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Status of Winter Flounder (*Pseudopleuronectes americanus*) stocks in the Gulf of Maine, Southern New England, and Middle Atlantic Areas

by

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EXECUTIVE SUMMARY

Total USA commercial landings of winter flounder from Gulf of Maine, Southern New England, and Middle Atlantic areas decreased 40% from a peak of 13.6 thousand mt in 1981 to 8.2 thousand mt in 1985. The largest single decrease in this period was between 1984-1985 (23%). Recreational landings for the North Atlantic and Mid-Atlantic areas in 1984 (13.1 thousand mt) were the second highest, behind 1979 (14.0 thousand mt). Landings by Canada and distant water fleets (primarily USSR) were highest prior to 1974. Since 1974, landings by non-USA vessels have been negligible.

Commercial landings in the Gulf of Maine area declined slightly from 1.7 thousand mt in 1984 to 1.6 thousand mt in 1985, down substantially from a peak of 2.8 thousand mt in 1982. Catch-per-unit-effort (CPUE; all trips) for tonnage class 2 otter trawlers decreased to a series low in 1985 (0.32 mt/df) from the 1981 high of 0.53 mt/df. In general, research vessel survey indices of abundance (spring, autumn;inshore, offshore; NEFC, Massachusetts DMF) decreased substantially between 1983-1986. These declines coupled with decreases in CPUE and an increased reliance on small fish suggest declining resource abundance.

Commercial landings for the Southern New England stocks were highest in 1981 (11.1 thousand mt) and 1980 (10.6 thousand mt). Landings have since declined 40% to 6.5 thousand mt in 1985. CPUE (all trips) for tonnage class 3 otter trawls, declined steadily since 1981 (1.28 mt/df to 0.42 mt/df in 1985). Spring and autumn research vessel survey indices (NEFC inshore, offshore, Massachusetts DMF) indicate a substantial resource decline from

peak levels in 1980-1981.

The Middle Atlantic area contributes the smallest proportion of total commercial harvest (1964-1985 average 1.5%). Commercial landings in 1985 (92 mt) more than doubled over 1984 landings (44 mt) but were still significantly less than landings in the late 1970's-early 1980's. NEFC autumn survey indices increased in 1985, whereas spring indices (inshore and offshore) both decreased. Both commercial landings and offshore survey indices were very high in the late 1960's preceding a substantial decline to the 1970's.

Relative exploitation rates (landings per unit survey biomass) have increased to record-high levels in recent years for the Gulf of Maine and Southern New England winter flounder stocks. The implied current high fishing mortality, combined with minimum landing sizes below those at full maturity, result in average spawning stock biomass/recruit values well below target levels prescribed by the New England FMC (20% of maximum SSB/R). High fishing mortality on both juveniles and adults resulting at least in part from significant discards in small mesh fisheries, constitutes an impediment to the recovery of winter flounder stocks.

INTRODUCTION

This document describes the status of the near-shore winter flounder (Pseudopleuronectes americanus) resource in the Gulf of Maine, Southern New England, and Middle Atlantic areas. It represents a first assessment of the species following an initial review in 1978 by Lange and Lux. The offshore Georges Bank winter flounder resource is assessed elsewhere (Gabriel and Foster 1986).

The data presented herein include U.S. (1964-1985) and distant water fleet (1962-1985) commercial nominal catch (defined as live weight equivalent of commercial landings excluding discards,hereafter referred to as landings), recreational landings estimates (1979-1985), and research vessel bottom trawl survey data (inshore and offshore; Northeast Fisheries Center (NEFC) 1963-1985, Massachusetts Division of Marine Fisheries (DMF), for 1978-1985). Commercial catch-per-unit effort (CPUE) indices based on trips landing various percentages of winter flounder are presented by stock area (1964-1985). The status of winter flounder by stock area is discussed, based on time series trends in commercial landings, CPUE and research vessel survey indices. Survey length frequencies are also considered.

MANAGEMENT

The New England Fishery Management Council has included winter flounder in its recently implemented Atlantic Demersal Finfish Fishery Management Plan. This plan includes a minimum commercial size for winter flounder of 11 inches (28 cm), as well as spawning stock biomass per recruit targets, and minimum

otter trawl mesh sizes. Other regulations affecting winter flounder include areas closed to protect haddock which may be taken with winter flounder in demersal trawling operations.

Various states have also enacted minimum size constraints for winter flounder, as follows:

Maine	- 11" = 28 cm	
New Hampshire	- 11" = 28 cm	(max. 5 fish less than 11")
Massachusetts	- 12" = 30 cm	
Rhode Island	- 11" = 28 cm	
Connecticut	- 10" = 25 cm	
New York	- 8" = 20 cm	
New Jersey	- 6" = 15 cm	

In general, these minimum size regulations are based on optimum yield per recruit objectives, or are set to ensure at least one spawning prior to capture. The adequacy of current size limits to achieve these management goals is evaluated in this paper based on maturity data (Morse 1977), and mesh selectivity coefficients (Smolowitz 1983).

DISCARD

Langan and Howell (MS 1986) assessed discard for various gear types fished in the western Gulf of Maine. Although discard rates for winter flounder were the lowest for the four flounder species evaluated, reported discard of winter flounder for 5.5 inch trawl cod-ends averaged 11.4% of the total winter flounder catch (including discards). Winter flounder discards were 42% of the total winter flounder catch in the northern shrimp fishery (average mesh size of 1.75 inches).

BIOLOGY

Distribution

Winter flounder occur in coastal waters from the south coast of Labrador to Georgia, and on offshore shoals, such as Georges Bank and Nantucket Shoals. In coastal waters, the species is usually found within 24 km (15 miles) of the shore. NEFC offshore research vessel trawl surveys have recorded catches of winter flounder at depths ranging from 36 m to 225 m (20 fm to 125 fm), with a mean depth of occurrence of 81 m (45 fm). Inshore, winter flounder can be found on all bottom types, but prefer sandy mud, and weedy or grassy bottoms (sand and gravel, however are preferred on Georges Bank). Color and pigment patterns vary to reflect the bottom (Bigelow and Schroeder 1953). Winter flounder can tolerate temperatures of from -1°C in winter to 22°C in summer in estuaries; and appears unaffected by wide changes in salinity occurring in estuaries with only slightly brackish water (Lange and Lux 1978).

Migrations of winter flounder are usually local, seasonal, onshore to offshore and back, and related to water temperature (McCracken 1963). In summer as the temperature reaches 15°C, mature flounder disperse from shoal areas to deeper waters but can be restricted to temperatures above 12°C) (McCracken 1963). Larger, older fish move further inshore than do younger fish (e.g., age four or younger; Massachusetts Division of Marine Fisheries 1961). In autumn, ripening individuals return to shallow water (Howe et al. 1970). In winter, mature fish move into bays and estuaries to spawn. In spring, both mature and immature fish are found inshore (McCracken 1963).

Stock Structure

Three stocks of winter flounder have been identified off the Northeast U.S.A. coast, based on fin ray counts (Lux et al. 1970) and tagging studies (Howe et al. 1970): (1) north of Cape Cod (Gulf of Maine); (2) east and south of Cape Cod (Southern New England and Middle Atlantic); and (3) Georges Bank. The two near-shore stocks may extend north to Nova Scotia and south to New Jersey. Examining mean pectoral fin ray counts from fish from New Jersey to Nova Scotia, Perlmutter (1947) found differences only among those north and south of Cape Cod and from Georges Bank. The potential degree of dispersion and interbreeding may be highest south of Cape Cod, declining along the tip of the Cape, and can be lowest between Georges Bank and inshore regions (Howe et al. 1970). Interbreeding may occur when winter flounder "home" to estuaries in Massachusetts, based on differences meristic characteristics (Pierce and Howe 1977).

Even though the above research indicates only two near-shore stocks, two stock units have been recognized south of Cape Cod in the present paper: a Southern New England and Middle Atlantic group, separated by the Hudson Canyon. This division was made since trends in resource abundance and landings indicated different resource dynamics in the two areas.

For the purposes of the present paper, the above units defined by statistical areas within a stock for commercial landings data are as follows: Gulf of Maine, 511-515; Southern New England, 521, 526, 537-539, 611-613, 616; and Middle Atlantic, 614, 615, 621, 622, 625, 626, 631, 632, 635, 636 (Figure 1). NEFC offshore sampling strata include the following: Gulf of Maine, 24, 26-30, 36-40; Southern New England, 1-12, 25; Middle Atlantic 61-76 (Figure 2). Corresponding inshore strata by stock area are as follows: Gulf of Maine,

57-82; Southern New England, 1-8, 45-56; and Middle Atlantic, 9-44 (Figure 2). As the Great South Channel area appears to be a transition regions between the Georges Bank, Gulf of Maine and Southern New England stocks, data from this area were not included in any of the following analyses. Data were analyzed from the Massachusetts DMF trawl surveys for sampling areas (Figure 3) corresponding with stock areas (Figure 2). Massachusetts Bay and Cape Cod Bay were considered to be representative of the Gulf of Maine stock, while East of Cape Cod, Nantucket Sound and Buzzards Bay/Vineyard Sound were considered to be representative of the Southern New England stock.

Spawning and Early Life History

Winter flounder spawn from January to May when water temperature is near the annual minimum. Spawning is inhibited if water temperatures exceed 6°C. In coastal waters, most spawning occurs in estuaries (Bigelow and Schroeder, 1953). Fecundity can range between 500 and 610 thousand eggs per female (Bigelow and Schroeder 1953; Saila 1962; but can also reach over 2 million eggs per female (Kennedy and Steele 1971). Morse (1977) calculated length at 50% maturity as 25 cm for males and 26 cm for females. Lengths at 75% maturity were 29 and 31 cm, respectively.

Eggs are demersal and adhesive, hatching on the bottom after 15 days at a temperature of 4°C (Bigelow and Schroeder 1953). Larvae are planktonic, but frequently rest on the bottom. This behavior, combined with egg characteristics, may be an adaptive advantage to minimize losses from estuarine nursery areas to tidal currents and flushing (Pearcy 1962; Bigelow and Schroeder 1953). Metamorphosis is complete at 8 mm, 8 to 25 weeks after hatching, depending on temperature (Bigelow and Schroeder 1953). Young of the

year remain near the estuaries and bays in which they were spawned during the first year of life, moving into deeper waters in subsequent years (Perlmutter 1947).

RECREATIONAL FISHERY

Winter flounder is one of the most highly desired species in the recreational fishery along the northeastern coast of the United States second only to bluefish in the North Atlantic region (Maine to Connecticut) (U.S. Dept. of Commerce 1984, 1985a, 1985b, 1986). The total number of winter flounder landed in the North Atlantic region exceeded landings of any other species. In the Mid-Atlantic region, winter flounder were sought behind bluefish, summer flounder, and weakfish in 1979 and 1980. It was the third most sought after species behind bluefish and summer flounder during 1982-1984.

Recreational landings of winter flounder from Maine to Virginia, estimated at 9.9 thousand mt in 1984, increased in 1985 to 13.1 thousand mt, the last year for which data are currently available (Table 1). Sampling procedures for data prior to 1979 are inconsistent with those for later years, as a result only data for 1979 -1985 are presented in this paper. Landings from 1979 to 1983 fluctuated between 14.0 thousand mt and 7.6 thousand mt, prior to the increase to 1985. The 1985 total was the second highest behind 1979 (14.0 thousand mt).

In the North Atlantic most landings originated from Massachusetts while landings from New York dominated in the Mid-Atlantic. There has been an overall decline in the proportion of landings from the North Atlantic since 1983. Mid-Atlantic landings have increased rapidly from 1982 -1985,

contributing the largest proportion of catches to the coastwide total during these years. The recent increase in the proportion of landings in the Mid-Atlantic region may reflect an increase in sampling intensity of the recreational fishery statistics program. The proportion of total commercial landings from Massachusetts ports fluctuated from 1982-1985 inconsistent with the proportion of recreational landings from this state. New York commercial landings decreased from 1982 to 1985 but recreational landings increased from 1982-1985.

DISTANT WATER FLEET FISHERY

Most winter flounder landings by distant water fleets (DWF) occurred prior to 1976 and were made by Canada and the USSR (Table 2). In 1977 the MFCMA regulations limiting landings by other countries were implemented. Total foreign landings increased overall from 1963-1967, they were substantially higher but fluctuating from 1968-1973, and decreased subsequently. Recent landings have fluctuated at levels substantially below historic levels.

Canadian landings increased from 1962-1965 and decreased in 1966-1967. They exceeded USSR landings during 1962-1964 and 1966. Landings by the USSR increased from 1966-1969, to the largest foreign landings in this time series (6.9 thousand mt) prior to a decrease from 1971-1975.

Winter flounder landings by NAFO divisions do not directly correspond to stock areas as defined in this document. NAFO division 5Y corresponds to the Gulf of Maine stock area while other NAFO subdivisions, 5Ze and 5Zw, and divisions 6A and 6B overlap Georges Bank, Southern New England, and Middle

Atlantic stock areas. U.S. sampling area 62 corresponds to the Middle Atlantic stock area.

ASSESSMENT OF STOCK STATUS

A. GULF OF MAINE

Commercial Landings

Of the three stocks considered in this document, U.S. commercial landings from the Gulf of Maine are second to Southern New England accounting for a mean of 17% of the total near-shore landings from the three near-shore stocks. Landings of winter flounder in the Gulf of Maine area were relatively stable from 1964-1974 (Table 3; Figure 4). There was a steady increase from 1974 (0.9 thousand mt) to 1982 (2.8 thousand mt). Since 1982, landings have declined to 1985 (1.6 thousand mt). Landings in 1985 were the lowest since 1976 (1.5 thousand mt).

The market category composition of landings was dominated by unclassified winter flounder from 1964-1972 (Table 4). This category contained all of what are now small, Xlarge, large/mix, medium, and peewee market categories. Generally, large market category winter flounder was the most important component of the landings from 1973-1976. Proportions of large and small market category winter flounder were about equal (mean % small = 50%; large = 49%) from 1978-1980. During 1980 and 1981 the proportion of landings of large winter flounder remained level while the proportion of small market category fish declined slightly. In 1982, the number of market categories doubled from 4 (unclassified, lemon sole, large and small) to 8 (X-large, large/mix, medium, and peewee in addition to the previous four). This increase made it more difficult to categorize market categories by specific length intervals.

Total landings of large and XLarge winter flounder have decreased since 1982, whereas, small size winter flounder (small and peewee market categories) landings comprised almost half the total landings in 1983 and 1984. Landings of peewees decreased by 43% from 1984-1985, while mediums more than tripled. Length ranges by market category generally follow the order: lemon sole>large>unclassified>small>medium>peewee.

Length frequencies derived from sampling commercial landings at dockside indicate that most fish landed measured between 25 cm and 45 cm, with the mode between 29 and 35 cm. during 1982-1985 (Figure 5). Data for 1984 indicate 35% of fish caught were less than 29 cm. This is more than a 50% increase (by number) over 1983. Landings in 1985 for winter flounder <30 cm. decreased.

Catch Per Unit Effort (CPUE)

The catch per unit effort (CPUE) index for the Gulf of Maine stock is based on catch (equivalent to landings) and effort by otter trawler vessels of 5-50 gross register tons (GRT) displacement, Tonnage Class 2 (TC 2; Table 5; Figure 6). Catches by this otter trawl tonnage class contributed 65-95% of the total catch from 1964-1985 (mean 77%). Effort was defined as days fished (df).

Days fished (df)/trip (defined as the length of a trip in days for all trips in which any winter flounder were caught) was the lowest from 1964-1968 (mean 0.40 df/trip) preceding a 32% increase (mean 0.59 df/trip) from 1969-1974. It increased to the time-series high from 1975-1980 (mean 0.85 df/trip). Days fished/trip decreased 33% in 1981 and continued to decrease to 1985 (1981-1985 mean 0.69 df/trip).

CPUE indices were calculated for the total fishery (all trips), directed fishery (trips where winter flounder comprised $\geq$ 50% of the total catch) and the highly directed fishery (trips where winter flounder comprised $\geq$ 80% of the total catch). The directed and highly directed fishery accounted for a mean of 52% and 35% of the catch and 14% and 8% of effort, respectively. CPUE (all trips) decreased rapidly from the 1968 high (0.96 mt/df) to 1976 (0.32 mt/df), the lowest in the time series. Since 1976 CPUE has fluctuated about an average of 0.42, considerably less than high levels seen in the late 1960's-early 1970's. CPUE decreased from 0.53 mt/df in 1981 to 0.32 mt/df in 1985, equalling the 1976 series low. At the same time, effort increased steadily from its lowest point in 1968 to the series high in 1980. Since 1980, effort has declined somewhat but still remains high. Catch, after remaining relatively stable from 1965 to 1974, peaked from 1980-1982 and decreased substantially to 1985. Catch in 1984 and 1985 was at levels close to those in the mid-1970's.

There has been an overall decrease in the CPUE for the directed fishery from 1971 (3.11 mt/df) to 1985 (1.17 mt/df), the lowest index in that time series. CPUE for the highly directed fishery followed the same trend as the directed fishery, peaking in 1971 (4.17 mt/df) followed by a decrease to 1985 (1.54 mt/df) also the lowest level in the time series. Examination of trends by vessel tonnage indicates that 11-15 GRT vessels (TC 23) have accounted for a declining proportion of directed catch of winter flounder since 1981 indicative of increased relative fishing by larger tonnage vessels.

Research Vessel Survey Indices

NEFC Offshore. Spring survey indices in weight (kg) and number of fish caught per tow increased 95% and 93% respectively in weight and number from 1978 to 1983, followed by 74% and 78% decreases in weights and numbers, respectively, to the 1985 levels (Table 6; Figure 7). Autumn survey indices have fluctuated with no apparent trend. The number per tow index decreased 57% from 1983 to 1985 while weight per tow decreased 41% during the same time period.

The mean length of Gulf of Maine winter flounder survey samples (Table 7, Appendix A-1) was 33.5 cm (coefficient of variation (CV) = 0.27, length range =26-39 cm) for the spring and 34.9 cm (CV = 0.39, length range = 28-44 cm) for the autumn. The higher mean length in autumn samples is probably due to the fact that during spring, spawning winter flounder are found inshore near estuaries, whereas smaller (pre-spawning) fish may remain further offshore. This is corroborated in the inshore NEFC and Massachusetts DMF survey data showing greater mean lengths in spring than in autumn.

NEFC Inshore The spring inshore survey indices decreased dramatically from the 1981 peak to the low 1984 indices preceding a small increase in 1985 (Table 8). The autumn indices followed a similar pattern initially but tended to increase from the 1981 level rather than decrease. The dramatic decrease in the indices in 1981 results from reduced sampling in that year and is not indicative of a pronounced decrease in resource abundance. Length frequencies are presented in Appendix A-2. The inshore spring index appears to be the most consistent of the NEFC research vessel survey time series for the Gulf of Maine stock, particularly since correlations between this index and commercial CPUE are the highest ("Conclusions and Implications").

Massachusetts Division of Marine Fisheries Inshore (Massachusetts DMF)

Both Cape Cod Bay and Massachusetts Bay sampling areas exhibit trends corresponding with the NEFC offshore indices. In the spring, the weight per tow index increased from 1978 to 1981, consistent with the offshore index (Table 9). The number per tow index fluctuated during this time. After a pronounced drop in 1982, the spring indices decreased from 1983 to 1985 also corresponding with the NEFC offshore indices. The autumn indices were highest in 1979 for the Cape Cod Bay area and 1980 in the Massachusetts Bay area. There was a steady decrease in the indices for both areas from 1982 to 1985. This was not reflected in the offshore indices. Length frequencies presented in Appendices A-3 and A-4.

Conclusions and Implications

Commercial landings and effort statistics indicate a substantial decline in winter flounder abundance (as evidenced by CPUE), from a peak in the late 1960's, to near-record low levels in the mid-1970's (Figure 6). Although CPUE was relatively high during the 1960's, landings of winter flounder from this stock area were low (<1000 mt/year) probably reflecting the relatively high abundance of other, more preferred, groundfish stocks in the near-shore Gulf of Maine region (ie. cod, pollock, American plaice, haddock; Murawski et al. 1983).

CPUE statistics for the Gulf of Maine region are significantly correlated with survey abundance indices from inshore waters. Statistically signifi-

cant correlations were developed between CPUE statistics and: (1) NEFC spring inshore indices (2) Massachusetts DMF spring Massachusetts Bay survey indices (Figure 8). CPUE statistics were not correlated with NEFC offshore survey indices (where small and highly variable proportion of the aggregate survey catch is taken). This analysis implies that trends in inshore survey indices are more reliable for analyzing the status of winter flounder. Inshore surveys sample in areas where small (young) winter flounder are present thereby providing data which gives an indication of year class strength.

A series of relatively strong year classes in the late 1970's - early 1980's, exhibited by increased catch/tow from inshore trawl surveys (Tables 8-9), resulted in increased stock abundance and yields, and a secondary peak in CPUE. These observations are confirmed by analyses of the size distribution and market categorization of landings (Table 4; Figure 5). Landings of winter flounder in the Gulf of Maine area peaked in 1982 at 2.8 thousand tons. CPUE in the recent period peaked in 1981, and has since declined to record low levels in 1985 (Table 5; Figure 6). Despite a decline in winter flounder landings of 34% between 1981 and 1985, directed effort on the species remained high during this period. This was due primarily to the even more substantial declines in traditional Gulf of Maine groundfish species (US Dept. Comm. 1986b). During the 1960's about 1,000 days were fished per year by TC 2 otter trawl vessels in the near-shore Gulf of Maine region (Table 5). During the same period about 200 days/year were fished in the directed winter flounder fishery by TC 2 vessels. These vessels historically accounted for an average of 74% of the region's winter flounder landings. During the 1980's, total effort by TC 2 vessels averaged 3,649 days, the corresponding average of directed trips was 534 days.

Inshore spring survey indices for 1985-1986 are among the lowest observed in the respective time series. Given the significant correlations between these spring indices and the annual CPUE indices, it is likely that commercial landings and CPUE will remain low and may decline still further in the immediate future. Furthermore, the dearth of small (<25 cm) winter flounder during the 1985 spring research vessel surveys (Appendices A2-A3), suggest that winter flounder abundance in the Gulf of Maine region will remain depressed for the next several years. Directed effort on the species is likely to remain above historical levels but below the 1980-1982 period when landings peaked. In the absence of significant new recruitment, landings from the Gulf of Maine region will result in further declines in 1986-1987. Recreational catches for the Gulf of Maine region (Table 1) have declined in recent years (states of Maine and New Hampshire), further indicative of the decline in winter flounder stock abundance. Massachusetts recreational landings increased in 1985, however, this total is comprised of flounder from two stock areas (Gulf of Maine and Southern New England).

B. SOUTHERN NEW ENGLAND

Commercial Landings

The Southern New England stock has accounted for the greatest proportion of winter flounder landings of all the stock. During 1964-1985 the Southern New England area accounted for an average of 82% of the near-shore total. Landings in the Southern New England area peaked in 1965 at 11.8 thousand mt followed by a steady decrease to the 22 year time series low in 1976 of 3.2

thousand mt (Table 3, Figure 4). Landings increased rapidly from 1976 to 1981 (11.1 thousand mt), but has since decreased substantially to 6.5 thousand mt in 1985.

The majority of winter flounder were landed in the unclassified or small market categories from 1964-1972 (Table 10). The unclassified market designation included Xlarge, large/mix, medium and peewee categories. Landings of small and large winter flounder were dominant from 1973-1980. The market categories doubled from 4 to 8 in 1982 as in the Gulf of Maine area. Since 1981, landings of small and large market category winter flounder have decreased while landings of peewee, medium, and Xlarge winter flounder have increased. The length intervals within each market category have varied since 1982 but generally follow the order: lemonsole=Xlarge> large>small>unclassified>medium>peewee.

Commercial length frequency data (Figure 9) indicate that lengths for most fish landed in this area are between 24 and 50 cm with a mode at approximately 30-34 cm. The frequency of fish less than 30 cm increased from 3% in 1979 to 23% in 1982, 27% in 1984, and 35% in 1985 indicating an increased reliance on small winter flounder by the commercial fishery.

Catch Per Unit Effort (CPUE)

CPUE indices for this stock are based on data for 51-150 GRT otter trawls (tonnage class 3). Catches (equivalent to landings) by this otter trawl tonnage class comprise 56-70% of the total Southern New England catch during 1964-1985. Trends in effort, catch and CPUE were analyzed for the total fishery (all trips) and directed fishery (trips where winter flounder

comprised ≥ 50% of the total catch). Catches and effort for the latter trips, termed here the directed fishery comprised an average of 46% of the nominal catch and 14% of the effort for this area. Data are not presented for highly directed trips (≥ 80%) because catches and effort accounted for an average of less than 20% and 5% of the totals, respectively, during these years.

The mean days fished per trip (df/trip) declined from a high of 2.9 during the period 1964-1968 to a low of 1.2 in 1979-1982, and more recently has increased slightly to 1.5 in 1983-1985. The recent increase in df/trip was probably due to more larger vessels (105-150 GRT) entering the fishery as well as increased effort due to declines in catches of other species caught coincident with winter flounder, namely yellowtail and cod.

CPUE for all vessel trips (total fishery) was relatively high from 1964-1967 prior to a decrease in 1968 (Table 11; Figure 10). Following this decrease, the index increased 40% to 1970. This peak was indicative of relatively high resource abundance in the 1960's and early 1970's. CPUE then declined substantially and remained relatively low during the mid-1970's and then increased (60%) to a peak of 1.28 mt/df in 1981. Since CPUE has decreased to the series low in 1985 at 0.42 mt/df. Maximum catches from the Southern New England area occurred in 1966 (11.8 thousand mt), and 1981 (11.1 thousand mt) coincident with peaks in CPUE.

The dramatic increase in Southern New England effort (all trips) in recent years (66% between 1981-1985) is not attributable to directed fishing on winter flounder (Table 11). Fifty percent and greater (directed) winter flounder trips actually decreased 34% overall during 1981-1985. Most of the increase in tonnage class 3 effort has been directed to other species,

particularly yellowtail flounder. The effect has been to increase the proportion of winter flounder as by-catch, and to decrease the proportion of winter flounder landed in directed trips (from 62% in 1981 to 34% in 1985; Table 11).

Decreasing catch and increasing effort since 1981 indicates that this stock has seriously declined. The by-catch fishery (trips where winter flounder comprised $\leq$ 20% of the total catch) rapidly increased effort from 1981 to 1983 (similar to the total fishery), implying that the winter flounder fishery in this area is not a directed fishery. Effort nearly tripled from 1970- 1985 (Table 11). CPUE for the directed fishery was relatively high between 1964-1965 and 1969-1970, declined in 1971 and remained relatively stable from 1971-1978. Subsequently the index increased to 1981 prior to a large decrease to 1985. Since 1981 there has been a 67% decrease in total CPUE, in comparison, directed CPUE has decreased 62% since 1980. Catches fluctuated greatly between 1964 and 1976 during which time it reached the lowest points of the time series in 1964, 1969, and 1976. There was a rapid increase in catch from 1976 to the peak in 1981, followed by a 70% decrease to 1985. Effort reached its highest level in 1981 and was followed by a period of fluctuations (around 1 thousand days fished per year). CPUE statistics indicate abundance of winter flounder in the Southern New England area has been decreasing since 1980.

Research Vessel Survey Indices

NEFC-Offshore. The spring survey indices in weight (kg.) and number of fish caught per tow decreased 95% and 91% respectively, from 1969 to 1975 (Table

12; Figure 11). Since 1975, the indices have fluctuated but remained fairly stable between 1976-1979 and 1982-1984. The indices peaked between 1980-1981. The autumn survey indices (Table 12; Figure 11) decreased from 1965 to 1968, fluctuated from 1969-1974 and increased from 1975-1981. There was little change in the 1985 survey indices from 1984. No major new recruitment is indicated by length frequencies (Appendix A-5). The mean length of Southern New England length frequency samples was 29.2 cm (CV =0.22, length range = 25-35 cm) for the spring and 29.3 cm (CV = 0.11 , length range = 25-34 cm) for autumn.

Inshore. The spring survey (Table 13) indices were highest in 1980 and 1981. The indices fluctuated substantially from 1973-1982, reaching a series low in 1975. Most recently the indices increased from 1982 to 1984 and decreased in 1985. The autumn survey was relatively low from 1973-1978 prior to a 94% and 88% increase in 1979 in weight and number per tow, respectively. Since then, the indices decreased to 1984 followed by a small increase in 1985. Length frequencies are presented in Appendix A-6.

Massachusetts Division of Marine Fisheries (Massachusetts DMF)

The spring indices (Table 14) decreased in Buzzards Bay/Vineyard Sound, Nantucket Sound, and East of Cape Cod areas in 1985 (Figure 3). The indices for the Nantucket Sound and East of Cape Cod areas decreased from 1982-1985. Indices were highest in 1979 for the Buzzards Bay/Vineyard Sound and Nantucket Sound areas. The East of Cape Cod area indices were highest in 1981.

Research survey indices trends by area are different for the autumn Massachusetts DMF surveys. Buzzards Bay/Vineyard Sound area indices increased from 1981 to 1983 followed by a decrease in number per tow from 1984-1985

nearing its lowest level; weight per tow remained stable in 1984 and decreased to its lowest level in 1985. Indices for the Nantucket Sound area were highest in 1978. Since then, indices have fluctuated with an increase in 1985 particularly in the number per tow. East of Cape Cod indices fluctuated from 1978-1981, peaked in 1982 and subsequently decreased steadily to the time series low in 1985. Length frequencies are presented in Appendices A-7 - A-9.

Conclusions and Implications

Commercial landings and effort statistics for the Southern New England area indicate that the abundance of winter flounder in this area were relatively high in the mid 1960's but declined to near-record low levels in the mid-1970's before recovering in the early 1980's. Even though CPUE was relatively high from 1965-1970 landings averaged 2.9 thousand mt compared with an average of 6.8 thousand mt landed from 1980-1981. The difference in landings during these two periods may in part be due to increased effort, as a result of larger vessels entering the fishery in later years. Effort averaged 2,993 days fished/year from 1964-1970 which was less than one-half of average days fished from 1980-1981 (5,639 days fished/year).

Relatively strong year classes in the early 1980's as indicated by increased catches of $\leq$ 20 cm. winter flounder during the inshore research vessel surveys resulted in the 1980-1981 peak in CPUE. Landings in the Southern New England area also peaked in 1980 and 1981 at 10.6 thousand mt and 11.1 thousand mt, respectively. In 1985 CPUE declined to the 22 year time-series low. Landings declined 46% between 1981 and 1985 while effort (all trips) increased 40%. This increase in effort was probably directed toward another species, yellowtail flounder whose abundance was also high in the

early 1980's. Directed effort was highest from 1980-1985 (average 1,071 days fished/year) but was still only 15% of the total effort. Effort for 1964-1975 averaged only 470 days fished/year. These statistics indicate that the winter flounder fishery in Southern New England probably operates as a by-catch fishery.

CPUE statistics for the Southern New England area are significantly correlated with survey abundance indices for offshore and inshore waters (Figure 12). Statistically significant correlations were developed between CPUE statistics and : (1) NEFC spring offshore indices (2) NEFC autumn inshore survey indices (3) Massachusetts DMF spring East of Cape Cod inshore survey. The East of Cape Cod area includes statistical area 521 (Figure 1) from which a majority of the commercial landings originate. Other offshore and inshore indices were not significantly correlated.

Offshore autumn and most spring inshore survey indices have declined overall since 1983. Statistically significant correlations between these offshore and inshore survey indices and annual CPUE confirmed the decline of catch and effort in 1986. However, spring offshore survey indices increased 2 fold in weight and 3 fold in number from 1984 to 1985. This corresponds with an increase in recreational landings in 1985. The 1985 increase in offshore survey indices and recreational landings may be the result of encountering large concentrations of winter flounder during sampling. Decreased abundance of winter flounder will continue in 1986 resulting in a decrease in CPUE and landings less than 6.0 thousand mt.

C. MIDDLE ATLANTIC

Commercial Landings

The Middle Atlantic stock area (Figure 1) has historically exhibited the lowest landings of all the three inshore stock areas. (1964-1985 mean 1.5%). Landings in the Middle Atlantic area increased 89% from 1964 (53 mt) to the time series high in 1967 (452 mt) (Table 3; Figure 4). This was followed by a rapid decrease to the lowest landings of the time series in 1973 and 1974 (4 mt). Landings fluctuated between 1974 and 1980 but remained at a low level. Landings increased 52% in 1985 (92 mt) after remaining approximately stable from 1982 to 1984 (mean 48 mt).

Most landings from the Mid-Atlantic area from 1978-1985 were in the unclassified market category, although small, large, lemon and medium were occasionally observed (Table 15).

Catch Per Unit Effort (CPUE)

CPUE was not calculated for this stock area because most of the catches before 1984 were made using fyke nets (an average of 57% of the total landings) for which there are no effort data. Recently, landings by otter trawls have accounted for an increasing percentage of the total landings (1984-48%; 1985-70%). CPUE data may become available if this trend continues.

Research Vessel Survey Indices

NEFC-Offshore The spring survey indices in weight (kg) and number per tow decreased overall from 1968 to 1975 and fluctuated between 1976-1978. The indices increased gradually from 1979 to 1982, remained stable between 1982 and 1984 preceding a decrease to 1986 (Table 16; Figure 13). The autumn survey indices (Table 16; Figure 13) decreased from 1967 to 1970. From 1975-

1982 there were no significant changes in the indices. This was followed by an increase in indices to 1983. Most recently the 1985 indices have decreased from 1983. The mean length of Middle Atlantic length frequency samples (Table 7) was 26.5 cm (CV = 0.41, length range = 20-32 cm) for the spring and 27.2 cm (CV = 0.26, length range = 23-33 cm) for the autumn.

Inshore The spring survey indices (Table 17) were highest in 1973 and decreased to a minimum in 1975. After fluctuating, the indices decreased again from 1982 to its most recent level in 1985. The autumn survey (1972-1985) indices were highest in 1977. The indices were approximately stable from 1982 to 1983 followed by a decrease in 1984 and an increase in 1985.

Conclusions and Implications

Landings are significantly correlated with autumn offshore survey indices of abundance. Recreational landings for the states of Delaware, Maryland and Virginia (Table 1) in this area are very low, totalling less than 30,000 fish for each state. Since the Middle Atlantic area contributes such a small amount to the total commercial and recreational near-shore fishery, as well as aggregate research vessel survey indices, any changes in regional abundance will likely have little effect on the total near-shore fishery. For future assessments this area will probably be combined with the Southern New England stock area.

DISCUSSION

Total landings from near-shore winter flounder stocks (Gulf of Maine, Southern New England, and Middle Atlantic), peaked in 1981 at 13.6 thousand mt and have since declined 40% to 8.2 thousand mt in 1985. The 1985 total is the lowest observed since 1977, and is 9% below the 1964-1985 annual average of 8.9 thousand mt (Table 3). Total estimated recreational landings appeared consistent with trends in total commercial landings for 1981-1983 only, during which time recreational and commercial landings increased in 1981 and decreased in 1982 and 1983. Research vessel survey indices (inshore, offshore, NEFC, Massachusetts DMF) indicate that a series of strong year classes in the late 1970's - early 1980's were primarily responsible for the peak in landings in the early 1980's. These strong year classes recruited simultaneously in the Gulf of Maine and Southern New England areas, suggesting that wide-spread favorable environmental conditions during that period may have been partially responsible for the generally increased recruitment.

Current recruitment prospects for these stock areas remain relatively poor, based on 1985 research vessel surveys indices. Research vessel indices in all areas are at or near the lowest levels observed, particularly for the Southern New England area, which traditionally supplies the majority of the near-shore winter flounder landings. In the absence of substantially improved recruitment in the Gulf of Maine and Southern New England areas, near-shore commercial landings should continue to decline during 1986-1987, particularly given record-high landings per unit stock biomass (ratio of commercial landings to survey weight per tow indices). For 1984 and 1985 the landings/biomass(kg.tow) ratios were 311 and 226 for the Gulf of Maine, and 1,097 and 1,010 for Southern New England, record levels in each time series. These patterns are consistent with declining catch and CPUE and increased

effort in these areas. Based on these results it is likely that fishing mortality rates are at an all-time high levels for these stocks. The 1964 instantaneous fishing mortality rate derived from Howe and Coates (1975) for winter flounder in Massachusetts coastal waters (S. of Cape Cod) was 0.27. The landings/biomass ratio for a corresponding statistical area and stratum was 16.2 in 1964 and 224.6 in 1985. Thus, the results imply that presently F is much higher than in 1964 even though the catch/biomass ratio is not directly proportional for the two years due to differences in the dimensions in the sampling areas analyzed ,the current fishing mortality rates on these stocks are probably extremely high, although no current age-specific abundance data are available with which to confirm these rates. Given these high rates of exploitation and current minimum sizes (ages) in effect for various management jurisdictions, (see "Management"), the percentage of maximum spawning stock biomass/recruit currently exhibited by these stocks is probably well below the 20% target level referenced by the New England Council (Gabriel et al. MS 1984).

The exploitation of pre-spawning sized fish and the significant discard of undersized winter flounder continue to be symptomatic of poor recovery by these stocks. The current minimum size for winter flounder from FCZ waters is 11 inches (28 cm). Given this minimum legal size, a large portion of the catch will not have spawned once prior to capture. Furthermore, with the current legal mesh size for the FCZ large mesh area (5.5 inches = 14 cm), and a winter flounder mesh selection factor of 2.2 (as defined in Smolowitz 1983), length at fifty percent selection is 31 cm. Thus, even under ideal selection conditions (i.e. no clogging of meshes) the current legal mesh size of 5.5 inches will select a portion of pre-spawning females. Recovery of these

stocks will occur only if effort decreases and mesh size and/or minimum size regulations are enacted which will enable the majority of the winter flounder stock to spawn before capture.

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Table 1. Recreational landings of winter flounder by region, state and entire coast from 1979-1985 (metric tons; including catches of <30,000 individuals, *)

	1979[1]	1980[1]	1981[2]	1982[2]	1983[3]	1984[3]	1985[4]
North Atlantic Region							
Maine	172	204	28	*	*	*	*
New Hampshire	150	185	57	20	52	59	14
Massachusetts	6,006	3,398	3,827	4,821	2,104	1,434	2,103
Rhode Island	218	98	114	349	351	370	828
Connecticut	703	639	338	488	393	694	595
Regional Total[5]	7,248	4,524	4,364	5,680	2,909	2,560	3,548
Total Retained[6]	(6,517)	(3,955)	(3,798)	(5,190)	(2,503)	(2,245)	(3,030)
Mid-Atlantic Region							
New York	5,826	2,777	3,869	1,334	4,059	5,597	6,377
New Jersey	912	335	586	1,723	900	1,750	3,144
Delaware	*	*	-	-	-	-	*
Maryland	-	-	-	-	*	*	-
Virginia	*	*	-	-	*	-	-
Regional Total	6,739	3,121	4,454	3,056	4,964	7,348	9,528
Total Retained	(4,801)	(2,212)	(3,240)	(2,290)	(3,842)	(5,239)	(6,708)
Coastwide Total	13,988	7,645	8,814	8,736	7,879	9,908	13,068
Total Retained	(11,319)	(6,166)	(7,034)	(7,480)	(6,352)	(7,484)	(9,730)

1 U.S. Dept. Commerce, 1984.
2 U.S. Dept. Commerce, 1985(a).
3 U.S. Dept. Commerce, 1985(b).
4 U.S. Dept. Commerce, 1986.
5 calculated as the ratio of catch in weight landed whole to the number landed whole multiplied by the total number of all catch types
6 Region Total minus fish released alive.

Table 2. Winter flounder landings (mt) by Canada and USSR from NAFO Divisions 5Y, Subdivisions 5ZE and 5ZW and Divisions 6A and 6B, 1962-1985.

	5Y		5ZE		5ZW		5Z		6A		6B		TOTAL
Year	CAN	USSR	CAN	USSR	CAN	USSR	CAN	USSR	CAN	USSR	CAN	USSR	
1962							26						26
1963							120	19					139
1964	14						146						160
1965	3						199	312					514
1966							164	156					320
1967							89	349					438
1968			59	372		783							1214
1969				235		6452				131		35	6853
1970			64	40		422				4		4	534
1971			65	1029		917				112		2	2125
1972			8	1699		818				14			2539
1973			14	693		793				30		3	1533
1974			12	82		89				32			215
1975			13	515		1				48			577
1976			11	1									12
1977			15	7						3			25
1978	1		65										66
1979			19										19
1980			44										44
1981			19										19
1982			19										19
1983	5		14										19
1984[2]													0
1985[3]			12										12

[1]Division 5Z landings not assigned to 5ZE or 5ZW.
[2]Provisional.
[3]Preliminary.

Table 3. Annual U.S. winter flounder commercial landings (metric tons) by regional stock area ,1964-1985

Year	Gulf of Maine	Southern New England	Middle Atlantic[1]	Total
1964	1081	7421	53	8555
1965	665	8578	100	9343
1966	785	11813	164	12762
1967	803	9026	452	10281
1968	864	6661	409	7934
1969	975	7901	206	9082
1970	1092	8536	67	9695
1971	1113	7332	35	8480
1972	1085	5178	12	6275
1973	1080	5569	4	6653
1974	885	4255	4	5144
1975	1181	3940	42	5163
1976	1465	3229	36	4731
1977	2161	4397	16	6574
1978	2194	6315	12	8654
1979	2021	6487	56	8563
1980	2437	10600	27	13064
1981	2406	11134	42	13583
1982	2793	9395	43	12231
1983	2096	8603	56	10775
1984	1698	8838	44	10580
1985	1582	6487	92	8161

[1]1964-1974 excludes statistical area 614 which was unavailable.

Table 4. Composition of commercial landings by market category from Gulf of Maine Region (metric tons, live weight), 1964-1985.

	Category															
	Small		Large		Lemon Sole		Unclassified		Peewee		Medium		Extra Large		Large Mix	
Year	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
1964	235.6	21.8	-	-	16.8	1.6	824.4	76.6	-	-	-	-	-	-	-	-
1965	163.0	24.6	-	-	8.5	1.3	490.7	74.1	-	-	-	-	-	-	-	-
1966	241.4	30.9	-	-	9.4	1.2	531.3	67.9	-	-	-	-	-	-	-	-
1967	176.2	22.0	-	-	2.8	0.4	619.5	77.6	-	-	-	-	-	-	-	-
1968	249.9	29.2	-	-	9.4	1.1	596.7	69.7	-	-	-	-	-	-	-	-
1969	271.6	28.1	-	-	5.2	0.5	689.3	71.3	-	-	-	-	-	-	-	-
1970	268.3	24.9	-	-	4.0	0.4	805.4	74.7	-	-	-	-	-	-	-	-
1971	308.4	27.7	-	-	9.1	0.8	796.0	71.5	-	-	-	-	-	-	-	-
1972	373.5	34.8	-	-	12.0	1.1	688.2	64.1	-	-	-	-	-	-	-	-
1973	427.0	39.7	629.0	58.5	18.5	1.8	-	-	-	-	-	-	-	-	-	-
1974	333.5	38.3	527.9	60.7	8.4	1.0	-	-	-	-	-	-	-	-	-	-
1975	371.9	31.5	800.9	67.8	8.2	0.7	-	-	-	-	-	-	-	-	-	-
1976	614.8	42.0	843.8	57.6	6.4	0.4	-	-	-	-	-	-	-	-	-	-
1977	1117.9	53.1	972.9	46.3	14.1	0.7	-	-	-	-	-	-	-	-	-	-
1978	1106.4	50.4	1079.4	49.2	8.0	0.4	0.1	<0.1	-	-	-	-	-	-	-	-
1979	1038.5	51.4	971.6	48.1	10.7	0.5	-	-	-	-	-	-	-	-	-	-
1980	1206.2	49.5	1210.9	49.7	14.9	0.6	5.3	0.2	-	-	-	-	-	-	-	-
1981	1120.4	46.6	1197.9	49.8	13.3	0.6	74.6	3.1	-	-	-	-	-	-	-	-
1982	963.7	34.5	1076.7	41.8	23.5	0.8	346.8	12.4	180.4	6.5	69.0	2.5	40.3	1.4	-	-
1983	755.1	36.0	629.6	33.1	31.3	1.5	306.1	14.6	243.6	11.6	64.0	3.1	2.7	0.1	0.2	<0.1
1984	571.5	33.6	546.2	32.1	11.1	0.7	248.4	14.6	207.1	12.2	114.0	6.7	0.6	<0.1	-	<0.1
1985	565.4	35.7	475.6	30.1	19.2	1.2	175.7	11.1	83.2	5.3	262.8	16.6	0.4	<0.1	0.1	<0.1

Table 5. Catch (mt), effort (days fished, df), and catch per unit effort (CPUE, mt/df) from the Gulf of Maine area for tonnage class 2 (5-50 gross tons) vessels (does not include 29's) using otter trawls (gear 5) based on trips in which landings consisted of winter flounder (total fishery), ≥50%, ≥80% winter flounder (weighouts only), 1964-1985.

Total fishery

Year	Catch	df	CPUE
1964	947.6	1213.2	.78
1965	535.2	1070.2	.50
1966	629.1	960.5	.66
1967	736.2	995.1	.74
1968	768.8	804.9	.96
1969	894.5	1113.9	.80
1970	938.9	1447.9	.65
1971	962.1	1398.7	.69
1972	899.0	1550.2	.58
1973	865.0	1471.1	.59
1974	677.2	1680.3	.40
1975	883.6	2458.1	.36
1976	945.3	2928.8	.32
1977	1444.2	3135.1	.46
1978	1463.7	3478.0	.42
1979	1501.9	3854.2	.39
1980	1799.0	4477.4	.40
1981	1766.7	3361.3	.53
1982	1804.9	4227.5	.43
1983	1462.4	3341.5	.44
1984	1107.7	3302.9	.34
1985	1002.9	3181.0	.32

≥50%

Year	Catch	df	CPUE
1964	548.2	286.6	2.26
1965	298.5	158.6	1.88
1966	398.7	195.9	2.04
1967	460.4	180.7	2.55
1968	523.0	171.5	3.05
1969	567.0	180.1	3.15
1970	611.4	234.3	2.61
1971	651.4	209.3	3.11
1972	596.5	278.4	2.14
1973	561.6	298.4	1.88
1974	396.0	201.4	1.97
1975	494.4	325.8	1.52
1976	434.5	252.7	1.72
1977	802.0	417.8	1.92
1978	811.5	517.6	1.57
1979	783.4	516.7	1.52
1980	1000.2	580.4	1.72
1981	934.9	635.6	1.47
1982	846.4	608.0	1.39
1983	723.5	446.4	1.62
1984	590.6	451.4	1.31
1985	565.6	482.9	1.17

≥80%

Year	Catch	df	CPUE
1964	504.4	199.9	2.52
1965	206.4	96.2	2.15
1966	245.9	99.0	2.48
1967	308.0	104.3	2.95
1968	364.7	105.2	3.47
1969	376.9	97.3	3.87
1970	370.6	119.6	3.10
1971	418.2	100.3	4.17
1972	382.4	140.4	2.72
1973	304.4	118.9	2.56
1974	197.3	78.4	2.52
1975	208.2	101.3	2.06
1976	176.5	76.6	2.30
1977	442.3	192.6	2.30
1978	461.8	236.8	1.95
1979	431.8	219.2	1.97
1980	589.2	255.1	2.31
1981	489.0	286.0	1.71
1982	450.9	255.9	1.76
1983	497.1	255.3	1.95
1984	308.0	193.2	1.59
1985	287.6	187.0	1.54

Table 6. Stratified mean catch per tow in weight (kg) and numbers of winter flounder in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine area, 1963-1985.

	Spring[1]		Autumn	
Year	Wt.	No.	Wt.	No.
1963	-	-	.17	.40
1964	-	-	.07	.09
1965	-	-	.89	.74
1966	-	-	.12	.20
1967	-	-	.04	.04
1968	.38	.42	.23	.20
1969	.29	.41	.22	.35
1970	.38	.39	.26	.22
1971	.24	.29	.10	.20
1972	.47	.72	.24	.56
1973	.06	.12	.12	.20
1974	.09	.17	.51	.98
1975	.01	.01	.03	.03
1976	.14	.17	.20	.27
1977	.26	.42	.56	1.22
1978	.05	.11	.18	.30
1979	.13	.22	.14	.23
1980	.21	.48	.74	.94
1981	.33	.58	.65	.83
1982	.35	.68	.20	.31
1983	.95	1.64	.32	.95
1984	.30	.48	.41	.70
1985	.21	.43	.19	.41

[1] Spring surveys, 1968-1972, 1982-1985, were performed with "#36 Yankee" trawl. Spring surveys, 1973-1981, were performed with "#41 Yankee". Adjustments were made to catch per tow data for the differences in gears. Catch per tow data from #41 Yankee trawls were divided by 1.86 (weight), 2.02 (number) to correspond to #36 Yankee trawl data.

Table 7. Estimated mean length (cm) from NEFC offshore bottom trawl surveys by area and season, 1963-1985.

Year	Spring GOM	Spring SNE	Spring MA	Autumn GOM	Autumn SNE	Autumn MA
1963	-	-	-	31.9	30.9	-
1964	-	-	-	34.3	29.4	-
1965	-	-	-	44.2	27.8	-
1966	-	-	-	33.4	28.6	-
1967	-	-	-	32.1	28.8	27.9
1968	38.5	27.5	25.6	41.9	28.1	26.6
1969	35.7	35.5	24.0	35.8	27.6	29.9
1970	36.8	29.3	31.5	39.8	32.3	26.8
1971	37.1	30.5	27.6	32.7	28.3	24.8
1972	34.5	30.0	29.5	30.7	31.9	29.4
1973	32.4	28.0	27.1	33.8	28.8	24.76
1974	32.9	29.0	27.0	33.0	30.7	No data
1975	25.9	27.9	No data	36.8	28.4	23.1
1976	37.4	27.4	24.0	37.7	33.7	26.1
1977	33.9	29.2	20.4	30.8	30.1	23.6
1978	30.9	30.5	32.0	33.4	30.7	29.0
1979	32.7	29.0	37.0[1]	33.7	25.4	32.5
1980	29.9	25.3	28.4	35.7	28.9	27.2
1981	32.8	26.3	26.0	36.8	28.0	27.1
1982	31.5	29.1	21.4	35.6	29.2	No data
1983	34.6	34.8	23.3	28.2	28.5	25.0
1984	34.2	29.4	28.7	33.8	28.9	31.1
1985	32.1	27.6	27.5	29.9	28.7	32.7
Mean	33.5	29.2	26.5	34.9	29.3	27.2
Range	25.9-38.54	25.26-35.47	20.43-31.95	28.2-44.18	25.36-33.7	23.11-32.52
Coefficient of Variation	.27	.22	.41	.39	.11	.26

[1] Two observations or less, not included in mean, range.

Table 8. Stratified mean catch per tow in weight (kg) and number and mean length ($\bar{T}$,cm) of winter flounder in NEFC inshore spring and autumn bottom trawl surveys in the Gulf of Maine area, 1979-1985.

Year	Spring[1] Wt.	Spring[1] No.	$\bar{T}$	Autumn[2] Wt.	Autumn[2] No.	$\bar{T}$
1979	9.14	34.14	24.3	14.00	32.62	29.5
1980	20.36	47.16	31.0	26.69	63.47	30.4
1981	34.27	91.33	28.7	2.03	5.69	28.1
1982	13.92	39.44	27.8	9.50	26.75	28.3
1983	11.11	25.00	26.9	14.36	38.33	28.2
1984	5.46	17.73	26.1	10.81	33.22	27.5
1985	6.99	19.51	28.2	20.76	79.48	25.4

1 Spring survey 1979-1981 performed with #41 Yankee, 1982-1985 performed with #36 Yankee. No adjustment was made for differences in trawls.

2 Autumn survey 1979-1985 performed with #36 Yankee trawl.

Table 9. Stratified mean catch per tow in weight (kg) and number and mean length ($\bar{l}$,cm) of winter flounder in the Massachusetts state inshore spring and fall bottom trawl surveys, 1978-1985.

	Cape Cod Bay						Massachusetts Bay					
	Spring			Autumn			Spring			Autumn		
Year	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$
1978	24.53	122.00	20.9	20.22	100.84	22.2	10.98	44.57	24.9	24.08	89.72	25.2
1979	37.78	170.97	22.2	87.95	353.22	25.1	24.98	106.35	23.9	42.23	151.59	23.9
1980	41.58	146.62	25.2	26.13	124.89	23.2	32.29	132.95	24.3	46.45	214.39	23.8
1981	52.18	181.55	25.0	13.47	49.63	25.8	64.31	231.75	25.2	12.97	44.82	26.1
1982	10.96	45.61	23.3	21.33	100.00	23.4	18.77	77.40	23.7	26.19	112.07	24.2
1983	23.95	94.70	23.3	15.02	72.67	22.6	33.54	131.58	25.2	16.61	105.23	21.2
1984	18.14	75.06	24.1	11.70	43.68	27.1	13.59	56.38	24.4	9.84	27.43	26.0
1985	15.90	59.88	23.8	7.59	50.45	28.8	11.04	36.25	26.5	7.15	38.07	21.7

Table 10. Composition of commercial landings by market category from Southern New England region (metric tons, live weight), 1964-1985.

	Category															
	Small		Large		Lemon Sole		Unclassified		Peewee		Medium		Large/Mix		Extra Large	
Year	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
1964	161.3	34.9	-	-	243.4	5.6	2591.6	59.5	-	-	-	-	-	-	-	-
1965	2235.4	40.4	-	-	206.3	3.7	3089.1	55.9	-	-	-	-	-	-	-	-
1966	3179.9	44.9	-	-	248.4	3.5	3654.1	51.6	-	-	-	-	-	-	-	-
1967	1952.9	42.8	-	-	155.4	3.4	2454.5	53.8	-	-	-	-	-	-	-	-
1968	2304.8	48.0	-	-	127.3	2.6	2372.9	49.4	-	-	-	-	-	-	-	-
1969	3267.8	49.0	-	-	146.6	2.2	3254.2	48.8	-	-	-	-	-	-	-	-
1970	3215.5	45.9	-	-	147.5	2.1	3638.2	52.0	-	-	-	-	-	-	-	-
1971	2513.3	41.2	-	-	211.6	3.4	3379.9	55.4	-	-	-	-	-	-	-	-
1972	1629.6	36.7	-	-	151.7	3.4	2664.0	59.9	-	-	-	-	-	-	-	-
1973	1799.7	39.3	2604.3	56.9	173.3	3.8	-	-	-	-	-	-	-	-	-	-
1974	1587.9	54.1	2073.8	41.4	172.3	4.5	-	-	-	-	-	-	-	-	-	-
1975	1548.1	42.2	1971.5	53.7	148.9	4.0	-	-	-	-	-	-	-	-	-	-
1976	1234.4	42.9	1507.7	52.4	134.3	4.7	-	-	-	-	-	-	-	-	-	-
1977	1856.5	47.7	1854.6	47.6	181.6	4.7	-	-	-	-	-	-	-	-	-	-
1978	2883.3	50.3	2589.5	45.2	178.5	3.1	76.9	1.3	-	-	-	-	-	-	-	-
1979	3072.7	52.9	2485.1	42.7	188.2	3.2	71.4	1.2	-	-	-	-	-	-	-	-
1980	5341.8	54.2	3836.4	38.9	253.2	2.6	422.7	4.3	-	-	-	-	-	-	-	-
1981	5533.7	54.0	4281.0	41.8	195.3	1.9	230.6	2.2	-	-	-	-	-	-	-	-
1982	3234.4	38.6	2786.1	33.2	153.0	1.8	662.3	7.9	151.4	1.8	1109.9	13.2	270.0	3.2	13.3	0.2
1983	2977.9	37.6	2096.4	26.5	111.0	1.4	367.9	4.6	547.1	6.9	1729.1	21.8	32.5	0.4	59.2	0.7
1984	2570.3	33.9	1860.9	24.5	80.2	1.1	506.5	6.7	598.2	7.9	1898.0	25.0	9.3	0.1	67.7	0.9
1985	1654.1	28.0	1344.7	22.7	69.1	1.2	846.3	6.6	543.3	9.2	1851.0	31.3	3.0	0.1	54.8	0.9

Table 11. Catch (mt), effort (days fished, df), and catch per unit effort (CPUE, mt/df) from the southern New England area for tonnage class 3 vessels (51-150 gross tons) using otter trawls (gear 5) based on trips in which landings consisted of any winter flounder (total fishery) and ≥50% winter flounder (weighouts only), 1964-1985.

	Total Fishery		
Year	Catch	df	CPUE
1964	2130.1	2368.0	.90
1965	2695.3	2695.2	1.00
1966	4333.6	4313.7	1.00
1967	2527.9	2629.2	.96
1968	1968.1	2808.8	.70
1969	3304.9	3077.2	1.07
1970	3535.8	3059.4	1.16
1971	3008.7	3241.6	.93
1972	1966.3	2718.7	.72
1973	2275.2	3109.6	.73
1974	2121.5	3780.6	.56
1975	2042.5	3371.7	.61
1976	1625.7	3214.2	.51
1977	2326.9	3395.9	.69
1978	3724.5	4526.7	.82
1979	3641.0	4767.5	.76
1980	6559.4	5813.6	1.13
1981	7013.9	5463.8	1.28
1982	5576.0	5919.7	.94
1983	5140.6	7758.2	.66
1984	5296.6	8317.0	.64
1985	3773.0	9047.2	.42

	≥50%		
Year	Catch	df	CPUE
1964	695.4	216.7	3.21
1965	1230.6	355.3	3.46
1966	2464.8	883.7	2.79
1967	1389.8	572.5	2.43
1968	795.2	302.9	2.63
1969	1754.5	511.1	3.43
1970	1921.9	593.5	3.24
1971	1622.1	627.1	2.59
1972	1011.1	426.6	2.37
1973	949.4	411.3	2.31
1974	808.8	358.6	2.26
1975	1077.7	431.5	2.50
1976	641.4	277.2	2.31
1977	849.6	369.3	2.30
1978	1705.5	738.3	2.31
1979	1315.0	438.9	3.00
1980	3174.7	934.0	3.40
1981	4311.9	1506.1	2.86
1982	2697.1	924.3	2.92
1983	2016.2	752.2	2.68
1984	2595.0	1306.4	1.99
1985	1296.8	1001.1	1.30

Table 12. Stratified mean catch per tow[1] in weights (kg) and numbers of winter flounder in NEFC offshore spring and autumn bottom trawl surveys in the Southern New England area, 1963-1985.

Year	Spring[1]		Autumn	
	Wt.	No.	Wt.	No.
1963	-	-	2.36	5.86
1964	-	-	3.12	9.14
1965	-	-	3.52	9.37
1966	-	-	2.35	6.74
1967	-	-	1.51	4.98
1968	.51	1.50	1.30	4.32
1969	3.54	5.22	1.56	5.60
1970	1.27	2.45	2.48	4.95
1971	.76	1.90	1.17	3.26
1972	.66	1.78	3.53	8.28
1973	.45	1.34	.80	2.38
1974	.28	.96	.98	2.30
1975	.18	.48	.76	2.17
1976	.27	.81	2.73	4.52
1977	.56	1.17	1.89	4.58
1978	.56	1.24	2.14	4.72
1979	.43	.95	2.62	10.14
1980	1.43	5.43	3.61	9.76
1981	1.91	6.57	3.63	11.02
1982	.69	1.81	1.37	3.54
1983	1.27	2.04	3.13	9.05
1984	.72	1.85	.79	2.30
1985	2.01	5.70	1.00	3.01

[1] Spring surveys, 1968-1972, 1982-1985, were performed with "#36 Yankee" trawl. Spring surveys, 1973-1981, were performed with "#41 Yankee". Adjustments were made to catch per tow data for the differences in gears. Catch per tow data from #41 Yankee trawls were divided by 1.86 (weight), 2.02 (number) to correspond to #36 Yankee trawl data.

Table 13. Stratified mean catch per tow in weight (kg) and number and mean length ($\overline{L}$, cm) of winter flounder in NEFC inshore spring and autumn bottom trawl surveys in the Southern New England area, 1972-1985.

	Spring[1]			Autumn[2]		
Year	Wt.	No.	$\overline{L}$	Wt.	No.	$\overline{L}$
1972	-	-		0.87	2.49	30.8
1973	11.90	42.85	27.3	-	-	
1974	6.32	12.71	32.0	-	-	
1975	0.86	3.85	24.9	1.11	3.11	28.5
1976	5.15	19.06	25.9	0.72	2.61	27.4
1977	8.33	37.77	22.7	2.31	7.28	27.7
1978	10.12	46.34	23.7	0.46	2.68	22.4
1979	3.25	9.30	28.6	8.15	22.62	29.1
1980	13.38	55.61	24.8	6.33	31.51	21.3
1981	17.16	50.64	28.1	6.33	18.38	27.3
1982	6.81	21.84	27.9	6.16	14.26	30.2
1983	15.63	29.12	29.3	5.01	15.10	28.3
1984	16.16	34.70	31.8	2.52	6.94	28.7
1985	12.16	29.09	30.2	4.68	11.72	30.5

1 Spring survey 1972-1975 performed with 3/4 #36 Yankee trawl, 1976-1981 performed with #41 Yankee trawl, 1982-1985 performed with #36 Yankee trawl. No adjustment was made for differences in trawls.

2 Autumn survey 1972 performed with 3/4 #36 Yankee trawl, 1975-1985 performed with #36 Yankee trawl. No adjustment was made for differences in trawls.

Table 14. Stratified mean catch per tow in weight (kg) and number and mean length (l,cm) of winter flounder in the Massachusetts state inshore spring and autumn bottom trawl surveys, 1978-1985.

	Buzzards Bay/Vineyard Sound						Nantucket Sound						East of Cape Cod					
	Spring			Autumn			Spring			Autumn			Spring			Autumn		
Year	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$	Wt.	No.	$\bar{l}$
1978	12.62	65.24	20.8	1.13	8.16	20.2	30.88	65.74	29.3	2.45	31.32	15.2	7.30	12.98	32.2	9.26	19.44	31.9
1979	51.66	183.03	25.4	1.05	7.83	19.5	37.76	99.10	27.8	0.29	1.32	21.6	18.99	32.26	31.8	7.13	13.89	31.4
1980	40.13	104.60	28.3	0.98	6.43	20.2	30.77	78.39	28.4	0.78	7.06	18.9	18.08	47.59	28.1	9.77	22.13	30.5
1981	32.90	117.76	24.2	0.90	3.13	26.7	31.37	87.27	26.2	0.15	0.52	26.4	32.39	73.71	29.8	1.01	2.07	31.0
1982	22.69	65.54	28.0	1.30	8.90	20.9	10.65	27.69	28.5	0.34	1.27	25.4	10.46	24.93	30.4	14.10	37.55	29.7
1983	25.45	98.92	25.3	1.41	9.34	21.1	15.75	35.41	29.7	0.04	0.13	24.5	16.88	29.89	29.9	8.08	19.65	29.6
1984	28.24	74.12	28.6	1.43	6.74	24.1	6.87	18.71	28.0	0.08	0.32	24.3	8.06	15.43	31.9	2.02	5.04	28.9
1985	21.00	77.82	24.9	0.59	3.84	21.4	6.59	19.64	25.5	0.18	1.79	18.1	6.42	13.36	30.2	0.18	0.64	23.4

Table 15. Composition of commercial landings by market category from Mid-Atlantic region (metric tons, live weight), 1964-1985.

	Category													
	Small		Large		Lemon Sole		Unclassified		Peewee		Medium		Extra Large	
Year	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
1964	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	0.1	100.0	-	-	-	-	-	-	-	-	-	-	-	-
1972	0.5	100.0	-	-	-	-	-	-	-	-	-	-		
1975	0.1	100.0	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	0.1	100.0	-	-	-	-	-	-	-	-	-	-	-	-
1978	0.1	0.7	-	-	-	-	18.3	99.9	-	-	-	-	-	-
1979	0.1	0.2	-	-	-	-	24.4	99.9	-	-	-	-	-	-
1980	0.1	0.2	0.2	1.2	-	-	17.7	98.5	-	-	-	-	-	-
1981	0.9	3.1	5.1	17.4	-	-	23.1	79.4	-	-	-	-	-	-
1982	3.4	9.6	2.1	6.1	2.6	7.5	26.8	76.4	0.1	0.4	-	-	-	-
1983	1.5	3.6	-	-	1.3	3.1	39.5	92.5	-	-	0.4	0.9	-	-
1984	0.9	2.0	-	-	-	-	43.0	97.4	-	-	0.3	0.6	-	-
1985	0.1	<0.1	-	-	0.1	<0.1	92.2	100.0	-	-	0.1	<0.1	0.2	<0.1

Table 16. Stratified mean catch per tow in weights (kg) and numbers of winter flounder in NEFC offshore spring and autumn bottom trawl surveys in the Middle Atlantic area, 1967-1985.

Year	Spring[1]		Autumn	
	Wt.	No.	Wt.	No.
1967	-	-	1.73	5.25
1968	.33	1.20	1.27	4.78
1969	.11	.61	.62	1.64
1970	.23	.47	.06	.33
1971	.05	.20	.17	.84
1972	.05	.14	.12	.44
1973	.02	.07	.13	.74
1974	.03	.12	.00	.00
1975	.00	.00	.05	.37
1976	.01	.02	.04	.15
1977	.02	.14	.07	.34
1978	.04	.07	.02	.04
1979	.01	.02	.06	.13
1980	.03	.08	.09	.25
1981	.04	.15	.10	.33
1982	.05	.34	.00	.00
1983	.04	.27	.15	.56
1984	.10	.31	.12	.32
1985	.04	.14	.21	.39

[1]Spring surveys, 1968-1972, 1982-1985, were performed with "#36 Yankee" trawl. Spring surveys, 1973-1981 were performed with "#41 Yankee". Adjustments were made to catch per tow data for the differences in gears. Catch per tow data from #41 Yankee trawls were divided by 1.86 (weight) and 2.02 (number) to correspond with #36 Yankee trawl data.

Table 17. Stratified mean catch per tow in weight (kg) and number and mean length ($\overline{l}$, cm) of winter flounder in NEFC inshore spring and autumn bottom trawl surveys in the Middle Atlantic area, 1972-1985.

Year	Spring[1] Wt.	Spring[1] No.	$\overline{l}$	Autumn[2] Wt.	Autumn[2] No.	$\overline{l}$
1972	-	-		0.43	1.29	26.8
1973	8.99	32.90	27.0	0.23	0.99	25.7
1974	3.11	9.40	28.2	0.00	0.05	25.0
1975	0.54	1.95	27.9	0.03	0.27	25.6
1976	1.73	8.07	23.1	0.05	0.25	25.8
1977	2.96	11.26	27.2	0.47	2.25	25.0
1978	4.35	24.38	21.1	0.02	0.06	28.0
1979	2.18	7.32	25.5	0.20	1.10	21.4
1980	5.70	22.83	25.1	0.20	1.15	22.6
1981	7.84	28.33	26.0	0.36	0.93	29.8
1982	3.40	13.75	24.8	0.05	0.21	25.4
1983	2.15	5.88	26.4	0.05	0.24	23.3
1984	1.16	4.52	26.0	0.02	0.08	25.9
1985	0.95	3.05	27.2	0.08	0.28	27.2

[1] Spring survey 1973-1975 performed with 3/4 #36 Yankee trawl, 1976-1981 performed with #41 Yankee trawl, 1982-1985 performed with #36 Yankee trawl. No adjustment was made for differences in trawls.

[2] Autumn survey 1972-1973 performed with 3/4 #36 Yankee trawl, 1974-1985 performed with #36 Yankee trawl. No adjustment was made for differences in trawls.

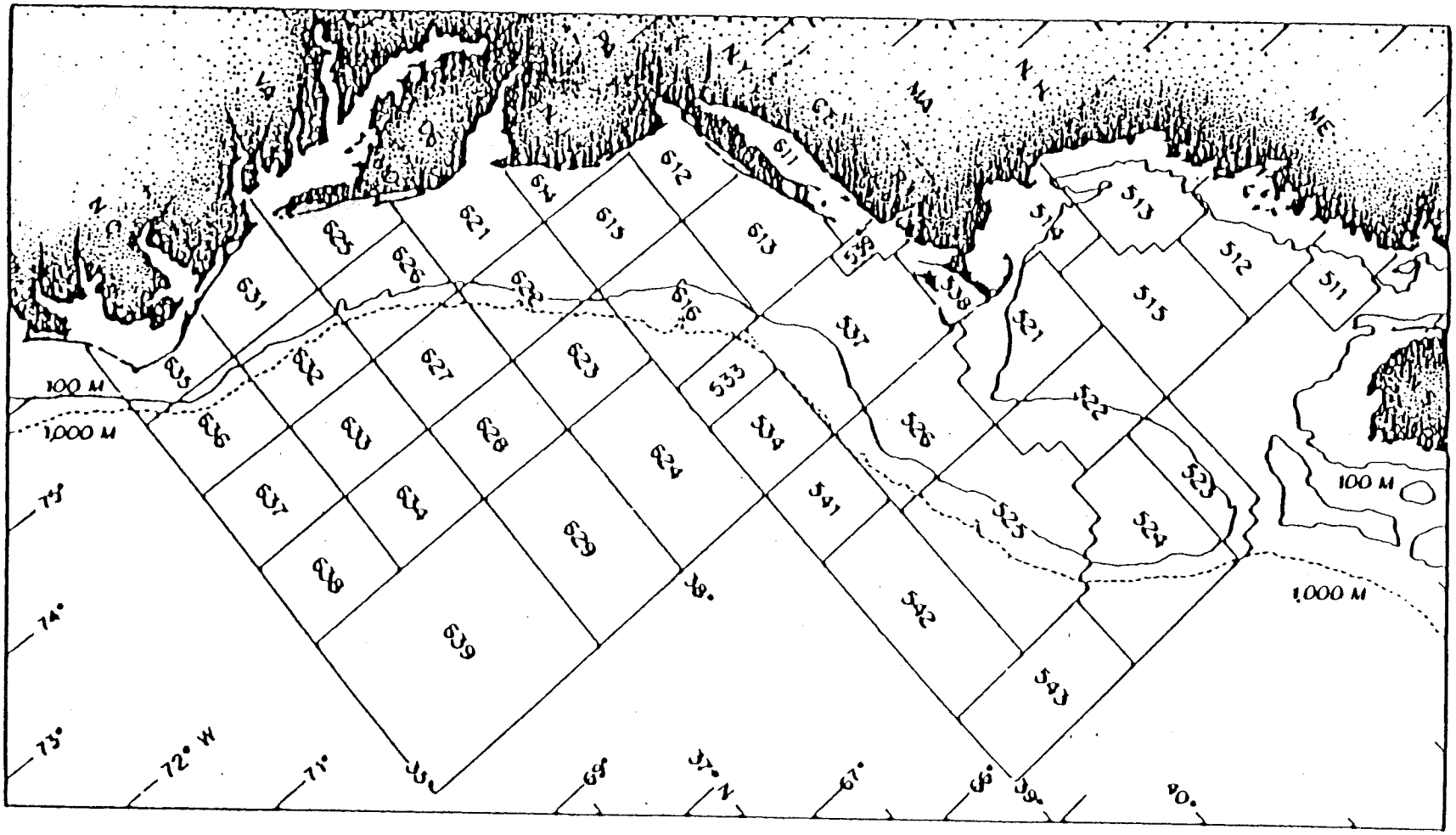


Figure 1. Statistical Areas used for reporting USA commercial fishery statistics.

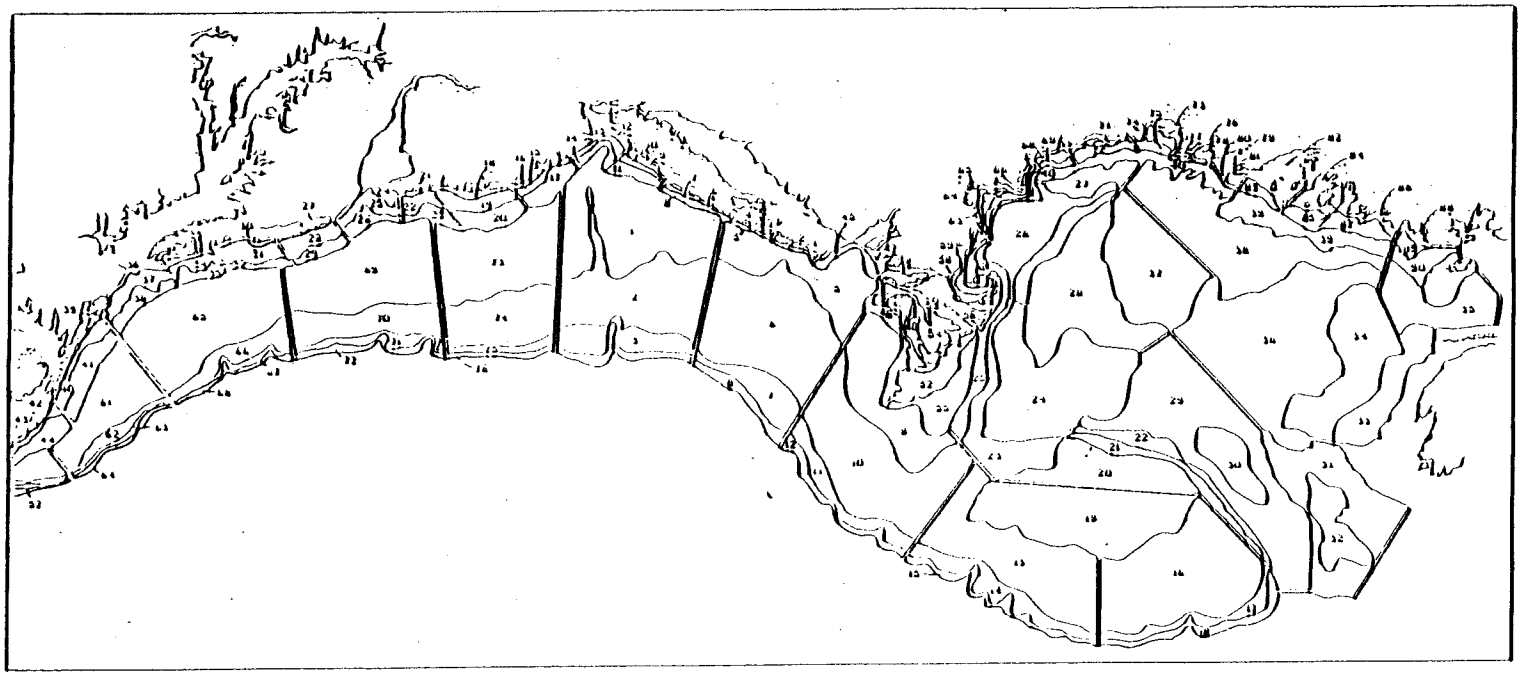


Figure 2. Sampling strata used in NEFC inshore and offshore bottom trawl surveys.

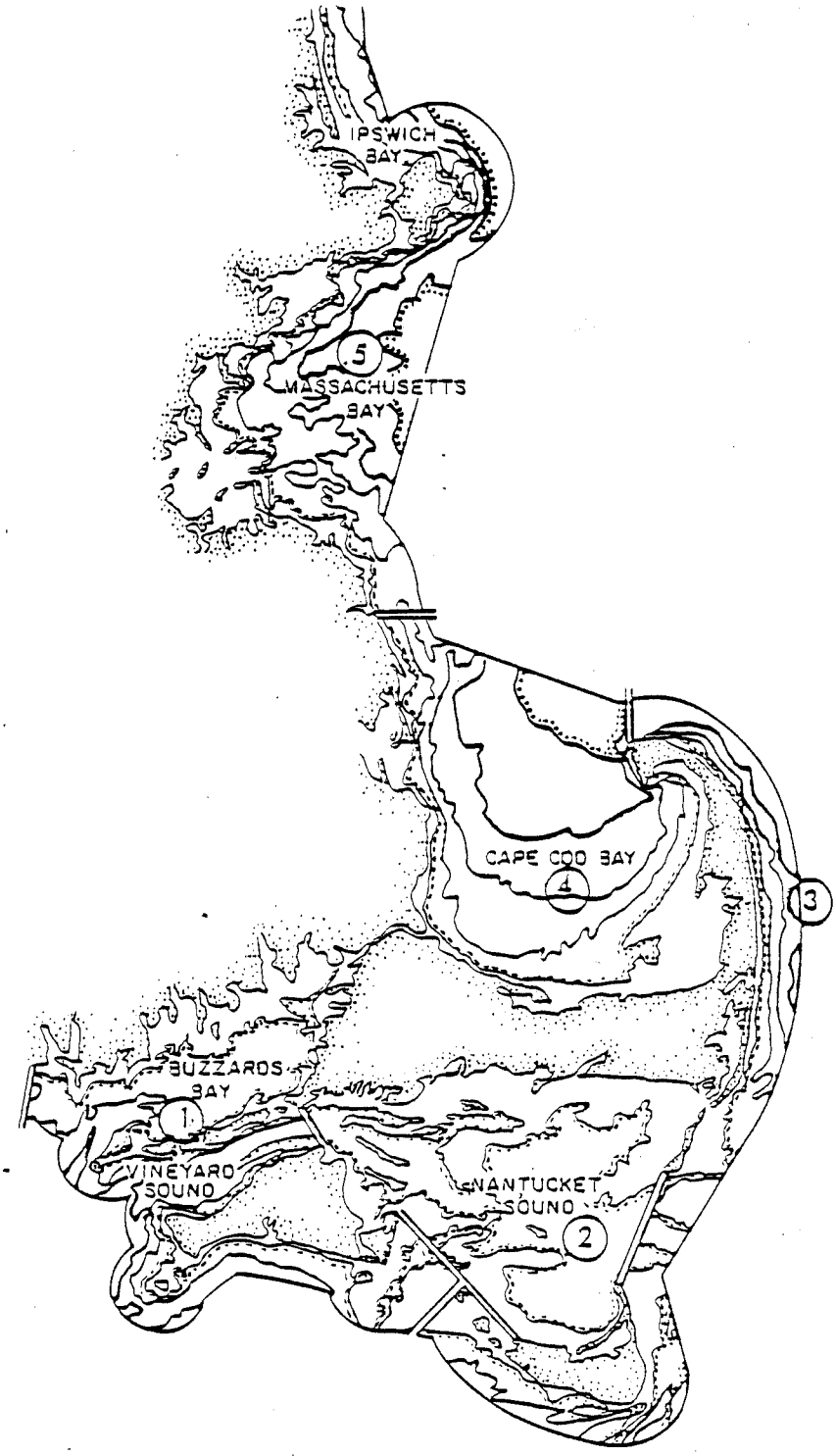


Figure 3. Massachusetts DMF inshore bottom trawl survey areas; (1)Buzzards Bay/Vineyard Sound, (2) Nantucket Sound, (3)East of Cape Cod, (4)Cape Cod Bay, (5)Massachusetts Bay.

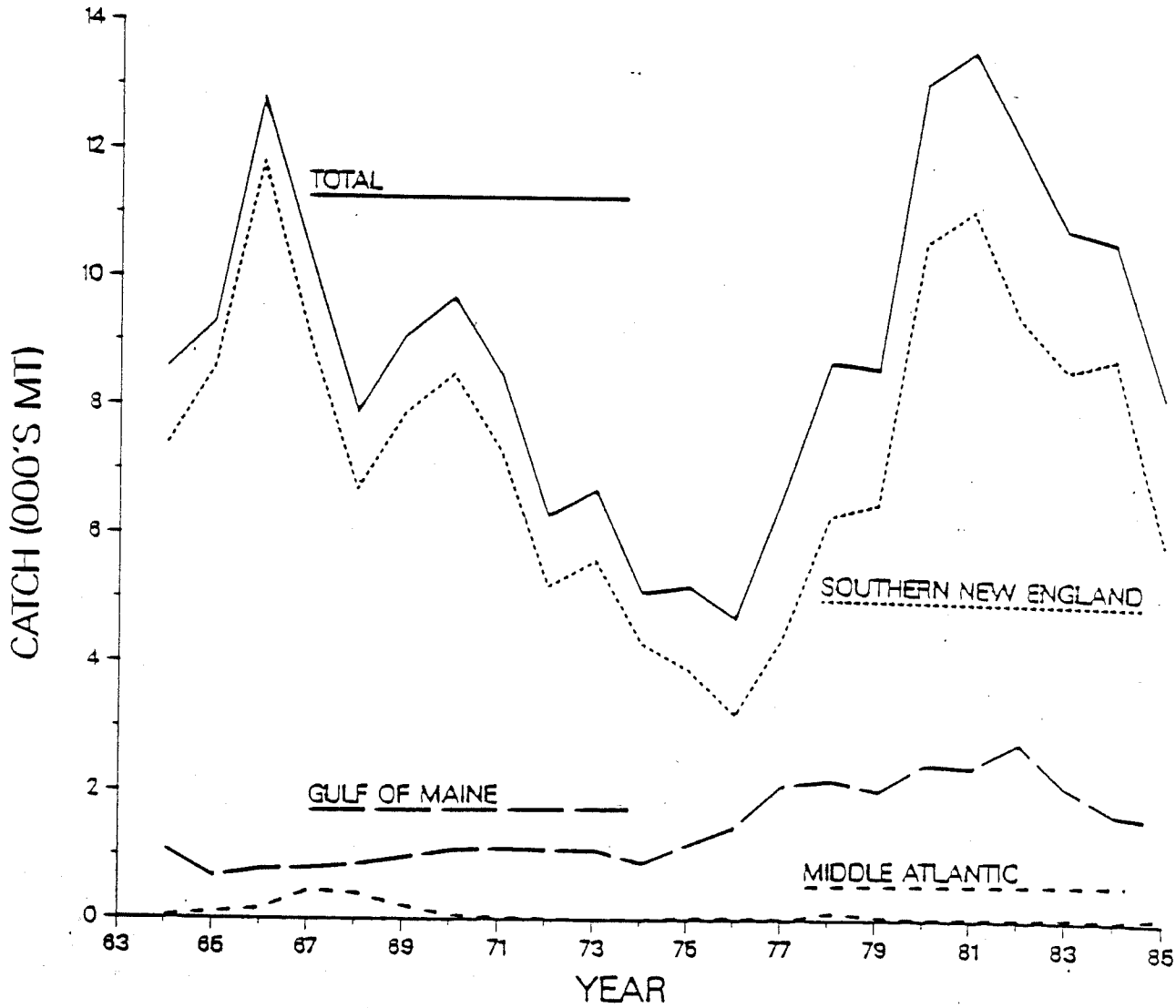


Figure 4. Commercial landings (mt.) of near shore spawning stocks of winter flounder by area, 1964-85.

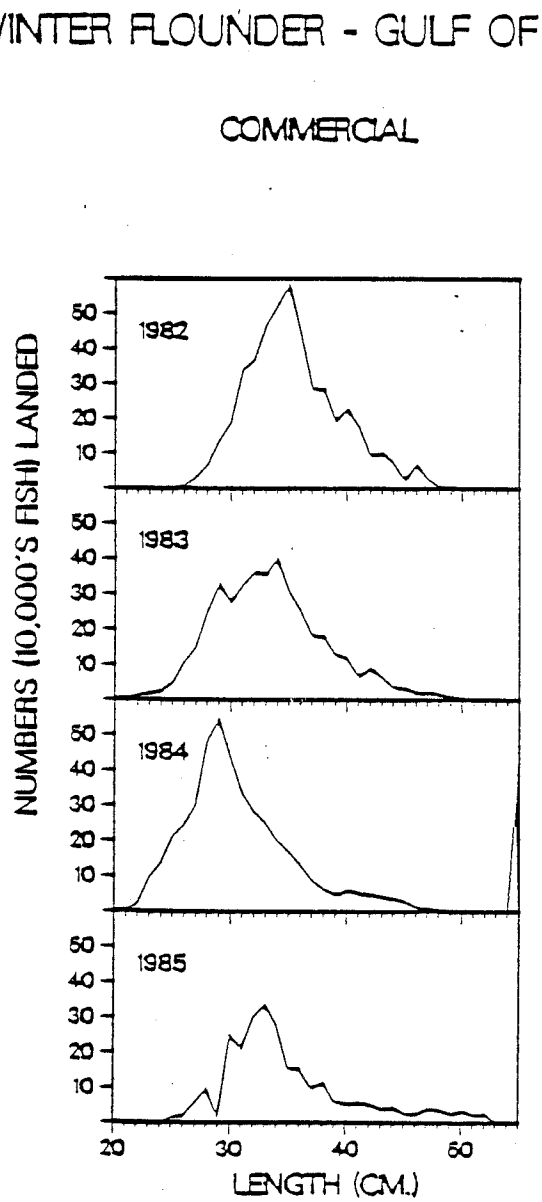


Figure 5. Length composition of winter flounder caught in the Gulf of Maine area, 1982-85.

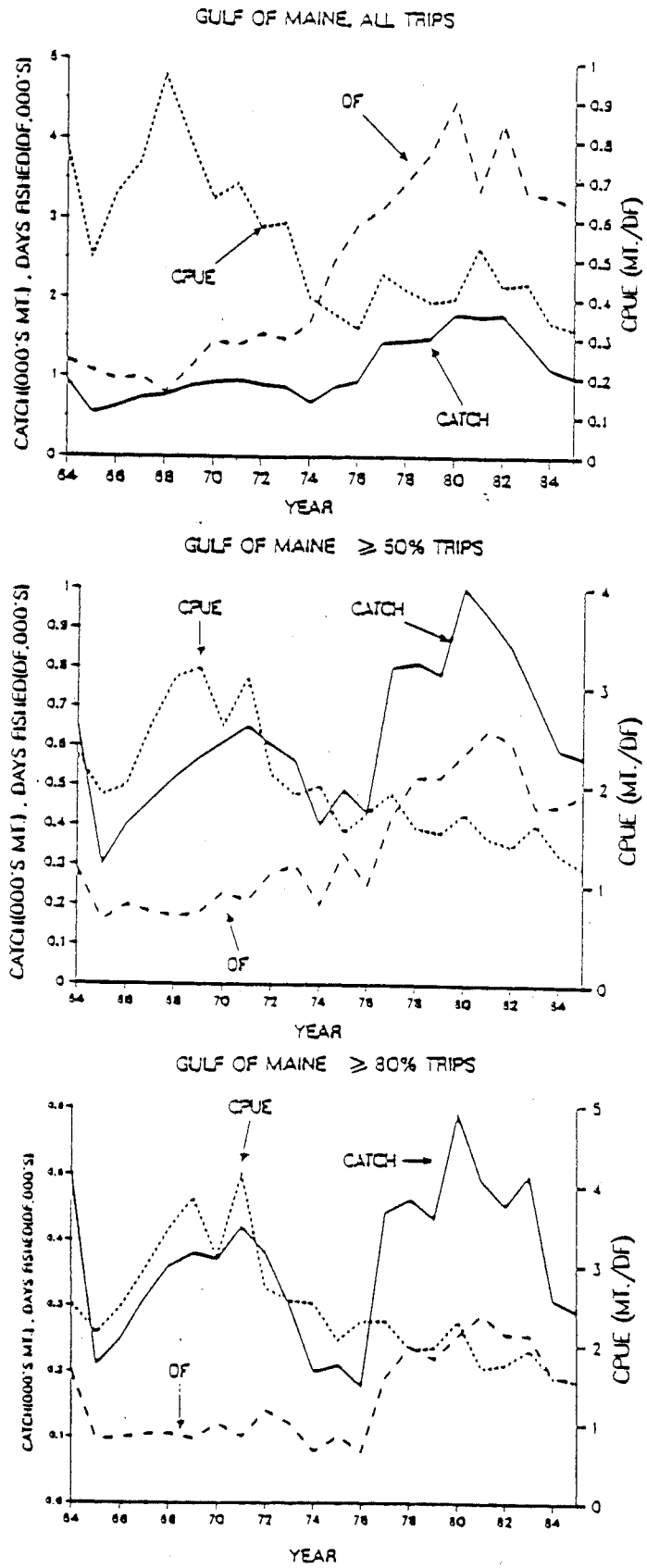
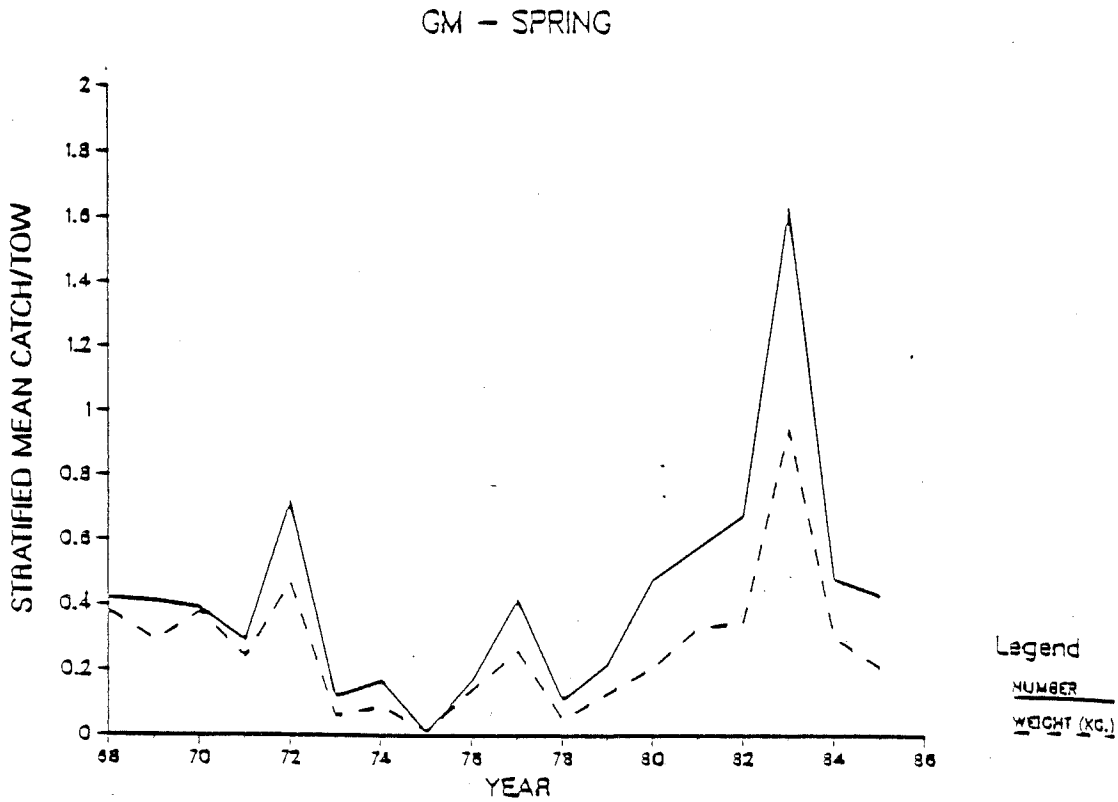


Figure 6 . Catch-per-unit-effort (CPUE), catch (mt.) and days fished (df) for all trips (otter trawlers, 5-50 gross tons) and trips containing ≥50% and ≥80% winter flounder in the Gulf of Maine area, 1964-85.



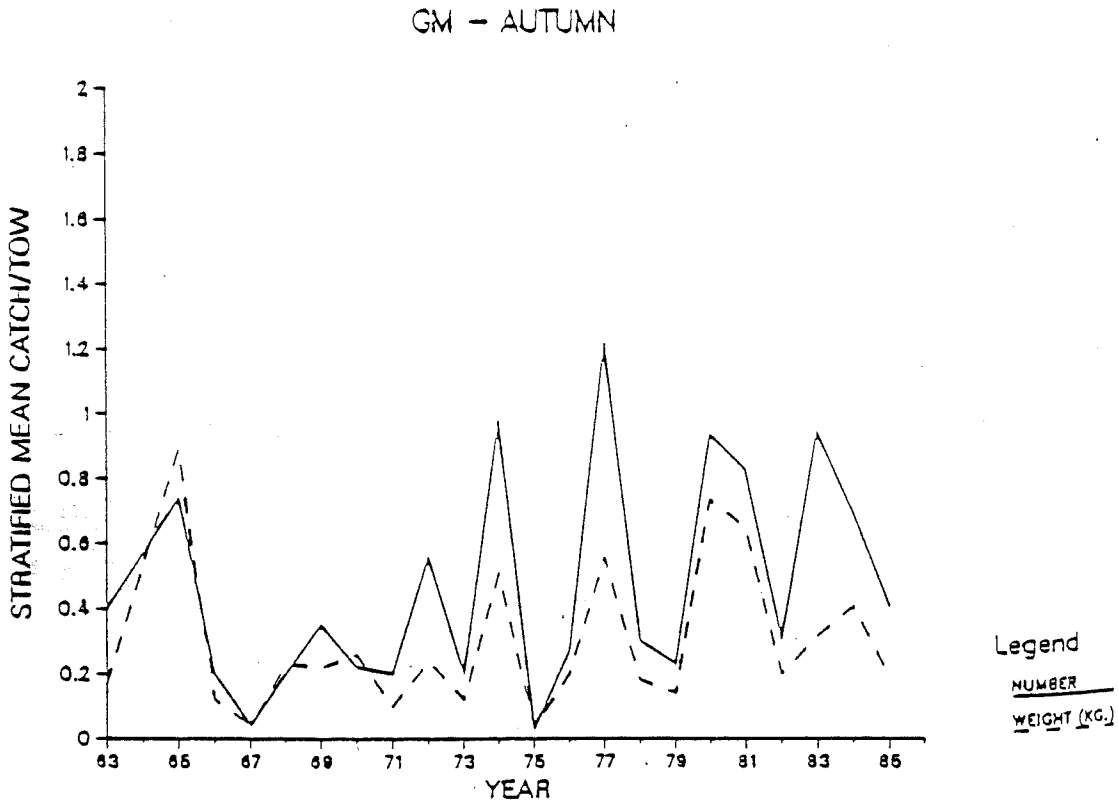


Figure 7. Stratified mean catch/tow in weight (kg.) and number for the spring and autumn NEFC offshore bottom trawl survey in the Gulf of Maine area, 1963-85.

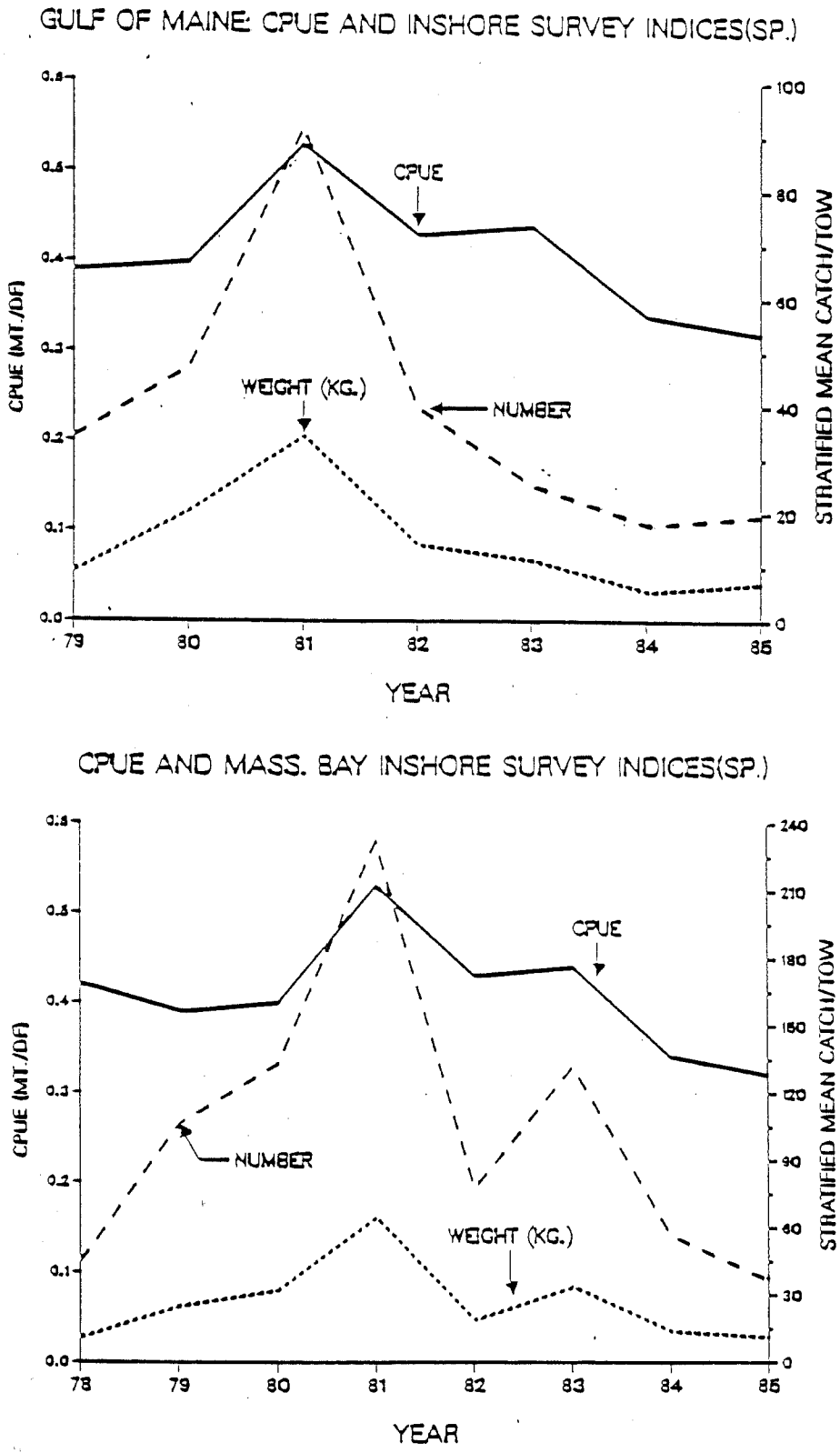


Figure 8. Correlations of Gulf of Maine catch-per-unit-effort (CPUE) for otter trawlers (5-50 gross tons, all trips) versus: (1) spring survey indices for NEFC inshore trawl survey, 1979-85 (no./tow r=.94**, kg./tow r=.86*) (2) Massachusetts DMF Massachusetts Bay inshore trawl survey, 1978-85 (no./tow r=.83*, kg./tow r=.81*) (* significant at .05, ** significant at .01).

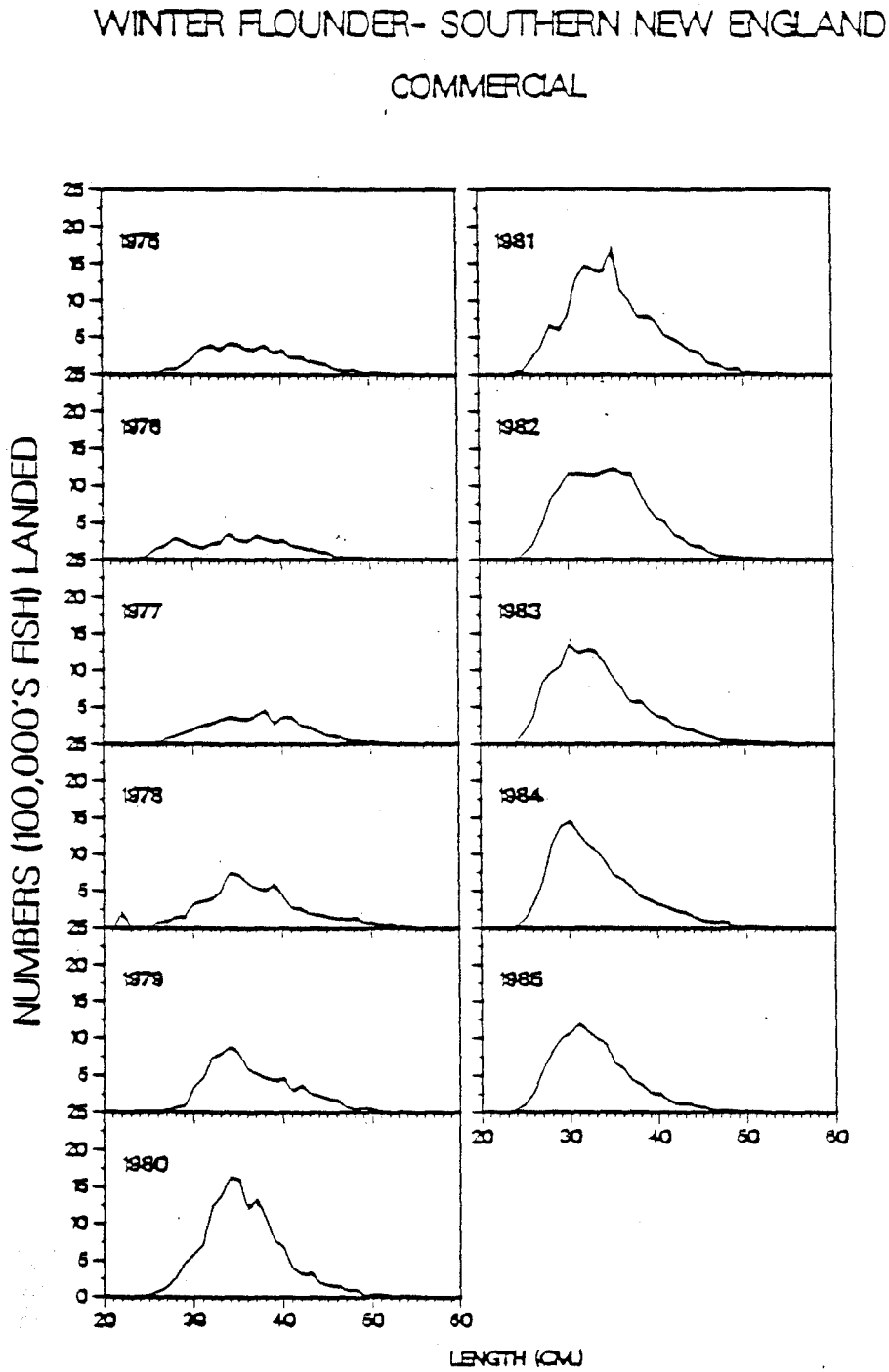


Figure 9. Length composition of winter flounder caught in the Southern New England area, 1975-85.

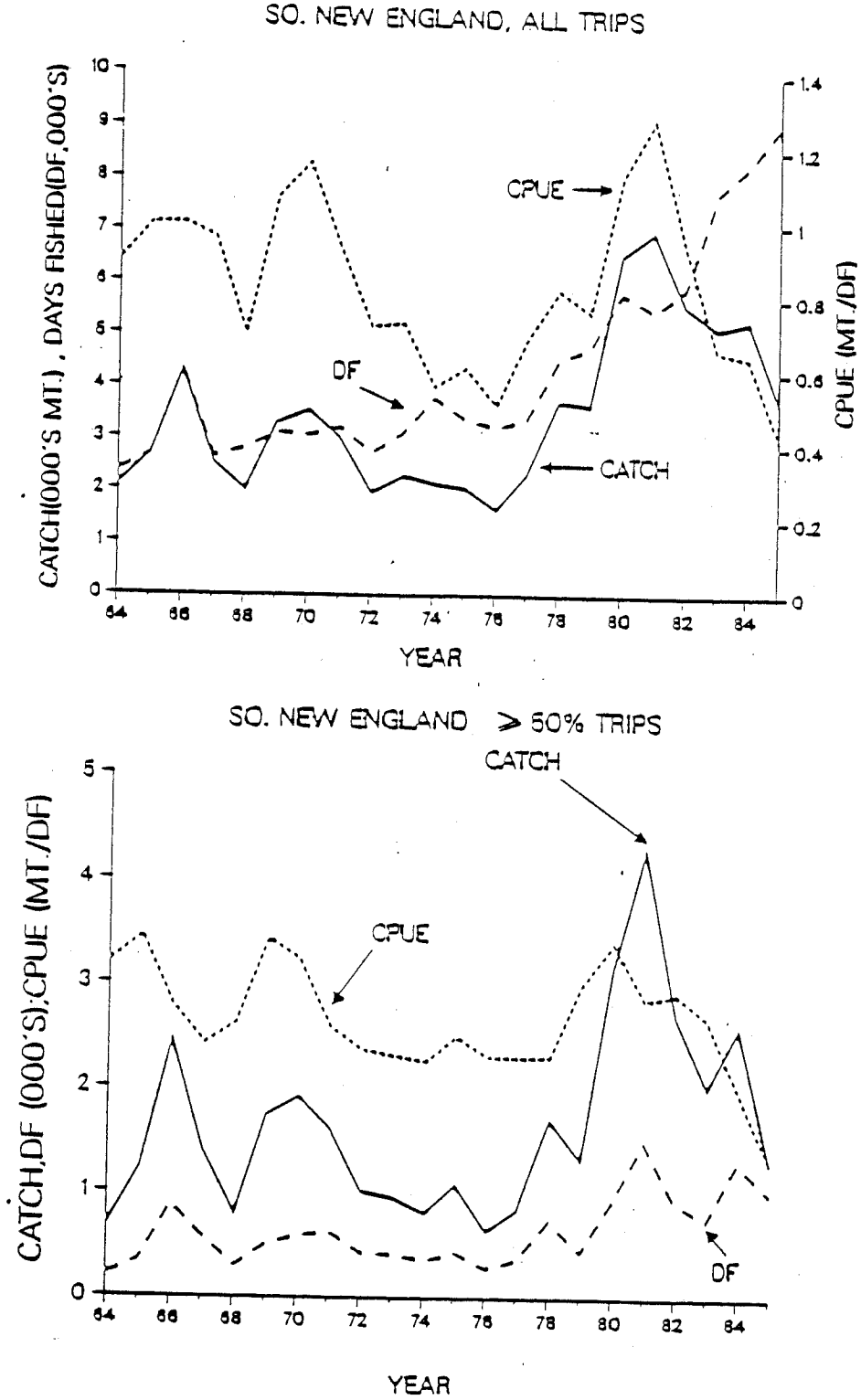


Figure 10. Catch-per-unit-effort (CPUE), catch (mt.) and days fished (df) for all trips (otter trawlers, 5-50 gross tons) and trips containing ≥50% winter flounder in the Southern New England area, 1964-85.

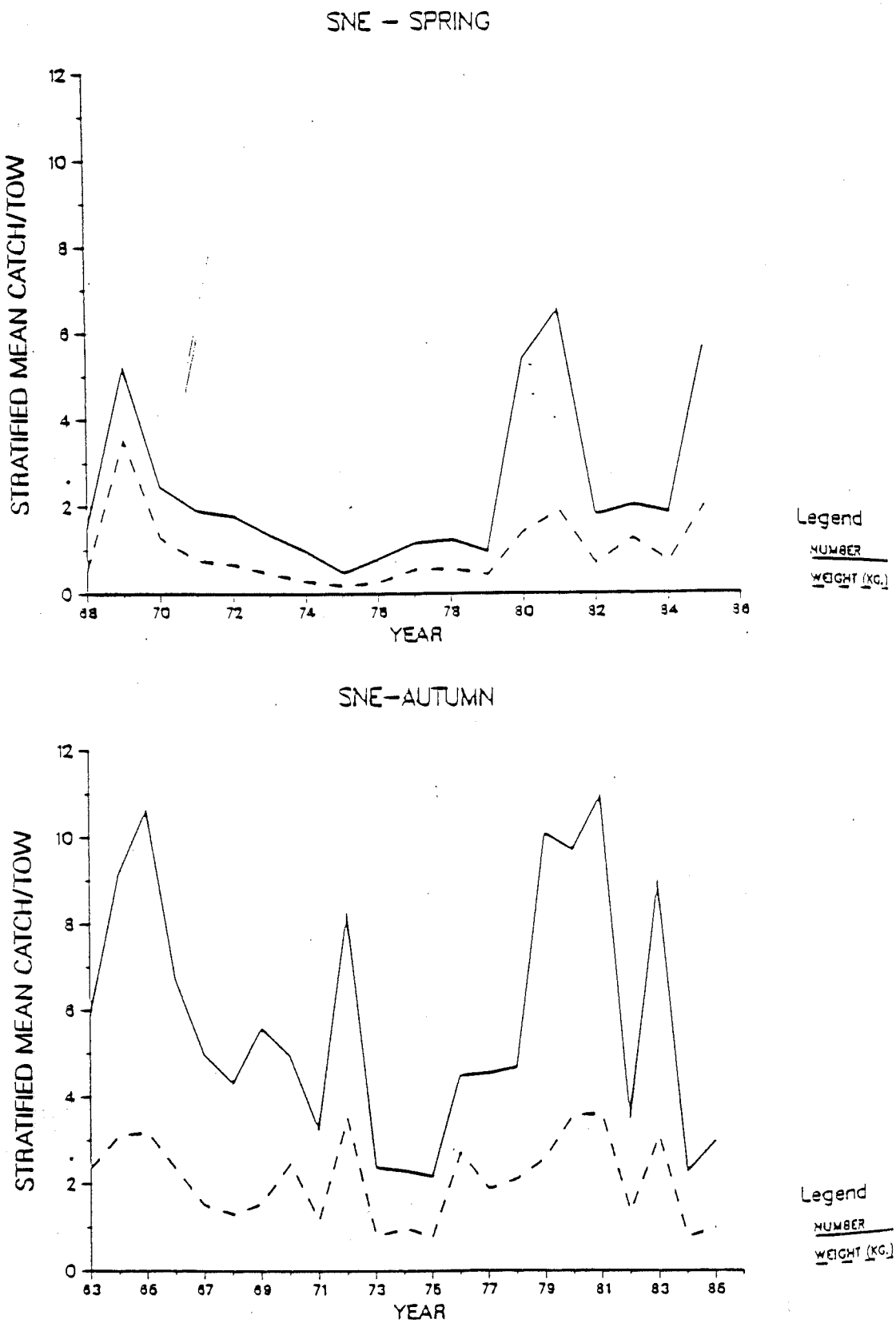


Figure 11. Stratified mean catch/tow in weight (kg.) and number for the spring and autumn NEFC offshore bottom trawl survey in the Southern New England area, 1963-1985.

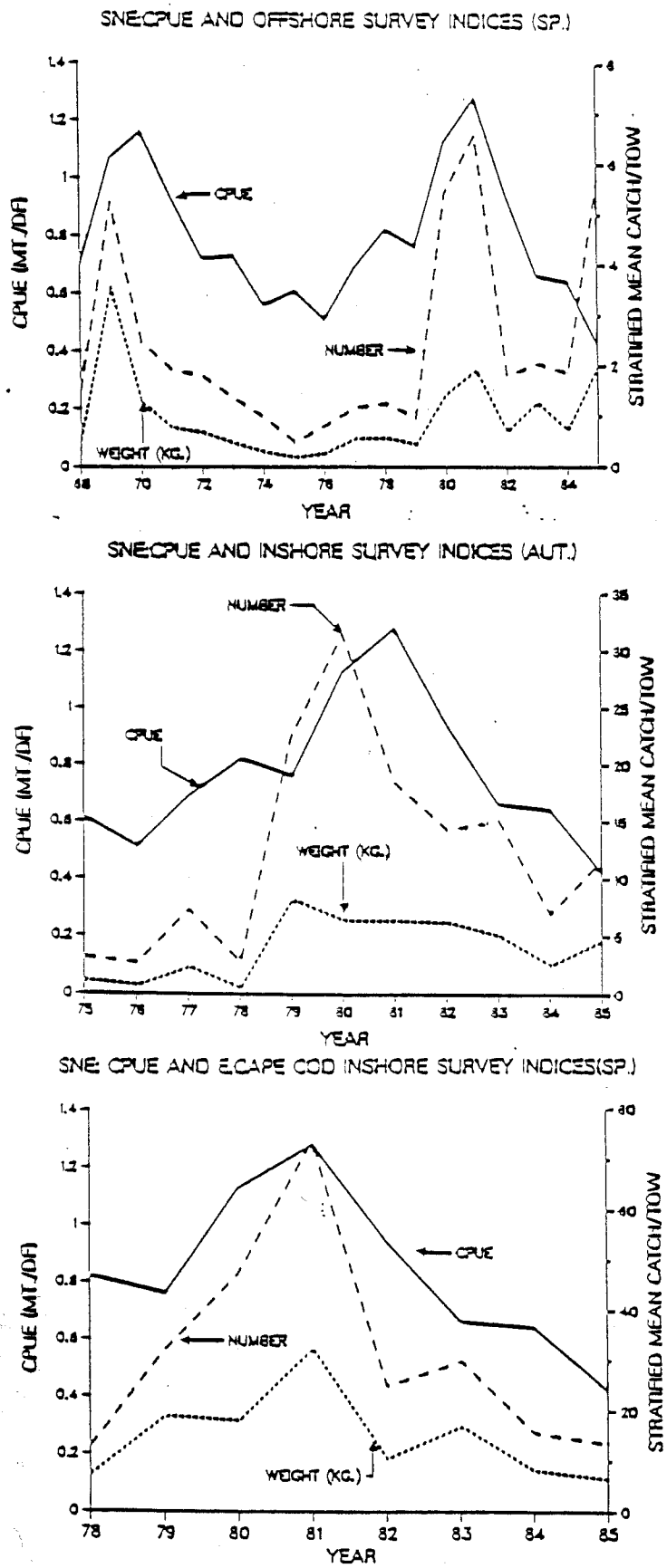
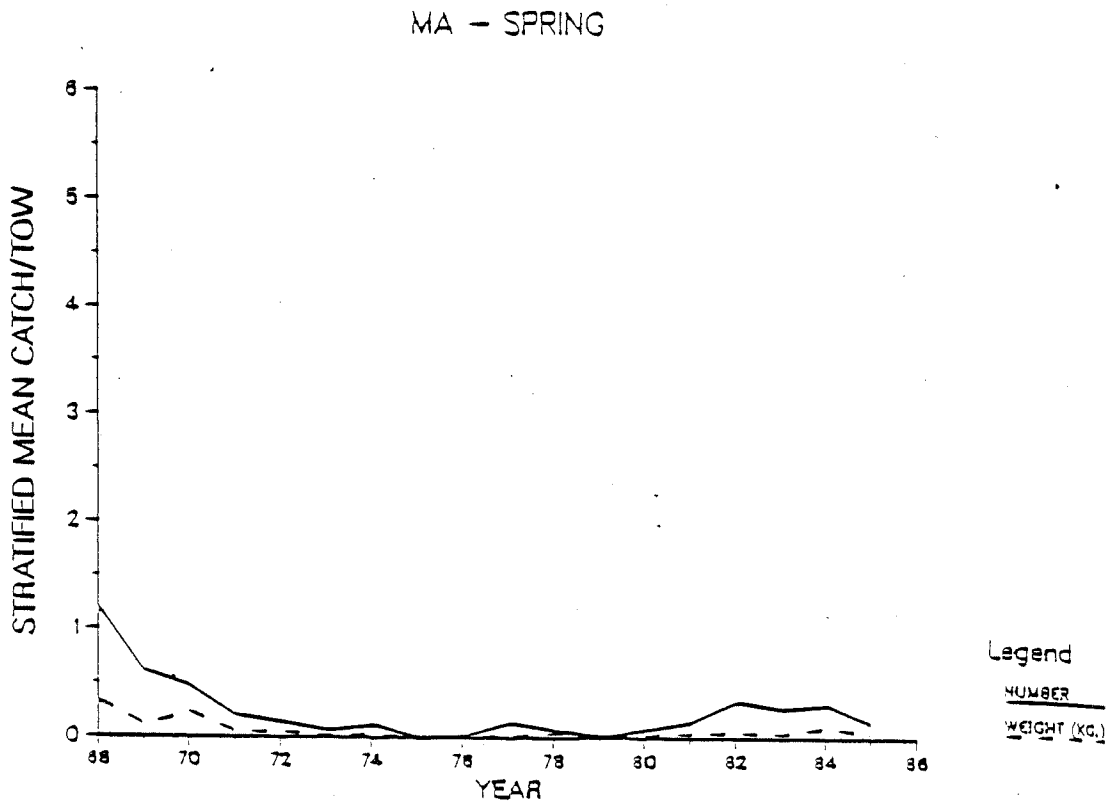


Figure 12. Correlations of Southern New England catch-per-unit-effort (CPUE) for otter trawlers (51-150 gross tons, all trips) versus: (1) spring survey indices for NEFC offshore trawl survey, 1968-85 (no./tow r=.52*. kg./tow r=.48*) (2) autumn survey indices for NEFC inshore trawl survey, 1975-85 no./tow r=.60*, kg./tow r=.49) (3) spring survey indices for Massachusetts DMF East of Cape Cod inshore trawl survey, 1978-85 (no./tow r=.84**, kg./tow r=.74*) (* significant at .05,** significant at .01).



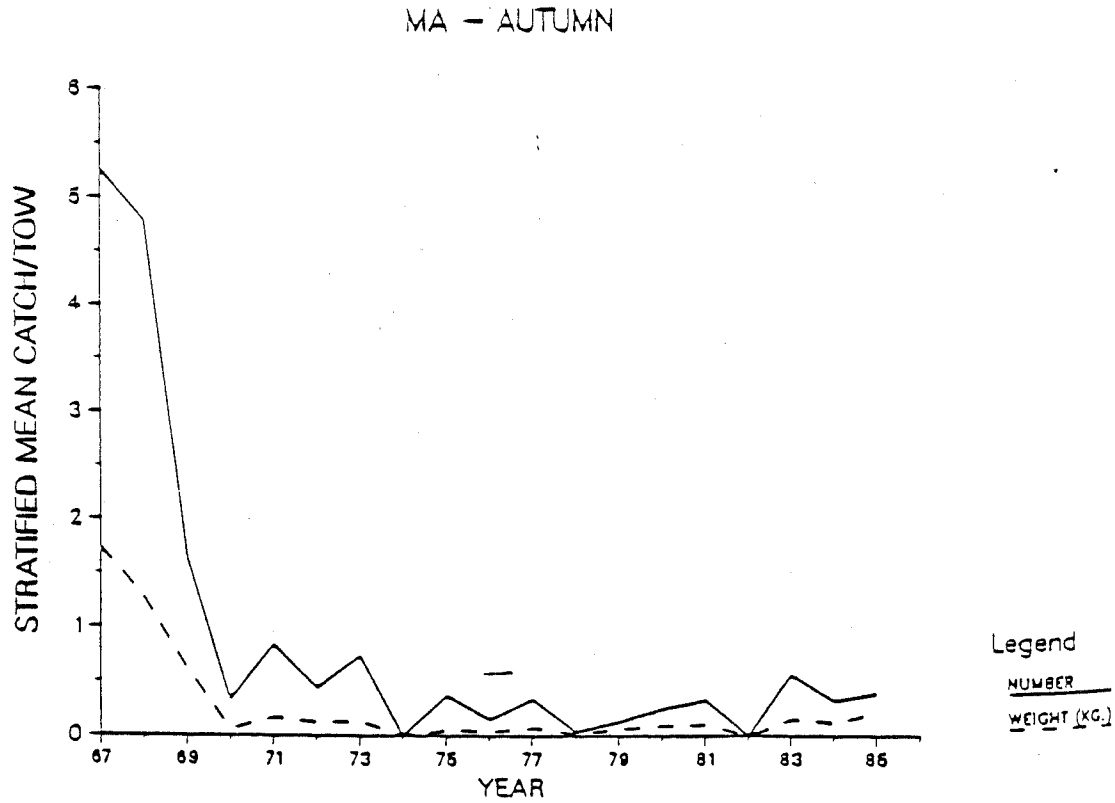
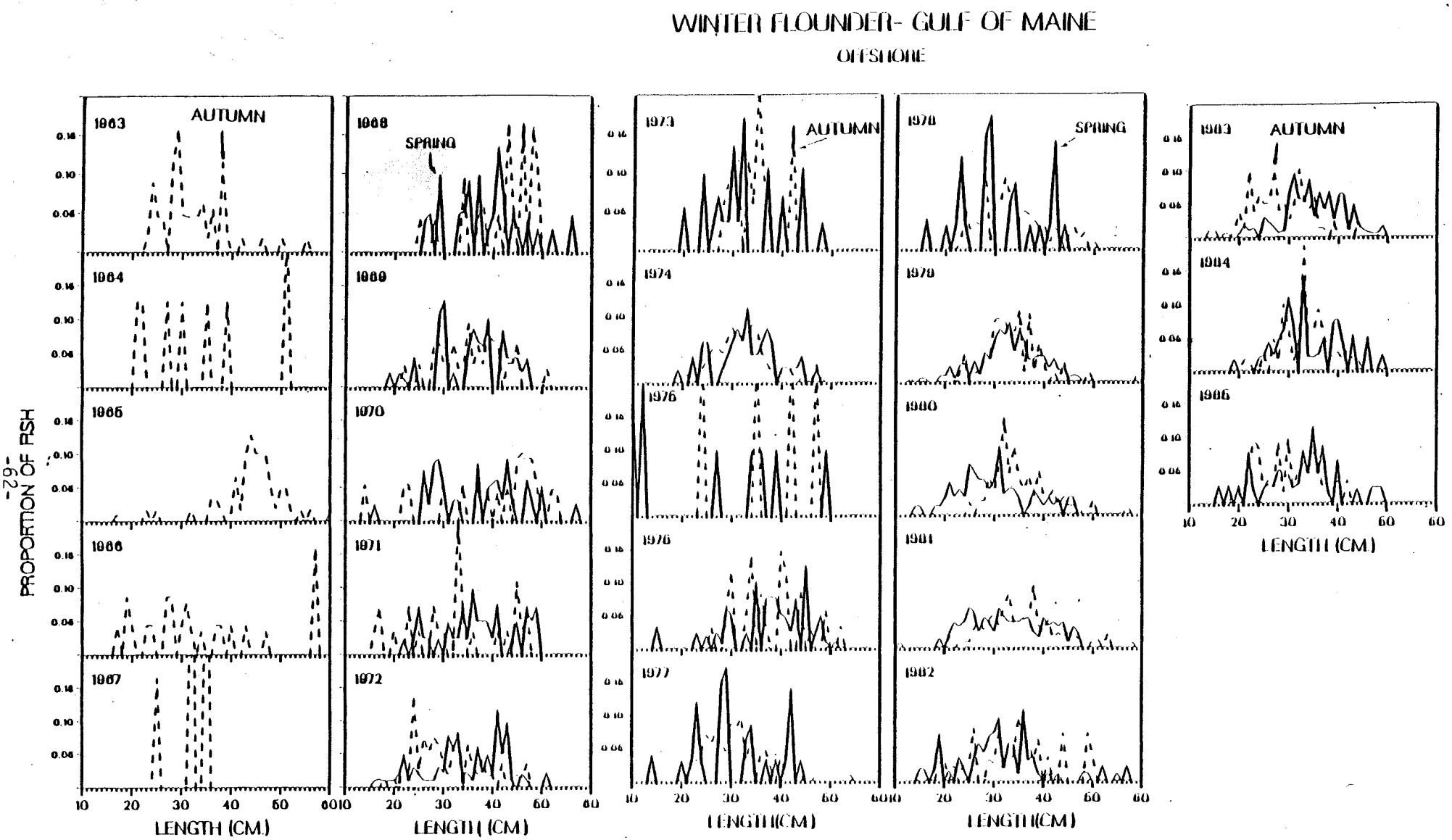
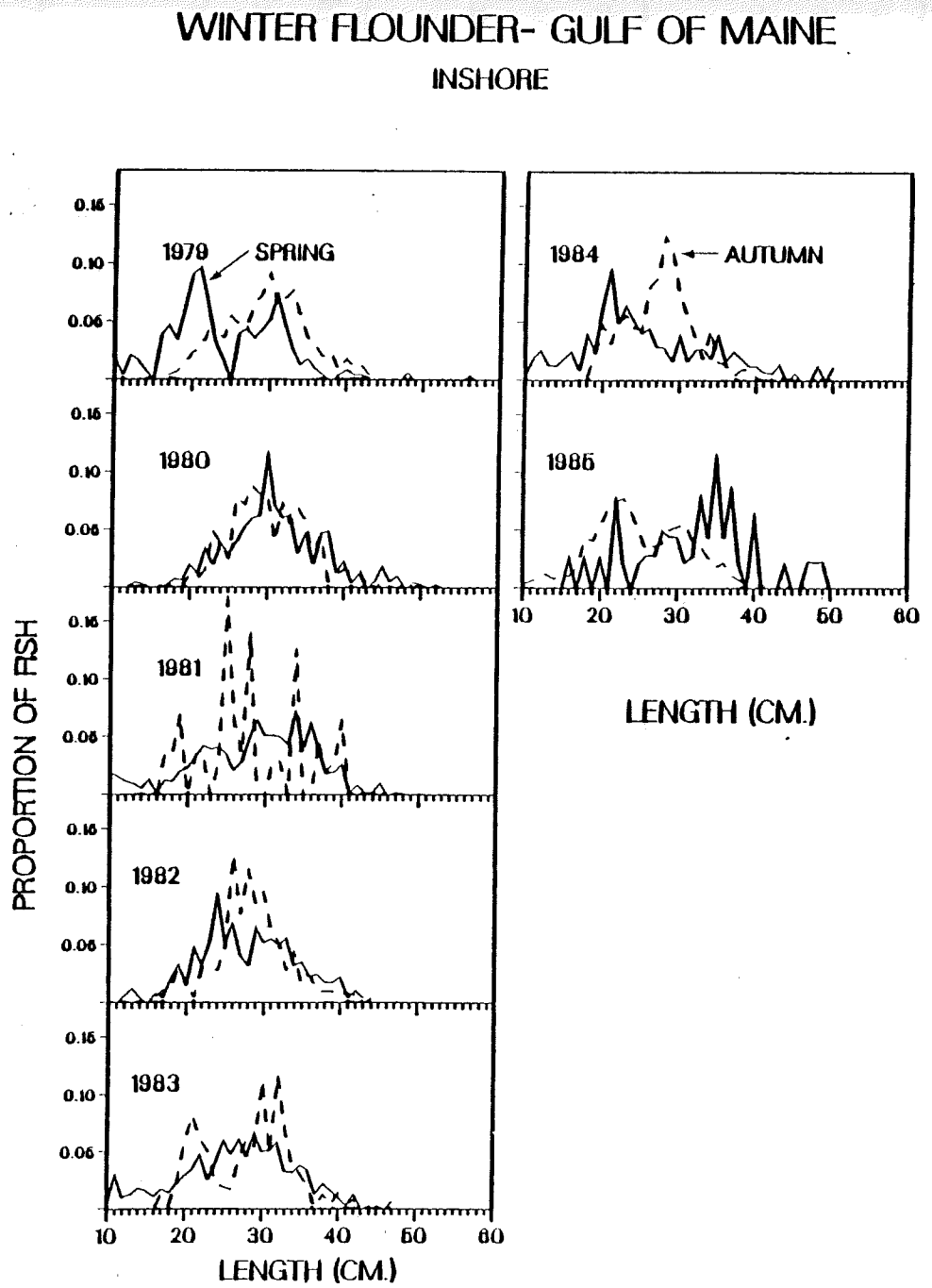


Figure 13. Stratified mean catch/tow in weight (kg.) and number for the spring and autumn NEFC offshore bottom trawl survey in the Middle Atlantic area, 1967-85.

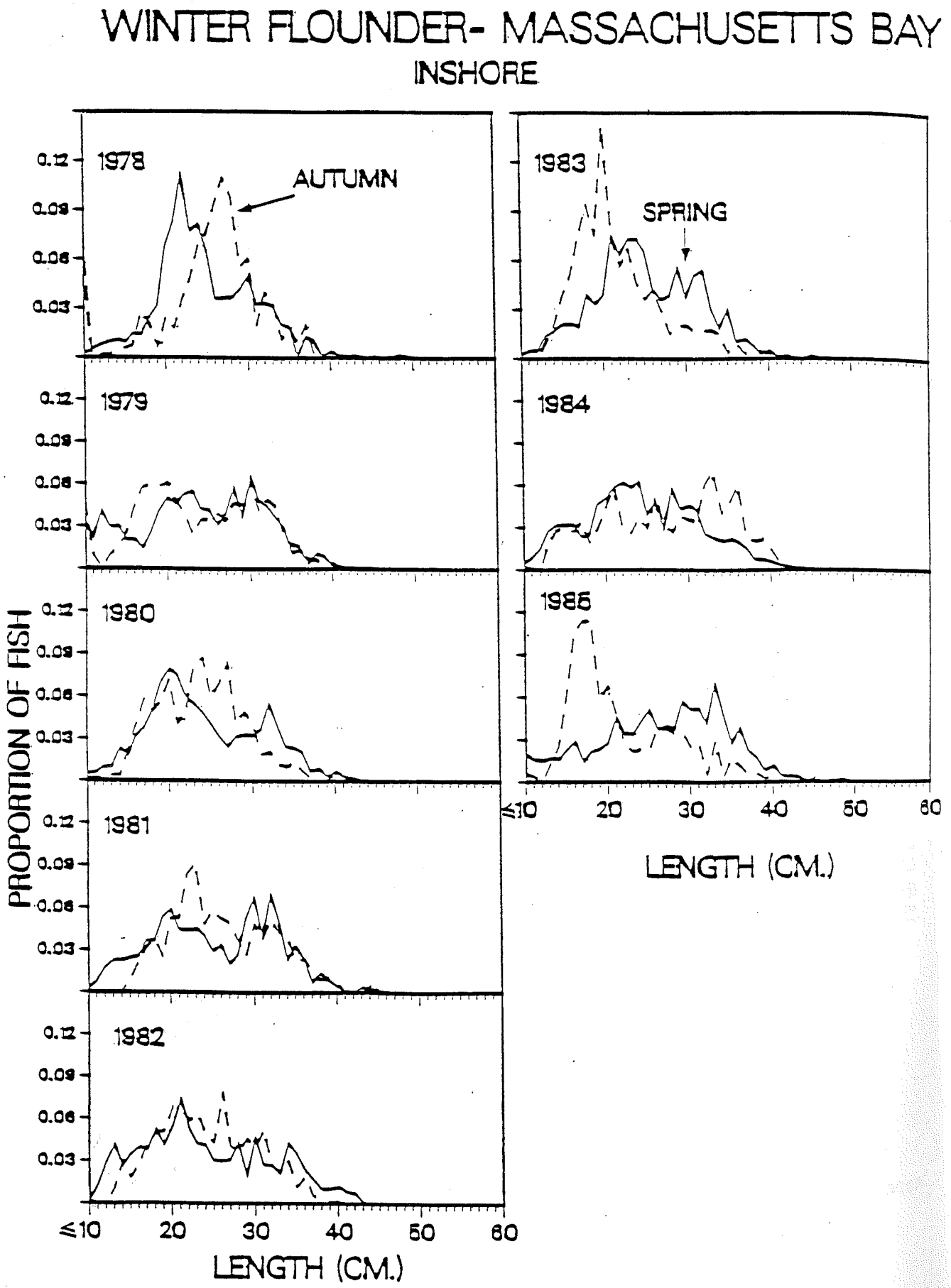
Appendices



Appendix A-1. Length frequencies (cm) for the NEFC offshore bottom trawl survey in the Gulf of Maine area, 1963-1986.

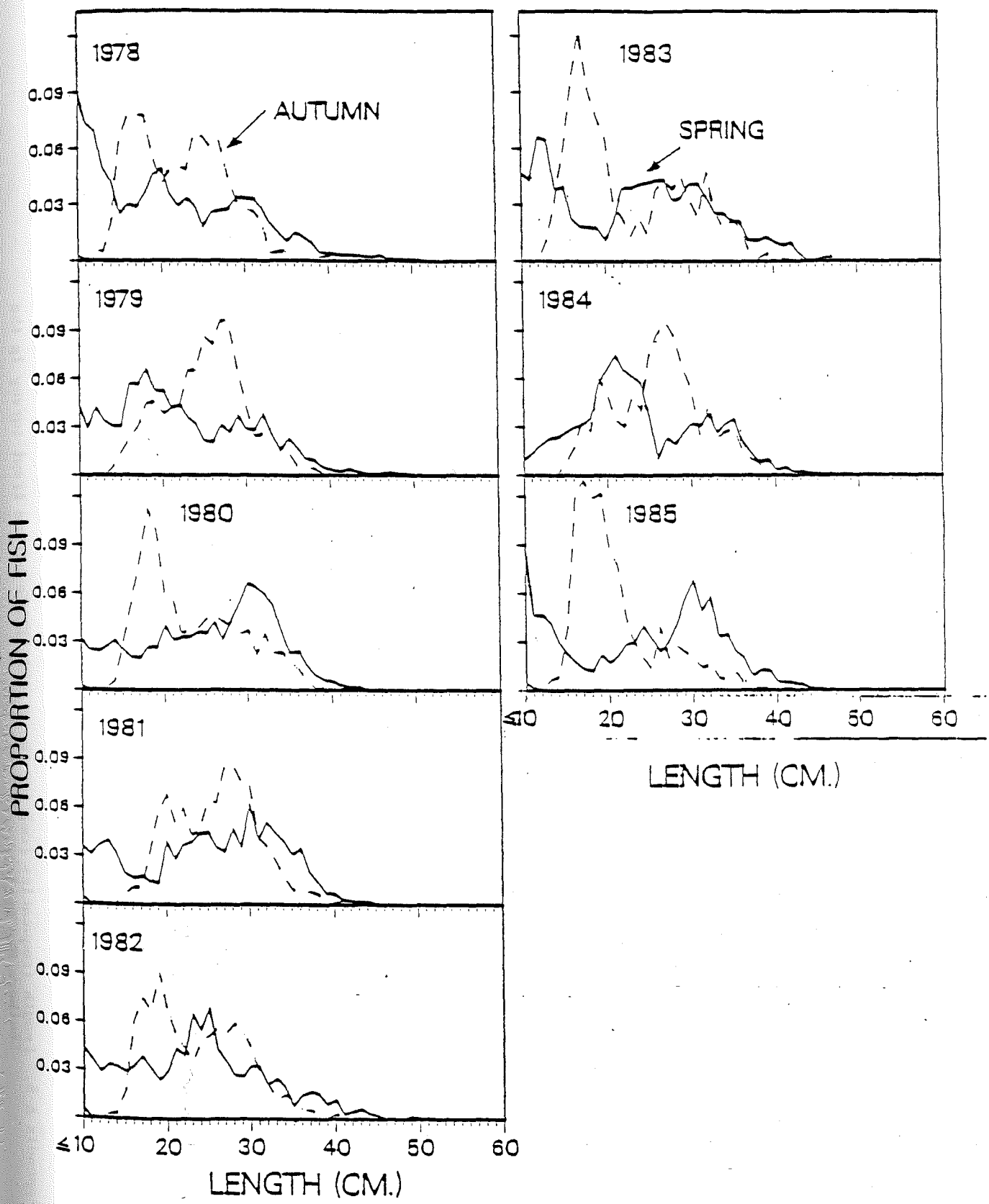


Appendix A-2. Length frequencies ($\leq$10 to 60 cm) for the NEFC inshore bottom trawl survey in the Gulf of Maine area, 1979-1986.

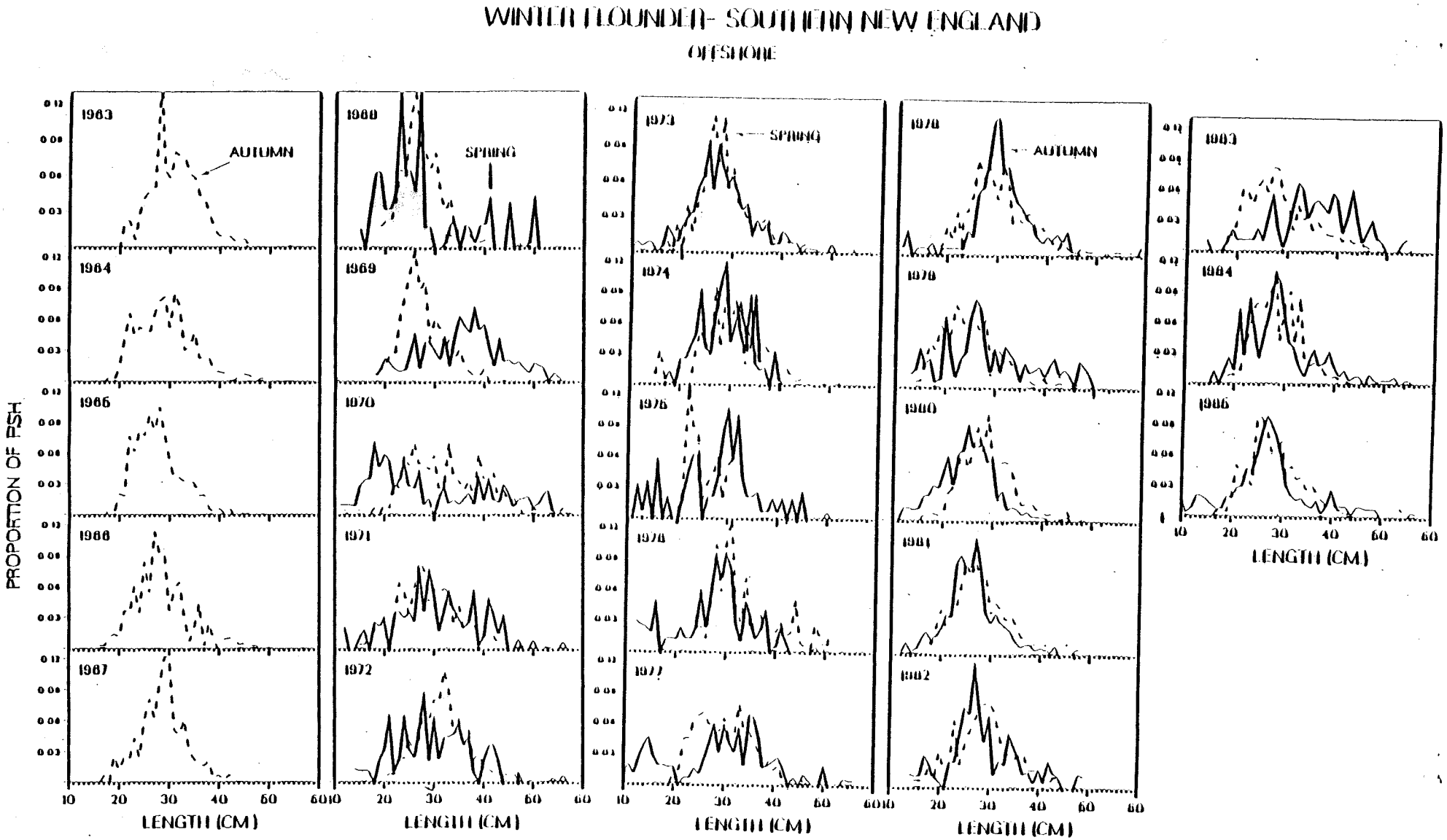


Appendix A-3. Length frequencies (≤10 to 60 cm) for the Massachusetts state inshore survey in the Massachusetts Bay area.

WINTER FLOUNDER- CAPE COD BAY
INSHORE

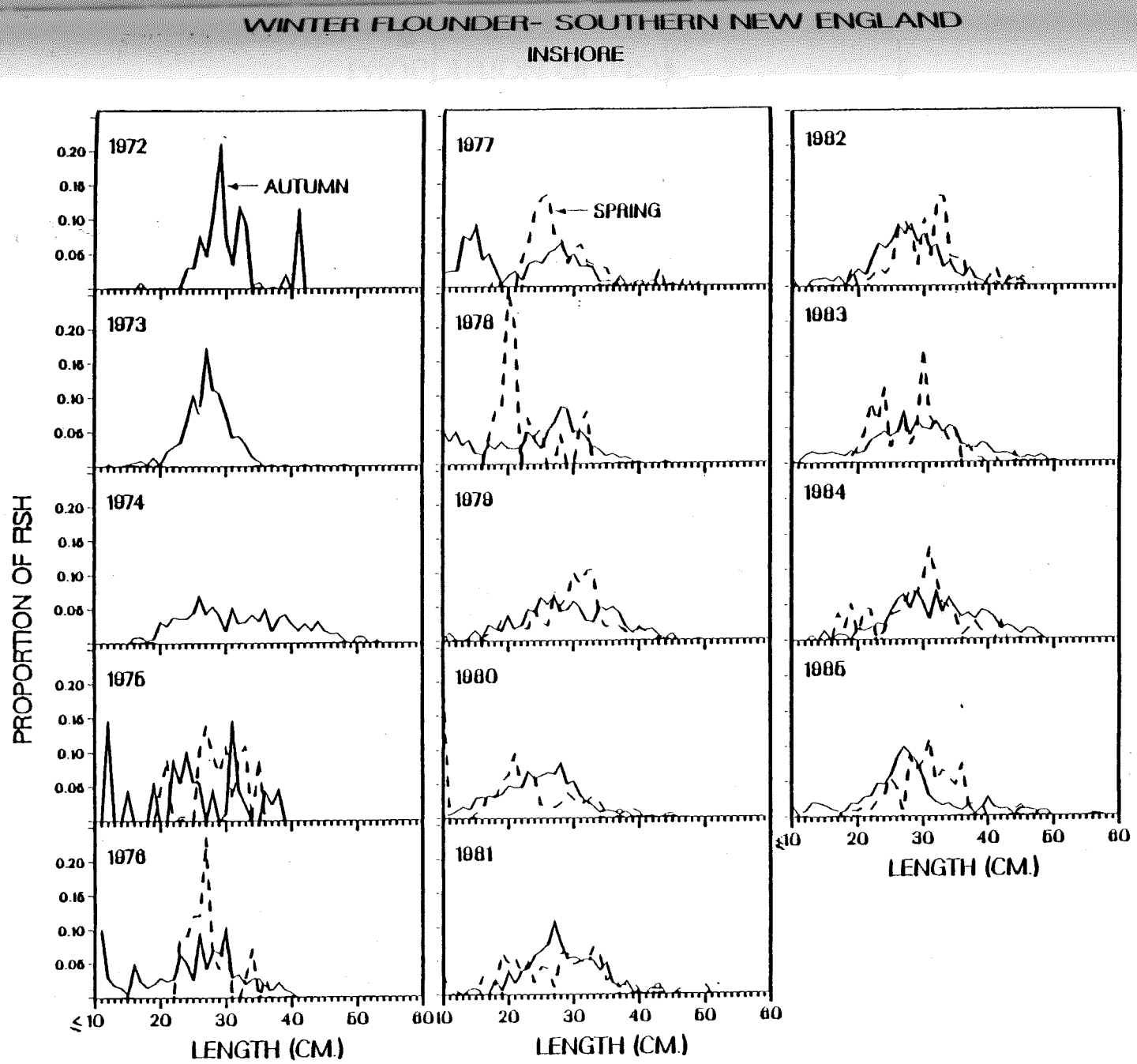


Appendix A-4. Length frequencies (≤10 to 60 cm) from the State of Massachusetts inshore survey in the Cape Cod Bay area, 1978-1985.

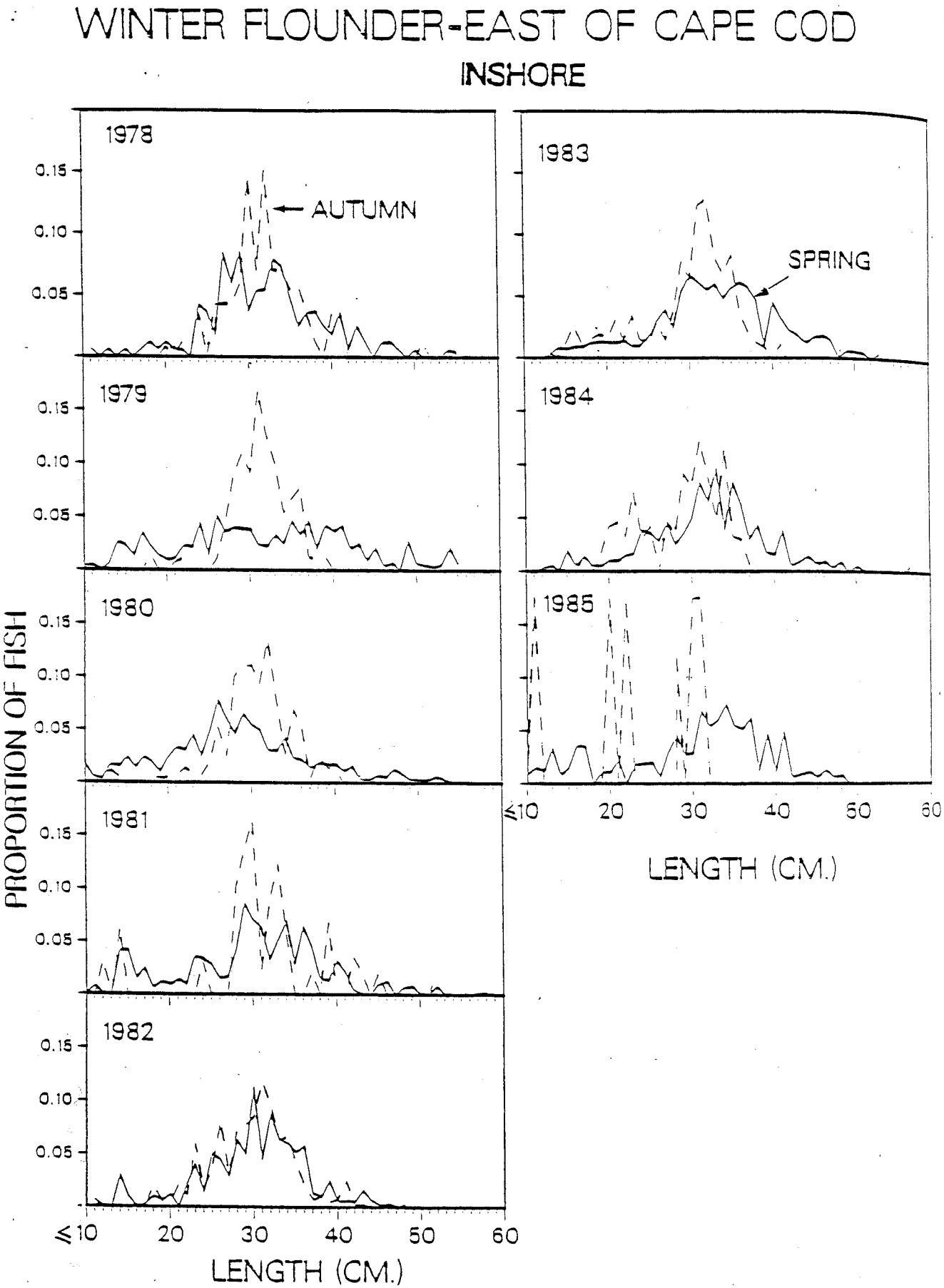


Appendix A-5. Length frequencies (cm) for the NEFC offshore bottom trawl survey in the Southern New England area, 1963-1986.

Appendix A-5. Length frequencies (cm) for the NEFC offshore bottom trawl survey in the Southern New England area, 1963-1986.



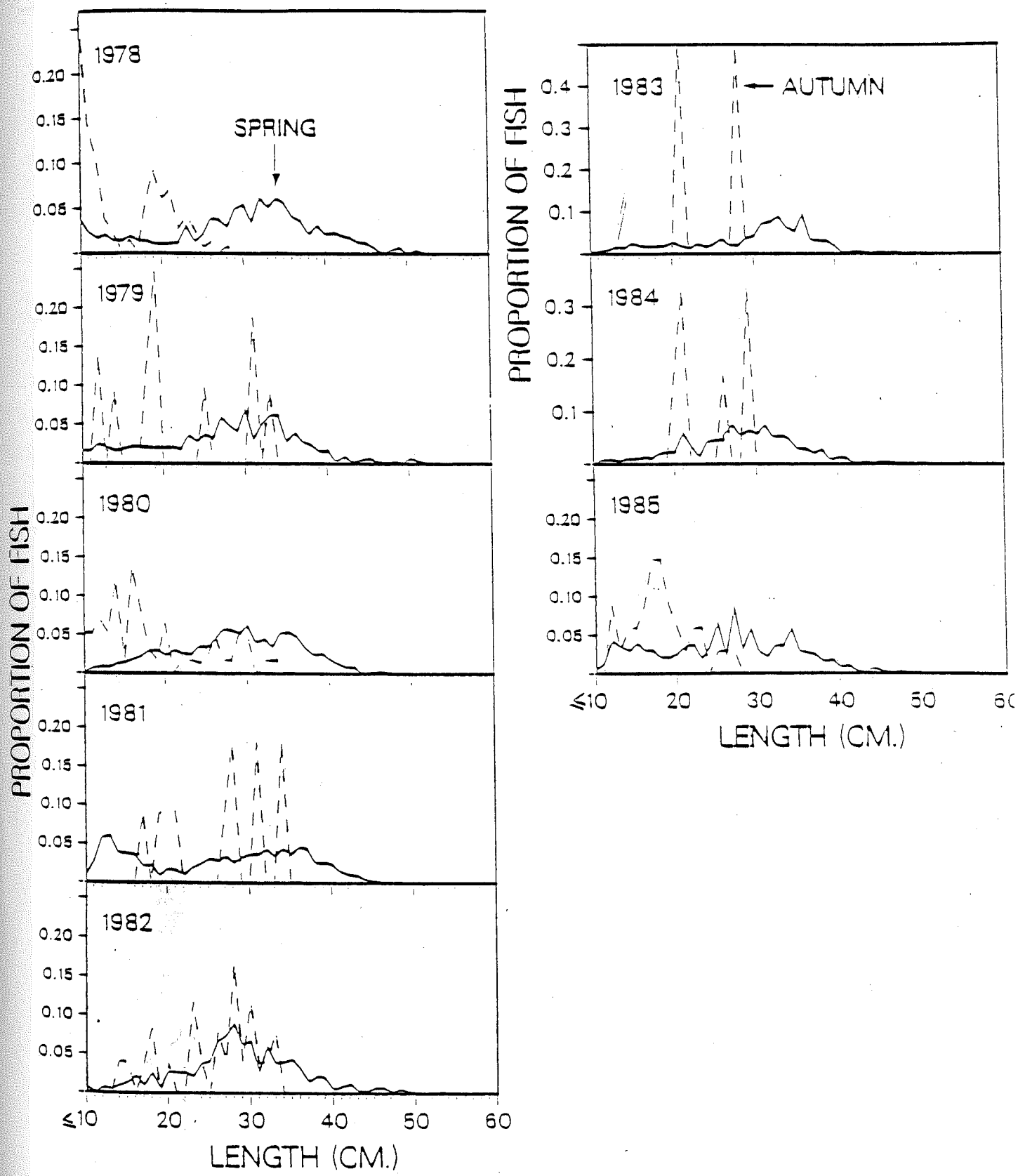
Appendix A-6. Length frequencies (cm) for the NEFC inshore bottom trawl survey in the Southern New England area, 1972-1986.



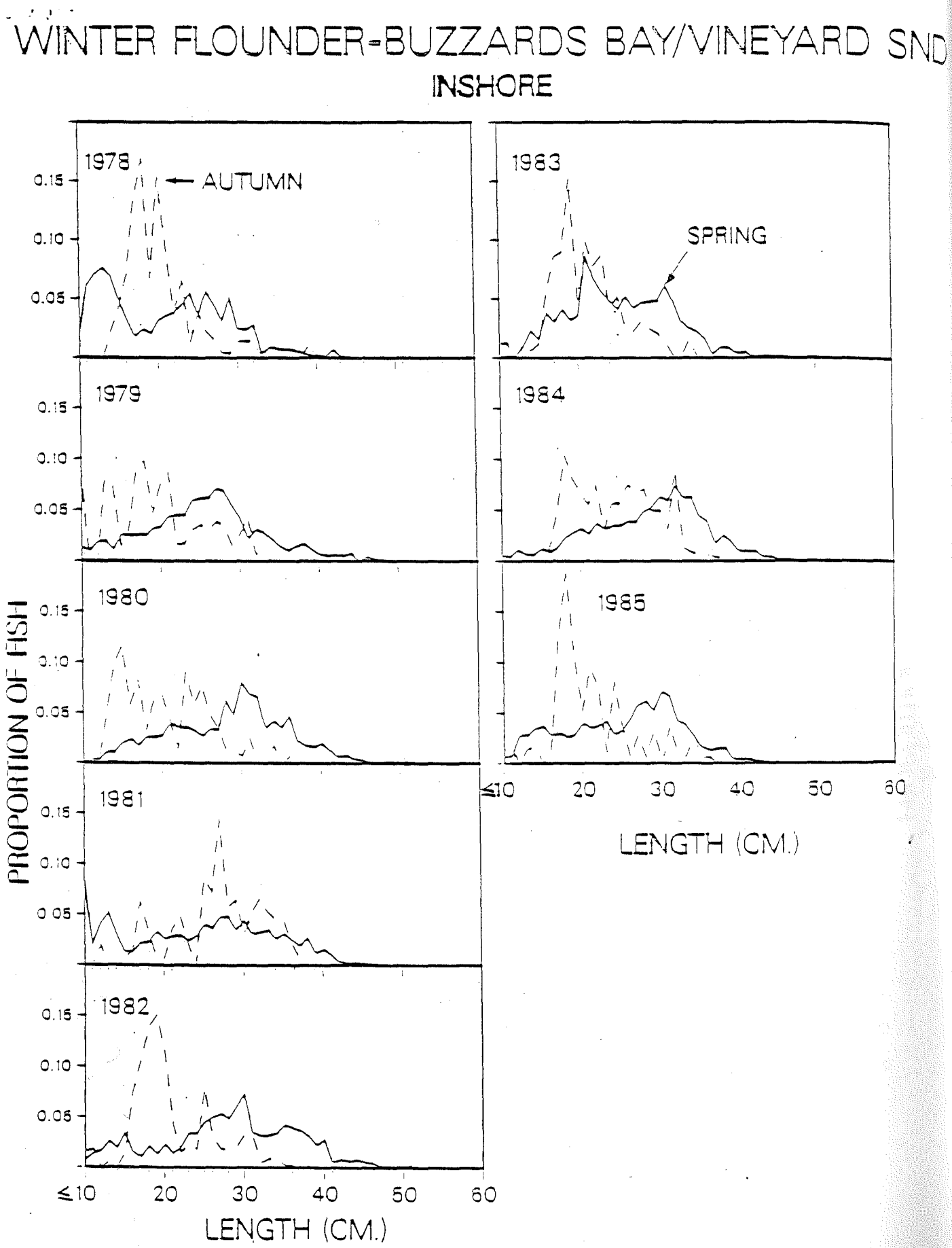
Appendix A-7. Length frequencies (cm) from the State of Massachusetts inshore survey in the east of Cape Cod area, 1978-1985.

WINTER FLOUNDER- NANTUCKET SOUND

INSHORE



Appendix A-8. Length frequencies (cm) from the State of Massachusetts inshore survey in the Nantucket Sound area, 1978-1985 (note difference in y-axis scale for 1983 and 1984).



Appendix A-9. Length frequencies (cm) from the State of Massachusetts inshore survey in the Buzzards Bay/Vineyard Sound area, 1978-1985.