1.04	1.66
1976				0.73	0.92	0.96		1.17	1.01	-
1977				-	0.66	0.94		1.28	1.67	-
1978				-	0.97	0.87		1.18	1.54	-
1979				0.55	0.76	1.02		1.19	1.35	-
1980				0.42	0.35	1.10		1.25	1.43	-
1981				0.45	0.50	0.80		1.05	1.16	-
1982				0.23	0.96	0.82		1.21	1.41	0.99
1983				-	0.40	1.25		1.12	1.26	-
Southern New England										
1964	----	0.95[2]	----	0.97	0.92	0.88		0.91	0.81	
1965	----	0.86	----	0.95	0.82	0.93		1.06	0.39	
1966	----	1.12	----	1.14	0.98	1.02		0.92	1.18	
1967	----	0.94	----	1.27	1.22	1.00		0.87	0.68	
1968	----	1.21	----	1.23	1.11	0.94		1.01	0.98	
1969	----	1.32	----	1.11	1.19	0.99		1.17	0.82	
1970	----	1.23	----	1.04	1.09	0.85		0.79	0.74	
1971	----	1.06	----	1.10	1.16	0.99		1.10	0.82	
1972	----	0.99	----	0.88	1.12	1.01		1.03	0.66	
1973	----	0.46	----	1.01	1.20	1.03	1.00	0.95	1.24	
1974	----	0.67	----	1.11	1.03	1.00		1.27	0.62	
1975	----	0.72	----	0.73	0.83	0.85		1.00	1.11	
1976	----	0.66	----	0.40	0.66	0.86		1.28	1.56	
1977	----	0.87	----	0.79	0.97	0.88		1.09	0.99	
1978	----	1.33	----	0.56	0.78	0.75		1.11	1.38	
1979	----	0.69	----	0.54	0.74	0.79		0.98	1.24	
1980	----	0.82	----	0.68	0.90	0.95		1.09	1.07	
1981	----	0.92	----	0.55	0.99	1.06		1.26	0.86	
1982	----	0.64	----	0.62	0.84	0.86		1.07	1.07	
1983	----	0.68	----	0.92	0.94	0.89		0.98	1.04	
Cape Cod Grounds										
1964	-	0.62	0.52	0.73		1.08	1.04	-	-	
1965	-	0.67	0.55	0.73		1.65	0.98	0.96	-	
1966	0.44	0.42	0.48	0.58		1.42	0.69	-	-	
1967	-	0.32	0.36	0.64		1.30	0.79	1.07	-	
1968	-	0.44	0.37	0.71		1.55	0.91	0.99	0.43	
1969	-	0.60	0.48	0.73		1.31	0.89	-	-	
1970	-	0.44	0.45	1.01		1.56	[3]	[3]	1.25	
1971	-	0.57	0.93	1.19		1.10	0.93	1.20	1.65	
1972	0.93	0.88	0.63	1.09		1.09	0.79	0.97	1.05	
1973	0.51	0.66	0.53	0.94	1.00	0.95	0.96	0.82	1.43	
1974	0.40	0.55	0.43	0.76		0.83	0.87	0.90	0.66	
1975	0.40	0.59	0.64	0.74		0.75	0.85	0.57	0.62	
1976	0.18	0.68	0.72	0.88		0.73	0.80	0.97	1.12	
1977	0.14	0.42	0.61	0.74		0.71	0.70	1.08	1.26	
1978	-	0.40	0.75	0.90		0.93	0.73	0.91	2.84	
1979	0.47	0.43	0.68	0.87		1.06	0.83	1.06	1.48	
1980	0.12	0.27	0.60	0.80		1.03	0.95	1.01	1.53	
1981	0.31	0.34	0.52	0.75		1.07	0.54	0.83	1.34	
1982	0.27	0.35	0.60	0.88		1.19	0.77	0.96	1.17	
1983	0.36	0.79	0.64	1.02		0.68	0.80	0.77	0.43	

[1] Standard Vessel Class on Georges Bank and Southern New England grounds = 32.

Standard Vessel Class on Cape Cod grounds = 25.

[2] Vessel classes 21, 22, and 23 combined on Southern New England grounds.

[3] Insufficient data for these categories.

Table 6. Relative fishing power coefficients calculated for the 1964-1983 period for three stocks of yellowtail flounder.

Tonnage Class	Georges Bank	Southern New England	Cape Cod
21	-	0.92	0.31
22	-	0.92	0.49
23	-	0.92	0.56
24	0.57	0.94	0.80
25	0.80	0.96	1.00*
31	0.96	0.92	1.01
32	1.00*	1.00*	0.81
33	1.07	1.09	0.95
41	1.12	1.05	1.17
42	1.17	-	-

*Denotes standard vessel tonnage class.

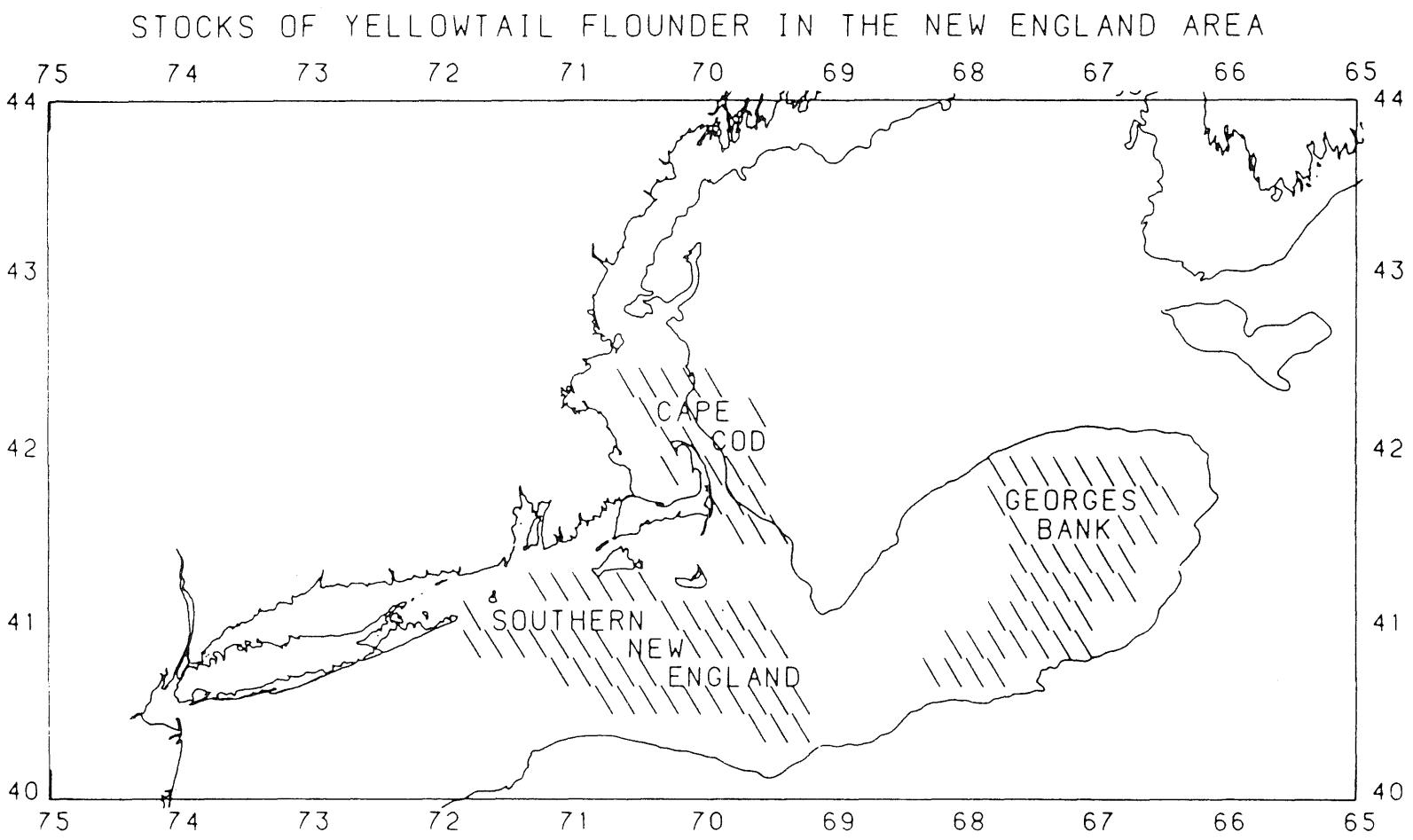


Figure 1. Yellowtail flounder stocks off the coast of New England (After Lux, 1963).

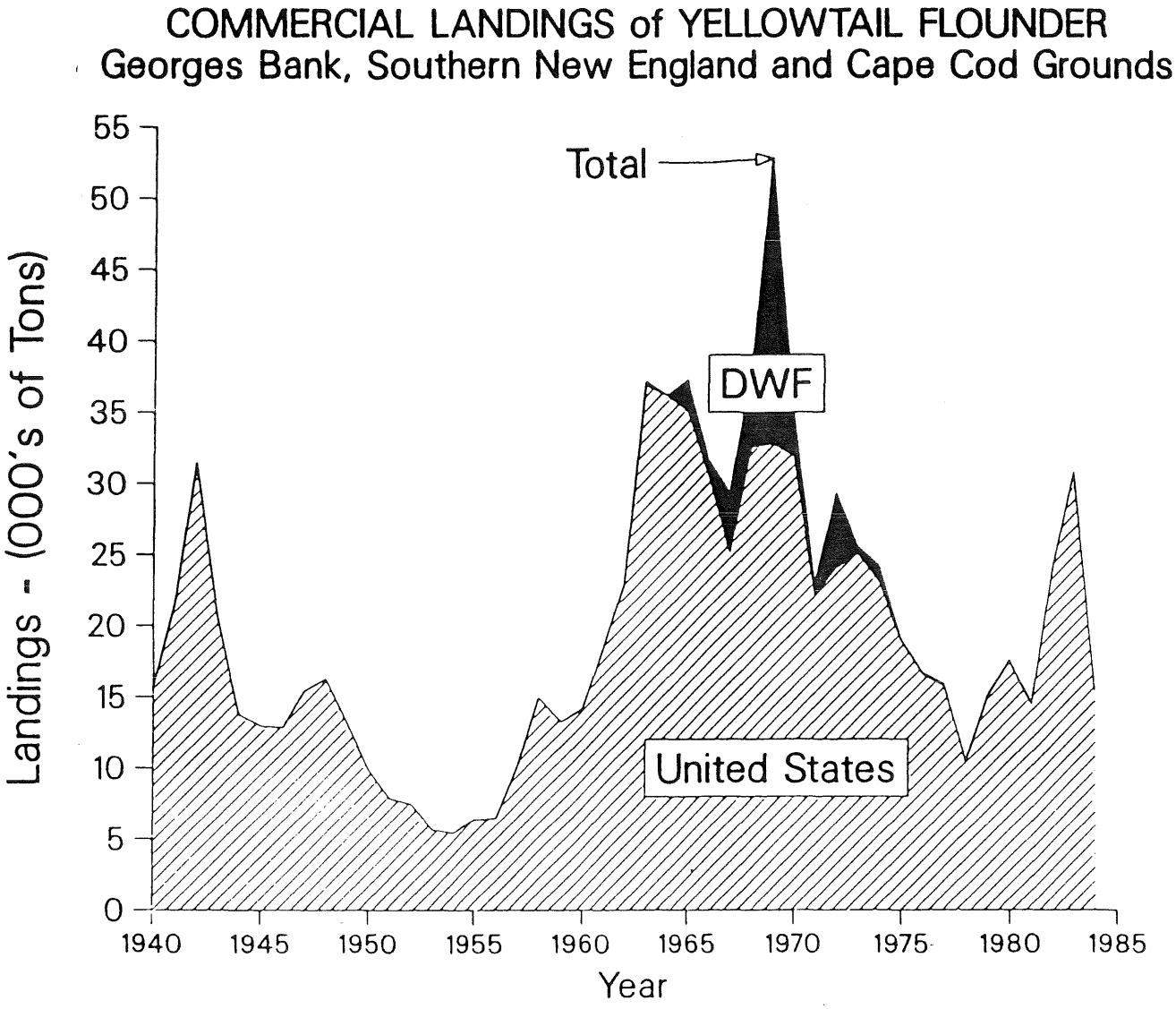


Figure 2. Yellowtail flounder landings (metric tons) by United States and distant water fleet vessels (DWF) from the combined Georges Bank, Southern New England, and Cape Cod grounds, 1940-1984.

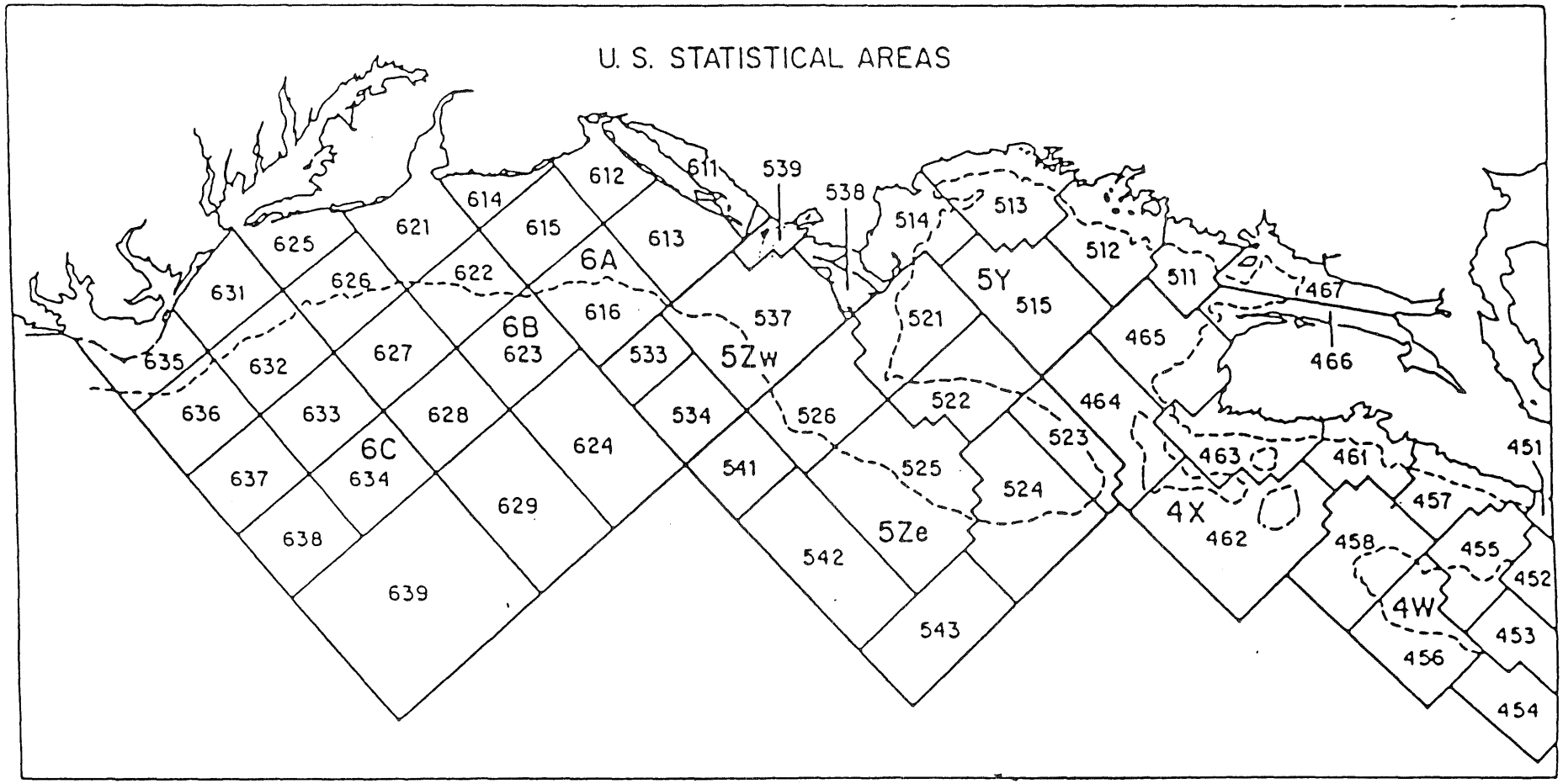
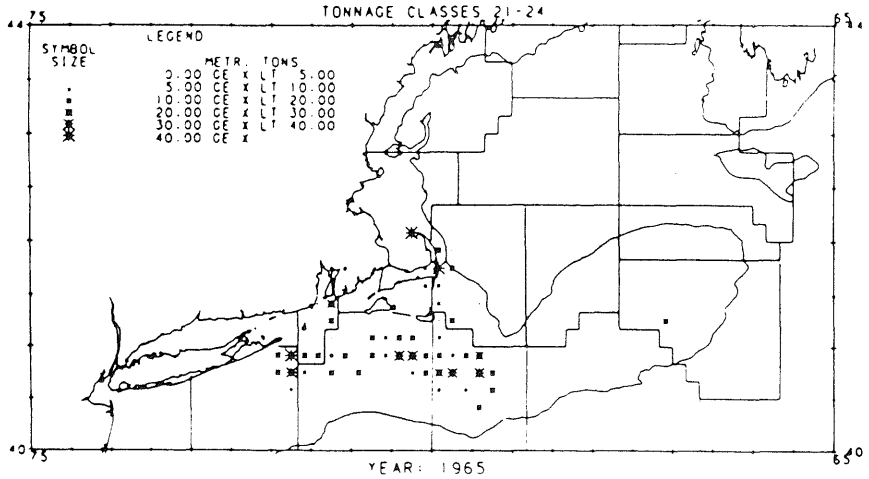
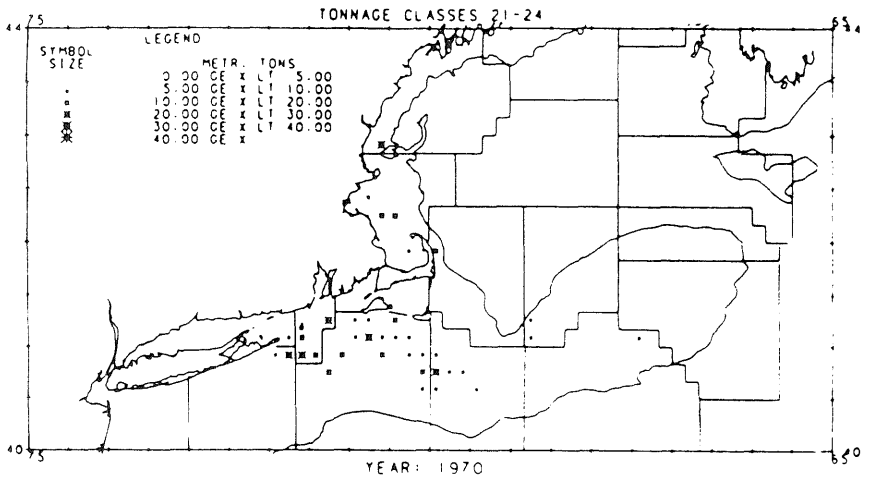
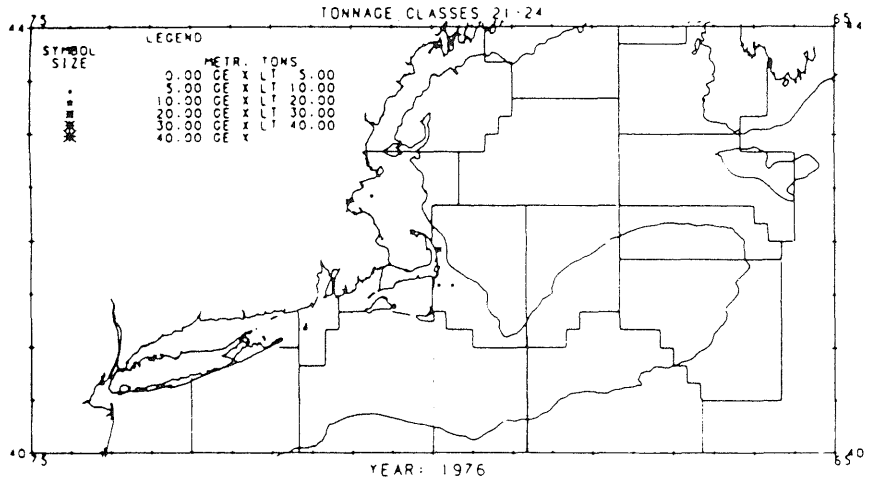


Figure 3. Northwest Atlantic Fisheries Organization divisions and subdivisions (bold lettering) and US statistical areas. Yellowtail fishing grounds defined by statistical area are as follows: Southern New England 526-539; Georges Bank, 522-525; Cape Cod, 514 and 521.







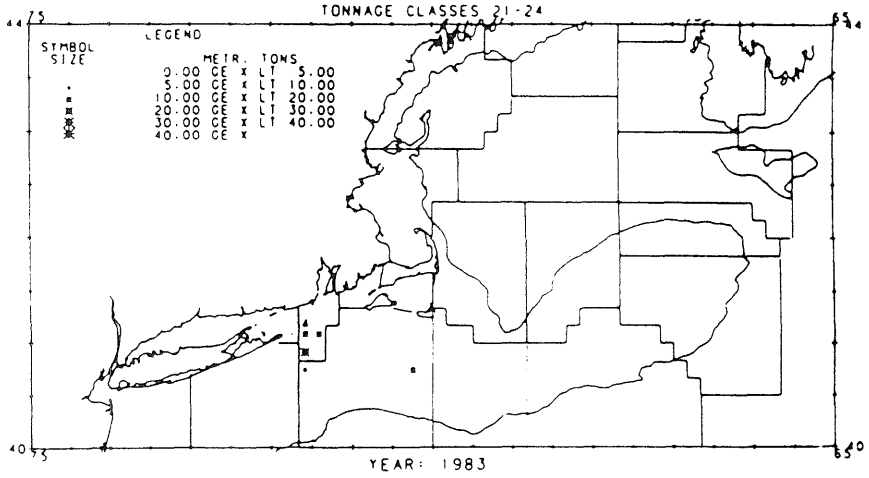
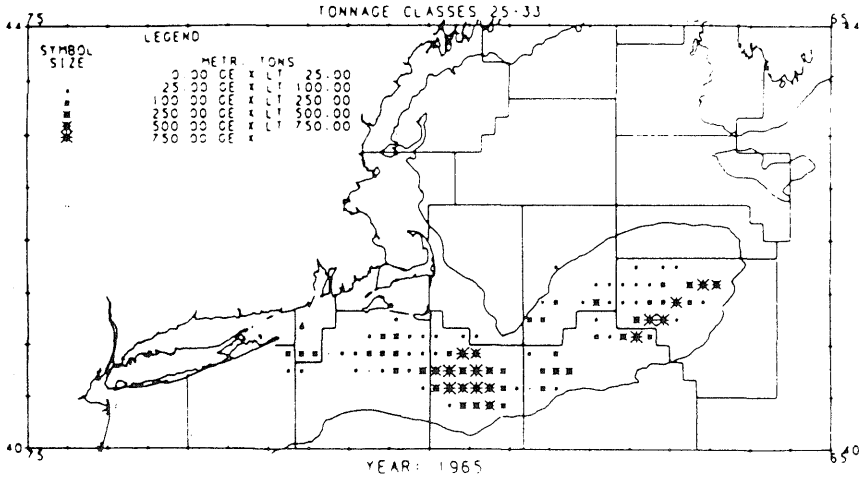
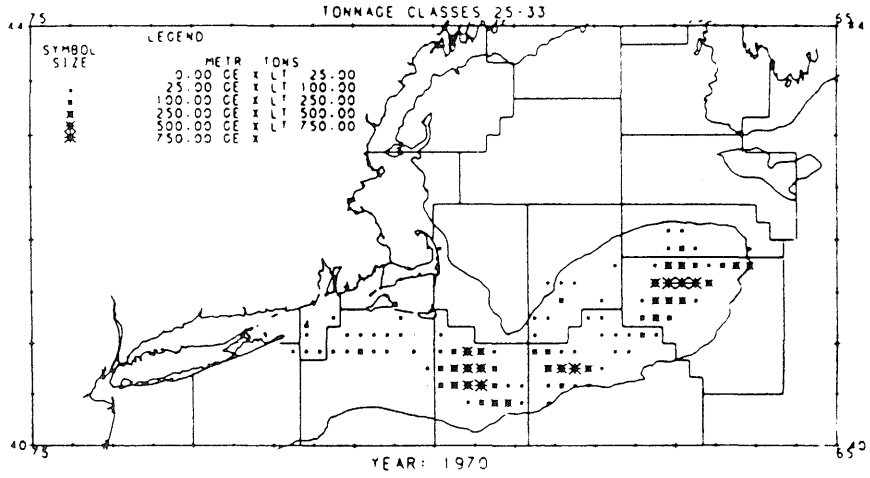
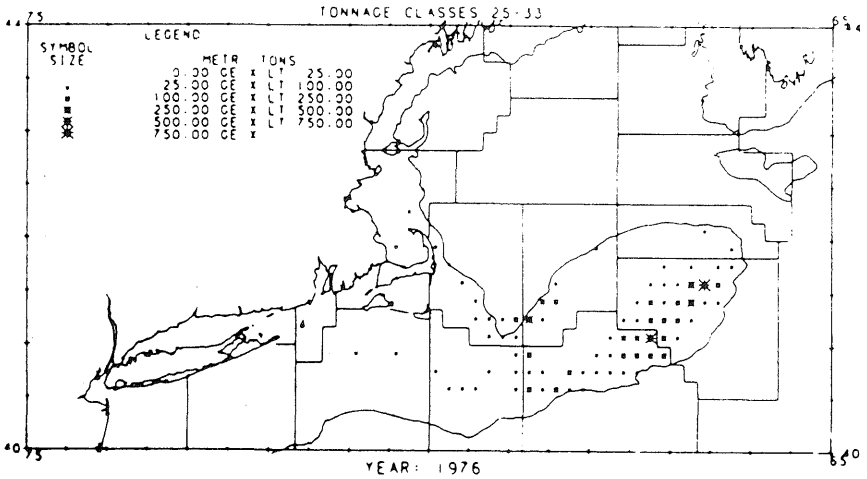


Figure 4. Distribution of yellowtail flounder landings in 1965, 1970, 1976 and 1983 for vessel tonnage classes 21-24.







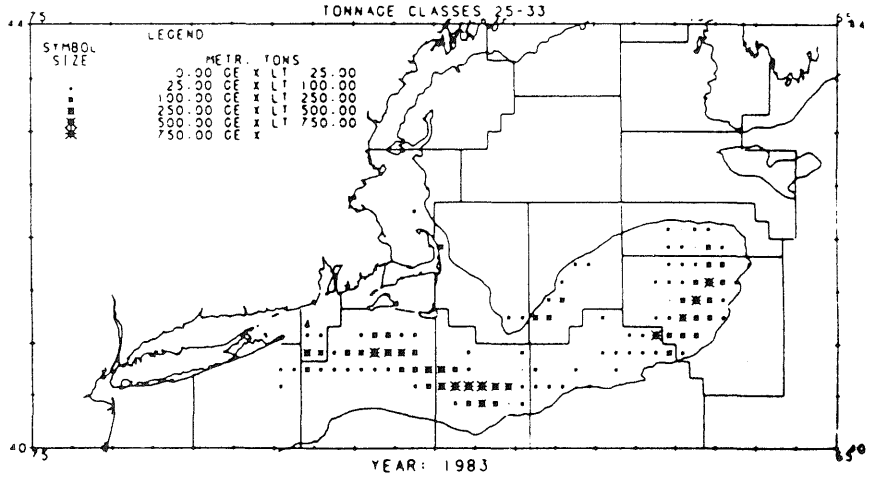


Figure 5. Distribution of yellowtail flounder landings in 1965, 1970, 1976, and 1983 for vessel tonnage classes 25-33.

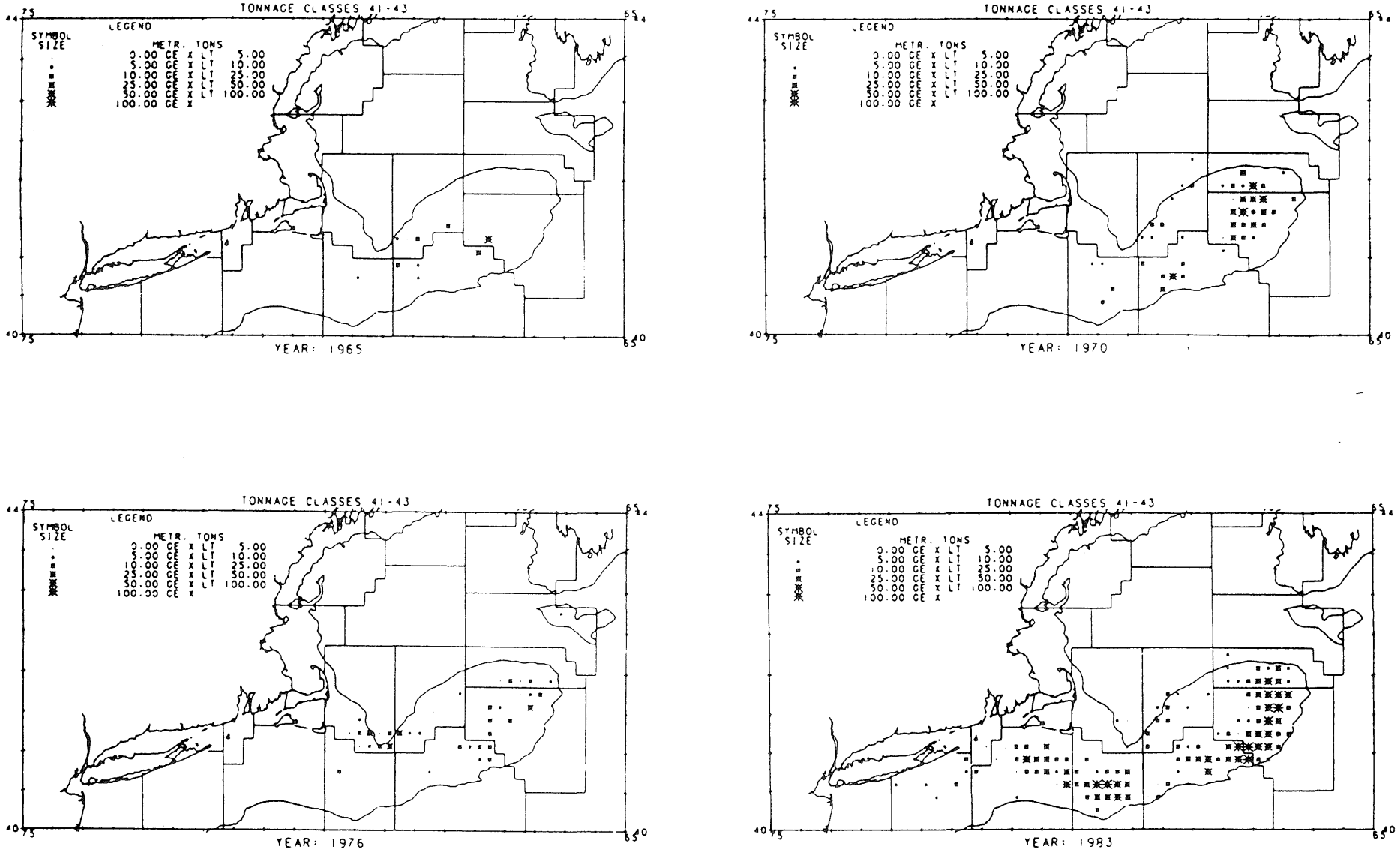


Figure 6. Distribution of yellowtail flounder landings in 1965, 1970, 1976, and 1983 for vessel tonnage classes 41-43.

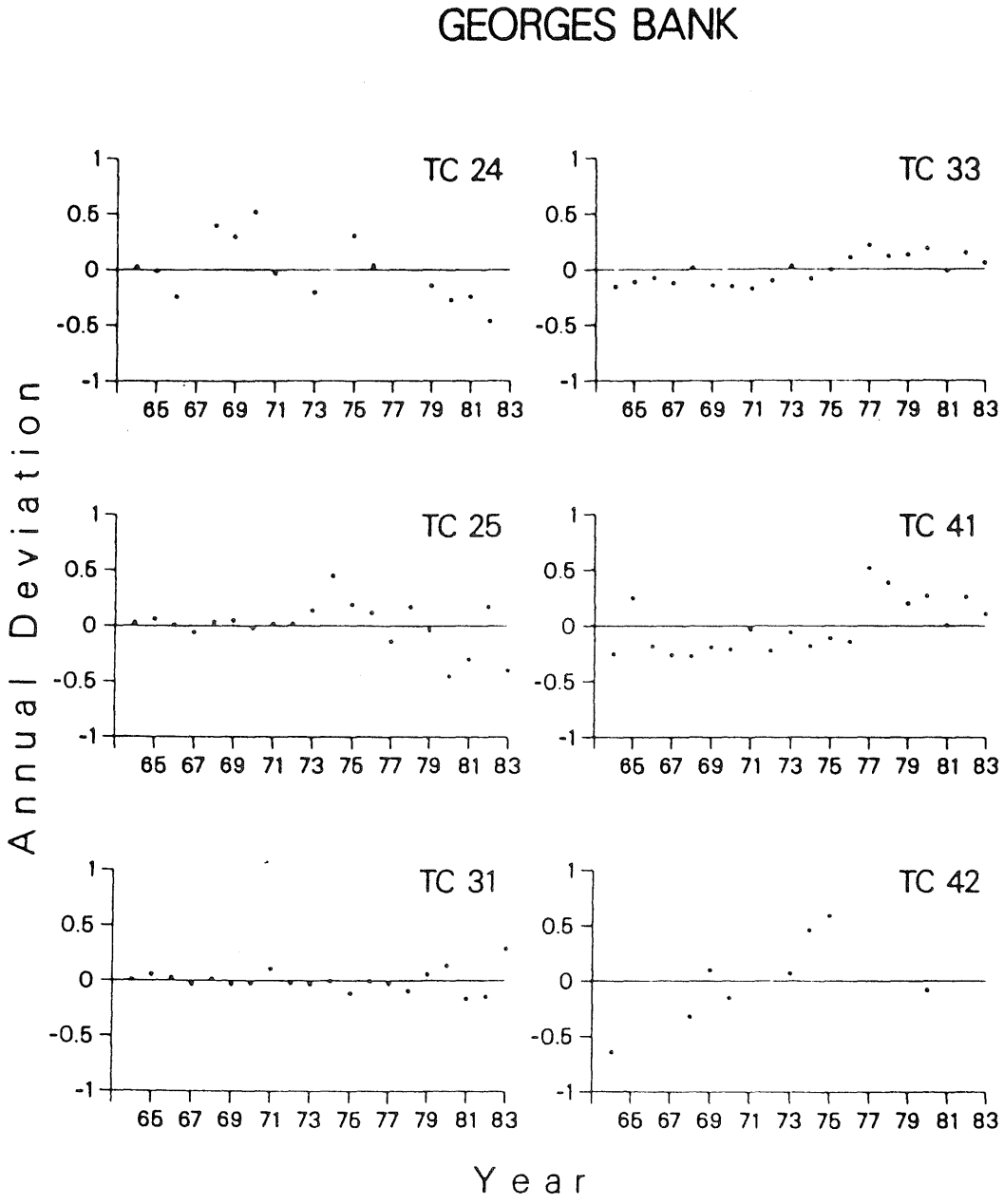


Figure 7. Deviations in annual fishing power from the 1964-1983 20-year mean for major vessel tonnage classes fishing on Georges Bank.

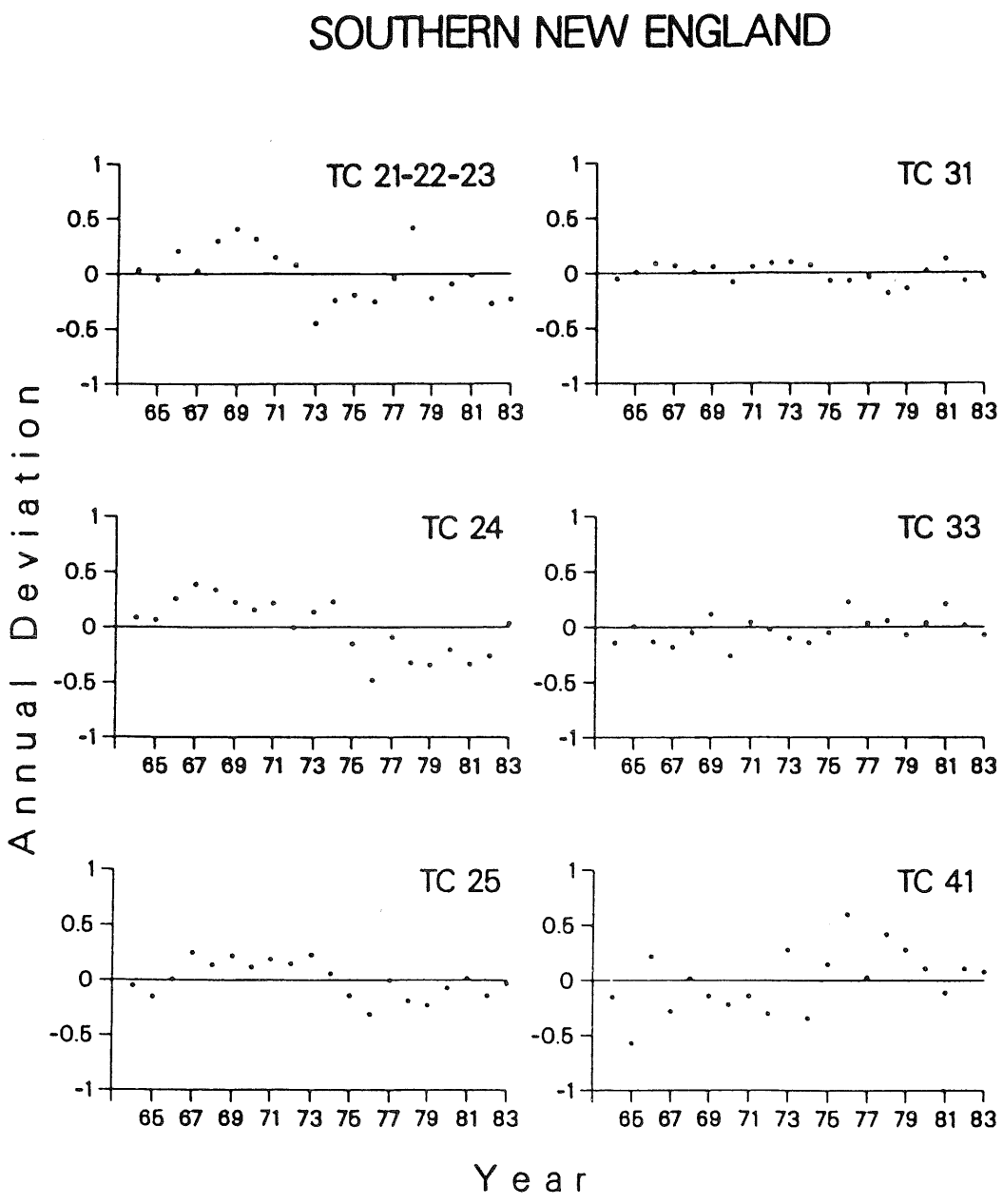


Figure 8. Deviations in annual fishing power from the 1964-1983 20-year mean for major vessel tonnage classes fishing on Southern New England grounds.

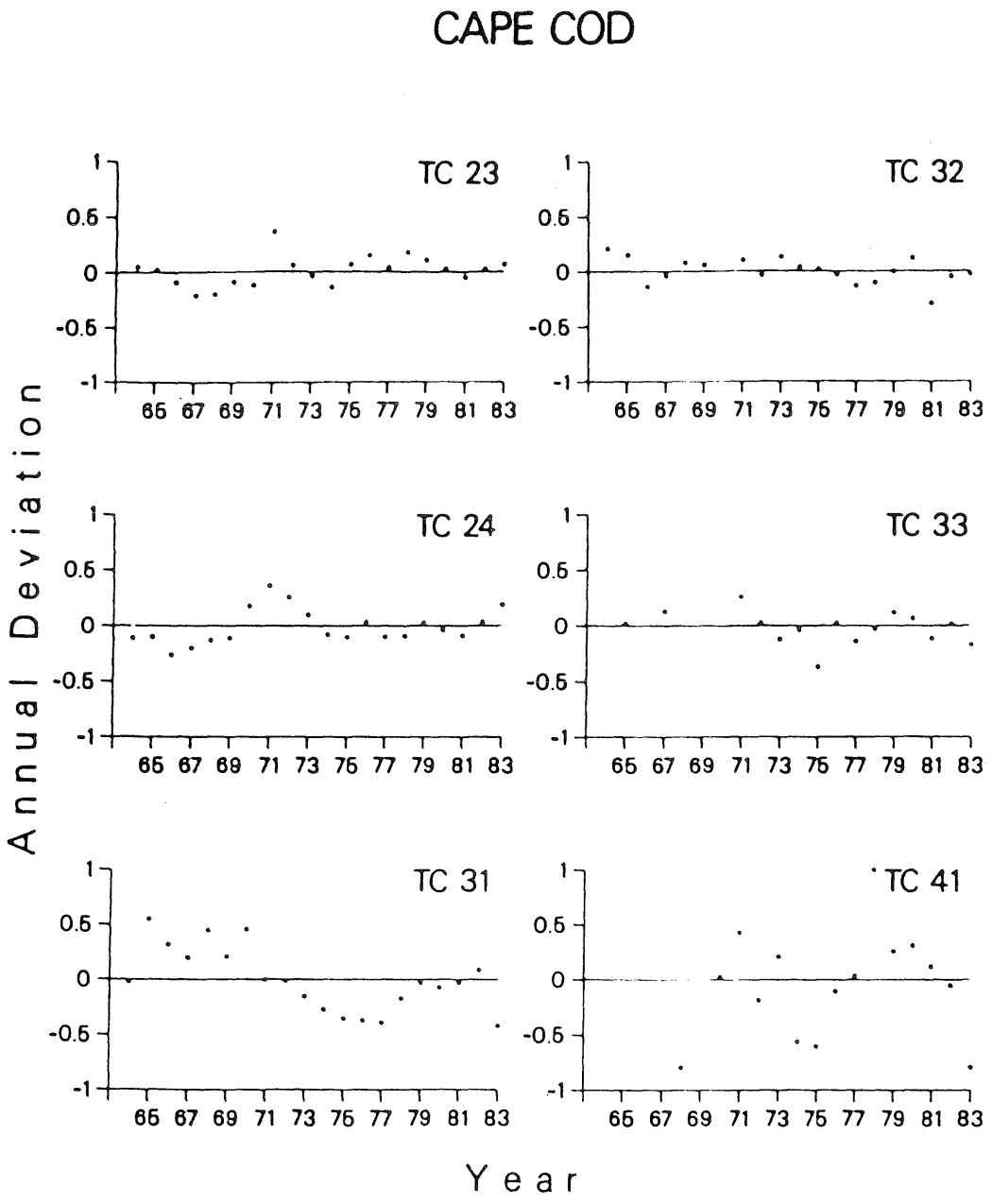


Figure 9. Deviations in annual fishing power from the 1964-1983 20-year mean for major vessel tonnage classes fishing on Cape Cod grounds.

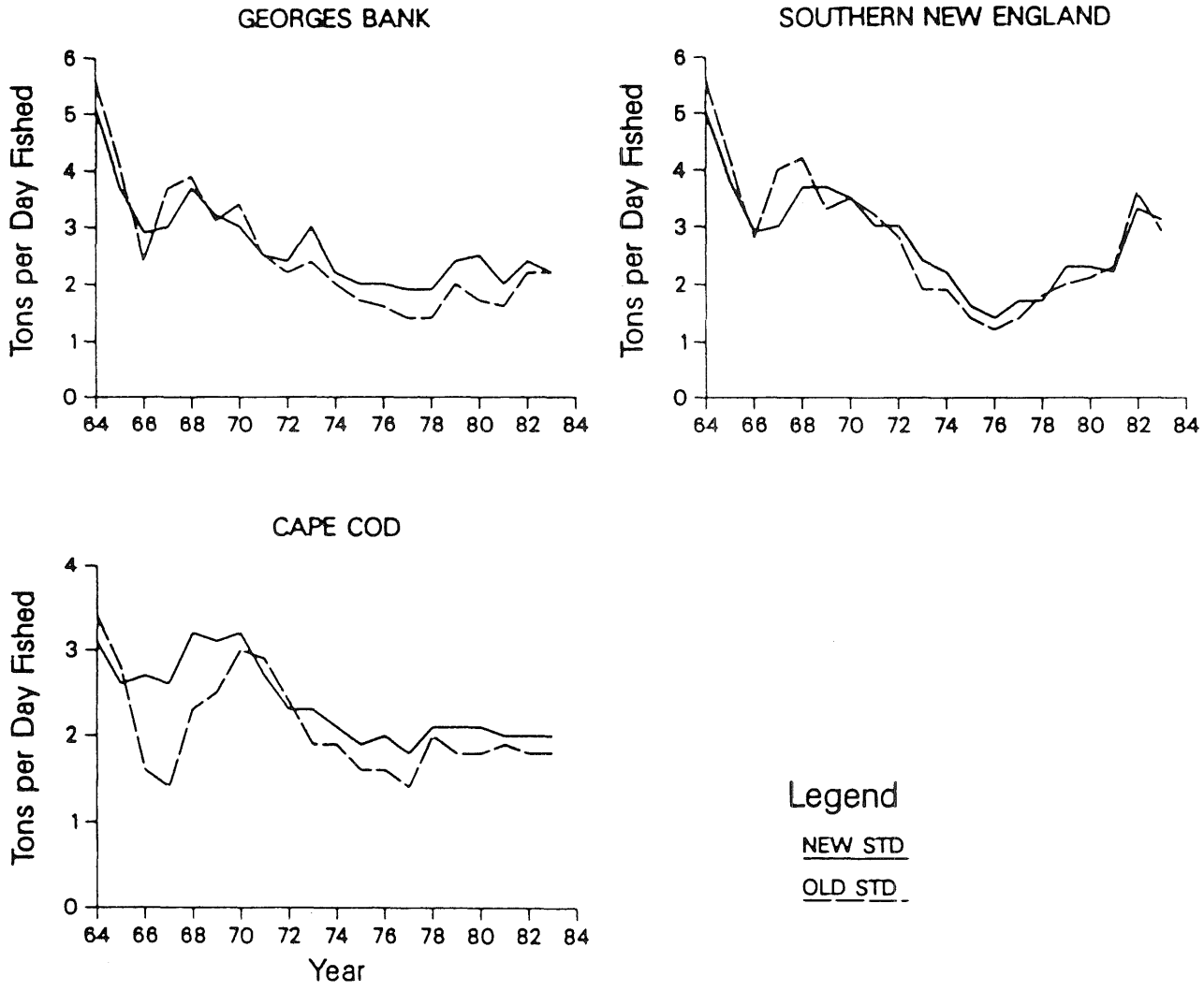


Figure 10. Trends in annual yellowtail flounder CPUE (metric tons per day fished) calculated with revised fishing power coefficients (NEW STD) and traditional coefficients (OLD STD).

APPENDICES

APPENDIX A. Calculation of Standardized Effort and CPUE.

APPENDIX B.

Table 1. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Georges Bank, 1964-1983.

Table 2. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Southern New England Grounds, 1964-1983.

Table 3. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Cape Cod Grounds, 1964-1983.

APPENDIX A

Calculation of Standardized Effort and CPUE

In the following example for Georges Bank (Appendix B, Table 1), annual standard fishing effort for yellowtail flounder is estimated for the data set by multiplying unadjusted fishing effort for each tonnage class by the corresponding fishing power coefficient as follows:

$$DF' = (DF_1 * FP_1) + (DF_2 * FP_2) + \ldots (DF_n * FP_n),$$

while annual unadjusted effort equals the sum over all tonnage classes,

$$DF = DF_1 + DF_2 + \ldots DF_n,$$

where:

DF_n = unadjusted days fished for tonnage class n,

FP_n = fishing power coefficient for tonnage class n, and

DF' = estimate of annual standard days fished for all tonnage classes.

Annual landings for the data set equals the sum of landings for each tonnage class,

$$L = L_1 + L_2 + \ldots L_n,$$

where:

L_n = landings for tonnage class n.

Standardized CPUE (CPUE') equals the sum of the landings divided by the sum of the standard days fished,

$$CPUE' = L/DF',$$

while unadjusted CPUE equals the sum of the landings divided by the unadjusted (raw) days fished,

$$CPUE = L/DF.$$

Using 1964 Georges Bank data, annual standard days fished equals

$$(13.0 * 0.57) + (396.4 * 0.80) + \ldots (2.5 * 1.17)$$
$$= 7.4 + 317.1 + \ldots 2.9 = 2593.0$$

while annual unadjusted days fished equals

$$13.0 + 396.4 + \ldots 2.5 = 2734.3,$$

and annual landings for the data set equals

$$46.0 + 1699.4 + \ldots 5.4 = 13184.2.$$

Thus, annual standardized CPUE equals

13184.2/2593.0 = 5.1 metric tons per standard day fished,

while annual unadjusted CPUE equals

13184.2/2734.3 = 4.8 metric tons per day fished.

Appendix B, Table 1. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Georges Bank, 1964-1983. Adjusted days fished calculated by applying 1964-1983 fishing power coefficients to unadjusted fishing effort by vessel tonnage class for the appropriate calendar year.

	Vessel Tonnage Class								CPUE	
	24	25	31	32	33	41	42	Total	Landings Per Day Fished	Landings Per Adj. Day Fished
1964										
Landings	46.0	1699.4	8140.5	2664.3	594.9	33.7	5.4	13184.2		
Days Fished	13.0	396.4	1667.0	520.3	127.1	8.0	2.5	2734.3	4.8	
Adj. Days Fished	7.4	317.1	1600.3	520.3	136.0	9.0	2.9	2593.0		5.1
1965										
Landings	9.6	949.0	817.6	2937.1	523.3	96.1	-	5332.7		
Days Fished	4.0	298.3	221.6	809.6	148.1	19.0	-	1500.6	3.6	
Adj. Days Fished	2.3	238.6	212.7	809.6	158.5	21.3	-	1443.0		3.7
1966										
Landings	5.0	660.9	3829.7	3843.0	504.8	823.7	-	9667.1		
Days Fished	4.0	281.4	1350.8	1311.9	172.5	287.8	-	3408.5	2.8	
Adj. Days Fished	2.3	225.1	1296.8	1311.9	184.6	322.3	-	3343.0		2.9
1967										
Landings	-	353.9	2862.6	3189.9	336.7	387.5	-	7130.6		
Days Fished	-	155.2	979.6	1030.0	111.8	133.2	-	2409.7	3.0	
Adj. Days Fished	-	124.2	940.4	1030.0	119.6	149.2	-	2363.4		3.0
1968										
Landings	15.5	242.0	4818.4	5243.3	621.9	689.8	26.9	11657.8		
Days Fished	4.0	76.2	1334.5	1424.1	154.0	215.3	10.0	3218.1	3.6	
Adj. Days Fished	2.3	61.0	1281.1	1424.1	164.8	241.1	11.7	3186.1		3.7
1969										
Landings	4.7	166.3	5712.9	5933.1	1363.0	1177.2	52.0	14409.2		
Days Fished	1.4	55.7	1831.8	1780.4	419.2	365.6	17.0	4471.0	3.2	
Adj. Days Fished	0.8	44.6	1758.5	1780.4	448.5	409.5	19.9	4462.2		3.2
1970										
Landings	23.6	130.7	4367.6	6304.9	2046.8	1010.5	-	13884.1		
Days Fished	6.7	55.4	1471.5	2053.8	710.0	343.6	-	4641.6	3.0	
Adj. Days Fished	3.8	44.3	1412.6	2053.8	760.3	384.8	-	4659.6		3.0
1971										
Landings	9.4	422.7	3047.4	4383.9	1039.4	681.1	-	9583.9		
Days Fished	6.1	217.3	1216.4	1752.8	437.4	280.4	-	3910.3	2.4	
Adj. Days Fished	3.5	173.8	1167.7	1752.8	468.0	314.0	-	3879.8		2.5
1972										
Landings	-	346.5	3602.4	6177.4	1440.9	882.9	-	12450.1		
Days Fished	-	170.8	1551.2	2502.0	589.0	384.7	-	5197.8	2.4	
Adj. Days Fished	-	136.6	1489.2	2502.0	630.2	430.9	-	5188.9		2.4
1973										
Landings	0.1	438.2	3204.4	6732.0	2371.8	1491.5	128.0	14366.0		
Days Fished	0.1	156.1	1154.4	2253.6	723.2	453.2	38.1	4778.7	3.0	
Adj. Days Fished	0.1	124.9	1108.2	2253.6	773.8	507.6	44.6	4772.7		3.0

Appendix B, Table 1 (continued)

	Vessel Tonnage Class								CPUE	
	24	25	31	32	33	41	42	Total	Landings Per Day Fished	Landings Per Adj. Day Fished
1974										
Landings	-	135.8	2457.2	6186.7	2837.8	1506.0	73.3	13196.8		
Days Fished	-	49.6	1124.1	2703.9	1249.7	670.0	22.9	5819.3	2.3	
Adj. Days Fished	-	39.7	1079.1	2703.9	1337.2	750.4	26.8	5937.1		2.2
1975										
Landings	1.9	83.1	1949.5	5036.1	3184.6	968.1	2.6	11225.9		
Days Fished	1.0	37.5	1100.6	2503.2	1490.7	467.0	0.8	5600.8	2.0	
Adj. Days Fished	0.6	30.0	1056.6	2503.2	1595.0	523.0	0.9	5709.3		2.0
1976										
Landings	4.0	38.3	1759.2	3522.1	4358.8	280.6	-	9963.0		
Days Fished	3.0	23.1	962.9	1833.6	2010.8	140.2	-	4973.6	2.0	
Adj. Days Fished	1.7	18.5	924.4	1833.6	2151.6	157.0	-	5086.8		2.0
1977										
Landings	-	88.8	1020.7	2189.4	3651.0	434.7	-	7384.6		
Days Fished	-	72.7	595.8	1232.9	1639.1	157.7	-	3698.3	2.0	
Adj. Days Fished	-	58.2	572.0	1232.9	1753.8	176.6	-	3793.5		1.9
1978										
Landings	-	19.6	174.4	533.4	1522.0	294.7	-	2544.1		
Days Fished	-	11.1	118.5	315.6	748.4	118.4	-	1311.9	1.9	
Adj. Days Fished	-	8.9	113.8	315.6	800.8	132.6	-	1371.7		1.9
1979										
Landings	14.6	90.0	310.5	535.7	1388.0	535.1	-	2873.9		
Days Fished	14.2	56.4	136.8	246.0	547.1	173.6	-	1174.2	2.4	
Adj. Days Fished	8.1	45.1	131.3	246.0	585.4	194.4	-	1210.3		2.4
1980										
Landings	28.4	31.2	181.7	552.3	1479.7	595.0	-	2868.3		
Days Fished	24.8	31.1	91.4	260.3	514.2	185.3	-	1107.0	2.6	
Adj. Days Fished	14.1	24.9	87.7	260.3	550.2	207.5	-	1144.7		2.5
1981										
Landings	4.5	50.2	228.6	559.1	1286.0	452.6	-	2581.0		
Days Fished	4.0	43.0	141.5	278.9	574.5	187.0	-	1228.8	2.1	
Adj. Days Fished	2.3	34.4	135.8	278.9	614.7	209.4	-	1275.5		2.0
1982										
Landings	1.0	105.6	338.7	1475.3	4389.0	2029.1	3.1	8341.8		
Days Fished	2.0	18.9	166.5	655.4	1748.5	660.3	1.5	3253.0	2.6	
Adj. Days Fished	1.1	15.1	159.8	655.4	1870.9	739.5	1.8	3443.6		2.4
1983										
Landings	-	3.1	316.7	1094.1	5592.6	2219.6	-	9226.1		
Days Fished	-	4.0	127.8	532.1	2494.1	845.6	-	4003.6	2.3	
Adj. Days Fished	-	3.2	122.7	532.1	2668.7	947.1	-	4273.8		2.2

Appendix B, Table 2. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Southern New England grounds, 1964-1983. Adjusted days fished calculated by applying 1964-1983 fishing power coefficients to unadjusted fishing effort by vessel tonnage class for the appropriate calendar year.

	Vessel Tonnage Class										CPUE	
	21	22	23	24	25	31	32	33	41	Total	Landings Per Day Fished	Landings Per Adj. Day Fished
1964												
Landings	70.9	11.2	303.1	1533.1	5617.1	7784.5	2212.1	224.9	13.4	17770.3		
Days Fished	30.5	4.8	38.5	323.7	1216.0	1693.9	429.0	48.9	2.7	3788.0	4.7	
Adj. Days Fished	28.1	4.4	35.4	304.3	1167.4	1558.4	429.0	53.3	2.8	3583.1		5.0
1965												
Landings	37.3	7.5	233.6	1045.0	5450.6	8098.7	1866.9	322.1	3.5	17065.2		
Days Fished	20.6	1.5	42.4	292.4	1690.6	2187.2	487.8	75.0	1.3	4799.4	3.6	
Adj. Days Fished	19.0	1.4	39.0	274.9	1623.0	1012.2	487.8	82.4	1.4	4541.1		3.8
1966												
Landings	12.3	23.9	88.6	426.4	3385.4	6183.4	1970.5	191.6	105.9	12388.0		
Days Fished	11.3	6.5	23.3	143.2	1313.7	2202.8	731.0	74.9	40.7	4547.4	2.7	
Adj. Days Fished	10.4	6.0	21.4	134.6	1261.2	2026.6	731.0	81.6	42.7	4315.5		2.9
1967												
Landings	13.4	1.8	28.7	379.6	2022.3	3977.3	1469.3	217.3	80.9	8190.6		
Days Fished	7.2	1.6	6.0	117.9	694.0	1446.9	524.3	88.5	32.5	2918.9	2.8	
Adj. Days Fished	6.6	1.5	5.5	110.8	666.2	1331.1	524.3	96.5	34.1	2776.6		3.0
1968												
Landings	7.4	26.6	64.1	516.3	1963.3	5574.4	2627.9	259.8	212.9	11252.7		
Days Fished	2.8	6.2	11.0	126.2	527.8	1633.0	725.3	74.8	54.8	3162.0	3.6	
Adj. Days Fished	2.6	5.7	10.1	118.6	506.7	1502.4	725.3	81.5	57.5	3010.4		3.7
1969												
Landings	6.9	27.3	84.8	383.5	1384.7	4311.7	2344.2	270.3	57.9	8871.3		
Days Fished	2.9	6.4	15.3	115.0	369.3	1254.8	681.2	66.5	21.3	2532.6	3.5	
Adj. Days Fished	2.7	5.9	14.1	108.1	354.5	1154.4	681.2	72.5	22.4	2415.8		3.7
1970												
Landings	7.7	25.5	110.0	347.3	1723.3	3828.8	3138.7	184.5	120.1	9485.9		
Days Fished	0.9	7.2	18.3	97.8	504.0	1248.9	854.3	66.4	37.1	2835.0	3.4	
Adj. Days Fished	0.8	6.6	16.8	91.9	483.8	1149.0	854.3	72.4	39.0	2714.6		3.5
1971												
Landings	3.5	23.6	106.6	185.8	1162.8	2252.3	2532.7	377.0	93.1	6737.4		
Days Fished	0.3	8.2	17.2	59.5	383.0	813.1	872.6	123.5	41.1	2318.5	2.9	
Adj. Days Fished	0.3	7.5	15.8	55.9	367.7	748.1	872.6	134.6	43.2	2245.7		3.0
1972												
Landings	-	8.8	46.1	183.6	1256.5	2443.6	2818.4	394.9	37.4	7189.3		
Days Fished	-	3.2	11.1	67.2	400.8	868.6	965.0	128.9	13.5	2458.2	2.9	
Adj. Days Fished	-	2.9	10.2	63.2	384.8	799.1	965.0	140.5	14.2	2379.9		3.0
1973												
Landings	-	4.8	4.9	83.1	822.4	2259.8	2331.9	626.4	114.5	6247.8		
Days Fished	-	4.8	2.3	39.2	322.5	978.8	995.2	282.9	42.6	2668.3	2.3	
Adj. Days Fished	-	4.4	2.1	36.8	309.6	900.5	995.2	308.4	44.7	2601.7		2.4

Appendix B, Table 2 (continued).

	Vessel Tonnage Class										CPUE	
	21	22	23	24	25	31	32	33	34	Total	Landings Per Day Fished	Landings Per Adj. Day Fished
1974												
Landings	-	3.7	13.1	47.1	527.4	2255.3	2026.2	684.3	27.5	5584.6		
Days Fished	-	2.2	4.3	21.2	253.8	1075.9	955.2	259.7	11.7	2583.9	2.2	
Adj. Days Fished	-	2.0	4.0	19.9	243.6	989.8	955.2	283.1	12.3	2509.9		2.2
1975												
Landings	-	1.0	4.6	11.5	200.1	986.2	841.6	455.7	34.8	2535.5		
Days Fished	-	1.8	3.0	11.6	163.2	680.9	486.3	252.3	19.0	1618.1	1.6	
Adj. Days Fished	-	1.7	2.8	10.9	156.7	626.9	486.3	275.0	20.0	1579.8		1.6
1976												
Landings	-	0.1	13.9	7.3	113.8	338.5	397.5	264.2	20.6	1155.9		
Days Fished	-	0.1	8.0	11.5	120.4	268.8	273.2	153.1	7.9	843.0	1.4	
Adj. Days Fished	-	0.1	7.4	10.8	115.6	247.3	273.2	166.9	8.3	829.6		1.4
1977												
Landings	-	6.3	25.0	26.0	298.8	436.1	610.8	495.4	31.7	1930.1		
Days Fished	-	8.0	13.6	17.2	182.2	277.5	367.8	259.5	14.7	1140.6	1.7	
Adj. Days Fished	-	7.4	12.5	16.2	174.9	255.3	367.8	282.9	15.4	1130.4		1.7
1978												
Landings	-	-	9.9	6.9	131.2	235.5	320.2	598.5	33.7	1335.9		
Days Fished	-	-	2.6	7.2	106.4	161.4	181.8	288.7	12.5	760.5	1.8	
Adj. Days Fished	-	-	2.4	6.8	102.1	148.5	181.8	314.7	13.1	769.4		1.7
1979												
Landings	0.2	20.0	38.6	91.4	462.0	661.9	1386.2	1280.3	182.3	4122.9		
Days Fished	0.2	15.2	17.6	69.4	277.0	337.7	549.9	474.8	47.0	1788.8	2.3	
Adj. Days Fished	0.2	14.0	16.2	65.2	265.9	310.7	549.9	517.5	49.4	1789.0		2.3
1980												
Landings	-	8.1	48.8	77.6	605.4	750.3	1510.2	991.4	203.9	4195.7		
Days Fished	-	7.8	19.1	61.5	287.9	346.7	641.1	377.1	72.2	1814.2	2.3	
Adj. Days Fished	-	7.2	17.6	57.8	276.4	319.0	641.1	411.0	75.8	1085.9		2.3
1981												
Landings	-	10.9	25.1	78.8	543.9	490.3	1014.7	708.0	46.8	2918.5		
Days Fished	-	6.0	9.3	67.6	246.2	234.8	480.4	262.4	24.3	1109.0	2.6	
Adj. Days Fished	-	5.5	8.6	63.5	236.4	216.0	480.4	286.0	25.5	1321.9		2.2
1982												
Landings	0.7	4.0	75.4	84.9	635.6	1091.5	2726.5	3371.5	669.5	8659.6		
Days Fished	0.3	2.0	31.4	40.3	231.1	374.3	804.3	890.4	172.5	2546.6	3.4	
Adj. Days Fished	0.3	1.8	28.9	37.9	221.9	344.4	804.3	970.5	181.1	2591.1		3.3
1983												
Landings	26.5	5.4	77.2	137.9	836.4	1023.5	4699.4	7024.6	1513.6	15344.5		
Days Fished	19.8	2.7	25.9	40.4	261.5	354.7	1471.9	2194.9	423.8	4795.5	3.2	
Adj. Days Fished	18.2	2.5	23.8	38.0	251.0	326.3	1471.9	2392.4	445.0	4969.1		3.1

Appendix B, Table 3. Landings (metric tons), days fished, and adjusted days fished, and resulting CPUE estimates for yellowtail flounder fishing trips on Cape Cod grounds, 1964-1983. Adjusted days fished calculated by applying 1964-1983 fishing power coefficients to unadjusted fishing effort by vessel tonnage class for the appropriate calendar year.

	Vessel Tonnage Class										CPUE	
	21	22	23	24	25	31	32	33	41	Total	Landings Per Days Fished	Landings Per Adj. Day Fished
1964												
Landings	-	139.0	85.8	390.3	395.6	84.8	24.6	-	-	1120.1		
Days Fished	-	75.3	53.9	158.2	132.3	28.5	7.5	-	-	455.7	2.5	
Adj. Days Fished	-	36.9	30.2	126.6	132.3	28.8	6.1	-	-	360.9		3.1
1965												
Landings	-	119.9	79.6	271.0	268.7	20.4	3.7	1.9	-	765.2		
Days Fished	-	74.6	58.6	138.6	104.6	5.2	1.6	0.9	-	384.1	2.0	
Adj. Days Fished	-	36.6	32.8	110.9	104.6	5.3	1.3	0.9	-	292.4		2.6
1966												
Landings	4.4	64.2	94.1	334.1	420.7	114.4	45.0	-	-	1076.9		
Days Fished	4.1	51.6	64.5	159.6	155.0	36.0	25.5	-	-	487.6	2.2	
Adj. Days Fished	1.3	25.3	36.1	127.7	155.0	36.4	20.7	-	-	402.5		2.7
1967												
Landings	-	17.6	30.2	258.2	238.4	137.5	63.0	-	-	744.9		
Days Fished	-	18.6	29.0	125.4	91.9	38.2	33.2	-	-	336.3	2.2	
Adj. Days Fished	-	9.1	16.2	100.3	91.9	38.6	26.9	-	-	283.0		2.6
1968												
Landings	-	62.1	40.2	376.3	255.4	107.8	43.7	1.3	0.9	887.7		
Days Fished	-	44.7	32.6	135.6	87.0	23.6	17.5	0.5	0.8	342.3	2.6	
Adj. Days Fished	-	21.9	18.3	108.5	87.0	23.8	14.2	0.5	0.9	275.1		3.2
1969												
Landings	-	44.4	26.6	163.2	183.7	125.4	32.8	-	-	576.1		
Days Fished	-	22.7	15.4	62.4	65.3	36.7	11.0	-	-	213.5	2.7	
Adj. Days Fished	-	11.1	8.6	49.9	65.3	37.1	8.9	-	-	180.9		3.2
1970												
Landings	-	22.1	14.7	154.1	138.3	48.4	68.0	27.2	27.3	500.1		
Days Fished	-	17.9	10.0	61.2	49.6	14.8	9.9	8.0	9.0	180.4	2.8	
Adj. Days Fished	-	8.8	5.6	49.0	49.6	14.9	8.0	7.6	10.5	154.0		3.2
1971												
Landings	-	56.9	21.6	263.4	161.0	118.3	75.8	23.0	26.0	746.0		
Days Fished	-	46.5	7.5	92.3	76.4	49.8	36.8	9.0	7.5	325.8	2.3	
Adj. Days Fished	-	22.8	4.2	73.8	76.4	50.3	29.8	8.6	8.8	274.7		2.7
1972												
Landings	3.1	68.2	14.5	187.6	140.7	139.6	30.6	36.5	18.0	638.8		
Days Fished	1.8	40.6	11.2	82.1	73.8	64.6	17.0	19.5	8.0	318.6	2.0	
Adj. Days Fished	0.6	19.9	6.3	65.7	73.8	65.2	13.8	18.5	9.4	273.2		2.3
1973												
Landings	9.0	54.2	18.7	190.0	247.5	134.5	115.0	49.5	43.5	861.9		
Days Fished	7.3	36.1	14.6	89.8	123.0	64.4	56.8	27.5	16.0	435.5	2.0	
Adj. Days Fished	2.3	10.1	8.2	71.8	123.0	65.0	46.0	26.1	18.7	371.2		2.3

Appendix B, Table 3 (continued)

	Vessel Tonnage Class										CPUE	
	21	22	23	24	25	31	32	33	41	Total	Landings Per Day Fished	Landings Per Adj. Day Fished
1974												
Landings	18.2	62.0	67.8	214.7	223.4	231.4	146.9	112.9	44.5	1121.8		
Days Fished	18.5	50.8	51.2	121.5	102.6	116.8	78.2	62.7	23.8	626.1	1.8	
Adj. Days Fished	5.7	24.9	28.7	97.2	102.6	118.0	63.3	59.6	27.8	527.8		2.1
1975												
Landings	5.0	62.4	58.6	231.6	218.2	186.1	115.7	38.3	20.4	936.3		
Days Fished	6.1	44.5	35.4	142.8	111.2	120.0	69.4	28.1	16.7	574.2	1.6	
Adj. Days Fished	1.9	21.8	19.8	114.2	111.2	121.2	56.2	26.7	19.5	492.5		1.9
1976												
Landings	5.0	66.4	96.2	431.2	444.0	315.2	342.9	200.9	39.0	1940.8		
Days Fished	28.0	45.9	63.8	240.4	231.7	203.4	200.3	106.6	16.7	1136.8	1.7	
Adj. Days Fished	8.7	22.5	35.7	192.3	231.7	205.4	162.2	101.3	19.5	979.3		2.0
1977												
Landings	0.3	35.2	57.2	310.7	338.6	245.6	126.8	178.4	22.6	1315.4		
Days Fished	1.0	48.2	48.6	204.9	169.8	178.6	94.2	82.8	8.9	837.0	1.6	
Adj. Days Fished	0.3	23.6	27.2	163.9	169.8	180.4	76.3	78.7	10.4	730.6		1.8
1978												
Landings	-	7.8	103.1	364.1	349.0	298.3	168.5	236.6	1.2	1528.6		
Days Fished	-	10.1	69.5	182.6	165.2	166.6	108.4	124.6	0.2	827.2	1.8	
Adj. Days Fished	-	4.9	38.9	146.1	165.2	168.3	87.8	118.4	0.2	729.8		2.1
1979												
Landings	11.1	55.6	121.0	471.3	506.3	313.2	213.7	277.0	28.9	1998.1		
Days Fished	9.7	62.7	87.9	246.5	245.3	156.5	134.0	133.4	12.6	1088.6	1.8	
Adj. Days Fished	3.0	30.7	49.2	197.2	245.3	158.1	108.5	126.7	14.7	933.4		2.1
1980												
Landings	14.8	82.2	125.4	351.0	546.9	396.1	174.9	291.5	61.6	2044.4		
Days Fished	45.0	149.1	90.6	199.9	259.9	194.9	96.8	139.1	20.3	1195.5	1.7	
Adj. Days Fished	14.0	73.1	50.7	159.9	259.9	196.8	78.4	132.1	23.8	988.7		2.1
1981												
Landings	24.5	43.6	113.8	211.0	333.9	260.7	92.3	140.0	21.4	1241.2		
Days Fished	31.6	49.1	90.2	106.1	147.1	128.9	84.9	92.2	7.8	737.9	1.7	
Adj. Days Fished	9.8	24.1	50.5	84.9	147.1	130.2	68.8	87.6	9.1	612.1		2.0
1982												
Landings	5.4	56.4	89.0	240.1	386.4	223.7	130.1	198.1	54.9	1384.1		
Days Fished	8.2	64.8	65.7	124.5	191.4	114.1	88.6	111.6	24.4	793.3	1.7	
Adj. Days Fished	2.5	31.8	36.8	99.6	191.4	115.2	71.8	106.0	28.5	683.6		2.0
1983												
Landings	1.1	54.7	32.1	114.3	121.9	89.2	86.1	135.4	5.7	640.5		
Days Fished	1.5	27.6	19.3	37.8	55.1	72.4	57.7	92.1	7.3	370.8	1.7	
Adj. Days Fished	0.5	13.5	10.8	30.2	55.1	73.1	46.7	87.5	8.5	325.9		2.0