Summer Flounder (*Paralichthys dentatus*) in the Northwest Atlantic

by

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INTRODUCTION

This paper reviews and summarizes data, analyses, and literature on summer flounder (*Paralichthys dentatus*). The information in Chang and Pacheco (1975) is supplemented and updated. New information includes results of recent ageing studies, analysis of bottom trawl survey data, a fecundity study, a unit stock analysis, a von Bertalanffy growth curve, and new weight-length curves.

BACKGROUND

Paralichthys dentatus, commonly called summer flounder or fluke, are distributed from Cape Hatteras to Cape Cod, occurring regularly in the Middle Atlantic area, less regularly in southern New England, and sporadically on Georges Bank. Mean size and weight are comparable in the southern New England and Georges Bank areas, but are larger than those found in the Middle Atlantic. Discriminant analysis of morphometric factors showed no basis for dividing fluke into subpopulations north of Cape Hatteras (Wilk et al., 1979 MS). Fluke are rarely found deeper than 180 meters and have never been captured by Northeast Fisheries Center research vessel surveys in the Gulf of Maine.

Eggs are spawned during autumn migrations to offshore overwintering grounds (about 150 meters depth). Eggs and larvae are planktonic, with a net inshore drift. The fry become demersal on reaching the coast, and the first year is spent in bays or inshore areas (Smith, 1973). The migratory pattern varies with latitude, with fish spawning and moving offshore earlier in the northern part of the range. At the end of the first year, some of the juveniles join the adult migration. The offshore population returns to the coast and bays in the spring. Thus, all ages are exploited by inshore and bay fisheries, both recreational and commercial, while fish exploited by the offshore commercial fishery are usually older than age III. The offshore fishery operates selectively, using otter trawls and seeking concentrations of large fluke. Thus, the size composition of the offshore landings does not present a complete picture of the population age structure.

DATA BASE

Commercial fishery data were obtained from files at NEFC or from published state bulletins and annual summaries; foreign fishing data, from ICNAF Statistical Bulletins; recreational data, from Saltwater Angling Surveys and special surveys; and biological data, from NEFC annual spring and fall bottom trawl surveys, from the literature, and from NMFS port agents' sampling. Data varies in detail and in dates covered. Effort (days fished) is reported only for New England interviewed landings. Three market categories were reported for New England landings up to 1977, and four categories are to be reported for all landings starting in 1978. In some data sources, summer flounder are reported as "flounder." Length frequencies and scales for ageing were collected for N.E. interviewed

landings in sufficient amounts for analysis in 1976 and 1977.

LANDINGS

Table 1 shows that U.S. commercial landings declined from a high of almost 10,000 tons in 1956 to a low of less than 2,000 tons in 1969, followed by an increase to slightly over 10,000 tons in 1976. Landings in 1978 are estimated at 6,000 tons. Recreational data were available from Saltwater Angling Surveys in 1960, 1965, 1970, and 1974 (Clark, 1962; Clark, 1968; Deuel, 1973; Deuel, personal communication). Since summer and winter flounder were combined in the 1960 survey, the data were prorated to species using the average ratio of summer to winter flounder in the other three surveys. The ratio of recreational to commercial landings in the closest survey year multiplied by commercial landings was used to estimate recreational landings for the intervening years. The recreational fishery probably accounts for 50-75% of the total landings. Foreign landings have been minor, never exceeding 6% of the total.

Estimated total landings also declined from 22,000 tons in 1956 to 8,000 tons in 1969, then increased to a new high of 36,000 tons in 1976 Figure 1). The oscillating pattern could be the result of variations in spawning stock size, spawning success, environmental factors, fishing mortality, or violation of the underlying assumption necessary to estimate recreational catch during non-survey years. Table 2 summarizes data for 1974-1977, giving catch in tons by state where landed vs. area where caught. The table does not represent total landings since equivalent data was not available for all states. Changes in distribution and in fishing mortality are discussed in later sections. A chart of statistical areas is included for reference in Figure 1.

BIOLOGICAL PARAMETERS

The instantaneous rate of natural mortality, M, is assumed to be .2. Chang and Pacheco (1976) selected 0.2 as a realistic estimate of M after dismissing higher estimates based on analysis of tagging data because of the apparent violation of some assumptions of the analysis. Although some variability in M is suspected, we have no means of estimating that at present. For example, the immediate effects of anoxic water conditions off the New Jersey coast in 1976 were reviewed in Freeman and Turner (1977) and Festa (1977). The most common summer fishing grounds are not within the areas where anoxic conditions occurred. Thus, observations producing quantitative data on unusual events were relatively scarce. Immediate effects included high mortality from added fishing intensity and also from pathological behavior as fish became trapped in large numbers in shallow waters. Evidence of the effect of the anoxic water condition on reproductive success will become available in 1979 when the 1976 year-class recruits to the commercial fishery.

Minimum age or size at maturity observations that have been published are: age 3, Eldridge (1962); age 3 (39.0 cm, female, 30.5 cm, male) Smith (1969); and 16½" (42 cm), Hildebrand and Cable (1931). Fecundity data analyzed by W. Morse (1978, NEFC, Sandy Hook Laboratory, personal communication) showed 50% mature at 35 cm. A review of inshore and offshore bottom trawl survey data indicates that few fish less than 25 cm migrate offshore. Although the surveys showed that 30% of the population inside 27 meters consists of fish $\leq$25 cm whereas only 4% of the population beyond 27 meters meet this criterion, inshore and offshore surveys used different gear (offshore trawls had rollers). Thus, proportions of large and small fish captured might, to some degree, depend on gear rather than on relative abundance.

The impact of fishing may be indicated by changes in the maximum observed size of summer flounder. The maximum in 1976 commercial data was 77 cm (age VIII), while the last 10 years of survey data show a maximum of 79 cm (not aged). A fish caught in 1948 (Bigelow and Schroeder) was about 95 cm long and weighed about 9 kg. Unfortunately, these values are in the neighborhood of the maximum size obtained by the species, therefore its age cannot be estimated accurately, but it was probably significantly older than any fish noted in recent years. Since fish may be exploited one or more years before spawning the first time and repeat spawning in later years may be reduced by fishing mortality, it is important to investigate both of these factors and to evaluate their effect on the spawning stock, on subsequent recruitment, and on maintaining harvesting levels.

The date of spawning varies by area. Based on larvae catches, Poole (1966) reported the following seasonal pattern:

Narragansett Bay	late July-January
Block Island Sound	mid November
Manasquan Estuary, New Jersey	November-December
Southern New Jersey	December
Virginia, offshore	October-March
Chesapeake Bay	January-March
North Carolina Sounds	December-April

SPECIES ASSOCIATED WITH SUMMER FLOUNDER CATCH

A brief review of dealer sales slips for New England and New Jersey shows that trips landing summer flounder also landed mixed groundfish, winter flounder, Loligo, scup, black sea bass, conchs, tilefish, and witch flounder.

SURVEY INDICES

Tables 3-10 summarize the NEFC bottom trawl survey data for 1963-1978. Before analysis, survey strata were grouped to represent three main areas: Georges Bank, southern New England, and the Mid Atlantic. Strata 13-25 were assigned to the first group, 1-12 to the second, and 61-76 to the third (Figure 2). Spring surveys since 1973 used a modified Yankee number 41 trawl instead of the Yankee number 36 trawl. Survey data during the latter years were adjusted to correspond to a catch with the number 36 trawl based on the relative fishing power of the nets as estimated by Sissenwine and Bowman (1978).

Mean number per tow (Tables 3 and 4) is an index of population density, and mean weight per tow (Tables 5 and 6) is an index of population biomass per unit area. The differences between successive surveys (to the extent these exceed sample variability) represent the net change due to recruitment and mortality.

Fluke were essentially absent from the Georges Bank area from 1963-1973. Then, numbers and biomass increased gradually but have only reached levels in the "low range" compared to other areas. In the southern New England area, number and biomass values have been generally higher in the 1970's than in earlier years, with the autumn 1978 values lower than in recent years. In the Middle Atlantic, the same trend occurs, but mean number per tow values are consistently higher than in the more northern areas, and the decline in autumn 1978 values is more pronounced.

Population age composition in the three areas can be compared by looking at differences in mean length (Table 7-8) and mean weight (Table 9-10). There is a consistent trend from larger to smaller fish going from north to

south, implying that the mean age or growth rate in the stock may also decrease from north to south. The means are determined by the distribution of sizes present and are a complex resultant of number of recruits, age span of older fish present, growth rates, and, perhaps, migratory drift northward of larger fish. Further analysis of the data base would be required to provide further information on these factors.

AGE COMPOSITION

Scales collected from 1976 commercial samples were aged by NEFC. The samples represented fish from Georges Bank and southern New England, but no samples were obtained from the Middle Atlantic. Samples were classified by market category as small, medium, large, or jumbo. Numbers of aged fish of age i and length j from each sample were weighted by sample size and vessel landings within category, then by landings per category for each month. The final frequencies were averaged to give mean length at age by month (Table 11). Samples for July, August, and December were too small to be used.

A review of length samples from commercial catches showed that only fish above a retention length of about 30 cm were represented, so that mean length for age class II and possibly for age class III would be overestimated. A straight line was fitted for $L_{t+1} = A + B\ L_t$, using only fully recruited ages at one year intervals. L_∞ and k were calculated from the equations $L_\infty = A/(1-B)$, $k = -\ln B$. t_0 was calculated by assuming that length at hatching, .30 cm, corresponds to (natural) age 0. The resulting parameters for mixed sexes are:

$A = 17.424$ $L_\infty = 92.24$ $t_o = -.01556$ (natural age)

$B = .8111$ $k = .20939$

The von Bertalanffy equation for the mean length of a fish at age t is $L(t) = L_\infty (1-e^{-k(t-to)})$. Smith and Daiber (1977) obtained values of A and B for fish from Delaware Bay and North Carolina:

$A = 13.672$ $B = .843$ females

$A = 14.38$ $B = .767$ males,

indicating that growth rate is slower for the fish in their samples vs. those in the commercial samples above. These values are smaller than Smith's earlier values (1969):

$A = 15.126$ $B = .812$ females

$A = 16.38$ $B = .703$ males

Smith and Daiber contains a good review of discrepancies encountered in ageing studies where otoliths were used. A comparative study of ageing by scales, otoliths, and finrays is ongoing (at NEFC).

The commercial samples also provided mean length-mean weight values for fitting a weight-length curve, $W = al^b$. The resulting values are $a = 5.4427 \times 10^{-6}$ and $b = 3.1170$ for weight in grams, length in millimeters. Other values in the literature are summarized in Table 12. Some apparent discrepancies may be accounted for by selective fishing for large fish in spring and fall migrations, or by lack of growth in November-January, followed by rapid growth in February-March, Eldridge (1962).

Figure 3 is a plot of length at age and weight at age based on the N.E. commercial samples. Although no fish from the Middle Atlantic were included, miscellaneous observations of length at age from the literature fall near the

curve. The curve was used to assign length ranges approximating age classes at dates corresponding to the spring and fall NEFC bottom trawl surveys (Table 13). These length ranges were then applied to the length frequencies in the survey data (for all strata) to obtain estimates of age composition. Since age I fish in the fall survey will be II in the spring survey, corresponding values of stratified means were combined to represent mean population size on the intervening January 1. The numbers shown are proportional to the numbers of fish overwintering in the offshore area outside 27 meters.

Table 14 shows that classes II and possibly III are not fully recruited to the offshore stock, that recruitment and total stock were low from 1970 to 1973 in comparison to other years, with the 1967-1969 year-classes extremely poor.

MORTALITY ESTIMATES

Estimates of Z in Table 15 represent total mortality, that is, offshore and inshore commercial fisheries, recreational and foreign fisheries, and natural mortality. Estimates of Z were calculated using values from Table 14, summed over fully recruited ages, and VPA formulas, with an assumed starting value of Z = 0.5 in 1977. Although the values look excessively high, there is currently no alternative data for estimating Z. Note that recent estimates of Z in Table 15 are most sensitive to errors in the assumed value of Z for 1977. The calculated value of Z is the effective total annual mortality rate resulting from the separate seasonal fishing mortality rates effected by the various fisheries.

SUMMARY

Summer flounder are migratory. The general pattern is an inshore-offshore migration for purposes of feeding, spawning, and overwintering. There may be a secondary annual drift northward of older fish. The effect of environmental

changes on migration patterns or spawning success is not known. Variability in abundance and recruitment probably increases with latitude.

The fishery operates over the whole range, in bays, inshore coastal areas, and offshore. The largest component, the recreational fishery, has the smallest data base. Landings track abundance as measured by bottom-trawl surveys. Over the last 20 years, abundance has been variable. Total estimated landings have varied from 8,000 to 36,000 metric tons, with a 28-year average of about 19,000 tons.

Biological studies are cumulating, but the results often disagree. Qualitative conclusions are that the fish are heavily exploited, beginning at age I or II, with full recruitment at age III or IV. First maturity occurs at about age III. The current life span is 6 or 7 years, with a potential life span of 15 to 20 years.

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Figure 1. ICNAF Statistical Divisions and statistical areas within Divisions in Subareas 4-6.

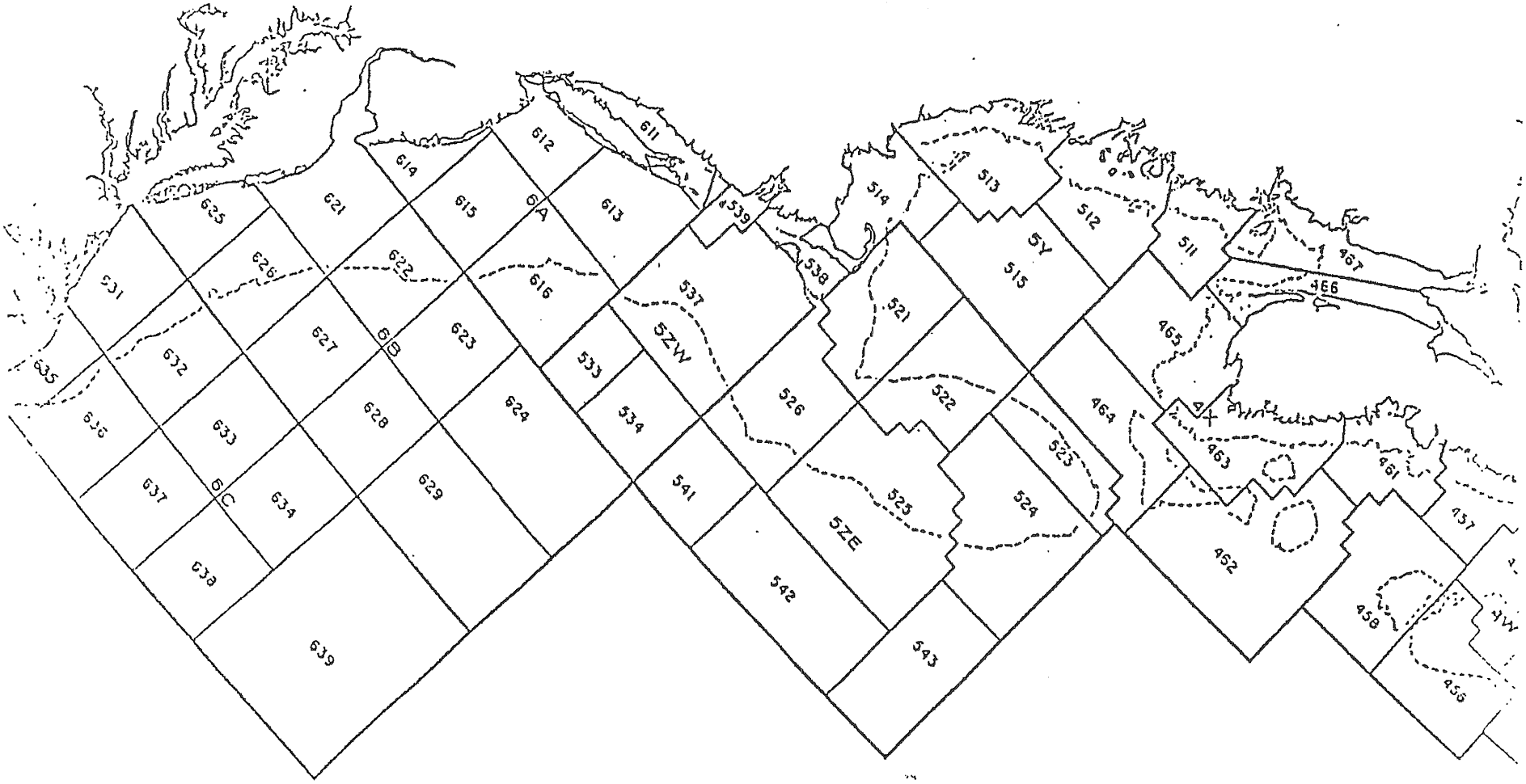

Figure 2. Research vessel bottom trawl survey strata.

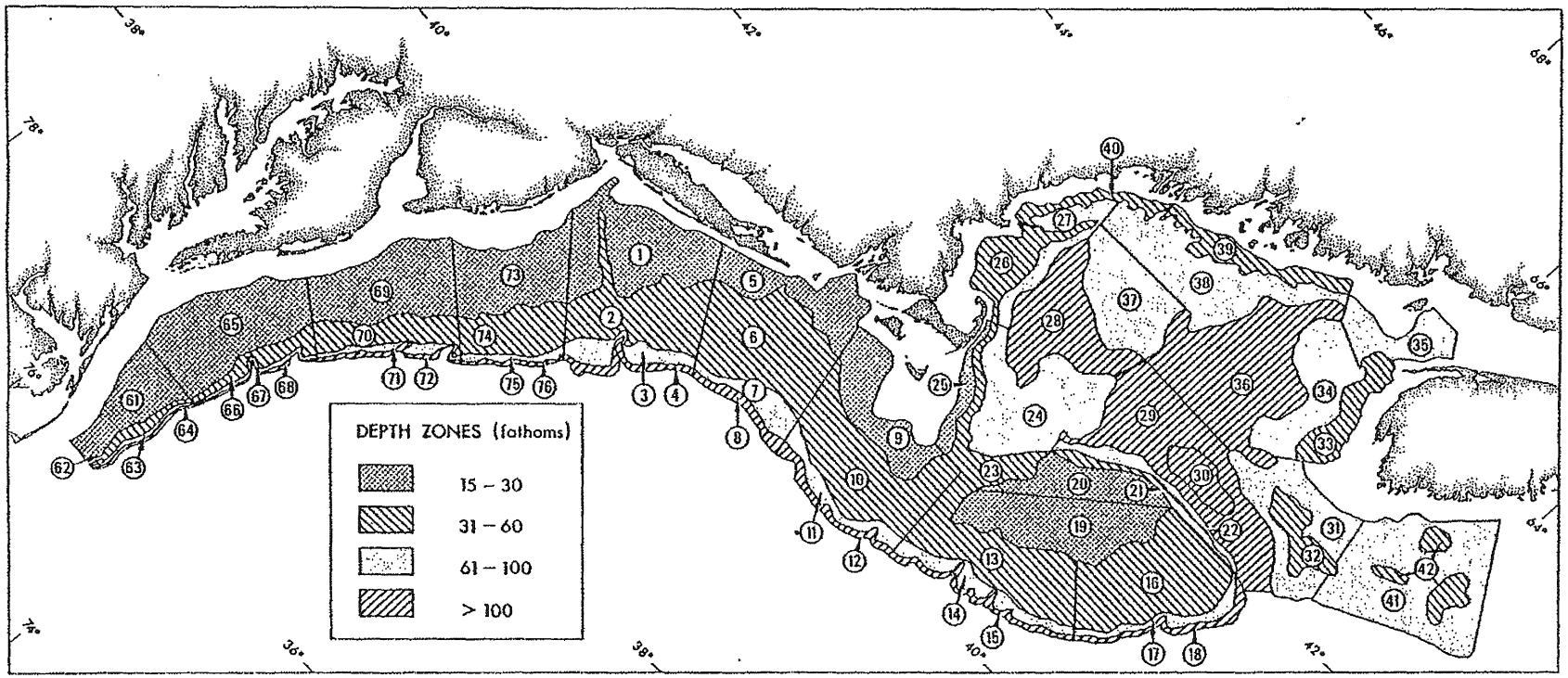

Figure 3. Length and weight of fluke by age class.

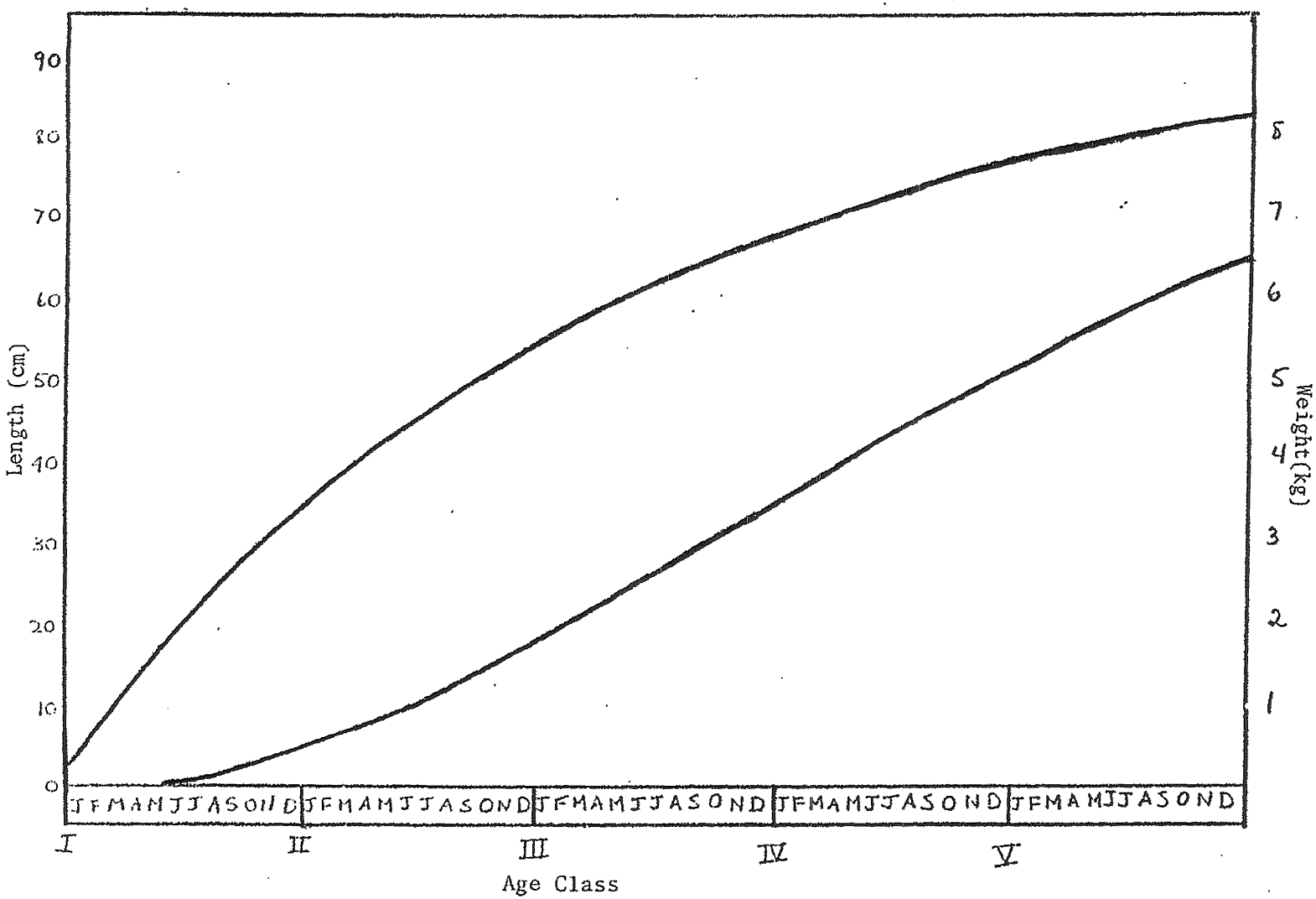

Table 1. Summer flounder landings in metric tons, Gulf of Maine to Middle Atlantic, 1950-1978.

Year	U.S.A. Commercial	U.S.A.* Recreational	Other Countries	Estimated total
1950	6,169	8,187		14,356
1951	6,345	8,421		14,766
1952	7,924	10,517		18,441
1953	8,332	11,058		19,390
1954	8,880	11,785		20,665
1955	8,437	11,198		19,635
1956	9,657	12,817		22,474
1957	8,896	11,807		20,703
1958 3/	8,905	11,819		20,724
1959	8,936	11,860		20,796
1960 2/	9,004	11,950		20,954
1961	7,941	10,539		18,480
1962	6,163	8,179		14,342
1963	4,964	14,933		19,897
1964	4,439	13,354		17,793
1965 1/	4,465	13,432	22	17,919
1966	4,578	13,772	31	18,381
1967	3,873	11,651	72	15,596
1968	2,926	9,936	35	12,897
1969	1,782	6,051	294	8,127
1970 1/	2,585	8,778	36	11,399
1971	2,423	8,228	904	11,555
1972	2,478	8,415	393	11,286
1973	4,464	10,488	22	14,974
1974 1/	6,738	15,830		22,568
1975	7,540	17,714	26	25,280
1976	10,862	25,519	15	36,396
1977	8,868	20,834	5	29,707
1978 4/	6,000	14,000		20,000

1/ Recreational data from saltwater angling surveys (see text).
2/ Summer flounder prorated from "flounder" in saltwater angling survey.
3/ Maryland and Virginia reported "flounder" until 1958.
4/ Preliminary estimates.

*Recreational landings in non-survey years estimated from the ratio of recreational and commercial landings in the closest survey year.

Table 2. Summer flounder landings in metric tons, by state landed, and U.S. statistical area (see Figure 2), 1974-1977.

	512-513	514	521	522	523	524	525	526	537	538	539	611	612	613	614	615	616	621	622	625	626	631	632	635	Total
1977																									
ME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA	-	26.1	9.7	5.6	.1	6.4	7.1	76.8	24.2	379.3	-	-	-	.8	-	.3	44.3	-	-	-	-	-	-	-	581
RI	-	-	2.7	2.6	.1	6.0	6.8	693.1	466.2	66.9	111.6	26.8	-	183.2	.7	31.9	238.1	2.4	-	-	-	-	.9	-	1841
NY	-	-	-	-	-	-	-	-	.3	5.6	.2	266.7	118.5	446.6	-	1.5	134.2	-	-	-	-	-	-	-	974
NJ	-	-	-	-	-	-	-	-	58.4	4.4	-	5.3	116.9	317.4	56.7	59.9	507.8	1074.6	747.5	.5	28.9	-	-	-	2978
VA	-	-	-	-	-	-	-	-	-	-	-	-	.4	-	-	9.0	5.5	124.3	35.2	683.4	528.7	344.2	177.0	143.1	2051
ME-VA	-	26.1	12.4	8.2	.2	12.4	13.9	769.9	549.1	456.2	111.8	298.8	235.8	948.0	57.4	102.6	929.9	1201.3	782.7	683.9	557.6	344.2	177.0	143.1	8425
1976																									
ME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA	.4	23.0	23.0	11.8	1.5	10.7	29.1	127.2	369.2	972.2	-	-	-	7.2	-	.6	188.8	-	11.7	-	-	-	-	-	1777
RI	-	-	.7	3.5	-	4.1	6.1	430.4	1067.0	195.8	216.0	25.7	14.5	200.5	-	9.4	865.8	2.8	37.8	-	-	-	-	-	3080
NY	-	-	-	-	-	-	-	-	41.8	191.5	-	323.5	213.9	540.1	-	6.3	135.6	-	-	-	-	-	-	-	1453
NJ	-	-	-	-	-	-	-	-	-	-	-	69.0	29.8	154.8	111.9	142.5	365.7	1117.5	570.3	-	-	-	-	-	2562
VA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.4	-	51.1	14.9	349.1	603.8	362.3	42.1	74.7	1498
ME-VA	.4	23.0	23.7	15.3	1.5	14.8	35.2	557.6	1478.0	1359.5	216.0	418.2	258.2	902.6	111.9	159.2	1555.9	1171.4	634.7	349.1	603.8	362.3	42.1	74.7	10369
1975																									
ME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA	.7	16.5	14.3	12.6	-	5.5	14.6	111.3	152.6	427.3	.2	-	.2	.1	-	.4	4.8	-	.1	-	-	-	-	-	761
RI	-	-	.1	4.5	-	4.1	13.7	98.0	789.5	138.3	186.7	30.4	17.7	26.2	-	-	93.7	-	-	-	-	-	-	-	1403
NY	-	-	-	-	-	.4	.4	-	7.0	-	-	390.1	463.8	604.0	-	.7	-	-	-	-	-	-	-	-	1466
NJ	-	-	-	-	-	-	-	-	-	-	17.6	.1	76.3	93.4	198.4	446.6	.3	866.7	257.5	-	-	-	-	-	1957
VA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138.6	22.0	605.4	335.0	300.7	148.4	-	1550
ME-VA	.7	16.5	14.4	17.1	-	10.0	28.7	209.3	949.1	565.6	204.5	420.6	558.0	723.7	198.4	447.7	98.8	1005.3	279.6	605.4	335.0	300.7	148.4	-	7137
1974																									
ME	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MA	-	26.6	14.4	5.0	1.0	3.2	13.5	44.7	73.6	546.9	-	-	-	-	-	2.0	2.2	.2	-	-	1.8	-	-	-	735
RI	-	-	1.0	1.0	.1	6.3	5.4	194.1	434.8	133.9	147.9	78.3	-	73.5	-	-	27.0	-	-	-	.9	-	-	-	1104
NY	-	-	-	-	-	-	-	-	-	-	.3	195.4	512.7	418.7	-	.9	-	-	-	-	-	-	-	-	1128
NJ	-	-	-	-	-	-	-	-	-	-	-	-	263.8	21.8	248.1	287.7	20.1	711.6	5.7	-	-	28.6	-	-	1587
VA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75.0	8.0	404.0	222.6	281.0	224.0	196.5	1411
ME-VA	-	26.6	15.4	6.0	1.1	9.5	18.9	238.8	508.4	680.8	148.2	273.7	776.5	514.0	248.1	290.6	49.3	786.8	13.7	404.0	225.3	309.6	224.0	196.5	5966

Delaware, Maryland, North Carolina do not report.

Table 3. Summer flounder mean number per tow from USA spring bottom trawl surveys, 1968-1978, by area.

Spring	Georges Bank	So. New England	Mid-Atlantic	Total
1968	.0	.055	.272	.099
1969	.0	.0	.416	.122
1970	.0	.0	.197	.058
1971	.0	.133	.326	.143
1972	.0	.015	1.018	.305
*1973	.004	.316	.973	.399
*1974	.093	.997	1.249	.750
*1975	.028	1.895	1.176	1.015
*1976	.029	2.379	2.215	1.498
*1977	.059	1.621	3.128	1.511
*1978	.268	.959	3.372	1.424

*Corrected for #41 Yankee trawl by dividing by 1.23.

Table 4. Summer flounder mean number per tow from USA autumn bottom trawl surveys, 1963-1978, by area.

Autumn	Georges Bank	So. New England	Mid-Atlantic[1/]	Total[1/]
1963	.0	.598	-	.296
1964	.0	.414	-	.206
1965	.0	.062	-	.031
1966	.0	.019	-	.010
1967	.0	.017	2.279	.676
1968	.0	.037	1.819	.548
1969	.0	.099	.918	.305
1970	.0	.075	.174	.077
1971	.0	.021	.683	.208
1972	.0	.206	.419	.196
1973	.066	.441	.957	.439
1974	.034	1.264	1.375	.861
1975	.151	1.021	4.001	1.589
1976	.106	.682	1.124	.608
1977	.351	1.325	2.110	1.211
1978	.117	.337	.128	.197

[1/] Mid-Atlantic not sampled in 1963-1966.

Table 5. Summer flounder mean weight per tow (kg) from USA spring bottom trawl surveys, 1968-1978, by area.

Spring	Georges Bank	So. New England	Mid-Atlantic	Total
1968	.0	.076	.261	.103
1969	.0	.0	.352	.104
1970	.0	.0	.187	.055
1971	.0	.305	.249	.180
1972	.0	.020	.428	.133
*1973	.002	.407	.404	.263
*1974	.064	.969	.947	.642
*1975	.034	1.788	.449	.785
*1976	.018	1.890	1.092	.992
*1977	.050	1.085	1.624	.876
*1978	.223	.785	1.455	.782

*Corrected for #41 Yankee trawl by dividing by 1.31.

Table 6. Summer flounder mean weight per tow (kg) from USA autumn bottom trawl surveys, 1963-1978.

Autumn	Georges Bank	So. New England	Mid-Atlantic[1/]	Total[1/]
1963	.0	.538	-	.266
1964	.0	.928	-	.462
1965	.0	.055	-	.027
1966	.0	.088	-	.004
1967	.0	.099	2.013	.627
1968	.0	.159	1.513	.501
1969	.0	.246	.760	.310
1970	.0	.153	.045	.067
1971	.0	.038	.413	.135
1972	.0	.249	.147	.131
1973	.012	.610	.333	.316
1974	.039	1.928	.849	.941
1975	.204	1.154	2.922	1.337
1976	.162	.749	.550	.482
1977	.339	1.594	1.074	.996
1978	.176	.517	.048	.258

[1/] Mid-Atlantic not sampled in 1963-1966.

Table 7. Mean length (cm) of summer flounder from USA spring bottom trawl survey, 1968-1978, by area.

Spring	Georges Bank	So. New England	Mid-Atlantic
1968	-	47.0	41.5
1969	-	-	42.2
1970	-	-	44.7
1971	-	53.8	42.0
1972	-	49.5	33.9
1973	42.0	46.6	32.8
1974	41.0	44.5	40.0
1975	49.9	44.7	31.4
1976	36.5	42.3	34.3
1977	43.7	39.5	34.7
1978	44.5	41.8	34.1

Table 8. Mean length of summer flounder from USA autumn bottom trawl surveys, 1963-1978, by area.

Autumn	Georges Bank	So. New England	Mid-Atlantic[1/]
1963	-	46.8	-
1964	-	58.4	-
1965	-	44.5	-
1966	-	42.0	-
1967	-	78.0	41.4
1968	-	68.0	40.4
1969	-	55.1	41.8
1970	-	50.5	31.7
1971	-	48.0	37.3
1972	-	50.3	33.2
1973	54.0	46.1	33.5
1974	45.5	47.0	35.4
1975	50.3	44.5	38.5
1976	47.7	44.9	34.6
1977	44.1	45.7	35.1
1978	49.3	48.7	32.0

[1/] Mid-Atlantic not sampled in 1963-1966.

Table 9. Mean weight (kg) of summer flounder from USA spring bottom trawl surveys, 1968-1978, by area.

Spring	Georges Bank	So. New England	Mid-Atlantic
1968	-	1.365	.957
1969	-	-	.846
1970	-	-	.947
1971	-	2.297	.764
1972	-	1.361	.420
1973	.453	1.370	.442
1974	.737	1.035	.807
1975	1.296	1.005	.407
1976	.650	.846	.525
1977	.927	.713	.553
1978	.883	.872	.460

Table 10. Mean weight (kg) of summer flounder from USA autumn bottom trawl surveys, 1968-1978, by area.

Autumn	Georges Bank	So. New England	Mid-Atlantic[1/]
1963	-	.900	-
1964	-	2.243	-
1965	-	.897	-
1966	-	.454	-
1967	-	5.897	.883
1968	-	4.309	.832
1969	-	2.477	.828
1970	-	2.044	.259
1971	-	1.814	.605
1972	-	1.205	.350
1973	1.814	1.383	.348
1974	1.134	1.525	.617
1975	1.351	1.130	.730
1976	1.536	1.098	.489
1977	.968	1.203	.509
1978	1.507	1.534	.375

1/ Mid-Atlantic not sampled in 1963-1966.

Table 11. Mean length per year class, of summer flounder, taken in the 1976 New England commercial fishery, by month.

	YEAR CLASS						
	1974	1973	1972	1971	1970	1969	1968
January	32.31	38.12	43.54	52.16	59.44	69.44	75.50
February	31.45	35.69	43.51	51.51	61.43	65.00	-
March	29.51	36.90	43.93	50.09	62.59	59.18	-
April	-	36.62	43.48	51.45	65.25	68.00	-
May	29.66	34.52	45.14	55.35	56.82	-	-
June	32.12	36.58	45.08	54.72	61.30	-	-
July	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-
September	34.82	39.97	46.00	55.05	57.76	-	-
October	35.57	40.30	50.76	60.66	67.00	-	-
November	35.38	42.34	52.93	55.05	65.40	-	-
December	-	-	-	-	-	-	-

Table 12. Published values of parameters for the length-weight equation, $W = aL^b$, for summer flounder.

Source	Area	Sex	$a(X10^{-6})$	b
Wilk, et al. (1978)	New York Bight	Male	5.1452	3.1265
		Female	2.8288	3.2263
		Combined	7.6666	3.0609
Smith and Daiber (1977)	Delaware Bay and North Carolina	Male	10.2	2.994
		Female	2.27	3.246
		Combined	4.04	3.151
Eldridge (1962)	Hampton Roads (commercial samples)	Male	30.257	2.81601
		Female	3.1405	3.20947
Lux and Porter (1966)	New York Bight (commercial samples)	Combined		
		Quarter 1	1.1641	3.3525
		Quarter 2	1.3872	3.3238
		Quarter 3	1.2758	3.3430
		Quarter 4	5.3220	3.1099

Table 13. Summer flounder estimated length-ranges per age class, by season, based on length at age curve (Figure 3).

Assigned age class	Length range	
	Spring	Autumn
I	-18	-25
II	19-32	26-38
III	33-43	39-48
IV	44-52	49-56
V	53-60	57-63
VI	61-66	64-69
VII	67-71	70-73
VIII	72-75	74-77
IX	76-78	78-81
X	79-81	

Table 14. Estimates of survey catch of summer flounder, per age class.

Jan. 1	II	III	IV	V	VI	VII	VIII	IX	Total
1968	196	678	1281	252	13	69	0	0	2489
1969	33	1134	604	250	84	0	26	21	2152
1970	-	416	509	165	62	0	0	16	1168
1971	39	330	174	98	22	0	22	21	706
1972	559	672	340	49	26	0	0	0	1646
1973*	648	654	364	165	37	0	9	34	1911
1974*	249	2359	744	260	100	40	63	0	3815
1975*	916	2222	2097	403	303	83	37	43	6104
1976*	1117	5016	2495	942	283	13	16	19	9901
1977*	1540	3378	1211	488	159	0	16	0	6792

*Corrected for #41 trawl in spring surveys.

Table 15. Estimates of total mortality (Z) for summer flounder based on catch at age[1/].

Year	Z
1968	1.416
1969	1.355
1970	1.268
1971	.910
1972	.532
1973	.534
1974	.659
1975	.913
1976	.986

1/ Estimated from survey length ranges (see Table 13).