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YELLOWTAIL FLOUNDER STOCK STATUS - 1981

by

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INTRODUCTION

The yellowtail flounder (*Limanda ferruginea*) has supported an important New England fishery since the mid-1930's. Yellowtail were unexploited prior to 1935, but with declines in abundance of winter flounder (Royce et al. 1959) the fishery developed rapidly and by 1942 total USA landings peaked at 31,500 MT. Subsequently, landings declined to an annual average of 7,600 MT in the mid-1950's before again increasing to a peak of 57,500 MT in 1969 (20,700 MT were taken by foreign nationals in that year). Landings then declined more or less continually to only 11,300 MT in 1978; provisional statistics for 1979 indicate landings of 15,900 MT and preliminary data for 1980 indicate landings of 18,300 MT. Enactment of catch quotas and landings restrictions under the Fisheries Conservation and Management Act of 1976 (FCMA) has resulted in extensive misreporting by area (and in many cases, landings have gone completely unreported); consequently, data for 1977-1980 are not considered reliable. Discard information is also inadequate with little discard being reported to NMFS statistical agents in recent years (particularly 1978-1980), although data for earlier years indicate that significant proportions of the total catch have been discarded. Foreign landings have been negligible since 1975.

Studies by Royce et al. (1959) and Lux (1963) indicate the existence of three distinguishable, although not completely discrete, yellowtail groups off the USA coast; one on Georges Bank, a second off southern New England, and a third smaller group to the east and north of Cape Cod. Yellowtail have also

been exploited in the Mid-Atlantic area and have been assessed separately. Two management units have been recognized; the Georges Bank (East of 69°W) unit and a second unit (West of 69°W) which includes the Cape Cod, southern New England, and Mid-Atlantic groups (New England Regional Fishery Management Council MS 1980).

Management

Since 1977, yellowtail flounder within the Fishery Conservation Zone (FCZ) have been managed by the New England Regional Fishery Management Council (NERFMC) under the Fishery Management Plan for Atlantic Groundfish (as amended). The 1977 Optimum Yields (OY's) of 10,000 MT for East of 69°W and 4,000 MT for West of 69°W were the same as recommended under ICNAF for that year. Other 1977 regulations included trip limits (later defined by vessel class) and mesh regulations.

In 1978, the above OY's were reduced to 4,400 MT and 3,700 MT, respectively, so as to correspond to F_{max} (Sissenwine et al. MS 1978). Other 1978 management actions included removal of incidental catch limitations, repeated revision of landings restrictions and establishment of management on a "fishing year" basis (October 1 - September 30). The West of 69°W fishery was closed in each of the first three quarters of 1979, and landings restrictions were also revised repeatedly.

Results of the 1979 assessment (McBride and Sissenwine MS 1979) indicated that stock size had stabilized in both management areas. The NERFMC subsequently determined that catches of 5,000 MT from each management unit were consistent with fishing at F_{max}, and proposed OY's of 5,000 MT (New

England Regional Fishery Management Council MS 1980); the fishery has since been regulated under these OY's although final approval has been delayed by executive order. A subsequent supplement containing a proposal for further OY increases based on 1980 assessment results (McBride et al. MS 1980) is in preparation. A summary of calendar and fishing year OY's implemented under FCMA since 1977 is as follows:

Year	East of 69°W	West of 69°W
1977 (calendar year)	10,000 MT	4,000 MT
1978 (calendar year)	4,400	3,700
1978-79 (fishing year)	4,400	3,700
1979-80 (fishing year)	5,000[1]	5,000[1]
1980-81 (fishing year)	5,000[1]	5,000[1]

[1]Proposed by NERFMC in September, 1979.

COMMERCIAL FISHERY

Commercial Catch

The USA yellowtail flounder fishery has been conducted chiefly off southern New England and on Georges Bank, although appreciable amounts have also been taken to the east and north of Cape Cod and in the Mid-Atlantic region (Table 1, Figure 1). Discard estimates for 1963-1977 (Table 1) were obtained from trip interview data; estimates for earlier years were based on average estimated percentage discard by area (relative to landings) for 1963-1969 (Brown and Hennemuth MS 1971). Given a general lack of interview data for 1978-1980, discard for these years has been estimated from gear selectivity data (Smolowitz MS 1979) as 10.7% of food landings assuming use of 130 mm mesh trawls and a 30 cm culling point (McBride et al. MS 1980). Industrial catches have been taken almost exclusively off southern New England and were appreciable only in the mid-to-late 1960's

(Table 1). Reported foreign landings have generally been minor, with the exception of 1969 when 20,700 MT were landed. Recreational catches appear to have been negligible; only 15 MT were reported in the 1979 Marine Recreational Fishery Statistics Survey of the Atlantic and Gulf coasts (United States Department of Commerce 1980) and no catches were reported in earlier surveys.

Historical trends in total catch (food landings, discard, and industrial and foreign landings) for the southern New England, Georges Bank, and Cape Cod grounds are given in Figure 1. Distinct peaks are evident for southern New England in the 1940's and 1960's, and Georges Bank catches peaked in the 1960's as well; however, catches for both areas declined sharply in subsequent years . Cape Cod catch generally appears to have been more constant (Figure 1). Again, it must be stressed that data for 1977-1980 appear to have been distorted considerably by misreporting or non-reporting; this is particularly evident for Cape Cod (Figure 1). Yellowtail catches in the Mid-Atlantic area peaked at 8,900 MT in 1972 before declining drastically in subsequent years (note, however, that some potential for misreporting existed in the early 1970's due to implementation of landings restrictions under ICNAF). Minor catches (500 tons or less) have also been reported in the Gulf of Maine in recent years (Table 1). The southern New England and Georges Bank areas have contributed approximately 80% of the total catch since 1960 (Table 1).

Age Composition of Commercial Food Landings

Age composition data (percent by number) for USA southern New England, Georges Bank, and Cape Cod commercial food landings are given in Figures 2-4. Again, total numbers landed at age are not available for recent years due to under-

reporting or misreporting by area, and even calculated percentages for recent years are probably distorted somewhat by misreporting or incomplete sample coverage, although data do appear adequate to represent general trends in age composition and relative year class strength.

Yellowtail landings in the mid-1960's were dominated by several age groups (Figures 2-4). From 1977-1979, southern New England landings were dominated by 2 and 3 year old fish (Figure 2). The 1976 and 1977 year classes were well represented in 1979 landings, while the 1976, 1977, and 1978 year classes were well represented in 1980. A shift towards increased percentages of younger age groups is also evident for Georges Bank in recent years (Figure 3). During 1979-1980, this fishery appears to have been supported primarily by the 1977 year class (Figure 3). Trends for the Cape Cod grounds have been similar, although the shift towards dominance by younger ages has not been as pronounced; the 1976 and 1977 year classes predominated in commercial landings from the Cape Cod grounds during 1979 although in 1980 a more balanced distribution is evident (Figure 4).

Commercial Abundance Indices

Commercial abundance indices for southern New England, Georges Bank, and Cape Cod (total food landings and discard in metric tons per standard day fished) have been calculated as in previous assessments using the method of Lux (1964). Calculations are based on trip data for vessels of 5-104 GT for which 50% or more of the total landed catch consists of yellowtail ("directed" trips) and involve standardization of effort by applying fishing power coefficients (originally obtained by Lux) to summarized effort data by vessel class using

26-50 GT vessels as standard. Adjusted effort data are then summarized over vessel classes and divided into summarized food landings and discard data for these vessel classes to obtain the index. Index values for 1960-1980 are given in Table 2, and values for 1943-1980 are plotted in Figure 5.

Data for southern New England and Georges Bank indicate a sharp decline in abundance since the mid-1960's followed by a slight recovery; this also appears to be true for Cape Cod yellowtail although trends are not as pronounced (Table 2, Figure 5). However, index values for recent years (1978-1980) are highly suspect due to discard and reporting uncertainties, and in any case are not directly comparable to earlier values because of landings restrictions implemented under FCMA. Sissenwine (1978) has also noted that the above 50% criterion for directed effort implies an upward bias if the target population is declining more rapidly than associated populations being taken as by-catch.

RESEARCH VESSEL SURVEYS

The Northeast Fisheries Center (NEFC) has conducted a stratified random bottom trawl survey in autumn in offshore areas (>27 m) from Hudson Canyon to the Scotian Shelf since 1963; the Mid-Atlantic area was added in 1967 (Figure 6). A spring survey covering the same area was initiated in 1968, and a summer survey has also been run intermittently (1963-1965, 1969, and 1977-1980). Similar surveys have also been conducted in inshore areas (<27 m) since 1972 (Figure 7). The vessels ALBATROSS IV and DELAWARE II have been used in these surveys; a "36 Yankee" trawl equipped with 41 cm (16 inch) rollers has been used in summer and autumn surveys and in spring surveys during 1968-1972, while a

"41 Yankee" trawl equipped with 30-46 cm (12-18 inch) rollers has been used in subsequent spring survey work. Both trawls are also equipped with 1.25 cm (0.5 inch) codend liners. Indices of relative abundance (stratified mean catch per tow in both numbers and weight) have been calculated for southern New England and Georges Bank (Tables 3-6, Figure 8) and for the Cape Cod and Mid-Atlantic area (Tables 7, 8, 10, and 11). Coverage in inshore surveys has been more limited or variable (and yellowtail catches have also been negligible in some areas). Consequently, corresponding inshore survey indices have not been derived for all area/season combinations.

The Massachusetts Division of Marine Fisheries (DMF) has conducted stratified random bottom trawl surveys in inshore areas along the Massachusetts coast during spring and autumn since 1978. To date, DMF surveys have been conducted using a 3/4 "North Atlantic" trawl equipped with a 0.64 cm (0.25 inch) mesh codend liner and a chain sweep fitted with 7.6 cm (3 inch) rubber discs. Sampling strata have been arranged in five regions (Figure 9). Areas sampled, sampling procedures and other information including catch-per-tow data for 1978 and 1979 are given in annual completion reports (Howe et al. MS 1979, MS 1980) and preliminary data are available for 1980 (Howe, pers. comm.). Yellowtail catches in the surveys have generally been minor in regions 1 and 2 (taken as representative of the southern New England grounds, Figure 9) but have been much higher in regions 3-5 (taken as representative of the Cape Cod grounds), and accordingly indices of relative abundance have been developed for Cape Cod yellowtail using Massachusetts DMF survey data for these regions. Information from all of the above surveys is summarized by area in the following sections.

Southern New England

NEFC survey data indicate a pronounced decline in abundance from the mid-1960's to the mid-1970's, with only slight if any improvement in subsequent years. The NEFC offshore spring survey (weight) index declined steadily from 32.2 kg in 1968 to an annual average of only 3.2 kg during 1974-1976; subsequently, values have fluctuated about an average of 3.8 kg (Table 3, Figure 8). The NEFC inshore spring survey index declined during 1977-1979 (Table 3). The offshore autumn survey index dropped from an average of 17.9 kg in 1963-1964 to only 1.9 kg during 1974-1976; the 1977-1980 average was 2.3 kg (Table 3, Figure 8). Summer survey index values were relatively constant (averaging 10.1 kg) during 1963-1965; 1977-1980 values were much lower, with the exception of the 1979 index value of 10.9 kg (Table 3). The autumn 1972 and summer 1979 index values appear anomalous and may reflect changes in availability, although actual increases in abundance could also have been involved (Tables 3 and 4). Trends in index values in terms of numbers have closely paralleled those calculated in terms of weight (Table 3).

Stratified mean catch per tow at age data for offshore strata (Table 4) indicate that during the mid to late 1960's recruiting year-class size was consistently stronger than during recent years. During 1963-1969, the population was dominated by pre-recruit (age 1) and age 2 and 3 fish in autumn and by age groups 2-4 in spring; catch per tow of pre-recruit yellowtail during the 1963-1969 autumn surveys averaged 17.7 fish, substantially higher than the 1977-1980 average of 2.0 fish. Similarly, catch per tow of age 2

yellowtail during spring 1968-1972 surveys averaged 30.0 fish compared to an average of 6.7 fish during 1977-1980. The 1976 and 1977 year classes contributed significantly to the pronounced increase observed in the summer of 1979 and generally appear stronger in spring and autumn surveys than other recent year classes although no consistent differences are evident (Table 4). Similarly, inshore spring survey data do not indicate consistent differences in the size of recent year classes, although catch per tow for the 1976 year class at age 2 was the highest observed in this time series (Table 4).

Increased commercial landings and industry reports suggest that current abundance may be in fact higher relative to previous levels than indicated by NEFC survey results. However, mortality rates generated from survey age composition data should be representative, e.g., observed rates of decline for fully recruited (age 3+) fish throughout the autumn survey time series are in fact very similar, and there is no evidence in Tables 3 and 4 to suggest catchability differences between years for recent (i.e. 1977-1979) spring and autumn survey data. It follows that mortality estimates generated from these data should be realistic (and can be compared to earlier estimates).

Apparently, mortality for southern New England yellowtail during the last two decades has been high. Lux (1969) reported that instantaneous total mortality (Z) averaged 1.02 during 1960-1965 based on analyses of commercial catch-effort data, while Penttila and Brown (1973) obtained an estimate of Z = 1.25 from analyses of research vessel survey data for 1963-1969. Assuming instantaneous natural mortality (M) = 0.2 for yellowtail, as in recent assessments, implies that instantaneous fishing mortality (F) averaged 0.82 and 1.05,

respectively, substantially above F_{max} (=0.5). In the present assessment, estimates of Z were obtained for 1977-1979 by pooling catch at age data (Table 4) over fully recruited age groups (age 3+ for autumn and age 4+ for spring) e.g., for autumn,

$$Z = \ln \frac{\Sigma \text{ age } 3+ \ 1976\text{-}1978}{\Sigma \text{ age } 4+ \ 1977\text{-}1979}$$

Resulting estimates of Z were 0.78 for spring and 1.03 for autumn; similarly, an estimate of 1.02 was obtained from autumn survey data for 1963-1966, identical to the 1960-1965 estimate obtained by Lux. Autumn survey data for 1979-1980 provided an estimate of Z = 2.13. Apparently, then, F for southern New England yellowtail has substantially exceeded F_{max} in recent years, as was the case for the 1960's.

Georges Bank

In contrast to the situation for southern New England, the most recent data for Georges Bank indicate a significant increase in abundance although changes in availability may also be involved. The NEFC spring survey index declined more or less continually from an annual average of 7.4 kg during 1970-1972 to only 1.3 kg during 1977-1979; however, the 1980 index value increased sharply to 6.0 kg (Table 5, Figure 8). The NEFC autumn survey index fluctuated about an average of 7.5 kg during the 1960's, declined to an average of 4.7 kg from 1970-1973, and then dropped sharply to only 1.2 kg in 1976; index values averaged 2.0 kg during 1977-1979 and then increased sharply to 6.1 kg in 1980 (Table 5, Figure 8). The summer survey index has gradually increased from 0.8 kg in 1977 to 1.5 kg in 1979-1980. Stratified mean catch-per-tow-at-age data (Table 6) again indicate that several strong year classes recruited in the mid-to-late 1960's (notably the 1965-1967 year classes) and the 1968-

1970 year classes appear to have been at least moderately strong. Subsequent year classes have been generally weaker, with the 1977 and 1978 year classes being perhaps the strongest of these; both of these year classes contributed significantly to the observed increases in NEFC 1980 spring and autumn survey index values (Table 6). However, the magnitude of the increase observed in catch per tow over 1979 in each case (Table 6) suggests that increased availability (rather than an actual increase in abundance) was probably involved to some degree.

Again, mortality rates in the last two decades appear to have consistently exceeded F_{max}. Lux (1969) obtained an estimate of Z = 1.02 for Georges Bank yellowtail, while Pentilla and Brown (1973) obtained an estimate of Z = 1.00 for 1963-1969. (An estimate of 0.98 was obtained for 1964-1966 in the present assessment as described above). For 1977-1979, estimates of Z equal to 1.44 and 1.19 were obtained for spring and autumn survey data, respectively. Thus, available data again indicate levels of F substantially in excess of F_{max} in recent years.

Cape Cod

NEFC offshore spring and summer survey indices for Cape Cod yellowtail have fluctuated without a definite trend, although autumn survey data suggest increased abundance since the mid-1970's (Table 7). Index values for 1980 were among the highest observed in all three surveys. Catch-per-tow-at-age data for 1976-1980 (Table 8) do not indicate any consistent differences in year-class size, although catch per tow for the 1979 year class at age 1 was the highest observed in recent summer and autumn surveys. Catch-per-tow data for Massachusetts

inshore surveys are consistent with NEFC inshore summer survey results in indicating relatively constant abundance and year-class size since 1978 (Tables 8 and 9). Pooled estimates of Z for 1977-1979 for NEFC offshore surveys (1.47 for spring and 2.07 for autumn) and for Massachusetts inshore surveys (1.88 for spring and 2.12 for autumn) again indicate high levels of mortality.

Mid-Atlantic

The situation for Mid-Atlantic yellowtail appears to be analogous to that observed for southern New England. The NEFC offshore spring survey index declined more or less continually from 29.4 kg in 1968 to an average of 0.9 kg in 1975-1976; subsequent index values have fluctuated somewhat but have generally increased (Table 10). The NEFC inshore spring survey index for 1976-1980 has fluctuated without a definite trend, as has the NEFC offshore summer survey index. The autumn survey index declined from an average of 11.2 kg in 1968-1970 to only 0.1 kg in 1976; the 1977-1980 average was 0.2 kg (Table 10). Stratified mean catch per tow at age data for 1976-1980 (Table 11) indicate that year-class size has been fairly constant in recent years.

COOPERATIVE SURVEYS

During February of 1980 and 1981 cooperative bottom trawl surveys were conducted for yellowtail flounder on the southern New England grounds (Figure 10). These surveys were jointly sponsored by the Point Judith Fishermen's Cooperative, the New Bedford Seafood Council, Inc., and the NERFMC. The project was coordinated and staffed by the Rhode Island Division of Fish and Wildlife; the NEFC provided technical assistance and participated in field sampling and data analysis.

The vessels M/V FRIESLAND and M/V FORAGER were used in 1980 and 1981, respectively. The vessels are similar in size and general construction. The gear used in each survey consisted of a 310 x 5" Shuman bottom trawl with a wire sweep fitted with 5.1 cm (2 inch) rubber discs and a 1.25 cm (0.5 inch) codend liner (Borden and Fogarty MS 1980). Survey design and procedures were identical to those employed on standard NEFC bottom trawl surveys. During each survey, 40 stations were occupied at randomly pre-selected locations within six strata at depths ranging from 37 to 73 m. Tow duration was 20 minutes at a vessel speed of 3.0 knots (5.55 km/hr).

In both years, yellowtail flounder were taken at all stations; catches ranged from 2 to 236 kg per tow in 1980 (Borden and Fogarty MS 1980) and from 1 to 225 kg in 1981. Stratified mean catch per tow in weight declined slightly from 60.6 kg in 1980 to 54.8 kg in 1981 (Table 12), while stratified mean catch per tow in number increased from 159.9 fish in 1980 to 187.6 fish in 1981. The stratified mean number and weight per tow values obtained for 1981 fall within the 95% confidence limits of the 1980 estimates (Table 12).

Length frequency data indicate a pronounced shift in population size and age composition (Figure 11). Whereas the population in 1980 was dominated by 32-36 cm (age 3) fish, 1981 data indicate a predominance of smaller 25-28 cm (age 2) fish. Larger (>30 cm) yellowtail were prevalent at all depths in 1980 (Borden and Fogarty MS 1980), while smaller yellowtail tended to predominate in all but the two deepest strata (3 and 6) in 1981 (Figure 10). The 1981 modal

length shift was therefore consistent throughout the survey area and was not confined to any one area or depth.

Age-length keys were constructed from samples collected during the 1980 survey and from the 1981 NEFC winter bottom trawl survey conducted in the same area in January, 1981. Application of these keys to 1980 and 1981 stratified mean number per tow at length data revealed the following age composition:

Year	1	2	3	4	5	6	7+
1980	0.20	46.48	86.46	23.93	2.12	0.66	0.06
1981	0.44	117.18	48.73	14.66	6.33	0.28	0.00

It is evident that the above shifts in modal length result primarily from a decline in abundance of 1977 year class fish and recruitment of 1979 year class fish in 1981. (The 1979 year class, however, does not appear to be particularly strong compared to other recent year classes based on research vessel survey results, Table 4). Total instantaneous mortality (Z) for 1980 was estimated at 1.40 for fully recruited (age 4+) fish, (supporting the above NEFC survey estimate of Z = 2.13). Again, results imply that F was quite high in 1980.

Cooperative survey data, and NEFC survey results, both indicate that abundance and biomass remained relatively stable during 1980, although it is diffcult to make inferences concerning current stock status relative to earlier years based on cooperative survey data. Stratified mean catch per tow values of 60.6 and 54.8 kg per 20 minute tow obtained in cooperative surveys, if expanded, would correspond to commercial index values of 4.4 and 3.9 MT per day fished, similar to those obtained in the mid to late 1960's when total commercial landings for southern New England were averaging about 22,000 tons. However, catch rates

expanded from these surveys cannot be directly compared to commercial catch rates because of the random nature of these surveys, tow duration, changes in fishing power, and lack of information on commercial discards (McBride et al. MS 1980).

DISCUSSION

Commercial catch-effort and research vessel survey data for southern New England indicate pronounced declines in abundance between the mid-1960's and the mid-1970's. Subsequent NEFC survey data indicate only slight improvement, although cooperative survey results suggest that biomass may have increased substantially, e.g. catch per tow values for 1980-1981 cooperative surveys imply commercial catch rates similar to those observed in the mid to late 1950's, although results are not directly comparable due to survey design and other factors. Cooperative survey results and NEFC survey data agree in indicating constant abundance and high mortality during 1980.

The 1976 and 1977 year classes have been well represented in 1979-1980 commercial landings and generally appear stronger than other recent year classes in NEFC surveys, although no consistent differences are evident. All recent year-classes, however, appear relatively weak. For example, the pre-recruit (age 1) yellowtail of the 1976, 1977, 1978 and 1979 year classes during 1977-1980 autumn surveys was 11% of the observed 1963-1969 average, while the average catch of age 2 yellowtail during 1977-1980 spring surveys was only 22% of the observed average for 1968-1972. Recent year classes may in fact be stronger than indicated; nevertheless, they appear to have been rapidly reduced by fishing.

Although there is no empirical basis for estimating the strength of recent year classes directly, general inferences are possible from previous studies. Brown and Hennemuth (MS 1971) obtained an average estimate of 71 million fish at age 2 for the 1958-1962 year classes; assuming this average to be representative of the mid-1960's (i.e., for the 1962-1964 year-classes), then recent (1975-1977) year classes were on the average approximately one-fifth the 1958-1962 year-class average based on pre-recruit catch per tow data.

Table 13 provides results of equilibrium yield calculations under different fishing mortality and recruitment options (catch and stock size estimates provided represent levels which would be achieved if mortality and recruitment levels specified were to be maintained indefinitely). Total catch increases somewhat as F is increased, but at higher levels of F stock size is reduced very substantially, e.g., assuming constant recruitment equal to one-fourth the 1958-1962 year class average, increasing F from 0.5 to 1.0 results in an increase of 3% in total catch and a 40% decline in stock size. At higher levels of F (>1.0) it can be seen that the fishery will become dependent almost entirely on incoming recruitment (Table 13). While recent stock size and recruitment levels for southern New England yellowtail are uncertain, results for low recruitment-high mortality options (Table 13) appear generally representative of current conditions as evidenced by available age composition data, and mortality estimates.

Commercial catch-effort data again indicate pronounced declines in abundance for Georges Bank between the mid-to-late 1960's and the mid-1970's;

NEFC survey data indicate a decline into the mid-to-late 1970's, followed by a sharp increase in 1980 (which may largely reflect increased availability). The 1977 and 1978 year classes contributed significantly to observed increases in 1980 spring and autumn survey index values, and the 1977 year class also appears to have predominated in 1980 commercial landings. Recent year classes again appear to be generally weaker than those recruiting in the mid-to-late 1960's, although the discrepancy does not appear to be as pronounced as for southern New England (note that catch per tow values for the 1977 and 1978 year classes in 1980 were comparable to those observed for several year classes in the mid-to-late 1960's and early 1970's).

Equilibrium yield calculations were again performed using a range of recruitment options based on VPA results by Brown and Hennemuth (MS 1971) which provided an average estimate of 39 million fish for the 1958-1962 year classes (Table 13). Results appear similar to those obtained for southern New England, e.g., under the assumption that recruiting year class size is equal to one-half the 1958-1962 year class average, increasing F from 0.5 to 1.0 will result in a 4% increase in equilibrium yield and a 40% decline in stock size. Higher levels of F would again result in the fishery becoming dependent almost completely on incoming recruitment.

Available evidence for the Cape Cod stock indicates a more stable situation than for southern New England or Georges Bank. Landings and commercial abundance index values declined somewhat from the mid-1960's into the early to mid-1970's, as did NEFC autumn survey index values; however, this index has since fluctuated about a substantially higher level. NEFC offshore spring and summer survey indices have fluctuated without a definite trend, while NEFC

and Massachusetts inshore survey results indicate relatively constant levels of abundance during 1978-1980. Recent year classes appear to have been comparable. Consequently, there is no evidence to suggest that catches in the order of 2-3,000 tons (the approximate 1960-1976 average) would adversely affect this resource, although recent catches could have been substantially higher; NEFC and Massachusetts spring and autumn survey data again indicate mortality levels substantially in excess of F_{max}.

Reported commercial catches for Mid-Atlantic yellowtail declined from an average of 8,400 MT in 1971-1972 to only 300 MT in 1976, while NEFC spring and autumn survey indices declined by at least an order of magnitude between the late 1960's and the mid-1970's. Subsequent data indicate slight, if any, improvement. Results appear very consistent with those obtained for southern New England in indicating continued low abundance and recruitment (and potentially high F levels) in recent years.

Commercial catches for Gulf of Maine yellowtail have increased more or less steadily since the early 1970's (reported landings averaged 400 tons from 1978-1980) as have NEFC spring and autumn survey catches.

SUMMARY

Reported yellowtail landings for Georges Bank (East of 69°W), southern New England, Cape Cod, and the Mid-Atlantic (West of 69°W), and the Gulf of Maine dropped from 57,500 MT in 1969 to only 11,300 MT in 1978 under ICNAF and FCMA restrictions; provisional statistics for 1979 indicate landings of 15,900 MT, and preliminary data for 1980 indicate landings of 18,300 MT.

Enactment of catch quotas and landings restrictions under FCMA appears to have resulted in extensive misreporting (or even nonreporting) of food landings, and discard information for recent years (particularly 1978-1980) is inadequate; consequently, recent landings and total catch data are not reliable. Age composition data for commercial food landings indicate that during the mid-1960's the fishery was supported by several age groups, although in recent years landings have been increasingly dominated by younger fish. The 1976 and 1977 year-classes have been well represented in recent commercial landings. Commercial abundance indices have declined substantially since the mid-1960's; recent data indicate slight improvement, but are highly suspect due to discard and reporting uncertainties.

NEFC survey data for southern New England indicate a pronounced decline in abundance between the mid-to-late 1960's and the mid-1970's, with only slight, if any, improvement in subsequent years. Catches of age 1 and 2 fish have been substantially lower during 1977-1980 than in former years. The 1976 and 1977 year classes generally appear stronger in spring and autumn surveys than other recent year classes although no consistent differences are evident. Total instantaneous mortality (Z) estimates for 1977-1979 obtained from spring and autumn survey data were 0.78 and 1.03; assuming M = 0.2, then F exceeded F_{max} = 0.5 in both cases. An estimate of Z = 2.13 was obtained from 1979-1980 autumn survey data.

Cooperative survey results for the southern New England grounds agree with NEFC autumn survey data in indicating relatively constant abundance and biomass and high mortality (Z = 1.40) during 1980; however, a pronounced shift in size and age composition of survey catches was noted, due primarily to a decline in abundance of 1977 year-class fish and recruitment of 1979 year-class fish in 1981. The 1979 year class, however, does not appear to be appreciably stronger than other recent year classes based on results of NEFC surveys. Stratified mean catch per tow values from cooperative surveys for 1980-1981 would correspond to commercial index values of 4.4 and 3.9 MT per day fished, similar to those observed in the mid to late 1960's when total commercial landings were averaging about 22,000 tons, although catch rates expanded from these surveys are not directly comparable to commercial catch rates due to survey design and other factors. Equilibrium yield calculations imply the potential for continued low abundance, and if mortality levels are as high (and current recruitment levels as low) as recent NEFC and cooperative survey results indicate, the fishery would be expected to become dependent almost completely on incoming recruitment.

In contrast for the situation for southern New England, NEFC survey data for Georges Bank indicate a recent increase in abundance; spring and autumn index values for 1980 both increased sharply over 1977-1979 levels, while the summer survey index has almost doubled since 1977. These results may largely reflect increased availability rather than an actual increase in abundance. Stratified mean catch-per-tow-at-age data again indicate that recent year classes have been generally weaker than those recruiting in the late 1960's and early 1970's; the 1977 and 1978 year classes are perhaps the strongest of these. Estimates of Z equal to 1.44 and 1.19 were obtained for 1977-1979 based on spring and autumn survey data, again indicating that F has substantially exceeded F_{max} in recent years. Equilibrium yield calculations again indicate the potential for continued low levels of abundance and dependence of the fishery

upon incoming recruitment if mortality remains high and recruitment is indeed poor compared to former years.

NEFC offshore spring and summer survey indices for Cape Cod yellowtail have fluctuated without a definite trend, although autumn survey data suggest increased abundance since the mid-1970's. NEFC and Massachusetts inshore survey results indicate relatively constant levels of abundance during 1978-1980. Recent year classes appear to have been comparable. All data are consistent in indicating a more stable situation than for southern New England or Georges Bank, and there is no evidence to suggest that total catches in the order of 2-3,000 tons (the approximate 1960-1976 average) would adversely affect this resource. The situation for the Mid-Atlantic area as evidenced by NEFC surveys appears comparable to that observed for southern New England, i.e., continued low abundance and recruitment in recent years, although abundance for the Gulf of Maine appears to have increased.

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1. Commercial catch[1] of yellowtail flounder (000's tons) from the southern New England, Georges Bank, Cape Cod, Mid-Atlantic, and Gulf of Maine areas[2], 1960-1980.

Southern New England					Georges Bank					Cape Cod				
Food landings	Discard	Indust.	Foreign	Total	Food landings	Discard	Indust.	Foreign	Total	Food landings	Discard	Indust.	Foreign	Total
7.8	3.2	0.5	-	11.5	4.4	1.5	-	-	5.9	1.5	0.5	-	-	2.0
11.6	4.7	0.7	-	17.0	4.2	1.5	-	-	5.7	1.8	0.6	-	-	2.4
13.1	5.3	0.2	-	18.6	7.7	2.7	-	-	10.3	1.9	0.6	-	-	2.5
22.0	5.4	0.3	0.2	27.9	11.0	5.6	-	0.1	16.7	3.6	1.0	-	-	4.6
19.0	9.5	0.5	-	29.0	14.9	4.9	-	-	19.8	1.8	0.6	-	-	2.4
18.4	7.0	1.0	1.4	27.8	14.2	4.4	-	0.8	19.2	1.5	0.5	-	-	2.0
14.9	5.3	2.7	0.7	23.6	11.3	2.1	-	0.3	13.7	1.8	0.3	-	-	2.1
10.8	7.7	4.5	2.8	25.8	8.4	5.5	-	1.4	15.3	1.5	0.8	-	-	2.3
14.3	6.3	3.9	3.5	28.0	12.8	3.6	-	1.8	18.2	1.6	0.6	-	-	2.2
11.4	2.4	4.2	17.6	35.6	15.9	2.6	-	2.4	20.9	1.3	0.3	-	-	1.6
13.1	4.7	2.1	2.5	22.4	15.5	5.5	-	0.3	21.3	1.2	0.4	-	-	1.6
8.2	3.3	0.4	0.3	12.2	11.9	3.1	-	0.5	15.5	1.7	0.7	-	-	2.3
8.2	1.7	0.3	3.0	13.2	14.2	1.2	-	2.2	17.6	1.4	0.3	-	-	1.6
7.2	0.1	0.3	0.2	7.8	15.9	0.6	-	0.3	16.7	1.7	<0.1	-	-	1.7
6.4	0.7	<0.1	0.1	7.1	14.6	1.2	-	1.0	16.8	2.1	0.2	-	-	2.3
3.2	0.2	<0.1	-	3.4	13.8	1.0	-	0.1	14.9	2.0	-	-	-	2.0
1.6	0.2	<0.1	<0.1	1.8	11.4	0.7	-	<0.1	12.1	3.6	0.1	-	-	3.7
2.8	<0.1	<0.1	<0.1	2.9	9.5	0.2	-	-	9.7	3.5	-	-	-	3.5
2.3	0.3	<0.1	-	2.6	4.5	0.5	<0.1	<0.1	5.0	3.7	0.4	-	-	4.1
5.4	0.6	<0.1	-	6.0	5.5	0.6	-	<0.1	6.1	4.2	0.5	-	-	4.7
6.0	0.6	<0.1	-	6.7	6.4	0.7	-	<0.1	7.1	5.1	0.6	-	-	5.7

landings-data taken from New England weighout files, state bulletins, and annual canvas data; discard and industrial ings estimated from interview data and commercial sampling of industrial catches. (Discard for 1978-1980 taken as 10.7% e estimated total catch.)

istical areas 526-539, 522-525, 514 and 521, 611+, and 511-513+515, respectively.

iminary.

1. (continuation)

Mid-Atlantic					Gulf of Maine					Total				
Food landings	Discard	Indust.	Foreign	Total	Food landings[1]	Discard	Indust.	Foreign	Total	Food landings	Discard	Indust.	Foreign	Total
-	-	-	-	-	-	-	-	-	-	13.7	5.2	0.5	-	19.4
-	-	-	-	-	-	-	-	-	-	17.6	6.8	0.7	-	25.1
-	-	-	-	-	-	-	-	-	-	22.7	8.6	0.2	-	31.5
-	-	-	-	-	-	-	-	-	-	36.6	12.0	0.3	0.3	49.2
1.8	-	-	-	1.8	-	-	-	-	-	37.5	15.0	0.5	-	53.0
2.1	-	-	-	2.1	-	-	-	-	-	36.2	11.9	1.0	2.2	51.3
2.4	-	-	-	2.4	-	-	-	-	-	30.4	7.7	2.7	1.0	41.8
5.3	-	-	-	5.3	-	-	-	-	-	26.0	14.0	4.5	4.2	48.7
3.3	-	-	-	3.3	-	-	-	-	-	32.0	10.5	3.9	5.3	51.7
3.9	-	-	0.7	4.6	0.1	-	-	-	0.1	32.6	5.3	4.2	20.7	62.8
4.1	-	-	0.1	4.2	0.1	-	-	-	0.1	34.0	10.6	2.1	2.9	49.6
6.9	-	-	1.0	7.8	0.1	-	-	-	0.1	28.8	7.1	0.4	1.8	38.0
8.8	-	-	0.1	8.9	0.2	-	-	-	0.2	32.8	3.2	0.3	5.3	41.6
4.9	0.2	-	0.2	5.4	0.1	-	-	-	0.1	29.8	0.9	0.3	0.7	31.8
1.9	<0.1	-	<0.1	1.9	0.1	-	-	-	0.1	25.1	2.1	<0.1	1.1	28.3
0.7	<0.1	-	<0.1	0.7	0.2	-	-	-	0.2	19.9	1.2	<0.1	0.1	21.2
0.3	-	-	-	0.3	0.3	-	-	-	0.3	17.2	1.0	<0.1	<0.1	18.2
0.5	<0.1	-	<0.1	0.6	0.2	-	-	-	0.2	16.5	0.2	<0.1	<0.1	16.9
0.4	<0.1	<0.1	-	0.4	0.4	-	-	-	0.4	11.3	1.2	<0.1	<0.1	12.5
0.5	<0.1	<0.1	-	0.6	0.3	-	-	-	0.3	15.9	1.7	<0.1	<0.1	17.7
0.3	<0.1	-	-	0.3	0.5	-	-	-	0.5	18.3	1.9	<0.1	<0.1	20.2

otnote legends above.

Table 2. Commercial catch (000's tons), days fished (000's) and catch per day (tons)[1] of yellowtail flounder for the Southern New England, Georges Bank, and Cape Cod grounds.

	Southern New England			Georges Bank			Cape Cod		
Year	Total catch	Days fished	Catch/ day	Total catch	Days fished	Catch/ day	Total catch	Days fished	Catch/ day
1960	11.5	4.60	2.5	5.9	2.02	2.9	2.0	1.12	1.8
1961	17.0	4.85	3.5	5.7	1.82	3.1	2.4	.91	2.6
1962	18.6	4.04	4.6	10.3	2.35	4.4	2.5	1.01	2.5
1963	27.9	5.47	5.1	16.7	3.63	4.6	4.6	1.00	4.6
1964	29.0	5.08	5.6	19.8	3.53	5.6	2.4	.71	3.4
1965	27.8	6.61	4.2	19.2	4.68	4.1	2.0	.70	2.8
1966	23.6	8.42	2.8	13.7	5.71	2.4	2.1	1.37	1.6
1967	25.8	6.51	4.0	15.3	4.13	3.7	2.3	1.69	1.4
1968	28.0	6.66	4.2	18.2	4.66	3.9	2.2	.99	2.3
1969	35.6	10.78	3.3	20.9	6.71	3.1	1.6	.68	2.5
1970	22.4	6.40	3.5	21.3	6.26	3.4	1.6	.53	3.0
1971	12.2	3.81	3.2	15.5	6.20	2.5	2.3	.79	2.9
1972	13.2	4.71	2.8	17.6	8.00	2.2	1.6	.67	2.4
1973	7.8	4.11	1.9	16.7	6.96	2.4	1.7	.89	1.9
1974	7.1	3.74	1.9	16.8	8.40	2.0	2.3	1.21	1.9
1975	3.4	2.43	1.4	14.6	8.59	1.7	2.0	1.25	1.6
1976	1.8	1.50	1.2	12.0	7.50	1.6	3.7	2.31	1.6
1977	2.9	2.00	1.4	9.7	6.70	1.4	3.5	2.42	1.4
1978	2.7	1.44	1.8	5.0	3.57	1.4	4.1	2.05	2.0
1979	6.0	3.00	2.0	6.1	3.05	2.0	4.7	2.61	1.8
1980	6.7	3.17	2.1	7.1	4.26	1.7	5.7	3.25	1.8

[1]Calculated for USA trawlers of 5-104 GT using trip data for which 50% of the total catch consisted of yellowtail.

Table 3. Stratified mean catch per tow in numbers and weight (kg) for southern New England yellowtail flounder in NEFC offshore[1] and inshore[2] spring, and offshore summer and autumn bottom trawl surveys, 1963-1980.

	Spring[3]		Summer		Autumn	
Year	Nos.	Wt(kg)	Nos.	Wt(kg)	Nos.	Wt(kg)
1963	-	-	28.17	8.96	50.59	16.83
1964	-	-	24.54	11.24	60.76	19.03
1965	-	-	38.48	10.00	38.74	12.68
1966	-	-	-	-	50.25	9.43
1967	-	-	-	-	57.67	14.05
1968	123.22	32.21	-	-	40.21	10.06
1969	100.60	23.10	59.45	12.91	54.75	14.39
1970	74.66	20.28	-	-	39.76	10.96
1971	74.48	18.49	-	-	41.70	9.18
1972	75.15	18.55	-	-	73.28	20.11
1973	57.30	14.69	-	-	7.94	2.25
1974	17.26	5.04	-	-	7.34	2.13
1975	6.99	1.98	-	-	2.89	0.71
1976	6.96(2.48)	2.45(1.36)	-	-	10.69	2.96
1977	5.13(14.45)	1.99(5.06)	9.04	2.98	5.01	1.50
1978	22.93(13.38)	5.15(3.32)	5.41	1.34	11.43	3.06
1979	10.26(2.52)	2.15(0.48)	38.58	10.87	9.00	2.57
1980	16.03(3.65)	5.95(1.42)	6.52	1.38	7.33	1.96

[1]Offshore strata 5, 6, 9, and 10.

[2]Inshore strata 1-5 and 46 (calculated index values in parentheses).

[3]Data for 1968-1972 multiplied by factors of 1.76(numbers) and 1.73 (weight) to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls (Sissenwine and Bowman 1978).

Table 4. Stratified mean catch per tow at age (numbers) for southern New England yellowtail flounder in NEFC offshore[1] and inshore[2] spring and offshore summer and autumn bottom trawl surveys, 1963-1980.

Year	Age 0	1	2	3	4	5	6	7	8+	Total Age 1+	Total Age 2+
Spring(offshore)[3]											
1968	0.00	2.80	45.36	46.22	27.17	1.44	0.16	0.09	0.00	123.24	120.44
1969	0.00	7.44	28.12	39.55	21.42	3.84	0.25	0.00	0.00	100.62	93.18
1970	0.00	2.15	15.24	28.93	20.38	5.98	1.55	0.33	0.14	74.70	72.55
1971[4]	-	-	-	-	-	-	-	-	-	74.48	74.48
1972	0.00	0.84	31.38	21.26	6.64	12.69	1.92	0.44	0.00	75.17	74.33
1973	0.00	1.90	10.47	18.34	9.06	6.15	9.53	1.18	0.66	57.29	55.39
1974	0.00	1.07	4.28	3.36	3.60	2.35	0.85	1.44	0.32	17.27	16.20
1975	0.00	0.82	2.25	0.72	1.00	1.28	0.68	0.05	0.21	7.01	6.19
1976	0.00	0.04	4.70	0.75	0.38	0.43	0.38	0.19	0.09	6.96	6.92
1977	0.00	0.35	1.76	2.24	0.22	0.26	0.12	0.04	0.16	5.15	4.80
1978	0.00	4.43	14.04	2.85	1.03	0.27	0.05	0.07	0.20	22.94	18.51
1979	0.00	2.22	4.84	2.57	0.45	0.16	0.00	0.00	0.01	10.25	8.03
1980	0.00	0.54	6.21	4.73	3.90	0.42	0.15	0.02	0.04	16.01	15.47
Spring(inshore)											
1976	0.00	0.00	1.05	0.32	0.34	0.32	0.23	0.04	0.18	2.48	2.48
1977	0.00	1.60	2.75	8.56	0.48	0.81	0.00	0.08	0.19	14.47	12.87
1978	0.00	0.13	11.35	1.76	0.14	0.00	0.00	0.00	0.00	13.38	13.25
1979	0.00	0.57	1.24	0.47	0.22	0.02	0.00	0.00	0.00	2.52	1.95
1980	0.00	0.00	1.71	1.14	0.79	0.00	0.00	0.00	0.00	3.64	3.64
Summer											
1963[4]	-	-	-	-	-	-	-	-	-	28.17	28.17
1964	0.00	0.67	9.34	4.60	6.28	3.00	0.48	0.17	0.00	24.54	23.87
1965	0.00	0.65	21.15	14.42	2.28	0.00	0.00	0.00	0.00	38.50	37.85
1969	0.11	0.07	13.87	41.92	3.49	0.00	0.00	0.00	0.00	59.35	59.28
1977	0.00	2.17	3.05	2.70	0.48	0.09	0.40	0.11	0.05	9.05	6.88
1978	0.00	0.25	4.62	0.20	0.28	0.04	0.00	0.04	0.00	5.43	5.18
1979	0.00	1.83	23.73	12.19	0.73	0.10	0.00	0.00	0.00	38.58	36.75
1980	0.00	1.88	3.15	1.17	0.33	0.00	0.00	0.00	0.00	6.53	4.65
Autumn											
1963	0.05	16.46	15.23	13.98	4.26	0.55	0.00	0.08	0.00	50.56	34.10
1964	0.00	18.47	26.19	4.80	7.13	3.27	0.80	0.11	0.00	60.77	42.30
1965	0.26	11.63	16.90	6.20	1.77	1.73	0.21	0.04	0.00	38.48	26.85
1966	0.88	35.92	10.44	1.78	1.02	0.19	0.00	0.00	0.00	49.35	13.43
1967	0.27	18.44	25.65	11.14	1.57	0.40	0.06	0.13	0.00	57.39	38.95
1968	0.00	10.72	9.47	18.08	1.12	0.00	0.61	0.19	0.04	40.23	29.51
1969	0.00	11.88	9.74	27.48	5.47	0.12	0.04	0.04	0.00	54.77	42.89
1970	0.04	4.23	5.52	16.34	10.62	2.51	0.43	0.07	0.00	39.72	35.49
1971	0.00	6.34	10.84	6.25	15.20	2.69	0.22	0.16	0.00	41.70	35.36
1972[4]	-	-	-	-	-	-	-	-	-	73.28	73.28
1973	0.00	1.56	1.19	1.80	1.34	1.00	0.83	0.23	0.00	7.95	6.39
1974	0.21	1.02	1.64	0.59	2.25	0.96	0.40	0.19	0.07	7.12	6.10
1975	0.00	1.67	0.50	0.19	0.23	0.22	0.00	0.09	0.00	2.90	1.23
1976	0.00	2.99	6.18	0.54	0.07	0.11	0.30	0.35	0.15	10.69	7.70
1977	0.04	1.70	2.19	0.80	0.12	0.04	0.04	0.08	0.00	4.97	3.27
1978	0.00	3.26	7.20	0.43	0.38	0.04	0.01	0.08	0.03	11.43	8.17
1979	0.00	1.73	4.42	2.40	0.37	0.04	0.04	0.00	0.00	9.00	7.27
1980	0.00	1.48	4.33	1.18	0.34	0.00	0.00	0.00	0.00	7.33	5.85

[1]Offshore strata 5, 6, 9, and 10.

[2]Inshore strata 1-5 and 46.

[3]Data for 1968-1972 adjusted by a factor of 1.76 to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls (Sissenwine and Bowman 1978).

[4]Age data not available.

Table 5. Stratified mean catch per tow in numbers and weight (kg) for Georges Bank yellowtail flounder in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys, 1963-1980.

Year	Spring[2]		Summer		Autumn	
	Nos.	Wt(kg)	Nos.	Wt(kg)	Nos.	Wt(kg)
1963	-	-	18.43	6.94	30.12	9.99
1964	-	-	11.18	3.85	22.96	10.64
1965	-	-	17.78	6.00	15.04	7.10
1966	-	-	-	-	14.77	3.12
1967	-	-	-	-	18.58	5.92
1968	11.23	3.77	-	-	25.62	8.22
1969	38.60	15.10	48.26	14.06	23.09	7.25
1970	20.06	7.16	-	-	13.38	3.88
1971	19.57	6.23	-	-	15.24	4.97
1972	27.77	8.72	-	-	14.56	4.93
1973	13.41	3.97	-	-	14.75	5.07
1974	9.08	3.67	-	-	9.95	2.86
1975	6.97	2.26	-	-	7.72	1.81
1976	10.53	3.07	-	-	2.52	1.18
1977	3.28	1.35	1.97	0.79	5.41	2.56
1978	3.62	1.00	3.59	1.18	7.18	2.15
1979	4.45	1.66	3.91	1.59	3.90	1.37
1980	15.98	6.02	3.75	1.44	12.74	6.07

[1]Spring and autumn, strata 13-21; summer, strata 13, 16, and 19-21.

[2]Data for 1968-1972 multiplied by factors of 1.76(numbers) and 1.73(weight) to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls (Sissenwine and Bowman 1978).

Table 6. Stratified mean catch per tow at age (numbers) for Georges Bank yellowtail flounder in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys, 1963-1980.

Year	Age 0	1	2	3	4	5	6	7	8+	Total Age 1+	Total Age 2+
Spring[2]											
1968	0.00	0.26	4.79	5.16	0.44	0.11	0.26	0.18	0.00	11.20	10.94
1969	0.00	1.55	13.46	16.05	4.47	2.06	0.65	0.12	0.25	38.61	37.06
1970	0.00	0.12	6.46	8.55	3.66	0.83	0.18	0.18	0.09	20.07	19.95
1971[3]	-	-	-	-	-	-	-	-	-	19.57	19.57
1972	0.00	0.19	10.31	10.40	5.09	1.43	0.05	0.16	0.14	27.77	27.58
1973	0.00	2.80	4.73	3.43	1.54	0.59	0.25	0.03	0.03	13.40	10.60
1974	0.00	0.46	3.22	2.67	1.80	0.52	0.27	0.10	0.03	9.07	8.61
1975	0.00	0.61	4.61	1.01	0.41	0.25	0.07	0.00	0.02	6.98	6.37
1976	0.00	1.58	6.26	1.81	0.45	0.28	0.04	0.07	0.06	10.55	8.97
1977	0.00	0.00	0.98	1.62	0.57	0.09	0.02	0.00	0.00	3.28	3.28
1978	0.00	1.36	1.16	0.73	0.30	0.06	0.00	0.01	0.00	3.62	2.26
1979	0.00	0.40	2.81	0.54	0.47	0.08	0.07	0.05	0.01	4.43	4.03
1980	0.00	0.08	6.69	8.39	0.68	0.08	0.05	0.00	0.00	15.97	15.89
Summer											
1963[3]	-	-	-	-	-	-	-	-	-	18.43	18.43
1964	0.00	2.38	4.27	2.53	1.48	0.47	0.02	0.00	0.00	11.15	8.77
1965	0.00	0.43	7.21	7.17	1.84	1.09	0.03	0.00	0.00	17.77	17.34
1969	0.00	4.70	23.65	14.94	3.96	0.20	0.58	0.12	0.12	48.27	43.57
1977	0.02	0.31	0.80	0.32	0.36	0.07	0.09	0.00	0.00	1.95	1.64
1978	0.00	1.32	1.07	0.73	0.39	0.07	0.02	0.00	0.00	3.60	2.28
1979	0.00	0.96	1.78	0.46	0.27	0.24	0.21	0.00	0.00	3.92	2.96
1980	0.00	0.21	1.98	1.35	0.13	0.08	0.00	0.00	0.00	3.75	3.54
Autumn											
1963	0.00	12.39	6.28	9.53	1.21	0.41	0.08	0.14	0.09	30.13	17.74
1964	0.00	1.42	7.97	6.04	4.92	2.21	0.31	0.08	0.02	22.97	21.55
1965	0.02	0.96	4.79	4.82	2.89	1.29	0.09	0.17	0.02	15.03	14.07
1966	1.17	9.93	1.46	1.40	0.67	0.10	0.04	0.00	0.00	13.60	3.51
1967	0.05	7.49	7.63	2.21	0.83	0.25	0.06	0.05	0.00	18.52	11.03
1968	0.00	9.67	9.72	4.76	0.64	0.78	0.03	0.00	0.00	25.60	15.93
1969	1.05	6.67	8.52	4.79	1.36	0.36	0.22	0.15	0.00	22.07	15.4[illegible]
1970	0.78	3.77	4.21	2.58	1.60	0.37	0.05	0.01	0.00	12.59	8.8[illegible]
1971	0.03	2.97	5.64	4.08	1.84	0.45	0.19	0.02	0.02	15.21	12.2[illegible]
1972[3]	-	-	-	-	-	-	-	-	-	14.56	14.5[illegible]
1973	0.10	2.04	4.51	4.18	2.41	1.00	0.34	0.14	0.02	14.64	12.6[illegible]
1974	1.01	3.79	2.35	1.24	0.87	0.38	0.20	0.11	0.00	8.94	5.1[illegible]
1975	0.36	3.79	2.06	0.72	0.47	0.27	0.03	0.00	0.03	7.37	3.5[illegible]
1976	0.00	0.27	1.58	0.39	0.10	0.10	0.03	0.00	0.06	2.53	2.1[illegible]
1977	0.00	0.91	2.13	1.56	0.01	0.10	0.06	0.04	0.02	5.43	4.5[illegible]
1978	0.04	4.59	1.24	0.75	0.39	0.13	0.01	0.00	0.02	7.13	2.5[illegible]
1979	0.02	1.27	2.00	0.25	0.13	0.13	0.03	0.06	0.02	3.89	2.6[illegible]
1980	0.08	0.66	5.27	5.57	0.67	0.27	0.16	0.03	0.03	12.66	12.[illegible]

[1]Spring and autumn, strata 13-21; summer, strata 13, 16, and 19-21.

[2]Data for 1968-1972 adjusted by a factor of 1.76 to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls(Sissenwine and Bowman 1978)

[3]Age data not available.

Table 7. Stratified mean catch per tow in numbers and weight(kg) for Cape Cod yellowtail flounder in NEFC offshore[1] and inshore[2] spring and summer and offshore autumn bottom trawl surveys, 1963-1980.

	Spring[3]		Summer		Autumn	
Year	Nos.	Wt(kg)	Nos.	Wt(kg)	Nos.	Wt(kg)
1963	-	-	5.46	1.33	9.07	3.54
1964	-	-	0.41	0.18	3.67	1.18
1965	-	-	2.39	0.95	4.50	1.23
1966	-	-	-	-	4.02	0.80
1967	-	-	-	-	0.74	0.27
1968	0.40	0.00[4]	-	-	0.88	0.29
1969	0.77	0.43	0.56	0.20	2.37	0.85
1970	4.00	1.16	-	-	1.16	0.31
1971	2.76	0.47	-	-	1.49	0.35
1972	1.78	0.28	-	-	10.24	2.75
1973	1.63	0.31	-	-	1.60	0.58
1974	1.81	0.71	-	-	0.22	0.12
1975	2.62	0.31	-	-	0.93	0.39
1976	3.31	0.84	-	-	4.81	1.21
1977	1.08	0.40	1.15(4.53)	0.52(1.25)	12.93	4.66
1978	0.22	0.08	2.15(25.50)	0.89(3.80)	4.51	1.37
1979	0.47(3.52)	0.11(1.27)	2.65(14.02)	0.88(2.12)	3.87	1.01
1980	2.25(11.18)	0.63(4.61)	2.75(20.93)	1.01(2.85)	12.60	3.47

[1]Offshore strata 24-26.

[2]Inshore strate 55, 58-61, and 64-66(spring); 55, 56, 58-61, and 63-66(summer) (values in parentheses)

[3]Data for 1968-1972 multiplied by factors of 1.76(numbers) and 1.73(weight) to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls (Sissenwine and Bowman 1978).

[4]Less than 0.01.

Table 8. Stratified mean catch per tow at age (numbers) for Cape Cod yellowtail flounder in NEFC offshore[1] and inshore[2] spring and summer and offshore autumn bottom trawl surveys, 1976-1980.

Year	Age 0	1	2	3	4	5	6	7	8+	Totals Age 1+	Age 2+
Spring(offshore)											
1976	0.00	0.20	1.88	1.06	0.08	0.01	0.02	0.02	0.06	3.33	3.13
1977	0.00	0.00	0.67	0.26	0.07	0.02	0.03	0.00	0.02	1.07	1.07
1978	0.00	0.00	0.05	0.08	0.02	0.08	0.00	0.00	0.00	0.23	0.23
1979	0.00	0.01	0.06	0.24	0.14	0.01	0.00	0.00	0.00	0.46	0.45
1980	0.00	0.00	1.75	0.36	0.13	0.00	0.00	0.00	0.00	2.24	2.24
Spring(inshore)											
1979	0.00	0.75	0.74	1.29	0.67	0.02	0.05	0.00	0.00	3.52	2.77
1980	0.00	0.00	5.23	4.08	1.53	0.34	0.00	0.00	0.00	11.18	11.18
Summer(offshore)											
1977	0.00	0.05	0.69	0.37	0.04	0.00	0.00	0.00	0.00	1.15	1.10
1978	0.00	0.30	0.79	0.39	0.51	0.04	0.00	0.13	0.00	2.16	1.86
1979	0.00	0.20	1.16	0.85	0.28	0.08	0.05	0.03	0.00	2.65	2.45
1980	0.00	0.52	1.23	0.63	0.24	0.05	0.09	0.00	0.00	2.76	2.24
Summer(inshore)											
1977	0.00	0.83	2.88	0.76	0.04	0.02	0.00	0.00	0.00	4.53	3.70
1978	0.00	11.81	8.49	3.86	1.23	0.03	0.08	0.00	0.00	25.50	13.69
1979	0.00	7.87	5.37	0.64	0.00	0.14	0.00	0.00	0.00	14.02	6.15
1980	0.00	13.08	5.95	1.41	0.28	0.09	0.12	0.00	0.00	20.93	7.85
Autumn											
1976	0.00	2.28	2.18	0.30	0.01	0.03	0.00	0.00	0.00	4.80	2.52
1977	0.00	3.33	6.27	2.98	0.26	0.00	0.00	0.00	0.08	12.92	9.59
1978	0.00	0.25	2.43	1.68	0.14	0.01	0.00	0.00	0.00	4.51	4.26
1979	0.01	1.63	1.26	0.76	0.17	0.03	0.00	0.00	0.00	3.85	2.22
1980	0.00	4.26	5.48	2.00	0.60	0.24	0.00	0.04	0.00	12.62	8.36

[1]Strata 24-26.

[2]Strata 55, 58-61, and 64-66(spring); 55, 56, 58-61, and 63-66(summer).

Table 9. Stratified mean catch per tow in numbers and weight (kg) for yellowtail flounder in Massachusetts inshore spring and autumn bottom trawl surveys[1] from Cape Cod to Massachusetts Bay, 1978-1980.

Season/ Year	Stratified mean catch per tow at age[1] (numbers) 0	1	2	3	4	5	6	7	8+	Total	Stratified mean catch/tow in weight(kg)
Spring											
1978	0.00	2.71	20.69	11.82	1.60	0.63	0.54	0.10	0.13	38.22	10.16
1979	0.00	2.63	22.58	13.85	3.68	0.86	0.00	0.17	0.00	43.77	11.38
1980	0.00	2.68	17.62	10.10	2.30	0.15	0.00	0.00	0.00	32.85	10.03
Autumn											
1978	0.04	7.13	7.74	1.45	0.11	0.00	0.01	0.00	0.00	16.48	2.80
1979	0.03	24.11	22.82	1.78	0.06	0.00	0.00	0.00	0.00	48.80	7.33
1980	0.03	26.54	12.38	2.70	0.35	0.00	0.00	0.00	0.00	42.00	5.90

[1] Regions 3, 4, and 5(strata 17-21, 25-30, and 31-36).

Table 10. Stratified mean catch per tow in numbers and weight (kg) for Mid-Atlantic yellowtail flounder in NEFC offshore[1] and inshore[2] spring, and offshore summer and autumn bottom trawl surveys, 1963-1980.

Year	Spring[3]		Summer		Autumn	
	Nos.	Wt(kg)	Nos.	Wt(kg)	Nos.	Wt(kg)
1963	-	-	4.02	0.66	28.83	8.93
1964	-	-	2.17	0.06	16.40	4.85
1965	-	-	3.33	0.11	49.05	5.82
1966	-	-	-	-	48.27	8.85
1967	-	-	-	-	55.58	9.31
1968	153.00	29.44	-	-	81.32	13.47
1969	120.74	23.87	9.35	1.31	45.35	9.92
1970	83.76	19.46	-	-	45.21	10.31
1971	64.24	13.63	-	-	26.97	3.77
1972	67.39	17.14	-	-	86.24	20.95
1973	32.10	9.19	-	-	8.24	1.87
1974	13.38	4.38	-	-	0.66	0.19
1975	2.01	0.80	-	-	0.87	0.15
1976	4.28(2.08)	0.95(0.69)	-	-	0.38	0.06
1977	7.30(6.77)	1.77(1.33)	0.44	0.05	1.43	0.18
1978	9.93(6.48)	2.02(1.17)	0.17	0.03	1.19	0.22
1979	2.41(1.61)	0.60(0.31)	1.67	0.15	1.04	0.20
1980	11.91(10.57)	3.59(1.99)	0.71	0.08	0.80	0.15

[1]Offshore strata 69, 70, 73-74, 1, and 2.

[2]Inshore strata 7-14, 16-20, 22, 23, and 25 (values in parentheses).

[3]Data for 1968-1972 multiplied by factors of 1.76(numbers) and 1.73(weight), to account for differences in catchability between the "36 Yankee" and the "41 Yankee" trawls (Sissenwine and Bowman 1978).

Table 11. Stratified mean catch per tow [illegible] flounder in NEFC offshore[1] and inshore[2] spring, and offshore summer and autumn bottom trawl surveys, 1976-1980.

Totals

Table 11. Stratified mean catch per tow at age (numbers) for [illegible] flounder in NEFC offshore[1] and inshore[2] spring, and offshore summer and autumn bottom trawl surveys, 1976-1980.

Year	Age 0	1	2	3	4	5	6	7	8+	Totals Age 1+	Age 2+
Spring(offshore)											
1976	0.00	0.00	3.34	0.30	0.21	0.10	0.32	0.02	0.00	4.29	4.29
1977	0.00	2.36	1.29	2.77	0.27	0.11	0.26	0.16	0.08	7.30	4.94
1978	0.00	1.19	6.68	0.73	0.60	0.23	0.19	0.20	0.12	9.94	8.75
1979	0.00	0.00	1.33	0.76	0.13	0.09	0.03	0.03	0.04	2.41	2.41
1980	0.00	0.72	5.46	3.88	1.56	0.27	0.00	0.00	0.00	11.89	11.17
Spring(inshore)											
1976	0.00	0.00	1.01	0.20	0.40	0.13	0.33	0.01	0.00	2.08	2.08
1977	0.00	3.96	0.21	1.84	0.22	0.11	0.22	0.14	0.05	6.75	2.79
1978	0.00	1.64	3.51	0.59	0.31	0.13	0.11	0.15	0.04	6.48	4.84
1979	0.00	0.29	0.48	0.76	0.03	0.06	0.00	0.00	0.00	1.62	1.33
1980	0.00	5.02	1.95	2.76	0.79	0.06	0.00	0.00	0.00	10.58	5.56
Summer											
1977	0.00	0.27	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.45	0.18
1978	0.00	0.03	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.14
1979	0.00	1.16	0.48	0.03	0.00	0.00	0.00	0.00	0.00	1.67	0.51
1980	0.00	0.51	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.72	0.21
Autumn											
1976	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.19
1977	0.00	1.40	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.03
1978	0.00	0.60	0.54	0.05	0.00	0.00	0.00	0.00	0.00	1.19	0.59
1979	0.00	0.43	0.59	0.02	0.00	0.00	0.00	0.00	0.00	1.04	0.61
1980	0.00	0.49	0.23	0.03	0.00	0.05	0.00	0.00	0.00	0.80	0.31

[1]Offshore strata 69, 70, 73-74, 1, and 2.

[2]Inshore strata 7-14, 16-20, 22, 23, and 25.

Table 12. Estimated mean number and weight (kg) per tow by stratum and stratified mean number and weight (kg) per tow for yellowtail flounder, 1980 and 1981 cooperative surveys.

Year	Stratum	Area (Nm)^2	No. tows	Mean No/tow	Mean kg/tow
1980	1	441	2	182.00	65.00
	2	1,325	11	217.36	73.82
	3	724	7	34.43	16.14
	4	557	6	163.50	72.16
	5	863	11	182.90	73.73
	6	382	3	115.66	47.00
1981	1	441	4	226.00	51.62
	2	1,325	12	297.33	87.25
	3	724	7	70.71	24.67
	4	557	5	110.60	25.60
	5	863	8	201.38	60.19
	6	382	4	65.25	33.38

Stratified Mean Catch per Tow		95% Confidence Limits	
Number		Lower	Upper
1980 :	159.89	127.30	192.48
1981 :	187.58	137.88	237.31
Weight			
1980 :	60.55	47.87	73.23
1981 :	54.80	40.92	66.67

Table 13. Results of equilibrium yield modeling[1] for Southern New England and Georges Bank yellowtail under different levels of recruitment and fishing mortality.

Instantaneous fishing mortality (F)	Recruits[2] Age 2 (000's)	Catch (MT)	Stock size Age 2+(MT)
Southern New England			
0.3[3]	17,629	4,311	17,606
	35,257	8,621	35,210
	52,885	12,931	52,816
	70,514	17,242	70,420
0.5[4]	17,629	4,953	12,921
	35,257	9,905	25,840
	52,885	14,857	38,761
	70,514	19,810	51,986
1.0	17,629	5,116	7,770
	35,257	10,232	15,539
	52,885	15,348	23,309
	70,514	20,465	31,078
Georges Bank			
0.3[3]	9,682	2,966	9,669
	19,363	5,932	19,337
	29,045	8,898	29,006
	38,726	11,364	38,675
0.5[4]	9,682	3,407	7,096
	19,363	6,815	14,191
	29,045	10,222	21,287
	38,726	13,629	28,383
1.0	9,682	3,544	4,267
	19,363	7,087	8,534
	29,045	10,631	12,801
	38,726	14,175	17,068

[1]Calculations performed assuming 50% recruitment at age 2 and full recruitment at older ages (assuming use of 130 mm mesh trawls) and mean weights at age as reported by Brown and Hennemuth (MS 1971).

[2]Assumed to be one-fourth, one-half, three-fourths, and equal to the 1958-1962 year-class average for these groups (Brown and Hennemuth MS 1971).

[3]$F_{0.1}$

[4]F_{max}

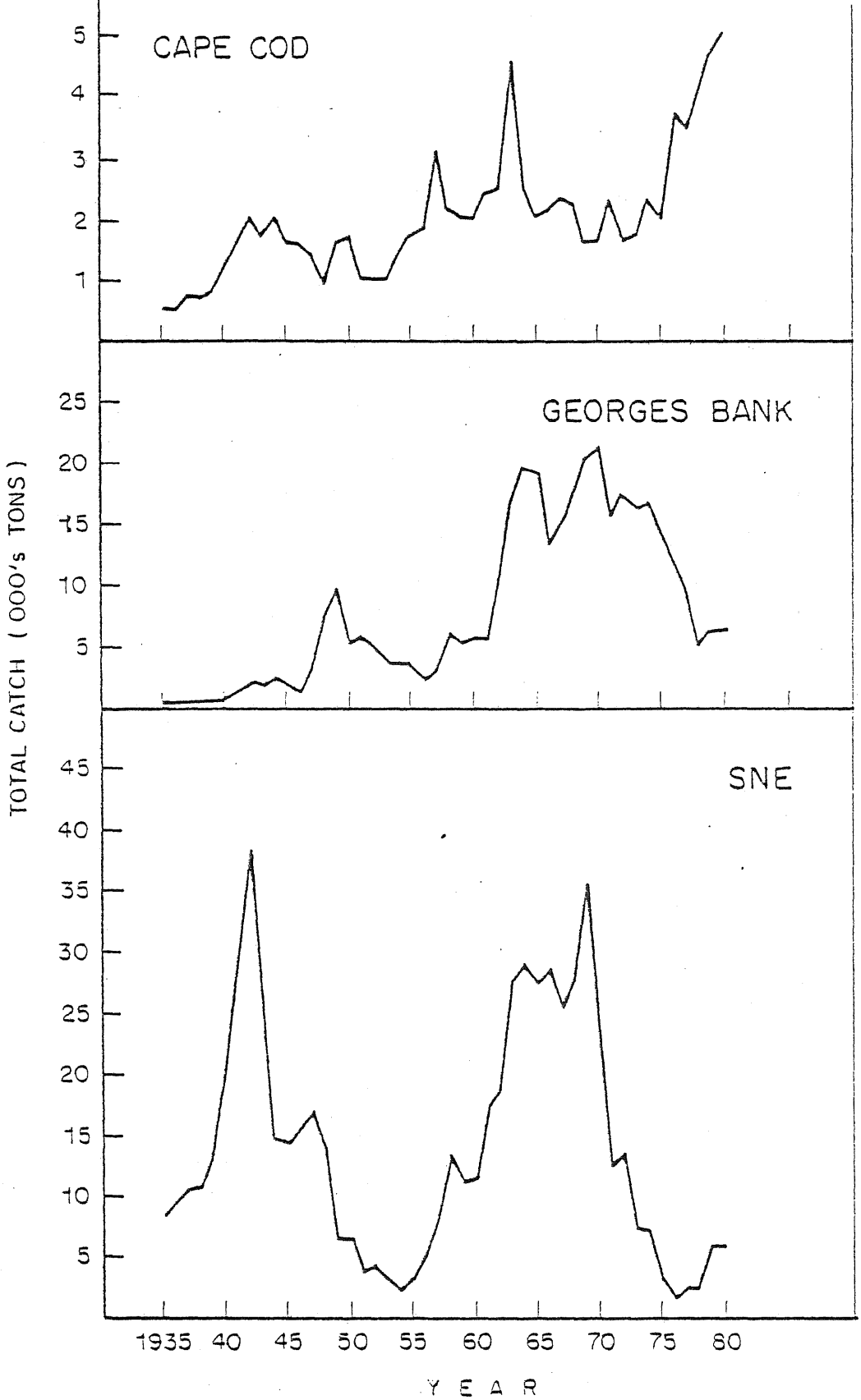

Figure 1. Total commercial catch of yellowtail flounder (000's of metric tons, live) for the Cape Cod grounds, Georges Bank, and southern New England, 1935-1980.

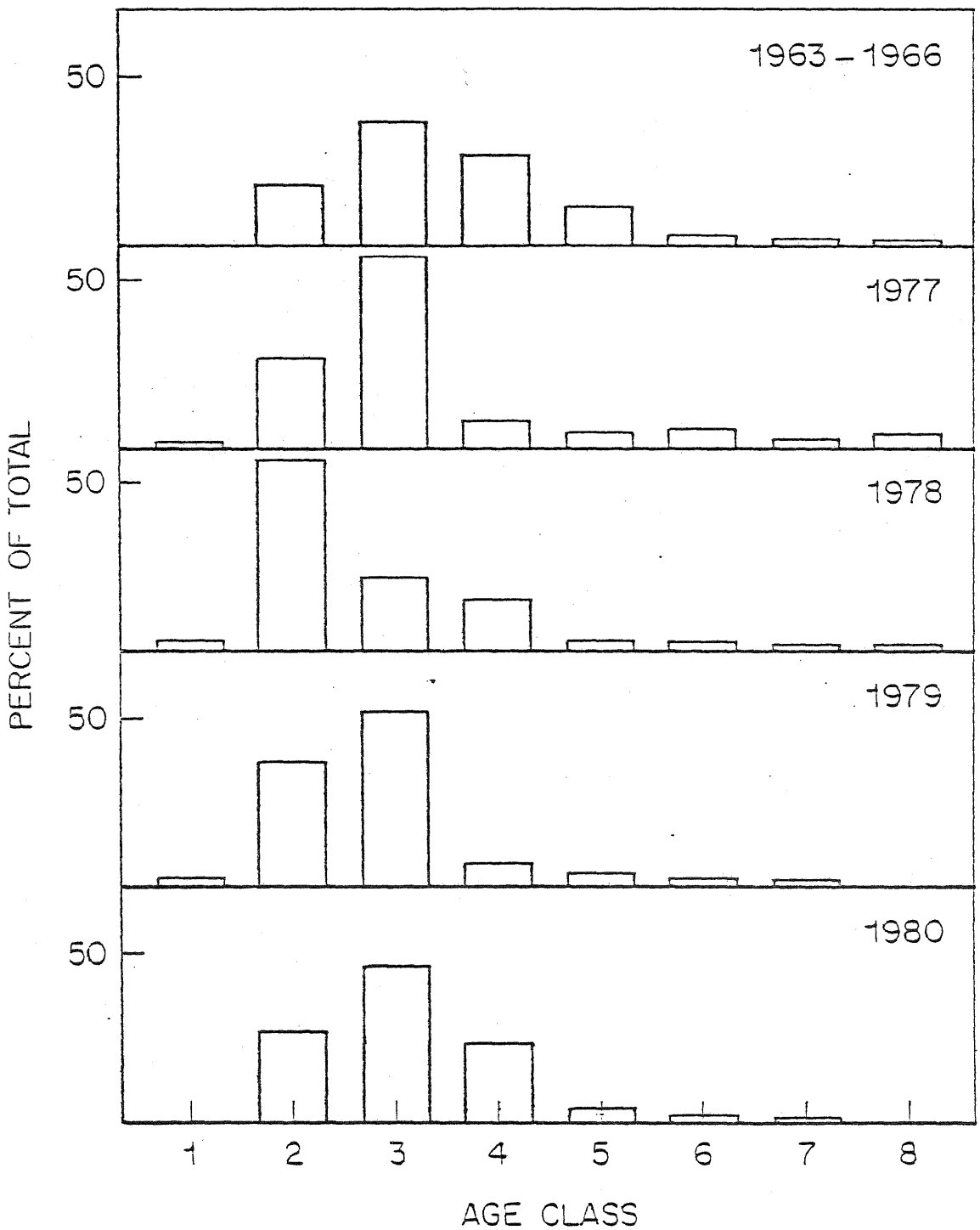

Figure 2. Age composition of southern New England yellowtail landings (percent by number) for 1963-1966 and 1977-1980.

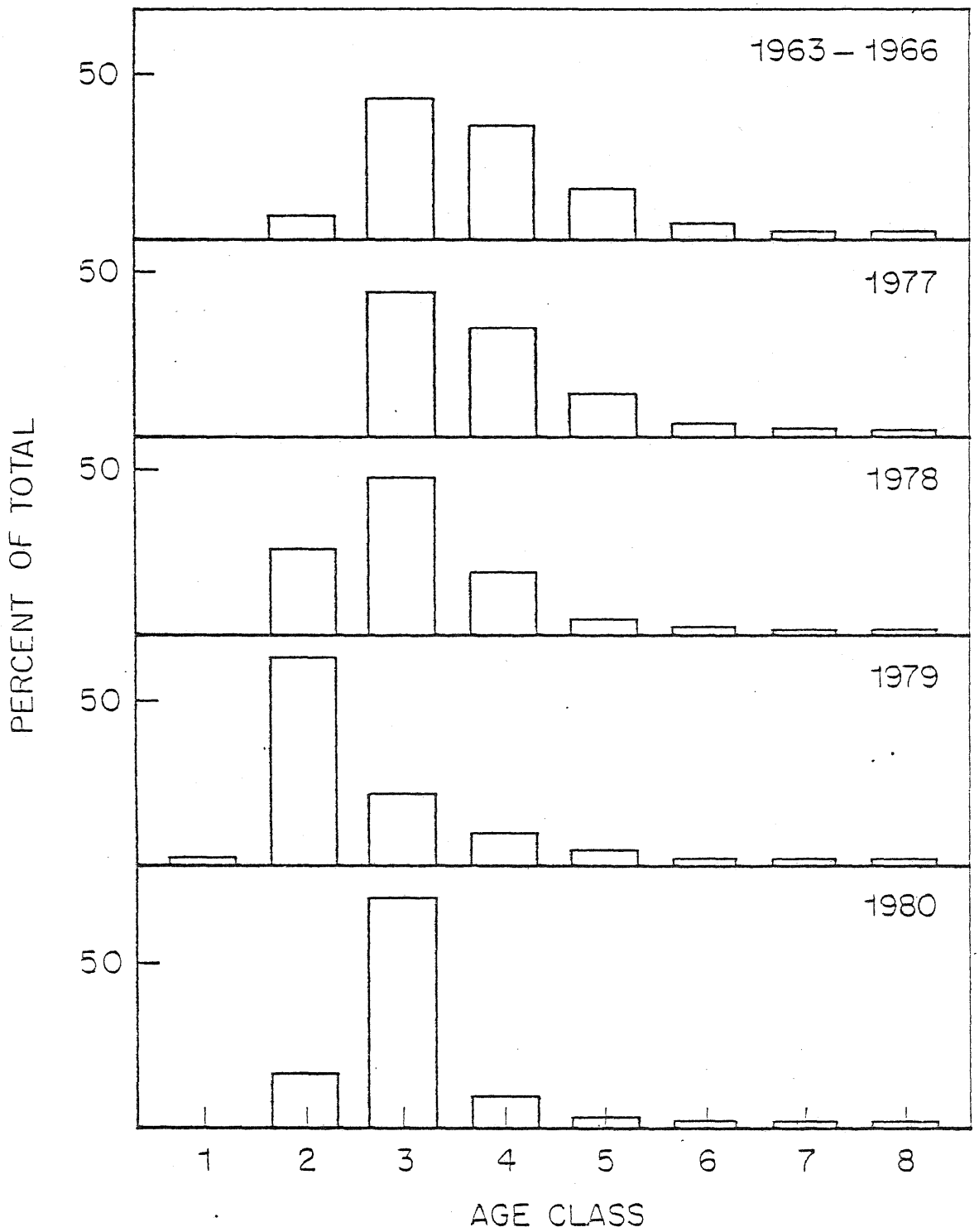

Figure 3. Age composition of Georges Bank yellowtail landings (percent by number) for 1963-1966 and 1977-1980.

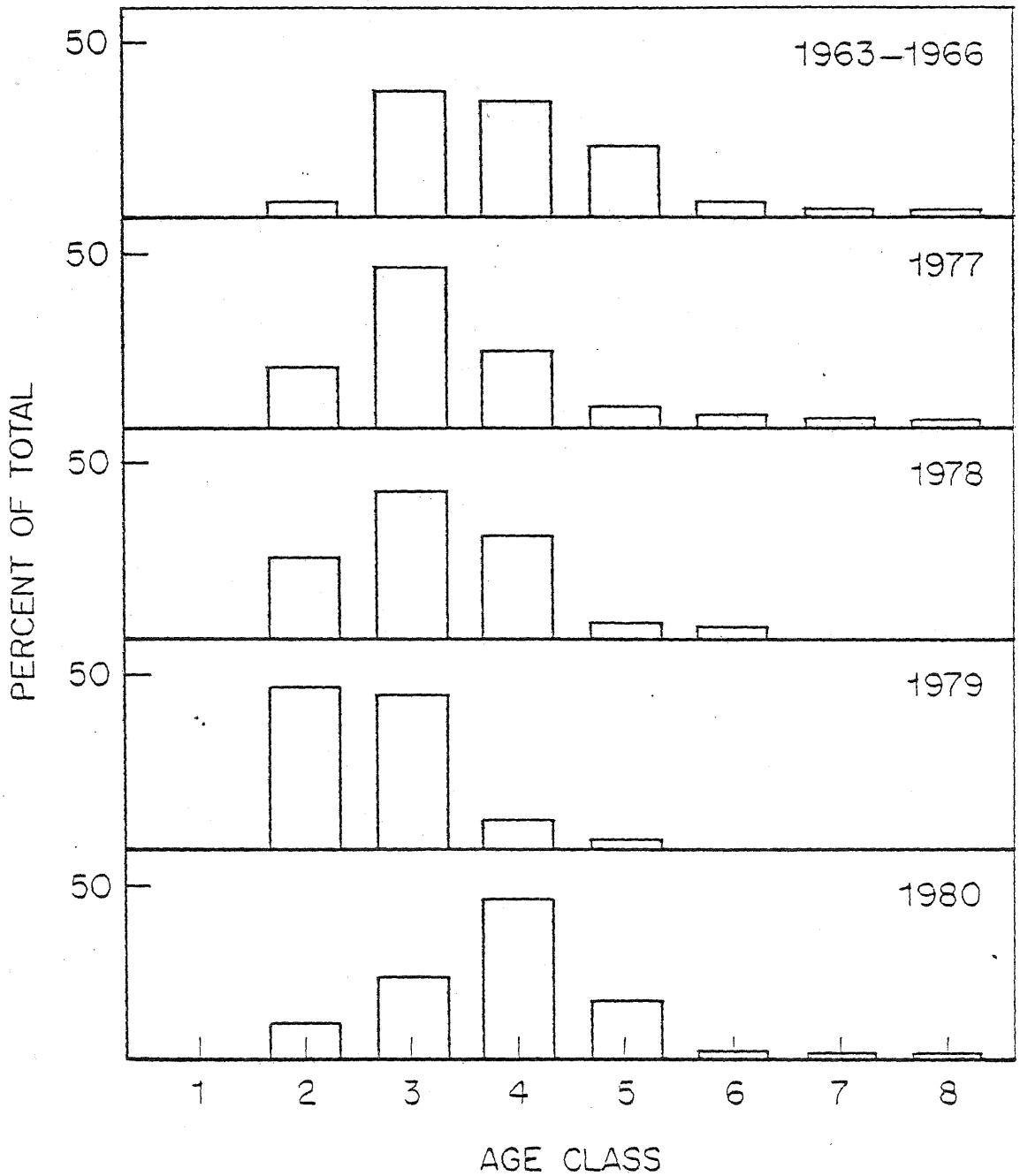

Figure 4. Age composition of Cape Cod yellowtail landings (percent by number) for 1963-1966 and 1977-1980.

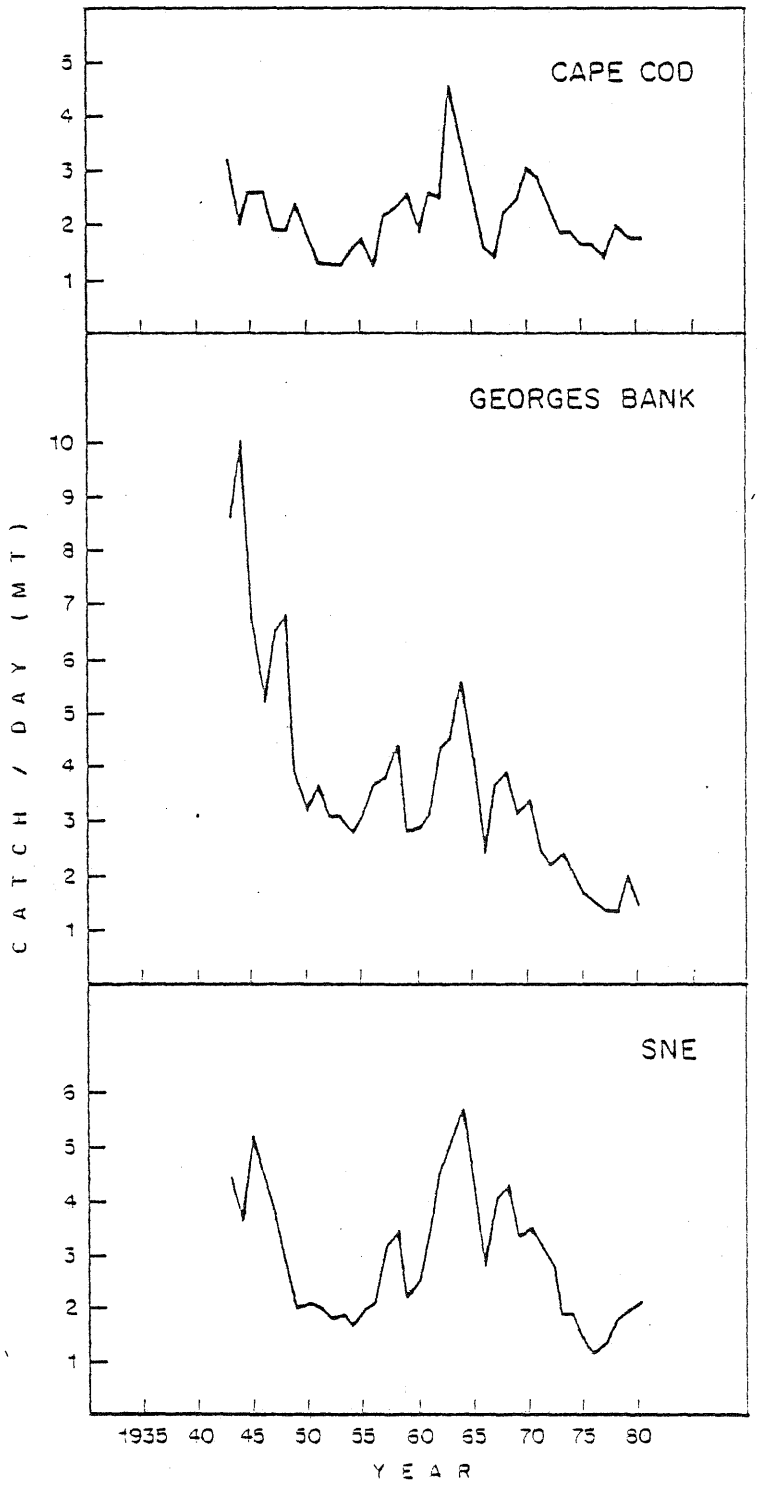

Figure 5. Commercial abundance indices (tons per standard day fished) for Cape Cod, Georges Bank, and southern New England yellowtail flounder, 1943-1980.

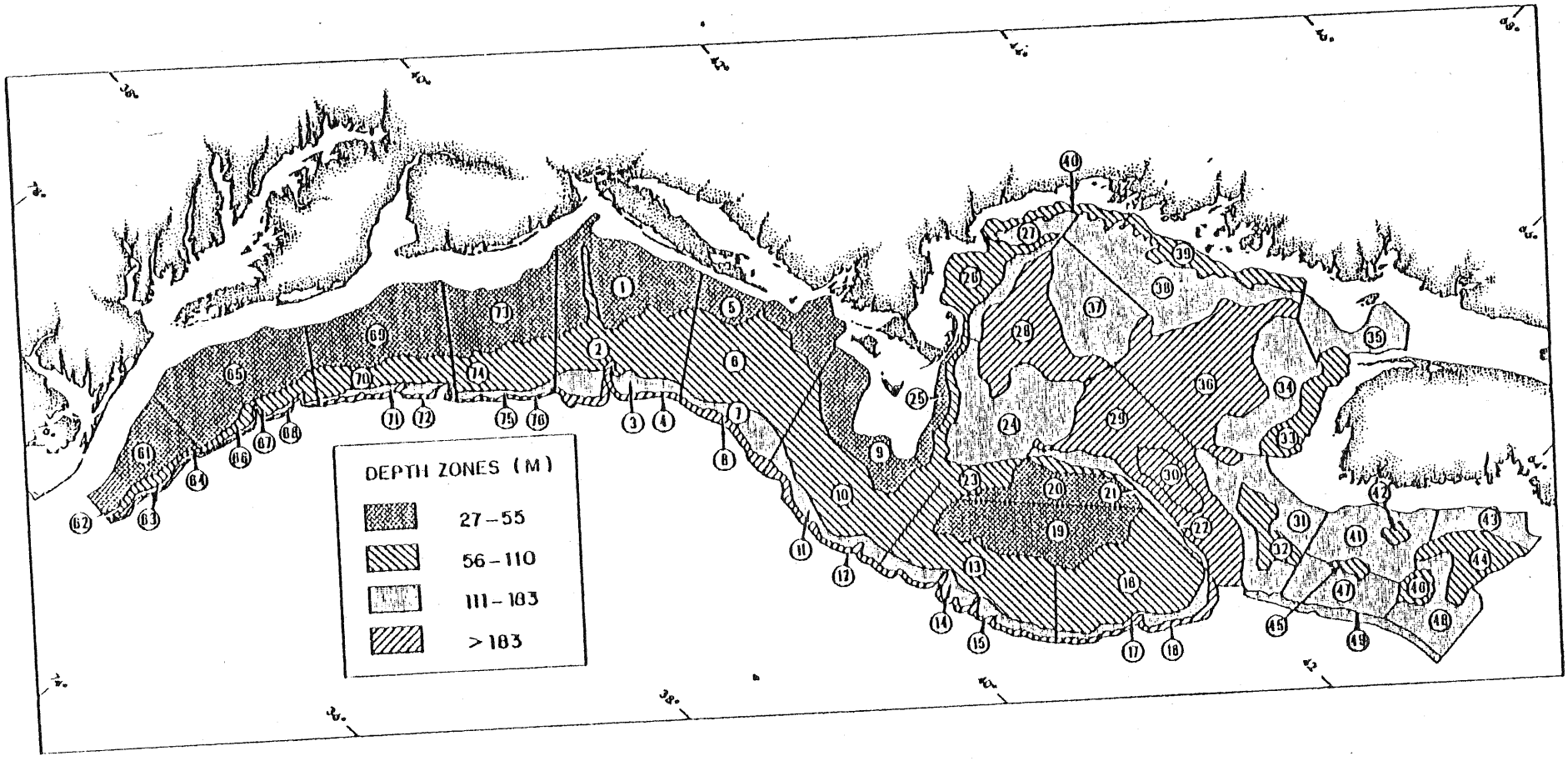

Figure 6. Strata used in NEFC offshore (>27 m) spring, summer, and autumn bottom trawl surveys.

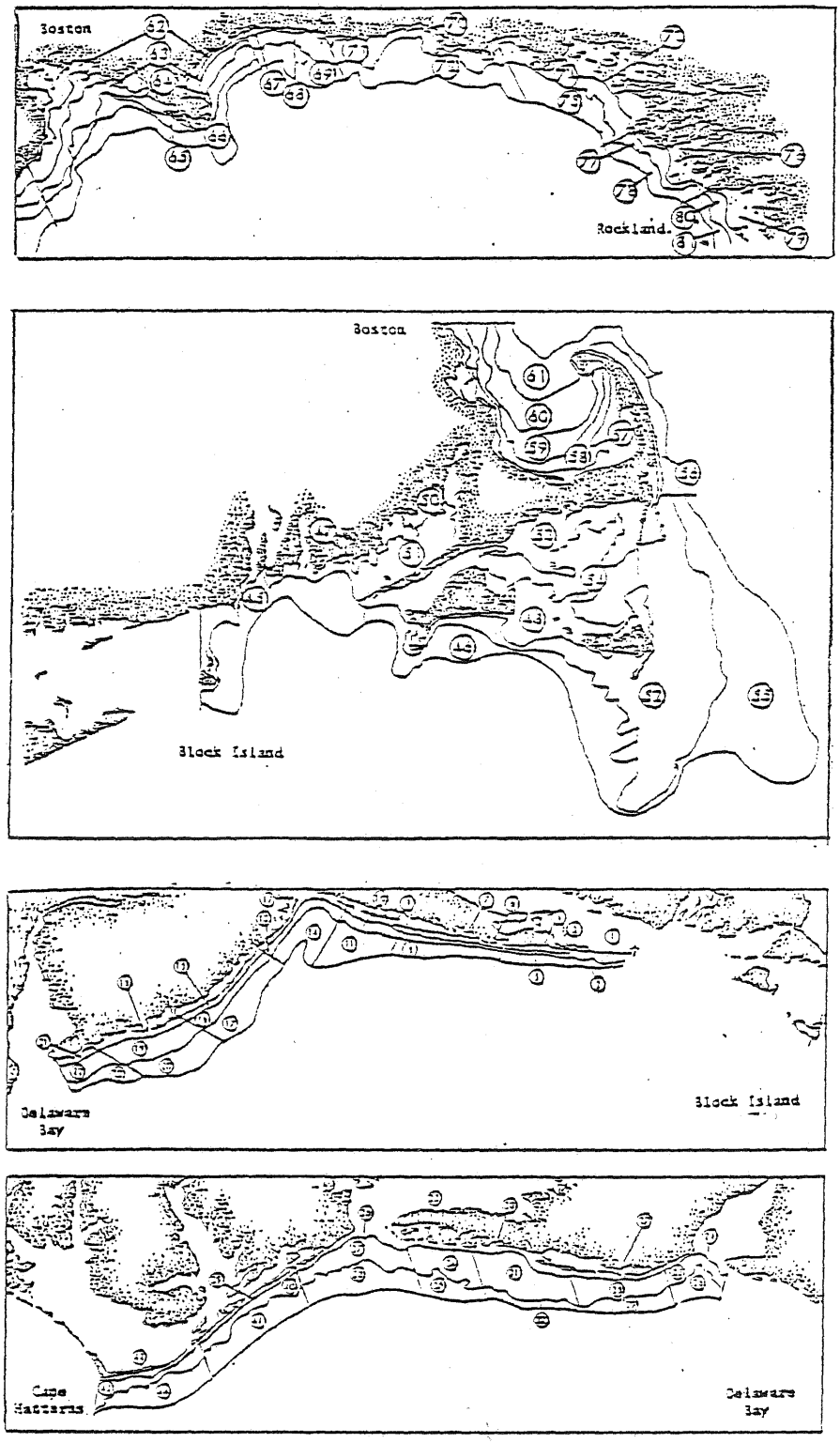

Figure 7. Strata used in NEFC inshore (<27 m) spring, summer, and autumn bottom trawl surveys.

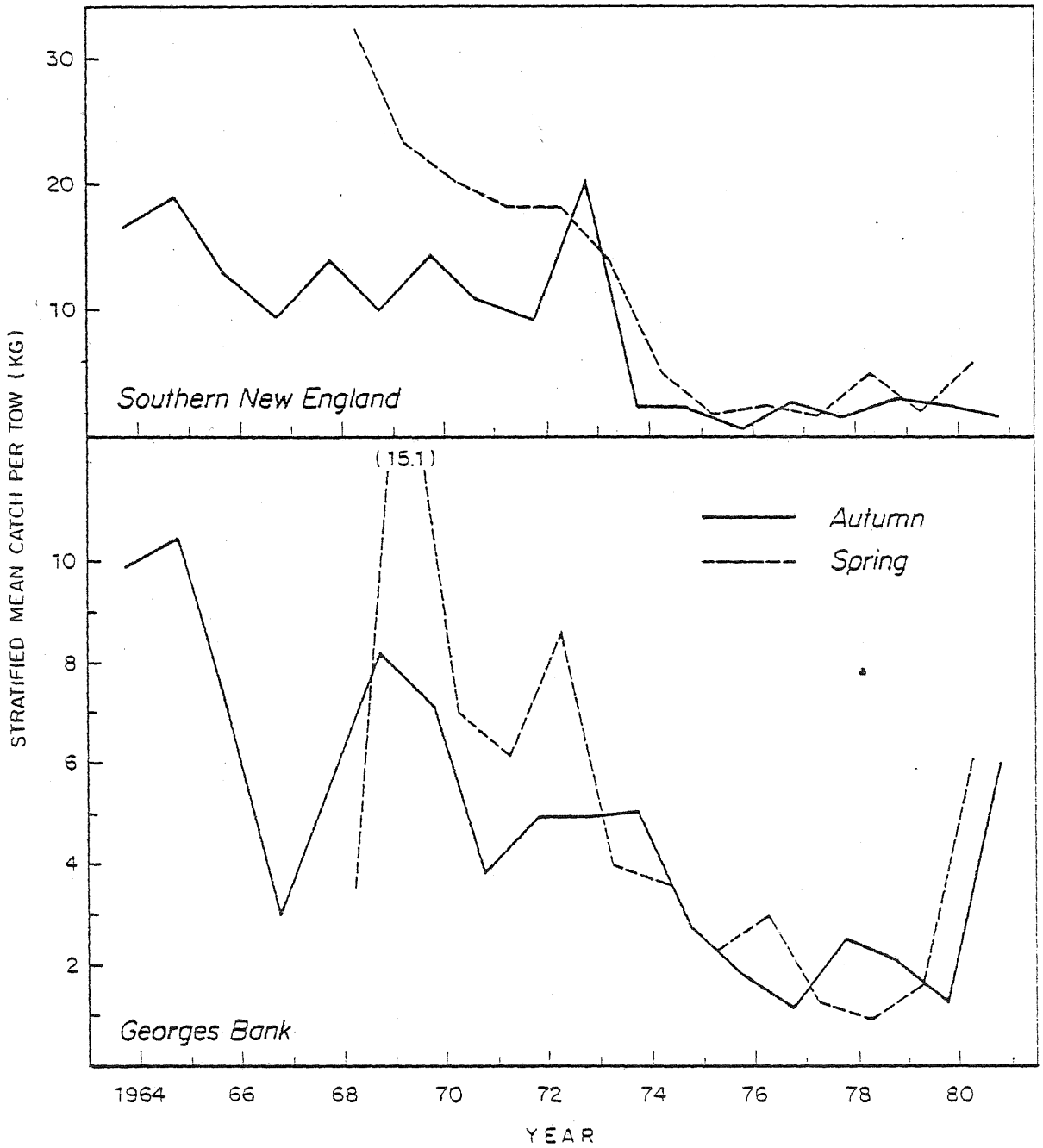

Figure 8. Stratified mean catch per tow (kg) of southern New England and Georges Bank yellowtail flounder in NEFC offshore spring and autumn bottom trawl surveys, 1963-1980.

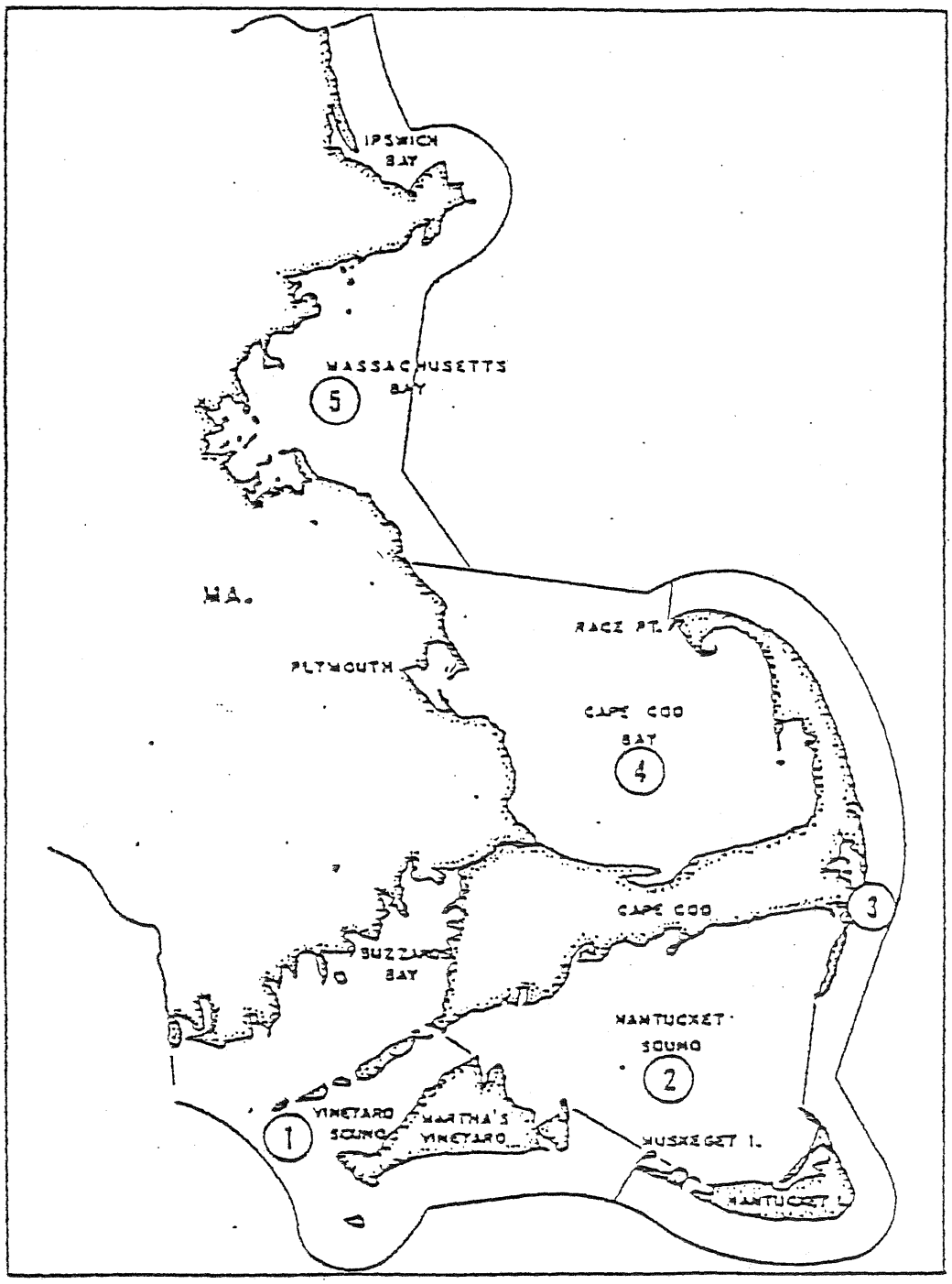

Figure 9. Massachusetts inshore survey area delineated by regions.

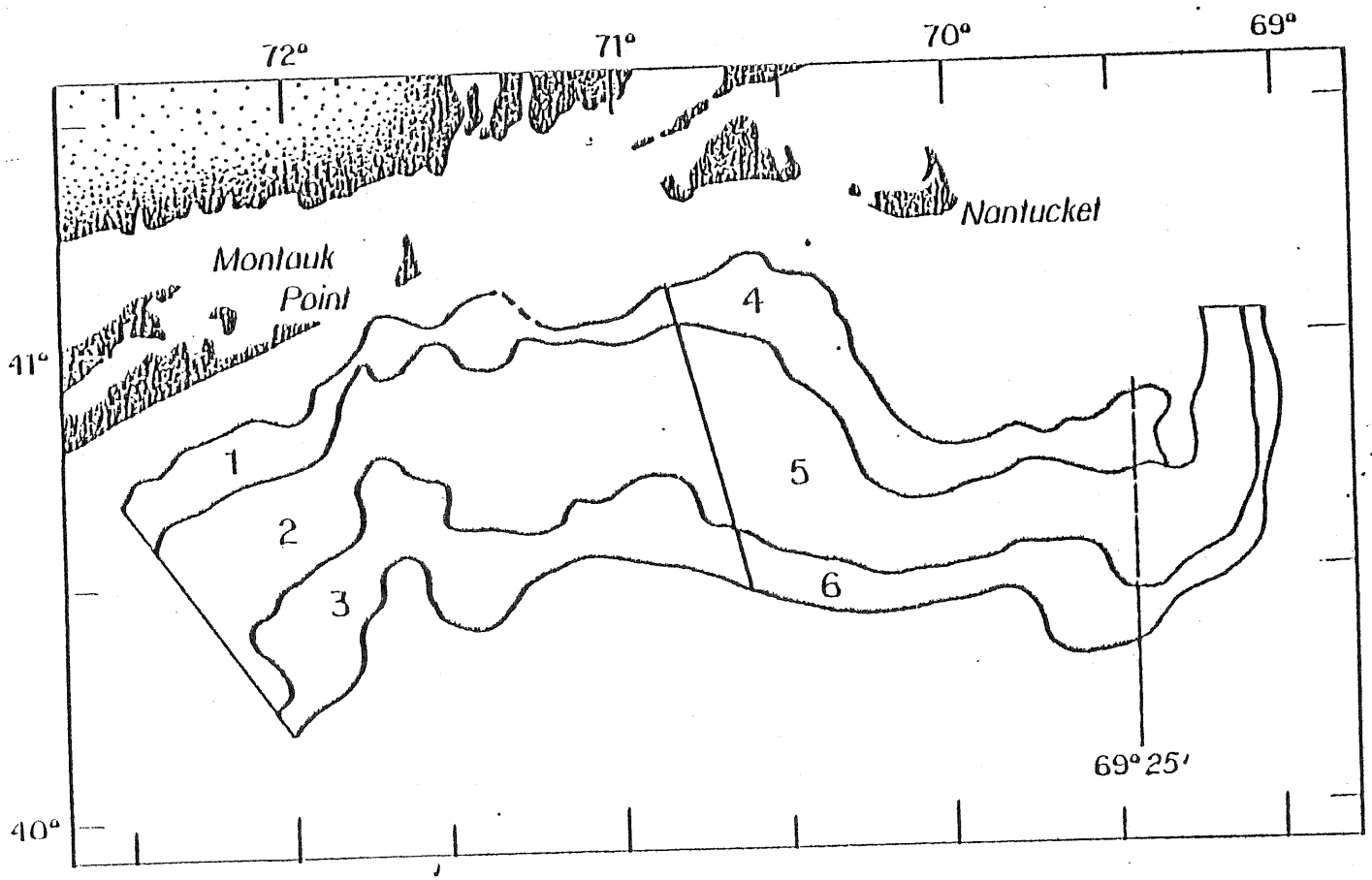

Figure 10. Strata used in M/V FRIESLAND and M/V FORAGER surveys.

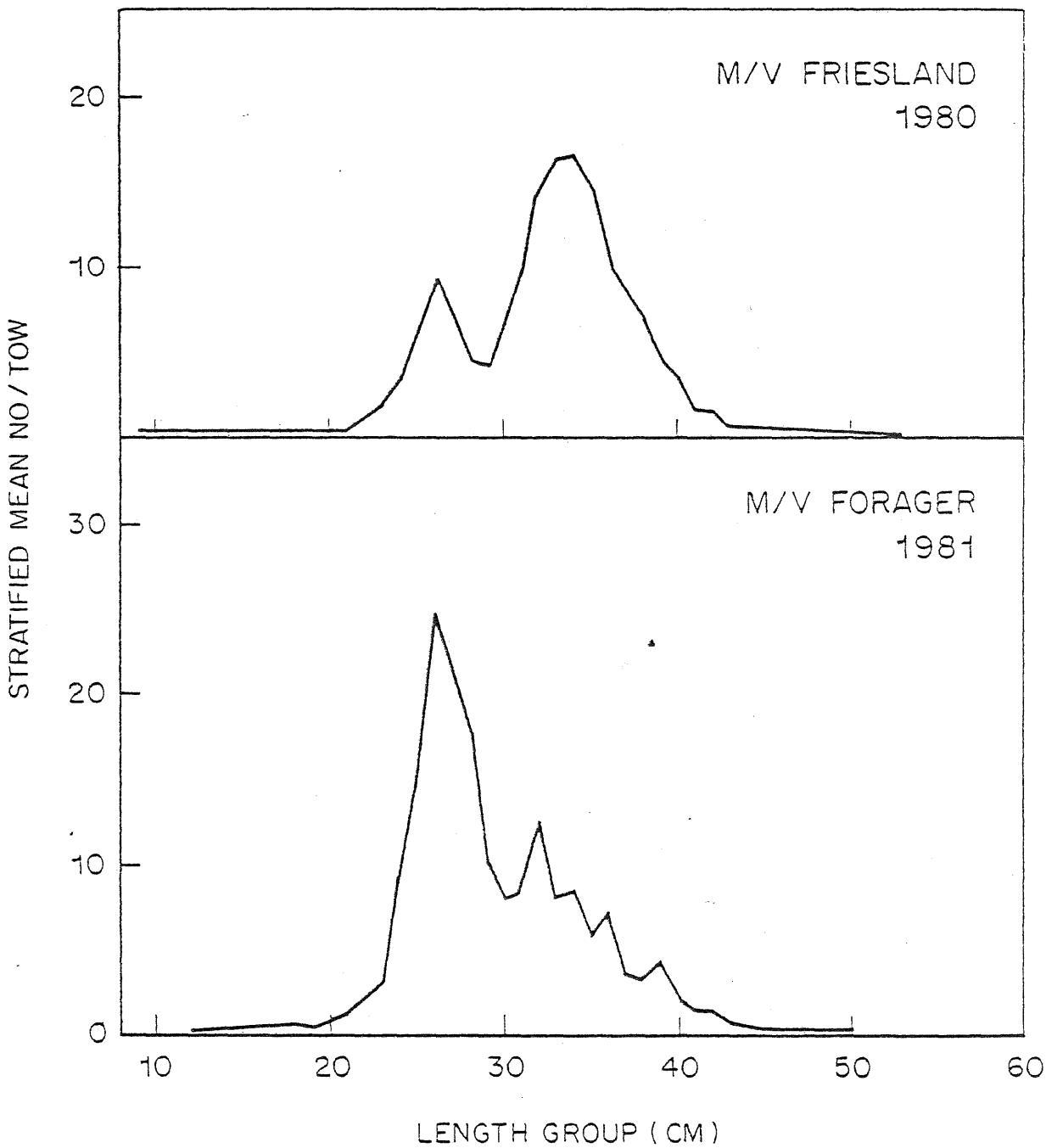

Figure 11. Length frequency distributions of yellowtail flounder taken in M/V FRIESLAND and M/V FORAGER surveys, 1980-1981.