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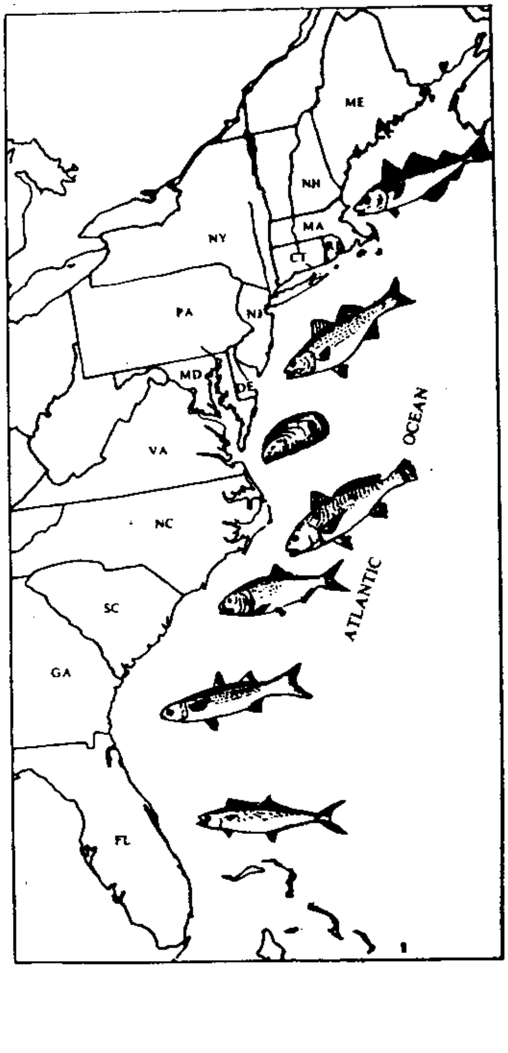

FISHERY MANAGEMENT PLAN FOR SUMMER FLOUNDER

October 1982

Fishery Management Plan
for the
Summer Flounder (*Paralichthys dentatus*) Fishery

September 1981

Prepared by
Paul G. Scarlett, Project Manager
N.J. Division of Fish, Game and Wildlife

in cooperation with

Summer Flounder Scientific and Statistical Committee
Summer Flounder Regional Citizens Advisory Committee

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Management Recommendations

The summer founder fishery occurs over a wide range crossing both state and federal boundaries along the Atlantic Coast. Recognizing that sound management of summer flounder would require the joint effort of the coastal States, Regional Councils, and Federal Government, the Atlantic States Marine Fisheries Commission, on October 14, 1982, adopted the Fishery Management Plan for the Summer Flounder (*Paralichthys dentalus*) Fishery. In approving the plan, the Commission recommended that the States adopt the following management measure: a 14 inch (total length) minimum size limit for all fisheries, to be achieved by minimum size regulations and/or mesh regulations. This management recommendation is discussed in greater detail on pages 40-47 of this document.

Introduction

This management plan for summer flounder was prepared by the State/Federal Summer Flounder Management Program under a contract between the New Jersey Division of Fish, Game and Wildlife and the National Marine Fisheries Service. It contains management measures to regulate fishing for summer flounder, the objectives of which are to:

1. Promote Optimum Yield of the fishery and reduce the probability of recruitment failure by protecting juvenile fish.

2. Insure that management strategies implemented to achieve objective #1 above are equitable to the major recreational and commercial components presently engaged in the fishery.

3. Improve understanding of the factors that interact to control the condition of the stocks.

4. Promote compatible management regulations between the territorial seas and the Fishery Conservation Zone.

5. Minimize regulations to achieve the management objectives recognized above.

DESCRIPTION OF STOCKS

Species or Group of Species and their Distribution

The geographic range of the summer flounder (*Paralichthys dentatus*) encompasses the estuarine and coastal waters from Nova Scotia to Florida (Leim and Scott, 1966; Gutherz, 1967). The center of its abundance lies within the Middle Atlantic Bight. North of Cape Cod, Massachusetts and south of Cape Fear, North Carolina its number begin to diminish. South of Oregon Inlet, North Carolina two closely related species, the southern flounder (*Paralichthys lethostigma*) and the gulf flounder (*Paralichthys albigutta*) occur and sometimes are not distinguished from summer flounder.

Summer Flounder normally inhabit coastal and estuarine waters during the warmer months of the year and remain offshore in 20 to 100 fathoms (36 to 182 meters) of water during the fall and winter (Bigelow and Schroeder, 1953). Spawning occurs during the fall and winter while the fish are moving offshore or at their wintering grounds. The migratory pattern varies with latitude, with fish spawning and moving offshore earlier in the northern part of the range. Larvae and post larvae drift and migrate inshore, entering coastal and estuarine nursery areas from October to May. The fry become demersal on reaching the coast and the first year is spent in bays or inshore areas over the entire range of the species (Smith, 1973).

The primary nursery grounds for juveniles are the sounds of North Carolina, Chesapeake Bay, and the bays of the eastern shore of Virginia; however, they are distributed during spring, summer and fall in estuaries from Massachusetts to North Carolina (Poole, 1966; Festa, 1974; Howe [1], pers. comm.). At the end of the first year, some of the juveniles join the adult migration. Juveniles in southern waters overwinter in bays and sounds whereas in the north there is some movement offshore, although many larval and juvenile summer flounder still remain inshore through the winter months (Smith and Daiber, 1977; Wilk et al., 1977). The offshore population returns to the coast and bays in the spring with a tendency to return to the same estuary as the year before or to move to the north and east (Poole, 1962; Murawski, 1970; Hamer and Lux, 1962).

Evidence exists that two stocks of summer flounder may contribute to the fisheries in the Middle Atlantic Bight. Although not conclusive, the evidence suggests the existence of an "offshore stock" with offshore-inshore migrations from southern New England to southern Virginia as described above, and a "trans-Hatteras or inshore stock" that spawns in the fall and winter in coastal waters less than 20 fathoms (36 meters) off Virginia and North Carolina, spends the early winter in coastal waters south of Cape Hatteras, and summers inshore from North Carolina to Rhode Island. Most of the "inshore stock" however, probably remains south of Delaware.

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[1] Howe, A., MA Div. of Mar. Fish., East Sandwich, MA.

Tagging studies conducted by Poole (1962) and Westman and Neville (1946) off Long Island, New York; Hamer and Lux (1962) north of Hudson Canyon; and Murawski (1970) off New Jersey; indicate that summer flounder migrate south and offshore in the fall from their summering areas in New Jersey and New York and spend the winter at the edge of the continental shelf. In spring they migrate inshore to the north and east. A total of 14,596 summer flounder were tagged north of Cape May, New Jersey. Including immediate recaptures, over 700 recaptures came from the offshore winter trawl fishery north of or off Maryland and Virginia. Only 43 recaptures, however, were taken in inshore waters south of Maryland. Including immediate recaptures, over 2,600 fish were recaptured, the remaining recaptures coming from inshore waters north of Maryland.

Since the 1960s a fall and winter trawl fishery for summer flounder has expanded inside the 20 fathom (36 meters) contour along the Virginia and North Carolina coast. These fish are very densely aggregated and in spawning condition. Typically the fishermen follow the fish down the beach from Virginia and North Carolina north of Cape Hatteras in late October and November to south around Cape Hatteras in January and February. The North Carolina Division of Marine Resources tagged large numbers (~7,300) of these flounder (Gillikin, et al., in prep.) in the fall and winter of 1973 and 1974. Other than immediate recaptures by trawlers working in the tagging area most (92 percent) recaptured fish came from North Carolina and Virginia coastal waters and from Chesapeake Bay during the summer. A small percentage (8 percent) of the returns were from north of Maryland. Some returns occurred the following fall and winter from the same general inshore area where the fish were tagged. Notably no returns have ever come from the offshore winter trawl fishery. To date, 216 tags have been returned, not counting those fish that were immediate recaptures (10 days) and those which provided insufficient data to assign recapture location.

There is ichthyoplankton survey evidence suggesting general spawning areas in the Middle Atlantic Bight. Smith (1973) noted a seasonal progression of spawning from north to south with spawning north of Chesapeake Bay from September to December and south of the bay from November to February. He suggested that there were three separate spawning populations. One segment of the species appeared to spawn principally north of Delaware Bay, a second from Virginia to Cape Hatteras, and a third south of Cape Hatteras. Smith's data (1973) and Gillikin's, et al., (in prep.) tagging work support one another and point to the possibility that two stocks of summer flounder may contribute to the fisheries in the Middle Atlantic Bight.

Wilk et al. (1980), did a morphometric comparison on summer flounder samples collected along the eastern seaboard from New York to Florida. They subjected their data to a linear discriminant analysis and concluded that there is a significant difference between summer flounder samples north of Cape Hatteras and those to the south. Ginsburg (1952) and Smith and Daiber (1977), using meristics, also found evidence of two stocks of summer flounder north and south of Cape Hatteras.

Although the above evidence indicates the possibility that two stocks may contribute to the fisheries in the Middle Atlantic Bight, the most reliable biological data available dictate that management options be based on a unit stock. The above analysis is not presented to support a two stock hypothesis, only to suggest that the stocks may exist.

Abundance and Present Condition*

The following discussion integrates available biological data with research survey information, commercial catch statistics, and estimates of the recreational catch to determine the abundance and present status of the population.

Relative Abundance Indices

Commercial Fishery

Total commercial landings of summer flounder from Massachusetts through North Carolina declined from an average 5,880 metric tons during 1964-67 to 2,734 metric tons in 1969. Landings subsequently increased gradually during 1970-1976 to 15,044 metric tons and remained relatively stable during 1977-78, averaging 13,540 metric tons (Table 1). Landings in 1979 were 18,127 metric tons, the highest on record and 40% increase over the 1974-1978 mean yield of 13,039 metric tons. Landings declined to 15,616 metric tons in 1980.

Increased landings may be due, in part, to increased levels of effort in the southern winter trawl fishery. The number of vessels participating in this fishery increased during 1976-79 by 125% over the 1965-75 mean level of 64 vessels (U.S. Department of Commerce, NMFS, Fisheries Statistics of the United States 1965-1975; Fisheries of the United States 1976-79). Du Paul and Baker (1978) further reported an increase in vessel size (Gross Registered Tonnage) in the Virginia trawl fishery, implying an increase in fishing power in the fleet.

Nominal effort statistics (standard 24 hr days fished) and individual trip landings data derived from NMFS interview and weighout records were utilized to examine CPUE trends for summer flounder during 1967-1980. Geographical coverage of the sample interview data is concentrated in NAFO SA 5; accordingly, the derived index is not representative of conditions throughout the entire Middle Atlantic Bight. The CPUE index was based on interview records in which summer flounder comprised $\geq$ 5% of the total landed weight. Trip records in which less than 5% of the catch was composed of summer flounder were considered to reflect strictly incidental catches. Analysis was further restricted to tonnage class 2 vessels (5-50 GRT) to eliminate difficulties in effort standardization for larger vessels which are characterized by higher fishing power and increased fishing range.

Catch per-day declined from 0.6 mt/day in 1967 to 0.4 mt/day in 1970, the lowest CPUE index in the time series. The CPUE index gradually increased to 1.2 mt/day in 1974 and subsequently declined to a relatively stable level averaging 0.9 mt/day during 1975-80.

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*This section has been taken from Fogarty (1981)

Recreational Fishery

Estimates of the recreational catch of summer flounder were available from national and regional marine angler surveys conducted in 1965, 1970, 1974, and 1979 (Deuel and Clark 1968, Deuel 1973, Deuel [2], and U.S. Department of Commerce, National Marine Fisheries Service 1980). A national recreational fishing survey conducted in 1960 did not distinguish between summer and winter flounder (Clark 1962) and therefore was not utilized in this analysis. Creel census surveys were conducted off Virginia during 1955-1962 (Richards 1965), in Great South Bay, NY, during 1957-1960 and 1965-1966 (Schaefer 1966), in Great Bay, NJ, during 1967-1978 (Festa 1979a, Himchak 1979), and off the New Jersey coast in 1978 (Christensen and Clifford 1979).

Estimated recreational catch derived from national and regional surveys ranged from 8,626 - 13,432 mt and comprised from 45 to 70% of total landings (Table 1). The reduced estimate of recreational catch in 1979 (8,626 mt) may reflect improvements in survey design and methodology; landings data in the 1979 survey were obtained through combined on-site and telephone interviews while previous surveys were based on telephone interviews which relied on angler recall for periods ranging from 2 months (1974 survey) to 1 year (1960, 1965, and 1970 surveys). Hiett and Worrall (1977) reported that fishermen over-estimated total catch by 32.6-123.17% after recall periods of 15-60 days, implying that survey designs with lengthy recall intervals may provide over-estimates of recreational catch.

Creel census surveys conducted in New York, New Jersey, and Virginia provide indicators of trends in the summer flounder recreational fishery for restricted time periods and geographical locations. Catch per angler trip ranged from 2.6 to 9.5 fish during 1955-1962 for anglers aboard charter boats operating off the eastern shore of Virginia (Richards 1965). Schaefer (1966) reported catch rates ranging from 4.0 to 6.8 fish per angler trip in Great South Bay, NY, during 1957-1960. Similar trends in CPUE are evident for both data sets in years for which comparisons are possible. Interviews in the Great South Bay study were not restricted to charter boats, possibly accounting for lower catch rates than those reported by Richards (1965). Catch per effort for anglers aboard charter boats is consistently higher than that of fishermen utilizing private or rental boats, presumably due to the skill of the charter-boat captains (Briggs 1962, Festa 1979a). Sharply lower catch rates were evident in Great South Bay in 1966 and 1967, paralleling trends in the commercial fishery. Creel census indices (no. per trip) available for Great Bay, NJ, declined from 0.6 in 1967 to 0.3 in 1970 and gradually recovered to 3.8 fish per trip in 1975 (Festa 1979a). Catch rates subsequently declined to 2.2 per trip in 1978 (Himchak 1979). The slightly higher 1978 estimate of 3.2 fish per trip reported by Christensen and Clifford (1979) was restricted to charter boat catches off the New Jersey coast; the Great Bay creel census did not include charter boats.

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[2] Deuel, D.G. National Marine Fisheries Service, Resource Statistics Division, Washington, DC, personal communication.

Recreational CPUE estimates derived for Great Bay, N.J. appear to follow trends in commercial landings of summer flounder in SA 5 when lagged by one year. A lag term of one year was used in this analysis since the sport fishery depends highly on newly recruited year classes (Poole 1961; Festa 1979a) while the commercial fishery operates on a broader age distribution. However, both time series were significantly ($p \simeq .05$) autocorrelated and no significant correlation between recreational catch-per-effort and commercial landings was detected after adjustment for serial correlation according to Quenouille (1952). It should be noted that use of commercial landings as an index of abundance implies a relatively constant expenditure of effort; changes in effort levels during the time series may introduce additional variability.

Survey Biomass Indices

A stratified random bottom trawl survey has been conducted in autumn by NEFC since 1967 in water depths ranging from 27 to 365 m on the continental shelf between Cape Hatteras and Nova Scotia. Autumn surveys during 1963-1966 sampled from New Jersey to Nova Scotia. Surveys have also been carried out in spring since 1968. Strata are defined by depth zone and geographical location and are intended to represent relatively homogeneous sampling units. Further details on sampling design and methods are provided by Grosslein (1969) and Clark (1979).

A standard '36 Yankee' trawl has been employed in all autumn trawl surveys and in spring surveys conducted from 1968 to 1972. A high-rise '41 Yankee' trawl has been used in spring surveys since 1973. Both trawls are equipped with roller gear (30-46 cm) and a 1.25 cm cod end liner. Fishing power coefficients and species specific conversion factors for these trawls are given in Sissenwine and Bowman (1978). The fishing power of the '41 Yankee' trawl is consistently higher for all flounder species and accordingly, summer flounder catch rates for spring surveys since 1973 were adjusted to reflect increased catchability with this trawl. Summer flounder conversion factors were 1.23 and 1.31 for catch in numbers and weight respectively (Sissenwine and Bowman 1978). Some caution in utilizing these conversion factors for summer flounder is necessary since some assumptions of the analysis were apparently not met (Sissenwine and Bowman 1978). The conversion factors are consistent, however, with the ratio of footrope lengths of the 41 and 36 trawls (1.25) implying that differences in calculated fishing power of the trawls for summer flounder may be a simple function of the trawl dimensions.

The spring survey biomass index (stratified mean catch per tow, kg) for the entire survey area increased from 0.11 kg during 1968-1972 to an average of 0.83 kg from 1974-77 and subsequently declined to 0.45 kg during 1978-80 (Figure 1). Stratified mean catch per tow increased in 1980 to 0.40 kg over the 1979 index of 0.17. Spring survey indices are considered to provide more consistent indicators of trends in relative abundance due to the availability of summer flounder on the outer continental shelf during late winter-early spring.

The autumn bottom trawl survey index for the entire survey area remained at relatively low levels during 1963-72, averaging 0.25 kg, and then increased during 1974-77 to a mean of 0.94 kg. The autumn index subsequently declined to an average of 0.39 kg during 1978-80. The 1980 index declined by 24% from the 1979 level of 0.51 kg. Similar trends were evident in stratified mean number per tow (Figure 2).

Both spring and autumn survey indices indicate a general recovery from low population levels observed during 1968-72 to peak levels from 1974-76 with a subsequent slight decline in apparent abundance during the latter part of the last decade.

Spring biomass indices (kg/tow) for the entire survey area were significantly correlated with commercial landings in NAFO areas 5 and 6 ($r = 0.98$; $p < 0.5$) after adjustment for autocorrelation. Due to sharply increased effort in the southern winter trawl fishery during 1978-80, data for this period were not included in this analysis. Significant correlation between the spring survey biomass index and the commercial CPUE index for tonnage Class 2 vessels in southern New England was also detected ($r = 0.67$; $p \simeq 0.05$). The serial correlation coefficient for the commercial CPUE index was not significant ($p > 0.05$) obviating adjustment in tests of significance (Quenouille 1952).

GROWTH

Parameters of the von Bertalanffy growth equation were determined for summer flounder collected during NMFS spring and autumn bottom trawl surveys using the weighted least squares method of Tomlinson and Abramson (1961). Age interpretation was based on a total of 1,889 scale samples taken from summer flounder obtained during 1976-1979. Scales were impressed in laminated plastic and examined at a magnification of 40X. Prior summer flounder age and growth analyses were based on examination of otoliths (Poole 1961, Eldridge 1962; Smith and Daiber 1977); these studies differed in interpretation of age at first distinct annulus formation. Ages were adjusted to reflect time of capture relative to an assigned average January 1 birthdate (e.g., a 2 yr. old fish collected in spring was assigned an age of 2.3 years). Growth equations were derived separately by sex and comparisons between parameter estimates for each sex were made using the homogeneity X^2 test of Rao (1973).

Female summer flounder attained a significantly larger asymptotic size (L_∞) than males ($X^2 = 47.5$; d.f. = 1; $p \simeq .005$; Table 2), a result consistent with previous analyses (Poole 1961, Smith and Daiber 1977, Powell 1974, Eldridge 1962, Richards 1970). No significant differences were found between Brody growth coefficients (k) (X_1^2 = 0.170; p>.05). No comparisons between estimates of the parameter were attempted since the properties of this parameter in uniquely defining a solution to the model often assume greater statistical than biological importance (Gallucci and Quinn 1979).

Previous estimates of L_∞ for female summer flounder ranged from 88 cm - 94 cm TL (Smith and Daiber 1977, Richards 1970). Henderson (1979) provided an estimate of L_∞ of 92 cm TL (sexes combined) based on analysis of commercial samples from the Georges Bank - southern New England region. Bigelow and Schroeder (1953) reported a maximum verified length of 94 cm TL. The estimate of L_∞ (73 cm TL) derived for males in the present study exceeds previously reported estimates of 62 cm (Smith and Daiber 1977) and 60.7 cm (Richards 1970) based on localized inshore collections.

Values of the growth constant (k) determined for both females and males were lower than previous estimates based on analyses of inshore populations (Smith and Daiber 1977, Richards 1970) possibly due to a greater representation of younger, faster growing fish in inshore areas.

MORTALITY

Tag Data

Maximum likelihood estimates of the instantaneous rate of fishing mortality (F) were derived by the method of Paulik (1963) based on tagging experiments conducted off southern New England (Lux and Nichy 1980), off New Jersey, during 1960-61 and 1966-67 (Murawski 1970) and off North Carolina in 1973-1974 (J. Gillikin, [3] per. comm.). Petersen disc tags were used in each experiment with the exception of the 1960-61 New Jersey operations in which Atkins tags were employed (Murawski 1970); both Atkins and Petersen disc tags were used in the 1961 experiments (Table 3). Recapture data for the southern New England and New Jersey experiments were grouped into 365 day intervals for analysis. Tag recoveries for North Carolina releases were grouped into 90 day intervals for analysis since comparatively few fish were at large for over one year. A total of 143 fish captured within 10 days of release were apparently not randomly distributed with respect to the untagged population and were not included in this analysis. An additional 51 tags were recovered with insufficient information of date of recapture to be used in mortality estimation. The total effective number of released individuals was therefore recalculated to account for immediate recaptures (adjusted for expected survival in this initial 10 day period) and unusable returns (adjusted for survival based on the mean time at liberty for fish with known recapture dates).

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[3] Gillikin, J., N.C. Div. of Mar. Fish., Morehead City, N.C.

Estimated fishing mortality rates for two experiments conducted off southern New England were 0.48 and 0.62 for Nantucket Sound and Pt. Judith releases respectively; recovery rates were 40.8% for Nantucket Sound and 50% for Pt. Judith. Chang and Pacheco (1975) provided slightly different mortality estimates for this data set, possibly due to different methods of calculation. A total of 6,669 summer flounder were tagged in four experiments off New Jersey during 1960-1967 with an overall recovery rate of 28%. Estimates of F ranged from 0.24-0.58 in these experiments (Table 3). The estimated fishing mortality rate for the North Carolina taggings, 0.11, was low relative to previous tagging experiments and apparently not indicative of true mortality rates. Non-reporting of tags may have contributed to the low return rate (J. Gillikin, [4] pers. comm.). Tag induced mortality cannot be discounted as an explanation for the low percentage of returns and an examination of the size distributions of released and recovered fish indicated a disproportionately low recovery rate for fish <30 cm TL. Accordingly, the data were reanalyzed following procedures noted above, however, only fish larger than 30 cm TL at release were considered. Estimated fishing mortality rate increased to F 0.24 but remained low relative to previous experiments.

Examination of the seasonal pattern of tag recoveries for experiments conducted in southern New England and New Jersey clearly indicate the influence of migratory activity and the seasonal distribution of fishing effort on tag returns. Summer flounder were tagged in Nantucket Sound and Block Island Sound immediately prior to the offshore autumn migration (Lux and Nichy 1980). Return rates declined sharply after the initial 30 day interval for Block Island Sound releases while recoveries remained uniformly low for Nantucket Sound fish during the first 90 days at large. Returns subsequently increased in both experiments as fish became available to the offshore winter trawl fishery (January - April) and again after 270 days at large, following the inshore migration when the fish were vulnerable to inshore trawlers and recreational fishermen. Of the total number of tag returns, approximately 2% of the Nantucket Sound and 6% of the Block Island Sound recoveries were reported by recreational fishermen.

Similar trends in recovery patterns are evident for fish tagged and released in September - October 1960 off Cape May and Sandy Hook, New Jersey. Subsequent tagging experiments in New Jersey were initiated in June and July when the fish were immediately available to intensive angler effort. In marked contrast to the southern New England experiments, 25-60% of the total tag returns were attributable to recreational fishermen in the New Jersey experiments (Murawski 1970).

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[4] Gillikin, J., N.C. Div. of Mar. Fish., Morehead City, N.C.

Total Mortality

Age composition of survey and commercial catch of summer flounder sampled during 1976-1979 was employed to estimate survival rates (S) and the instantaneous rate of total mortality (Z) by the method of Chapman and Robson (1960) and Robson and Chapman (1961). Catch curves were constructed by sex for summer flounder obtained during NEFC spring and autumn groundfish surveys for each of four years with available age data and for combined data (Table 4). Age-length keys derived for commercial samples collected in southern New England during 1976-1979 were also utilized in catch curve analyses for each year of collection. For both survey and commercial data, successive age at full recruitment values were employed until no significant differences (X^2 test; $p > 0.01$) were found between Heincke's survival estimate and the minimum variance estimator of Robson and Chapman (1961).

Estimates of Z derived from survey age composition varied with year of sample collection and by sex (Table 4). Total mortality ranged from 0.67-1.35 for females and from 0.87-2.85 for males. The mortality estimate for males collected in 1978 (2.85) appears unreasonably high and may be due to sampling variability.

To reduce the effect of variable year class strength, age composition data were pooled over years of collection. Calculated mortality rates for females and males were 0.93 and 1.11 respectively. The higher mortality estimates for males is of interest since it has been suggested that the absence of male fish older than age 7 may be due to higher natural mortality rates (Poole 1966, Chang and Pacheco 1976). Henderson (1979) reported estimates of Z for summer flounder ranging from 0.53-1.42.

Estimates of Z for age-length samples collected from commercial sources during 1976-79 exhibited higher variability than those derived using survey data (Table 4); possibly reflecting variations in year class strength which are accentuated by high levels of fishing mortality and dependence of the commercial fishery on recruiting year classes. Total mortality estimates derived from commercial data ranged from 0.91-2.26. Adequate estimates of annual fishing effort were not available to adjust commercial catch-at-age data.

YIELD PER RECRUIT

Yield per recruit was evaluated using the incomplete beta function solution to the Beverton-Holt yield equation (Paulik and Gales 1964) since isometric growth could not be assumed. Parameter estimates of the model were based on the above growth equations and length-weight equations (Wilk et al. 1978) by sex. The instantaneous rate of natural mortality (M) was assumed to be 0.2 (Chang and Pacheco 1975; Henderson 1979), the effect of varying natural mortality rates was also examined. A sensitivity analysis was employed to determine the effect on yield and optimal fishing mortality rates of systematically varying the parameters k and L_∞ by $\pm$10%.

Summer flounder are fully recruited to the fishery at ages 2-3 (Poole 1966; Chang and Pacheco 1975). Maximum yield per recruit for females (0.55kg) occurs at an F_{max} level of 0.19 assuming an age at entry to the exploited phase (t_c) of 2 years (Figure 3); the corresponding $F_{0.1}$ level (Gulland and Boerema 1973) is 0.16. Increasing age at entry to 3 years results in an increase in maximum yield per recruit to 0.63 kg at an optimal level of fishing mortality (F_{max}) of 0.25. An increase in t_c to 4 years results in a further increase to 0.713 kg (F_{max} =0.35; Figure 3). Optimal age at entry to the fishery ranges from 5-7 years assuming a range in F of 0.3-0.7 (Figure 4). Calculated F_{max} values for male summer flounder ranges from 0.32-0.66 as t_c increases from 2-4 years (Figure 5). At age entry of 2 years, $F_{0.1}$ =0.20. Optimal age at entry ranges from 4-5 years as F increases from 0.3-0.5 (Figure 6).

Summer. flounder are currently managed under a system of minimum legal size limits administered by individual states. Connecticut, New York, and New Jersey prohibit the taking of summer flounder less than 35.6 cm (14") TL, however, recreational anglers are presently exempted from this regulation in New Jersey. Minimum size limits of 30.5 cm (12") TL and 28 cm (11") TL are currently in effect in Virginia and North Carolina, respectively. Expected yield per recruit under minimum legal size limits of 25.4 - 38.1 cm (10"-15") TL was evaluated at two levels of fishing mortality. Assuming F = 0.5, yield per recruit ranged from 0.31-0.42 kg and from 0.44-0.63 kg for males and females respectively (Table 5); at F = 0.75, yield per recruit increased from 0.27 kg to 0.42 kg for males and from 0.36 kg to 0.58 kg for females (Table 5).

Increasing natural mortality rates results in a decrease in yield per recruit and an increase in F_{max} (Table 6).

The effect of varying the von Bertalanffy parameters k and L_∞ by $\pm$ 10% was examined in an attempt to determine possible consequences of managing the fishery under uncertainty regarding stock intermixture. Seasonal intermixing of the northern and southern groups is known to occur based on tagging results (Gillikin, personal communication), however, the relative contribution of each in the area of mixing cannot currently be determined.

Systematic variation of the parameters resulted in substantial changes in yield per recruit for both males and females (Tables 7 and 8). Maximum yield per recruit ranged from 0.32 to 0.88 kg for females and from 0.18 to 0.50 kg for males. Values of F_{max}, however, remained relatively stable, ranging from 0.18 - 0.21 for females and from 0.31 - 0.33 for males (Table 7 and 8). If growth rates among possible stock components vary within the ranges examined, management measures may be devised which are relatively insensitive to differences in growth.

Widely differing growth rates between males and females necessitated treating the sexes separately in these analyses; however, the fishery operates on combined sexes and appropriate management strategies must be devised accordingly. Alternative management options include setting target fishig mortality or age at entry levels based on relative contribution of each sex to the catch or managing on the basis of optimal fishing mortality (or age at entry) for one sex only. The most conservative strategy would be to direct management strategies toward females since F_{max} for females is lower and optimal age at entry to the fishery is higher. Mean size at maturity is also higher for females (Morse, in press.)

Yield per recruit estimates for each sex were employed in conjunction with a range of possible recruitment values to determine equilibrium yields under the assumption of a 1:1 sex ratio and an age at recruitment of 2 years. Morse (in press) noted an overall 1:1 sex ratio for summer flounder collected in the Middle Atlantic region. Additional calculations were performed assuming that current levels of F are on the order of 0.80 (based on estimated $Z \simeq 1.0$ and $M = 0.2$); projected yields under management strategies directed at females with target F levels of F_{max} (0.19) and $F_{0.1}$ (0.16) were considered in this analyses.

The relative advantage of reducing fishing mortality rates from current levels to the F_{max} assuming $t_c = 2$ years is clearly indicated (Figure 7); for example, at a recruitment level of 40 x 10^6 fish, estimated yield would increase from 12,000 mt at $F = 0.8$ to 17,000 mt at $F = 0.19$.

Chang and Pacheco (1975) provided stock size estimates for summer flounder in the Middle Atlantic Bight based on virtual population analysis. Geometric mean stock size for age 1 summer flounder during 1967-1972 was 57 x 10^6 fish. Some caution must be employed in evaluating this estimate since annual recreational catches, which were based on interpolation of the 1965 and 1970 national recreational fishing surveys, may have been inflated. In addition, age-composition of the catch was available only for samples collected in Delaware Bay during 1966-1968. Stock size estimates derived by Chang and Pacheco (1975) if qualitatively adjusted for possible over-estimation of recreational catch indicate probable average recruitment of 40-45 x 10^6 fish at age 2. Provisional estimates of maximum equilibrium yield would therefore range from approximately 17,000 - 20,000 mt (Figure 7). Chang and Pacheco (1975) calculatd a maximum sustainable yield of 20,000 mt.

Ecological Relationships

Trophic

The summer flounder is predacious. Ginsburg (1952) reported that it lies on the bottom partly concealed by sand and partly by its coloration. When suitable prey appears, it rushes out and devours the victim. It is a swift swimmer and sometimes pursues schools of small fish to the surface.

Olla, Samet and Studholme (1972) reported on feeding behavior of the summer flounder under laboratory conditions. Vision plays a primary role in prey selection and capture. Fish feed on the bottom or in the water column. Bottom feeding was always preceded by active prey search. Basic elements of prey selection and visual fixation were essentially the same on the bottom or in the water column.

According to Ginsburg (1952), reported prey of the summer flounder are mackerel, menhaden, tautog, sand lances, silversides, butterfish, scup, crabs, shrimp, squid, small molluscs, worms and sand dollars. The species has also been reported to feed on cusk eels (D. Greenly, [5], J. Sadowski, [6], N. Delanoy, [7], pers. comm.).

Poole (1962) studied the feeding habits of summer flounder in Great South Bay, New York. He found the principal prey species to be sand shrimp, winter flounder, and in one year, blue crab. Other organisms eaten in order of importance were opossum shrimp, northern pipefish, menhaden, bay anchovy, bivalve molluscs, squirrel hake, Atlantic silverside, gastropod molluscs, bluefish, weakfish, mummichog, mud crabs, hermit crabs, sea squirts, isopods, grubby and horseshoe crabs. Smith and Daiber (1977) reported the summer flounder in Delaware Bay ate primarily weakfish, silversides, herrings, anchovy, mysids, squid and sand shrimp. Summer flounder over 45 cm fed predominantly on fish.

Festa, (1979b), in an analysis of the fish forage base in the Little Egg Harbor Estuary, New Jersey, found that fish remains comprised 32.6 percent of the diet volume of 6-24 cm summer flounder and 74.3 percent of the volume recovered for 25-65 cm specimens. In the smaller size group, prey identified included anchovies, sticklebacks and silversides. Diet was also supplemented by mysid and caridean shrimp, of which Crangon was of somewhat more importance. At least seven species of fish occurred in the stomachs of the larger fish. These included silversides, anchovies, sticklebacks, silver perch, sea robins, winter flounder and pipefish. Crabs, primarily Callinectes, were of secondary importance in this size group.

The feeding habits of summer flounder in Pamlico Sound and adjacent waters have also been studied (Powell and Schwartz, 1979). Crustaceans were the dominant items in the stomachs of fish less than 300 mm. In addition

[5] Greenly, D., Del. commercial fishing representative, Frederica, Del.
[6] Sadowski, J., Del. recreational fishing representative, Wilmington, Del.
[7] Delanoy, N., N.Y. recreational fishing representative, West Islip, N.Y.

crustaceans were present to a lesser extent in the diet of larger fish. Fishes were of little importance in the diet of summer flounder less than 101 mm, but occurred more frequently in larger fish.

Natural predators of adult summer flounder are relatively unknown, but larger predators such as large sharks and goosefish probably include summer flounder in their diets. Results of food habits studies by NMFS from 1969-1972 showed that Pleuronectiformes occurred in the stomachs of a number of fish eating species; these include spiny dogfish, goosefish, cod, silver hake, red hake, spotted hake, sea raven, longhorn sculpin and fourspot flounder (Bowman, et al., 1976). These data do not indicate the proportion of summer flounder among the flatfish prey but it is likely they are represented. Bluefish have also been noted to prey on summer flounder (Wilk, 1977).

Faunal

A brief review of dealer sales slips for New England and New Jersey by Henderson (1979) showed that catches including summer flounder also landed mixed groundfish, winter flounder, Loligo, scup, black sea bass, conchs, tilefish, and witch flounder. Similarly, the major species in the catch from the Virginia winter trawl fishery for the years 1929-1959 were summer flounder, black sea bass, scup and croaker (Eldrige, 1962).

Major species of demersal fishes which occur in Chesapeake Bight have been divided into two rather loosely-margined groups by Musick and McEachran (1968). One group (warm-temperate), having southern affinities and including summer flounder, is found inshore during the summer and migrates offshore or to the south or both during the winter. Included with summer flounder in this group are northern searobin, spotted hake, butterfish, black sea bass, and scup. All members of the southern group were captured in abundance at temperatures greater than 10 degrees C and none were abundant at temperatures less than 7 degrees or 8 degrees C.

During the winter, northern searobin, summer flounder and scup were most abundant between 41 and 60 fathoms (75 and 109 meters) where they often occurred with spotted hake, butterfish and black sea bass. During the spring, all of the species with southern affinities showed evidence of movement inshore and to the north. During the fall, all species were widely dispersed over the Chesapeake Bight. Most showed evidence of movement offshore and to the south. Scup and summer flounder were most abundant offshore north of 37 degrees N, suggesting an influx of these species from northern summering areas (Musick and McEachran, 1968).

The compositon and distribution of fish assemblages in the Middle Atlantic Bight was described by Colvocoresses and Musick (1979) by subjecting the National Marine Fisheries Service bottom trawl survey data to cluster analyses. Summer flounder, scup, northern searobin and black sea bass, all warm temperate species, were regularly classified in the same group during spring and fall. In the spring this group was distributed in the warmer waters on the southern shelf and along the shelf break at depths of approximately 80 fathoms (145 meters). During the fall this group was distributed primarily on the inner shelf at depths of less than 33 fathoms (60 meters) where they were often joined by smooth dogfish.

In an ecological study of the Delaware River estuary, Meldrim (1976) examined fish communities in terms of affinities between species and diversity within habitats. Summer flounder were found to have a positive affinity with bay anchovy, weakfish, spot and hogchoker. Because species were not separated on the basis of size, positive affinities between summer flounder and other species may potentially reflect predator-prey relationships as well as interspecific competition.

The ecological relationship between juvenile summer flounder and southern flounder was studied by Powell and Schwartz (1977) in North Carlolina estuaries. The spatial distribution of the two species relative to each other appeared to be related to the salinity gradient. Southern flounder were dominant at low salinities (<11‰) while summer flounder were dominant at intermediate to high salinities (12‰ to 35‰). In a study of meroplankton in North Carolina estuaries, Williams and Deubler (1968) found that the distribution of gulf flounder was also controlled by salinity to some degree, finding the species only in salinities ranging from 22‰ to 35‰ .

The distribution of summer flounder and southern flounder in relation to salinity may have adaptive significance. Peters and Angelovic (1971) and Peters and Kjelsen (1975) found that at warm temperatures (~21 C) summer flounder grew faster at intermediate to high salinities (24‰ to 34‰) while southern flounder grew faster at lower salinities. Each species could achieve maximum growth if it were located in the optimum combinations of salinity and temperature.

Benthic substrate also appeared to influence summer flounder and southern flounder distributions. Summer flounder were dominate in sandy substrates while southern flounder were dominate in muddy substrates (Powell and Schwartz, 1977).

Parasites, Diseases, Injuries and Abnormalities

The parasites of the summer flounder have not been studied extensively (MacPhee, 1975), but Wilson (1932) mentions that they are afflicted with the fish lice Argulus laticauda and Argulus megalops and the copepods Acanthocandrea galerita (Rathbun) and Lepioptheirus edwardsi.

Mahoney, Midlege and Deuel (1973) described a fin rot disease which affected summer flounder in the New York Bight. External signs of the disease were fin necrosis, skin hemorrhages, skin ulcer and occasional blindness. In summer flounder necrosis usually began on dorsal and anal fins. The agent of the disease was apparently bacterial; numerous gram-negative bacilli belonging chiefly to three genera, Aeromonas, Pseudomonas and Vibrio, were found on necrotic fins and internal organs of fish with advanced necrosis.

Summer flounder in captivity also suffer from vibriosis, occurring when they are exposed to stressful conditions such as high temperatures, overcrowding and dirty water (MacPhee, 1975).

Abnormalities in summer flounder include incomplete ambicoloration, total ambicoloration, incomplete eye rotation and hooked dorsal fin (Hussakof 1914; Gudger, 1935; Pearson, 1932; Gudger, 1936; Deubler and Fahy, 1958; White and Hoss, 1964; Powell and Schwartz, 1972).

DESCRIPTION OF HABITAT

Condition of the Habitat*

Climate, physiographic and hydrographic differences separate the ocean region from Cape Hatteras to the Gulf of Maine into two distinct areas: the Middle Atlantic-Southern New England region, and the New England region, with the natural division occurring at Nantucket Shoals.

The Middle Atlantic-Southern New England region is relatively uniform physically and is influenced by many large coastal rivers and the Chesapeake Bay, the largest estuary in the United States. Additional significant estuarine influences are Narragansett Bay, Long Island Sound, the Hudson River estuary, Delaware Bay, and the nearly continuous band of estuaries behind barrier beaches along southern Long Island, New Jersey, Delaware, Maryland and Virginia. The southern edge of the region includes the significant estuarine complex of Currituck, Albermarle and Pamlico Sounds behind the outer banks of Cape Hatteras.

At Cape Hatteras, the continental shelf (characterized by water less than 109 fathoms (198 meters) deep) extends seaward aproximately 20 miles (32 kilometers), widens gradually to 70 miles (113 kilometers) off New Jersey and Rhode Island and then broadens to 120 miles (193 kilometers) off Cape Cod, forming Georges Bank. The substrate of the shelf in this region is predominantly sand interspersed with large pockets of sand-gravel and sand-shell. Beyond 109 fathoms (198 meters), the substrate becomes a mixture of silt, silt-sand and clay. As the continental slope turns into the Abyssal Plain (at depths greater than 1093 fathoms (1988 meters), clay predominates over silt and becomes the major substrate.

South of Cape Hatteras, the shelf widens to a breadth of approximately 80 miles (132 kilometers) near the Georgia-Florida border; narrows to 35 miles (56 kilometers) off Cape Canaveral, Florida; and further narrows to 10 miles (16 kilometers) or less off the southeast coast of Florida and the Florida Keys. Off West Palm Beach, Florida, the Atlantic coast shelf is at its narrowest, reaching seaward about 2 miles (3 kilometers). The edge of the shelf occurs at depths of less than 6 fathoms (10 meters) at this point.

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*This discussion is based largely on Saila (1973) and Gusey (1976).

Mineral resources of the area include large sand and gravel deposits, now being mined in some localities near shore. There are potentially recoverable offshore deposits of phosphate rock, placer deposits of titanium, monazite and zircon, and oil. Locally important concentrations of sulfur, salt, anhydrite, potash, and magnesium are known. It is also probable that manganese-oxide nodules occur offshore. However, current technology is inadequate for economic recovery.

Water temperatures range from less than 3 degrees C in New York Bight in February to approximately 27 degrees C off Cape Hatteras in August. The annual range of surface temperature at any location may be 15 degrees C in slope waters to greater than 20 degrees C near shore. During the coldest season, the vertical thermal gradient is minimized. In late April - early May a thermocline develops although stormy surges over Nantucket Shoals retard thermocline development there. Surface waters begin to cool in early autumn, weakening the thermocline so that by mid-November surface to bottom water temperature is nearly homogeneous.

A core of cold bottom water extending from south of Long Island to the mouth of the Chesapeake during the summer months has been described by Bigelow (1933) and more recently by Cook and Hausknecht (1977). Minimum temperatures within the cold cell remain low (8 - 9 degrees C) throughout the summer. The cold water has been found in relatively shallow depths (11 to 22 fathoms; 20 to 40 meters) in the spring, but apears to move into deeper waters as warming of shelf waters increase during the summer.

The salinity cycle results from stream flow and the intrusion of slope water from offshore. The salinity maximum of winter is reduced to a minimum in early summer by large volumes of spring river runoff. Inward drifts of offshore saline water throughout the autumn eventually counterbalance the fresh water outflow and return the region's salinity distribution to the winter maximum. Water salinities near shore average 32 ‰ along the shelf edge, and exceed 36.5 ‰ along the main lines of the Gulf Stream.

Tidal currents attain considerable velocity in the passages between the Bight and the estuaries, but are of moderate velocity, approximately one knot, over the inner parts of the shelf and generally less than 0.1 knot over the outer parts of the shelf. The currents are semi-diurnal and rotate in a clockwise direction.

On the continental shelf, surface circulation is generally southwesterly during all seasons, although this may be interrupted by coastal indrafting and some reversal of flow at the northern and southern extremities of the area. Speeds of the drift are on the order of five knots per day. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. This drift, fundamentally the result of temperature-salinity distribution, may be made final by the wind. A persistent bottom drift at speeds of tenths of nautical miles per day extends from beyond mid-shelf toward the coast and eventually into the estuaries. Offshore, the Gulf Stream flows northeasterly.

The New England region from Nantucket Shoals to the Gulf of Maine includes two of the world's most productive fishing grounds: Georges Bank and Browns Bank. The Gulf of Maine which is a deep cold water basin is nearly sealed off from the open Atlantic by these two Banks. The outer edges of Georges and Browns Banks fall off sharply into the continental shelf. Other major features include Vineyard and Nantucket Sounds, Cape Cod Bay, and Cashes Ledge and Stellwegen Basin within the Gulf of Maine.

Bottom sediments of the region range from rock to silt. Sediments of the inner coast from Cape Ann to southwestern Nova Scotia are typically rock or rock-gravel, while those of the deeper central Gulf of Maine are mainly some form of silt. Sand and sand-gravel are the major bottom types for Georges and Browns Banks, respectively.

Water temperatures range from 2 to 17 degrees C at the Banks, and 4 to 9 degrees C at 109 fathoms (199 meters) in the inner Gulf of Maine. Mean salinity values vary from about 32 to 35 ‰ depending on depth and location. However, lower salinity values generally occur close to shore. In addition, both water temperatures and salinities within the region, but especially along the southern boundary of Georges Bank and the deep basins of the inner Gulf of Maine, are influenced by intrusion of slope waters.

Surface circulation within the Gulf of Maine is generally counterclockwise. Cold Nova Scotian waters enter through the Eastern Channel and move across Browns Bank while slope waters enter through the Northeast (Fundian) Channel. Gulf of Maine waters spill out over Georges Bank and through the Great South Channel onto Nantucket Shoals. The anticyclonic eddy over Georges Bank that develops in the spring breaks down into a westerly and southerly drift by autumn.

Gulf Stream meanders and warm core eddies, two oceanographic phenomena which normally remain in deep offshore waters, can profoundly affect environmental conditions of the fishing grounds off the northeast United States when either one moves close along the continental slope. The warm core eddies seen off the New England coast mostly form in the slope water region southeast of Georges Bank by detaching from meanders of the Gulf Stream. Rotation is in a clockwise direction at speeds varying from 0.6 to 1.8 knots.

Environmental effects and their possible influence on fishery resources resulting from meanders and eddies have been identified by Chamberlin (1977) and are as follows:

1. Warming of the upper continental slope and outer shelf by direct contact of a meander or eddy. This may influence the timing of seasonal migrations of fish as well as the timing and location of their spawning.

2. Injection of warm saline water into the colder less saline waters of the shelf by turbulent mixing at the inshore boundary of a meander or eddy. This may have influences on the fishery resources similar to that of direct warming, and also cause mortality of fish eggs and larvae on the shelf when the colder water in which they live is warmed beyond their tolerance by the mixing-in of warm slope water.

3. Entrainment of shelf water off the shelf, an effect frequently seen in satellite imagery. Mortality of Georges Bank fish larvae is known to occur presumably because of temperature elevation when shelf water in which they occur is carried into the slope water (Colton, 1959). The most profound effects of the entrainment on the fishing grounds may be changes in circulation and in water mass properties resulting from the replacement of the waters lost from the shelf.

4. Upwelling along the continental slope, which may result in nutrient enrichment near the surface and increased primary biological productivity.

GENERAL BIOLOGICAL ASPECTS

Biogeographically, Cape Cod is the southern boundary for organisms belonging to the American Atlantic Boreal Region; 60 to 80 percent of the forms in various taxa are common to both the Eastern and Western Atlantic. South of Cape Cod, the American Atlantic Temperate Region, only 6 to 8 percent of the forms in various taxa are common to both the Eastern and Western Atlantic. The temperate region is basically a transitional zone between the boreal region to the north and the warmer subtropical and tropical waters to the south. It has few endemic species and most of its species are contributed by the tropical Atlantic region. There are two subregions: the Virginian Province extending from south of Cape Cod to Cape Hatteras and the Carolinian Province extending from Cape Hatteras to Cape Canaveral (Briggs, 1974).

The ecosystem can be divided into the following fundamental groups which are necessary for the system to continue indefinitely: abiotic (non-living) substances; autotrophic organisms (primary producers) which are able to use abiotic material to store solar energy in the form of organic matter; and decomposers which break down organic matter, using the stored energy of the organic matter for maintenance. The rate of transfer of material and energy between parts of the ecosystem is affected by the amount, type or condition of abiotic or biotic material (factors) in the system (Krebs, 1972).

Annual Cycle of the Plankton Community

The annual cycle of the plankton community (drifting organisms) of the region is typical of the temperate zone. During the winter, phytoplankton (plant plankton) and zooplankton (animal plankton) populations are low. Nutrients are available, but production is suppressed by low levels of solar radiation and low temperatures. As spring approaches, and the level of solar radiation increases, enormous diatom blooms occur. As the bloom progresses, concentrations of inorganic nutrients decrease (Raymont, 1963).

As water temperatures increase during late spring and summer, phytoplankton and zooplankton become increasingly abundant because of the more rapid development of early life stages, the spawning of fish and benthos, and the abundant food supply (Raymont, 1963).

During summer, zooplankton reaches maximum abundance while phytoplankton declines to a level near the winter minimum. Dinoflagellates and other forms apparently better suited than diatoms to warm, nutrient-poor waters become more abundant during summer. Bacteria in the sediments actively regenerate nutrients, but because of vertical temperature and salinity gradients, the water column is stable and nutrients are not returned to the euphotic zone (where solar radiation and nutrients are "fixed" into organic matter). On Georges Bank, nutrients regenerated by sedimentary bacteria are immediately available to phytoplankton because of mixing. Thus, diatoms dominate throughout the year on Georges Bank (Cohens, 1975).

During autumn, as water temperatures decrease, the water column becomes unstable due to mixing and nutrients are recycled to the euphotic zone. This stimulates another phytoplankton bloom which is limited by decreasing levels of solar radiation. Phytoplankton and zooplankton levels then decline to their winter minimum while nutrient levels increase to their winter maximum.

Anomalous conditions within the generalized annual cycles are probably common. The stability of the water column which affects nutrient availability may be disrupted by severe storms. Anomalies in temperature may disturb the timing between the annual cycles of interacting species.

Zooplankton feed predominantly but not exclusively on phytoplankton and thus form an intermediate link between phytoplankton, the primary producers in the sea, and the larger animals of the nekton and benthos. For example, copepods, one of the most important groups of zooplankton, are commonly utilized as food by fish larvae (Marak, 1960, 1974; Sherman and Honey, 1971; Sherman and Perkins, 1971). However, zooplankton, particularly Sagitta and ctenophores prey upon fish larvae (Bigelow, 1926; Lillelund and Lasker, 1971; Theilacker and Lasker, 1974). Exact relationships within food webs are poorly understood, but it is certain that the zooplankton play an important role in the conversion of plant to animal tissue (Saila, 1973).

Nekton

The nekton (swimmers as opposed to plankton, which are free-floating organisms) includes fishes, marine mammals, squid, turtles and other marine organisms. The feeding habits of nekton vary by species, size of individuals, season of the year, and food availability. Small fish, including the young of some large species, often feed on plankton. There are also some large species (various whales, basking sharks and ocean sunfish) which are plankton feeders throughout life. Other fish, squid and small benthic invertebrates are also common food of nektonic species (McConnaughey, 1974).

Benthos

Benthic organisms are those organisms living on or within bottom sediments. They are distinguished from demersal nekton by the latter's ability to move from one location to another by swimming freely in the water column. Numerous factors determine the distribution and abundance of benthic species. Among the most important factors are the composition of the sediment and the stability of the physical environment associated with water depth (McConnaughey, 1974).

Except in shallow water when autotrophic macroalgae are common, the primary source of food for benthos is sinking organic matter (phytoplankton and detritus). Deposit feeders include polycaetes and amphipods. Many benthic predators and scavengers are present such as shrimps, crabs, lobsters, and snails. Eventually, much of the energy and nutrients stored in organic material is released by the bacteria of the sediments. Although there are marine bacteria in the water column also, these are of less importance in the recycling process (Russell-Hunter, 1970). Although benthos is dependent on sinking organic matter for food, many benthic species interact with plankton and nekton in the water column. Benthic species such as lobsters, sea scallops and surf clams have planktonic larvae, and therefore the abundance of their benthic stages depends upon the interaction of such larvae with planktonic and nektonic predators and prey, and the transport of their larvae to a suitable benthic environment (McConnaughey, 1974).

Habitat Areas of Particular Concern

Estuaries and Inshore Oceanic Waters

Estuaries and inshore oceanic water habitats are critically important to the life cycle of summer flounder. Because these areas are utilized for summer feeding grounds by adults and for nursery grounds by juveniles, any major alteration of these habitats could disrupt the life cycle of summer flounder.

Adult summer flounder migrate inshore in early spring. Once inshore some of the fish enter bays, others remain in inshore waters, and the remainder move north and eastward. Remaining for the entire summer, they feed on a variety of estuarine organisms.

According to Williams and Deubler (1968), summer flounder larvae develop at sea and then move into estuaries. In general, larvae begin entering estuaries from New Jersey to North Carolina from October to May. Poole (1966) stated that published and unpublished reports indicate the primary nursery grounds for juveniles are the sounds of North Carolina, Chesapeake Bay and the bays of the eastern shore of Virginia; however, they are distributed in spring, summer and fall in estuaries from Massachusetts to North Carolina. Early juvenile stages of summer flounder have been captured only in estuaries, suggesting that the young fish are estuarine dependent. Their tolerance to wide ranging temperatures and salinities further suggests that they are physiologically adapted to utilize the estuarine zone for nursery grounds (Smith, 1973).

1976 Anoxia in the Middle Atlantic Bight

During the summer and early autumn of 1976, oxygen concentrations at bottom depths were severely depleted and widespread mortalities of benthic organisms occurred in a section of the New York Bight off New Jersey. This near-anoxic (and in places anoxic) region of oxygen levels less than 2 parts per million (ppm) was located approximately 4 miles (6.5 km) off New Jersey and covered an area about 100 miles (160 km) long and 40 miles (64 km) wide during the most critical phases of the depletion (Sharp, 1976). Normal oxygen levels in this region are greater than 4ppm.

Investigations to date indicate that this state was probably induced by a combination of meteorological and circulatory conditions in conjunction with a large-scale algal bloom (predominantly of Ceratium tripos). Lack of normal seasonal turbulence occasioned by relatively few storms (Hurricane Belle notwithstanding), unusual wind patterns, and above-average surface water temperatures probably all contributed to depletion of the oxygen content of waters beneath the permanent thermocline in this region (Sharp, 1976). It is not known to what degree the routine dumping of wastes (sewage sludge and dredge spoils) in the ocean contributed to the depletion. However, it is reasonable to assume that any effect would have been detrimental (Atkinson, 1976).

The species of most commercial importance affected by the anoxia were surf clams, red hake, lobster, and crabs. Finfish were observed to be driven to inshore areas to escape the anoxia, or were trapped in water with concomitant high levels of hydrogen sulfide (Steimle, 1976).

The distribution of summer flounder and the catches made by recreational fishermen along the New Jersey coast were very unusual throughout most of the 1976 summer season (Freeman and Turner, 1977). This unusual distribution began appearing in late June coinciding with the formation of anoxic water close along the sea floor. At various times and various points along the coast the movement of the anoxic water, controlled presumably by wind-driven currents, caused large numbers of summer flounder to be pressed into the surf zone and into inlets and bays where dissolved oxygen levels could sustain aquatic life. This resulted in placing large numbers of summer flounder within easy reach of recreational fishermen. Festa (1977) reported that anglers in Great Bay, New Jersey averaged 5.63 summer flounder per trip in July of 1976, the highest monthly average in the 11 year history of a survey to determine the recreational catch of summer flounder.

Reduction in oxygen levels in New York Bight below normal levels has been observed several times in recent history (Atkinson, 1976) although not to levels as low as those observed in summer, 1976. The relative contribution of any of the above mentioned factors to the anoxia cannot yet and may never fully be assessed. However, it is important to note that each of these conditions, by itself, was not a unique, previously unobserved phenomenon.

Habitat Protection Programs

A. Coastal Zone Management

The Coastal Zone Management Act of 1972, 16 USC 1451

The Act establishes a national policy and initiates a national program to encourage state planning for the management, beneficial use, protection and development of the Nation's coastal zones (generally, the submerged lands and waters of the territorial sea and the adjacent shorelands having a direct and significant impact on such waters). Six states within the management area have coastal zone management programs which have been approved by the Secretary of Commerce: Massachusetts, Rhode Island, New Jersey, Delaware, Maryland and North Carolina.

B. Other Federal Programs, Laws and Policies

Fish and Wildlife Coordination Act of 1956, USC 742(a)-754

Established a comprehensive national policy on fish and wildlife resources; authorized programs and investigations that may be required for the development, advancement, management, conservation and protection of the fisheries resources of the United States.

National Environmental Policy Act of 1969, 42 USC 4321-4347

Requires detailed environmental impact statements of proposals for legislation and other major Federal actions which may significantly affect the quality of the human environment. Prior to making the detailed statement, the responsible Federal official is required to consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Also requires that documents must be available to the public and their comments must be considered.

The Ports and Waterways Safety Act of 1972, 33 USC 1221-1227

This Act deals with transportation and pollution problems resulting from operation and casualties of vessels carrying oil and other hazardous substances. It is designed to protect coastal waters, living resources, recreational resources and scenic values.

Federal Water Pollution Control Act, and Amendments of 1972, 33 USC 1251-1376

This Act initiated major changes in the enforcement mechanism of the Federal water pollution control program from water quality standards to effluent limits. Among other things, it requires that permits be issued by the Environmental Protection Agency or the states for discharge of effluents into waters of the United States.

The Marine Protection, Research and Sanctuaries Act of 1972 (the Ocean Dumping Act), 33 USC 1401-1444

This Act regulates the transportation from the United States of material for dumping into the oceans, coastal and other waters, and the dumping of material from any source into waters over which the United States has jurisdiction. The Environmental Protection Agency is empowered to issue permits for transportation or dumping where it will not unreasonably degrade or endanger human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities. Section 106 of the Act provides for the provisions of the Fish and Wildlife Coordination Act to apply.

Marine Mammals Protection Act of 1972, 16 USC 1361-1407

This Act, with certain exceptions, places a moratorium on the taking and importation of all marine mammals and marine mammal products. It makes the Secretary of Commerce responsible for protecting whales, porpoises, seals, sea lions; and the Secretary of the Interior responsible for all other marine mammals, specifically sea otters, walruses, polar bears and manatees. Also protects the habitat of marine mammals, including food sources.

Endangered Species Act of 1973, PL 93-205

This Act gives the Departments of Commerce and Interior regulatory and statutory authority on endangered and threatened fauna and flora not included in previous acts. The purpose of the Act being to conserve endangered and threatened species and the ecosystems upon which they depend.

Deepwater Port Act of 1974, 33 USC 1501-1524

Establishes procedures for the location, construction and operation of deepwater ports off the coasts of the United States.

Magnuson Fishery Conservation and Management Act of 1976, 16 USC 180

Establishes a fishery conservation and management regime to be implemented by the Secretary of Commerce. Establishes a fishery conservation zone extending from the limits of the territorial sea to 200 nautical miles from the baseline from which the territorial sea is measured. The Act defines fishery resource to include ". . .any habitat of fish", and enjoins the Secretary to carry out a research program which must include ". . .the impact of pollution on fish, the impact of wetland and estuarine degradation, and other matters. . ."

National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, PL 95-273

Designates NOAA as the lead agency in the development of a comprehensive five-year plan for a Federal program relating to ocean pollution research, development and monitoring. This plan is to provide for the coordination of existing Federal programs relating to the oceans and for the dissemination of information emerging from these programs to interested parties. In addition, the plan shall provide for the development of a base of information necessary to the utilization, development and conservation of ocean and coastal resources in a rational, efficient and equitable manner.

FISHERY MANAGEMENT JURISDICTION, LAWS AND POLICIES

Management Institutions

The U.S. Department of Commerce, acting through the Mid-Atlantic, New England and South Atlantic Fishery Management Councils, pursuant to P.L. 94-265 (Magnuson Fishery Conservation and Management Act), has authority to manage the stocks throughout their range.

Treaties and International Agreements

Foreign fishing for summer flounder is regulated by P.L. 94-265 pursuant to which Governing International Fishery Agreements are negotiated with foreign nations for fishing within the FCZ.

Federal Laws, Regulations and Policies

The only known Federal law that can regulate the management of the summer flounder fishery is P.L. 94-265.

State Laws, Regulations and Policies

All states have the power to regulate or legislate laws pertaining to the taking of summer flounder. Those that have regulatory powers are Massachusetts, Rhode Island, Connecticut, New Jersey and North Carolina. Those that must legislate laws are New York, Delaware and Maryland. Virginia has the power to regulate size limits but must legislate laws pertaining to area closures.

Massachusetts

Has no specific laws relating to summer flounder but are indirectly regulated by a number of special acts which control trawling by season and area within the territorial limit.

Rhode Island

Has no specific laws relating to summer flounder but are indirectly regulated by laws which control methods of taking fish within the territorial limit.

Connecticut

Illegal to offer for sale, take or attempt to take with gill net, seine, trap, fyke, weir, trawl or similar device, any summer flounder less than 14 inches in length. Any taken by the above described methods shall, without avoidable injury, be returned to the water from which taken.

New York

Summer flounder not less than 14 inches in length may be taken in any manner and in any number. Such summer flounder lawfully taken and possessed may be bought and sold at any time.

New Jersey

Illegal to purchase, sell, offer for sale or expose for sale any quantity of summer flounder where more than 5 percent are less than 14 inches in length.

Delaware

Has no specific laws relating to summer flounder but are indirectly regulated by laws which control trawling within the territorial limit.

Maryland

Illegal to possess any summer flounder less than 10 inches in length.

Virginia

Illegal to take or catch and retain possession of any summer flounder which is less than 12 inches in length, measured from nose to tip of tail. Any summer flounder below the lawful size must immediately be returned to the water unless obviously injured or dead. It is also illegal for any dealer or wholesaler of fish for human consumption to buy from others or to otherwise possess for purposes of resale any summer flounder less than 12 inches. Tolerance of not more than 10 percent by count of any catch shall be allowed.

North Carolina

Illegal to possess any quantity of flounder more than 5 percent of which are less than 11 inches in total length. The 5 percent tolerance can be based on weight or number.

Local and Other Applicable Laws, Regulations and Policies

No local or other laws, regulations or policies are known to exist relative to this fishery

DESCRIPTION OF FISHING ACTIVITY

History of Exploitation

There are two fisheries for summer flounder, the recreational fishery and the commercial fishery. The recreational fishery employs mostly hook and line, although some gigging is done. In addition, some recreationally caught fish are sold. The commercial fishery utilizes the otter trawl, haul seines, pound nets, and fyke nets. Most of the catch is taken by otter trawl. Widerstrom (1959) described the gear used by New Jersey trawlers. Most of the inshore boats use a conventional otter trawl with a large mesh net designed to be towed at low speeds. The offshore trawlers use a trawl net like that used for ground fish with a smaller mesh designed to be towed at higher speeds. Other modifications are use of a heavier twine, larger doors, wooden rollers on the bottom edge of the net, and much longer legs that attach the doors to the wings of the net. According to Bruce (1967) the most commonly used trawls were the number 36 otter trawl and the flounder trawl.

Commercial landings of summer flounder have varied widely in the past. In 1964, U.S. commercial fishermen landed over 5,000 mt (11,000,000 lbs.) of summer flounder. Annual landings decreased to a low of approximately 2,734 mt (6,014,800 lbs.) in 1969, but have generally increased since then to over 15,500 mt (34,400,000 lbs.) landed in 1980. Landings by state are listed in Table 1 for the years from 1964 to 1980. Table 9 lists 1980 reported U.S. commercial catches of summer flounder by distance from shore. Of the 1980 total landings, approximately 29 percent or 4,462 mt (9,800,000 lbs.) of summer flounder were captured from 0-3 miles offshore while approximately 71 percent or 11,165 mt (24,600,000 lbs.) were captured greater than 3 miles from shore.

Estimated U.S. recreational catches for the years 1965, 1970 & 1979 are listed in Table 1. Recreational catch during 1979 accounted for approximately 45 percent of the total commercial and recreational catch from Maine through Virginia. Results of the 1965, 1970 and 1974 surveys are assumed to be less accurate than the results of the 1979 survey due to the longer fishermen recall period used in the earlier surveys.

Domestic Commercial and Recreational Fishing Activity

Commercial Fishery

There are two major commercial fisheries for summer flounder, the inshore summer fishery and the offshore winter fishery.

The winter trawl fishery (October to June), which began about 1920 when trawlers from New Jersey initiated exploratory fishing for Atlantic croaker (*Micropogonias undulatus*) off the coasts of Virginia and North

Carolina, was described by Pearson (1932) and Nesbit and Neville (1935). During the 1920s small shallow draft oyster and crab dredge boats equipped with trawls joined the larger vessels. The smaller vessels were based primarily at Ocracoke Inlet, North Carolina and fished within 10 to 20 miles (16 to 32 Km) of the shore whenever weather conditions permitted. In 1930, the North Carolina Legislature prohibited all trawling in state waters (this law has since been repealed). This regulation affected the small trawlers considerably, for weather conditions often prevented them from working outside the three mile limit. Moreover, flounder, which represented their principal catch, seemed to prefer the sandy inshore areas. Despite these factors, some of the small trawlers continued to fish the offshore grounds and by the winter of 1930-1931 there were about 20 small boats still operating.

Through the winters of 1928 to 1930 an increasing number of trawlers came from northern ports and fished regularly in the offshore waters. The catches of the vessels were landed chiefly at ports in the Hampton Roads area. In the winter of 1930-1931, 25 northern vessels, in addition to the local Chesapeake Bay boats, exploited the winter stocks (Pearson 1932). The number of boats in the winter fishery increased from 50 in the 1931-1932 season to about 100 in the 1934-1935 season. Of this number about one-half were equipped to fish in deep water (Nesbit and Neville 1935). Since 1935 the smaller boats have left the fishery. During the 1961-1962 season about 30 Hampton based vessels fished the winter stocks (Eldridge 1962). Many of these trawlers fished off the New England coast during the summer. The number of vessels participating in the fishery has steadily increased. Seventy vessels were active in Virginia's offshore fishery during 1970. By 1978, the fleet had nearly tripled to 196 vessels with summer flounder representing the major component of the trawler landings (DuPaul and Baker, 1979). During the 1979-1980 season over 200 vessels over 65 feet from North Carlina alone participated in the winter trawl fishery (J. Gilliken, [8], pers. comm.).

In general, the winter trawl fishery is located in depths of 15 to 25 fathoms (27 to 46 meters) and progresses to the 100 fathom (182 meters) line as the summer flounder migrate offshore (Eldridge, 1962). The inshore summer trawl fishery operates within the 16 fathom (5 meters) contour (MacPhee, 1975). The inshore fleet usually consists of small and medium-sized vessels under 50 feet in length which make daily trips to nearby fishing grounds from May to October (Reintjes and Roithmayr, 1960). The inshore fishery depends upon the arrival of summer flounder in shallow water with rising temperatures and thus, the beginning and the end of the fishing season depends on water temperature and other factors which may influence migration.

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[8] Gillikin, J., N.C. Div. Mar. Fish, Morehead City, N.C.

Massachusetts Commercial Landings

Approximately 250 Massachusetts based vessels from 15 ports land summer flounder in a summer trawl fishery and, to a lesser extent, an offshore winter trawl fishery. The majority of the landings are taken by draggers fishing inshore grounds. Larger trawlers, particularly from New Bedford, fish the continental shelf from southern New England to Virginia. Additional catch occurs in a coastal trap net fishery. Since the early 1970's the contribution of up to 18 traps has been 1-3 percent of the annual Massachusetts landings.

The Massachusetts commercial summer flounder landings in 1980 were 148 mt (325,000 lbs.) with an ex-vessel value of $296,000.

Rhode Island Commercial Landings

The commercial fishery for summer flounder in Rhode Island is mainly an inshore summer trawl fishery with some additional catch from an inshore pound net fishery. Occasionally vessels from Rhode Island participate in the winter trawl fishery for summer flounder.

The Rhode Island commercial summer flounder landings in 1980 were 580 mt (1,276,000 lbs.) with an ex-vessel value of $1,163,000.

Connecticut Commercial Landings

There is no active commercial fishery for summer flounder within Connecticut state waters. The majority of the landings are caught offshore with some incidental catches made within state waters.

The Connecticut commercial summer flounder landings in 1980 were 3 mt (6,000 lbs.) with an ex-vessel value of $6,000.

New York Commercial Landings

The commercial fishery for summer flounder in New York is mainly an inshore summer trawl fishery. Participation from New York in the winter trawl fishery is minimal.

The New York commercial summer flounder landings in 1980 were 566 mt (1,246,000 lbs.) with an ex-vessel value of $1,193,000.

New Jersey Commercial Landings

Vessels from New Jersey participate in both an inshore summer trawl fishery and an offshore winter trawl fishery that account for 99 percent of the total New Jersey summer flounder landings.

The New Jersey commercial summer flounder landings in 1980 were 2,184 mt (4,805,000 lbs.) with an ex-vessel value of $2,725,000.

Delaware Commercial Landings

There is no active commercial fishery for summer flounder in Delaware state waters. Vessels participate in the offshore trawl fishery but the majority of the catch is landed in Cape May, New Jersey or Ocean City, Maryland.

There were no reported commercial landings of summer flounder in Delaware for 1980.

Maryland Commercial Landings

Vessels participating in the Maryland commercial fishery for summer flounder are concentrated primarily at the sole coastal port of Ocean City, with minor landings on the Chesapeake. It is a year-round fishery with the majority of the catch being made between the months of February and October. In pounds landed, summer flounder constitutes the third highest finfish catch in the state and the highest finfish catch on the coast.

The Maryland commercial summer flounder landings in 1980 were 602 mt (1,324,000 lbs.) with an ex-vessel value of $620,000.

Virginia Commercial Landings

A small pound net fishery and haul seine fishery occur from April to November in Chesapeake Bay and along the ocean beach south of Virginia Beach. These fisheries land some summer flounder. A winter offshore trawl fishery is present with an influx of boats from other states. A summer inshore trawl fishery occurs off the Eastern Shore.

The Virginia commercial summer flounder landings in 1980 were 3,859 mt (8,489,000 lbs.) with an ex-vessel value of $3,850,000.

North Carolina Commercial Landings

Since the 1960s a fall and winter trawl fishery for summer flounder has expanded along the coast. Since the 1970s, mostly due to the construction of larger vessels over 65 feet in length, North Carolina vessels have moved up the coast as far north as Massachusetts during the late spring and early summer. Over 200 of these large vessels are now fishing for summer flounder.

The North Carolina commercial summer flounder landings in 1980 were 7,674 mt (16,882,000 lbs.) with an ex-vessel value of $7,888,000. Because adequate information is not available to separate the three different paralichthid flounders present in the other fisheries, these landings are based on the North Carolina offshore trawl fishery, which consists solely of summer flounder. The offshore trawl fishery has averaged 90 percent of the total flounder landings over the last 17 years. Therefore, the landings from the offshore trawl fishery are used to estimate summer flounder landings in North Carolina (J. Gillikin, [9], pers. comm.).

Recreational Fishery

The recreational fishery is effective in catching summer flounder with hook and line in bays and inshore ocean waters from April or May to October. The most recent estimates of the recreational catch were available for 1979 from the U.S. Department of Commerce (1980). The recreational catch of summer flounder was estimated to be 14,212,000* fish weighing approximately 8,000 mt (17,600,000 lbs.). Of the total, 3 percent of the catch was taken in ocean waters greater than three miles off shore, 37 percent was taken in ocean waters less than three miles from shore, 57 percent was taken in inland bays and estuaries, and 3 percent was not classified (catch location not available.

Estimated recreational catch was also divided into four fishing modes: man-made, beach/bank, party/charter, and private/rental. Catch aboard private/rental boats accounted for 78 percent of the total, 16 percent was taken while fishing from the beach/bank, 5 percent from man-made structures (piers, docks, bridges, jetties, etc.), and 1 percent while fishing aboard party/charter boats. Catch per effort by species was not calculated in the survey; but in the North Atlantic area fishermen aboard private/rental boats had the highest catch per effort for all species combined, while fishermen aboard party/charter boats had the highest catch per effort in both the Mid-Atlantic and South-Atlantic areas.

The recreational fishery is present to some degree throughout the states from Massachusetts to North Carolina (Freeman and Walford, 1974a, b, c; 1976a, b). There is evidence that the recreational catch is higher in the more northern states than it is in the southern states. In 1959, Virginia's sport catch of summer flounder in Chesapeake Bay was 461,000 fish (Richard, 1962), whereas in the same year anglers caught 1,643,000 fish in Great South Bay, New York (Briggs, 1962). Similarly, estimated catch for 1979 (U.S. Dept. of Commerce, 1980) in New York and Virginia was 4,016,000 and 2,244,000 summer flounder, respectively. The likeness in catch rates, however, reported for Great South Bay in New York and

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[9] Gillikin, J., N.C. Div. of Mar. Fish., Morehead City, N.C.

*Some of the recreational catch of summer flounder in the South-Atlantic area, specifically North Carolina, is made up of other paralichthid flounders beside *P. dentatus*. The species were all included in the survey under the heading summer flounder.

New Jersey's Great Bay in 1968 suggest that a degree of uniformity does exist for the Middle Atlantic Bight (Festa, 1979a). Recreational creel surveys from New York and New Jersey indicate that angler catches reach a peak in early July but then drop off sharply in August (Poole, 1962; Festa, 1979b).

The following regional information is taken from the U.S. Department of Commerce, National Marine Fisheries Service (1980):

North Atlantic States

Fishermen in North Atlantic states landed approximately 4 percent of the total recreational summer flounder catch in 1979 with Massachusetts, Rhode Island, and Connecticut fishermen catching 378,000, 153,000 and 39,000 summer flounder respectively. Of all North Atlantic fishermen contacted, 3.44 percent reported the principal species they sought was summer flounder.

Mid-Atlantic States

Fishermen in the Mid-Atlantic states landed approximately 88 percent of the total recreational summer flounder catch in 1979, with New York, New Jersey, Delaware, Maryland, and Virginia fishermen catching 4,016,000, 5,142,000, 493,000, 757,000 and 2,244,000 summer flounder respectively. Of all fishermen contacted, 15.61 percent reported the principal species they sought was summer flounder.

South Atlantic States

Fishermen in the South Atlantic states landed approximately 8 percent of the total recreational summer flounder catch in 1979, however an unknown proportion of this total is made up of southern and gulf flounders. All three species were grouped together in the survey. Estimated catch of the three species in North Carolina was 711,000 fish. Of all South Atlantic fishermen contacted, 4.27 percent reported the principal species they sought was summer flounder.

Interactions Between Foreign and Domestic Commercial and Recreational Participants in the Fishery*

Some interactions between commercial and recreational participants in the summer flounder fisheries do take place. Party boats, charter boats and private boats fish in many of the same areas as small trawlers fish during the summer and are therefore competing for the same fish. Commercial fishermen may even be able to reduce localized abundance and thus affect the

*This section has been taken from Wilk and Brown (1980).

catch-per-unit-effort in the recreational fishery. In the areas inside of three miles, where small summer flounder are found, trawling is prohibited through much of the species range. Therefore, at present, the recreational fishery has the opportunity to catch younger fish prior to their recruitment to the commercial fishery and therefore may have the potential of limiting recruitment to the offshore fisheries.

There has already been a conflict between various user groups. The offshore by-catch of foreign distant water fleets was vigorously opposed to by both Mid-Atlantic and Southern New England recreational and commercial interests prior to MFCMA. They argued that this offshore winter fishery had the potential, if great enough, to reduce inshore productivity, and because it occurred at the very beginning of the year, at a time when U.S. fishery interests, particularly in the northern section, were not harvesting the resource, could lower abundance sufficiently to affect availability during summer inshore fisheries. The current U.S. southern offshore fishery, (VA and NC), to a degree, may have the same potential impact on the nearshore fisheries because effort has increased recently.

Foreign Fishing Activities

Foreign fishing fleets, principally that of the U.S.S.R. (Union of Soviet Socialist Republics) have reported relatively minor landings not exceeding 904 mt (1,988,800 lbs.) (Table 1). Landings by Soviet vessels during 1965-1973 averaged 201 mt (442,200 lbs.). Ireland, Spain and Italy have taken combined incidental catches of less than 52 mt (114,400 lbs.) since 1975. Since the implementation of the Magnuson Fishery Conservation and Management Act of 1976, no allocations (other than by-catch) of summer flounder to foreign vessels have been assigned (Fogarty, 1981). As has been reported for other species such as black sea bass (Musick and Mercer, 1977), summer flounder are taken by foreign vessels incidentally with other species. Although this by-catch has been reduced since implementation of the MFCMA, it still certainly contributes to summer flounder mortality, although to what degree is probably unknown.

DESCRIPTION OF ECONOMIC CHARACTERISTICS OF THE FISHERY

Domestic Harvesting Sector

Commercial Fishery

Historical records of summer flounder landings are available for the states of Massachusetts through North Carolina. Historical information indicates that a successful commercial fishery for summer flounder has been operating in the region since the 1920s (Widerstrom 1959, Reintjes and Roithmayr 1960).

The total ex-vessel value of the summer flounder landings from Massachusetts to North Carolina remained fairly stable from the early 1960s through the early 1970s, ranging between $2,071,000 and $3,301,000. Since 1973, however, the total ex-vessel value has steadily increased and in 1980 was $28,212,000. Table 10 lists total landings and ex-vessel values from 1964 to 1980.

Table 11 lists the summer flounder landings and ex-vessel values in all counties in the Massachusetts to North Carolina region for 1979 and 1980. States, and counties within each state, are listed in descending order of metric tons of summer flounder landed in 1979. The 11 highest counties for summer flounder landings and total ex-vessel values in 1979 and 1980 were: Dare, Pamlico, and Carteret, North Carolina; City of Hampton and Accomac, Virginia; Cape May and Ocean, New Jersey; Washington and Newport, RhodeIsland; Worcester, Maryland; and Suffolk, New York. All of these counties experienced a drop in landings from 1979 to 1980.

Table 12 presents an analysis of major commercial food finfish fisheries in 1980 from Massachusetts through North Carolina in terms of total weights landed and total ex-vessel revenues. In 1980, summer flounder ranked 7th by total poundage and 3rd in total ex-vessel revenue.

Recreational Fishery

Data on the summer flounder recreational fishery is available from the Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1979. This survey consisted of two phases. One phase was a random telephone survey to identify saltwater fishermen in the general population and to determine the number of fishing trips that they made. The other phase was a creel census or intercept phase that consisted of personal interviews with anglers to determine the composition of their catch. Difficulties in obtaining accurate and unbiased estimates of the recreational catch due to the diverse nature of the recreational fishery and large number of participants, however, must be recognized. For instance, biologists in New Jersey (Hamer [10], pers. comm.), have recently noted that the survey underestimated the recreational catch of weakfish.

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[10] Hamer, P.E., N.J. Div. Fish, Game and Wildlife, Absecon, NJ.

The 1979 survey estimated that 1,131,000 New England, 2,834,000 Mid-Atlantic, and 1,966,000 South Atlantic coastal state residents participated in marine recreational fishing during 1979. Those people, plus out-of-state residents, made a total of 6,983,000 fishing trips for New England, 18,433,000 trips for the Mid-Atlantic, and 13,771,000 trips for the South Atlantic (U.S. Dept. of Commerce, 1980).

While the survey does not include data on angler participation categorized by species, it does report species sought-by fishermen interviewed in the intercept phase of the survey. In New England, approximately 3 percent of those interviewed reported they were fishing for summer flounder. In the Mid-Atlantic, approximately 16 percent were fishing for summer flounder. In the South Atlantic, approximately 4 percent were fishing for summer flounder. Some of the South Atlantic fishermen were undoubtedly fishing for gulf flounder and southern flounder in addition to summer flounder. The three species are all included under the heading of summer flounder in the Angler Survey (U.S. Dept. of Commerce, 1980).

Centaur Management Consultants (1977) conducted a study for the National Marine Fisheries Service to develop estimates of the economic values of marine recreational fishing in terms of employment, wages, salaries and other economic measures. In the coastal area from Maine to Cape Hatteras, North Carolina, the Centaur Study shows the direct economic impacts of the recreational fishery in 1975 to be about $630 million and employment to be 17,350 person-years. The indirect and induced economic impacts (for wages and salaries, value added, and annual capital expenditures) were about $374 million in the area from Maine to Cape Hatteras, North Carolina. The summer flounder fishery certainly is not directly related to these total costs but it does account for some portion of them.

Domestic Processing Sector

Summer flounder is almost strictly a fresh fish product and is generally iced on the dock at unloading and shipped directly to market. Some filleting is done (four processors contacted in New Jersey and Virginia reported filleting 5 to 25 percent of the summer flounder they receive), but no data is available to document the total amount filleted.

International Trade

No data are reported on international transactions of summer flounder. Therefore, it is probable that international trade in summer flounder is insignificant.

DESCRIPTION OF THE BUSINESSES, MARKETS AND ORGANIZATIONS ASSOCIATED WITH THE SUMMER FLOUNDER FISHERY

Relationship Among Harvesting and Processing Sectors

Since summer flounder is generally sold fresh, there is no major processing with the possible exception of filleting. Although no data is available to document the total amount filleted, four processors contacted in New Jersey and Virginia reported filleting 5 to 25 percent of the summer flounder they receive.

Fishery Cooperatives or Associations

There are four active fishermen's cooperatives in the Massachusetts to North Carolina area. Although some purchasing of expendable equipment for fishing vessels is undertaken, their main business is marketing members' landings. Cooperative operations are typical of the region's packing or dock practice, supplying fuel, ice, water and trip service to members. Three of the cooperatives are located in New Jersey: the Belford Seafood Cooperative Association, Inc., the Point Pleasant Fishermen's Dock Cooperative, Inc., and the Cape May Fishery Cooperative. The fourth cooperative is the Pt. Judith Fishermen's Cooperative in Rhode Island.

Labor Organizations

Labor organizations identified with the harvesting and processings sectors of the fisheries in the New England area and North Carolina have not been specifically described. Some of the participants in the summer flounder fishery in these areas are, however, undoubtedly represented by labor organizations.

Labor organizations identified with the harvesting and processing sectors of the fisheries in the Mid-Atlantic area are limited to four organizations: the Seafarers International Union of North America, the International Longshoremen's Association, the United Food and Commercial Workers International Union (UF&CW) of the AFL-CIO, and the International Brotherhood of Teamsters. The following discussion is related to Mid-Atlantic fisheries generally and is taken from Development Sciences, Inc. (1980). Information is not available to identify activities that relate directly to summer flounder.

In the Mid-Atlantic area union involvement is almost entirely limited to onshore seafood handling, processing, and distribution activities. Vessel crews are not organized by any of the identified unions although some attempts have been made in the past to include fishermen in organized unions. The UF&CW recently attempted to organize vessel crews who were employees of a seafood processing company. Although their efforts were met favorably by the crew members, the National Labor Relations Board ruled that the UF&CW was in violation of the labor law because each boat was owned by a separate owner and, therefore, all boat crews could not be organized under the same union. Since that ruling, the UF&CW has not attempted to organize vessel crews in any other locations.

Onshore seafood handling is generally non-unionized. To the extent that it is, the International Longshoremen's Association is the primary national union involved in seafood handling workers. Most union activity occurs in the region's major urban centers (New York, Philadelphia, Baltimore, and Norfolk) and include handling workers at boat docks and in warehousing facilities located at processing plants.

Fish processing workers, when unionized, are represented by the United Food and Commercial Workers International Union. This union represents oyster and clam shuckers, fish cleaners and cutters, freezermen, warehousemen, some distribution workers, and wholesale and retail clerks.

Transportation of seafood products, especially from processing facilities to wholesale and retail fish distributors is organized under the International Brotherhood of Teamsters, with headquarters in Washington, D.C. and regional offices in major urban centers throughout the Mid-Atlantic region.

Preliminary analysis of labor union activity in the Mid-Atlantic region indicates that the seafood harvesting, handling, and processing industry is not highly organized. Although union activity occurs in all major urban centers, the overall percentage of union members employed in the seafood industry is relatively low. For example, in the Hampton Roads area, only five percent of all workers employed in the seafood harvesting and processing industry are organized by the unions.

The reasons for limited union involvement include the low-wage seasonal nature of employment in the processing industry, and the diverse highly competitive and independent nature of the fishermen, brokers, and processors. In many instances, wages are extremely low, approaching minimum wage in some localities. Often, fish processing employees are the lowest paid employees covered by the unions. These employees, subject to difficult working conditions and unstable employment prospects, change employment continuously, leaving employers with no work and hiring on with companies that do have work. Seasonality of employment and constant changeover from shellfish to finfish processing affects steady employment and limits the unions' ability to organize onshore workers.

Unionization of vessel crews and fishermen is limited by the small size of individual crews and the investor-owner fishing boats. National Labor Relations Board rulings against organization of fishing fleets have added to the organization and administrative problems of including fishermen in national union structures.

Foreign Investment in the Domestic Fishery

Data on foreign investment in the fishery are not known to exist. Therefore, it is probable that if investment exists, it is insignificant.

DESCRIPTION OF SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

Uniform socio-economic data on fishing communities are not available. Certain information is available from the Federal censuses on a county basis. Therefore, summer flounder landings in 1979 were examined by county to identify those counties with a significant involvement in this fishery (Table 11). Newport and Washington, Rhode Island; Cape May and Ocean, New Jersey; Suffolk, New York; Worcester, Maryland; Accomac and City of Hampton, Virginia; and Carteret, Dare, and Pamlico, North Carolina were selected as being relatively important in this fishery (over 1,000,000 lbs. of summer flounder landed in 1979). Data from the census are presented in Table 13.

DETERMINATION OF OPTIMUM YIELD

Specific Management Objectives

One of the purposes of the Magnuson Fishery Conservation and Management Act (MFCMA) is "to promote domestic and recreational fishing under sound conservation and management principles." Section 301(a) of the MFCMA sets forth the following national standards:

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery.

2. Conservation and management measures shall be based upon the best scientific information available.

3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be:

   a. fair and equitable to all such fishermen;

   b. reasonably calculated to promote conservation; and

   c. carried out in such a manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

5. Conservation and management measures shall, where practicable, promote efficiency in the utilization of the fishery resources; except that no such measure shall have economic allocation as its sole purpose.

6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

Specific objectives of this Fishery Management Plan are to:

1. Promote Optimum Yield of the fishery and reduce the probability of recruitment failure by protecting juvenile fish.

2. Insure that management strategies implemented to achieve objective #1 above are equitable to the major recreational and commercial components presently engaged in the fishery.

3. Improve understanding of the factors that interact to control the condition of the stocks.

4. Promote compatible regulations between the territorial seas and the FCZ.

5. Minimize regulations to achieve the management objectives recognized above.

Description of Alternatives and Analysis of Beneficial and Adverse Impacts of Potential Management Options.

A. Present Management Options

1. Take no Action at this Time -- This would mean that the Preliminary Fishery Management Plan (PMP) prepared by the National Marine Fisheries Service would remain in effect. The PMP regulates only foreign fishing and allows foreign fishermen to catch summer flounder incidentally to other species only.

Not having a means to control the domestic fisheries might result in a reduction of stock size to a level beneath that required for efficient utilization of the resource. The summer flounder stock is currently experiencing high levels of fishing mortality and the stock has been reduced to low levels in the past. Although stock-recruitment relationships for summer flounder are not known, and it is not clear what role environmental factors play in controlling recruitment, it may be that at very low levels of abundance, spawning stock size and recruitment (i.e., future abundance) are related. The stock should not be drastically reduced if the economic future of this fishery is to be safeguarded and the objectives of this management plan are to be attained. Therefore, the "No Action" alternative is unacceptable at this time.

2. Limit Fishing Mortality -- This would be accomplished by limiting effort, limiting catch, or both.

Limiting fishing mortality via limiting effort appears to be impractical for the summer flounder fisheries. Limiting effort in the receational fishery would be difficult. In addition, limiting commercial effort for summer flounder would also indirectly limit effort for other species taken in a mixed fishery.

Limiting fishing mortality via limiting catch also appears to be impractical for the summer flounder fisheries. This alternative requires a considerable amount of data and requires continual monitoring. In addition, limiting catch in the recreational fishery would be difficult and probably would not be supported by recreational fishermen.

The "Limit Fishing Mortality" alternative seems to be unacceptable at this time.

3. Control Quality or Composition of the Catch -- This would be accomplished by seasonal/area closures, minimum legal size limits, and/or mesh regulations.

Controlling quality or composition of the catch via seasonal/area closures appears to be impractical for the summer flounder fisheries. By imposing seasonal/area closures on the commercial fishery, this alternative would indirectly effect the taking of other species in a mixed fishery, or the catch of summer flounder would continue in a mixed fishery directed at species other than summer flounder. Therefore, seasonal/area closures seem to be unacceptable at this time.

Controlling quality or composition of the catch via minimum legal size limits appears to be a practical alternative for the summer flounder fisheries. This alternative seems to be the easiest to administer and the easiest to enforce in both the commercial and recreational fisheries. Two options have been proposed under this alternative:

a). Allow U.S. fishermen unrestricted catches of summer flounder, but impose a 14 inch (total length) size limit -- The Optimum Yield would equal all summer flounder 14" total length or larger caught by U.S. fishermen. Under this option, it would be illegal for fishermen, processors, or dealers to possess any summer flounder less than 14 inches in total length. Tolerance of not more than 5 percent by count or weight of any catch not taken by hook and line shall be allowed, but summer flounder less than 14 inches total length cannot be bought, sold or offered for sale. Foreign fishermen would not be permitted to retain summer flounder since U.S. fishermen, by definition, would harvest the Optimum Yield. Vessels fishing commercially for summer flounder, either directly or as a by-catch from other fisheries, and vessels for hire in the recreational fishery (party and charter boats) which fish directly or indirectly for summer flounder would be required to obtain permits and submit reports as required by the National Marine Fisheries Service or the state marine fishery agencies.

As discussed in the Fishery Management Jurisdiction, Laws, and Policies section, several states already have size limits ranging from 10" to 14". Most of the size limits, however, pertain to commercially caught summer flounder only. Imposing a 14" size limit on the commercial and recreational fishery would increase yield per recruit (fishing mortality = 0.75) as shown in the following table (Fogarty, 1981):

	Male			Female		
Minimum Length	Increase Yield (lbs.)	Percent Increase	Cumulative Percent Increase	Increase Yield (lbs.)	Percent Increase	Cumulative Percent Increase
10"(25.4cm)	0.598			0.788		
11"(27.9cm)	0.664	11.0	11.0	0.878	11.4	11.4
12"(30.5cm)	0.735	10.7	22.9	0.975	11.0	23.7
13"(33.0cm)	0.801	9.0	33.9	1.074	10.2	36.3
14"(35.6cm)	0.865	8.0	44.6	1.173	9.2	48.9

In addition to an increase in yield per recruit, a 14" size limit would allow summer flounder to spawn at least once prior to capture (mean size at sexual maturity for females = 32.2cm, 12.7"). At 14", approximately 65 percent of summer flounder females are mature (Morse, in press).

The economic impact of a 14" size limit probably would be greatest on inshore trawlers in Virginia and North Carolina. The percentage of summer flounder less than 14" caught in this fishery is most likely higher than that in the commercial offshore winter fishery or the commercial inshore fishery in states north of Virginia. In order to lessen the immediate economic impact of a 14" size limit in the southern inshore commercial fisheries, an incremental size limit starting at 12" and increasing annually to 14" may be necessary,

b). Allow U.S. fishermen unrestricted catches of summer flounder, but impose a 14 inch (total length) size limit in those states from Delaware and north; and impose a 12 inch (total length) size limit in those states from Maryland and south. -- The Optimum Yield would equal all summer flounder 14" total length or larger from Delaware north and 12" total length or larger from Maryland south caught by U.S. fishermen. Under this option, it would be illegal for fishermen, processors, or dealers to possess any summer flounder less than 14 inches in total length from Delaware north and less than 12 inches in total length from Maryland south. Tolerance of not more than 5 percent by count or weight of any catch not taken by hook and line shall be allowed, but summer flounder less than 14 inches total length from Delaware north and 12 inches total length from Maryland south cannot be bought, sold or offered for sale. Foreign fishermen would not be permitted to retain summer flounder since U.S. fishermen by definition, would harvest the Optimum Yield. Vessels fishing commercially for summer flounder, either directly or as a by catch from other fisheries, and vessels for hire in the recreational fishery (party and charter boats) which fish directly or indirectly for summer flounder would be required to obtain permits and submit reports as required by the National Marine Fisheries Service or the state marine fishery agencies.

As discussed in the Fishery Management Jurisdiction, Laws, and Policies section, several states already have size limits ranging from 10" to 14". Most of the size limits, however, pertain to commercially caught summer flounder only. Imposing a size limit as above on the commercial and recreational fishery would increase yield per recruit as shown in the table under size limit alternative (a).

In addition to an increase in yield per recruit, a size limit as described above would increase the number of summer flounder allowed to spawn at least once prior to capture (mean size at sexual maturity for females = 32.2cm, 12.7"). At 14", approximately 65 percent of summer flounder females are mature. At 12", approximately 34 percent of summer flounder females are mature (Morse, in press). There is evidence, however, to suggest that summer flounder females south of Delaware Bay mature at a smaller size than those to the north. Mean size at sexual maturity for females south of Delaware Bay was 12" (30.51cm) while mean size at sexual maturity for females north of Delaware Bay was 13.1" (33.22cm). Some caution must be used in interpreting these data, however, in that overall mean size of females captured south of Delaware Bay was smaller then those captured north of Delaware Bay (Morse [11], pers. comm.)

The economic impact of a minimum legal size limit as described above may be greatest on dock owners in northern states, especially in New Jersey and Delaware. Catches of summer flounder less than 14" may be landed in states instituting a 12" minimum legal size limit, thereby reducing landings to northern docks, and at the same time reduce the biological effectiveness of a 14" minimum legal size limit in those states from Delaware and north. Instituting the above described size limits may possibly encourage overland shipment of illegal fish from south to north.

Controlling quality or composition of the catch via mesh regulations in conjunction with one of the above size limits also appears to be a possible alternative for the summer flounder commercial fishery.

c). Impose a mesh regulation, the size of which shall allow undersized summer flounder to escape according to the size limit options above. -- This option would apply to all commercial fishermen fishing with mobile gear (i.e. otter trawl, beam trawl, etc.) in a directed summer flounder fishery.

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[11] Morse, W., National Marine Fisheries Service, Sandy Hook Laboratory, Highlands, N.J.

Based on catch data from otter trawl vessels operating off the northeast coast of the U.S. during 1964-1980 (Murawski, et. al., 1981) and Northeast Fisheries Center bottom trawl surveys during 1963 to 1980 (Mayo, et. al., 1981), a directed fishery can be defined as containing at least 60% summer flounder by weight. Specifically, the fishery described by Mayo, et. al. (1981) is composed of the following:

Species	% Composition
Summer Flounder	64.12
Yellowtail Flounder	10.21
Goosefish	4.42
Croaker	4.26
Weakfish	2.58
Sea Scallop	2.33
Bluefish	2.28

Net mesh selectivity for otter trawl cod-ends for summer flounder has been determined by Gillikin (in press). The data presented in the following table are based on preliminary studies.

Mesh Size		Summer Flounder 50% Retention Point		95% Confidence Limits
mm	in	mm	in	mm
114.97	4.5	278.7	11.0	261 - 297
125.75	5.0	326.0	12.8	317 - 335
130.85	5.2	320.5	12.6	234 - 407
145.57	5.7	363.8	14.3	300 - 428
159.97	6.3	428.2	16.9	367 - 489

According to the above data, a 5.5" mesh would be necessary in conjunction with a 14" size limit, and a 4.5" to 5.0" mesh would be necessary in conjunction with a 12" size limit. Cod-end mesh sizes were measured stretched using an ICES (International Council for the Exploration of the Sea) net gauge set at 4 kg tension.

Although mesh regulations will allow undersized fish to escape, thereby decreasing mortality, indications from Gillikin (1981) are that cod-end mesh sizes greater than 97mm (3.8in) will allow a significant proportion of other marketable commercial species to escape, principally Atlantic croaker, weakfish, spot, squid, black sea bass, and scup.

B. Management Recommendations

The Summer Flounder Scientific and Statistical Committee and Regional Citizens Advisory Committee recommends that management alternatives 3(a) and 3(c) be implemented.

C. Future Management Options

At the present time, adequate information is not available to determine stock size. Once stock size estimates are available possible management options will include those which limit fishing mortality or control quality or composition of the catch. If stock size falls below some critical level, specific management options which are suggested include:

1. Bag limit on the recreational fishery

2. Prohibit landing summer flounder during October and November in those ports from Chincoteague, Virginia and north; and during November and December in those ports south of Chincoteague in order to protect the stock during spawning and when they are heavily concentrated in some areas.

RECOMMENDATIONS FOR RESEARCH

The following research recommendations are deemed essential in order to monitor the effectiveness of this management plan and enable additional management options to be utilized, if necessary, in the future.

Immediate Research Needs

1. Gear selectivity and discard mortality

In order to evaluate the impact of different minimum legal size limits and/or mesh regulations in the commercial fishery, a consistent and accurate sampling program is needed to determine the mesh selectivity for summer flounder and other commercial species taken in a mixed fishery; and to determine mortality of discards.

2. Stock identification via meristics, morphometrics, biochemical research and tagging (particularly off Virginia and North Carolina).

The summer flounder population assessment presented in this management plan is based on a unit stock. Some evidence does exist, however, to suggest the possibility that two stocks of summer flounder are present in the Middle Atlantic Bight during some times of the year. If two stocks exist, and basic biological characteristics such as growth and size at maturity are different, uniform management regulations based on one stock may not be appropriate over the entire range of the species.

3. Detailed socio-economic study of the summer flounder fisheries

Biological as well as socio-economic data should be, when available, considered in the formulation of a fishery management plan. Very little socio-economic data exist for the summer flounder fisheries. It is therefore necessary to clearly define the socio-economic complexities of the summer flounder fisheries in order to aid in the refinement of the management recommendations contained in this plan and/or select other management tools that may be available in the future.

Long-Term Monitoring Needs

1. Collection and analysis of age/length samples and catch/effort data from the commercial and recreational fisheries throughout the range of the species.

The systems in place at the present time to collect this information on summer flounder are inadequate to establish basic biological data to determine stock size. Increased collection of age/length samples and catch/effort data through the existing NMFS port sampling program and in conjunction with the current national sport fishery survey would provide much of this necessary data.

2. Abundance of juvenile summer flounder should be monitored on a yearly basis.

In order to determine trends in year class strength and spawning success (future recruitment), the above monitoring should be initiated.

OTHER RECOMMENDATIONS

A Summer Flounder Advisory Committee composed of fishery biologists currently members of the Scientific and Statistical Committee and commercial and recreational fishermen currently members of the Regional Citizens Advisory Committee should meet at least annually to review data bearing on the status of the resource, formulate recommendations for updating management strategies, and promote implementation of the management plan. The Summer Flounder Board should also be retained in its present form to provide policy and guidance to the Summer Flounder Advisory Committee.

Table 1. Reported U.S. commercial landings, estimated U.S. recreational catches and reported foreign catches of summer flounder, 1964-1980 (metric tons)

	Reported U.S. Commercial												
Year	Mass	RI	Conn	NY	NJ	Del	MD	Va	NC[a)]	TOTAL	FOREIGN[b)]	Estimated U.S. Rec.	U.S. Rec as % of U.S. TOTAL
1964	629	308	61	843	1669	7	254	678	936	5385	0		
1965	199	227	48	1114	1645	11	334	899	1813	6290	22	13432	68
1966	120	207	41	1121	1741	6	286	1065	1620	6207	31		
1967	203	321	22	893	1380	0	200	864	1755	5638	72		
1968	74	175	16	553	972	0	159	984	864	3797	35		
1969	35	121	10	261	580	0	92	685	950	2734	295		
1970	19	118	10	409	890	0	169	975	1192	3782	36	8778	70
1971	40	125	15	495	841	0	135	776	1659	4086	906		
1972	42	125	3	500	842	0	126	844	1750	4232	394		
1973	230	291	24	830	1405	*	225	1469	2928	7402	22		
1974	768	1160	12	1130	1590	0	322	1414	4627	11023	0	13137[c)]	67
1975	804	1406	18	1470	1960	2	406	1554	4431	12051	26		
1976	1841	3087	36	1456	2567	1	317	1501	4238	15044	9		
1977	672	1845	29	976	2985	2	331	2064	4742	13646	52		
1978	596	1456	73	885	2461	*	307	2700	4955	13433	12		
1979	559	1285	14	648	2854	*	777	4554	7436	18127	11	8626[c)]	45
1980[d)]	148	580	3	566	2184	0	602	3859	7674	15616			

a) Personal communication, NC Dept. of Nat. & Ec. Res.
b) ICNAF Subarea 5 and Statistical Area 6
c) Maine thru Virginia
d) Preliminary and incomplete
*) Less than 500 pounds

Sources: US Commercial Landings: Fishery Statistics of the US, 1964-1980

US Recreational Catches: Deuel, D.G. & J.R. Clark 1968. The 1965 salt-water angling survey. USF&WS Res. Publ. 67:51 p.

Deuel, D.G. 1973. 1970 salt-water angling survey. US Dept. Comm., Curr. Fish. Stat. 6200:54 p.

Deuel, D.G. 1977. Personal communication (1974 survey of marine anglers)

U.S. Dept. of Commerce. 1980. Marine recreational fishery statistics survey, Atlantic and Gulf Coasts, 1979. NOAA/NMFS Curr. Fish. Stat. 8063:139 p.

Foreign Catches: International Commission for the Northwest Atlantic Fisheries, Statistical Bulletins

TABLE 2. Parameters of the von Bertalanffy growth equation derived for summer flounder in the Middle Atlantic Bight. Asymptotic standard errors for each parameter in parentheses. Rao's homogeneity X^2 was used to test for sex related differences in the parameters L_∞ and k.

Parameter	Male	Female	X^2
L_∞	72.72 (6.36)	90.61 (6.14)	47.55**
k	0.17899 (.030007)	0.16406 (.02101)	0.169
t_0	-0.2587 (.16015)	0.0475 (.12719)	

TABLE 3. Estimates of annual survival rate and instantaneous fishing mortality rate for summer flounder based on tag-recapture experiments using the maximum likelihood method of Paulik (1963).

Area	Release Dates	Tag Type	Number Released	Number Recovered	$\hat{S}$	$\hat{F}$	Source
Nantucket Sound	Sept. 6-8, 21, 1962	Petersen Disc	600	245	0.307	0.482	Lux 1980
Block Island Sound	Sept. 6-8, 1962	Petersen Disc	406	203	0.289	0.622	Lux 1980
New Jersey	Sept. 23 - Oct. 19, 1980	Atkins Tag	692	96	0.174	0.244	Murawski 1970
New Jersey	July 31 - Aug. 10, 1961	Atkins Tag	613	133	0.102	0.496	Murawski 1970
New Jersey	July 18 - Aug. 31, 1961	Petersen Disc	2,767	949	0.314	0.397	Murawski 1970
New Jersey	June 20 - Aug. 29, 1966	Petersen Disc	1,392	420	0.147	0.580	Murawski 1970
New Jersey	June 12 - Aug. 22, 1966	Petersen Disc	1,205	296	0.192	0.407	Murawski 1970
North Carolina	Nov. 8, 1973 - Dec. 19, 1974	Petersen Disc	7,040*	178	0.343	0.107	Gillikin, Pers. Comm.
		>30 cm TL ONLY	2,300*	133	0.396	0.240	

*Adjusted total (see text)

TABLE 4. Estimates of annual survival rate and instantaneous rate of total mortality based on catch curve analysis of survey and commercial age-length data. Standard errors of estimates in parentheses.

	SURVEY				COMMERCIAL	
	FEMALE		MALE		SEXES COMBINED	
Sample Year	S	Z	S	Z	S	Z
1976	0.26 (.028)	1.35 (.109)	0.20 (.027)	1.60 (.138)	0.33 (.002)	1.10 (.005)
1977	0.35 (.041)	1.05 (.116)	0.41 (.046)	0.87 (.110)	0.10 (.006)	2.26 (.065)
1978	0.51 (.025)	0.68 (.050)	0.04 (.037)	2.85 (.037)	0.40 (.009)	0.91 (.024)
1979	0.51 (.031)	0.67 (.061)	0.41 (.035)	0.89 (.034)	0.13 (.006)	2.07 (.049)
TOTAL	0.40 (0.21)	0.93 (.053)	0.33 (.018)	1.11 (.055)		

Table 5. Effects on yield per recruit (kg) of varying age at entry to the fishery by adjusting minimum legal size limits at two levels of fishing mortality (0.50, 0.75) for male and female summer flounder at an assumed natural mortality rate of M = 0.2.

Mimimum Length (cm)	Male		Female	
	0.50	0.75	0.50	0.75
25.4 (10")	0.31	0.27	0.44	0.36
27.9 (11")	0.33	0.30	0.48	0.40
30.5 (12")	0.36	0.33	0.51	0.44
33.0 (13")	0.38	0.36	0.55	0.49
35.6 (14")	0.40	0.39	0.59	0.53
38.1 (15")	0.42	0.42	0.63	0.58

Table 6. Effect of varying instantaneous natural mortality rates (M) on yield per recruit (kg) and F_{max} (in parentheses) for male (M) and female (F) summer flounder.

	NATURAL MORTALITY					
	0.1		0.2		0.3	
	Male	Female	Male	Female	Male	Female
t_c = 2	0.485 (.26)	1.135 (.13)	0.310 (.32)	0.548 (.19)	0.212 (.40)	0.321 (.28)
t_c = 3	0.585 (.35)	1.276 (.16)	0.372 (.45)	0.632 (.25)	0.251 (.62)	0.379 (.42)
t_c = 4	0.690 (0.49)	1.424 (.20)	0.427 (0.66)	0.713 (.35)	0.279 (1.00)	0.429 (.69)

Table 7. Effect of varying growth parameters L_∞ and k by $\pm$ 10% on maximum yield per recruit (kg) and F_{max} (in parentheses) for female summer flounder.

	L	k	L_∞^{+10}	k^{+10}	L_∞^{-10}	k^{-10}
L_∞		0.55 (0.19)		0.65 (0.20)		0.45 (0.18)
k			0.75 (0.19)		0.39 (0.19)	
L_∞^{+10}				0.88 (0.20)		0.62 (0.18)
k^{+10}					0.48 (0.21)	
L_∞^{-10}						0.32 (0.18)

Table 8. Effects of varying growth parameters L_∞ and k by ± 10% on maximum yield per recruit (kg) and F_{max} (in parentheses) for male summer flounder.

	L	k	L_∞^{+10}	k^{+10}	L_∞^{-10}	k^{-10}
L_∞		0.31 (0.32)		0.37 (0.33)		0.25 (0.31)
k			0.42 (0.32)		0.22 (0.32)	
L_∞^{+10}				0.498 (0.33)		0.34 (0.31)
K^{+10}					0.27 (0.33)	
L_∞^{-10}						0.18 (0.32)

Table 9. 1980 reported U.S. commercial catches of summer flounder by distance from shore.

State	0-3 MILES Metric Tons	0-3 MILES Pounds (000's)	0-3 MILES Dollars (000's)	3-200 MILES Metric Tons	3-200 MILES Pounds (000's)	3-200 MILES Dollars (000's)
Massachusetts	82.2	181	194	65.5	144	102
Rhode Island	84.1	185	209	496.0	1,091	954
Connecticut	0	0	0	13.6	30	25
New York	496.0	1,091	1,044	70.5	155	149
New Jersey	224.5	494	335	1,959.5	4,311	2,390
Delaware	0	0	0	0	0	0
Maryland	29.5	65	48	572.3	1,259	572
Virginia	562.7	1,238	588	3,296.0	7,251	3,262
North Carolina	2,982.3	6,561	3,157	4,691.4	10,321	4,731
TOTALS	4,461.3	9,816	5,575	11,164.5	24,562	12,185
Percent of Grand Total		29	31		71	69

Source: National Marine Fisheries Service
Resource Statistics Division
Washington, D.C.

TABLE 10. Total commercial summer flounder landings and ex-vessel value from Massachusetts to North Carolina, 1964-1980.

Year	Landings (metric tons)	Ex-Vessel Value (000's dollars)
1964	5,385	2,804
1965	6,290	3,009
1966	6,207	3,019
1967	5,638	3,139
1968	3,797	2,541
1969	2,734	2,071
1970	3,782	2,636
1971	4,086	2,928
1972	4,232	3,301
1973	7,402	5,317
1974	11,023	6,675
1975	12,051	9,337
1976	15,044	13,727
1977	13,646	14,343
1978	13,433	17,249
1979	18,955	21,930
1980	15,616	28,212

Sources: Fishery Statistics of the U.S. 1964-1978
NMFS, Resources Statistics Division, Washington, DC
North Carolina Dept. of Natural & Economic Resources

TABLE 11 1979 and 1980 Summer Flounder Landings and Ex-Vessel Values by County for the States of Massachusetts to North Carolina (in descending order of landings).

NORTH CAROLINA

County	Landings (metric tons) 1979*	Landings (metric tons) 1980	Ex-Vessel Value (dollars) 1979	Ex-Vessel Value (dollars) 1980
Dare	3,263	2,809	3,469,574	2,695,806
Pamlico	2,427	2,127	2,495,600	2,133,529
Carteret	1,572	676	1,650,197	691,755
Onslow	383	198	445,806	213,337
Hyde	344	364	380,308	372,449
Beaufort	257	NA	284,873	NA
New Hanover	39	31	37,257	31,427
Brunswick	28	29	24,990	30,789
Pender	26	NA	32,816	NA
Craven	7	NA	8,148	NA
Tyrrel	5	NA	6,045	NA
Washington	1	NA	2,142	NA
Chowan	0.2	NA	297	NA
Pasquotank	0.1	NA	70	NA

VIRGINIA

County	Landings (metric tons) 1979	Landings (metric tons) 1980	Ex-Vessel Value (dollars) 1979	Ex-Vessel Value (dollars) 1980
City of Hampton	3,199	2,807	2,934,566	2,716,182
Accomac	780	300	844,260	347,488
Elizabeth City	242	97	257,538	86,678
City of Portsmouth	117	118	83,169	168,038
Northumberland	67	131	69,502	133,714
Mathews	53	21	54,371	22,799
City of Newport News	31	267	26,480	238,668
Northampton	25	35	26,343	46,397
Gloucester	13	25	11,863	32,129
Lancaster	7	0.8	6,910	1,147
York	4	23	3,368	20,359
City of Virginia Beach	3	25	4,280	30,721
Westmoreland	3	8	3,107	11,638
Prince William	0.2	0.1	142	97

*1979 landings for N.C. may include other paralichthids in addition to summer flounder

NA Data not available

TABLE 11. (continued)

NEW JERSEY

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Cape May	2,106	1,467	2,788,322	1,757,253
Ocean	628	502	958,174	704,617
Atlantic	89	80	137,852	116,869
Monmouth	24	36	45,746	65,763
Cumberland	0.7	1	1,037	1,271

RHODE ISLAND

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Washington	646	310	1,096,111	650,845
Newport	635	269	956,626	514,144

MARYLAND

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Worcester	774	596	809,939	614,524
St. Marys	1	2	1,058	2,418
Kent	0.9	0	858	0
Dorchester	0.7	3	727	3,372
Queen Annes	0.1	0	118	0
Calvert	0.1	0	133	0

NEW YORK

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Suffolk	572	441	1,020,131	929,822
Nassau	46	108	87,763	225,787
Kings	28	16	51,823	37,394
New York	1	0.2	1,660	350

TABLE 11 (continued)

MASSACHUSETTS

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Bristol	239	23	329,890	26,139
Barnstable	160	83	312,693	186,777
Dukes	44	30	98,244	66,657
Plymouth	19	2	36,140	3,042
Essex	2	2	1,229	1,430

CONNECTICUT

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
New London	10	2	17,775	4,199
New Haven	3	0.2	5,362	42
Fairfield	0.6	0.3	936	630
Middlesex	0.4	0.6	715	1,260

DELAWARE

County	Landings (metric tons) 1979	1980	Ex-Vessel Value (dollars) 1979	1980
Kent	0.3	0	225	0

Source: NMFS, Resource Statistics Division, Wash., D.C.

TABLE 12. 1980 U.S. Reported Commercial Landings of Top 10 Food Finfish (including squid and shrimp) Species from Massachusetts through North Carolina Ranked by Overall Landed Weight and Ex-Vessel Value.

Species	Metric Tons	% of Total	Species	Thousands of Dollars	% of Total
Atlantic cod	46,750	16.2	Atlantic cod	28,183	13.7
Atlantic herring	31,607	11.0	yellowtail flounder	19,452	9.5
haddock	20,845	7.2	SUMMER FLOUNDER	17,732	8.6
yellowtail flounder	18,875	6.6	haddock	17,653	8.6
winter flounder	16,359	5.7	shrimp	17,185	8.4
silver hake	15,819	5.5	winter flounder	13,118	6.4
SUMMER FLOUNDER	15,611	5.4	scup/porgies	7,296	3.6
weakfish	33,897	5.4	weakfish	6,995	3.4
pollock	23,852	3.8	silver hake	6,025	2.9
croaker	21,878	3.5	tilefish	6,014	2.9

Source: National Marine Fisheries Service -- State Monthly Bulletins

TABLE 13 Selected 1970 Population and Economic Characteristics for Counties with Significant Summer Flounder Landings.

Population	U.S.	Newport RI	Washington RI	Cape May NJ	Ocean NJ	Suffolk NY	Worcester MD	Accomac VA	City of Hampton VA	Carteret NC	Dare NC	Pamlico NC
Total (000)	203,212	95	86	60	208	1,295	24	29	120	32	7	9
% Change 60-70	13.3	15.1	45.1	22.7	92.6	69.0	3.0	-5.3	35.3	15.2	17.9	-3.9
% Net mig 60-70	1.7	.4	24.6	21.9	79.5	49.3	-5.5	-9.4	13.8	3.4	10.6	-10.5
% 18 yrs & over	65.6	69.6	68.0	71.7	67.1	60.3	65.2	65.7	63.0	66.2	69.2	62.9
% 65 yrs & over	9.9	7.2	7.8	20.0	15.8	7.6	12.9	7.9	5.0	9.1	13.1	11.6
Median age	28.3	23.9	23.7	38.9	32.7	26.4	31.9	27.0	24.4	28.5	34.3	29.5
Median school yrs completed	12.1	12.2	12.2	11.3	11.9	12.2	10.2	9.5	12.1	10.9	10.5	9.9
Labor Force												
Total (000)	82,049	47	37	21	71	404	10	11	50	12	3	3
Civilian (000)	80,051	27	28	20	69	403	10	11	42	12	2	3
% Fem/w husb.	57.0	56.9	58.3	54.8	59.9	61.3	60.1	59.7	65.0	66.0	62.2	63.9
% Unemployed	4.4	4.6	4.3	6.5	4.7	3.5	3.2	6.3	3.5	5.4	3.8	5.8
% Emp in mfg	25.9	17.0	27.9	11.4	18.6	21.8	22.3	23.7	23.1	14.4	5.7	20.5
% Emp oustide county	17.8	13.2	22.1	15.8	32.3	34.4	18.1	20.7	39.7	26.2	3.2	45.6
% Families/ female head	10.8	14.1	10.4	10.1	8.2	7.2	11.9	13.3	10.5	11.2	10.4	12.2
Median family income	$9,586	$9,162	$9,603	$8,295	$9,245	$12,081	$7,386	$5,670	$9,670	$7,155	$6,536	$5,761
% Families low income	10.7	11.7	9.0	8.9	6.8	4.6	17.3	25.2	8.8	16.6	13.7	11.2
Mfg. Estab.												
Total	311,140	53	74	52	184	1,475	50	56	59	60	4	13
% 20-99 emp	24.3	13.2	31.1	26.9	18.5	26.5	34.0	10.7	28.8	15.0	-	23.1
% Total Retail Sales												
Eating & drinking places	7.7	10.2	7.6	19.6	10.1	7.1	12.2	5.1	5.9	7.5	10.9	2.8
% Selected Services Receipts												
Hotels, etc.	11.6	27.8	25.7	58.3	30.6	7.4	51.2	NA	18.5	NA	NA	NA
Amusements	13.7	22.5	D	18.1	25.8	15.8	27.3	NA	D	NA	NA	NA

D = Data not available. NA = Not available.

From: County and City Data Book, 1972.

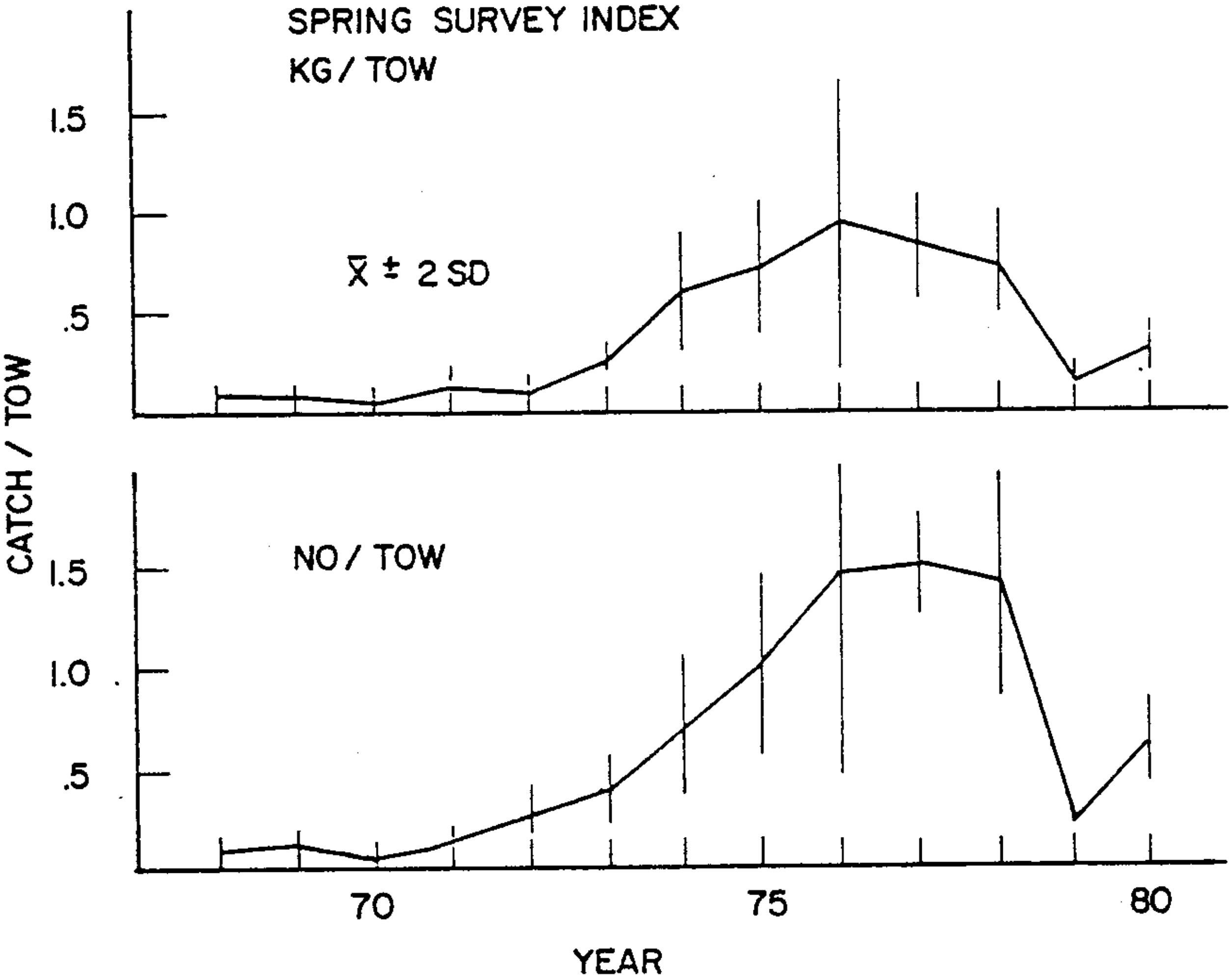

FIGURE 1. STRATIFIED MEAN CATCH PER TOW OF SUMMER FLOUNDER FOR NMFS, NEFC, SPRING BOTTOM TRAWL SURVEYS IN WEIGHT (UPPER) AND NUMBERS (LOWER).

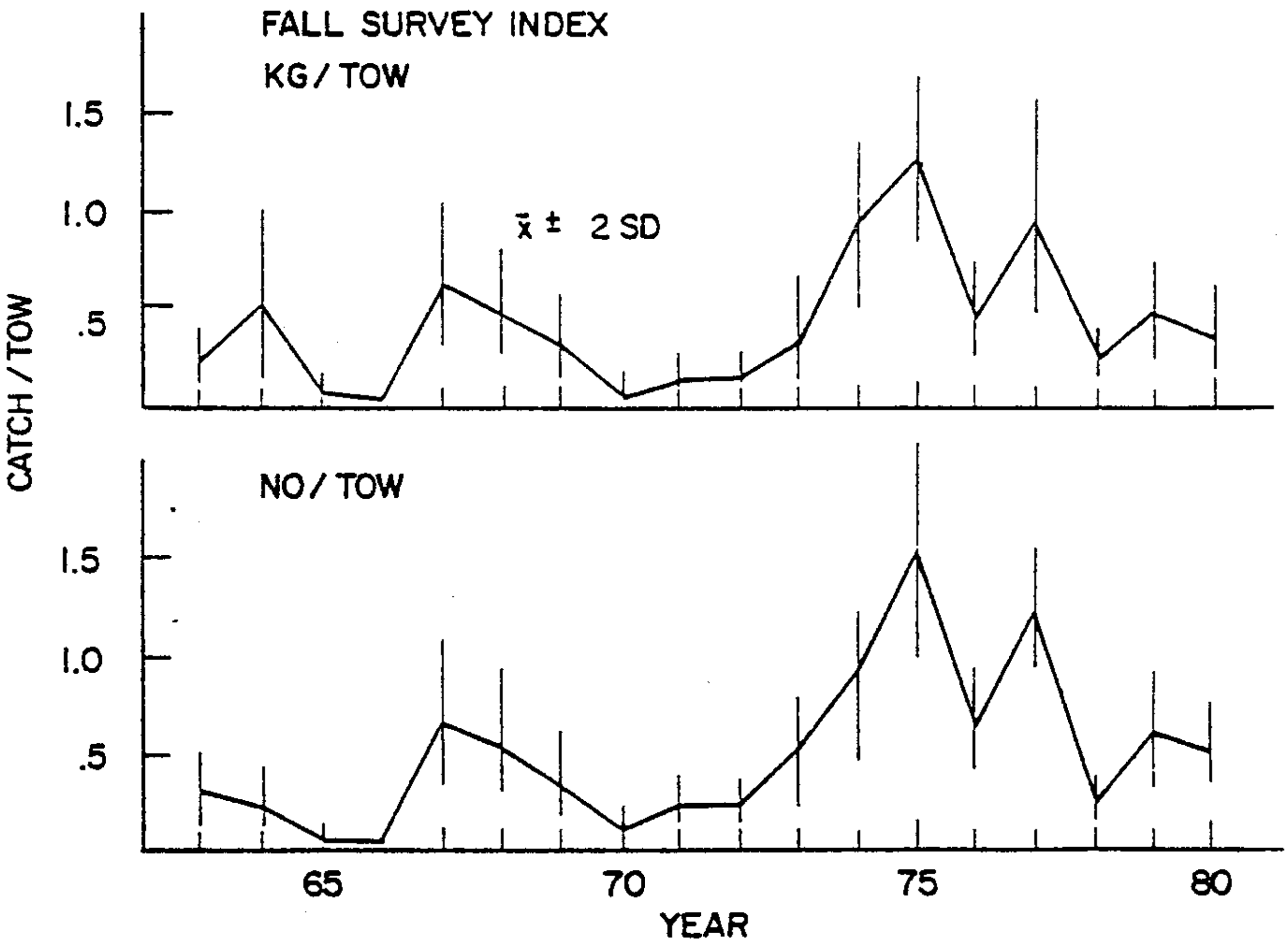

FIGURE 2. STRATIFIED MEAN CATCH PER TOW OF SUMMER FLOUNDER FOR NMFS, NEFC, AUTUMN BOTTOM TRAWL SURVEYS IN WEIGHT (UPPER) AND NUMBERS (LOWER).

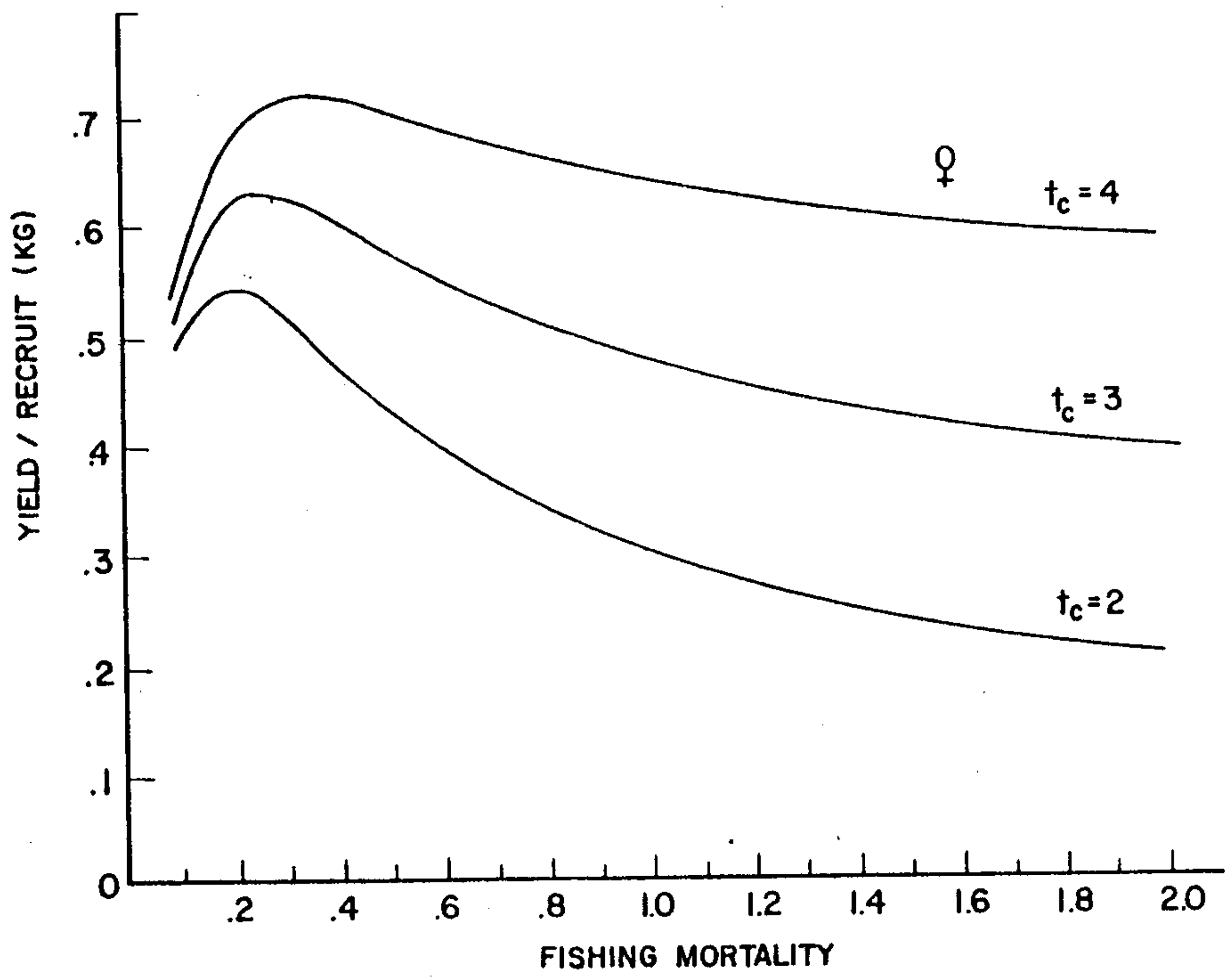

FIGURE 3. YIELD PER RECRUIT (KG) AS A FUNCTION OF FISHING MORTALITY FOR FEMALE SUMMER FLOUNDER ASSUMING M=0.2

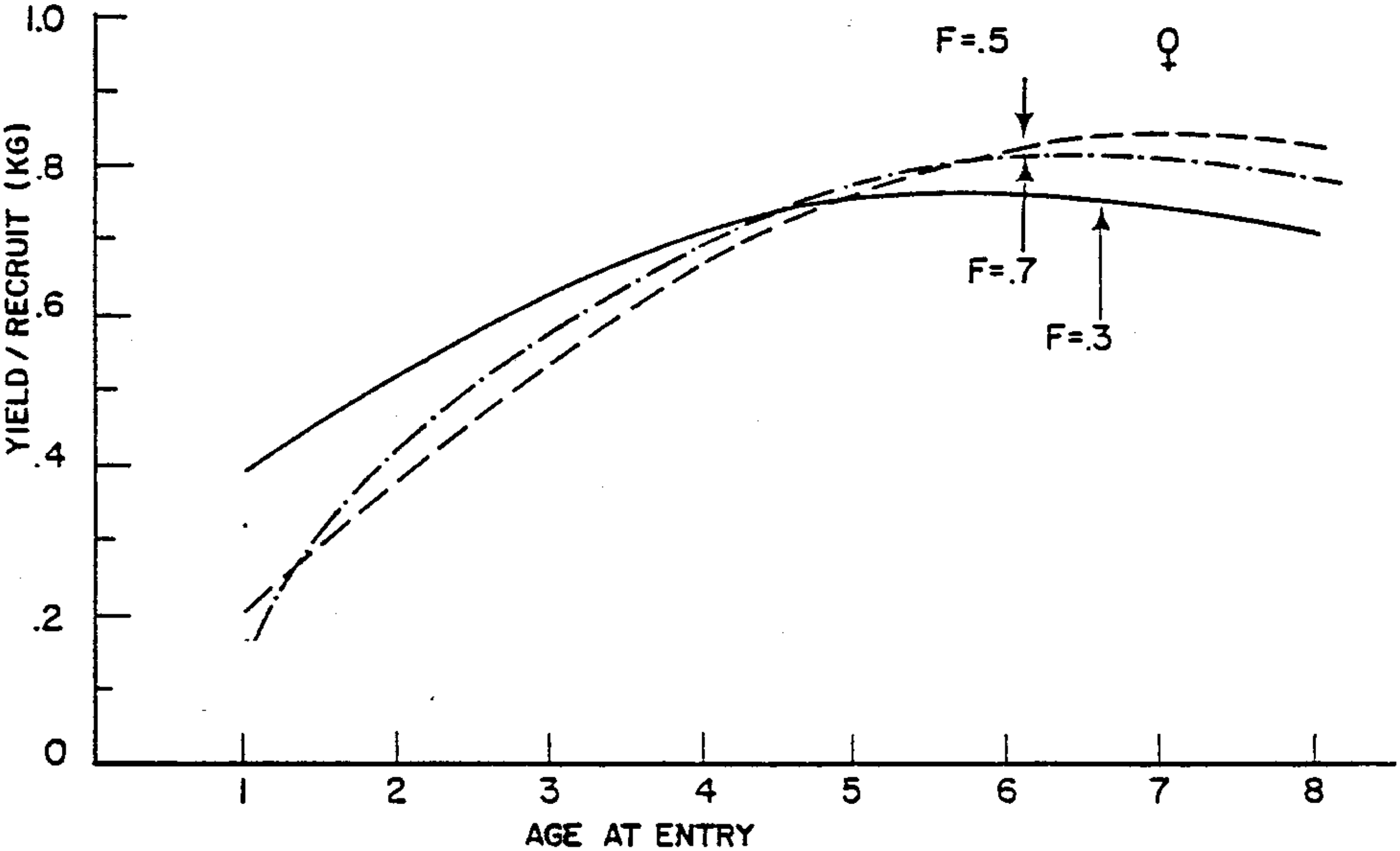

FIGURE 4. YIELD PER RECRUIT (KG) AS A FUNCTION OF AGE AT ENTRY TO THE FISHERY FOR FEMALE SUMMER FLOUNDER ASSUMING M=0.2

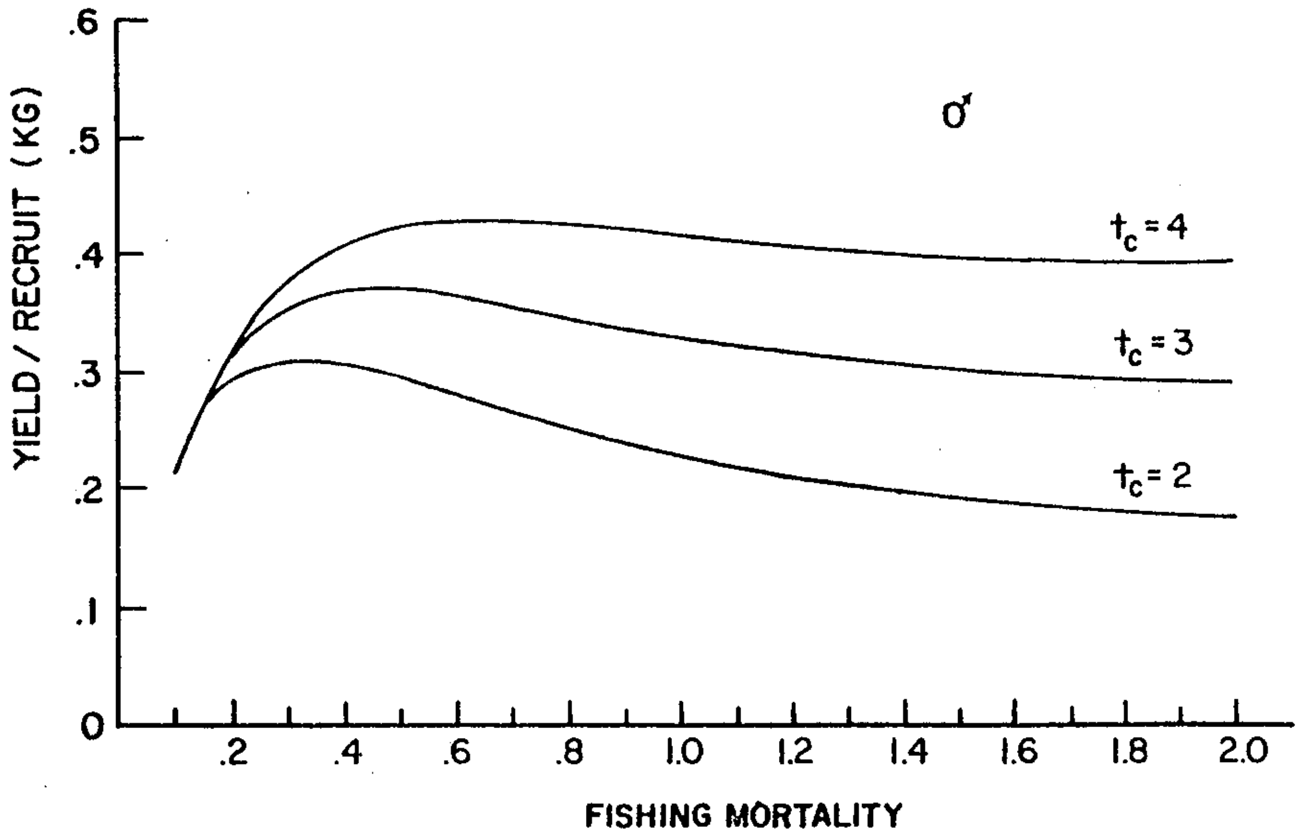

FIGURE 5. YIELD PER RECRUIT (KG) AS A FUNCTION OF FISHING MORTALITY FOR MALE SUMMER FLOUNDER ASSUMING M=0.2

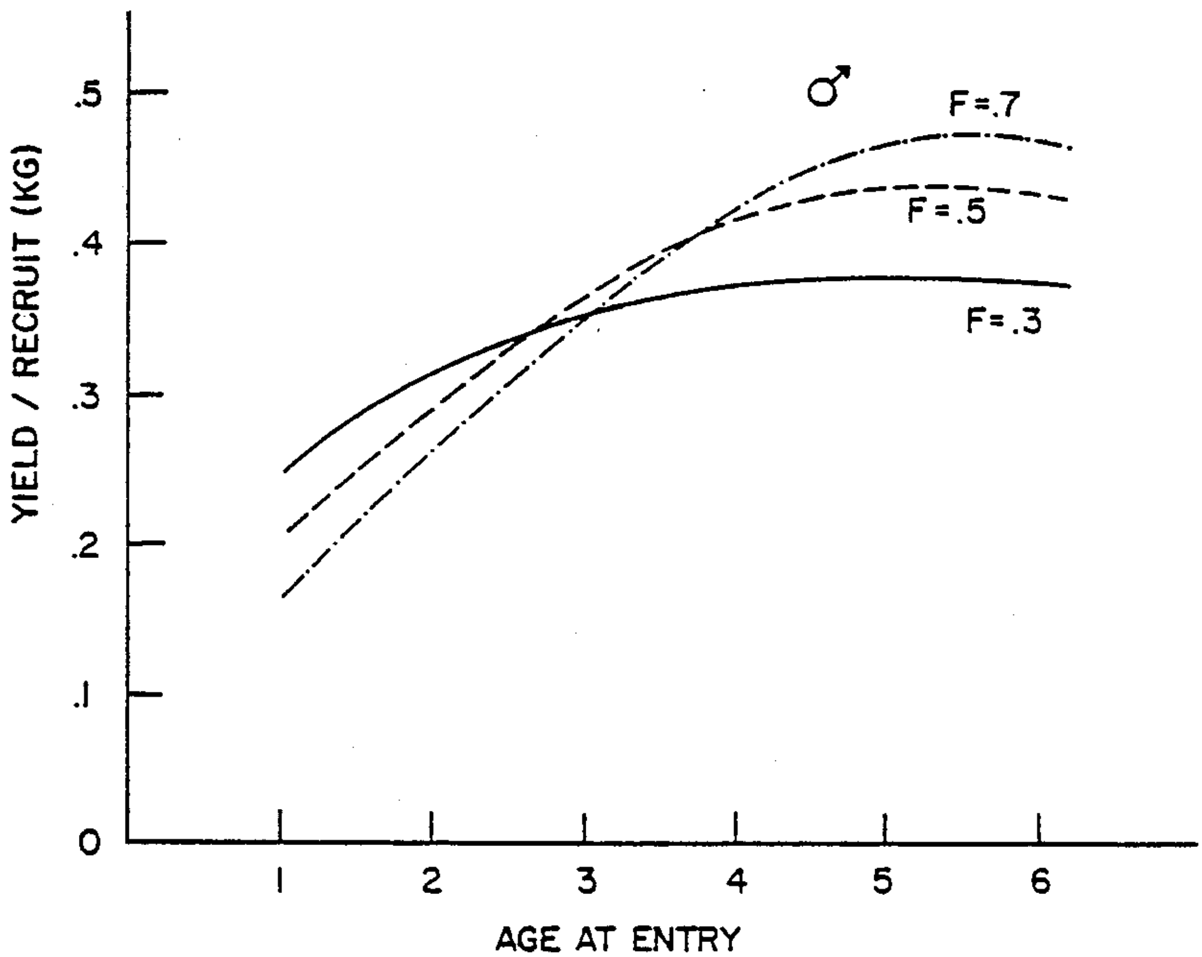

FIGURE 6. YIELD PER RECRUIT (KG) AS A FUNCTION OF AGE AT ENTRY TO THE FISHERY FOR MALE SUMMER FLOUNDER ASSUMING M=0.2.

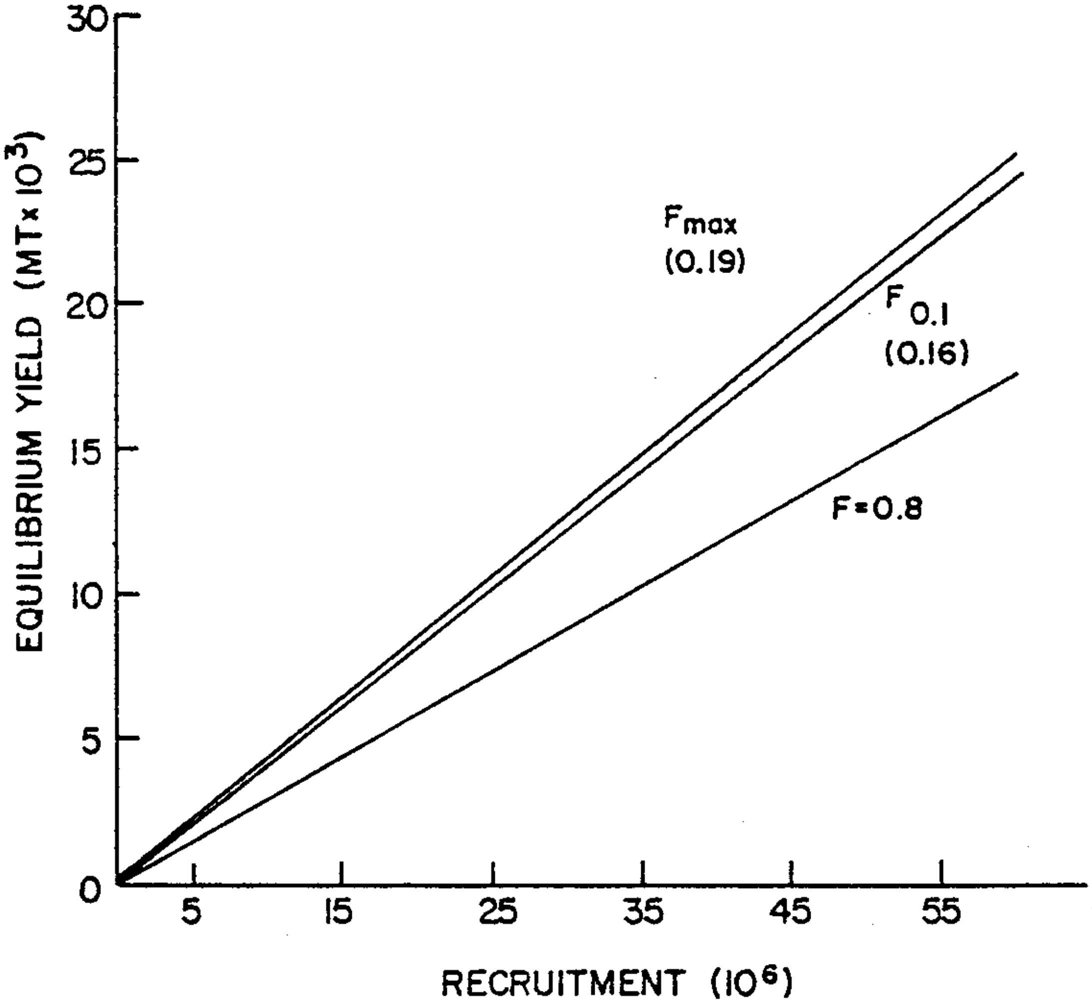

FIGURE 7. EQUILIBRIUM YIELD (MT) AS A FUNCTION OF RECRUITMENT LEVELS.

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