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STATUS OF WITCH FLOUNDER IN THE GULF OF MAINE - 1983

by

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Summary

This report presents information on the biology and distribution of witch flounder (Glyptocephalus cynoglossus) in the Gulf of Maine - Georges Bank region (Northwest Atlantic Fisheries Organization or NAFO Subarea 5) and provides a preliminary assessment of the status of this resource based on analysis of commercial catch and effort and Northeast Fisheries Center (NEFC) research vessel survey data. In USA fisheries, witch flounder have been taken primarily as by-catch, although the species has also been subjected to intensive directed effort on occasion, e.g., as an intended component in mixed fishery situations. Since 1960, nominal catches from NAFO Subarea 5 have averaged approximately 3,000 metric tons (MT), with a range of from 1,000 to 6,000 MT; the 1982 total was 5,100 MT, and an increase to perhaps 7,000 MT is projected for 1983. Total effort, and landings of smaller fish, also appear to be increasing. Tonnage Class (TC) 3 vessels of from 51-150 gross registered tons (GRT) have dominated the fishery, although landings and effort by TC 4 vessels (>150 GRT) increased substantially in 1982.

Research vessel survey data suggest declines in abundance and biomass in recent years, and a consistent declining trend occurred following landings of from 5-6,000 MT in the early 1970s. As survey data do not provide a consistent basis for evaluating recruitment, future prospects are uncertain, but given current survey trends and past events in the fishery it does not appear that landings of 6-7,000 MT will be sustainable. Declines in abundance and biomass can be expected in the immediate future if current levels of harvest are maintained.

INTRODUCTION

The witch flounder, or grey sole [Glyptocephalus cynoglossus (L.)], is common throughout the Gulf of Maine and represents an important component of the mixed fishery resource in that area. Nominal catches in Northwest Atlantic Fisheries Organization (NAFO) Subarea 5 have generally been minor, averaging approximately 3,000 metric tons (MT) per year since 1910, with a range of 1,000-6,000 MT. Nevertheless, the species commands a high ex-vessel price compared to many other flatfishes and commercial interest in this species has been strong. Exploitation now appears to be increasing towards levels that have been associated with declines in abundance and biomass.

Witch flounder were managed under the International Commission for Northwest Atlantic Fisheries (ICNAF) "Other Flounders" group from 1973 to 1977 and averaged 10% of the total allowable catch for that category during that period. Catch of witch flounder has been unregulated since the United States' withdrawal from ICNAF in December of 1976, but this species is targeted for inclusion in the Atlantic Demersal Finfish Plan (ADF) which is currently under preparation by the New England Fishery Management Council.

No studies on stock structure have been conducted in the Georges Bank - Gulf of Maine region, although Northeast Fisheries Center (NEFC) spring and autumn survey catch-per-tow data indicate witch flounder in the central basin of the Gulf of Maine and along the northern fringes of Georges Bank to be relatively discrete from those on the western Scotian Shelf or further south (Figure 1). Properly, this would include

U.S. Statistical Areas 511-515 and 521-523 (Figure 2) although for convenience all witch flounder in Northwest Atlantic Fisheries Organization (NAFO) Subarea 5 are herein considered as a unit. Landings in the remainder of Subarea 5 have been of minor importance (<10% of the 1975-1982 total). The research vessel survey data base used includes catch data from NEFC survey sampling strata 22, 24, 26-30, and 33-40 (Figure 3), and catch data from Massachusetts survey sampling strata 25-36 in Regions 4 and 5 (Figure 4).

This report examines the biology and distribution of witch flounder in the Georges Bank - Gulf of Maine region, commercial fishery trends, and recent trends in abundance as evidenced by research vessel survey data.

BIOLOGY AND DISTRIBUTION

The witch flounder is a small-mouthed, right-handed flounder inhabiting deep, cold regions on both sides of the North Atlantic. Off North America, it ranges from Newfoundland to Cape Hatteras, although few are found south of New Jersey (Bigelow and Schroeder 1953). Caught in depths of 25 to 2,300 meters (m), witch flounder most commonly occur on mud or muddy sand bottom 90 to 275 m deep (Bigelow and Schroeder 1953, Lange and Lux 1978). In United States waters, witch flounder are most abundant throughout the Gulf of Maine and in deeper areas along the fringes of Georges Bank, Massachusetts Bay, and the Great South Channel (Figure 1). Witch flounder prefer temperatures of 2° to 4°C in winter and 7° to 9°C during the summer, although they can tolerate a range from -1° to 10°C (Bigelow and Schroeder 1953).

Juvenile witch flounder feed primarily on small crustaceans, but polychaete worms assume increased importance in their diet as size increases. Euphausiids comprise 70% of the diet of fish less than 20 cm, with amphipods (14%) and small polychaetes (65%) the major prey items of fish 21-25 cm in length (Bowman and Michaels 1982). By 30 cm, polychaetes are the principal component of the diet, with fish larger than 60 cm feeding almost exclusively on them. Little is known concerning predation on this species, but spiny dogfish (Squalus acanthias), halibut (Hippoglossus hippoglossus), and large cod (Gadus morhua) are frequent predators on flatfish in the Gulf of Maine (Bigelow and Schroeder 1953).

Spawning grounds have not been delineated, but the species appears to spawn widely throughout the western Gulf of Maine (Marak et al. 1962a, 1962b, Evseenko and Nevinsky 1973). Spawning takes place over a protracted season and through a broad range of water temperatures. Ripe fish have been found from March to October. Colton et al. (1979) report peak spawning in May and June, while Bigelow and Schroeder (1953) and Evseenko and Nevinsky (1973) have found highest egg densities in July and August. Bottom temperatures during spawning range from 0° to 10°C, with incubation of the pelagic eggs occurring in 7-8 days at surface temperatures of 7° to 13°C (Bigelow and Schroeder 1953).

The pelagic larval stage is lengthy, lasting from 4-6 months (Bigelow and Schroeder 1953) to a year (Evseenko and Nevinsky 1973). Shelf water circulation transports some larvae south and southwestward, apparently accounting for the southern extension of witch flounder distribution along the continental shelf south of Georges Bank (Markle

1975). Powles and Kohler (1970) reported that after metamorphosis juveniles in Nova Scotia waters inhabit greater depths than do adults.

Witch flounder do not undertake clearly defined seasonal movements. However, there is evidence that witch flounder form dense pre-spawning concentrations, with a concomitant seasonal increase in availability to commercial gear (Bowering 1976). This is reflected by NEFC groundfish survey catches, which are generally higher (and more variable) during spring. This springtime concentration also corresponds rather well with the period of peak commercial landings in NAFO Subarea 5 (late spring and early summer).

No growth studies have been completed for witch flounder in the Gulf of Maine, although preliminary NEFC studies suggest higher growth rates than for Canadian waters. Growth is relatively slow compared to most other flatfish species. Ages (sizes) for fish at 50% maturity in the Gulf of St. Lawrence and off Newfoundland are 4-6 years (25-30 cm) for males and 7-10 years (40-50 cm) for females, respectively (Bowering 1976). Powles and Kennedy (1967) calculated von Bertalanffy growth equations for Nova Scotian witch flounder to be:

$$l_t = 61.1\ [1-e^{-0.13(t-0.25)}] \text{ (Males)}$$

$$l_t = 79.1\ [1-e^{-0.08(t+0.09)}] \text{ (Females)}$$

where l_t = length at age t (years).

Lux (1969) derived a length-weight relationship for 188 witch flounder (sexes combined) caught in Statistical Area 526 (Figure 2), viz.

$$W = 0.00000045\ L^{3.450}$$

where W = weight(g) and L = length in mm. This compares closely with Powles' (1967) relationship for the Scotian Shelf (NAFO Division 4W), viz.

$$W = 0.00000059\ L^{3.649}$$

where W = weight (kg) and L = length in cm. Witch flounder attain lengths up to 78 cm and ages of up to 36 years (Powles 1965), although most do not exceed a length of 64 cm and weights of 2 kg or so (Bigelow and Schroeder 1953). Ages in excess of 20 years are also uncommon (Powles and Kennedy 1967).

COMMERCIAL FISHERY

Although prized as a table fish (by its more common name, grey sole) and commanding a high market price compared to other flounders, witch flounder are not abundant enough in the New England region to support a continuous directed fishery of any magnitude. Accordingly, this species has been primarily taken both as an intended component in mixed fishery situations and as by-catch. There is no recreational fishery for witch flounder due to the depths they inhabit and their small mouth size.

Nominal Catch and Discard

Nominal catches (live weight equivalent of landings exclusive of discard, hereafter referred to as "landings") from NAFO Subarea 5 averaged 2,900 MT during 1960-1982, ranging from a low of just under 1,000 MT in 1962 to a high of 5,900 MT in 1971 (Table 1, Figure 5). USA vessels have accounted for most of these landings (averaging 2,500 MT

during this period). Landings subsequently declined to an average of 2,000 MT during 1974-1976. Landings have since increased to an average of around 3,300 MT during 1978-1981; the 1982 total was 5,100 MT, and landings in 1983 are expected to approximate 7,000 MT based on extrapolations from preliminary landings data collected through October 1983.

Landings by foreign nationals were generally minor until 1969, when Union of Soviet Socialist Republics (USSR) vessels began to take substantial quantities. Foreign fishing peaked in 1971-1972, with landings of 2,900 MT and 2,600 MT, respectively, most of which was taken by the USSR on Georges Bank and in adjacent areas (NAFO Div. 5Z). Subsequently, landings by foreign nationals declined to an average of <50 MT from 1976 to 1980. Since 1980, landings from NAFO Subarea 5 by other countries have been negligible (Table 1, Figure 5).

Until 1976, most of the United States catch was landed in Massachusetts ports (landings averaged 1,800 MT, or 62% of the total, with Gloucester the leading port). Since that year, landings in Maine ports (especially Portland and Rockland) have increased sharply and comprised over 50% of the 1982 total. Increases in effort in a number of Gulf of Maine fisheries, e.g., the northern shrimp fishery which is prosecuted primarily by vessels from Gloucester and Maine ports, undoubtedly contributed to this shift as well as to the general increase in landings observed in recent years.

Discard levels for witch flounder have not been well documented. Differences in distribution between juveniles and adults have been thought to result in minimal amounts of discarding off Nova Scotia (Powles and Kohler 1970). Some discarding, however, has been known to occur in U.S. waters, e.g., 11% of the total catch by weight caught with a 127 mm (5-inch) stretched mesh codend trawl was discarded during a fishing trip in 1980[1]. There is also evidence that considerable discarding of small witch flounder may occur during directed shrimp fishing operations with 44 mm (1.75-inch) stretched mesh codends. The recent increase in codend mesh size under the New England Fishery Management Council's Interim Groundfish Plan (from 130 mm or 5.1 inches to 140 mm or 5.5 inches, effective April 1, 1983) implies an increase in the 50% retention length from 29 cm to 31 cm (Mayo et al. 1981). This increase, coupled with increased demand for witch flounder in the "peewee" market category (28-31 cm), should reduce discarding. Recent interview data suggest minimal levels except in unusual situations, e.g., clogging of codends by large catches of skates.

Vessels and Gear

Witch flounder are caught almost exclusively by bottom trawling (>98% of the total since 1964). Small amounts are taken in Danish seines, scallop dredges, and, more recently, sinking gillnets. Since 1964, 56% of the total has been taken by Tonnage Class (TC) 3 vessels of 51-150 GRT; 34% has been taken by TC 2 vessels (0-50 GRT) with TC 4 vessels (151-500 GRT) accounting for the remaining 10%. The proportion taken by larger vessels has gradually increased since the mid-1970s.

[1]William Overholtz, NEFC, Woods Hole Laboratory, personal communication, July 1983.

Area and Season

The bulk of witch flounder landings in recent years has been taken by TC 2 and 3 vessels fishing year-round in the Gulf of Maine, and by TC 3 and 4 vessels during late spring and early summer on Georges Bank and along the Great South Channel. The most productive grounds are located in Statistical Areas 512 and 513 (western Gulf of Maine), 514 (Massachusetts Bay), 521 (Great South Channel), and 522 (western Georges Bank). About 80% of the Subarea 5 total was taken in these areas during 1975-1982 (Table 2).

In the Gulf of Maine, seasonal differences in landings have been relatively minor, although there has been a tendency for an increase during summertime. On Georges Bank, however, 53% of the 1975-1982 total was taken between April and July (Table 3). Commercial interview data suggest a seasonal increase in directed effort during spring and early summer, witch flounder being an intended component of a combined witch flounder-American plaice (*Hippoglossoides platessoides*) fishery. This appears to reflect increased availability of witch flounder in spring and early summer due to formation of prespawning concentrations as discussed above.

Size Composition of Commercial Landings

Although market categories vary from port to port, witch flounder have typically been sorted as large (>40 cm) or small (32-40 cm). Increased quantities of "peewee" flounder (28-31 cm) have also been landed in recent years (which may have been previously discarded). Biological sampling of commercial landings has revealed that few of these "peewees" are sexually mature.

Figure 6 presents quarterly distributions of witch flounder landings for the Georges Bank - Gulf of Maine region by market category for 1975-1982, with "large" and "small" categories defined as above ("peewee" flounder included in the "small" category). No consistent trends are evident throughout the time series, although a tendency is evident for increased percentages of landings in the "small" category in recent years. This may reflect changes in market conditions although increased exploitation of smaller flounders cannot be discounted.

Effort and Catch Per Unit Effort (CPUE)

Trends in commercial effort and catch per unit effort (CPUE) for a mixed-fishery species, such as witch flounder, are difficult to evaluate, and accordingly the present analysis is limited to a preliminary examination of recent data by tonnage class. Nominal catch, effort in terms of days fished, and CPUE data were summarized by vessel tonnage class for 1975-1982 using both data for all trips in which witch flounder were landed and data for trips in which at least 40% of total landings consisted of witch flounder. The latter analysis represented an attempt to isolate "directed" effort although there is no basis for assuming that such trips were in fact directed towards this species.

Results of these analyses (Table 4) reveal a general increase in catch and effort since the mid-1970s for all tonnage classes. Data for TC 2 vessels reveal no consistent trends in CPUE throughout the time series; CPUE for TC 3 and 4 vessels has increased somewhat, although this trend could reflect shifts in directed effort rather than an actual increase in abundance. The most striking change has been the increase in effort by TC 4 vessels which has more than doubled since the mid-1970s.

RESEARCH VESSEL SURVEY INDICES

Since Autumn 1963, the Northeast Fisheries Center (NEFC) has conducted stratified random bottom trawl surveys from Hudson Canyon to the Scotian Shelf (the survey area was extended southward to Cape Hatteras in 1967) (Figure 3). A spring survey was added in 1968, and inshore surveys were initiated in 1972. In addition, the Commonwealth of Massachusetts began stratified random surveys of inshore areas along the Massachusetts coast beginning in 1978 (Figure 4). Indices of relative abundance and biomass (stratified mean catch per tow in numbers and weight) have been developed from the resulting data. The entire autumn time series of NEFC surveys was conducted with a standard "36 Yankee" trawl, and this trawl was also used for spring surveys in 1968-1972 and in 1982-1983. The spring surveys during 1973-1981 employed a modified high-opening "41 Yankee" trawl. Further details on NEFC survey methodology and the application of survey data to stock assessments are provided by Grosslein (1969), Azarovitz (1981), and Clark (1981). Howe et al. (1979) describe the Commonwealth of Massachusetts survey program.

Indices of witch flounder abundance and biomass (stratified mean catch per tow in numbers and weight) derived from NEFC and Commonwealth of Massachusetts survey data are presented in Tables 5 and 6 and Figures 7-10. No consistent trends are evident for NEFC spring survey indices, although NEFC autumn survey data indicate a steady decline in abundance and biomass from 1969 to 1976. Both autumn indices increased in 1977 and have since fluctuated considerably although trends have been

gradually downward (Table 5, Figures 7 and 8). Index values for Autumn 1982 were the lowest observed in the history of this survey. Both indices increased in 1983, although catch per tow in weight remained below the 1977-1981 average (Table 5, Figures 7 and 8). Massachusetts data suggest moderate declines in numbers and biomass in recent years (Table 6, Figures 9 and 10).

Analyses of length frequency distributions of witch flounder sampled in NEFC and Commonwealth of Massachusetts surveys (Figures 11, 12, and 13) reveal limited availability of juveniles ($\leq$25 cm) to the sampling gear. This may be associated with the tendency for the young to inhabit greater depths and rougher bottom than the adults as suggested by Powles and Kohler (1970). Spring survey data suggest that two or three above-average year classes were produced during the early to mid-1970s (Figure 11), which appear to have contributed to the increase in biomass observed in subsequent years (Figures 7 and 8). Data for Spring of 1983 indicate the potential for relatively strong recruitment (Figure 11), and there is also some suggestion of improved recruitment from the 1982 Massachusetts autumn survey data (Figure 13). However, in general, larger fish have dominated the survey catches, and evaluation of trends in year-class strength has been difficult.

DISCUSSION

Exploitation of witch flounder in the Gulf of Maine - Georges Bank region has increased sharply in recent years. Landings rose from approximately 2,000 MT per year in the mid-1970s to an average of 3,300 MT

from 1978-1981, and the 1982 total of 5,100 MT was the highest since the early 1970s. Effort (days fished) has increased substantially for all tonnage classes, particularly the large (TC 4) vessels, and landings of smaller flounders (28-40 cm) are increasing. These developments appear to be associated with increased by-catch of witch flounder in other directed fisheries, an emerging fishery directed towards American plaice and witch flounder, and possible changes in market conditions (permitting landing of previously unmarketable fish). Projections based on preliminary 1983 landings data suggest that the 1983 total will approximate 7,000 MT.

Evaluations of resource status have been based previously on analysis of research vessel survey data and examination of commercial landings trends. Unfortunately, NEFC spring and autumn survey results have not been consistent and are therefore difficult to interpret. The decline evidenced by NEFC autumn survey data during the early to mid-1970s may reflect increased exploitation by distant-water fleets (Table 1). Failure of the NEFC spring values to respond in similar fashion may have resulted from availability changes associated with formation of prespawning aggregations or other factors. The decline in landings which occurred during the mid-1970s (Table 1) suggests that NEFC autumn survey results accurately reflected population trends during these years. The resource recovered somewhat in 1977-1978 (Table 5, Figures 7 and 8) but a declining trend has since been evident. Massachusetts surveys, despite their more limited areal coverage, likewise suggest declining abundance and biomass since 1978.

While the data base for the resource is limited, it does appear adequate to suggest that current harvest levels (>5,000 MT since 1981) may be excessive. Removals of this magnitude during the early 1970's were followed by apparent declines in abundance and biomass and below average landings, and there is no consistent evidence for above average recruitment to offset recent increases in removals. Biological considerations, i.e., that the witch flounder is a slow-growing, relatively long-lived species which would be expected to be less resilient to exploitation than many other flatfish species represents an added complication. It appears probable that if present fishery trends continue, abundance and stock biomass will decline further. Close monitoring of this resource should be continued to insure that future management options are not compromised.

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Table 1. Nominal catch[1] of witch flounder (metric tons, live) from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), by country, 1960-1982.

	Subarea/Division													
	5Y[2]			5Z			6[3]			Totals				
Year	Canada	USA	Others[4]	Canada	USA	Others[4]	Canada	USA	Others[4]	Canada	USA	Others	Total SA5	Total SA5&6
1960	-	601	-	-	654	-	-	-	-	-	1,255	-	1,255	1,255
1961	-	524	-	2	498	-	-	-	-	2	1,022	-	1,024	1,024
1962	-	463	-	1	513	-	-	-	-	1	976	-	977	977
1963	-	641	-	27	585	121	-	-	-	27	1,226	121	1,374	1,374
1964	6	703	-	31	678	-	-	-	-	37	1,381	-	1,418	1,418
1965	-	730	-	22	1,410	502	-	-	-	22	2,140	502	2,664	2,664
1966	31	744	-	37	2,149	311	-	42	-	68	2,935	311	3,272	3,314
1967	16	895	-	47	2,933	249	-	42	-	63	3,370	249	3,640	3,682
1968	4	1,040	-	52	1,749	191	-	18	-	56	2,807	191	3,036	3,054
1969	0	1,138	-	0	1,375	1,291	-	29	19	-	2,542	1,310	3,804	3,852
1970	10	978	14	9	1,981	114	-	153	2	19	3,112	130	3,106	3,261
1971	19	1,072	-	16	2,086	2,736	-	62	124	35	3,220	2,860	5,929	6,115
1972	1	1,121	3	12	1,787	2,530	-	26	35	13	2,934	2,568	5,454	5,515
1973	1	1,176	-	9	1,247	621	-	11	8	10	2,434	629	3,054	3,073
1974	3	640	-	6	1,116	264	-	11	28	9	1,767	292	2,029	2,068
1975	5	909	-	8	1,184	125	-	13	92	13	2,106	217	2,231	2,336
1976	1	1,041	-	4	801	6	-	11	-	5	1,853	6	1,853	1,864
1977	-	1,756	-	11	708	-	-	14	13	11	2,478	13	2,475	2,502
1978	3	2,552	-	15	956	4	-	12	2	18	3,520	6	3,530	3,544
1979	2	2,031	-	15	960	-	-	23	-	17	3,014	-	3,008	3,031
1980	-	2,532	-	18	826	-	-	18	1	18	3,376	1	3,376	3,395
1981	-	2,534	-	7	854	-	-	34	-	7	3,422	-	3,395	3,429
1982[5]	4	3,826	-	5	1,246	-	-	71	-	9	5,143	-	5,081	5,152

[1] As reported to ICNAF/NAFO for 1960-1982.

[2] NK landings for SA5 assigned to Division 5Y.

[3] Statistics not available prior to 1963.

[4] Includes West Germany, East Germany, Poland, Spain, Japan, and the USSR.

[5] Provisional (incomplete).

Table 2. U.S. nominal catch[1] of witch flounder (metric tons, live) by statistical area for the Georges Bank-Gulf of Maine region (NAFO Subarea 5), 1975-1982.

	Statistical Area[2]														
Year	511	512	513	514	515	521	522	523	524	525	526	537	538	539	6+
1975	18	150	360	289	92	371	238	10	159	281	105	13	-	3	4
1976	25	140	470	365	37	278	209	24	81	144	50	12	2	1	2
1977	15	196	756	682	101	257	250	19	62	70	30	14	2	5	2
1978	8	333	1,369	642	164	366	306	85	86	38	45	20	8	4	10
1979	67	269	1,025	416	120	367	393	97	35	15	28	21	1	3	14
1980	44	278	1,320	385	258	317	231	67	26	38	111	19	1	6	15
1981	66	317	1,410	419	322	390	183	68	62	48	40	39	-	9	28
1982	154	759	1,432	427	760	558	289	120	52	69	96	51	6	12	64
Mean	50	305	1,018	453	232	363	262	61	70	88	63	24	3	5	17
% of Total	1.7	10.1	33.8	15.0	7.7	12.0	8.7	2.0	2.3	2.9	2.1	0.8	0.1	0.2	0.6

[1] Source: NEFC weighout files.

[2] Statistical areas given in Figure 1.

le 3. U.S. nominal catch[1] of witch flounder (metric tons, live) by month from the Gulf of Maine (NAFO Division 5Y) and Georges Bank (NAFO Division 5Z), 1975-1982.

	5Y (Gulf of Maine)											
ar	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
75	39	40	43	103	90	127	118	100	77	61	66	44
76	35	65	81	79	143	153	172	100	89	28	42	52
77	99	131	220	137	123	184	207	186	134	102	131	93
78	195	344	156	297	323	288	245	170	129	125	112	131
79	174	129	172	133	165	261	194	159	144	106	125	135
80	144	248	184	211	201	307	228	210	165	157	100	130
81	231	170	303	206	158	297	218	186	206	167	175	216
82	250	255	435	287	271	314	302	280	248	292	287	311
an	146	173	200	182	184	241	211	174	149	130	130	139
of tal	7.1	8.4	9.7	8.8	8.9	11.7	10.2	8.5	7.2	6.3	6.3	6.8

	5Z (Georges Bank)											
ear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
975	37	46	77	117	211	153	175	92	88	71	78	35
976	22	20	57	146	89	147	88	55	55	69	35	16
977	7	18	31	87	102	85	90	84	58	60	43	41
978	8	26	50	71	131	169	113	107	91	100	67	25
979	29	17	55	73	91	185	152	110	75	95	66	13
980	12	26	38	96	123	115	120	97	82	46	43	17
981	19	27	52	65	138	150	97	81	83	71	32	26
982	33	39	74	132	189	142	148	116	113	106	94	67
ean	21	27	54	98	134	143	123	93	81	77	57	30
of otal	2.2	2.9	5.8	10.4	14.3	15.2	13.1	9.9	8.6	8.2	6.1	3.2

[1]Source: NEFC weighout files.

Table 4. Nominal catch[1] (C), days fished (DF) and catch per day fished (C/DF) by vessel tonnage class for trips in which some witch flounder were landed, and trips for which 40% or more of the total catch consisted of witch flounder, 1975-1982.

	Tonnage Class								
	2			3			4		
Year	C	DF	C/DF	C	DF	C/DF	C	DF	C/DF
	All trips								
1975	762	3,519	0.22	1,158	8,239	0.14	152	1,184	0.13
1976	791	3,791	0.21	924	6,933	0.13	97	904	0.11
1977	1,178	3,963	0.30	1,080	6,501	0.17	158	922	0.17
1978	1,450	4,620	0.31	1,679	7,729	0.22	279	1,265	0.22
1979	990	4,977	0.20	1,487	7,384	0.20	275	1,611	0.17
1980	1,149	5,847	0.20	1,461	7,777	0.19	374	2,047	0.18
1981	1,193	4,508	0.26	1,652	7,816	0.21	427	2,688	0.16
1982	1,298	5,365	0.24	2,402	9,816	0.24	885	3,707	0.24
	40% trips								
1975	300	187	1.61	207	168	1.23	4	4	1.00
1976	204	144	1.42	136	91	1.49	3	-	-
1977	159	102	1.55	123	81	1.53	1	4	0.25
1978	228	176	1.30	194	81	2.40	7	2	3.50
1979	89	78	1.13	99	67	1.48	7	2	3.50
1980	116	119	0.98	107	40	2.66	54	25	2.17
1981	127	74	1.73	212	102	2.07	22	13	1.70
1982	200	133	1.51	292	135	2.16	55	31	1.75

[1]Source: NEFC weighout and interview files. Nominal catch and catch per day fished given in metric tons.

Table 5. Stratified mean catch per tow in numbers and weight (kg) of witch flounder from NEFC offshore spring and autumn bottom trawl surveys[1] in the Gulf of Maine and on Georges Bank, 1963-1983.

Year	Spring		Fall	
	Nos.	Wt.	Nos.	Wt.
1963	-	-	5.25	3.30
1964	-	-	2.86	2.04
1965	-	-	4.12	2.55
1966	-	-	7.52	4.48
1967	-	-	2.70	1.82
1968	4.41	3.09	4.69	3.51
1969	3.81	2.62	5.74	4.45
1970	5.94	4.15	4.96	3.95
1971	3.06	2.35	3.94	2.68
1972	5.78	4.39	3.16	2.44
1973	8.09	6.20	3.72	2.51
1974	6.27	3.75	2.22	1.48
1975	3.74	2.75	1.76	1.12
1976	5.24	3.56	1.40	1.00
1977	3.96	1.88	5.29	3.58
1978	3.83	2.57	3.84	2.78
1979	2.86	1.75	2.16	1.85
1980	8.05	3.88	3.07	2.52
1981	10.25	6.17	3.60	2.25
1982	3.76	2.17	0.91	0.76
1983	6.28	2.63	4.28	1.93

[1]Strata 22, 24, 26-30 and 33-40 (see Figure 3).

Table 6. Stratified mean catch per tow in numbers and weight (kg) of witch flounder from Massachusetts inshore[1] spring and autumn bottom trawl surveys, 1978-1982.

Year	Spring		Fall	
	Nos.	Wt.	Nos.	Wt.
1978	1.37	0.99	1.07	1.07
1979	0.62	0.64	0.63	0.50
1980	0.68	0.65	0.77	0.83
1981	1.71	1.44	0.17	0.11
1982	0.55	0.44	0.54	0.33

[1]Regions 4 and 5 (strata 25-36); see Figure 4.

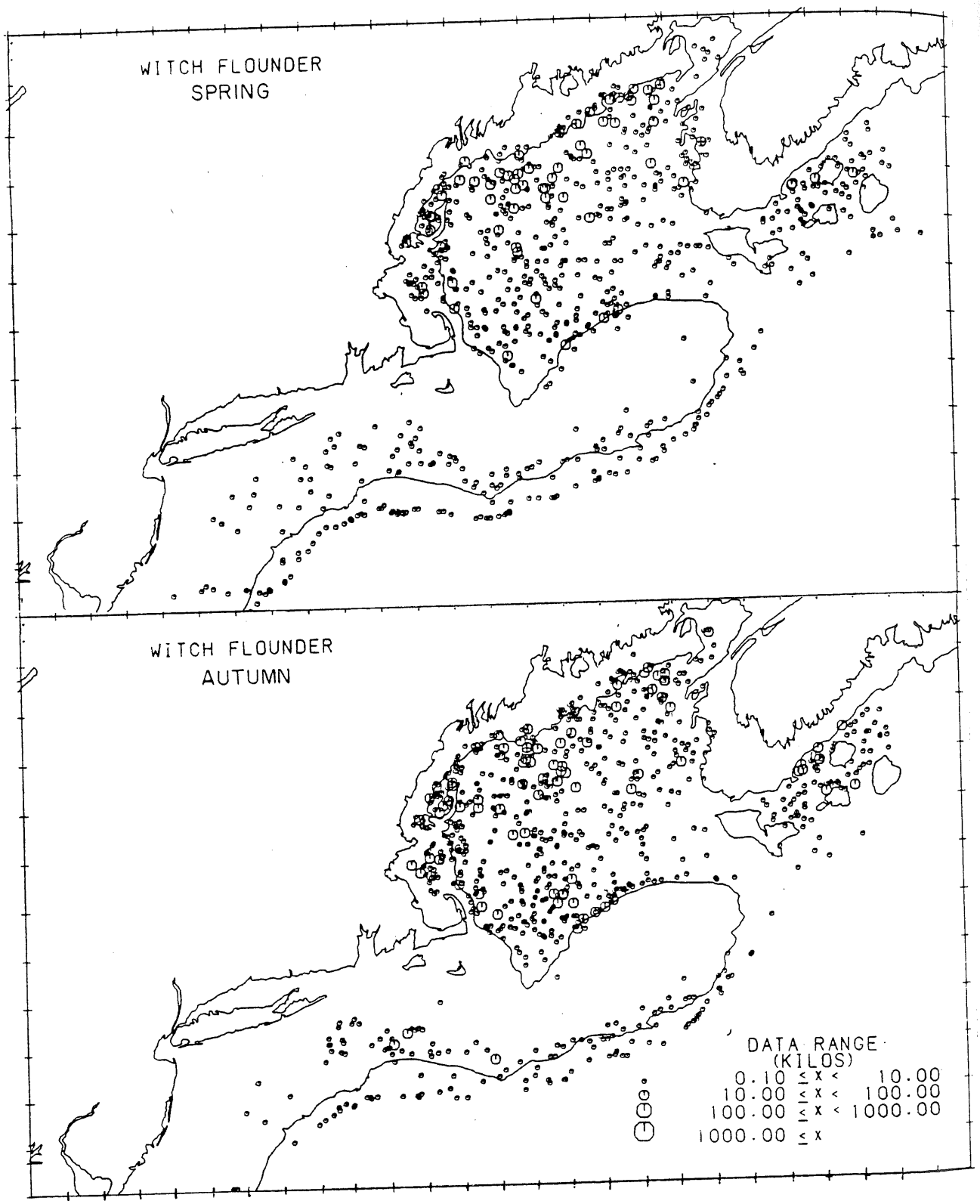

Figure 1. Distributions of witch flounder observed in Northeast Fisheries Center (NEFC) offshore spring and autumn bottom trawl surveys.

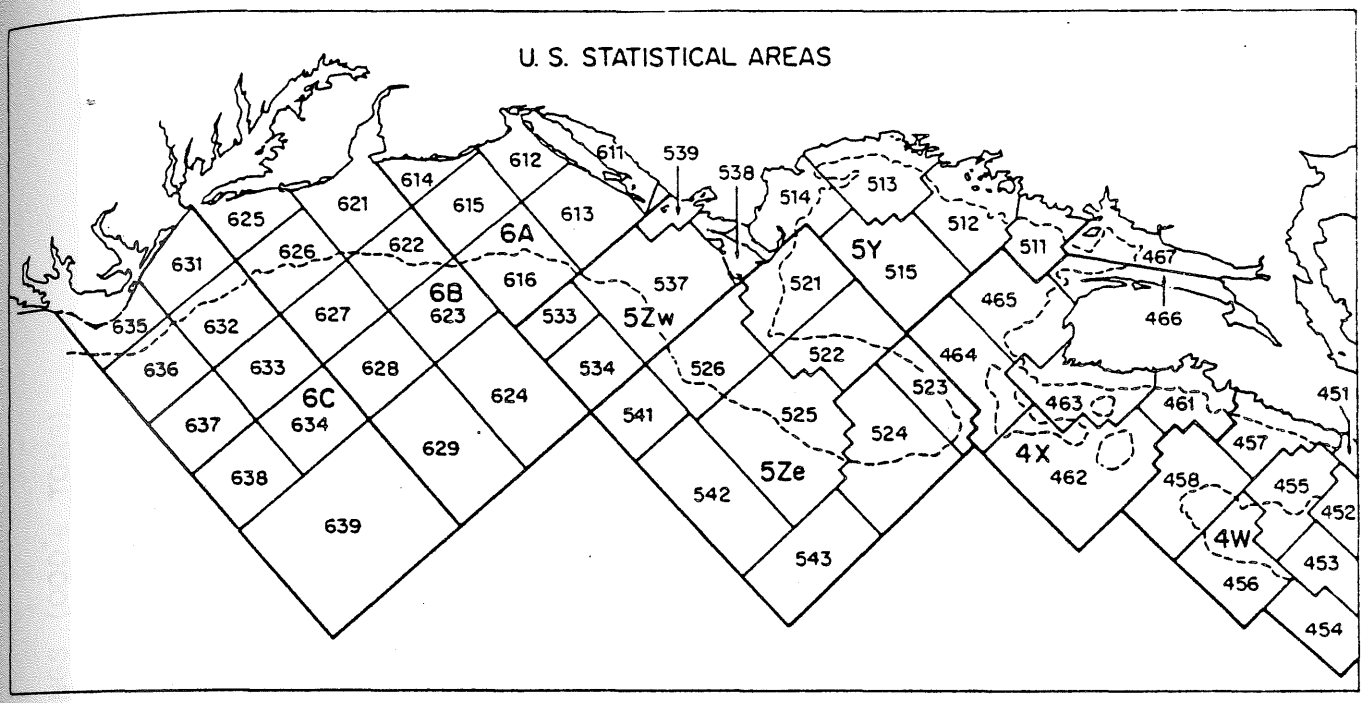

Figure 2. Statistical Areas used for reporting USA commercial fishery statistics.

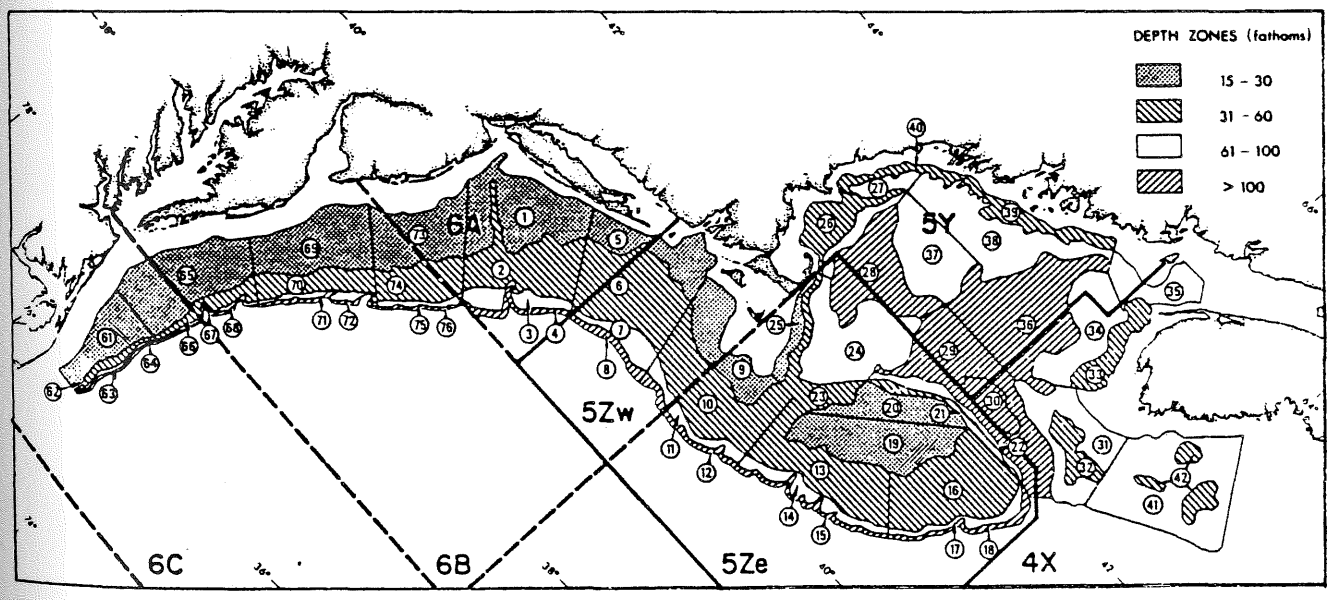

Figure 3. Sampling strata used in NEFC offshore bottom trawl surveys.

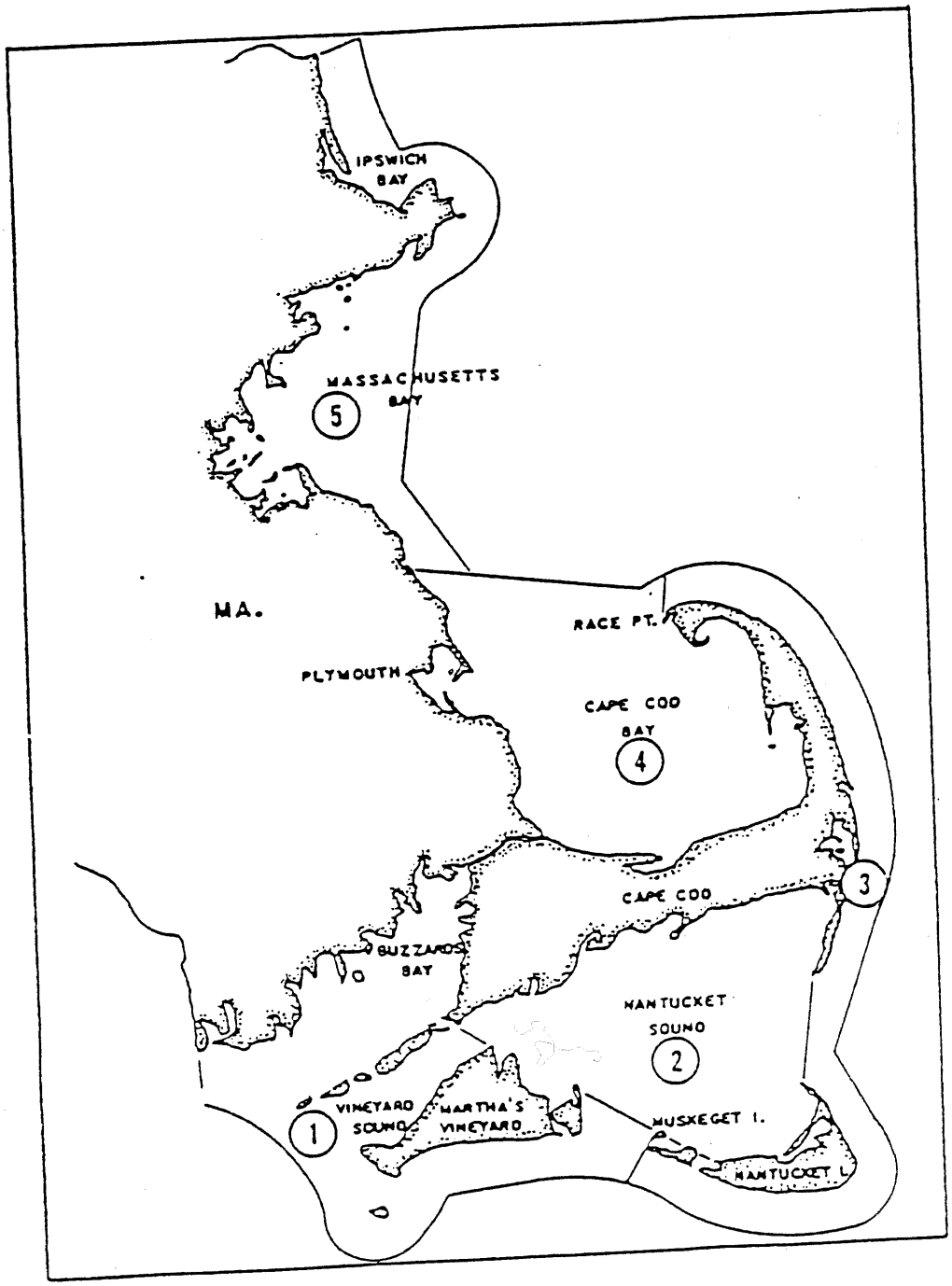

Figure 4. Massachusetts inshore bottom trawl survey area delineated by regions.

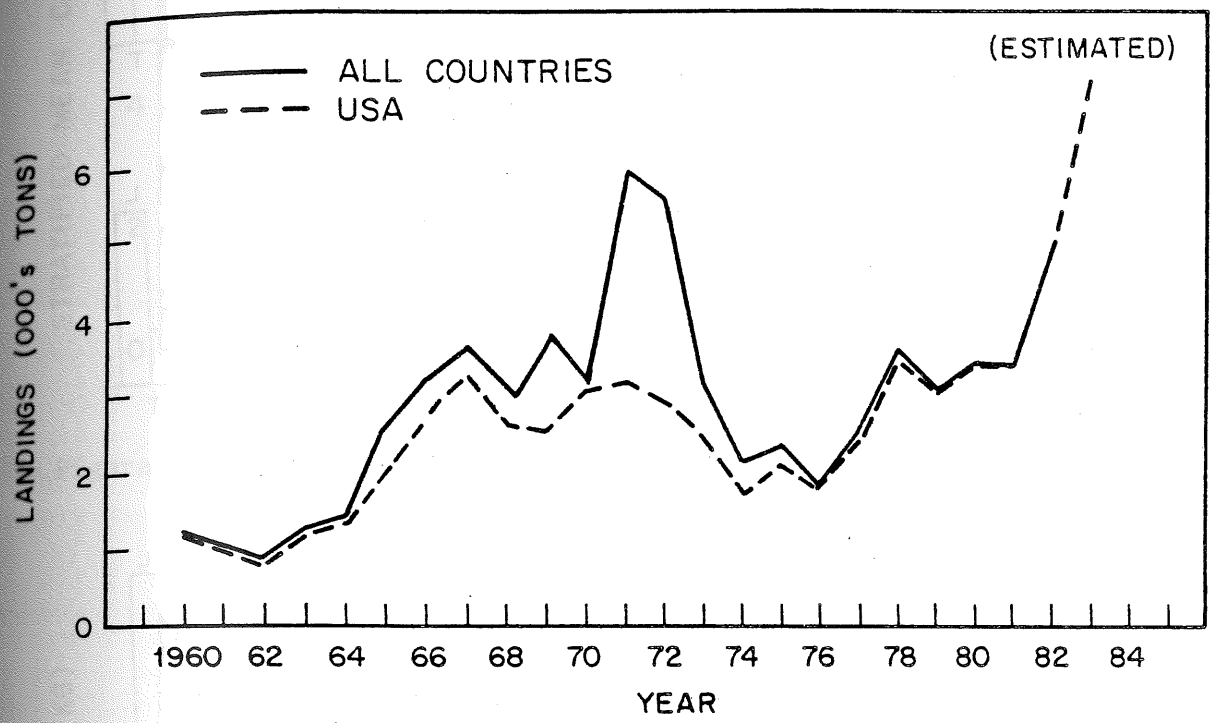

Figure 5. Total landings (metric tons, live) of witch flounder from Georges Bank and the Gulf of Maine (NAFO Subarea 5), 1960-1982.

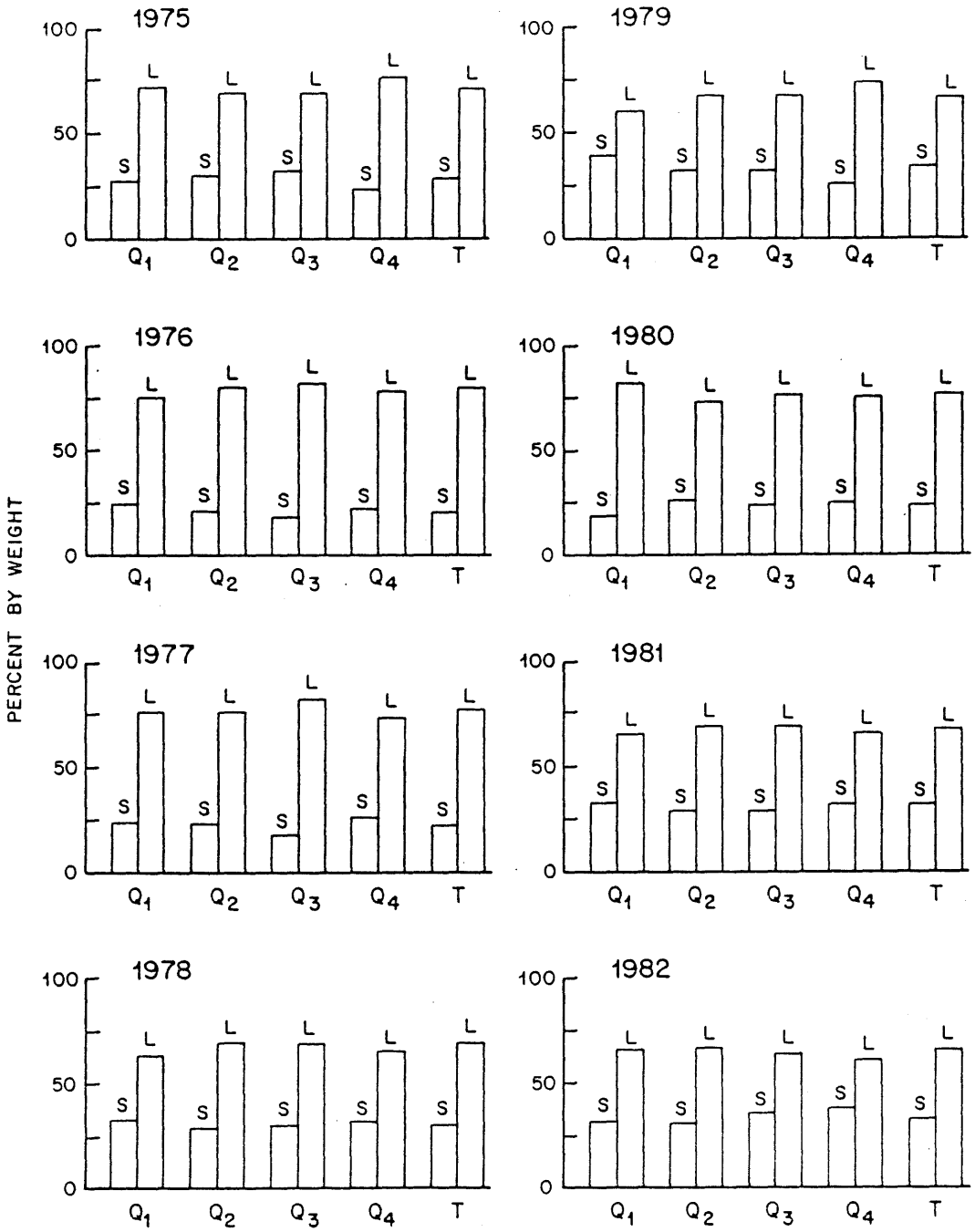

Figure 6. Distribution of U.S. commercial landings of witch flounder by market category and season, 1975-1982. (S = Small, 28-40 cm total length; L = Large, >40 cm total length). Q_1 begins January 1.

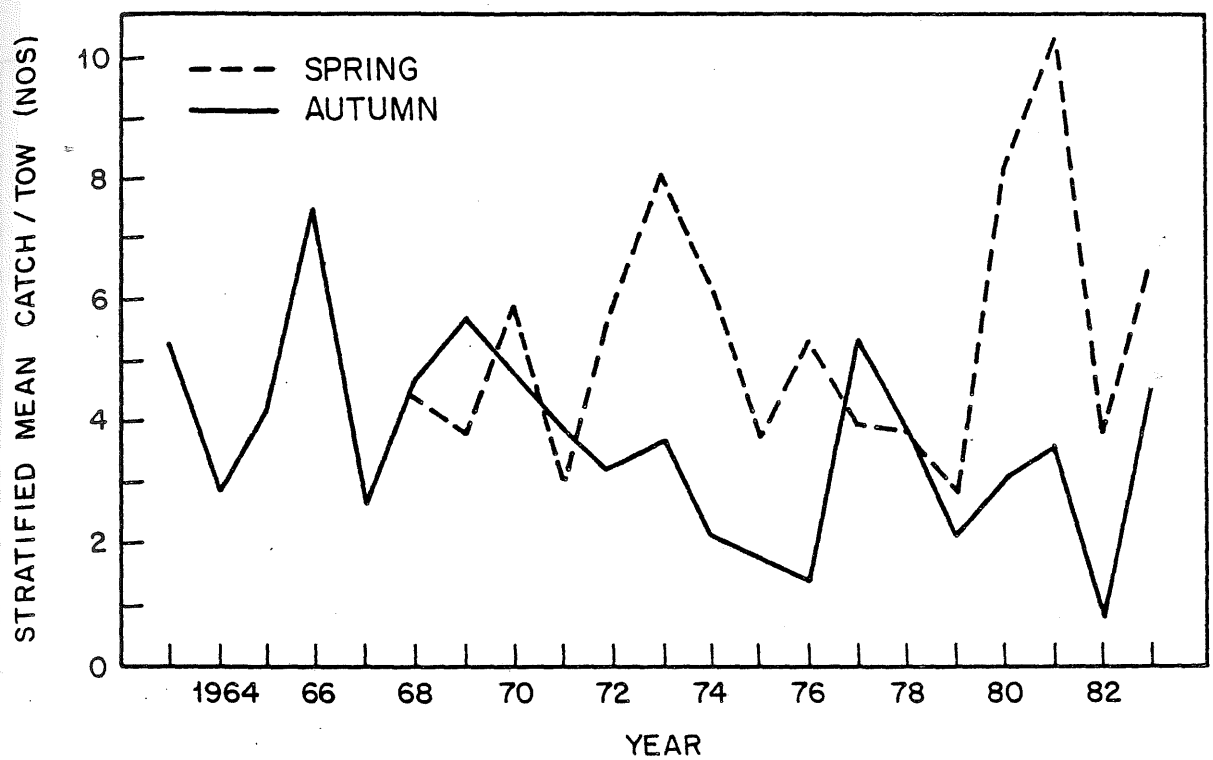

Figure 7. Stratified mean catch per tow (numbers) of witch flounder in NEFC offshore spring and autumn bottom trawl surveys in the Georges Bank-Gulf of Maine region (Strata 22, 24, 26-30, and 33-40), 1963-1983.

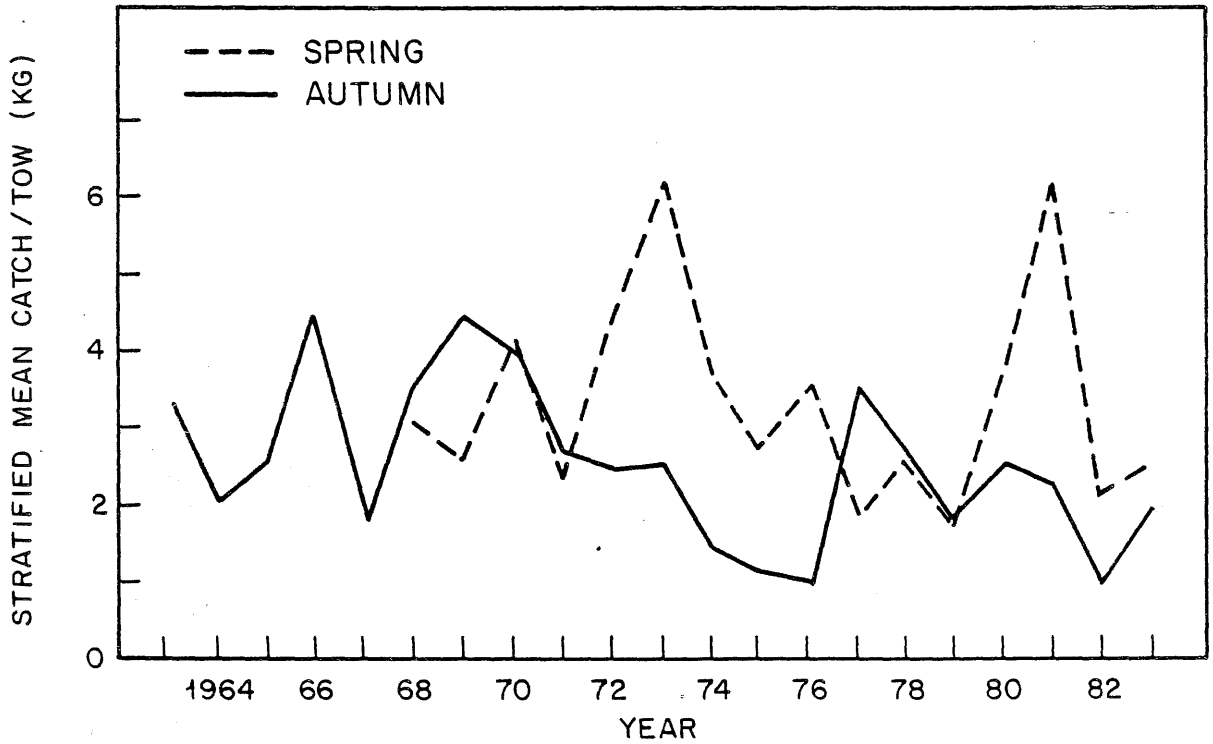

Figure 8. Stratified mean catch per tow in weight (kg) of witch flounder in NEFC offshore spring and autumn bottom trawl surveys in the Georges Bank-Gulf of Maine region (Strata 22, 24, 26-30, and 33-40), 1963-1983.

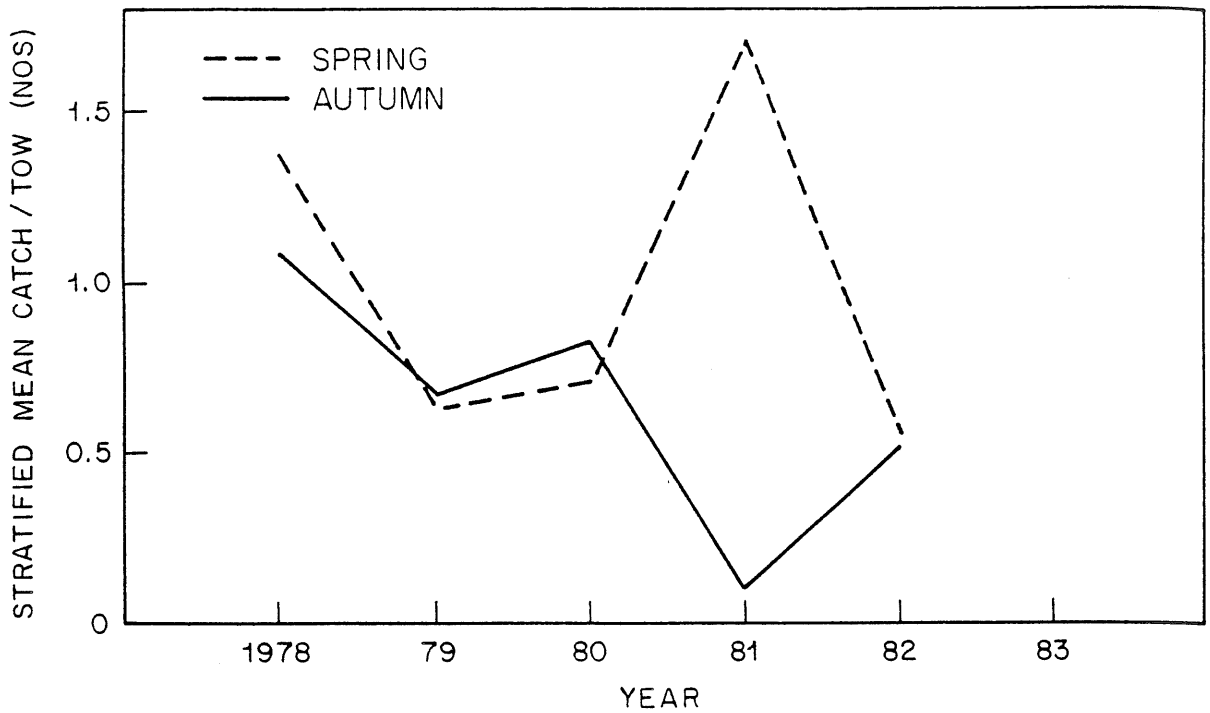

Figure 9. Stratified mean catch per tow (numbers) of witch flounder in Massachusetts inshore spring and autumn bottom trawl surveys (Regions 4 & 5, Strata 25-36), 1978-1982.

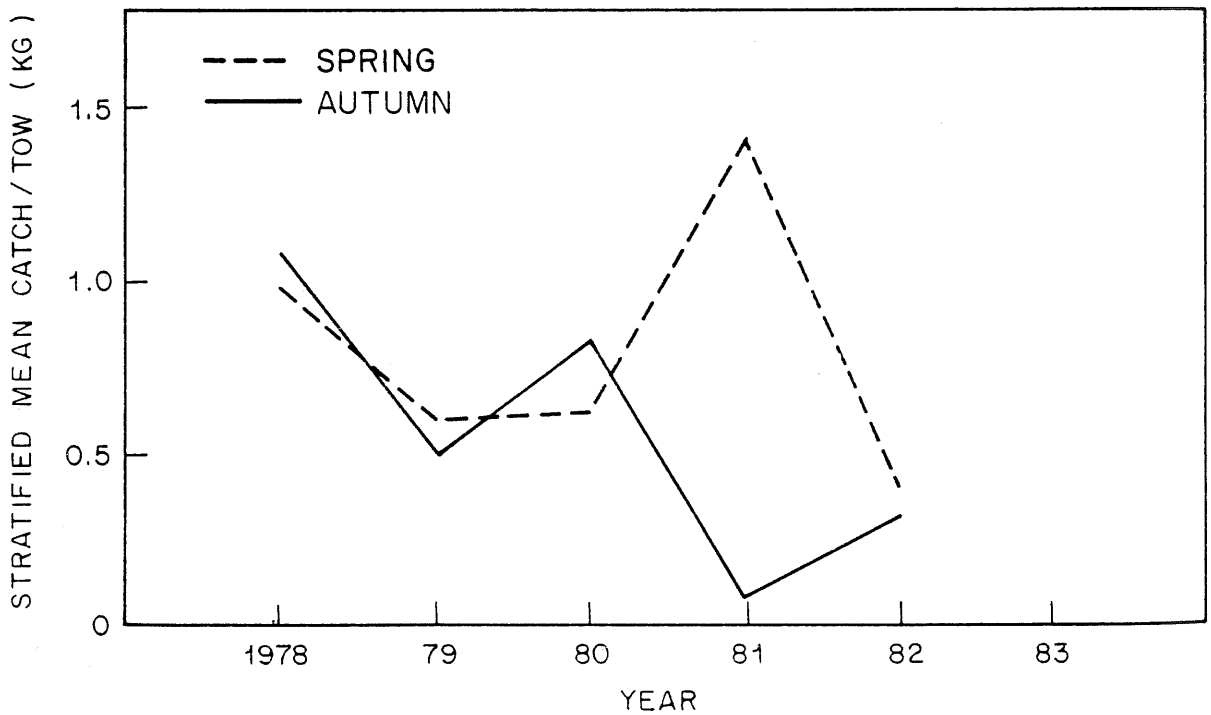

Figure 10. Stratified mean catch per tow in weight(kg) of witch flounder in Massachusetts inshore spring and autumn bottom trawl surveys (Regions 4 & 5, Strata 25-36), 1978-1982.

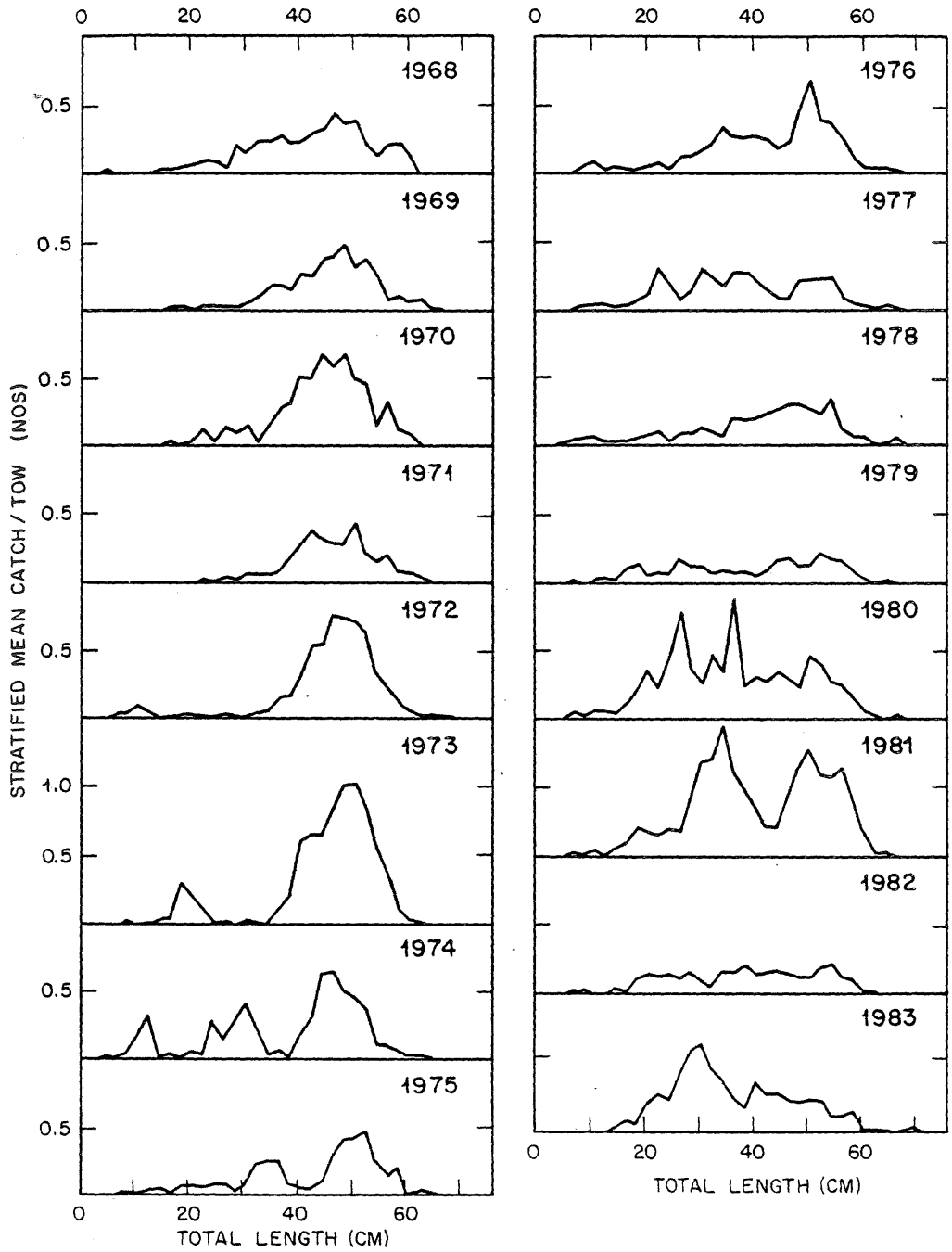

Figure 11. Witch flounder length frequency distributions from NEFC spring offshore bottom trawl surveys, 1968-1983.

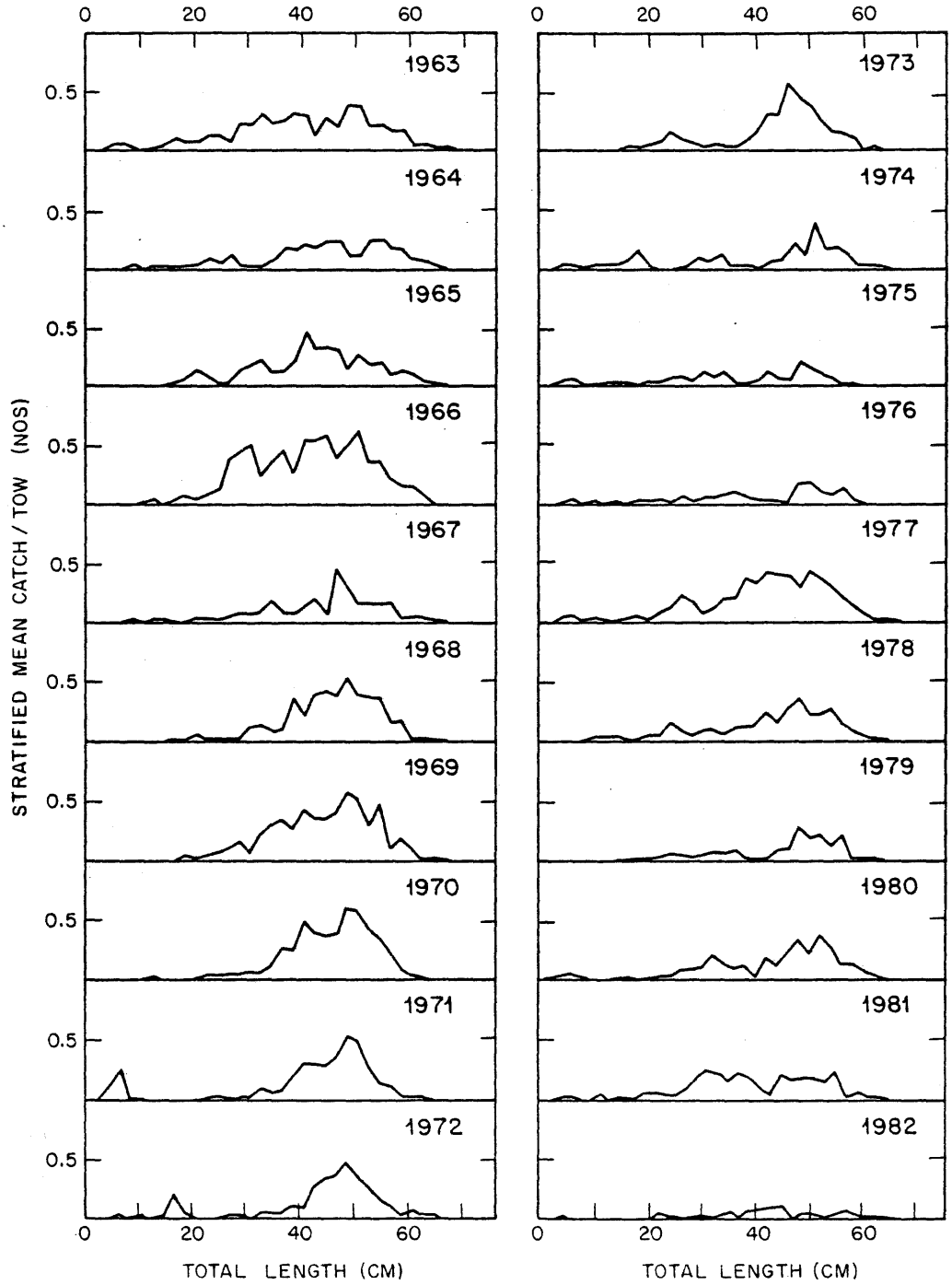

Figure 12. Witch flounder length frequency distributions from NEFC autumn offshore bottom trawl surveys, 1963-1982.

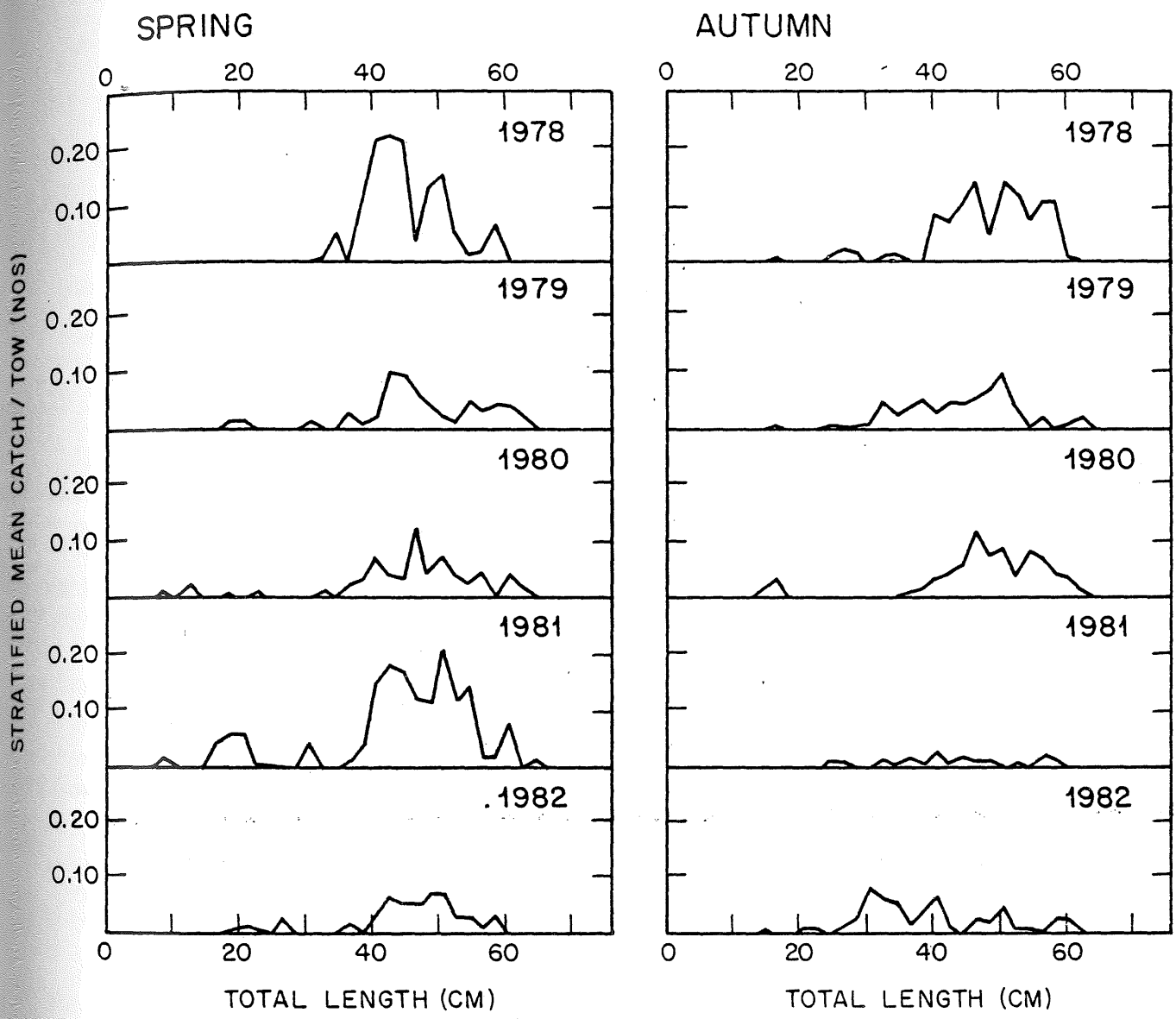

Figure 13. Witch flounder length frequency distributions from Commonwealth of Massachusetts spring and autumn bottom trawl surveys, 1978-1982.