Papers of the Northeast Regional
Stock Assessment Workshops

Length Composition Analysis of Atlantic Sea Scallop Using the Multifan Method

by

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LENGTH COMPOSITION ANALYSIS OF ATLANTIC SEA SCALLOP USING THE MULTIFAN METHOD

Introduction

This analysis was prepared for the Sea Scallop Methods Working Group to provide estimates of growth and total mortality rate for sea scallops. Two types of data were used, length frequency information from sea scallop surveys and commercial sea scallop size composition data. Results of these analyses are reported herein.

MULTIFAN and Sea Scallop Survey Data, 1982-1990

We applied MULTIFAN (Fournier et al. 1990, Fournier et al. 1991) to Northeast Fisheries Center (NEFC) sea scallop survey length frequency data from the Delmarva, South Channel, and NY Bight strata sets for 1982-1990. MULTIFAN is a likelihood-based method using the mixture of distributions approach for the classification of lengths to age, with consideration of biological constraints, to simultaneously analyze several length frequency distributions sampled at different times.

The major assumptions of the method include 1) the lengths of the animals in each age class are normally distributed about the mean length at age, 2) growth follows the von Bertalanffy function, and 3) standard deviation of lengths about the mean length at age varies as a simple function of mean length at age. The log-likelihood function used in MULTIFAN compares the expected probability that a fish picked at random will lie in a given length interval with the observed number of fish in that interval, for the set of growth parameters being tested. The statistical basis of MULTIFAN allows for a structured and relatively objective means of evaluating alternative interpretations of the processes producing the observed length frequency distributions, i.e., the growth rate and resulting number of significant age classes. One may also include selectivity on the youngest age class and evidence of a length dependent trend in the standard deviation of length at age as additional model terms. The basic set of parameters in terms of which the model can be expressed and the log-likelihood function calculated thus includes 1) the proportions at age, 2) the mean length of the first age group, 3) the mean length of the last age group, 4) the von Bertalanffy growth parameter K, 5) two parameters which determine the standard deviation of length at age, 6) a parameter determining the extent of selectivity bias on the first age group, and 7) a parameter determining the overall variance of the sampling errors in the length frequency data sets (see Fournier et al. 1991 for detailed notation of the MULTIFAN model parameterization for survey data).

For example, in the case of two suspected age classes underlying a set of five length frequency samples, the model would have a total of nine parameters. The addition of one age class to the model (one age, five samples) would increase the number of parameters by one to ten. Accounting for a length dependent trend in standard deviation of length at age (LDSD) in the three age class case would increase the number of parameters by one to eleven; accounting for selectivity bias on the first age group would again increase the number of parameters estimated by one to twelve. A chi-square test is used to determine the best fitting growth structure. The statistical significance of increases in the log-likelihood values obtained by the addition of age classes are determined by the 0.90 point of the chi-square random variable; the significance of the addition of other parameters is determined at the 0.95 level (Fournier et al. 1990). After an initial inspection of modes apparent in the length frequency data, initial constraints for MULTIFAN may include reasonable ranges for 1) the number of expected age classes, 2) the corresponding values for the von Bertalanffy parameter K, and 3) ranges for the mean lengths at age of obvious modes.

For the MULTIFAN analysis of NEFC survey data, scallops with shell heights less than or equal to 22 mm were excluded, because of their apparently limited availability/catchability to the survey, and some uncertainty about possible changes in the survey protocol for measuring small scallops. Since our version of MULTIFAN can look at five samples per run, and initial inspection of the data suggested that modal length at age varied considerably over time and between areas, several different aggregations of annual samples were tested to find the best combination that could be fit with an average growth pattern. Final runs were for Delmarva 1982-1986 and 1987-1990, South Channel 1982-1986 and 1987-1990, and NY Bight 1982-1984, 1985-1988, and 1989-1990.

For background perspective on the MULTIFAN results, consider empirical scallop mean shell height at age data compiled by the NEFC Fisheries Biology Investigation (FBI) from an age validation study for scallops from New York Bight: age 3 - 56.0 mm, age 4 - 85.0 mm, age 5 - 103.2 mm, age 6 - 111.3 mm, age 7 - 116.5 mm, age 8 - 122.0 mm, age 9 - 132.4 mm, and age 10 -128.0 mm. Fitting a von Bertalanffy curve to these data, ages 3-10 only, provides K = 0.442, L_{inf} = 132.5 (t_0 = 1.734). Initial constraints for the MULTIFAN runs were therefore set to a range of 4 to 6 age groups, with K varying from 0.3 to 0.5.

Results for Delmarva

1982-1986:

Initial runs did not converge to reasonable results, due to difficulties in interpreting the age of the relatively large number of age 2 scallops, shell height range 27-32 mm, present in the 1984 to 1986 samples. Including selectivity bias on the first (age 2) age group as an added model parameter did not resolve this problem, as the age 2 animals in the samples are just too large relative to the true mean shell height at age 2 for MULTIFAN to fit a reasonable growth function. With these animals removed from the samples by beginning the length intervals at 37 mm, subsequent analysis of the Delmarva 1982-1986 data provided the best fitting parameters of the seven runs: K = 0.325, L_{inf} = 159 mm, with six significant age classes (Table 1, Figure 1).

1987-1990:

These data were difficult to fit with an average growth function, due to the changing position of modes, with the apparently abundant 1985 and 1986 cohorts exhibiting mean shell heights at ages 3 and 4 nearly 10 mm smaller than the shell heights at age of previous cohorts. The best fit was for 4 age classes with K = 0.599 and L_{inf} = 120 mm (Table 2, Figure 2).

Summarized Delmarva 1982-1990:

The summary age composition combining the results of both runs, formatted in the original scale, was used for calculating total instantaneous mortality rates (Z) for age 3 to 4 and 4 to 5 by simple ratios of ln CPUE. Results look reasonable (cohorts generally decline in abundance with age), and provide evidence of high and possibly increasing mortality rates in the Delmarva region (Table 3).

Results for South Channel

1982-1986:

Growth structure for these samples was fit reasonably well, with the best fit for eight age classes, K = 0.279, L_{inf} = 148 mm (Table 4, Figure 3). Note that all cohorts increased in abundance from 1984 to 1985, suggesting the influence of changing catchability and/or sampling error between these years. This phenomenon might also be caused by MULTIFAN; if large cohorts have a larger than average standard deviation of length at age, some of the age 3 scallops from the strong 1983 year class may be incorrectly classified to older ages.

1987-1990:

Again, a reasonable fit was obtained, and with the slowest growth/smallest shell heights of the seven runs (Table 5). Note especially the modal shell heights of the 1984 (first mode in 1987) and 1986 (first mode in 1990) cohorts at age 3 (Figure 4). Based on the trend in cohort abundances, the same phenomena that affected 1984/1985 may also be influencing 1989/1990.

Summarized South Channel 1982-1990:

As noted above, the 1984/1985 and 1989/1990 problems result in apparently unreasonable Z estimates for the affected cohorts (1980-1982, 1985-1986). The remaining estimates suggest mortality rates that may be even higher than those in the Delmarva region (Table 6).

Results for NY Bight

The shifts in mean shell height at age apparent in the Delmarva 1988 and 1989 samples were even more troublesome in the NY Bight samples. Initially, we attempted to aggregate the samples into groups of three (1982-1984, 1985-1987, and 1988-1989). The small size of the age 3 mode in 1988 provided unreasonably low numbers of age 4 animals (corresponding to the large cohort at age

3 in 1987) when samples were aggregated in this order. We shifted 1988 to the 1985-1987 aggregation for the final run.

1982-1984:

The best fit was for 5 significant age classes with K = 0.361 and L_{inf} = 158 mm (Table 7, Figure 5). The estimated abundance of age 4 scallops in 1984 seems underestimated; MULTIFAN did not "expect" so many animals from the 1980 cohort in 1984, given the relatively low number present in 1983 at age 3.

1985-1988:

The best fit for these data was for 5 significant age classes with K = 0.615 and L_{inf} = 116 mm (Table 8). This fit does not match the mean length of the 1985 cohort very well (age 3 in 1988), but the resulting resolution to age, corresponding to the first normal distribution in 1988, seems reasonable (Figure 6).

1989-1990:

With 1988 removed, a fairly good description of the growth structure for these data was obtained, with best fit for 4 age classes, K = 0.397 and L_{inf} = 116 mm (Table 9, Figure 7).

Summarized NY Bight 1982-1990:

The value of Z is undefined for the 1981 cohort at age 3 in 1984 and the 1985 cohort at age 3 in 1988, but it is not clear if this is the result of sampling variability, catchability problems due to patchy distribution, or the partial selection of age 3 scallops by the survey dredge. In general, mortality rates seem lower than for the Delmarva and South Channel regions (Table 10).

MULTIFAN and Commercial Sea Scallop Data

Since April 1987, sea scallop vessels based in Virginia, fishing mainly in the Delmarva region, have provided shellstock samples (generally one basket of scallops) from their last tows to Kirkley and DuPaul of VIMS. We attempted to resolve these raw shell height frequency data to ages using MULTIFAN. An initial look at these VIMS commercial shell height frequency distributions found them to be nearly unimodal, making it unlikely that any length frequency analysis method could provide reasonable results without some 'subjective interference.' Initial MULTIFAN runs could produce reasonable results when the number of possible age classes was set at 2-10, with K set at 0.4-0.8 in 0.10 steps, but when we attempted to estimate K for the best fitting number of age groups (7) within these constraints, MULTIFAN converged to unreasonably low values of K (e.g., 0.01 to 0.02) and correspondingly high values of L_{inf}, as it tried to fit several age groups within the single dominant mode.

We next examined NEFC survey data that would be comparable to the VIMS commercial samples, i.e., the Delmarva strata set for 1987-89 (1990 not available at the time of the analysis). These survey data show a bimodal length frequency distribution. Initial search range was for 2-10 possible age classes, with K range from 0.3 to 0.5, with a best fit for 3 age classes, K = 0.699, L_{inf} = 123.4.

With a reasonable description of the growth pattern for summer sampled Delmarva scallops in hand, we looked at the VIMS commercial sample data aggregated over the same period (July-August, but including 1990 samples). While the NEFC survey data begin with age 3 (mode at about 55 mm), the VIMS commercial data begin with age 4 (mode at 90 mm). The commercial data also include a greater proportion of animals larger than 100 mm than do the survey data. We attempted to classify the commercial shell heights to ages by searching in the range of K determined to be appropriate by our examination of the survey data, but without letting MULTIFAN estimate K. The search was for 2-8 age classes, with K from 0.5 to 0.8 in 0.05 steps. Table 11 shows results for the "best fit" of this constrained search; 5 significant age classes, K = 0.5. The primary mode (age 4) is fit well in all samples. Given these parameters, the small mode in 1990 at about 110 mm is called age 5, and the small modes at 125 mm and 130 mm in 1989 are classified as age 6 and ages 7/8+, respectively (Figure 8).

The VIMS data as resolved to age are simply aggregated raw sample data, and to do mortality estimation, they need to be standardized. One method would have been to raise the shell height sample to the total baskets caught on a per time for individual tow basis (since tow times vary) and then taking a mean of all tows, as with the standard treatment of NEFC survey data, to get mean number at length per time towed, before looking at the data with MULTIFAN. But, since we had already aggregated the raw data from all sample baskets to form the distributions for these initial runs, to see if MULTIFAN would work at all, we had to do something else post-facto (there was no time during the meeting at which these data were analyzed to go back and recompile the data). We have the data for total number of sample baskets, the total number of baskets caught on sampled tows, and the total number of minutes towed. We raised the combined sample numbers at age by the ratio of total baskets to sampled baskets, to get number at age in all baskets caught. Numbers at age were then divided by the total minutes (or hours) towed to derive c.p.u.e. at age (numbers at age per hour towed). Table 12 shows the results of that exercise.

References

Fournier, D.A., J.R. Sibert, J. Majkowski, and J. Hampton. 1990. MULTIFAN a likelihood-based method for estimating growth parameters and age composition form multiple length frequency data sets illustrated using data for southern bluefin tuna (Thunnus maccoyii). Can. J. Fish. Aquat. Sci., 47:301-317.

Fournier, D.A., J.R. Sibert, and M. Terceiro. 1991. Analysis of length frequency samples with relative abundance data for the Gulf of Maine northern shrimp (Pandalus borealis) by the MULTIFAN method. Can. J. Fish. Aquat. Sci. 48:591-598.

TABLE 1. NEFC SEA SCALLOP SURVEY: DELMARVA 1982-1986

Objective function value = 2205.07104; total penalty = 0.01413
Maximum gradient component = 0.00030
Approximate number of degrees of freedom: 117

Number of age classes: 6
Parameter Estimates:
von Bertalanffy K = 0.325 (1/year); L infinity = 158.8

First Length = 65.856; Last Length = 140.520; Brody rho = 0.722

Mean shell height at age:
65.86 91.67 110.31 123.77 133.50 140.52
Standard Deviations of shell height at age:
8.34 8.34 8.34 8.34 8.34 8.34

NEFC SEA SCALLOP SURVEY: DELMARVA 1982-1986

Numbers at age:
Sample

Coded Age	1982	1983	1984	1985	1986
1	13110	29507	12194	61248	153146
2	2844	5807	13170	4615	39598
3	5964	1260	2592	4984	2984
4	1741	2642	562	981	3223
5	2220	771	1179	213	634
6	2669	2165	1311	942	747
n	28548	42152	31007	72983	200332

TABLE 2. NEFC SEA SCALLOP SURVEY: DELMARVA 1987-1990

Objective function value = 1722.17505; total penalty = 0.18931
Maximum gradient component = 0.00023
Approximate number of degrees of freedom: 94

Number of age classes: 4
Parameter Estimates:
von Bertalanffy K = 0.599 (1/year); L infinity = 120.1

First Length = 54.407; Last Length = 109.139; Brody rho = 0.549

Mean shell height at age:
54.41 83.97 100.22 109.14
Standard Deviations of shell height at age:
8.36 8.36 8.36 8.36

NEFC SEA SCALLOP SURVEY: DELMARVA 1987-1990

Numbers at Age:
Sample

Coded Age	1987	1988	1989	1990
1	34755	79510	133784	22628
2	49114	10274	54056	54645
3	25596	14519	6985	22079
4	199	7626	15055	9002
n	109664	111929	209880	108354

TABLE 3. NEFC SEA SCALLOP SURVEY: DELMARVA 1982-1990
SUMMARY AGE FREQUENCY
STRATIFIED MEAN NUMBER PER TOW

	YEAR								
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990
~~3~~	~~13.1~~	~~29.5~~	~~12.2~~	~~61.2~~	~~153.1~~	~~34.8~~	~~79.5~~	~~133.8~~	~~22.6~~
4	2.8	5.8	13.1	4.6	39.6	49.1	10.3	54.0	54.6
5	6.0	1.3	2.6	5.0	3.0	25.6	14.5	7.0	22.1
6+	6.0	5.6	3.1	2.1	4.5	2.0	7.6	15.1	9.0

COHORT TOTAL MORTALITY RATES (Z):

COHORT	AGE 3/4	AGE 4/5
1978	n/c	0.767
1979	0.815	0.802
1980	0.812	0.963
1981	0.975	0.427
1982	0.440	2.937
1983	1.437	1.220
1984	1.217	0.386
1985	0.387	0.893
1986	0.896	n/c

u = undefined
n/c = not calculated

TABLE 4. NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1982-1986

Objective function value = 2131.98096; total penalty = 0.11419
Maximum gradient component = 0.00035
Approximate number of degrees of freedom: 129
Number of age classes: 8

Parameter Estimates:
von Bertalanffy K = 0.279 (1/year); L infinity = 148.4

First Length = 56.216; Last Length = 135.339; Brody rho = 0.756

Mean shell height at age:
56.22 78.67 95.66 108.50 118.22 125.57 131.13 135.34
Standard Deviations of shell height at age:
11.28 11.28 11.28 11.28 11.28 11.28 11.28 11.28

NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1982-1986

Numbers at Age:
Sample

Coded Age	1982	1983	1984	1985	1986
1	205585	13718	12912	32540	114673
2	36961	47182	3206	22505	11276
3	6284	8483	11025	5587	7798
4	1746	1442	1982	19215	1936
5	1604	401	337	3455	6658
6	3070	368	94	587	1197
7	5001	705	86	163	204
8	5855	2492	747	1452	560
n	266107	74790	30388	85504	144301

TABLE 5. NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1987-1990

Objective function value = 1064.59802; total penalty = 0.05546
Maximum gradient component = 0.00061
Approximate number of degrees of freedom: 100
Number of age classes: 7

Parameter Estimates:
von Bertalanffy K = 0.149 (1/year); L infinity = 198.1

First Length = 50.638; Last Length = 137.944; Brody rho = 0.861

Mean shell height at age:

50.64	71.11	88.74	103.92	116.99	128.25	137.94

Standard Deviations of shell height at age:

9.66	9.66	9.66	9.66	9.66	9.66	9.66

NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1987-1990

Numbers at Age:
Sample

Coded Age	1987	1988	1989	1990
1	68833	23628	19360	238455
2	37925	21943	6065	36671
3	20734	12090	5633	11489
4	6712	6609	3103	10669
5	2050	2140	1697	5878
6	1043	653	549	3214
7	1232	725	354	1711
n	138528	67788	36761	308086

TABLE 6. NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1982-1990
SUMMARY AGE FREQUENCY
STRATIFIED MEAN NUMBER PER TOW

	YEAR								
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990
3	205.6	13.7	12.9	32.5	114.7	68.8	23.6	19.4	238.5
4	37.0	47.2	3.2	22.5	11.3	37.9	21.9	6.1	36.7
5	6.3	8.5	11.0	5.6	7.8	20.7	12.1	5.6	11.4
6+	17.3	5.4	10.0	24.9	10.5	11.0	10.0	5.7	21.5

COHORT TOTAL MORTALITY RATES (Z):

COHORT	AGE 3/4	AGE 4/5
1978	n/c	1.471
1979	1.472	1.456
1980	1.454	u
1981	u	1.059
1982	1.056	u
1983	1.107	1.142
1984	1.145	1.364
1985	1.353	u
1986	u	n/c

u = undefined
n/c = not calculated

TABLE 7. NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1982-84

Objective function value = 1221.47400; total penalty = 0.00772
Maximum gradient component = 0.00053
Approximate number of degrees of freedom: 71
Number of age classes: 5

Parameter Estimates:
von Bertalanffy K = 0.361 (1/year); L infinity = 158.2

First Length = 49.542; Last Length = 132.577; Brody rho = 0.697

Mean shell height at age in month 1:
49.54 82.47 105.43 121.43 132.58
Standard Deviations of length at age in month 1:
11.57 11.57 11.57 11.57 11.57

NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1982-84

Numbers at age:

	Sample		
Coded age	1982	1983	1984
1	9659	12708	18691
2	15690	3912	7576
3	2644	6355	2332
4	1660	1071	3789
5	2005	1484	1523
n	31658	25530	33911

TABLE 8. NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1985-88

Objective function value = 1694.23206; total penalty = 0.02583
Maximum gradient component = 0.00022
Approximate number of degrees of freedom: 102
Number of age classes: 5

Parameter Estimates:
von Bertalanffy K = 0.615 (1/year); L infinity = 115.6

First Length = 53.861; Last Length = 110.295; Brody rho = 0.541

Mean shell height at age in month 1:
53.86 82.20 97.52 105.81 110.29
Standard Deviations of length at age in month 1:
9.69 9.69 9.69 9.69 9.69

NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1985-88

Numbers at age
Sample

Coded age	1985	1986	1987	1988
1	44762	48816	89873	53175
2	18958	29646	21674	79378
3	2943	12581	13163	19143
4	1472	1953	5586	11626
5	4332	3852	2578	7210
n	72378	96848	132873	170532

TABLE 9. NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1989-90

Objective function value = 833.34131; total penalty = 0.06641
Maximum gradient component = 0.00089
Approximate number of degrees of freedom: 47
Number of age classes: 4

Parameter Estimates:
von Bertalanffy K = 0.397 (1/year); L infinity = 116.2

First Length = 43.278; Last Length = 94.011; Brody rho = 0.672

Mean shell height at age in month 1:
43.28 67.16 83.21 94.01
Standard Deviations of length at age in month 1:
8.35 8.35 8.35 8.35

NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1989-90

Numbers at age:

Coded Age	Sample 1989	Sample 1990
1	145630	33563
2	55472	108167
3	27637	41202
4	13302	30407
n	242040	213339

TABLE 10. NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1982-1990
SUMMARY AGE FREQUENCY
STRATIFIED MEAN NUMBER PER TOW

	YEAR								
AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990
3	9.7	12.7	18.7	44.7	48.8	89.9	53.2	145.6	33.6
4	15.7	3.9	7.6	19.0	29.6	21.7	79.4	55.5	108.2
5	2.6	6.4	2.3	2.9	12.6	13.2	19.1	27.6	41.2
6+	3.7	2.6	5.3	5.8	5.8	8.2	18.8	13.3	30.4

COHORT TOTAL MORTALITY RATES (Z):

COHORT	AGE 3/4	AGE 4/5
1978	n/c	0.897
1979	0.911	0.528
1980	0.513	0.963
1981	u	0.411
1982	0.412	0.808
1983	0.810	0.128
1984	0.124	1.057
1985	u	0.298
1986	0.297	n/c

u = undefined
n/c = not calculated

Table 11. VIMS COMMERCIAL SAMPLES: JULY-AUGUST 1987-1990

Objective function value = 1816.85901; total penalty = 0.12534
Maximum gradient component = 0.00078
Approximate number of degrees of freedom: 73
Number of age classes: 5

Parameter Estimates:
von Bertalanffy K = 0.500 (1/year); L infinity = 141.6

First Length = 92.344; Last Length = 134.933

Mean length at age in month 1:
92.34 111.72 123.48 130.61 134.93
Standard Deviations of length at age in month 1:
7.82 7.82 7.82 7.82 7.82

VIMS COMMERCIAL SAMPLES: JULY-AUGUST 1987-1990

Coded Age	Numbers at age: Sample			
	1987	1988	1989	1990
1	2427	3580	2413	1959
2	281	1454	339	320
3	12	132	187	56
4	13	131	57	11
5	60	103	239	42
n	2794	5400	3235	2388

Table 12. Derivation of index of abundance at age from VIMS commercial sample data, 1987-1989.

RAW NUMBERS AT AGE FROM ALL SAMPLE BASKETS

TRUE AGE	YEAR 1987	1988	1989	1990
4	2427	3580	2413	1959
5	281	1454	339	320
6	12	132	187	56
7	13	131	57	11
8+	60	103	239	42
Total	2794	5400	3235	2388

BASKETS, MINUTES

	YEAR 1987	1988	1989	1990
#BASKETS SAMPLED	12.20	32.85	14.95	11.60
#BASKETS CAUGHT	49.25	214.25	65.00	40.50
RAISE FACTOR	4.04	6.52	4.35	3.49
TOTAL TOW MINUTES	380	1437	804	505
TOTAL TOW HOURS	6.33	23.95	13.40	8.42

STEP 1. TOTAL NUMBER AT AGE (NUMBER PER SAMPLE * RAISE FACTOR) IN ALL BASKETS

TRUE AGE	YEAR 1987	1988	1989	1990
4	9805	23342	10497	6837
5	1135	9480	1475	1117
6	48	861	813	195
7	52	854	248	38
8+	242	672	1040	147
Total	11282	35209	14073	8334

STEP 2. DIVIDE NUMBER AT AGE IN ALL BASKETS BY TOTAL HOURS TO GET INDEX OF ABUNDANCE

TRUE AGE	YEAR 1987	1988	1989	1990
4	1549	975	783	812
5	179	396	110	133
6	8	36	61	23
7	8	36	19	5
8+	38	28	78	17
Total	1782	1471	1051	990

Figure 1.

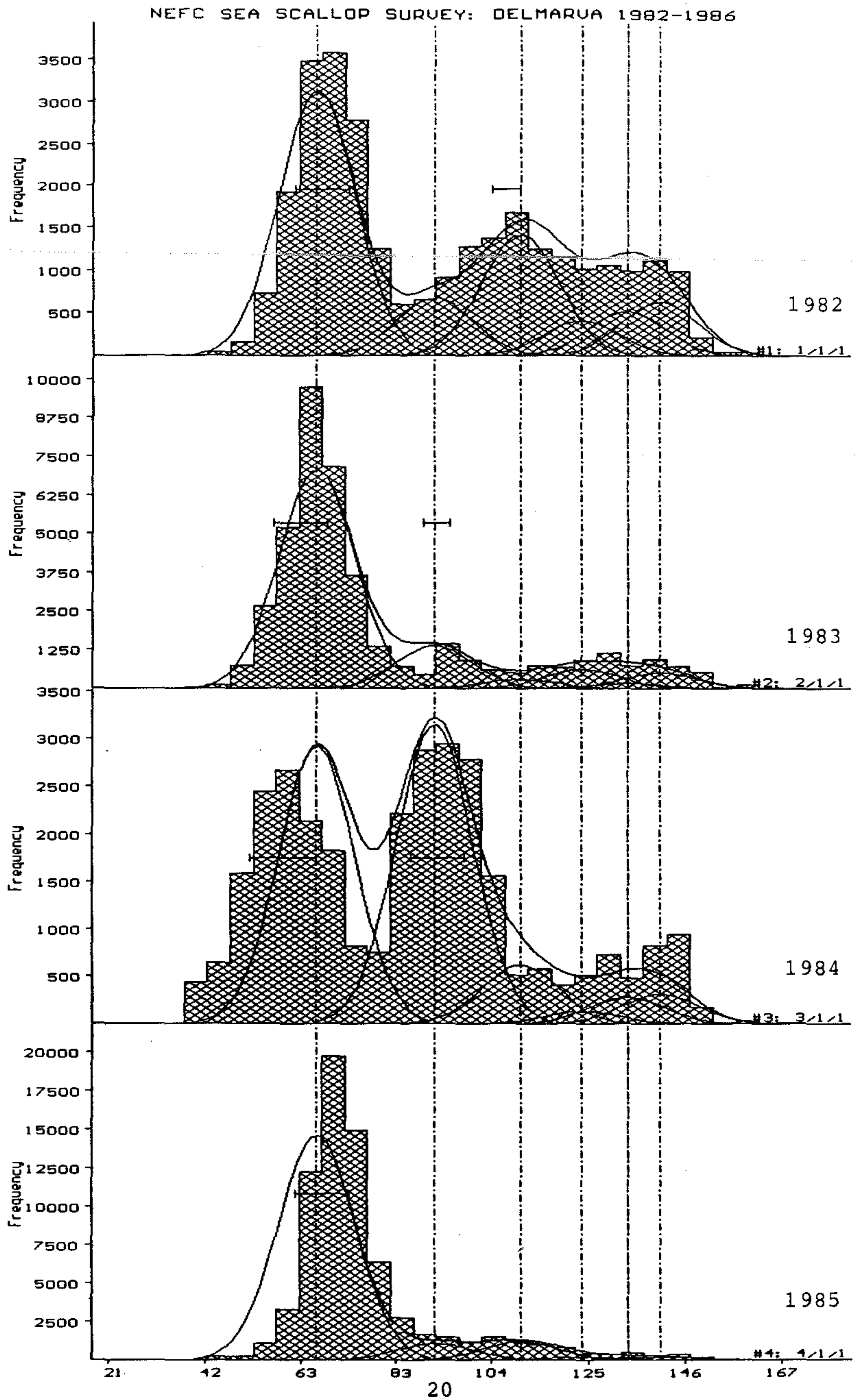

NEFC SEA SCALLOP SURVEY: DELMARVA 1982-1986
Frequency
3500
3000
2500
2000
1500
1000
500
1982
#1: 1/1/1
10000
8750
7500
6250
5000
3750
2500
1250
1983
#2: 2/1/1
3500
3000
2500
2000
1500
1000
500
1984
#3: 3/1/1
20000
17500
15000
12500
10000
7500
5000
2500
1985
#4: 4/1/1
21
42
63
83
104
125
146
167

Figure 1 cont'd.

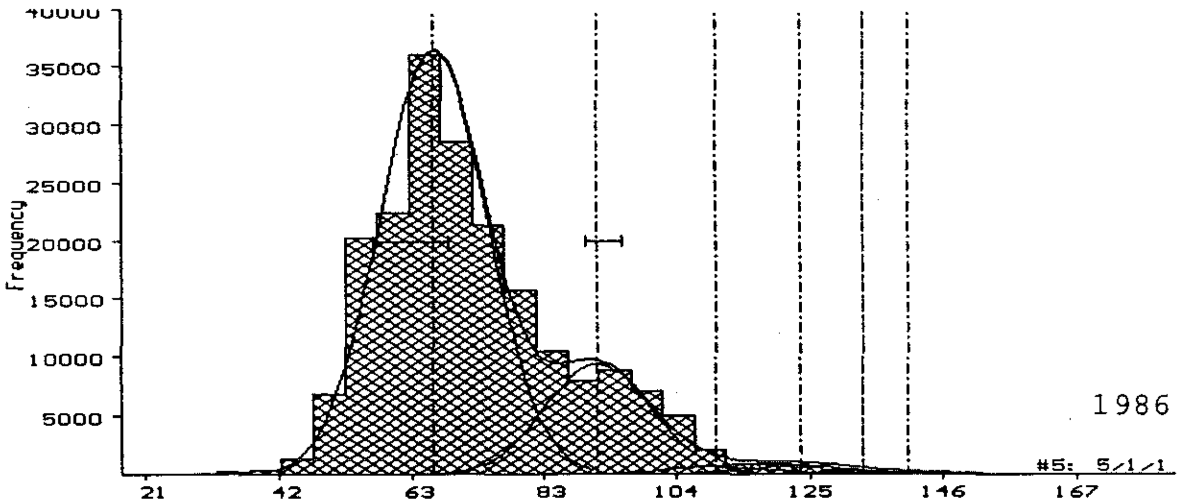


Figure 2.

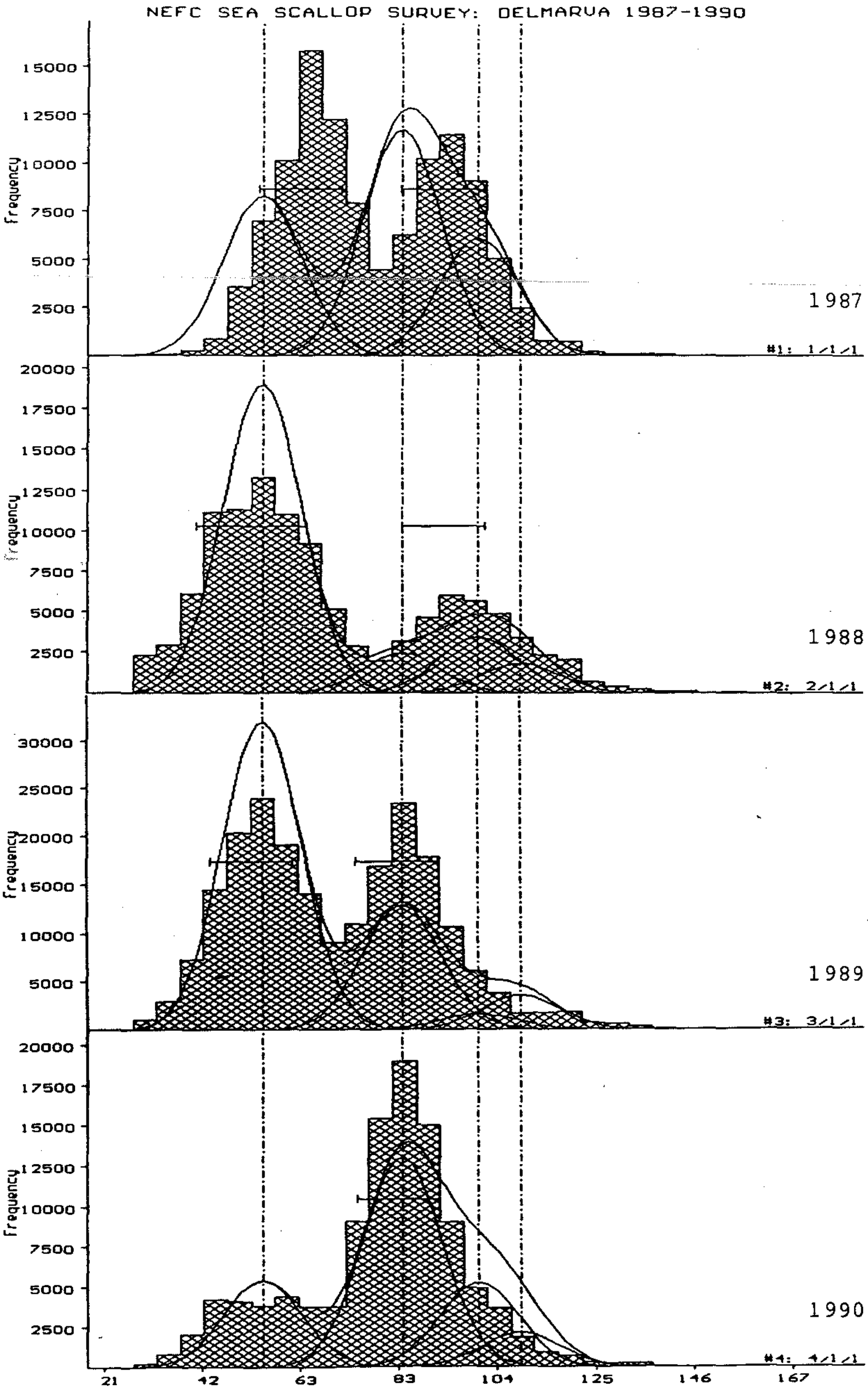
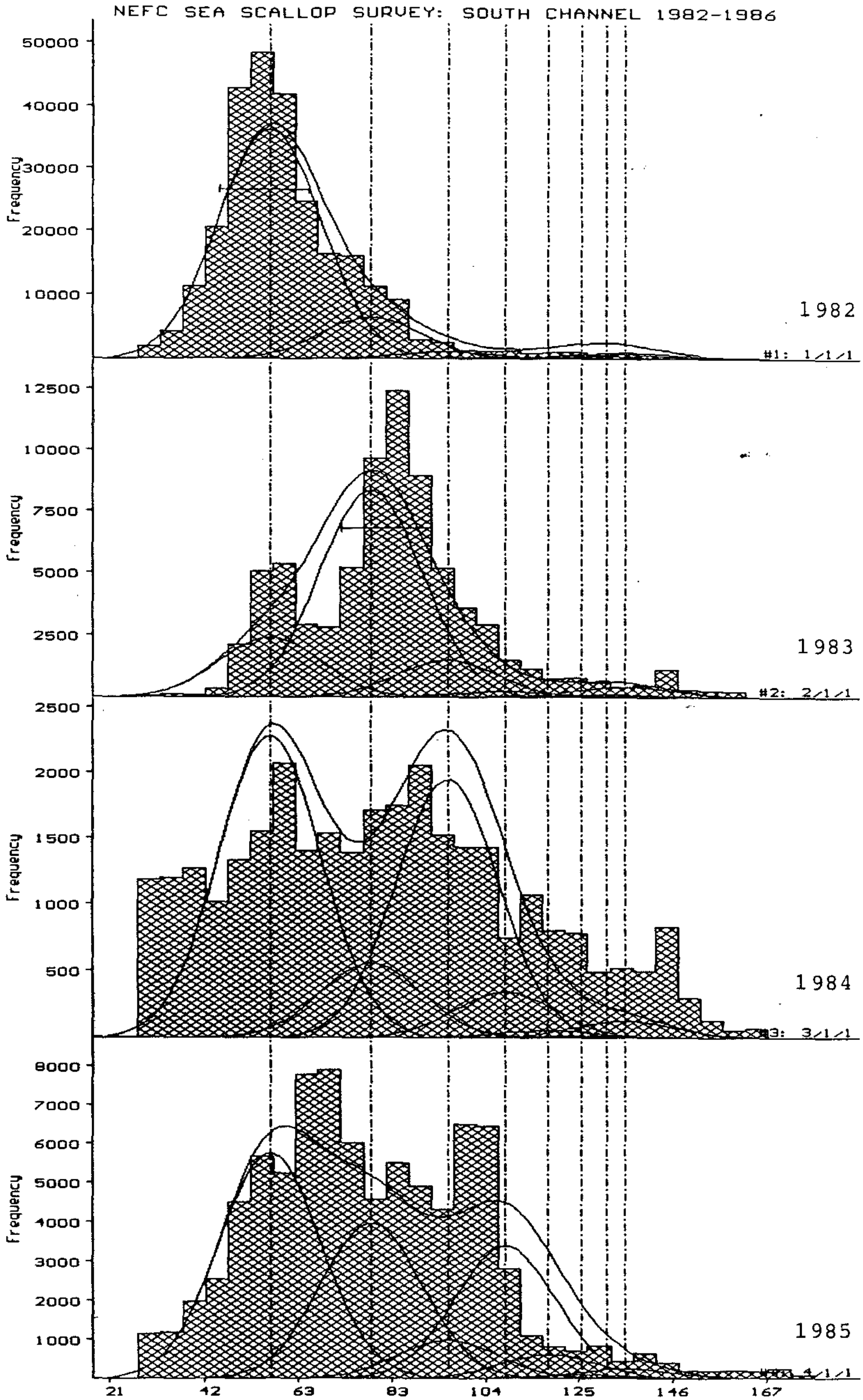
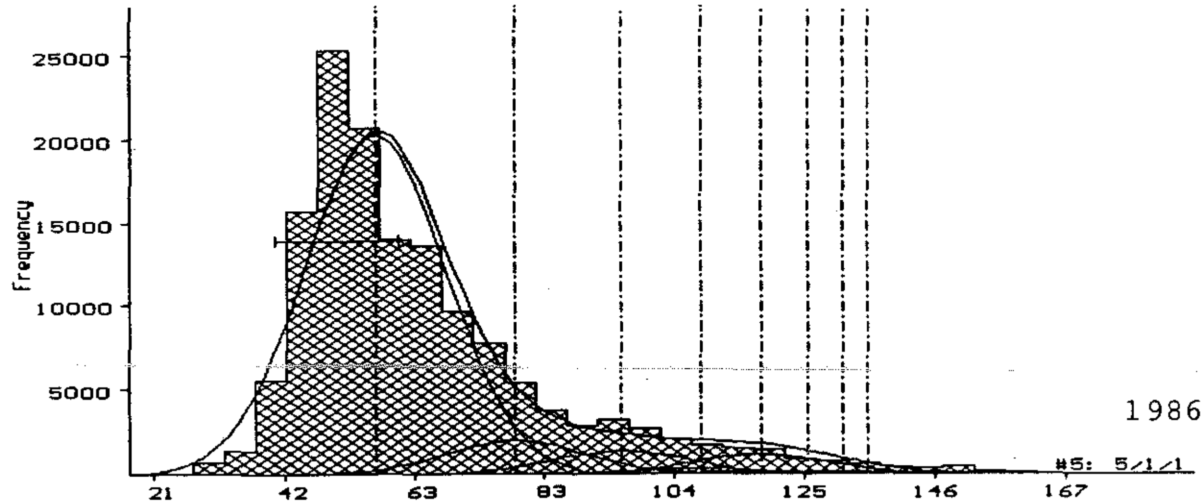

NEFC SEA SCALLOP SURVEY: DELMARVA 1987-1990
15000
12500
10000
7500
5000
2500
Frequency
1987
#1: 1/1/1
20000
17500
15000
12500
10000
7500
5000
2500
Frequency
1988
#2: 2/1/1
30000
25000
20000
15000
10000
5000
Frequency
1989
#3: 3/1/1
20000
17500
15000
12500
10000
7500
5000
2500
Frequency
1990
#4: 4/1/1
21
42
63
83
104
125
146
167

Figure 3.



NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1982-1986
50000
40000
30000
20000
10000
Frequency
1982
#1: 1/1/1
12500
10000
7500
5000
2500
Frequency
1983
#2: 2/1/1
2500
2000
1500
1000
500
Frequency
1984
#3: 3/1/1
8000
7000
6000
5000
4000
3000
2000
1000
Frequency
1985
4/1/1
21
42
63
83
104
125
146
167

Figure 3 cont'd.



1986

Figure 4.

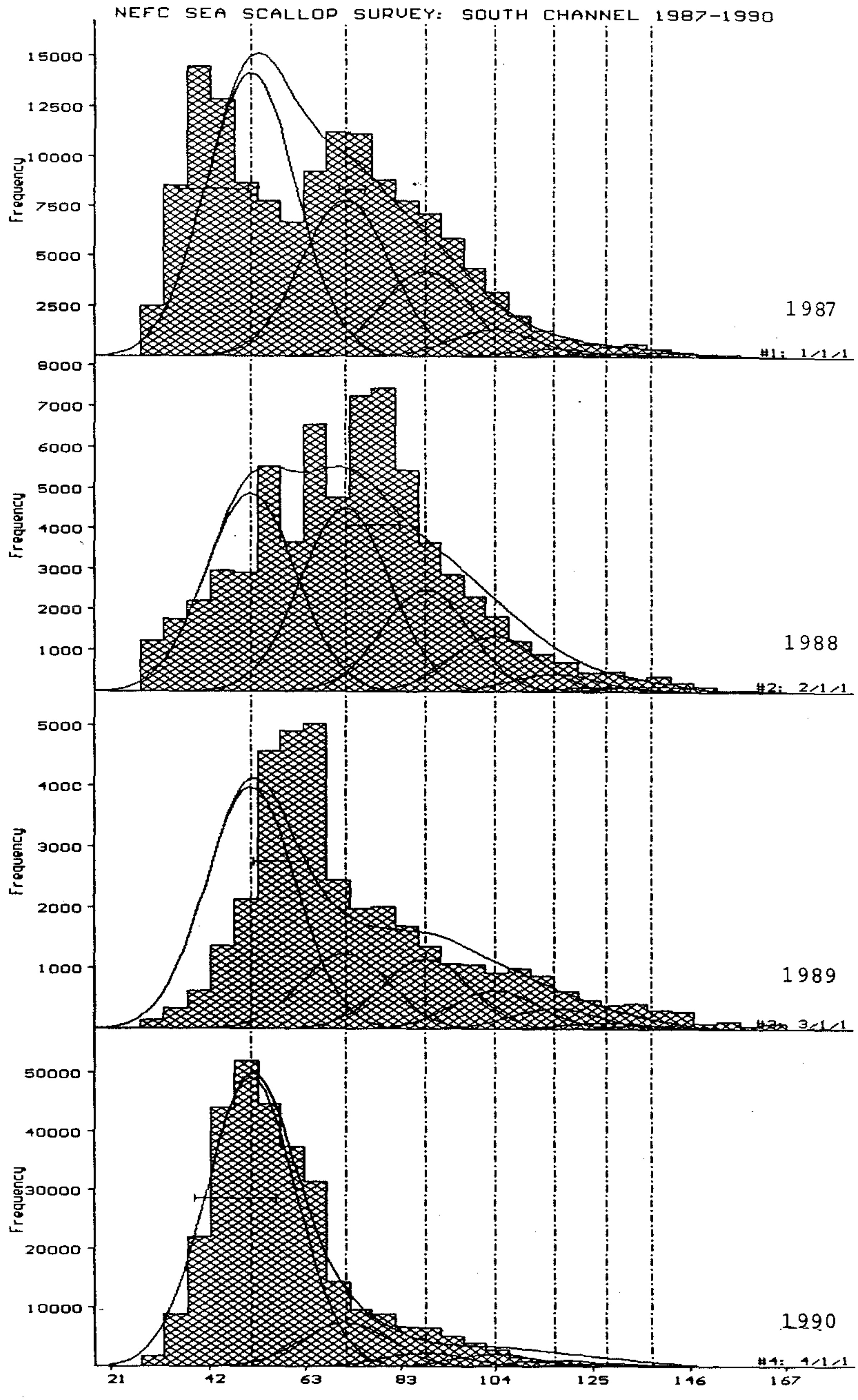
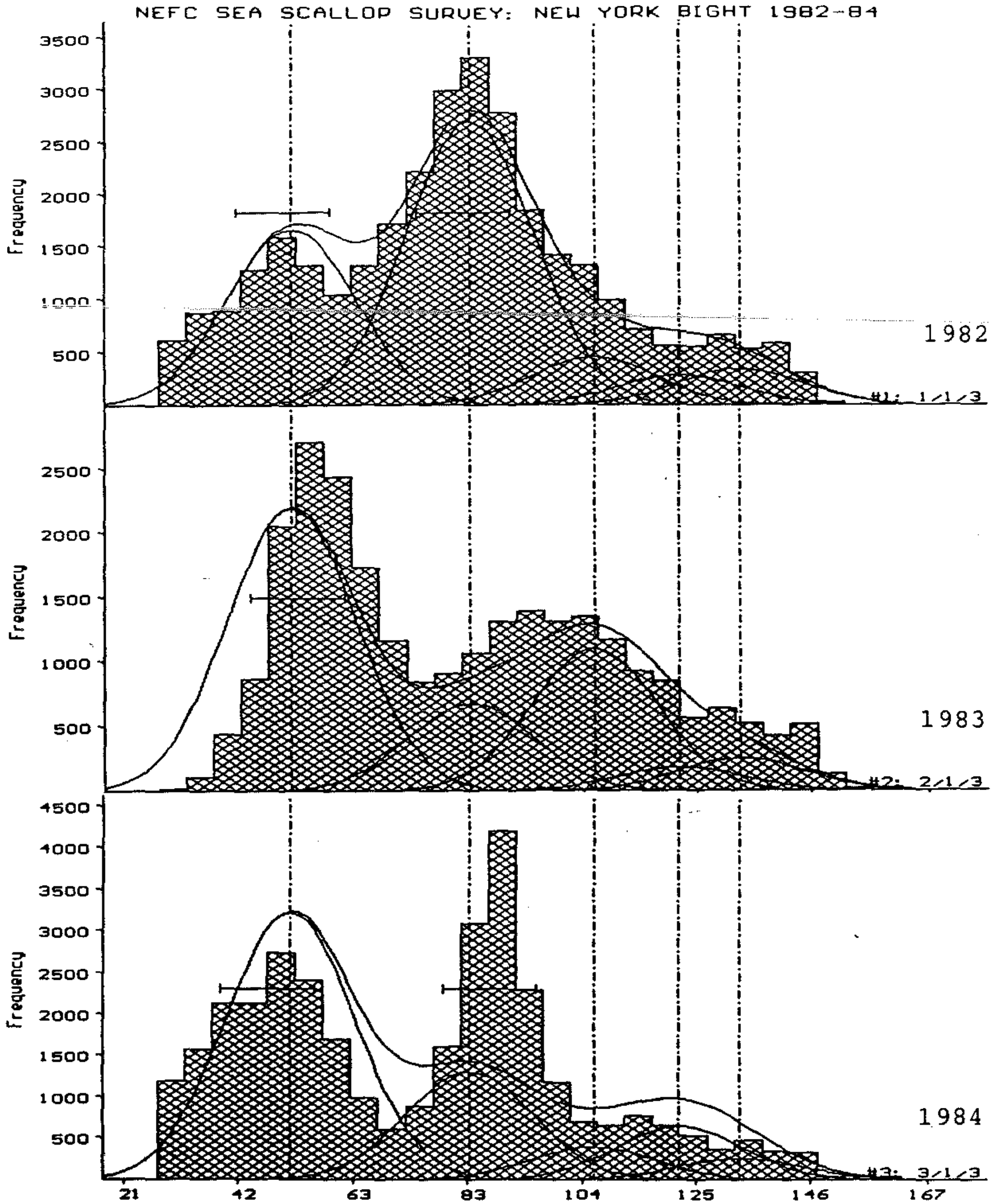

NEFC SEA SCALLOP SURVEY: SOUTH CHANNEL 1987-1990
Frequency
15000
12500
10000
7500
5000
2500
1987
#1: 1/1/1
8000
7000
6000
5000
4000
3000
2000
1000
1988
#2: 2/1/1
5000
4000
3000
2000
1000
1989
3/1/1
50000
40000
30000
20000
10000
1990
#4: 4/1/1
21
42
63
83
104
125
146
167

Figure 5.



NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1982-84
Frequency
3500
3000
2500
2000
1500
1000
500
1982
#1: 1/1/3
2500
2000
1500
1000
500
1983
#2: 2/1/3
4500
4000
3500
3000
2500
2000
1500
1000
500
1984
#3: 3/1/3
21
42
63
83
104
125
146
167

Figure 6.

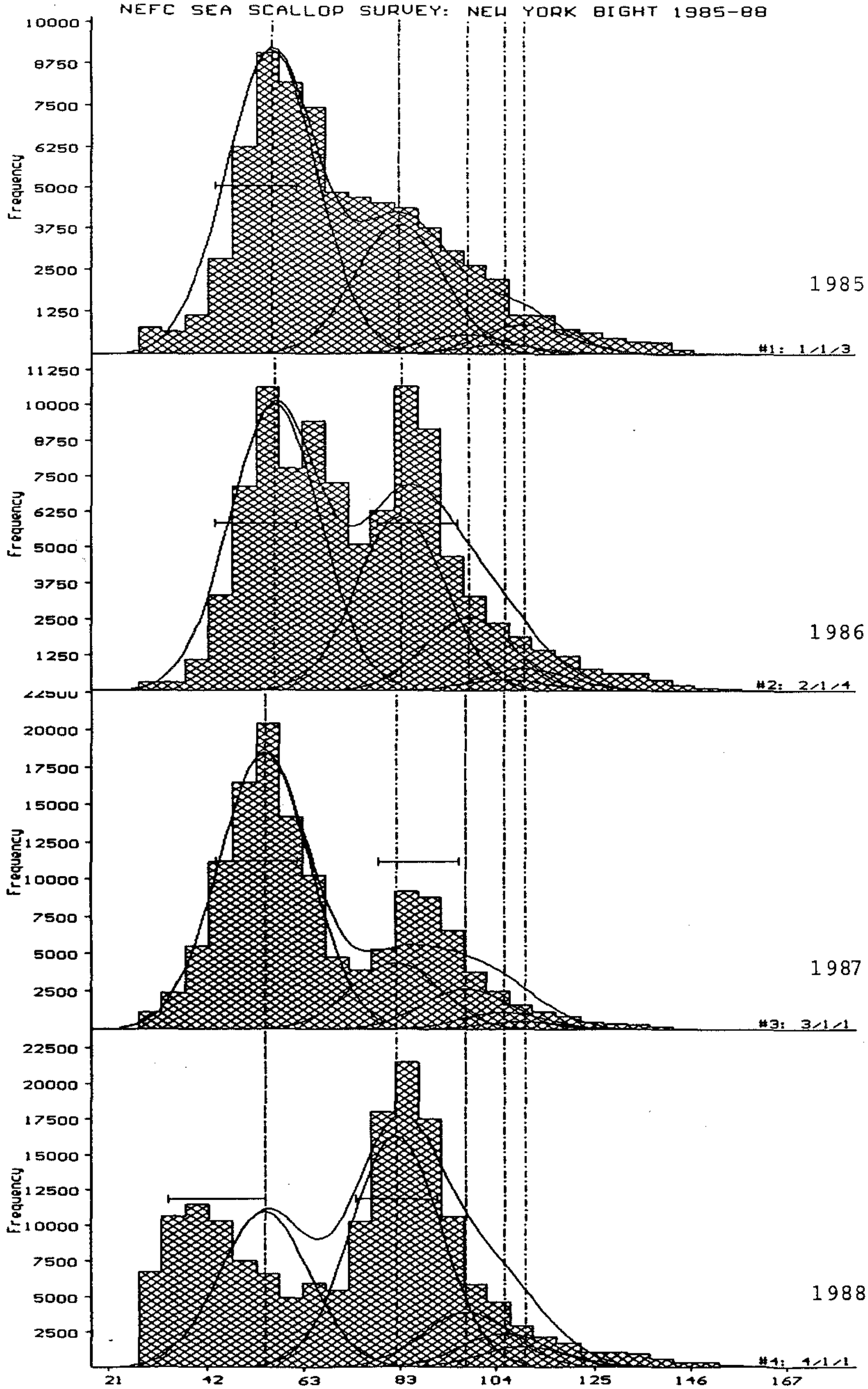

NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1985-88
Frequency
1985
#1: 1/1/3
1986
#2: 2/1/4
1987
#3: 3/1/1
1988
#4: 4/1/1
21
42
63
83
104
125
146
167

Figure 7.

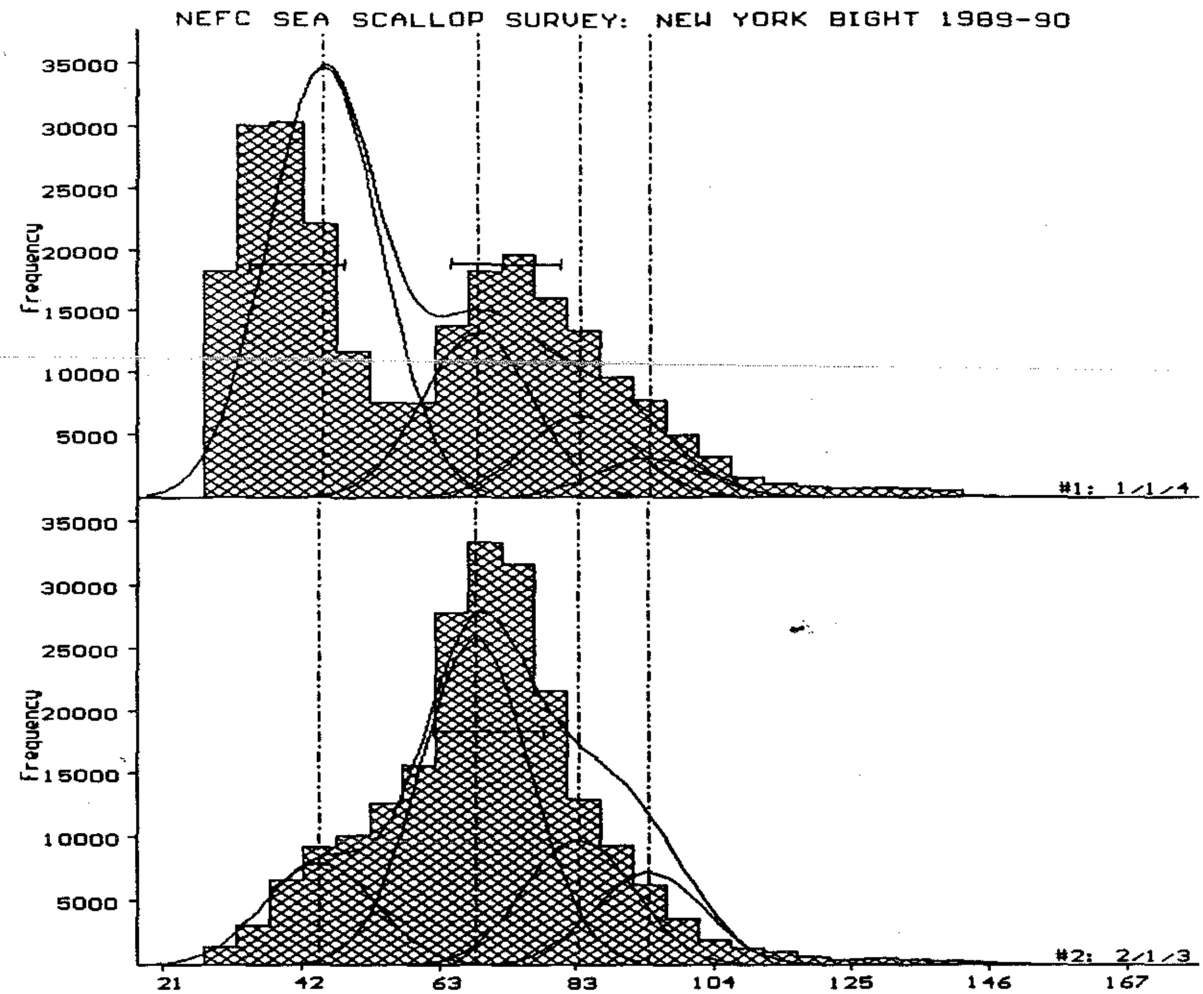
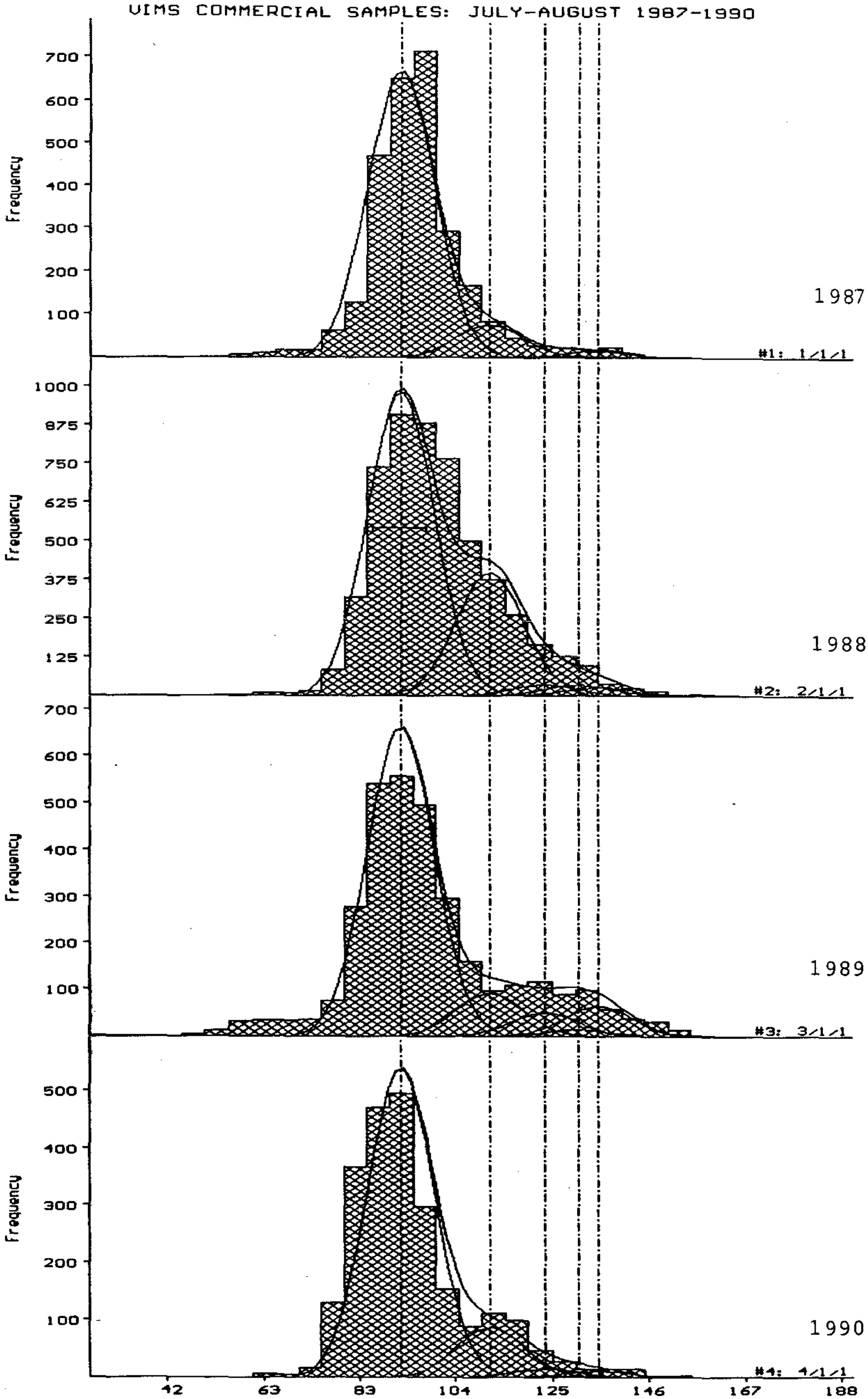

NEFC SEA SCALLOP SURVEY: NEW YORK BIGHT 1989-90
35000
30000
25000
20000
15000
10000
5000
Frequency
#1: 1/1/4
#2: 2/1/3
21
42
63
83
104
125
146
167

Figure 8.



VIMS COMMERCIAL SAMPLES: JULY-AUGUST 1987-1990
Frequency
700
600
500
400
300
200
100
1987
#1: 1/1/1
Frequency
1000
875
750
625
500
375
250
125
1988
#2: 2/1/1
Frequency
700
600
500
400
300
200
100
1989
#3: 3/1/1
Frequency
500
400
300
200
100
1990
#4: 4/1/1
42
63
83
104
125
146
167
188

Papers of the Northeast Regional
Stock Assessment Workshops

A DeLury Model for Scallops Incorporating Length-Based Selectivity of the Recruiting Year-Class to the Survey Gear and Partial Recruitment to the Commercial Fishery

by

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/2

INTRODUCTION

The non-age-structured DeLury model (Collie and Sissenwine 1983) is extended to incorporate partial selectivity of the recruiting year-class to the research survey gear. Collie and Sissenwine assumed that the catchability of the recruits and the fully-recruited ages was identical, i.e. that they were all fully-recruited. In this model, the recruiting year-class is not assumed to be fully recruited. Selectivity of the recruits relative to the full-recruited ages can be estimated in the model or alternatively, it can be defined *a priori* using data exogenous to the model, e.g. from gear experiments. Selectivity can be modelled as either an age-based or length-based process.

A further extension allows partial recruitment of the recruiting year-class to the commercial fishery. Partial recruitment is modelled as a length-based process. It is not assumed to be constant over years.

Survey indices of abundance for recruits, indices for the fully-recruited age group, and mean size of the recruiting year-class are all assumed to be available each year. Generally, annual estimates of catch in number are also available for most fisheries. The initial specification of this model will assume so. The model will then be generalized to allow implementation when catch in number is unknown. In the latter case, commercial landings; age composition from the annual research survey; and annual partial recruitment functions for the commercial fishery are used jointly to estimate the catch in number.

THE EXTENDED DELURY MODEL

Define terms as follows:

- R_{0y} population size (in number) of the recruiting year-class at the beginning of year y **[age 3 for scallops]**
- N_{0y} population size (in number) of the fully recruited age group at the beginning of year y **[ages 4+ for scallops]**
- C_y catch in number during year y **[ages 3+ for scallops]**
- M instantaneous rate of natural mortality (yr^{-1})

A year is defined as the period between successive research surveys **[July 1 - June 30 for scallops]**. Consequently population size estimates refer to number of animals in the population at the beginning of the year **[i.e. on July 1 for scallops]**.

Then using the DeLury framework, the first order difference equation

$$N_{0,y+1} = (N_{0y} + R_{0y} - C_y)\, e^{-M} \tag{1}$$

relates the fully-recruited stock size at the beginning of a year, $N_{0,y+1}$, to the fully-recruited stock size at the beginning of the previous year, N_{0y}, plus recruitment, R_{0y}, minus the catch, C_y, all discounted for natural mortality, M.

The survey indices of abundance, n_y and r_y, are related to absolute stock sizes by catchability coefficients:

$$n_y = q_n N_{0y} \tag{2}$$

$$r_y = q_r R_{0y} \tag{3}$$

Substituting Equations (2) and (3) into (1) and introducing a process error term, gives

$$n_{y+1} = \left(n_y + \frac{r_y}{s_r} - q_n C_y\right) e^{-M} e^{\epsilon_y} \tag{4}$$

where

$$s_r = \frac{q_r}{q_n} \tag{5}$$

is the selectivity of the recruits relative to the fully recruited ages; and ϵ_y is a normally distributed random variable with mean 0 and variance σ_ϵ^2 representing the process error.

The measured survey index of abundance for the fully-recruited ages (n'_{y0}) is related to the *true* index of abundance by

$$n'_y = n_y\, e^{\eta_y} \tag{6}$$

Similarly for the recruits,

$$r'_y = r_y\, e^{\delta_y} \tag{7}$$

where η_y and δ_y are normally distributed random variables, which represent the survey measurement error.

If selectivity is assumed be an age-based process, then relative selectivity can be estimated in the model, i.e. s_r is assumed constant over time and a single parameter is estimated for the recruiting year-class. As specified above, the model described is essentially that of Collie and Sissenwine (1983) with two modifications:

(1) an additional parameter is estimated, i.e. s_r

(2) the process error term is assumed to be lognormally distributed (Collie and Sissenwine assumed normally distributed process error)

Let Y be the number of years of available data. Then there are 2Y+1 parameters to be estimated:

n_y for all years
r_y for all years except the last year
q_n
s_r

The objective function to be minimized is

$$\lambda_\epsilon \sum_{y=1}^{Y-1} \epsilon_y^2 + \sum_{y=1}^{Y} \eta_y^2 + \lambda_\delta \sum_{y=1}^{Y-1} \delta_y^2 \qquad (8)$$

where λ_ϵ and λ_δ are relative weights for the process error and recruit measurement error, respectively (relative to the measurement error for indices of the fully-recruited ages).

The objective function has 3Y-2 residual error terms. This leaves Y-3 degrees of freedom for the model.

LENGTH-BASED SELECTIVITY

If the mean length at age of the recruiting year-class varies appreciable from year to year and selectivity is thought to be principally a function of length, then it may be advantageous to treat the selectivity as a length-based process.

This model is more complex mathematically, but statistically more parsimonious because the s_r are determined using data exogenous to the modified Collie-Sissenwine model, described above. s_r is treated as a function of the mean length of the recruiting year class:

$$s_{ry} = \Psi\left(\mu_{r0y}\right) \tag{9}$$

where

μ_{r0y} mean length of the recruiting year class at the beginning of the year **[for scallops, mean length of age 3's from the survey as estimated by Multifan or other mixture distribution model]**

s_{ry} as before, selectivity of recruits relative to the fully recruited ages. However, because the process is now length-based, s_{ry} need not be constant over years

Ψ a function relating μ_{r0y} and s_{ry} that is invariant with time. Ψ may be derived, for example, from gear experiments that measure selectivity as a function of length **[for scallops, the size selection data from Serchuk and Smolowitz (1980) may be used to define Ψ].**

When this form of the model is used, the year-specific s_{ry} replaces the year invariant s_r in Equation 4. When annual estimates of catch in number are available, parameter estimation proceeds in a parallel fashion to that of the modified Collie-Sissenwine model.

When annual estimates of catch in number are not available, commercial landings data along with age composition data from the research surveys may be used to estimate the C_y term in Equation 4. However, additional exogenous information on growth rates and mean size of the fully-recruited ages is needed. The mathematical model becomes more complex but as with the length-based selectivity, no additional parameters are estimated. The statistical model remains parsimonious, although some parameter correlation may be introduced. An algorithm for computing C_y, when needed, is provided in Appendix 1.

POPULATION SIZE AND MORTALITY RATES

Given estimates of $\hat{n}_y$, $\hat{r}_y$, and $\hat{q}_n$ from nonlinear least squares, and estimates of s_{ry} (generally from gear experiments), population size and fishing mortality rates for the recruits and the fully-recruited ages are determined as follows:

(1) Use mean length of the recruiting year-class at the beginning of the year (μ_{r0y}), defined above, along with von Bertalanffy growth parameters to estimate mean length of the year-class during the year, $\mu_{ry}(t)$.

The von Bertalanffy "age" associated with μ_{r0y} is

$$a_{r0y} = t_0 - \frac{1}{k} \log_e \left(1 - \frac{\mu_{r0y}}{L_\infty}\right) \qquad (10)$$

where t_0, k, and L_∞ are the von Bertalanffy growth parameters. Assume that during the course of a year, mean length of the recruiting year-class follows von Bertalanffy growth. Then

$$\mu_{ry}(t) = L_\infty \left[1 - e^{-k(a_{r0y}+t-t_0)}\right] \qquad for\ 0 \le t \le 1 \qquad (11)$$

and the expected annual growth in length is

$$\Delta\mu_{ry} = \mu_{ry}(t) \Big|_{t=0}^{t=1} \qquad (13)$$

(2) Define partial recruitment of the recruiting year-class to the commercial fishery.

Partial recruitment (PR) to the commercial fishery is assumed to be a function of length rather than age. However, it is assumed that the PR process is completed within one year, i.e. all recruits are assumed to be fully recruited by the end of the year in which they begin to recruit. A functional relationship relating the mean length of the recruiting year class to PR is required input.

$$p_{Ry}(t) = \Phi_y \left[\mu_{ry}(t)\right] \qquad for\ 0 \le t \le 1 \qquad (14)$$

where

p_{Ry} partial recruitment of the recruiting year-class to the commercial fishery over the course of year y

Φ_y a function relating μ_{ry} and p_{Ry} during year y

This relationship (Φ_y) should reflect not only the performance of the commercial gear, but all other factors that affect partial recruitment as well, e.g. the effects of regulations. The functional relationship may change over years, but is assumed constant within each year.

(3) Calculate population sizes and fishing mortality rates.

$$N_{0y} = \frac{\hat{n}_y}{\hat{q}_n} \qquad for\ y=1,...,Y \tag{15}$$

$$R_{0y} = \begin{cases} \dfrac{\hat{r}_y}{s_{ry}\hat{q}_n} & for\ y=1,...,Y-1 \\[2ex] \dfrac{r_y^{\prime}}{s_{ry}\hat{q}_n} & for\ y=Y \end{cases} \tag{16}$$

where N_{0y} and R_{0y} represent the fully-recruited and recruit population sizes, respectively, as in Equation 1.

$$Z_{R+N,y} = \log_e\left(\frac{N_{0y}+R_{0y}}{N_{0,y+1}}\right) \qquad for\ y=1,...,Y-1$$

$$F_{R+N,y} = Z_{R+N,y} - M \tag{17}$$

where $Z_{R+N,y}$ and $F_{R+N,y}$ are the total mortality and fishing mortality rates, respectively, between surveys for all animals of recruitment age and older (i.e. recruits plus the fully-recruited group)

As is generally done in virtual population analysis (VPA), the fishing mortality rate for a group of ages can be expressed as a weighted average of the F's on the individual components that make up the group. This gives an alternative expression for $F_{R+N,y}$

$$F_{R+N,y} = \frac{R_{0y}F_{Ry} + N_{0y}F_{Ny}}{R_{0y} + N_{0y}} \tag{18}$$

The fishing mortality rates of the recruits (F_{Ry}) and the fully-recruited ages (F_{Ny}) are related by

$$F_{Ry} = \bar{p}_{Ry}F_{Ny} \tag{19}$$

where $\bar{p}_{Ry}$ is the average partial recruitment of the recruiting year-class over the course of year y, i.e.

$$\bar{p}_{Ry} = \frac{1}{\Delta\mu_{ry}} \int_{\mu_{r0y}}^{\mu_{r0y}+\Delta\mu_{ry}} \Phi_y(L)\ dL \tag{20}$$

where $\Delta\mu_{ry}$ is the expected annual growth in length (assuming von Bertalanffy growth) of recruits with mean length μ_{r0y} at the beginning of the year (Equation 13).

Substituting Equation (19) into Equation (18) and solving for F_{Ny} gives

$$F_{Ny} = \frac{F_{R+N,y}\left(R_{0y} + N_{0y}\right)}{\bar{p}_{Ry}R_{0y} + N_{0y}} \tag{21}$$

and F_{Ry} is obtained from Equation 19.

APPLICATION TO SEA SCALLOPS IN THE DELMARVA AREA

Better insight into the performance of the model can be gained through application of the model to sea scallops in the Delmarva area.

Semi-annual landings for calendar years (CY) 1982-90 were obtained from the NEFC weighout files. Estimates of the semi-annual mean shell height of the catch were computed from the shell samples provided by cooperating commercial fishermen. Semi-annual catch numbers were obtained as the quotient of the above. Semi-annual catch numbers were grouped into survey years (SY) 1982-89 and summed to provide annual SY catch numbers. A SY begins in July and ends the following June, e.g. SY1987 extends from 1 July 1987 through 30 June 1988.

The annual NEFC scallop survey data (catch number per tow in 5mm groups) were "aged" into two groups (age 3 and ages 4+) using the Multifan procedure (Fournier et al. 1990). Indices of abundance for age 3 and ages 4+ (assumed proportion to stock size on July 1); and estimates of mean size of the recruiting year-class (age 3) were obtained from the Multifan results. Since the mean size of the recruiting year-class appeared to vary considerably from year to year, seven Multifan runs were used: 1982-83, 1984, 1985, 1986, 1987, 1988, 1989-90.

A selectivity ogive for the research survey gear on the recruiting year-class was estimated using data from alternate tow dredge selection experiments in the Delmarva area (Serchuk and Smolowitz 1980; Table 3). The raw observed retention proportions (by 5mm shell height group) were smoothed using Tukey's (1977) 3RSR procedure; and then normalized to the mean smoothed proportion for the 72-152mm shell height groups. The resulting ogive was applied to the Multifan annual estimates of mean size of age 3 scallops to estimated an annual selectivity for the recruiting year-class.

Partial recruitment (PR) to the commercial fishery was also modeled as a length-based process. The PR function was developed assuming that scallops with 65mm shell height (age 3 from the Serchuk et al. (1979) growth curve) are not generally vulnerable to the commercial fishery; but by 88mm (age 4) they are fully vulnerable. The PR was set to zero for scallops less than 65mm; and increased linearly to PR=1.0 at 88mm and above. This PR function was assumed invariant with time. Using this function and the Multifan estimates of mean size of recruits at the beginning of the SY, annual average partial recruitment of the recruits was calculated via Equation 20.

The full DeLury model output for the Delmarva area is provided as Appendix 2. All of the input quantities, described above, are shown in this Appendix as well as the final parameter estimates, residuals, mortality rates, etc.

ACKNOWLEDGEMENTS

Andy Rosenberg suggested the use of the DeLury model for scallops and provided beneficial comments during the model development. Susan Wigley provided monthly landings data and the NEFC survey data for the Delmarva example run. Mark Terceiro developed the Multifan estimates of mean size at age 3; as well as the "aged" survey indices. Fred Serchuk provided the mean shell height estimates from the commercial catch. The SAW Scallop Working Group provided useful discussion and feedback that benefitted the model development.

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APPENDIX 1

ESTIMATING CATCH IN NUMBER

When annual estimates of catch in number are not available, commercial landings data along with age composition data from the research surveys may be used to estimate the C_y term in Equation 4. However, additional exogenous information on growth rates and mean size of the fully-recruited ages is needed.

Given estimates of $\hat{n}_y$, $\hat{r}_y$, and $\hat{q}_n$ within the iterative least squares procedure (from Equations 2, 3, and 4), calculate fishing mortality rates for the recruits and the fully-recruited age group (F_{Ry} and F_{Ny}, respectively) using Equations (15) through (21).

Then mean weight in the exploited population ($\overline{w}_y$) is computed as follows:

(1) Proceeding similarly as with recruits (Equation 10 ff), estimate mean length of the fully-recruited age groups during the year, $\mu_{ny}(t)$. The von Bertalanffy "age" associated with μ_{n0y} is

$$a_{n0y} = t_0 - \frac{1}{k} \log_e \left(1 - \frac{\mu_{n0y}}{L_\infty}\right) \tag{22}$$

where μ_{n0y} is the mean length of the fully recruited ages at the beginning of the year **[for scallops, mean length of ages 4+ from the survey as estimated by Multifan or other mixture distribution model]**. Then

$$\mu_{ny}(t) = L_\infty \left[1 - e^{-k(a_{n0y} + t - t_0)}\right] \qquad for\ 0 \le t \le 1 \tag{23}$$

(2) Calculate the weight associated with $\mu_{ry}(t)$ and $\mu_{ny}(t)$ using the length-weight relationship.

$$w_{ry}(t) = \alpha\left[\mu_{ry}(t)\right]^{\beta} \tag{24}$$

$$w_{ny}(t) = \alpha\left[\mu_{ny}(t)\right]^{\beta} \tag{25}$$

where α and β are parameters of the length-weight relationship.

(3) Calculate mean weight of individuals in the exploited population during year y ($\bar{w}_y$), conditional upon the current parameter estimates.

Population numbers of the fully recruited population over the year are given by

$$N_y(t) = N_{0y}\ e^{-(M+F_{Ny})t} \qquad for\ 0 \le t \le 1 \tag{26}$$

Similarly, population numbers of the recruiting year-class over the year are

$$R_y(t) = R_{0y}\ e^{-(M+F_{Ry})t} \qquad for\ 0 \le t \le 1 \tag{27}$$

Population numbers of the exploited recruits over the course of the year is approximated by

$$R_y'(t) \doteq \bar{p}_{Ry}\ R_y(t) \tag{28}$$

Then mean weight of all individuals in the exploited population during year y is

$$\bar{w}_y \doteq \int_0^1 \frac{R_y'(t)w_{ry}(t) + N_y(t)w_{ny}(t)}{R_y'(t) + N_y(t)}\ dt \tag{29}$$

where $w_{ry}(t)$ and $w_{ny}(t)$ are defined in Equations 24 and 25, respectively.

Catch in number (C_y in Equation 4) is then calculated as

$$C_y = \frac{\Lambda_y}{\bar{\bar{w}}_y} \tag{30}$$

where Λ_y represents landings (in weight) during year y.

APPENDIX 2

DELURY MODEL OUTPUT FOR SEA SCALLOPS IN THE DELMARVA AREA

DELURY Run Number 57 1991 5 22 13 3 57
DELURY MODEL FOR SCALLOPS -- DelMarVa Area
Prepared for SARC 12 -- June 1991
Recruits = Age 3 Fully Recruited = Ages 4+
dmv

INPUT PARAMETERS AND OPTIONS SELECTED

CALENDAR YEAR	LANDINGS (mt) Jan-Jun	Jul-Dec	MEAN WEIGHT (g) Jan-Jun	Jul-Dec	CATCH NUMBERS (millions) Jan-Jun	Jul-Dec
1982	135.300	221.100	28.209	32.326	4.796393	6.839611
1983	112.400	184.000	29.425	33.263	3.819816	5.531605
1984	364.700	579.900	27.171	22.901	13.422448	25.322259
1985	276.500	248.300	26.491	26.155	10.437704	9.493586
1986	429.000	383.900	20.465	21.925	20.962722	17.509692
1987	1079.500	1719.600	17.829	19.681	60.548442	87.372721
1988	1566.600	1120.300	21.042	23.899	74.449683	46.876438
1989	1322.400	775.200	19.632	20.252	67.359413	38.277890
1990	1910.000	972.800	14.624	19.904	130.609007	48.874107

Data used in fitting the model:

Natural mortality is 0.1

SURVEY YEAR	-- INDICES OF ABUNDANCE -- RECRUITS	FULLY-RECRUITED	TOTAL CATCH (millions)
1982	12449	16099	10.659427
1983	30655	11497	18.954054
1984	13512	17496	35.759964
1985	59856	13127	30.456308
1986	153737	46594	78.058134
1987	62297	47367	161.822404
1988	77143	34785	114.235852
1989	113719	96160	168.886897
1990	22281	85974	

Note that a survey year (SY) begins in July and ends the following June, e.g. SY1987 is 1 JUL 87 thru 30 JUNE 88.

Indices of abundance are from the NEFC scallop survey. They are assumed to be proportional to stock abundance of July 1st. The survey size composition is "aged" using MultiFan to develop indices for recruits (age 3) and for the fully recruited ages (ages 4+).

Note that the recruit abundance index for the last year is NOT used in the least squares estimation. It is, however, used in conjunction with the least squares estimate of q_n and the calculated selectivity of the recruits to calculted recruit population size in 1990 (see RESULTS section).

SELECTIVITY OF RESEARCH SURVEY GEAR BY 5mm SIZE INTERVAL

SHELL HEIGHT (mm)	SELECTIVITY OF SURVEY GEAR	
12	0.000	1
17	0.000	2
22	0.000	3
27	0.096	4
32	0.240	5
37	0.248	6
42	0.275	7
47	0.322	8
52	0.461	9
57	0.581	10
62	0.691	11
67	0.756	12
72	1.000	13
77	1.000	14
82	1.000	15
87	1.000	16
92	1.000	17
97	1.000	18
102	1.000	19
107	1.000	20
112	1.000	21
117	1.000	22
122	1.000	23
127	1.000	24
132	1.000	25
137	1.000	26
142	1.000	27
147	1.000	28
152	1.000	29

MEAN SIZE OF RECRUITING YEAR-CLASS AND SELECTIVITY OF SURVEY GEAR RELATIVE TO THE FULLY-RECRUITED AGES

YEAR	MEAN SHELL HEIGHT (mm)	SELECTIVITY
1982	65.8	0.741
1983	65.8	0.741
1984	59.2	0.628
1985	70.5	0.926
1986	66.1	0.745
1987	64.5	0.723
1988	53.6	0.500
1989	53.2	0.489
1990	53.2	0.489

AVERAGE PARTIAL RECRUITMENT OF RECRUITS TO THE COMMERCIAL FISHERY

Survey Year	Average Partial Recruitment
1982	0.520
1983	0.520
1984	0.300
1985	0.681
1986	0.530
1987	0.469
1988	0.170
1989	0.160
1990	0.160

Measurement error in the abundance indices for both the recruits and the fully-recruited ages is assumed to be lognormally distributed. Process error is assumed to follow a lognormal distribution.

Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

	Parameter	Initial Est	Lower Bnd	Upper Bnd
1	n 4+ 1982	1.6099000E4	1.0000000E-10	1.0000000E6
2	n 4+ 1983	1.1497000E4	1.0000000E-10	1.0000000E6
3	n 4+ 1984	1.7496000E4	1.0000000E-10	1.0000000E6
4	n 4+ 1985	1.3127000E4	1.0000000E-10	1.0000000E6
5	n 4+ 1986	4.6594000E4	1.0000000E-10	1.0000000E6
6	n 4+ 1987	4.7367000E4	1.0000000E-10	1.0000000E6
7	n 4+ 1988	3.4785000E4	1.0000000E-10	1.0000000E6
8	n 4+ 1989	9.6160000E4	1.0000000E-10	1.0000000E6
9	n 4+ 1990	8.5974000E4	1.0000000E-10	1.0000000E6
10	r 3 1982	1.2449000E4	1.0000000E-10	1.0000000E6
11	r 3 1983	3.0655000E4	1.0000000E-10	1.0000000E6
12	r 3 1984	1.3512000E4	1.0000000E-10	1.0000000E6
13	r 3 1985	5.9856000E4	1.0000000E-10	1.0000000E6
14	r 3 1986	1.5373700E5	1.0000000E-10	1.0000000E6
15	r 3 1987	6.2297000E4	1.0000000E-10	1.0000000E6
16	r 3 1988	7.7143000E4	1.0000000E-10	1.0000000E6
17	r 3 1989	1.1371900E5	1.0000000E-10	1.0000000E6
18	Surv q 4+	1.0000000E0	1.0000000E-10	1.0000000E3

```
BEGIN MARQUARDT ALGORITHM
-------------------------


LAMBDA        1.00000E-2
RSS           8.95989E0
NPHI          8.95989E0

par
   1.60990E4     1.14970E4     1.74960E4     1.31270E4     4.65940E4     4.73670E4     3.47850E4     9.61600E4     8.
     59740E4      1.24490E4     3.06550E4     1.35120E4     5.98560E4     1.53737E5     6.22970E4     7.71430E4     1
     .13719E5      1.00000E0

LAMBDA        1.00000E-1
RSS           7.35832E0
NPHI          7.35832E0

par
   1.59323E4     1.16929E4     1.78995E4     1.30019E4     4.60878E4     4.95065E4     3.43319E4     9.46843E4     8.
     75527E4      1.23145E4     3.02101E4     1.35877E4     6.00298E4     1.48728E5     6.28967E4     7.77708E4     1
     .12238E5      1.44664E2

LAMBDA        1.00000E0
RSS           6.09873E0
NPHI          6.09873E0

par
   1.57664E4     1.18771E4     1.82847E4     1.29134E4     4.57050E4     5.15424E4     3.39518E4     9.35337E4     8.
     90550E4      1.21808E4     2.97656E4     1.36494E4     6.00977E4     1.44200E5     6.35128E4     7.82459E4     1
     .10746E5      2.56165E2

LAMBDA        1.00000E1
RSS           5.17411E0
NPHI          5.17411E0

par
   1.55916E4     1.20476E4     1.86135E4     1.29216E4     4.54986E4     5.32960E4     3.38714E4     9.29173E4     9.
     06556E4      1.20403E4     2.92699E4     1.36409E4     5.99595E4     1.39883E5     6.36867E4     7.82960E4     1
     .09047E5      3.31203E2

LAMBDA        1.00000E0
RSS           1.59112E0
NPHI          1.59112E0
```

```
par
   1.41221E4       1.31181E4      2.00866E4      1.39169E4      4.53279E4      6.16608E4      3.65394E4      9.28746E4      1.
      04137E5       1.08711E4      2.51932E4      1.26030E4      5.71657E4      1.08795E5      5.80021E4      7.41480E4      9
      .36463E4      6.20557E2

LAMBDA        1.00000E-1
RSS           9.61491E-1
NPHI          9.61491E-1

par
   1.36634E4       1.35184E4      2.18193E4      1.31200E4      4.33910E4      7.23089E4      3.29070E4      8.70622E4      1.
      05368E5       1.05000E4      2.41793E4      1.33041E4      5.68451E4      1.03000E5      6.63270E4      7.68181E4      9
      .16947E4      8.04349E2

LAMBDA        1.00000E-2
RSS           8.69809E-1
NPHI          8.69809E-1

par
   1.37511E4       1.32558E4      2.26525E4      1.23960E4      4.23943E4      7.64005E4      3.24502E4      8.51696E4      9.
      83439E4       1.05716E4      2.52709E4      1.45003E4      5.84726E4      1.07277E5      7.60784E4      8.15013E4      9
      .45729E4      9.14443E2

LAMBDA        1.00000E-3
RSS           8.63423E-1
NPHI          8.63423E-1

par
   1.37411E4       1.31856E4      2.27654E4      1.23636E4      4.23318E4      7.57907E4      3.26110E4      8.52604E4      9.
      67123E4       1.05630E4      2.54171E4      1.49281E4      5.89017E4      1.06656E5      7.93860E4      8.27472E4      9
      .46896E4      9.39743E2

LAMBDA        1.00000E-4
RSS           8.62953E-1
NPHI          8.62953E-1

par
   1.37331E4       1.31664E4      2.27614E4      1.23536E4      4.22472E4      7.53825E4      3.26438E4      8.52111E4      9.
      63587E4       1.05568E4      2.54267E4      1.50172E4      5.89336E4      1.06317E5      8.02072E4      8.29439E4      9
      .46855E4      9.44644E2

LAMBDA        1.00000E-5
RSS           8.62900E-1
NPHI          8.62900E-1

par
   1.37314E4       1.31621E4      2.27605E4      1.23513E4      4.22251E4      7.52624E4      3.26519E4      8.52020E4      9.
      62822E4       1.05554E4      2.54291E4      1.50370E4      5.89382E4      1.06210E5      8.04119E4      8.29874E4      9
      .46832E4      9.45718E2
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001
```

RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES	0.862900
ORTHOGONALITY OFFSET.........	0.003787
MEAN SQUARE RESIDUALS	0.123271

	PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
1	n 4+ 1982	1.37314E4	4.39044E3	3.12756E0	0.32
2	n 4+ 1983	1.31621E4	3.77347E3	3.48805E0	0.29
3	n 4+ 1984	2.27605E4	5.84311E3	3.89528E0	0.26
4	n 4+ 1985	1.23513E4	4.09842E3	3.01367E0	0.33
5	n 4+ 1986	4.22251E4	1.26432E4	3.33975E0	0.30
6	n 4+ 1987	7.52624E4	2.04965E4	3.67197E0	0.27
7	n 4+ 1988	3.26519E4	1.11063E4	2.93995E0	0.34
8	n 4+ 1989	8.52020E4	2.60352E4	3.27257E0	0.31
9	n 4+ 1990	9.62822E4	3.08417E4	3.12182E0	0.32
10	r 3 1982	1.05554E4	3.34694E3	3.15375E0	0.32
11	r 3 1983	2.54291E4	7.07332E3	3.59508E0	0.28
12	r 3 1984	1.50370E4	4.39503E3	3.42136E0	0.29
13	r 3 1985	5.89382E4	1.54096E4	3.82477E0	0.26
14	r 3 1986	1.06210E5	2.86944E4	3.70142E0	0.27
15	r 3 1987	8.04119E4	2.21710E4	3.62689E0	0.28
16	r 3 1988	8.29874E4	1.94718E4	4.26194E0	0.23
17	r 3 1989	9.46832E4	2.45116E4	3.86280E0	0.26
18	Surv q 4+	9.45718E2	1.64664E2	5.74331E0	0.17

CORRELATION BETWEEN PARAMETERS ESTIMATED 22/ 5/91

■	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 ■	1.00	0.31	0.05	-0.01	-0.00	0.02	-0.01	-0.00	-0.02	-0.23	-0.03	0.03	0.02	0.03	0.06	0.04	0.03	0.10
2 ■	0.31	1.00	0.10	0.03	0.00	-0.01	0.00	0.00	0.01	0.32	-0.19	-0.07	-0.01	-0.01	-0.02	-0.01	-0.01	-0.03
3 ■	0.05	0.10	1.00	0.20	0.01	0.05	-0.02	-0.01	-0.03	0.06	0.47	-0.41	0.01	0.06	0.14	0.08	0.07	0.21
4 ■	-0.01	0.03	0.20	1.00	0.08	-0.03	0.02	0.01	0.03	-0.01	0.05	0.23	-0.15	-0.07	-0.12	-0.07	-0.06	-0.18
5 ■	-0.00	0.00	0.01	0.08	1.00	0.08	0.02	0.00	0.01	-0.00	-0.01	0.00	0.53	-0.18	-0.08	-0.02	-0.01	-0.04
6 ■	0.02	-0.01	0.05	-0.03	0.08	1.00	0.11	0.00	-0.03	0.02	0.06	0.09	0.09	0.52	-0.41	0.06	0.07	0.21
7 ■	-0.01	0.00	-0.02	0.02	0.02	0.11	1.00	0.07	0.03	-0.01	-0.03	-0.05	-0.02	0.03	0.19	-0.22	-0.06	-0.11
8 ■	-0.00	0.00	-0.01	0.01	0.00	0.00	0.07	1.00	0.15	-0.00	-0.01	-0.02	-0.01	-0.01	-0.01	0.52	-0.31	-0.04
9 ■	-0.02	0.01	-0.03	0.03	0.01	-0.03	0.03	0.15	1.00	-0.02	-0.05	-0.07	-0.03	-0.05	-0.11	0.02	0.43	-0.16
10 ■	-0.23	0.32	0.06	-0.01	-0.00	0.02	-0.01	-0.00	-0.02	1.00	-0.03	0.03	0.02	0.03	0.07	0.04	0.03	0.10
11 ■	-0.03	-0.19	0.47	0.05	-0.01	0.06	-0.03	-0.01	-0.05	-0.03	1.00	-0.09	0.05	0.09	0.19	0.11	0.10	0.29
12 ■	0.03	-0.07	-0.41	0.23	0.00	0.09	-0.05	-0.02	-0.07	0.03	-0.09	1.00	0.05	0.14	0.29	0.17	0.15	0.44
13 ■	0.02	-0.01	0.01	-0.15	0.53	0.09	-0.02	-0.01	-0.03	0.02	0.05	0.05	1.00	-0.02	0.11	0.08	0.07	0.20
14 ■	0.03	-0.01	0.06	-0.07	-0.18	0.52	0.03	-0.01	-0.05	0.03	0.09	0.14	-0.02	1.00	-0.04	0.11	0.10	0.32
15 ■	0.06	-0.02	0.14	-0.12	-0.08	-0.41	0.19	-0.01	-0.11	0.07	0.19	0.29	0.11	-0.04	1.00	0.21	0.21	0.66
16 ■	0.04	-0.01	0.08	-0.07	-0.02	0.06	-0.22	0.52	0.02	0.04	0.11	0.17	0.08	0.11	0.21	1.00	-0.03	0.38
17 ■	0.03	-0.01	0.07	-0.06	-0.01	0.07	-0.06	-0.31	0.43	0.03	0.10	0.15	0.07	0.10	0.21	-0.03	1.00	0.33
18 ■	0.10	-0.03	0.21	-0.18	-0.04	0.21	-0.11	-0.04	-0.16	0.10	0.29	0.44	0.20	0.32	0.66	0.38	0.33	1.00

SURVEY YEAR	STOCK SIZE ESTIMATES (millions - July 1) RECRUITS	FULLY-RECRUITED	Z on ages 3+	F on age 3	F on ages 4+
1982	15.063	14.520	0.75	0.45	0.87
1983	36.288	13.918	0.74	0.51	0.97
1984	25.316	24.067	1.33	0.58	1.92
1985	67.311	13.060	0.59	0.45	0.67
1986	150.792	44.649	0.90	0.66	1.25
1987	117.550	79.582	1.74	1.13	2.40
1988	175.372	34.526	0.85	0.41	2.43
1989	204.803	90.092	1.06	0.37	2.31
1990	48.195	101.809			

Note that the recruit population estimate for the last year (1990) is NOT a least squares estimate. It is calculated from the observed survey index, the least squares estimate of q, and the calculated selectivity.

MEASUREMENT ERROR -- Fully-recruited index with lognormal errors

ERROR TERM	OBSERVED	PREDICTED	WEIGHT	RESIDUAL	STD RES	%SS
n 4+ 1982	16099.0	13731.4	1.0000	0.1591	0.4531	2.9
n 4+ 1983	11497.0	13162.1	1.0000	-0.1353	-0.3852	2.1
n 4+ 1984	17496.0	22760.5	1.0000	-0.2631	-0.7492	8.0
n 4+ 1985	13127.0	12351.3	1.0000	0.0609	0.1735	0.4
n 4+ 1986	46594.0	42225.1	1.0000	0.0985	0.2804	1.1
n 4+ 1987	47367.0	75262.4	1.0000	-0.4631	-1.3189	24.8
n 4+ 1988	34785.0	32651.9	1.0000	0.0633	0.1802	0.5
n 4+ 1989	96160.0	85202.0	1.0000	0.1210	0.3446	1.7
n 4+ 1990	85974.0	96282.2	1.0000	-0.1132	-0.3225	1.5
SUM				-0.4719	-1.3440	43.1

MEASUREMENT ERROR -- Recruit index with lognormal errors

ERROR TERM	OBSERVED	PREDICTED	WEIGHT	RESIDUAL	STD RES	%SS
r 3 1982	12449.0	10555.4	1.0000	0.1650	0.4700	3.2
r 3 1983	30655.0	25429.1	1.0000	0.1869	0.5323	4.0
r 3 1984	13512.0	15037.0	1.0000	-0.1069	-0.3046	1.3
r 3 1985	59856.0	58938.2	1.0000	0.0155	0.0440	0.0
r 3 1986	153737.0	106210.0	1.0000	0.3698	1.0533	15.9
r 3 1987	62297.0	80411.9	1.0000	-0.2552	-0.7270	7.6
r 3 1988	77143.0	82987.4	1.0000	-0.0730	-0.2080	0.6
r 3 1989	113719.0	94683.2	1.0000	0.1832	0.5218	3.9
SUM				0.4852	1.3818	36.5

PROCESS ERROR -- DeLury equation with lognormal errors

ERROR TERM	PREDICTED	CALCULATED	WEIGHT	RESIDUAL	STD RES	%SS
n 4+ 1983	13162.1	16192.7	1.0000	-0.2072	-0.5902	5.0
n 4+ 1984	22760.5	26742.4	1.0000	-0.1612	-0.4592	3.0
n 4+ 1985	12351.3	11657.3	1.0000	0.0578	0.1647	0.4
n 4+ 1986	42225.1	42713.1	1.0000	-0.0115	-0.0327	0.0
n 4+ 1987	75262.4	100446.5	1.0000	-0.2886	-0.8221	9.7
n 4+ 1988	32651.9	30215.4	1.0000	0.0776	0.2209	0.7
n 4+ 1989	85202.0	81860.1	1.0000	0.0400	0.1140	0.2
n 4+ 1990	96282.2	107828.2	1.0000	-0.1133	-0.3226	1.5
SUM				-0.6064	-1.7273	20.4

25 residual error terms
18 parameters estimated
7 degrees of freedom

Time stamp at end of run 1991 5 22 13 4 11

Papers of the Northeast Regional
Stock Assessment Workshops

Current Resource Conditions in USA Georges Bank and Mid-Atlantic Sea Scallop Populations

Results of the 1990 NEFC Sea Scallop Research Vessel Survey

by

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Northeast Fisheries Science Center
Woods Hole, MA

Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/3

INTRODUCTION

Sea scallop research vessel surveys have been conducted by the Northeast Fisheries Center [NEFC] of the National Marine Fisheries Service in 1975 and annually from 1977 onward to monitor and assess trends in abundance, population composition, and recruitment patterns of USA offshore (3-200 n mi from the USA coastline) sea scallop resources. Together with commercial fisheries data, the survey results have been used to evaluate stock and fishery status and to forecast future resource conditions (Serchuk and Wigley 1988, 1989a, 1989b).

This document presents the results of the 1990 NEFC sea scallop research vessel survey, and provides an evaluation of current resource conditions, recruitment prospects, and abundance levels in the USA Georges Bank and Mid-Atlantic sea scallop populations. These data were used in the analytical assessment prepared for SAW 12.

METHODS

The 1990 NEFC sea scallop survey was conducted from 26 July to 20 August 1990 using the ***R/V Oregon II***. Areas sampled included the Georges Bank and Mid-Atlantic regions in depths between 28-110 meters [15 to 60 fm] (Figure 1). The sampling design used in the 1989 NEFC survey was maintained in the 1990 survey, that is strata which historically [1975-1988] yielded no or few scallops were not surveyed in 1990 (Serchuk and Wigley 1989a). Revised strata sets developed in 1989 for assessing and summarizing resource conditions were used for all of the 1990 analyses. The 'revised strata sets' are as follows:

Region	**'Revised Strata Set'**
Virginia - No. Carolina:	Strata 6-7.
Delmarva:	Strata 10-11; 14-15; 18-19.
New York Bight:	Strata 22-31; 33-35.
South Channel:	Strata 46-47; 49-55.
Southeast Part:	Strata 58-60.
USA No. Edge & Peak:	Strata 61,621,631,651,661,71,72,74.
CAN No. Edge & Peak:	Strata 622,632,64,652,662.

The entire sea scallop survey time series [comprised of 15 annual surveys (1975,1977-1990)] has been analyzed with respect to the revised strata set groupings. The results presented in the remainder of this report reflect these revisions.

Survey sampling procedures in 1990 were identical to those in previous USA surveys. Sampling was performed using a 2.44 m [8 ft] wide commercial sea scallop dredge equipped with a 5.1 cm [2 in] ring bag and a 3.8 cm [1.5 in] polypropylene mesh liner to retain small scallops. Detailed specifications of this gear, used in all NEFC sea scallop surveys since 1979, are provided in Serchuk and Smolowitz (1980).

As in the past, a stratified sampling design was used in the 1990 survey. Offshore regions were stratified into geographical zones [strata] based on water depth and latitude (Figure 1), and sampling stations allocated to strata in proportion to stratum area and assigned randomly within strata. For selected strata in which either commercial fishing activity or sea scallop concentrations were known to occur, additional randomly-selected stations were added prior to the survey to increase precision of the resultant survey abundance indices. Sampling stations occupied in the 1990 survey are depicted in Appendix Figures 1-3. Individual station (tow) catch and LORAN-C location data are provided in the 1990 NEFC Sea Scallop Fishermen's Report (NEFC 1990).

At each station, the survey dredge was towed for 15 minutes at 3.5 knots with a 3:1 wire scope. After each tow, the catch was sorted into biological and trash components. All live scallops were counted and shell height measurements taken, by 5-mm interval, on all individuals. Occasionally, subsampling was necessary when large quantities of scallops were caught. By-catch of finfish and other invertebrates was also enumerated and measured. Trash components was measured by volume, and substrate type and composition noted. Hydrographic and navigational data were recorded for each station including distance towed over bottom from a Doppler speed log. The survey dredge and liner were routinely inspected for damage, and repaired or replaced as appropriate.

RESULTS

Sampling Intensity and Overall Catch

A total of 467 sampling tows was conducted within the revised strata sets; results presented below are based upon 214 tows on Georges Bank and 216 tows in the Mid-Atlantic region (Tables 1-4, Appendix Tables 1 and 2). Sampling intensity (tows per sq n mi) for the strata sets averaged 1:39 in the Mid-Atlantic and 1:43 on Georges Bank. Individual stratum sampling intensity varied from one tow per four sq n mi (Stratum 652 on Georges Bank) to one tow per 219 sq n mi (Stratum 29 in Delmarva).

Sea scallop catches ranged from 0 (59 tows) to 12,288 scallops per tow (Tow 50-5 in the South Channel). A total of 128,073 scallops were taken over the entire region: 48,456 in the Mid-Atlantic and 79,617 on Georges Bank. In 25 tows, scallop catches exceeded 1,000 individuals per haul (9 tows in New York Bight; 5 tows in the South Channel; 11 tows on the Northern Edge and Peak). Together, these 25 tows yielded 81,206 scallops (63% of the total number of scallops caught in the 1990 survey).

Relative Abundance Indices

Survey indices of relative abundance and biomass were calculated in terms of mean number and mean meat weight per tow[1] for each sampling stratum included in the Mid-Atlantic and Georges Bank strata sets (Table 1), and in terms of stratified mean catch per tow (numbers and weight) for the principal scallop regions within the Mid-Atlantic and Georges Bank areas (Tables 1-4; Figures 2-3). Survey indices were derived for:

a. pre-recruit scallops [<70 mm shell height; >80 meat count];

b. recruit or harvestable-size scallops [≥70 mm shell height; ≤80 meat count]; and

c. total scallops [all sizes] per tow .

Size-related parameters [mean shell height and average meat count] were also calculated for each stratum and region (Table 1). Survey catch per tow data were further analyzed in terms of catch distributions among various meat count intervals (meat count refers to the number of scallop meats per pound). For each stratum, region, and area, percentage distributions of the number of scallops within five meat count intervals (>80 meat count; 80-40 count; 40-35 count; 35-30 count; and <30 count) were calculated (Table 1). Meat count distributions of harvestable-size scallops were derived, by geographic region and area, in terms of both biomass and numbers (Tables 5-13; Figures 4-6).

MID-ATLANTIC AREA

The 1990 survey results indicate that sea scallop abundance in the Mid-Atlantic area is at a very high level (Table 2; Figure 2). The 1990 survey index of harvestable-size scallops (≥70 mm shell height) was the highest on record (90.6 scallops/tow), while abundance indices of total and pre-recruit scallops per tow were the second highest in the survey time series (193.8 and 103.2, respectively), exceeded only by the record-high 1989 values. Mid-Atlantic biomass (wt/tow) indices in 1990 were at or near historic highs. The exceptional 1986 year class remains extremely abundant in all areas, but has been followed by a regionally variable 1987 cohort.

Overall, small scallops dominate the Mid-Atlantic resource (53% of the number of scallops caught in the Mid-Atlantic region were ≥80 count: Table 1). Of the harvestable biomass (scallops <80 count), scallops between 80-40 count accounted for 62% of the Mid-Atlantic resource, while 78% of the harvestable biomass was accounted for by scallops >30 meat count (Tables 5, 6 and 13; Figure 4).

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[1] Meat weight per tow values were derived by applying area-specific NEFC sea scallop survey shell height-meat weight equations to the survey shell height frequency distributions. See footnote 2 in Tables 2-4.

Abundance patterns and resource conditions within the three principal scallops regions in the Mid-Atlantic [New York Bight; Delmarva; Virginia-North Carolina] are described below.

New York Bight (Strata 22-31; 33-35) - The high levels of scallop abundance and biomass observed in the 1989 survey of the New York Bight region continued in 1990. Nearly all of the 1990 catch per tow indices were among the highest values observed in the survey time series (Table 2; Figure 2).

Record-high total catch per tow indices were recorded in two of the 13 survey strata sampled (Strata 23 and 31; Table 1), while record-high abundance values were obtained for pre-recruits in Stratum 31 for harvestable-size scallops in strata 23 and 28 (Table 1 and Appendix Tables 4 and 5). Although stratum biomass indices were generally lower in 1990 than in 1989, record-high values occurred in strata 23, 27, and 28 (Table 1 and Appendix Table 6).

Survey size frequency data reveal that the New York Bight resource is currently dominated by small scallops (Figure 8). Due to the outstanding 1986 and moderate 1987 year classes, 57% of the number of scallops caught in the 1990 survey in the region were less than 70 mm in shell height [>80 count] while 92% were less than 90 mm in shell height [>40 count] (Table 1). Although 72% of the total biomass in the region was comprised of harvestable-size scallops [<80 count] (Table 5), nearly two thirds (63%) of the harvestable biomass was accounted for by scallops between 80-40 count and about 78% by scallops >30 count (Tables 5, 6, and 13; Figure 4). In terms of numbers, 82% of the harvestable biomass was accounted for by individuals between 80-40 count and 92% by scallops >30 count (Tables 7 and 8). Small scallops are expected to be somewhat less dominant in the New York Bight region during 1991 when the exceptional 1986 cohort grows into the 40-35 meat count size interval and the moderate 1987 year class replaces the 1986 year class in the 80-40 count range.

Delmarva (Strata 10-11; 14-15; 18-19) - All survey indices of abundance and biomass in Delmarva declined in 1990 from the generally record-high levels observed in the 1989 survey (Table 2, Figure 2). Total number and weight per tow indices decreased 48% and 30%, respectively. Number and weight per tow values for harvestable-size scallops fell 17% and 20% (Table 2). Pre-recruit indices (in both numbers and weight) in 1990 were the lowest since 1984.

Declines in abundance were widespread throughout Delmarva; in all six survey strata comprising the revised Delmarva strata set, the 1990 indices of total and pre-recruit scallops declined from 1989 and were among the lowest observed since 1984-1986 (Appendix Tables 3 and 4). As well, total biomass indices and abundance values of harvestable-size scallops declined in 1990 in four of six Delmarva sampling strata, although record-high values were observed in stratum 19 (Table 1, Appendix Tables 5 and 6).

Survey size frequency data (Figure 9) indicate that the resource in the Delmarva region is dominated by the strong 1986 cohort. The 1987 cohort seems to be very weak and appears to be the poorest in the region since the 1981 year class.

Due to the weak 1987 cohort, the Delmarva resource is no longer dominated by small scallops. Only 26% of the total number of scallops caught in Delmarva during the 1990 survey were less than 70 mm in shell height (>80 count) (Table 1). The harvestable stock was dominated by 80-40 count scallops (i.e., the 1986 cohort) which comprised 57% of the harvestable biomass by weight and by 73% by number (Tables 6 and 8; Figure 4). In 1991, scallops in the 80-40 meat count interval should account for much less of the harvestable resource in Delmarva than in 1990 since the weak 1987 year class will replace the strong 1986 cohort in the 80-40 count size range.

Virginia - North Carolina (Strata 6-7) - The Virginia-North Carolina region is at the southernmost extremity of the distribution range of sea scallops. Abundance of scallops in this region is generally ephemeral and recruitment erratic. Although survey coverage during 1990 consisted of only six tows, the limited sampling results indicated that scallop abundance in the region increased to record-high levels (Tables 1 and 2; Figure 2). The 1990 total and harvestable-size number per tow indices (129.6 and 93.1, respectively) were the highest in the time series, and nearly double the previous record-high values. The 1990 pre-recruit abundance index (36.5) was also a record-high (slightly greater than the 1989 value of 35.7) suggesting that the 1987 year class is as strong as the outstanding 1986 cohort was in the region (Table 2). Survey biomass indices in 1990 were the highest since 1978. Harvestable biomass in 1990 was dominated by the 1986 cohort (80-40 count scallops) which comprised 81%, by number, and 67% by weight of the harvestable population (Tables 6, 8, and 13; Figure 4).

Survey size frequency data (Figure 10) suggest that the harvestable stock of scallops in the Virginia-North Carolina region in 1991 should reach new record-high levels as the exceptional 1987 year class recruits to the fishery.

GEORGES BANK AREA

In the USA portion of Georges Bank, virtually all of the 1990 survey catch per tow indices were the highest in the time series since partitioning of the Bank by the International Court of Justice in 1984 (Table 4). As in the Mid-Atlantic region, small scallops dominated the USA Georges Bank scallop resource (61% of the number of scallops caught in the USA Georges Bank region were >80 count: Table 1). Of the harvestable biomass in the USA sector, 67% was accounted for by scallops between 80-40 count, while scallops >30 meat count accounted for 82% of the harvestable biomass (Tables 9, 10 and 13, Figure 5). Based on survey height frequency data (Figures 11, 13-15), recruitment of the 1986 year class appears very strong in the USA Northern Edge and Peak region, while the 1987 year class seems to be excellent in the South Channel region.

For all of Georges Bank (USA and Canadian sectors combined), the 1990 survey results indicate that a marked improvement in abundance has occurred. Abundance indices of total scallops (320.9 per tow) and pre-recruit scallops (193.6 per tow) were the highest since 1980, while the 1990 abundance index of harvestable-size scallops (127.3) was the highest since 1981 (Table 3, Figure 3). In general, scallop size-distribution and recruitment patterns for the entire Georges Bank area paralleled those observed for the USA sector of Georges Bank (Figure 12 vs Figure 11).

Abundance patterns and resource conditions within the three principal scallops regions on Georges Bank [South Channel; Southeast Part; and USA Northern Edge and Peak] are described below.

South Channel (Strata 46-47; 49-55) - In the South Channel region, all survey indices of abundance and biomass sharply increased in 1990. The 1990 total number per tow index (308.7) was the highest in the time series and the 1990 total weight per tow index (1.14 kg) was the highest since 1982 (Table 3, Figure 3). Catch per tow values for harvestable-size scallops (#/tow: 49.9; wt/tow: 0.60 kg) were the highest since 1987, increasing from the record-low 1989 levels. Most importantly, abundance and biomass indices for pre-recruit scallops in 1990 were the highest ever recorded in the South Channel region (Table 3).

Increases in scallop abundance were widespread throughout the South Channel area. Total number per tow indices increased [compared to 1989] in eight of the nine South Channel sampling strata, while total weight per tow indices increased in every stratum. Record-high pre-recruit abundance values were recorded in six of nine strata, while record-setting total abundance indices were obtained in four strata with near-record values (2nd highest) obtained in three others (Table 1, Appendix Tables 7-10).

Survey size frequency data (Figure 13) show that the pronounced increase in South Channel scallop abundance is due to an exceptional 1987 year class. This cohort appears to be the strongest ever produced in the region, and should provide outstanding recruitment to the South Channel fishery in mid-1991 and during 1992. This recruitment will be particularly important since it follows two cohorts (i.e., 1985 and 1986 year classes) which were both below-average in abundance.

Given the abundance of the 1987 year class in the South Channel region, small scallops dominate the resource (Figure 13). Scallops <70 mm shell height [>80 count] comprised 84% of the 1990 survey catch, while scallops <30 count accounted for only 3% of the catch (Table 1). The harvestable stock was dominated by scallops from the 1986 year class (80-40 count animals) which comprised 43% of the harvestable biomass. Scallops <30 count accounted for only 35% of the exploitable biomass (Tables 9, 10 and 13, Figure 5).

Southeast Part (Strata 58-60) - Survey indices of total abundance and biomass indices from the Southeast Part region of Georges Bank in 1990 were the lowest in the time series (Table 3, Figure 3). Abundance of harvestable-size scallops declined to record-low levels (#/tow: 8.4; wt/tow: 0.15 kg), and pre-recruit indices were among the lowest recorded (Table 3). In all three sampling strata in the Southeast Part, survey catch per tow values declined between 1989 and 1990; the sole exception was in Stratum 59 where the abundance of harvestable-size scallops was slightly above the low 1989 level (Appendix Tables 7-10).

Survey size frequency data (Figure 14) indicate that the 1986 year class, which was one of the strongest ever observed in the region, has been rapidly fished-down. Since the average size of 1986-year-class scallops in the 1990 survey was only about 40 count, intense harvesting of very small individuals (> 40 count) of this cohort must have occurred in the fishery between August 1989 and August 1990 to produce the large reduction in cohort abundance evident in the 1990 survey.

Larger-size scallops dominate the Southeast Part resource. This is due to the poor 1987 year class in the region, and to full recruitment of the 1986 cohort into the harvestable portion of the population. Survey meat count distributions indicate that about 59% of the harvestable biomass in the region was accounted for by scallops <30 meat count (Tables 9, 10, 13; Figure 5).

USA Northern Edge & Peak (Strata 61, 621, 631, 651, 661, 71, 72, 74) - Abundance and biomass of scallops in the USA Northern Edge and Peak region of Georges Bank increased sharply in 1990 to their highest levels since the partitioning of Georges Bank in 1984 (Table 4). The 1990 number per tow index of harvestable-size scallops (196.8) was three times greater than in 1988 [no NEFC survey was conducted of the Northern Edge and Peak region in 1989], while the 1990 pre-recruit abundance index remained at the relatively high levels observed in the 1987 and 1988 surveys.

Examination of the 1990 survey results, by sampling stratum, revealed a pronounced areal dichotomy in scallop abundance. Record-high abundance indices were recorded in sampling strata located in the southeastern portion of the Peak (Strata 61 and 621), while record-low abundance levels were observed in strata located in the northwestern portion of the region (Strata 651 and 661) (Table 1 and Appendix Tables 7-10). Although the reasons for these geographic differences are not clear, they may be due to differential spatial localization and success of the 1986 and 1987 year classes between the two areas and/or differential fishing mortality rates amongst the two areas.

As an entity, the USA Northern Edge and Peak region is dominated by scallops from the outstanding 1986 year class (Figure 15). Although much less abundant, the 1987 cohort still appears to be a good one, equivalent in size to the above-average 1983 and 1984 year classes. Due to the 1986 year class, the harvestable component of the Northern Edge and Peak resource was overwhelming dominated by 80-40 meat count scallops (constituting nearly 80% of the harvestable biomass); large scallops (<30 meat count) accounted for less than 9%, by weight, of the exploitable stock (Tables 9, 10, and 13, Figure 5).

SUMMARY

Results of the 1990 NEFC sea scallop research vessel survey indicate that scallop abundance in both the Mid-Atlantic and Georges Bank areas is at or near record-high levels. In the Mid-Atlantic area, survey abundance and biomass indices in 1990 were among the highest in the 16-year survey time series. As expected, the exceptional 1986 year class recruited to the exploitable stock in all three Mid-Atlantic regions during 1990, generating a sharp increase in harvestable biomass in Virginia-North Carolina and high (i.e., 1988/1989) biomass levels in the New York Bight and Delmarva regions. Survey pre-recruit indices indicate that the strength of the 1987 year class varies by region, being excellent in Virginia-North Carolina, very strong in the New York Bight, but weak in Delmarva.

On Georges Bank, scallop abundance increased markedly in 1990, particularly in the South Channel and USA Northern Edge and Peak regions. Survey abundance indices in 1990 for each of these regions were the highest ever due to excellent recruitment of the 1987 year class in both areas, and strong recruitment of the 1986 year class in the Northern Edge and Peak region. In the Southeast Part of the Bank, however, survey indices declined to record-low levels in 1990 suggesting that intense harvesting of the strong 1986 year class occurred during the past year. Scallop abundance will remain low in the Southeast Part during 1991 since recruitment of the 1987 year class in this region is extremely poor.

In both the Mid-Atlantic and USA Georges Bank resources, small scallops were predominate. In the Mid-Atlantic area, scallops >40 count comprised 91% of the population by number and 71% by weight. In the USA Georges Bank area, scallops >40 accounted for 93% of the population by number and 75% by weight. Larger-size scallops will become more dominant in 1991 as the exceptional 1986 year class grows into the 40-35 meat count interval.

Meat count distributions derived from the 1990 survey indicated that 80-40 count scallops (i.e., scallops from the strong 1986 year class) accounted for 62% of the harvestable biomass in the Mid-Atlantic area, and 67% of the harvestable biomass in the USA portion of Georges Bank (Figure 6). For the combined USA Mid-Atlantic and Georges Bank areas, 64% of the total harvestable biomass was accounted for by 80-40 count scallops; large scallops (<30 count), by contrast, accounted for only 20%, by weight, of the total exploitable stock (Table 13, Figure 6).

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Table 1. Summary of 1990 NEFC sea scallop research vessel survey data for sea scallops, by sampling stratum. Shell height data are in mm (25.4 mm = 1 inch); meat weight data are in grams (453.6 g = 1 pound); meat count refers to numbers of meats per pound, pre-recruit refers to scallops <70 mm in shell height, recruit refers to scallops ≥70 mm in shell height. Area mean number and mean weight per tow values represent stratified means weighted by stratum area.

Stratum Region	Depth Range	No. of Tows	Mean Number Per Tow: Pre-recruit	Mean Number Per Tow: Recruit	Mean Number Per Tow: Total	All Scallops: Average Shell Height	All Scallops: Calcd Meat Count[1]	Average Meat Weight (g) Per Tow	Percent Distribution of Catch in Numbers: >80 Count	80-40 Count	40-35 Count	35-30 Count	<30 Count
1	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
2	25-30	N/S	-	-	-	-	-	-	-	-	-	-	-
3	30-40	N/S	-	-	-	-	-	-	-	-	-	-	-
4	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
5	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
6	25-30	3	3.0	32.3	35.3	90	35	459	8.5	28.3	29.2	24.5	9.4
7	30-40	3	81.7**	175.0**	256.7**	70	72	1617**	31.8	63.5	3.4	0.4	0.9
8	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
Virginia - No. Carolina (6-7)	30-60	6	36.5**	93.1**	129.6**	73	62	952	28.2	58.0	7.4	4.2	2.2
9	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
10	25-30	8	10.5	29.1	39.6	82	42	424	26.5	42.0	8.8	7.6	15.1
11	30-40	8	20.8	33.5	54.3	72	60	412	38.2	44.0	6.7	4.6	6.5
12	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
13	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
14	25-30	12	60.7	74.3	135.0	72	62	990	44.9	39.5	5.6	3.9	6.1
15	30-40	12	14.6	72.7	87.3	81	48	829	16.7	58.5	10.0	5.2	9.6
16	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
17	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
18	25-30	10	7.9	90.2	98.1	84	43	1028	8.1	63.4	13.8	4.9	9.9
19	30-40	12	53.9	157.7**	211.6	75	58	1652**	25.5	58.3	6.8	4.1	5.4
20	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
Delmarva (10-11; 14-15; 18-19)	25-40	62	27.7	80.9	108.6	77	53	930	25.6	54.0	8.4	4.5	7.5
21	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
22	25-30	8	10.7	24.3	35.0	81	40	402	30.7	26.4	6.4	9.6	26.8
23	30-40	16	326.1	372.8**	698.9**	69	79	4016**	46.7	47.7	2.6	1.4	1.7
24	40-60	5	1.2	5.6	6.8	75	61	51	17.6	73.5	2.9	5.9	0.0
25	15-25	3	2.3	1.7*	4.0*	70	36	50*	58.3	8.3	0.0	0.0	33.3
26	25-30	12	6.2	18.6	24.8	86	34	335	25.2	29.5	7.0	4.7	33.6
27	30-40	17	571.9	332.0	903.9	65	94	4386**	63.3	33.1	2.5	0.6	0.5
28	40-60	10	36.2	65.1**	101.3	73	68	677**	35.7	58.0	4.2	1.2	0.8
29	15-25	5	30.2	16.2	46.4	74	40	521	65.1	6.0	1.7	3.0	24.1
30	25-30	14	43.4	45.9	89.2	73	54	751	48.6	28.7	6.8	4.1	11.8
31	30-40	24	261.0**	131.2	392.2**	64	94	1886	66.5	27.4	2.6	1.9	1.6
32	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
33	15-25	10	21.7	13.5	35.2	70	48	330	61.6	9.1	3.7	5.4	20.2
34	25-30	14	30.7	47.9	78.6	77	45	790	39.0	22.1	9.7	8.0	21.2
35	30-40	10	2.6	8.6	11.2	83	38	135	23.2	20.5	19.6	16.1	20.5
36	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
New York Bight (22-31; 33-35)	15-60	148	121.1	92.8	213.9	67	79	1232	56.6	35.4	2.9	1.7	3.4
Mid-Atlantic (6-35)	15-60	216	103.2	90.6**	193.8	68	75	1174	53.3	37.5	3.5	2.0	3.7

[1] Derived by applying NEFC survey shell height - meat weight equations to shell height frequency distributions.

* Lowest value in 1975-1990 survey time series.

** Highest value in 1975-1990 survey time series.

N/S = Not sampled in 1990 survey.

Table 1. (continued).

Stratum Region	Depth Range	No. of Tows	Mean Number Per Tow: Pre-recruit	Recruit	Total	All Scallops: Average Shell Height	Calcd Meat Count[1]	Average Meat Weight (g) Per Tow	Percent Distribution of Catch in Numbers: >80 Count	80-40 Count	40-35 Count	35-30 Count	<30 Count
37	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
38	25-30	N/S	-	-	-	-	-	-	-	-	-	-	-
39	30-40	N/S	-	-	-	-	-	-	-	-	-	-	-
40	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
41	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
42	25-30	N/S	-	-	-	-	-	-	-	-	-	-	-
43	30-40	N/S	-	-	-	-	-	-	-	-	-	-	-
44	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
So. New England (37-44)	15-60	N/S	-	-	-	-	-	-	-	-	-	-	-
45	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
46	25-30	6	68.2**	42.3	110.5**	66	79	632	61.7	27.1	5.7	3.2	2.3
47	30-40	12	147.7**	39.1	186.8**	59	102	834	79.1	12.7	2.8	2.7	2.7
48	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
49	15-25	6	824.4**	75.8	900.2**	58	135	3032	91.6	7.2	0.4	0.2	0.7
50	25-30	9	1462.7**	56.6	1519.3	48	223	3089	96.3	1.7	0.4	0.4	1.2
51	30-40	9	995.8	36.4	1032.2	42	323	1448	96.5	1.9	0.4	0.4	0.8
52	40-60	10	153.5**	95.4	248.9**	67	78	1446	61.7	29.3	4.2	1.5	3.4
53	40-60	7	3.2	17.9	21.1	94	27	355	15.5	22.3	8.1	10.1	43.9
54	30-40	7	65.5**	94.4	159.9	78	48	1519	40.9	32.3	5.1	6.0	15.7
55	30-40	10	10.5	20.9**	31.4	78	45	318	33.4	39.2	5.1	5.7	16.6
56	40-60	N/S	-	-	-	-	-	-	-	-	-	-	-
South Channel (46-47; 49-55)	15-60	76	258.8**	49.9	308.7**	56	123	1143	83.8	10.4	1.7	1.4	2.7
57	30-40	N/S	-	-	-	-	-	-	-	-	-	-	-
58	40-60	8	0.8	0.3*	1.1	62	66	8	77.8	0.0	0.0	11.1	11.1
59	30-40	12	1.5	14.4	15.9	89	31	232*	9.4	56.5	9.9	5.8	18.3
60	40-60	12	2.0	7.4*	9.4*	89	29	149*	21.2	32.7	4.4	8.0	33.6
So. East Part (58-60)	30-60	32	1.6	8.4*	10.0*	89	30	150*	16.3	44.3	7.2	6.9	25.3
61	30-40	8	22.9	220.9**	243.8**	79	55	2020	9.4	85.6	3.9	0.6	0.5
621	40-60	12	231.7**	516.1**	747.8**	74	62	5437**	31.0	61.4	4.5	1.3	1.7
631	30-40	7	3.2	4.7	7.9	92	26	139	40.0	12.7	1.8	5.5	40.0
651	30-40	12	26.1*	61.3	87.4*	77	51	777*	29.8	49.7	7.0	4.7	8.9
661	40-60	12	6.7*	65.8	72.5*	89	35	944*	9.3	44.6	17.9	7.6	20.6
71	25-30	6	43.4	120.3	163.7	78	53	1413	26.5	58.6	5.8	3.3	5.9
72	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
73	15-25	N/S	-	-	-	-	-	-	-	-	-	-	-
74	25-30	8	1.0	5.4	6.4	102	22	134	15.7	15.7	5.9	5.9	56.9
USA No. Edge & Peak (61-661, 71,74)	15-60	65	66.9**	196.8**	263.7**	76	58	2052**	25.4	66.2	4.6	1.4	2.4
622	40-60	6	142.5	149.5**	292.0	66	66	2000	48.8	30.1	6.5	4.7	9.9
632	30-40	7	110.0	112.7	222.7	74	52	1938	49.4	33.7	4.6	2.0	10.3
64	40-60	16	653.1	323.9	977.0	58	85	5213	66.8	17.0	4.4	3.3	8.4
652	30-40	9	469.3	599.7	1069.0	72	60	8103	43.9	37.9	4.3	3.8	10.1
662	40-60	3	11.3*	479.0	490.3	91	33	6719	2.3	48.7	6.7	7.7	34.6
CAN No. Edge & Peak (622-662, 64)	30-60	41	431.7**	287.9	719.6	62	73	4480	60.0	21.6	4.6	3.6	10.2

Table 1. (continued).

Stratum Region	Depth Range	No. of Tows	Mean Number Per Tow			All Scallops		Average Meat Weight (g) Per Tow	Percent Distribution of Catch in Numbers				
			Pre-recruit	Recruit	Total	Average Shell Height	Calcd Meat Count[1]		>80 Count	80-40 Count	40-35 Count	35-30 Count	<30 Count
Total No. Edge & Peak (61-66, 71,74)	15-60	106	223.8	236.0	459.8	66	67	3097	48.7	36.1	4.6	2.9	7.7
USA Georges Bank	15-60	173	135.2[**]	87.8[**]	223.0[**]	64	84	1202[**]	60.6	32.2	2.9	1.5	2.8
USA Georges Bank & Mid-Atlantic	15-60	214	117.7	89.3	207.0	66	79	1187	56.8	34.9	3.2	1.8	3.4

[1] Derived by applying survey shell height-meat weight equations to shell height frequency distributions.

[*] Lowest value in 1975-1990 survey time series.

[**] Highest value in 1975-1990 survey time series.

Table 2. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), (meats only, kg), mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys in the Mid-Atlantic, 1975, 1977-1990. Data are presented by principal scallop regions in the Mid-Atlantic[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow: Pre-recruit	Recruit	Total	Standardized Stratified Mean Weight (kg) Per Tow[2]: Pre-recruit	Recruit	Total	Mean Shell Height	Average Meat Count
New York Bight	1975	28	39.4	34.7	74.1	0.10	0.62	0.72	75.3	46.9
	1977	101	1.4	56.7	58.1	<0.01	1.03	1.03	98.6	25.6
	1978	116	3.3	52.7	56.0	0.01	1.15	1.16	102.8	21.9
	1979	120	5.3	17.6	22.9	0.01	0.43	0.44	93.6	23.7
	1980	121	15.4	15.2	30.6	0.02	0.36	0.38	75.5	35.7
	1981	117	18.8	19.0	37.8	0.03	0.29	0.32	67.7	53.5
	1982	134	10.9	20.9	31.8	0.02	0.33	0.35	78.4	41.2
	1983	136	11.5	14.0	25.5	0.03	0.29	0.32	80.3	36.6
	1984	142	17.4	18.4	35.8	0.03	0.29	0.32	69.2	51.0
	1985	137	47.4	30.9	78.3	0.10	0.43	0.53	65.6	67.1
	1986	152	53.2	49.3	102.5	0.13	0.65	0.78	69.6	59.9
	1987	154	94.5	46.0	140.5	0.18	0.58	0.76	61.7	83.7
	1988	154	75.9	100.5	176.4	0.11	1.25	1.36	68.6	58.9
	1989	157	168.6	81.8	250.4	0.25	0.90	1.15	56.4	99.1
	1990	148	121.1	92.8	213.9	0.35	0.88	1.23	67.2	78.7
Delmarva	1975	15	36.2	24.0	60.2	0.11	0.44	0.55	75.2	49.3
	1977	10	10.7	47.5	58.2	0.03	0.91	0.94	92.2	28.1
	1978	45	27.3	75.8	103.2	0.09	1.58	1.67	91.6	28.0
	1979	43	25.4	64.6	90.0	0.04	0.95	0.99	78.8	41.2
	1980	43	81.1	35.9	117.0	0.13	0.68	0.81	63.3	65.7
	1981	41	4.7	14.3	19.0	0.01	0.32	0.33	90.3	26.2
	1982	44	10.0	18.6	28.6	0.04	0.43	0.47	89.8	27.8
	1983	49	25.7	16.5	42.2	0.09	0.37	0.46	77.0	41.7
	1984	52	19.8	19.3	39.1	0.03	0.38	0.41	69.8	43.7
	1985	54	70.4	35.8	106.2	0.15	0.43	0.58	58.9	82.5
	1986	62	123.5	83.5	207.0	0.37	0.93	1.30	68.5	72.3
	1987	61	52.9	59.5	112.4	0.16	0.74	0.90	74.1	56.7
	1988	62	75.9	39.1	115.0	0.15	0.62	0.77	64.6	67.9
	1989	62	113.1	97.2	210.3	0.24	1.09	1.33	67.5	71.6
	1990	62	27.7	80.9	108.6	0.06	0.87	0.93	76.9	53.0
Virginia-No. Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	1	0.0	10.0	10.0	0.00	0.23	0.23	108.0	20.0
	1978	3	15.3	50.3	65.6	0.06	1.10	1.16	91.8	25.7
	1979	3	23.7	22.7	46.4	0.04	0.37	0.41	71.7	51.3
	1980	3	6.6	39.0	45.6	0.02	0.59	0.61	87.6	34.1
	1981	3	0.9	7.6	8.5	<0.01	0.20	0.20	107.7	18.8
	1982	7	0.4	3.7	4.1	<0.01	0.12	0.12	111.5	15.8
	1983	8	25.8	11.7	37.5	0.10	0.36	0.46	78.1	37.2
	1984	9	0.2	14.6	14.8	<0.01	0.27	0.27	98.7	25.3
	1985	10	1.7	7.3	9.0	<0.01	0.23	0.23	104.8	17.8
	1986	10	5.6	1.8	7.4	<0.02	0.04	0.06	69.1	55.9
	1987	10	0.1	2.1	2.2	<0.01	0.04	0.04	93.4	28.3
	1988	10	3.1	11.0	14.1	0.01	0.21	0.22	89.8	28.9
	1989	10	35.7	5.9	41.6	0.07	0.13	0.20	57.9	92.9
	1990	6	36.5	93.1	129.6	0.07	0.88	0.95	73.2	61.7
Mid-Atlantic (All Areas)	1975	43	38.8	32.6	71.4	0.10	0.59	0.69	75.3	47.2
	1977	112	2.8	55.1	57.9	0.01	1.00	1.01	97.7	25.9
	1978	164	7.8	56.8	64.6	0.02	1.23	1.25	99.4	23.4
	1979	166	9.1	26.2	35.3	0.02	0.52	0.54	86.5	29.8
	1980	167	27.1	19.2	46.3	0.04	0.42	0.46	70.1	45.8
	1981	161	16.1	18.0	34.1	0.02	0.30	0.32	70.1	48.2
	1982	185	10.6	20.3	30.9	0.03	0.34	0.37	80.4	38.1
	1983	193	14.3	14.4	28.7	0.04	0.30	0.34	79.4	37.8
	1984	203	17.6	18.5	36.1	0.02	0.31	0.33	69.5	49.2
	1985	201	51.0	31.5	82.5	0.11	0.43	0.54	64.1	69.8
	1986	224	65.2	54.8	120.0	0.17	0.69	0.86	69.3	63.3
	1987	225	85.7	47.9	133.6	0.17	0.61	0.78	63.6	78.0
	1988	226	74.9	88.3	163.2	0.12	1.12	1.24	68.1	59.9
	1989	229	156.9	83.6	240.5	0.24	0.93	1.17	58.1	93.5
	1990	216	103.2	90.6	193.8	0.29	0.88	1.17	68.2	74.9

[1] New York Bight: Strata 22-31, 33-35; Delmarva: Strata 10-11, 14-15, 18-19; Va-NC: Strata 6-7.

[2] Mean meat weight derived by applying the 1977-1982 USA Mid-Atlantic research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -12.1628 + 3.2539 ln Shell Height (mm) (n = 11943, r = 0.98), to the survey shell height frequency distributions.

Table 3. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys on Georges Bank, 1975, 1977-1990. Data are presented by principal scallop regions on Georges Bank[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow: Pre-recruit	Recruit	Total	Standardized Stratified Mean Weight (kg) Per Tow[2]: Pre-recruit	Recruit	Total	Mean Shell Height	Average Meat Count
South Channel	1975	58	45.1	29.9	75.0	0.11	0.81	0.92	76.4	37.0
	1977	30	6.3	89.1	95.4	0.02	1.94	1.96	101.3	22.1
	1978	46	7.7	49.7	57.4	0.02	1.15	1.17	101.2	22.2
	1979	47	6.8	88.2	95.0	0.01	1.53	1.54	93.2	28.0
	1980	40	79.7	30.2	109.9	0.12	0.55	0.67	58.2	74.6
	1981	56	15.5	36.5	52.0	0.03	0.65	0.68	80.5	34.8
	1982	61	213.8	53.0	266.8	0.49	0.67	1.16	58.6	103.9
	1983	69	19.0	55.8	74.8	0.06	0.77	0.83	81.4	41.0
	1984	69	13.6	17.7	31.3	0.03	0.36	0.39	77.3	36.7
	1985	77	40.3	47.3	87.6	0.11	0.76	0.87	75.0	45.7
	1986	68	115.3	37.0	152.3	0.24	0.58	0.82	59.5	84.2
	1987	86	84.6	56.1	140.7	0.17	0.72	0.89	63.6	71.6
	1988	91	32.5	36.0	68.5	0.08	0.46	0.54	70.6	57.7
	1989	88	21.7	15.1	36.8	0.06	0.27	0.33	72.0	50.5
	1990	76	258.8	49.9	308.7	0.54	0.60	1.14	55.9	122.5
Southeast Part	1975	21	1.8	38.4	40.2	<0.01	1.02	1.02	110.3	17.8
	1977	21	3.2	27.2	30.4	0.01	0.68	0.69	103.6	20.0
	1978	18	2.2	27.1	29.3	<0.01	0.93	0.93	117.2	14.2
	1979	20	7.7	21.2	28.9	0.01	0.71	0.72	99.4	18.2
	1980	20	21.5	41.7	63.2	0.03	0.71	0.74	78.2	38.8
	1981	19	1.4	19.4	20.8	<0.01	0.46	0.46	102.5	20.5
	1982	22	0.8	9.8	10.6	<0.01	0.32	0.32	113.5	15.2
	1983	20	11.3	9.2	20.5	0.02	0.25	0.27	78.1	34.0
	1984	20	4.6	12.9	17.5	0.01	0.23	0.24	85.7	33.0
	1985	28	9.1	11.8	20.9	0.02	0.22	0.24	75.3	39.9
	1986	32	28.9	20.6	49.5	0.05	0.41	0.46	66.2	48.5
	1987	32	23.1	39.6	62.7	0.06	0.60	0.66	79.0	42.8
	1988	32	1.4	16.1	17.5	<0.01	0.32	0.32	96.9	24.6
	1989	31	23.6	11.8	35.4	0.07	0.23	0.30	70.2	54.4
	1990	32	1.6	8.4	10.0	<0.01	0.15	0.15	88.7	30.3
No. Edge & Peak	1975	51	83.8	135.9	219.7	0.21	2.02	2.23	78.1	44.7
	1977	71	66.1	384.8	450.9	0.23	5.06	5.30	85.3	38.6
	1978	76	177.7	372.9	550.6	0.31	7.60	7.91	85.1	31.6
	1979	153	72.0	257.9	329.9	0.21	4.46	4.67	87.2	32.1
	1980	311	665.7	143.7	809.4	0.91	2.05	2.96	52.4	123.9
	1981	101	277.4	405.7	683.1	0.63	3.79	4.42	68.9	70.1
	1982	80	40.9	65.3	106.2	0.12	0.95	1.07	78.1	45.1
	1983	82	48.2	37.1	85.3	0.08	0.67	0.75	68.2	51.9
	1984	82	293.8	54.0	347.8	0.29	0.84	1.13	46.7	139.3
	1985	108	84.5	192.2	276.7	0.25	1.85	2.10	73.9	59.6
	1986	216	173.0	195.6	368.6	0.39	2.59	2.98	72.0	56.2
	1987	118	150.2	122.2	272.4	0.30	1.61	1.91	66.9	64.6
	1988	119	99.3	124.4	223.7	0.23	1.53	1.76	70.5	57.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	106	223.8	236.0	459.8	0.42	2.68	3.10	66.4	67.4
Georges Bank (All Areas)	1975	130	51.7	74.6	126.3	0.13	1.34	1.47	79.9	39.0
	1977	122	34.3	218.3	252.6	0.12	3.18	3.30	87.6	34.7
	1978	140	79.7	184.0	263.7	0.14	3.88	4.02	87.1	29.8
	1979	220	36.6	152.3	188.9	0.10	2.70	2.80	88.6	30.6
	1980	371	377.4	92.3	469.7	0.52	1.37	1.89	53.4	112.6
	1981	176	97.2	152.4	249.6	0.22	1.62	1.84	70.6	61.5
	1982	163	91.0	51.2	142.2	0.22	0.74	0.96	66.5	66.9
	1983	171	31.9	38.2	70.1	0.06	0.63	0.69	73.4	46.3
	1984	171	148.7	34.6	183.3	0.15	0.57	0.72	49.1	114.9
	1985	213	56.3	111.6	167.9	0.17	1.19	1.36	74.1	56.2
	1986	316	129.9	123.0	252.9	0.28	1.68	1.96	70.1	58.5
	1987	236	105.5	85.4	190.9	0.21	1.14	1.35	66.9	64.3
	1988	242	59.5	75.6	135.1	0.14	0.96	1.10	71.2	55.9
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	214	193.6	127.3	320.9	0.38	1.47	1.85	63.0	78.7

[1] South Channel: Strata 46-47, 49-55; Southeast Part: Strata 58-60; No. Edge & Peak: Strata 61-662, 71-72, and 74.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98), to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 not sampled, excluded from analyses.

Table 4. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFC surveys in the USA and Canadian sectors of Georges Bank, 1985-1990. Data are presented for the USA and Canadian Northern Edge and Peak regions of Georges Bank[1], and the entire USA sector of Georges Bank. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
USA No. Edge & Peak	1985	67	21.8	26.6	48.4	0.06	0.39	0.45	72.2	48.9
	1986	70	45.6	28.6	74.2	0.13	0.48	0.61	70.4	55.2
	1987	71	62.0	54.6	116.6	0.12	0.73	0.85	67.1	62.1
	1988	71	65.8	60.9	126.7	0.15	0.77	0.92	66.4	62.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	65	66.9	196.8	263.7	0.22	1.83	2.05	75.8	58.3
Canada No. Edge & Peak	1985	41	186.0	460.3	646.3	0.58	4.20	4.78	74.1	61.3
	1986	146	379.6	466.0	845.6	0.80	6.01	6.81	72.3	56.3
	1987	47	293.0	231.7	524.7	0.59	3.04	3.63	66.9	65.6
	1988	48	153.7	227.1	380.8	0.36	2.77	3.13	72.8	55.3
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990	41	431.7	287.9	719.6	0.68	3.80	4.48	61.9	72.9
USA Sector of Georges Bank	1985	172	26.5	31.8	58.3	0.07	0.50	0.57	74.2	46.4
	1986	170	61.3	28.9	90.2	0.14	0.49	0.63	64.4	64.9
	1987	189	62.6	51.9	114.5	0.12	0.70	0.82	66.8	63.0
	1988	194	38.0	40.8	78.8	0.09	0.54	0.63	69.4	56.6
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	173	135.2	87.8	223.0	0.31	0.89	1.20	63.9	84.1

[1] USA No. Edge & Peak: Strata 61, 621, 631, 651, 662, 71, 72, and 74.
Canada No. Edge & Peak: Strata 622, 632, 64, 652, and 662.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98), to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table 5. Distribution of standardized stratified mean weight (g, meat) per tow among various meat count intervals for sea scallops from NEFC sea scallop research vessel surveys in the Mid- Atlantic, 1975, 1977-1990.

				Meat Weight (g, meat) Per Tow [1]				
		Total Biomass	Harvestable[2] Biomass	Meat Count Interval[3]				
Area	Year	Per Tow(g)	Per Tow (g)	80 - 40	40 - 35	35 - 30	30 - 25	<25
New York Bight	1975	717	622	94	53	63	65	347
	1977	1029	1025	165	68	95	142	555
	1978	1158	1151	58	45	92	142	814
	1979	439	430	28	7	15	22	358
	~~1980~~	~~370~~	~~356~~	~~33~~	~~12~~	~~16~~	~~15~~	~~280~~
	1981	321	292	86	16	14	13	163
	1982	350	327	93	24	22	24	164
	1983	317	289	34	18	20	24	193
	1984	318	294	89	30	18	13	144
	1985	530	427	140	40	40	41	166
	1986	776	651	268	60	51	43	229
	1987	761	582	239	85	59	46	153
	1988	1357	1249	568	137	89	84	371
	1989	1146	901	452	100	76	58	215
	1990	1232	882	553	80	55	36	158
Delmarva	1975	555	444	48	42	51	63	240
	1977	941	911	162	72	63	69	545
	1978	1672	1584	186	74	78	108	1138
	1979	991	951	327	62	50	53	459
	1980	808	678	104	17	33	73	451
	1981	329	320	47	8	6	10	249
	1982	467	431	38	12	19	25	337
	1983	459	371	42	18	14	11	286
	1984	406	374	61	38	42	28	205
	1985	584	430	176	19	18	27	190
	1986	1299	925	416	115	110	91	193
	1987	899	739	244	148	139	91	117
	1988	768	621	109	77	86	88	261
	1989	1332	1090	582	138	93	69	208
	1990	930	867	493	116	75	66	117
Virginia-North Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	227	227	11	13	15	18	170
	1978	1159	1097	177	7	15	18	880
	1979	411	372	111	49	46	26	140
	1980	608	592	174	35	24	55	304
	1981	204	201	4	4	9	15	169
	1982	119	118	1	4	4	3	106
	1983	458	361	26	7	3	4	321
	1984	265	265	35	49	48	28	105
	1985	231	228	1	-	5	18	204
	1986	60	44	4	-	1	3	36
	1987	35	35	10	2	3	3	17
	1988	222	215	16	12	26	30	131
	1989	203	134	10	11	7	10	96
	1990	952	880	591	123	82	23	61
Mid-Atlantic (All Areas)	1975	686	588	85	51	61	64	327
	1977	1012	1005	163	69	91	131	551
	1978	1251	1228	82	50	89	134	873
	1979	538	523	83	18	22	27	373
	1980	458	417	48	13	19	26	311
	1981	321	296	78	14	12	13	179
	1982	368	343	82	21	21	24	195
	1983	344	305	36	18	19	21	211
	1984	333	308	83	31	23	16	155
	1985	536	425	144	36	36	38	171
	1986	861	693	291	70	61	51	220
	1987	777	604	236	96	73	54	145
	1988	1237	1123	478	125	88	84	348
	1989	1167	925	470	105	79	59	212
	1990	1174	880	543	87	59	41	150

[1] Meat weight values derived from shell height values using 1977-1982 USA research survey equation, ln Meat Weight (g) = -12.1628 + 3.2539 ln Shell Height (mm) (n = 11943, r = 0.98).

[2] Stratified mean weight (g, meat) per tow for sea scallops ≥70 mm; ≤80 count.

[3] Meat count is expressed as number of meats per pound.

Table 6. Percentage distribution of harvestable biomass (meat weight) of sea scallops in the Mid-Atlantic region, within various meat count intervals. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from distribution of standardized stratified mean meat weight per tow in NEFC sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977-1990.

		Percent of Harvestable Biomass Meat Count Interval[1]					
Area	Year	80 - 40	40 - 35	35 - 30	30 - 25	<30	<25
New York Bight	1975	15.1	8.5	10.2	10.4	66.2	55.8
	1977	16.0	6.7	9.3	13.9	68.0	54.1
	1978	5.0	3.9	8.0	12.3	83.1	70.8
	1979	6.5	1.8	3.5	5.0	88.2	83.2
	1980	9.3	3.4	4.6	4.0	82.7	78.7
	1981	29.5	5.4	4.7	4.6	60.4	55.8
	1982	28.6	7.3	6.6	7.3	57.5	50.2
	1983	12.0	6.2	6.9	8.4	74.9	66.5
	1984	30.4	10.0	6.2	4.3	53.4	49.1
	1985	32.7	9.4	9.5	9.5	48.4	38.9
	1986	41.1	9.3	7.8	6.6	41.8	35.2
	1987	41.0	14.7	10.1	7.9	34.2	26.3
	1988	45.5	10.9	7.2	6.7	36.4	29.7
	1989	50.2	11.0	8.5	6.4	30.3	23.9
	1990	62.7	9.1	6.3	4.0	21.9	17.9
Delmarva	1975	10.8	9.4	11.6	14.1	68.2	54.1
	1977	17.8	8.0	6.9	7.5	67.3	59.8
	1978	11.8	4.7	4.9	6.8	78.6	71.8
	1979	34.4	6.5	5.2	5.7	53.9	48.2
	1980	15.4	2.5	4.8	10.8	77.3	66.5
	1981	14.8	2.7	1.8	3.0	80.7	77.7
	1982	8.7	2.7	4.6	5.8	84.0	78.2
	1983	11.4	5.0	3.8	2.8	79.8	77.0
	1984	16.2	10.1	11.4	7.5	62.3	54.8
	1985	40.8	4.6	4.1	6.3	50.5	44.2
	1986	45.0	12.4	11.9	9.8	30.7	20.9
	1987	33.0	20.0	18.8	12.3	28.2	15.9
	1988	17.6	12.5	13.9	14.1	56.0	41.9
	1989	53.4	12.6	8.6	6.3	25.4	19.1
	1990	56.8	13.4	8.7	7.6	21.1	13.5
Virginia-North Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S
	1977	4.7	5.7	6.7	7.9	82.9	75.0
	1978	16.1	0.7	1.4	1.6	81.8	80.2
	1979	29.8	13.3	12.3	6.9	44.6	37.7
	1980	29.4	5.9	4.1	9.3	60.6	51.3
	1981	1.9	1.8	4.4	7.7	91.9	84.2
	1982	1.3	3.1	3.7	2.2	91.9	89.7
	1983	7.1	2.0	0.9	1.1	90.0	88.9
	1984	13.2	18.4	18.3	10.5	50.1	39.6
	1985	0.3	-	2.3	7.6	97.4	89.8
	1986	9.1	-	3.0	6.9	87.9	81.0
	1987	29.3	4.2	7.5	8.8	59.0	50.2
	1988	7.6	5.7	12.1	14.0	74.6	60.6
	1989	7.0	8.5	5.2	7.7	79.3	71.6
	1990	67.1	14.0	9.3	2.6	9.6	7.0
Mid-Atlantic (All Areas)	1975	15.1	8.5	10.2	10.4	66.2	55.8
	1977	16.3	6.8	9.0	13.0	67.9	54.9
	1978	6.7	4.1	7.2	10.9	82.0	71.1
	1979	15.9	3.4	4.1	5.3	76.6	71.3
	1980	11.4	3.2	4.6	6.1	80.8	74.7
	1981	26.4	4.9	4.1	4.3	64.6	60.3
	1982	24.0	6.2	6.2	6.9	63.6	56.7
	1983	11.8	5.9	6.1	7.0	76.2	69.2
	1984	27.1	10.2	7.4	5.1	55.3	50.2
	1985	34.0	8.4	8.5	8.9	49.1	40.2
	1986	42.0	10.0	8.8	7.4	39.2	31.8
	1987	39.2	15.8	12.0	8.9	33.0	24.1
	1988	42.6	11.1	7.8	7.5	38.5	31.0
	1989	50.8	11.3	8.5	6.4	29.4	23.0
	1990	61.7	9.9	6.7	4.7	21.7	17.0

[1] Meat count is expressed as number of meats per pound.

Table 7. Distribution of standardized mean number per tow among various meat count intervals for sea scallops from NEFC sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977-1990.

Area	Year	Stratified Mean Number of Scallops Per Tow						
		Total Number Per Tow	Harvestable Number Per Tow	Meat Count Interval				
				80 - 40	40 - 35	35 - 30	30 - 25	<25
New York Bight	1975	74.1	34.7	10.7	4.1	4.2	3.6	12.1
	1977	58.1	56.7	17.4	5.4	6.3	7.9	19.7
	1978	56.0	52.7	6.7	3.5	6.1	7.9	28.5
	1979	22.9	17.6	3.6	0.6	1.0	1.2	11.2
	1980	30.6	15.2	3.9	0.9	1.1	0.8	8.5
	1981	37.8	19.0	11.2	1.2	0.9	0.8	4.9
	1982	31.8	20.9	11.4	1.9	1.4	1.3	4.9
	1983	25.5	14.0	4.1	1.4	1.3	1.4	5.8
	1984	35.8	18.4	9.9	2.3	1.2	0.7	4.3
	1985	78.3	30.9	17.5	3.1	2.7	2.3	5.3
	1986	102.5	49.3	31.4	4.7	3.3	2.4	7.5
	1987	140.5	46.0	27.5	6.7	3.9	2.6	5.3
	1988	176.4	100.5	67.6	10.7	5.9	4.6	11.7
	1989	250.4	81.8	59.0	7.8	5.0	3.2	6.8
	1990	213.9	92.8	75.8	6.3	3.6	2.0	5.1
Delmarva	1975	60.2	24.0	5.7	3.2	3.4	3.5	8.2
	1977	58.2	47.5	17.7	5.7	4.1	3.8	16.2
	1978	103.2	75.8	22.0	5.8	5.1	6.0	36.9
	1979	90.0	64.6	38.9	4.8	3.3	3.0	14.6
	1980	117.0	35.9	12.8	1.3	2.2	4.1	15.5
	1981	19.0	14.3	5.4	0.7	0.4	0.5	7.3
	1982	28.6	18.6	5.3	0.9	1.3	1.4	9.7
	1983	42.2	16.5	6.3	1.4	0.9	0.6	7.3
	1984	39.1	19.3	6.7	2.9	2.8	1.6	5.3
	1985	106.2	35.8	25.9	1.5	1.2	1.5	5.7
	1986	207.0	83.5	55.9	8.9	7.2	5.1	6.4
	1987	112.4	59.5	29.1	11.5	9.2	5.1	4.6
	1988	115.0	39.1	12.8	6.0	5.7	4.9	9.7
	1989	210.3	97.2	69.1	10.7	6.1	3.9	7.4
	1990	108.6	80.9	58.7	9.1	5.0	3.7	4.4
Virginia-North Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	10.0	10.0	1.0	1.0	1.0	1.0	6.0
	1978	65.6	50.3	26.2	0.6	1.0	1.0	21.5
	1979	46.4	22.7	11.0	3.9	3.0	1.4	3.4
	1980	45.6	39.0	20.7	2.7	1.6	3.1	10.9
	1981	8.5	7.6	0.4	0.3	0.6	0.9	5.4
	1982	4.1	3.7	0.1	0.3	0.3	0.1	2.9
	1983	37.5	11.7	4.1	0.6	0.2	0.2	6.6
	1984	14.8	14.6	3.4	3.8	3.2	1.5	2.7
	1985	9.0	7.3	0.1	-	0.3	1.0	5.9
	1986	7.4	1.8	0.5	-	0.1	0.2	1.0
	1987	2.2	2.1	1.2	0.1	0.2	0.2	0.4
	1988	14.1	11.0	1.9	1.0	1.7	1.7	4.7
	1989	41.6	5.9	1.3	0.9	0.4	0.6	2.7
	1990	129.6	93.1	75.2	9.6	5.4	1.3	1.6
Mid-Atlantic (All Areas)	1975	71.4	32.6	9.7	4.0	4.0	3.6	11.3
	1977	57.9	55.1	17.3	5.4	5.9	7.3	19.2
	1978	64.6	56.8	9.7	3.9	5.8	7.5	29.9
	1979	35.3	26.2	10.1	1.4	1.4	1.5	11.8
	1980	46.3	19.2	5.7	1.0	1.3	1.4	9.8
	1981	34.1	18.0	10.1	1.1	0.8	0.7	5.3
	1982	30.9	20.3	10.1	1.7	1.4	1.3	5.8
	1983	28.7	14.4	4.5	1.4	1.2	1.2	6.1
	1984	36.1	18.5	9.2	2.4	1.5	0.9	4.5
	1985	82.5	31.5	18.8	2.8	2.4	2.1	5.4
	1986	120.0	54.8	35.4	5.4	4.0	2.8	7.2
	1987	133.6	47.9	27.5	7.4	4.8	3.0	5.2
	1988	163.2	88.3	56.9	9.7	5.8	4.7	11.2
	1989	240.5	83.6	60.1	8.2	5.2	3.3	6.8
	1990	193.8	90.6	72.7	6.8	3.9	2.3	4.9

Table 8. Percentage distribution of harvestable numbers of sea scallops in the Mid-Atlantic region, within various meat count intervals. Harvestable scallops are defined as all scallops ≥70 mm shell height. Data derived from distribution of standardized stratified mean number per tow of scallops in NEFC sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977-1990.

Area	Year	Percent of Harvestable Scallops By Meat Count Interval[1]					
		80 - 40	40 - 35	35 - 30	30 - 25	<30	<25
New York Bight	1975	30.8	11.9	12.0	10.4	45.3	34.9
	1977	30.7	9.4	11.1	14.0	48.8	34.8
	1978	12.8	6.7	11.5	15.0	69.0	54.0
	1979	20.4	3.3	5.6	6.8	70.7	63.9
	1980	25.8	6.2	7.0	5.3	61.0	55.7
	1981	59.1	6.5	4.7	4.0	29.7	25.7
	1982	54.3	8.9	6.8	6.3	30.0	23.7
	1983	29.5	9.9	9.4	9.7	51.2	41.5
	1984	53.6	12.5	6.5	3.9	27.4	23.5
	1985	56.7	10.1	8.6	7.3	24.6	17.3
	1986	63.6	9.5	6.8	4.9	20.1	15.2
	1987	59.8	14.5	8.4	5.6	17.3	11.7
	1988	67.3	10.6	5.8	4.7	16.3	11.6
	1989	72.2	9.5	6.1	3.9	12.2	8.3
	1990	81.7	6.8	3.9	2.1	7.6	5.5
Delmarva	1975	23.9	13.5	14.0	14.6	48.6	34.0
	1977	37.3	11.9	8.6	8.0	42.2	34.2
	1978	29.0	7.7	6.7	7.9	56.6	48.7
	1979	60.3	7.5	5.0	4.6	27.2	22.6
	1980	35.7	3.8	6.0	11.3	54.5	43.2
	1981	37.8	4.7	2.7	3.8	54.8	51.0
	1982	28.7	5.0	6.9	7.4	59.4	52.0
	1983	38.0	8.7	5.6	3.6	47.7	44.1
	1984	34.7	15.3	14.5	8.1	35.5	27.4
	1985	72.4	4.3	3.2	4.2	20.1	15.9
	1986	67.0	10.7	8.6	6.1	13.7	7.6
	1987	48.9	19.4	15.4	8.6	16.3	7.7
	1988	32.7	15.5	14.5	12.5	37.3	24.8
	1989	71.1	11.0	6.3	4.0	11.6	7.6
	1990	72.6	11.2	6.1	4.6	10.1	5.5
Virginia-North Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S
	1977	10.0	10.0	10.0	10.0	70.0	60.0
	1978	52.2	1.1	2.0	2.0	44.7	42.7
	1979	48.4	17.0	13.2	6.3	21.4	15.1
	1980	53.1	7.0	4.0	7.9	35.9	28.0
	1981	5.6	3.8	7.6	11.3	83.0	71.7
	1982	3.9	7.7	7.7	3.8	80.7	76.9
	1983	34.8	4.9	1.8	1.8	58.5	56.7
	1984	23.2	26.1	21.8	10.6	28.9	18.3
	1985	1.2	-	4.6	13.2	94.2	81.0
	1986	29.6	-	4.9	9.8	65.5	55.7
	1987	56.7	5.5	8.1	8.1	29.7	21.6
	1988	17.4	8.7	15.5	15.3	58.4	43.1
	1989	21.3	15.0	7.8	9.7	55.9	46.2
	1990	80.7	10.4	5.8	1.4	3.1	1.7
Mid-Atlantic (All Areas)	1975	29.8	12.1	12.3	11.0	45.8	34.8
	1977	31.5	9.7	10.8	13.2	48.0	34.8
	1978	17.1	6.9	10.2	13.2	65.8	52.6
	1979	38.4	5.3	5.5	5.9	50.8	44.9
	1980	29.8	5.4	6.6	7.4	58.2	50.8
	1981	55.9	6.2	4.4	3.9	33.5	29.6
	1982	49.9	8.2	6.9	6.5	35.0	28.5
	1983	31.3	9.7	8.5	8.3	50.5	42.2
	1984	49.8	13.2	8.1	4.7	28.9	24.2
	1985	59.7	8.9	7.5	6.7	23.9	17.2
	1986	64.5	9.9	7.3	5.2	18.3	13.1
	1987	57.4	15.6	9.9	6.3	17.1	10.8
	1988	64.4	11.0	6.6	5.3	18.0	12.7
	1989	71.9	9.8	6.2	4.0	12.1	8.1
	1990	80.2	7.5	4.3	2.5	8.0	5.5

[1] Meat count is expressed as number of meats per pound.

Table 9. Distribution of standardized stratified mean weight (g, meat) per tow among various meat count intervals for sea scallops from NEFC sea scallop research vessel surveys on Georges Bank, 1975, 1977-1990. Values in parentheses ( ) refer to the USA sector of Georges Bank.

Area	Year	Total Biomass Per Tow (g)	Harvestable[2] Biomass Per Tow (g)	Meat Weight (g, meat) Per Tow[1] — Meat Count Interval[3]: 50 - 40	40 - 35	35 - 30	30 - 25	<25
South Channel	1975	918	812	39	26	34	43	670
	1977	1957	1938	156	102	218	220	1242
	1978	1173	1149	51	45	74	118	861
	1979	1541	1529	475	141	45	38	830
	1980	668	552	127	15	13	21	376
	1981	677	652	165	39	32	27	389
	1982	1165	671	296	34	22	21	298
	1983	827	773	313	67	55	53	285
	1984	387	360	59	20	22	26	233
	1985	869	763	174	56	100	117	316
	1986	820	577	153	42	41	38	303
	1987	891	724	281	77	69	59	238
	1988	539	459	188	37	36	34	164
	1989	331	271	57	14	17	17	166
	1990	1143	603	259	68	65	53	158
Southeast Part	1975	1023	1018	16	20	36	67	879
	1977	687	679	57	30	29	24	539
	1978	934	928	19	10	15	14	870
	1979	720	710	34	6	14	13	643
	1980	739	707	245	52	25	12	373
	1981	461	458	55	30	25	16	332
	1982	316	315	9	9	11	7	279
	1983	273	248	14	4	12	19	199
	1984	240	228	63	28	12	10	115
	1985	238	219	46	15	14	19	125
	1986	463	407	78	19	18	13	279
	1987	664	604	153	116	73	35	227
	1988	323	319	46	22	28	36	187
	1989	296	233	25	17	19	26	146
	1990	150	146	41	9	11	5	80
Northern Edge and Peak	1975	2228	2015	538	285	207	162	823
	1977	5299	5064	1826	522	621	531	1564
	1978	7910	7604	632	468	746	818	4940
	1979	4666	4461	1009	261	233	256	2702
	1980	2963	2052	623	236	227	164	802
	1981	4417	3788	2565	244	221	157	601
	1982	1068	950	294	94	98	104	360
	1983	746	669	128	56	66	65	354
	1984	1133	837	227	74	65	65	406
	1985	2104 (450)	1846 (393)	1287 (125)	130 (30)	104 (26)	92 (17)	233 (195)
	1986	2676 (610)	2592 (481)	754 (103)	510 (38)	498 (43)	351 (33)	479 (264)
	1987	1913 (852)	1613 (735)	549 (286)	168 (59)	178 (62)	181 (62)	537 (266)
	1988	1760 (918)	1533 (772)	635 (302)	176 (104)	164 (74)	141 (65)	417 (227)
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	3097(2052)	2679(1832)	1382(1457)	278 (159)	204 (58)	201 (40)	614 (118)
Georges Bank (All Areas)	1975	1471	1343	236	130	105	96	776
	1977	3298	3178	938	289	372	329	1250
	1978	4028	3879	295	220	351	398	2615
	1979	2801	2702	633	169	124	132	1644
	1980	1892	1373	412	139	128	94	600
	1981	1841	1625	919	103	92	66	445
	1982	964	743	243	59	57	59	325
	1983	688	627	168	51	53	52	303
	1984	725	569	142	48	41	42	296
	1985	1358 (574)	1193 (505)	694 (127)	85 (37)	86 (54)	87 (38)	241 (229)
	1986	1961 (632)	1678 (489)	477 (111)	301 (34)	294 (36)	209 (29)	397 (279)
	1987	1348 (826)	1136 (701)	388 (254)	129 (79)	123 (67)	114 (55)	382 (246)
	1988	1096 (632)	958 (544)	381 (199)	102 (59)	97 (48)	86 (46)	292 (192)
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.						
	1990[4]	1848(1202)	1467 (894)	732 (597)	153 (84)	118 (50)	112 (37)	352 (126)

[1] Meat weight values derived from shell height values using 1978-1982 USA research survey equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98).

[2] Stratified mean weight (g, meat) per tow for sea scallops ≥70 mm, ≤80 count.

[3] Meat count is expressed as number of meats per pound.

[4] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table 10. Percentage distribution of harvestable biomass (meat weight) of sea scallops on Georges Bank, within various meat count intervals. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from distribution of standardized stratified mean meat weight per tow in NEFC sea scallop research vessel surveys on Georges Bank, 1975, 1977-1990. Values in parentheses ( ) refer to the USA sector of Georges Bank.

		Percent of Harvestable Biomass By Meat Count Interval[1]					
Area	Year	60 - 40	40 - 35	35 - 30	30 - 25	<30	<25
South Channel	1975	4.8	3.2	4.2	5.2	87.8	82.6
	1977	8.0	5.3	11.3	11.4	75.4	64.0
	1978	4.5	3.9	6.4	10.3	85.2	74.9
	1979	31.1	9.2	2.9	2.5	56.8	54.3
	1980	23.1	2.7	2.3	3.8	71.9	68.1
	1981	25.3	6.0	4.8	4.1	63.9	59.8
	1982	44.1	5.0	3.3	3.2	47.6	44.4
	1983	40.4	8.7	7.2	6.9	43.7	36.8
	1984	16.5	5.5	6.1	7.2	71.9	64.7
	1985	22.7	7.4	13.2	15.3	56.7	41.4
	1986	26.5	7.3	7.2	6.6	59.0	52.4
	1987	38.8	10.7	9.5	8.2	41.0	32.8
	1988	41.0	8.2	7.8	7.3	43.0	35.7
	1989	21.2	5.2	6.0	6.3	67.6	61.3
	1990	43.0	11.2	10.8	8.7	35.0	26.3
Southeast Part	1975	1.6	1.9	3.5	6.7	93.0	86.3
	1977	8.3	4.4	4.3	3.6	83.0	79.4
	1978	2.0	1.2	1.6	1.5	95.2	93.7
	1979	4.8	0.8	1.9	1.9	92.5	90.6
	1980	34.6	7.3	3.5	1.7	54.6	52.9
	1981	11.9	6.6	5.5	3.4	76.0	72.6
	1982	2.8	2.9	3.5	2.3	90.8	88.5
	1983	5.5	1.6	5.0	7.8	87.9	80.1
	1984	27.8	12.2	5.3	4.2	54.7	50.5
	1985	20.9	6.7	6.4	8.7	66.0	57.3
	1986	19.2	4.7	4.4	3.3	71.7	68.4
	1987	25.3	19.3	12.0	5.8	43.4	37.6
	1988	14.5	7.0	8.9	11.0	69.7	58.6
	1989	10.6	7.3	8.2	11.1	73.9	62.8
	1990	27.8	6.4	7.3	3.7	58.5	54.8
Northern Edge and Peak	1975	26.7	14.1	10.3	8.1	48.9	40.8
	1977	36.1	10.3	12.2	10.5	41.4	30.9
	1978	8.3	6.2	9.8	10.7	75.7	65.0
	1979	22.6	5.9	5.2	5.7	66.3	60.6
	1980	30.3	11.5	11.1	8.0	47.1	39.1
	1981	67.7	6.4	5.9	4.1	20.0	15.9
	1982	30.9	9.9	10.3	10.9	48.9	38.0
	1983	19.1	8.4	9.8	9.7	62.7	53.0
	1984	27.1	8.9	7.7	7.8	56.3	48.5
	1985	69.7 (31.7)	7.1 (7.6)	5.6 (6.7)	5.0 (4.4)	17.6 (54.0)	12.6 (49.6)
	1986	29.1 (21.3)	19.7 (8.0)	19.2 (8.9)	13.5 (6.9)	32.0 (61.8)	18.5 (54.9)
	1987	34.0 (38.9)	10.5 (7.9)	11.0 (8.5)	11.2 (8.5)	44.7 (44.7)	33.3 (36.2)
	1988	41.4 (39.1)	11.5 (13.4)	10.7 (9.6)	9.2 (8.5)	36.4 (37.9)	27.2 (29.4)
	1989	N/S	N/S	N/S	N/S	N/S	N/S
	1990[2]	51.6 (79.5)	10.4 (8.7)	7.6 (3.2)	7.5 (2.2)	30.4 (8.6)	22.9 (6.4)
Georges Bank (All Areas)	1975	17.6	9.6	7.8	7.2	65.0	57.8
	1977	29.5	9.1	11.7	10.4	49.7	39.3
	1978	7.6	5.7	9.0	10.3	77.7	67.4
	1979	23.4	6.3	4.6	4.9	65.7	60.8
	1980	30.0	10.1	9.3	6.9	50.6	43.7
	1981	56.5	6.4	5.6	4.1	31.5	27.4
	1982	32.7	7.9	7.7	7.9	51.7	43.8
	1983	26.8	8.1	8.4	8.4	56.7	48.3
	1984	24.9	8.4	7.2	7.5	59.5	52.0
	1985	58.1 (25.2)	7.1 (7.4)	7.3 (10.6)	7.3 (11.5)	27.5 (56.8)	20.2 (45.3)
	1986	28.4 (22.6)	18.0 (7.0)	17.5 (7.3)	12.5 (6.0)	36.1 (63.1)	23.6 (57.1)
	1987	34.2 (36.3)	11.3 (11.2)	10.8 (9.6)	10.1 (7.8)	43.7 (42.9)	33.6 (35.1)
	1988	39.7 (36.5)	10.7 (10.8)	10.1 (8.9)	9.0 (8.4)	39.5 (43.8)	30.5 (35.4)
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.					
	1990[2]	49.9 (66.7)	10.4 (9.4)	8.1 (5.6)	7.6 (4.2)	31.6 (18.3)	24.0 (14.1)

[1] Meat count is expressed as number of meats per pound.

[2] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table 11. Distribution of standardized mean number per tow among various meat count intervals for sea scallops from NEFC sea scallop research vessel surveys on Georges Bank, 1975, 1977-1990. Values in parentheses ( ) refer to the USA sector of Georges Bank.

		Stratified Mean Number of Scallops Per Tow						
		Total Number	Harvestable	Meat Count Interval				
Area	Year	Per Tow	Number Per Tow	80 - 40	40 - 35	35 - 30	30 - 25	<25
South Channel	1975	75.0	29.9	4.6	2.0	2.2	2.3	18.8
	1977	95.4	89.1	18.6	7.9	14.2	12.2	36.2
	1978	57.4	49.7	5.4	3.5	4.8	6.5	29.5
	1979	95.0	88.2	47.9	10.8	2.9	2.1	24.5
	1980	109.9	30.2	15.9	1.1	0.8	1.2	11.2
	1981	52.0	36.5	19.0	3.0	2.1	1.5	10.9
	1982	266.8	53.0	39.7	2.6	1.4	1.2	8.1
	1983	74.8	55.8	36.3	5.2	3.6	2.9	7.8
	1984	31.3	17.7	6.9	1.5	1.4	1.5	6.4
	1985	87.6	47.3	21.1	4.3	6.5	6.5	8.9
	1986	152.3	37.0	19.9	3.3	2.7	2.1	9.0
	1987	140.7	56.1	35.0	5.9	4.5	3.3	7.4
	1988	68.5	36.0	23.9	2.9	2.3	1.8	5.1
	1989	36.8	15.1	7.1	1.1	1.1	0.9	4.9
	1990	308.7	49.9	32.3	5.2	4.2	2.9	5.3
Southeast Part	1975	40.2	38.4	1.9	1.5	2.3	3.8	28.9
	1977	30.4	27.2	6.2	2.3	1.9	1.3	15.5
	1978	29.3	27.1	2.0	0.8	1.0	0.8	22.5
	1979	28.9	21.2	4.0	0.4	0.9	0.7	15.2
	1980	63.2	41.7	25.8	4.0	1.6	0.7	9.6
	1981	20.8	19.4	5.8	2.3	1.6	0.9	8.8
	1982	10.6	9.8	0.9	0.7	0.7	0.4	7.1
	1983	20.5	9.2	1.6	0.3	0.8	1.1	5.4
	1984	17.5	12.9	6.4	2.2	0.8	0.5	3.0
	1985	20.9	11.8	5.3	1.1	0.9	1.1	3.4
	1986	49.5	20.6	9.2	1.5	1.2	0.7	8.0
	1987	62.7	39.6	16.7	9.0	4.7	1.9	7.3
	1988	17.5	16.1	5.2	1.7	1.8	2.0	5.4
	1989	35.4	11.8	3.0	1.3	1.2	1.4	4.9
	1990	10.0	8.4	4.5	0.7	0.7	0.3	2.2
Northern Edge and Peak	1975	219.7	135.9	61.9	21.9	13.4	9.0	29.7
	1977	450.9	384.8	220.5	40.1	40.3	29.5	54.4
	1978	550.6	372.9	71.1	35.9	48.5	45.4	172.0
	1979	329.9	257.9	122.4	20.0	15.1	14.2	86.2
	1980	809.4	143.7	75.4	18.2	14.8	9.0	26.3
	1981	683.1	405.7	343.4	18.7	14.4	8.7	20.5
	1982	106.2	65.3	34.1	7.3	6.3	5.7	11.9
	1983	85.3	37.1	14.1	4.3	4.3	3.6	10.8
	1984	347.8	54.0	28.3	5.7	4.2	3.6	12.2
	1985	276.7 (48.4)	192.2 (26.6)	162.8 (16.2)	10.0 (2.3)	6.8 (1.7)	5.1 (0.9)	7.5 (5.5)
	1986	368.6 (74.2)	195.6 (28.6)	86.5 (13.0)	39.2 (2.9)	32.4 (2.8)	19.5 (1.8)	18.0 (8.1)
	1987	272.4 (116.6)	122.2 (54.6)	67.5 (34.3)	13.0 (4.5)	11.6 (4.1)	10.0 (3.4)	20.1 (8.3)
	1988	223.7 (126.7)	124.4 (60.9)	77.3 (31.3)	13.6 (6.7)	10.7 (4.1)	7.8 (3.1)	15.0 (6.5)
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[1]	459.8 (263.7)	236.0 (19[illegible].8)	166.1 (174.4)	21.3 (12.3)	13.3 (3.8)	11.2 (2.2)	24.1 (4.1)
Georges Bank (All Areas)	1975	126.3	74.6	27.2	10.0	6.8	5.3	25.3
	1977	252.6	218.3	113.0	22.2	24.2	18.2	40.7
	1978	263.7	184.8	32.9	16.9	22.8	22.1	89.3
	1979	188.9	152.3	73.2	13.0	8.1	7.3	50.7
	1980	469.7	92.3	49.2	10.7	8.4	5.2	18.8
	1981	249.6	152.4	121.3	7.9	6.0	3.7	13.5
	1982	142.2	51.2	29.9	4.5	3.7	3.3	9.8
	1983	70.1	38.2	19.1	3.9	3.4	2.9	8.9
	1984	183.3	34.6	17.3	3.7	2.7	2.3	8.6
	1985	167.9 (58.3)	111.6 (31.8)	87.4 (15.8)	6.5 (2.9)	5.6 (3.5)	4.8 (3.2)	7.3 (6.4)
	1986	252.9 (90.2)	123.0 (28.9)	55.3 (14.0)	23.2 (2.7)	19.1 (2.3)	11.6 (1.6)	13.8 (8.3)
	1987	190.9 (114.5)	85.4 (51.9)	47.6 (30.7)	9.9 (6.1)	8.0 (4.4)	6.3 (3.0)	13.6 (7.7)
	1988	135.1 (78.8)	75.6 (40.8)	46.6 (24.5)	7.9 (4.5)	6.3 (3.2)	4.8 (2.5)	10.0 (6.1)
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.						
	1990[1]	320.9 (233.0)	127.3 (87.8)	88.3 (71.9)	11.8 (6.4)	7.7 (3.2)	6.2 (2.1)	13.3 (4.2)

[1] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table 12. Percentage distribution of harvestable number of sea scallops on Georges Bank, within various meat count intervals. Harvestable scallops are defined as all sea scallops ≥70 mm shell height. Data derived from distribution of standardized stratified mean number per tow of scallops in NEFC sea scallop research vessel surveys on Georges Bank, 1975, 1977-1990. Values in parentheses ( ) refer to the USA sector of Georges Bank.

Area	Year	Percent of Harvestable Scallops By Meat Count Interval					
		80 - 40	40 - 35	35 - 30	30 - 25	<30	<25
South Channel	1975	15.3	6.6	7.5	7.9	70.6	62.7
	1977	20.9	8.8	15.9	13.7	54.4	40.7
	1978	10.8	6.9	9.7	13.2	72.6	59.4
	1979	54.3	12.3	3.3	2.4	30.1	27.7
	1980	52.6	3.8	2.7	3.9	40.9	37.0
	1981	52.2	8.2	5.6	4.1	34.0	29.9
	1982	74.9	4.9	2.7	2.2	17.5	15.3
	1983	65.0	9.3	6.4	5.3	19.3	14.0
	1984	39.1	8.6	8.1	8.1	44.2	36.1
	1985	44.5	9.1	13.8	13.7	32.6	18.9
	1986	53.9	8.8	7.2	5.7	30.1	24.4
	1987	62.3	10.6	8.0	5.8	19.1	13.3
	1988	66.2	8.0	6.5	5.2	19.3	14.1
	1989	47.1	7.1	7.1	6.2	38.7	32.5
	1990	64.7	10.4	8.5	5.8	16.4	10.6
Southeast Part	1975	4.8	3.9	6.1	9.8	85.2	75.4
	1977	22.7	8.4	6.9	5.0	62.0	57.0
	1978	7.4	3.0	3.6	2.8	86.0	83.2
	1979	18.7	2.1	4.2	3.5	75.0	71.5
	1980	62.1	9.5	3.9	1.6	24.5	22.9
	1981	29.7	12.0	8.4	4.5	49.9	45.4
	1982	8.9	7.2	7.3	4.1	76.6	72.5
	1983	17.0	3.3	8.8	11.6	70.9	59.3
	1984	49.8	16.6	6.2	4.1	27.4	23.3
	1985	45.1	9.5	7.7	8.9	37.7	28.8
	1986	44.8	7.2	5.7	3.6	42.3	38.7
	1987	42.2	22.6	11.9	4.9	23.3	18.4
	1988	32.4	10.6	11.4	12.1	45.6	33.5
	1989	25.1	11.1	10.5	12.1	53.3	41.2
	1990	53.0	8.6	8.2	3.6	30.2	26.6
Northern Edge and Peak	1975	45.5	16.1	9.9	6.7	28.5	21.8
	1977	57.3	10.4	10.5	7.7	21.8	14.1
	1978	19.1	9.6	13.0	12.2	58.3	46.1
	1979	47.4	7.8	5.9	5.5	38.9	33.4
	1980	52.5	12.6	10.3	6.3	24.6	18.3
	1981	84.7	4.6	3.5	2.1	7.2	5.1
	1982	52.1	11.1	9.7	8.8	27.1	18.3
	1983	37.9	11.7	11.5	9.7	38.9	29.2
	1984	52.4	10.6	7.8	6.7	29.2	22.5
	1985	84.7 (60.7)	5.2 (8.7)	3.5 (6.4)	2.7 (3.6)	6.6 (24.2)	3.9 (20.6)
	1986	44.2 (45.3)	20.1 (10.3)	16.6 (9.7)	9.9 (6.4)	19.1 (34.7)	9.2 (28.3)
	1987	55.3 (62.8)	10.6 (8.2)	9.4 (7.4)	8.2 (6.3)	24.7 (21.6)	16.5 (15.3)
	1988	62.2 (60.5)	10.9 (13.1)	8.5 (7.9)	6.3 (6.0)	18.4 (18.5)	12.1 (12.5)
	1989	N/S	N/S	N/S	N/S	N/S	N/S
	1990[1]	78.4 (88.6)	9.1 (6.2)	5.6 (2.0)	4.7 (1.1)	14.9 (3.2)	10.2 (2.1)
Georges Bank (All Areas)	1975	36.5	13.3	9.1	7.2	41.1	33.9
	1977	51.7	10.2	11.1	8.4	27.0	18.6
	1978	17.9	9.2	12.4	12.0	60.5	48.5
	1979	48.1	8.5	5.3	4.8	38.1	33.3
	1980	53.3	11.6	9.0	5.7	26.1	20.4
	1981	79.6	5.2	3.9	2.4	11.3	8.9
	1982	58.4	8.9	7.2	6.4	25.5	19.1
	1983	50.1	10.2	8.9	7.6	30.8	23.2
	1984	49.9	10.7	7.8	6.8	31.6	24.8
	1985	78.3 (49.6)	5.9 (9.0)	5.0 (11.0)	4.3 (10.2)	10.8 (30.4)	6.5 (20.2)
	1986	44.9 (48.4)	18.8 (9.1)	15.6 (8.1)	9.4 (5.6)	20.7 (34.4)	11.3 (28.8)
	1987	55.7 (59.1)	11.6 (11.7)	9.4 (8.4)	7.4 (5.9)	23.3 (20.8)	15.9 (14.9)
	1988	61.7 (60.1)	10.4 (11.0)	8.3 (7.7)	6.3 (6.2)	19.6 (21.2)	13.3 (15.0)
	1989	Not calculated since Northern Edge & Peak was not sampled in 1989 USA sea scallop survey.					
	1990[1]	69.4 (81.8)	9.2 (7.3)	6.0 (3.7)	4.9 (2.4)	15.4 (7.2)	10.5 (4.8)

[1] Stratum 72 was excluded from the analysis since it was not sampled in 1990.

Table 13. 1990 percentage distribution of harvestable biomass (meat weight) of sea scallops in the USA Georges Bank and Mid-Atlantic regions, within various meat count intervals. Harvestable biomass is defined as all sea scallops ≥70 mm shell height (≤80 count). Data derived from distribution of standardized stratified mean meat weight per tow in NEFC 1990 research vessel sea scallop survey.

	Percent Harvestable Biomass			
	Meat Count Interval			
Area	80-40	40-35	35-30	<30
South Channel	43.0	11.2	10.8	35.0
Southeast Part	27.8	6.4	7.3	58.5
USA No. Edge And Peak	79.5	8.7	3.2	8.6
USA Georges Bank	**66.7**	**9.4**	**5.6**	**18.3**
New York Bight	**62.7**	**9.1**	**6.3**	**21.9**
Delmarva	**56.8**	**13.4**	**8.7**	**21.1**
Virginia-No. Carolina	**67.1**	**14.0**	**9.3**	**9.6**
Mid-Atlantic	**61.7**	**9.9**	**6.7**	**21.7**
Total USA Georges Bank and Mid-Atlantic Areas	**64.0**	**9.7**	**6.2**	**20.1**

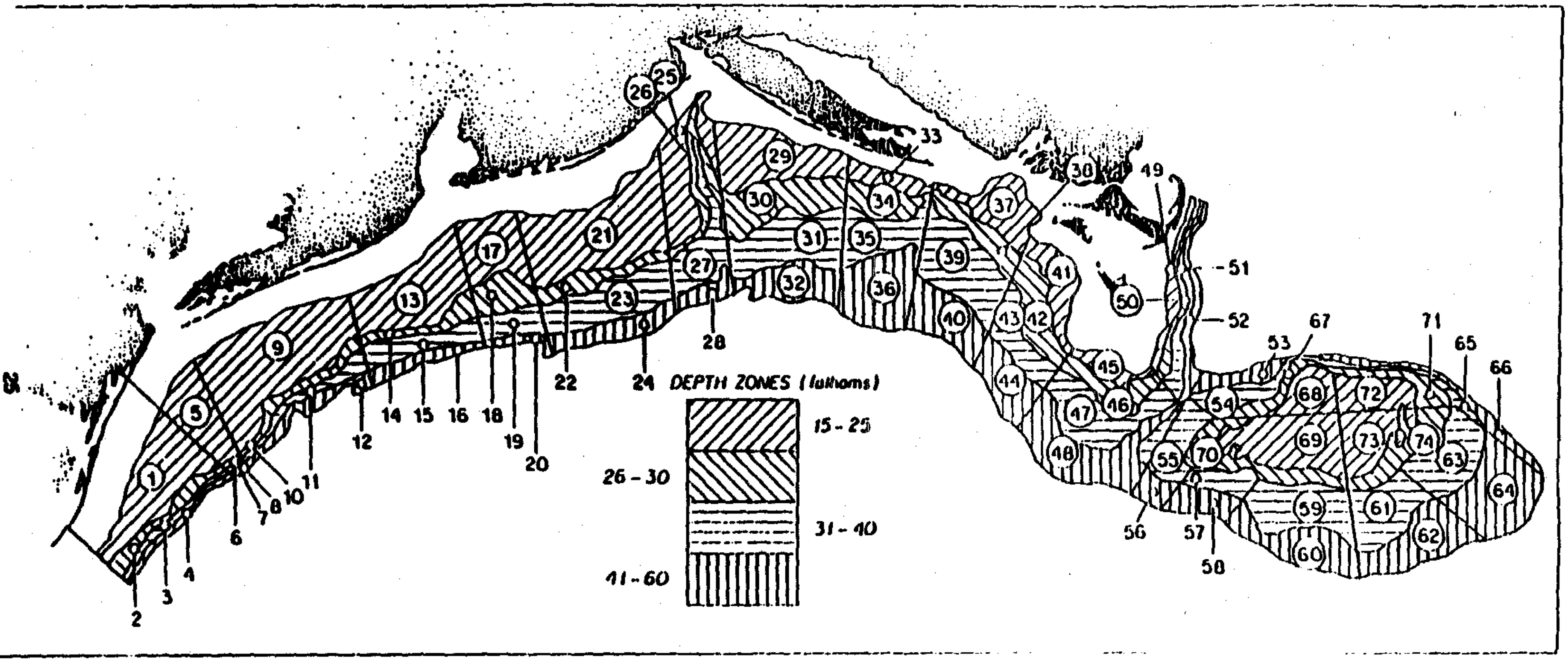


Figure 1. USA Northeast Fisheries Center sea scallop research vessel survey sampling strata in the Northwest Atlantic, Georges Bank to Cape Hatteras, used in annual surveys since 1979. For analytic purposes, survey strata are grouped by major fishing regions: Virginia-North Carolina (Strata 6-7); Delmarva (Strata 10-11, 14-15, 18-19); New York Bight (Strata 22-31, 33-35); South Channel (Strata46-47, 49-55); Southeast Part (Strata 58-60); Northern Edge and Peak (61-66, 71-72, 74).

USA SEA SCALLOP RELATIVE ABUNDANCE INDICES

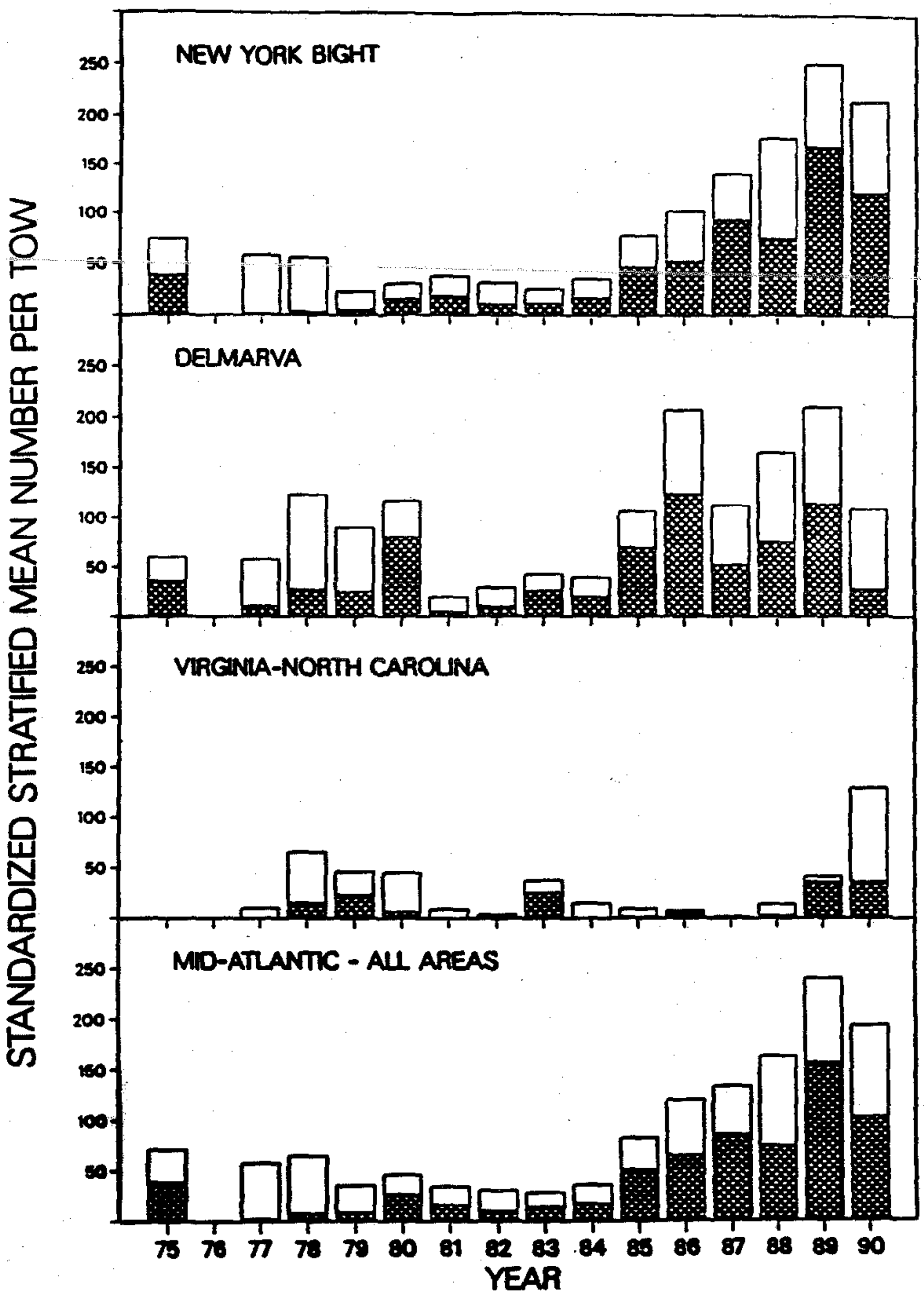


Figure 2. Relative abundance indices of sea scallops, by principal scallop region in the Mid-Atlantic, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1990. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops (≥70 mm shell height).

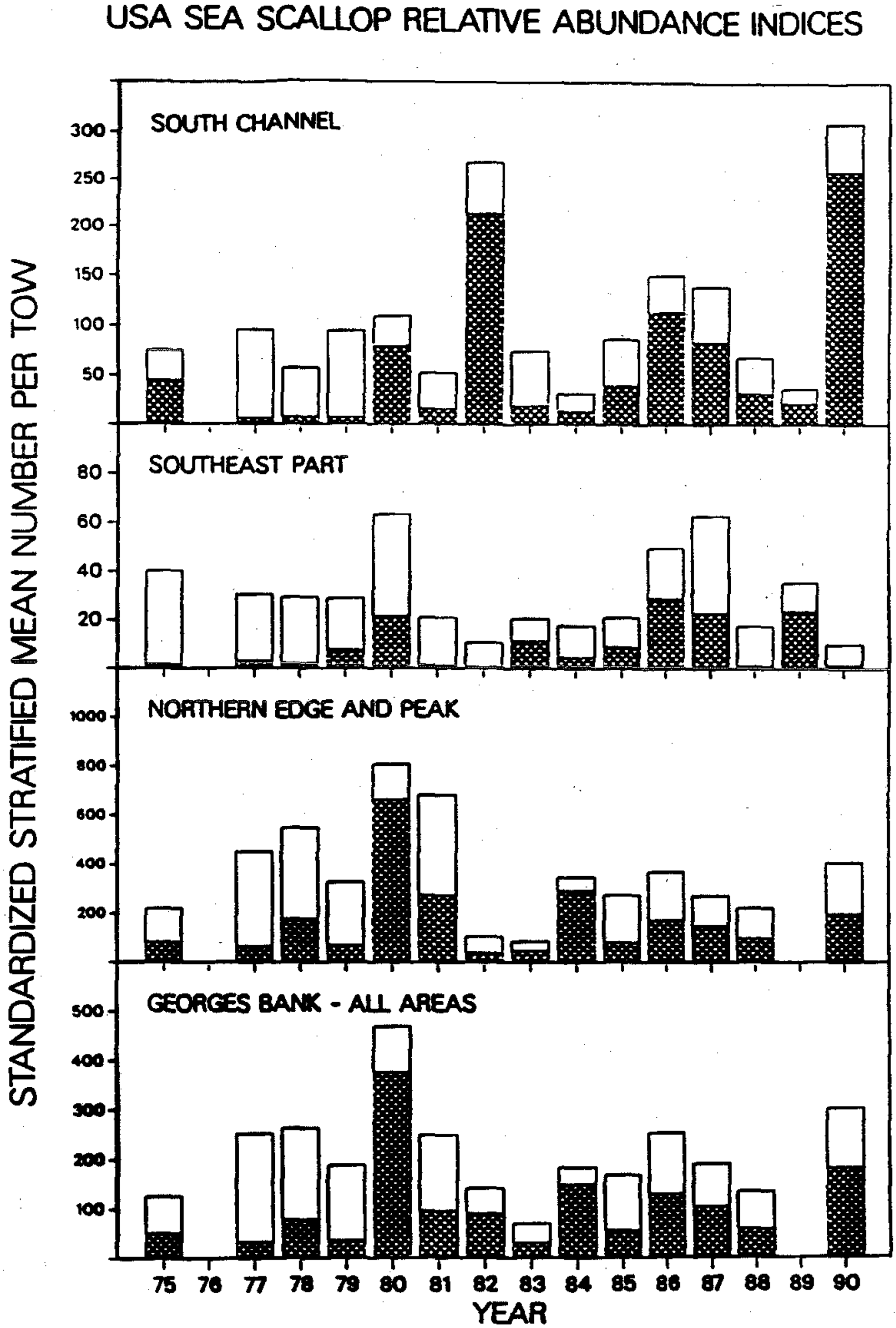


Figure 3. Relative abundance indices of sea scallops, by principal scallop region on Georges Bank, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1990. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops (≥70 mm shell height).

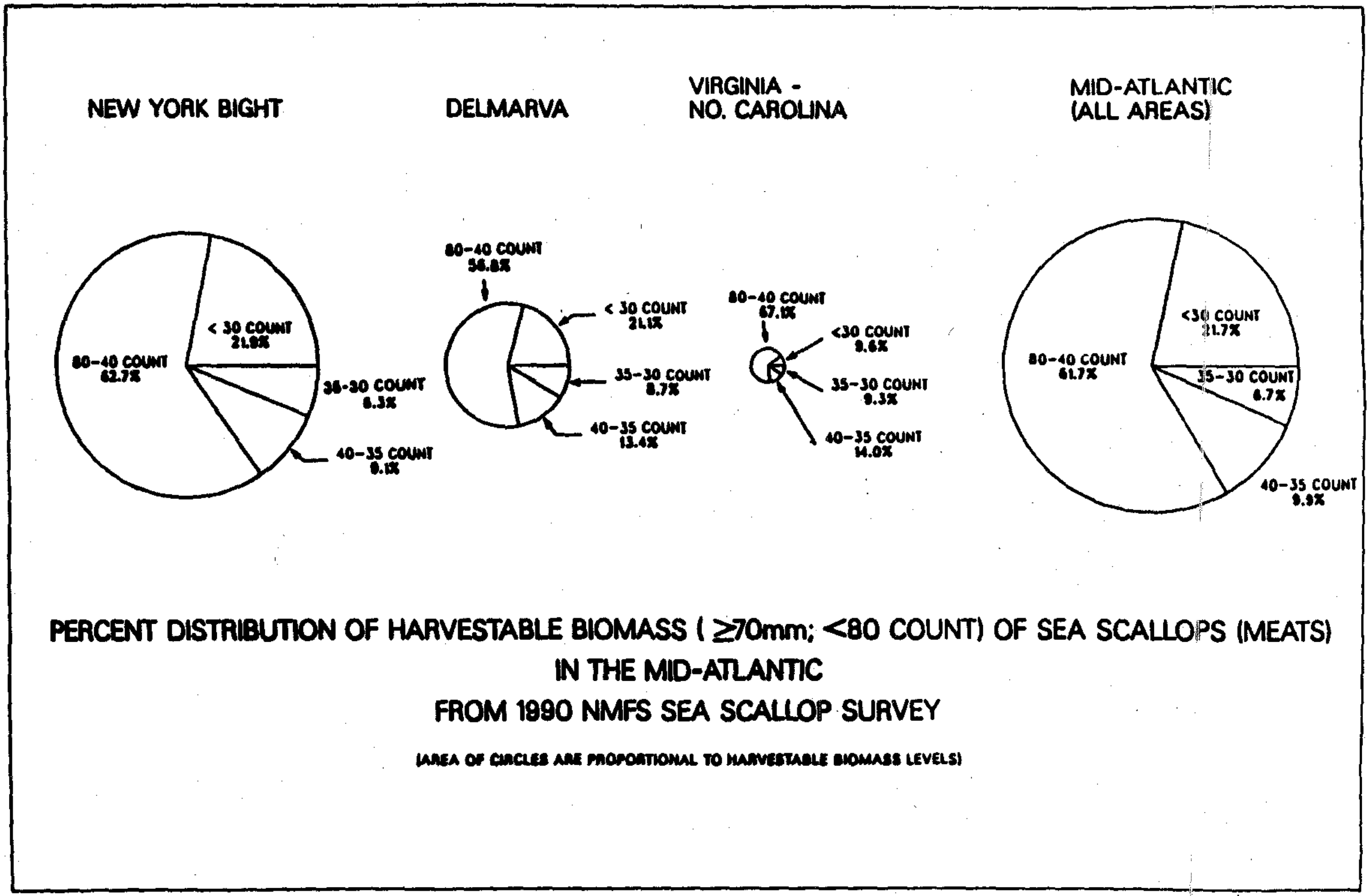
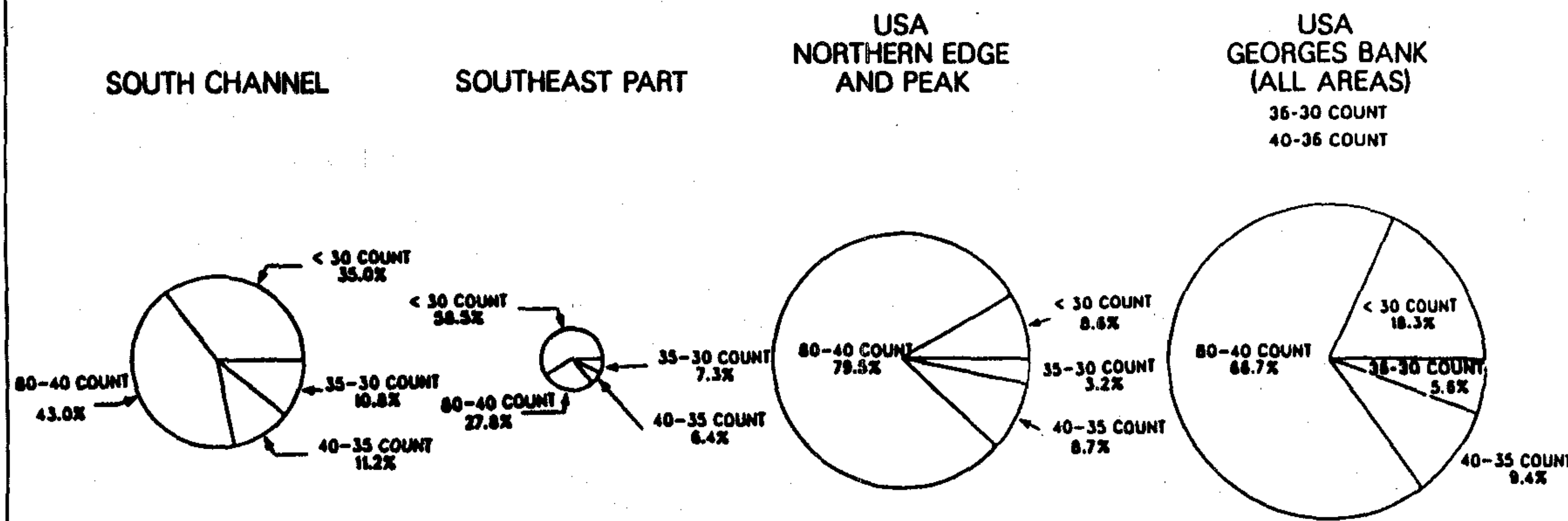


Figure 4. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1990 USA sea scallop research vessel survey in the Mid-Atlantic region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1990 survey distributions of standard stratified mean meat weight per tow.



PERCENT DISTRIBUTION OF HARVESTABLE BIOMASS (≥70mm; <80 COUNT) OF SEA SCALLOPS (MEATS)
IN USA SECTOR OF GEORGES BANK
FROM 1990 NMFS SEA SCALLOP SURVEY

(AREA OF CIRCLES ARE PROPORTIONAL TO HARVESTABLE BIOMASS LEVELS)

Figure 5. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1990 USA sea scallop research vessel survey in the USA portion of Georges Bank region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1990 survey distributions of standard stratified mean meat weight per tow.

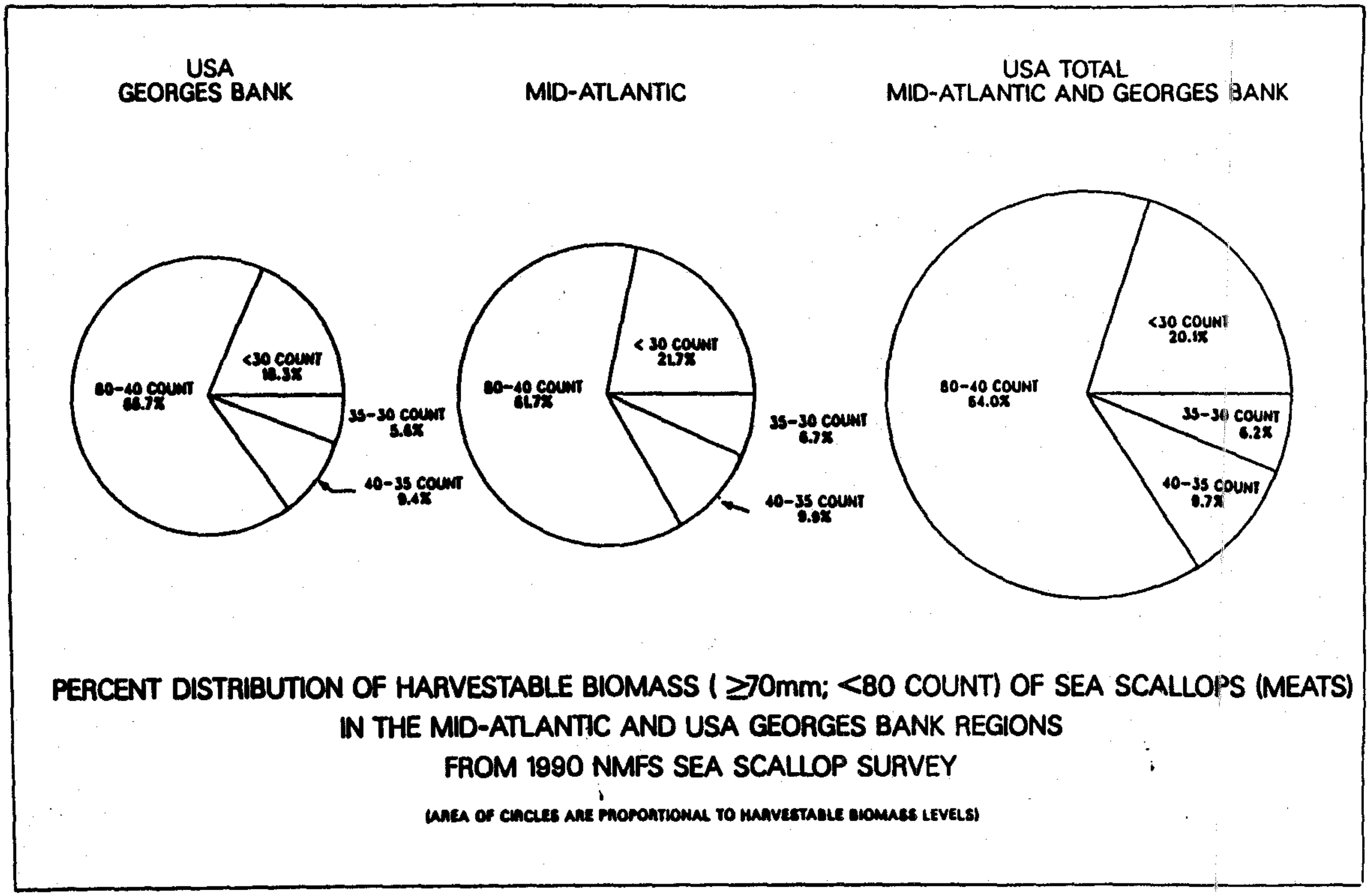


Figure 6. Percentage distribution of harvestable biomass [meat weight] of sea scallops, within various meat count intervals [number of meats per pound], from the 1990 USA sea scallop research vessel survey in the USA portion of Georges Bank and the Mid-Atlantic region. Harvestable biomass is defined as all sea scallops ≥70 mm shell height. Data derived from the 1990 survey distributions of standard stratified mean meat weight per tow.

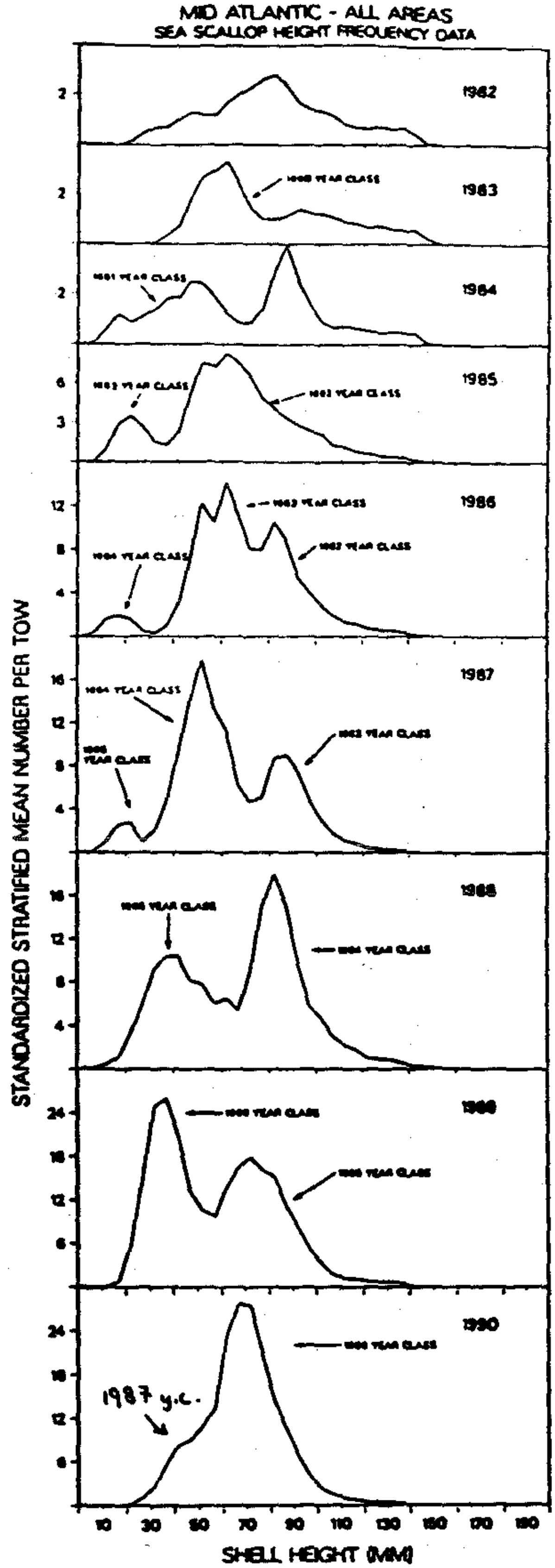


Figure 7. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the Mid-Altantic area, 1982-1990.

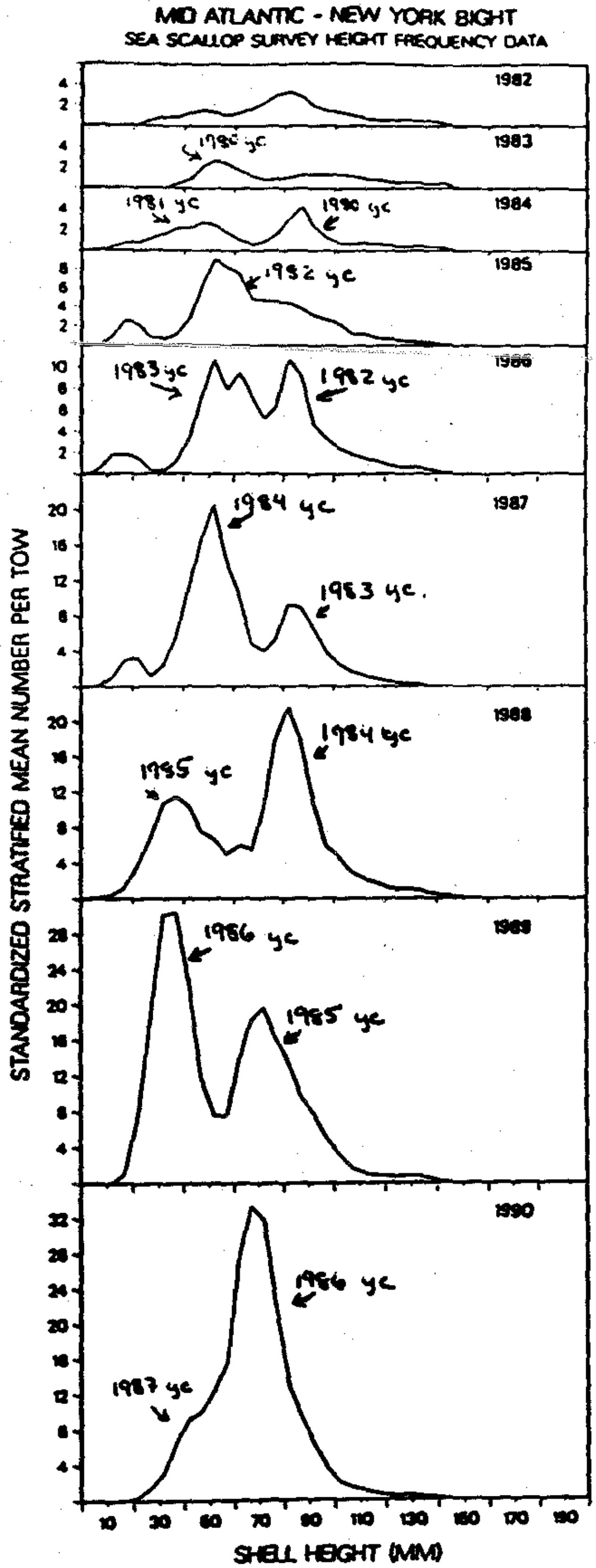


Figure 8. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the New York Bight region (Strata 22-31, 33-35) of the Mid-Atlantic, 1982-1990.

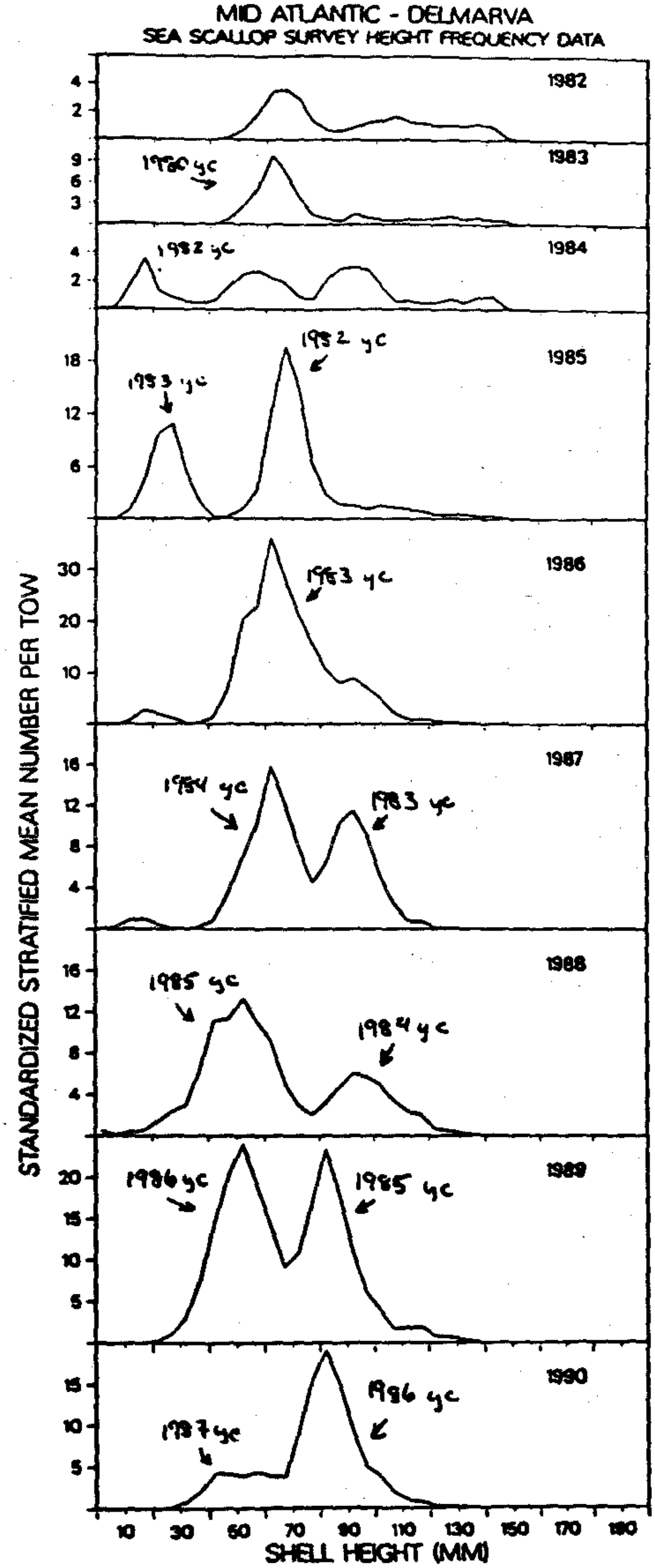


Figure 9. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the Delmarva region (Strata 10-11, 14-15, 18-19) of the Mid-Atlantic, 1982-1990.

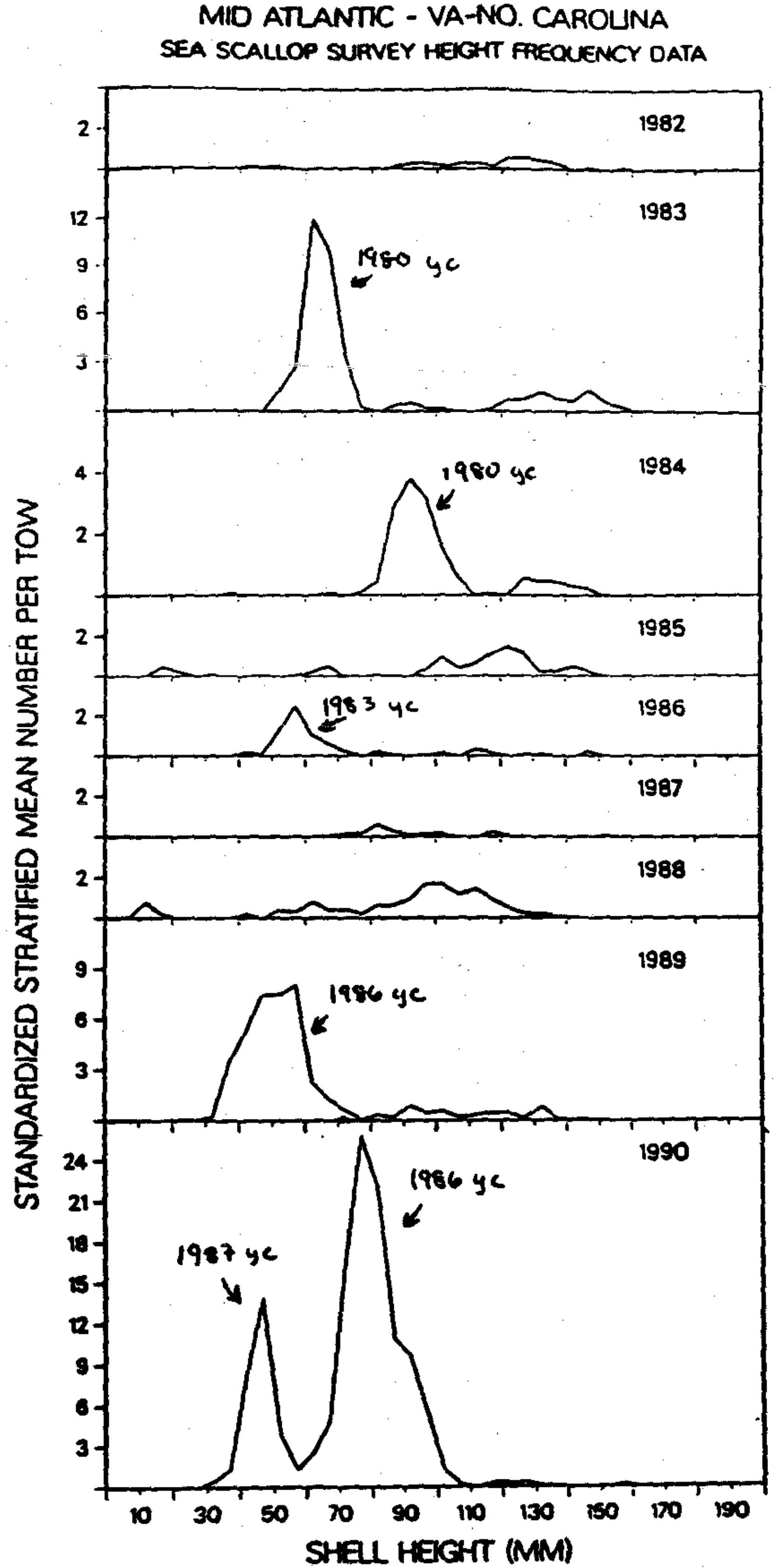


Figure 10. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the Virginia-North Carolina region (Strata 6-7) of the Mid-Atlantic, 1982-1990.

USA GEORGES BANK
SEA SCALLOP SURVEY HEIGHT FREQUENCY DATA

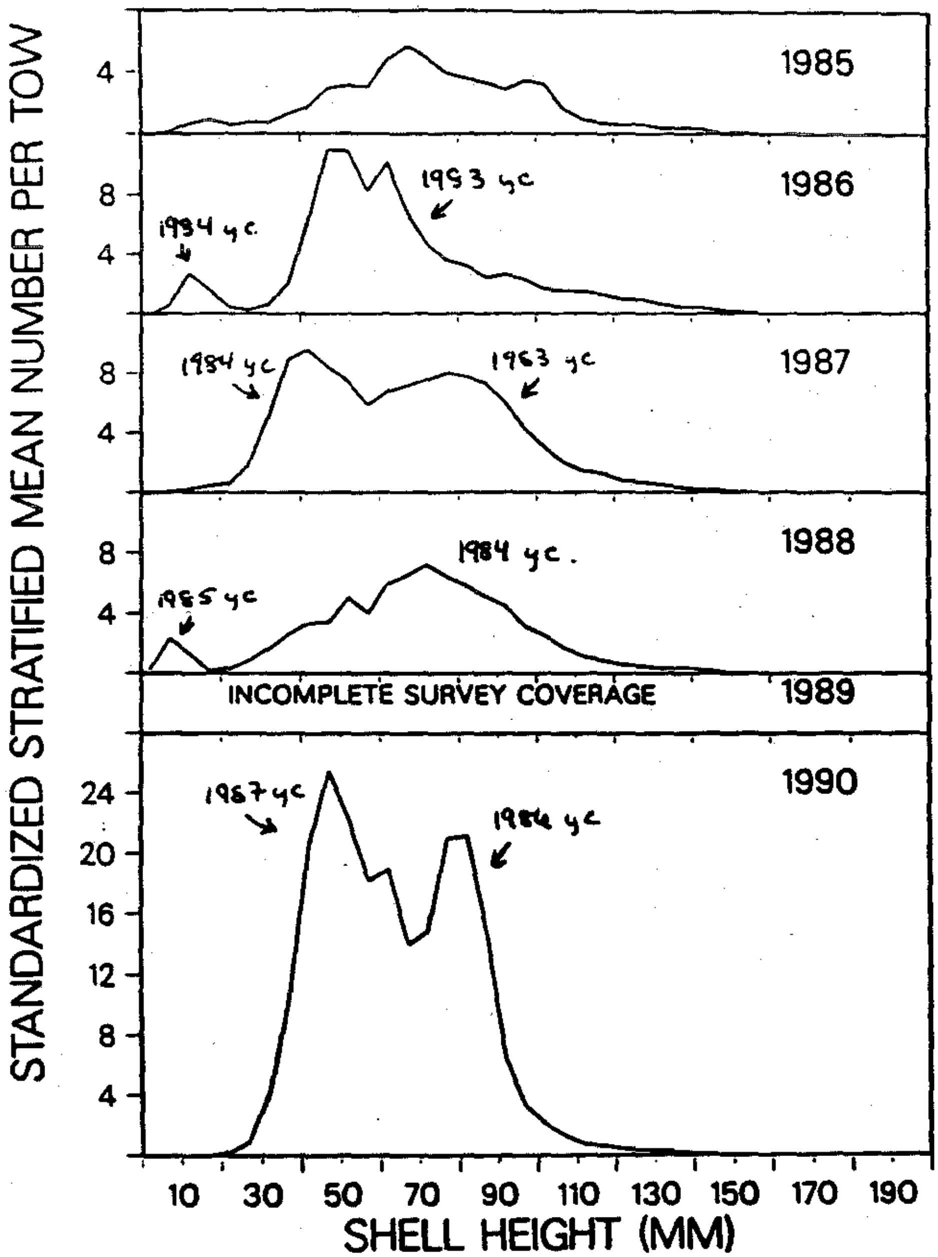


Figure 11. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the USA portion of Georges Bank area, 1982-1990.

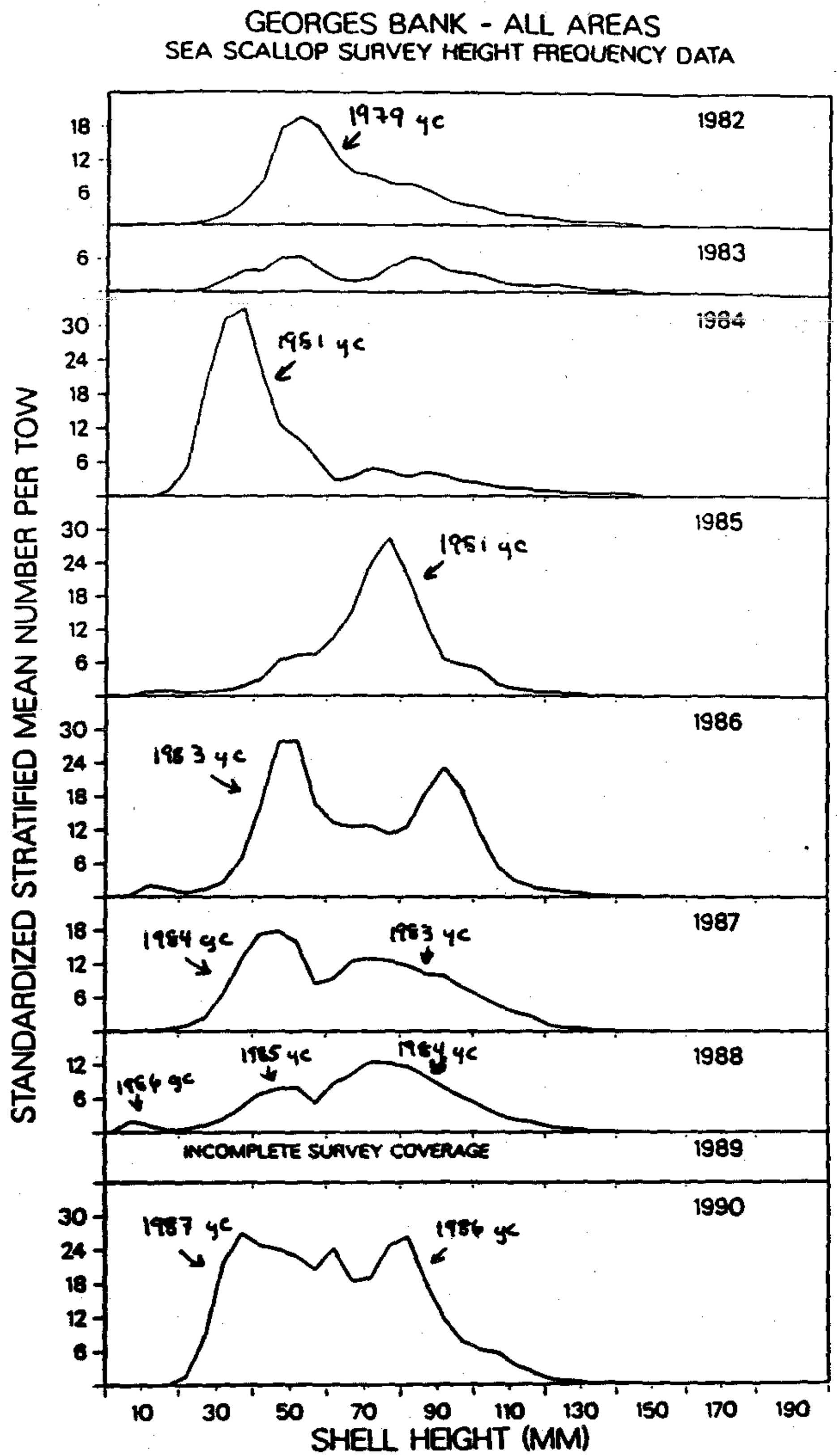


Figure 12. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the Georges Bank area, 1982-1990.

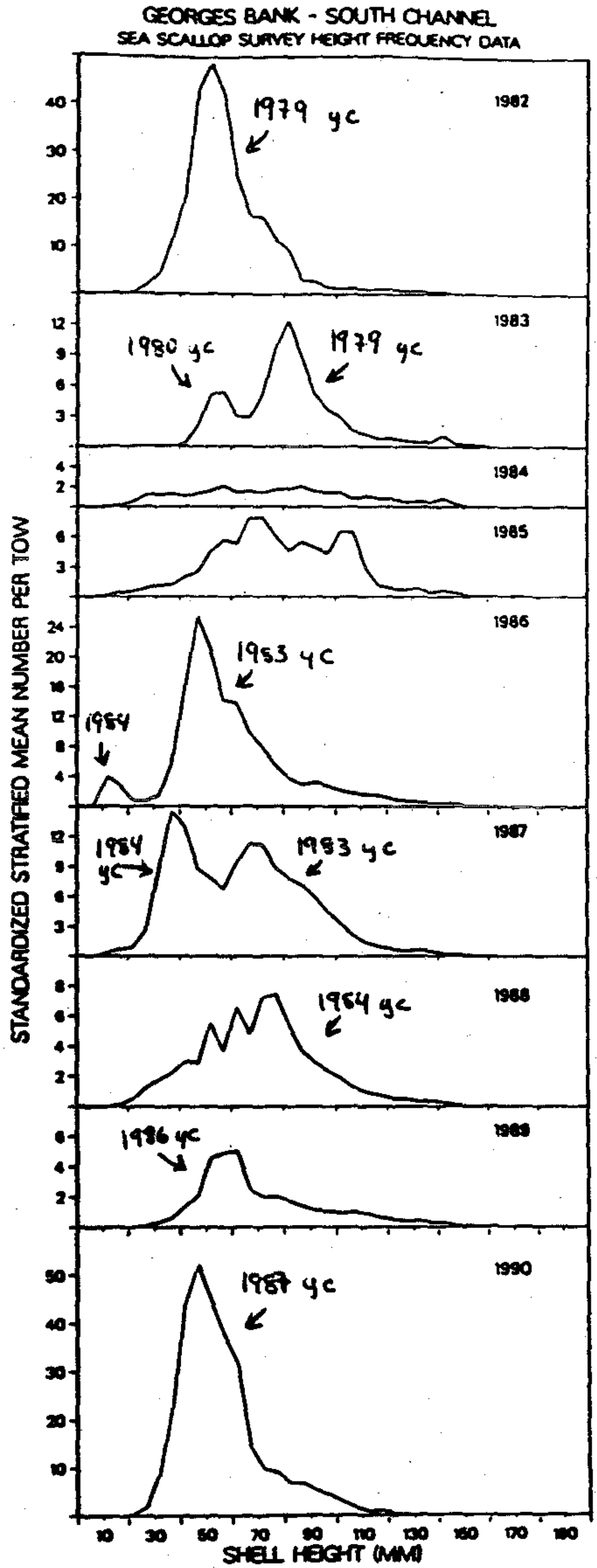


Figure 13. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the South Channel region (Strata 46-47, 49-55) of Georges Bank, 1982-1990.

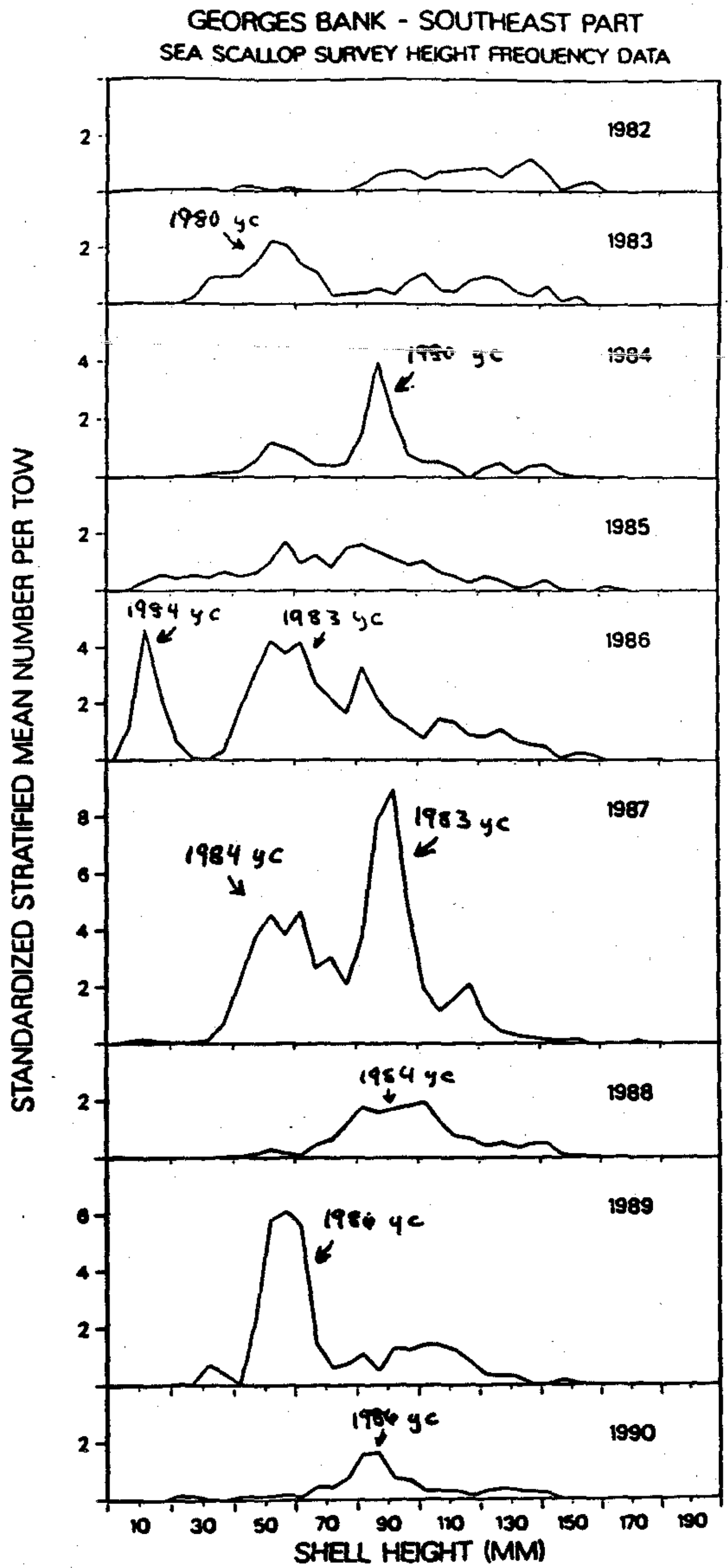


Figure 14. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the Southeast Part region (Strata 58-60) of Georges Bank, 1982-1990.

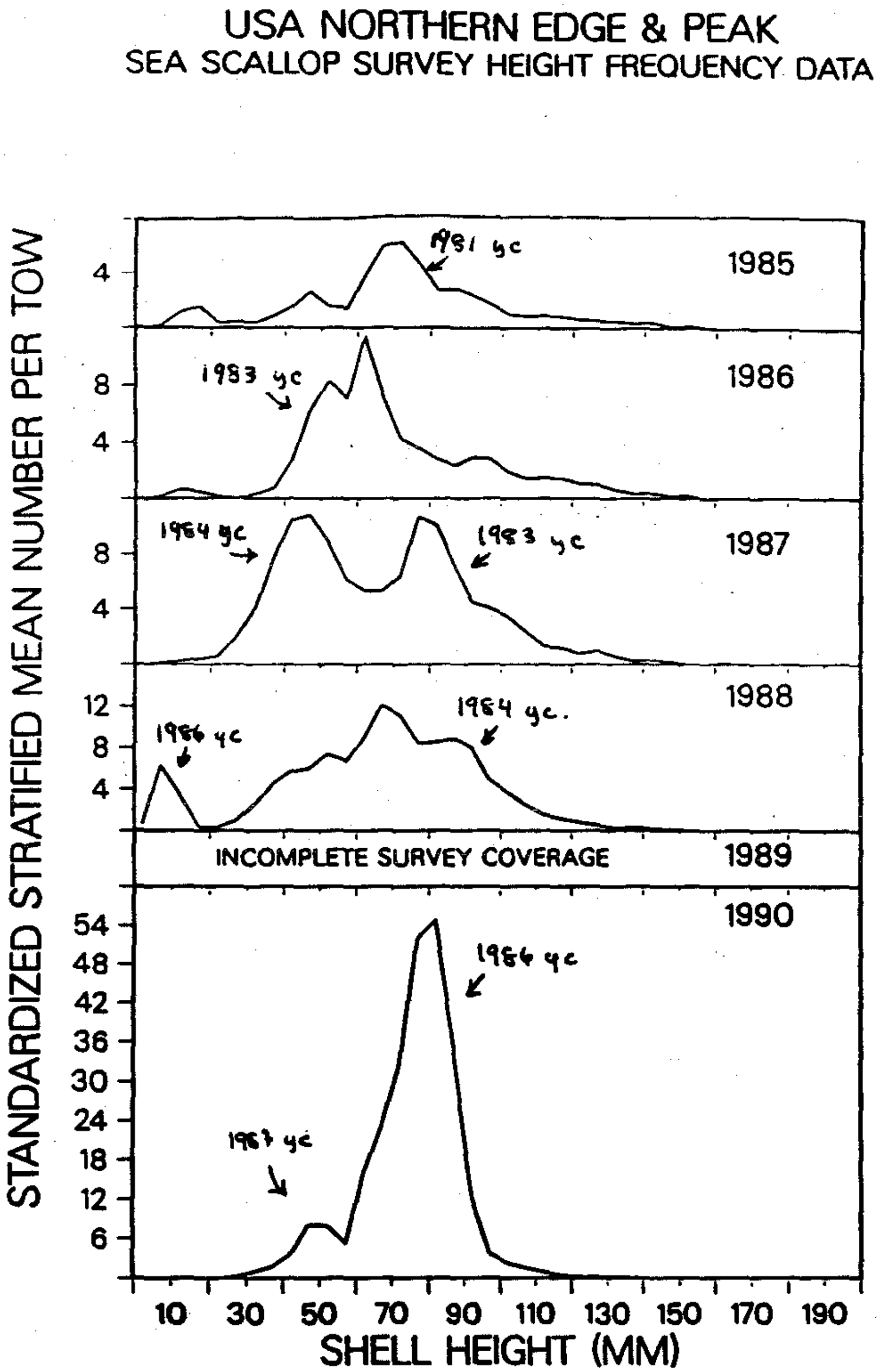


Figure 15. USA sea scallop research vessel survey shell height frequency distributions of sea scallops from the USA Northern Edge and Peak region (Strata 61, 621, 631, 651, 661 71, 74) of Georges Bank, 1982-1990.

Appendix Table 1 . Number of tows accomplished in USA sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977-1990.

		Year														
Stratum	Area (sq. mi.)	1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1163	5	5	5	N/S	N/S	N/S	2	2	4	3	3	3	3	N/S	N/S
2	175	2	N/S	5	N/S	2	2	2	2	4	3	3	3	3	N/S	N/S
3	126	1	2	4	N/S	2	2	2	2	3	3	3	3	3	N/S	N/S
4	117	4	1	2	N/S	N/S	2	2	2	2	3	3	3	4	N/S	N/S
5	453	1	2	4	4	4	4	3	3	3	3	3	3	3	N/S	N/S
6	62	N/S	N/S	2	2	1	2	4	4	5	5	5	5	6	5	3
7	46	N/S	1	1	1	2	1	3	4	4	5	5	5	4	5	3
8	74	N/S	N/S	N/S	1	2	1	2	2	2	3	3	3	3	3	N/S
VA - NC (6-7)	108	N/S	1	3	3	3	3	7	8	9	10	10	10	10	10	6
9	2171	5	6	8	8	8	8	8	6	6	4	4	4	3	N/S	N/S
10	152	2	N/S	5	5	5	5	8	8	8	8	8	8	8	8	8
11	229	3	3	7	7	7	6	6	8	8	8	8	8	8	8	8
12	204	1	4	2	2	2	3	3	3	4	4	4	4	4	4	N/S
13	1127	4	2	5	5	5	4	4	4	4	4	4	3	4	N/S	N/S
14	219	1	1	7	7	7	6	6	8	10	10	12	12	12	12	12
15	394	5	2	12	12	12	12	12	12	12	12	12	11	12	12	12
16	211	1	1	2	2	2	3	3	7	7	8	8	7	8	8	N/S
17	749	2	3	4	3	4	4	4	4	4	3	3	1	3	N/S	N/S
18	249	2	N/S	8	7	7	7	7	6	6	8	10	10	10	10	10
19	274	2	4	6	5	5	5	5	7	8	8	12	12	12	12	12
20	120	N/S	1	N/S	1	1	3	3	3	3	3	3	3	3	3	N/S
Delmarva (10-11, 14-15, 18-19)	1517	15	10	45	43	43	41	44	49	52	54	62	61	62	62	62
21	1650	4	16	7	6	6	4	4	4	4	4	4	2	4	N/S	N/S
22	312	1	5	15	12	12	12	12	8	8	8	8	8	8	8	8
23	714	3	27	16	20	20	2	20	16	16	16	16	16	16	16	16
24	476	3	19	3	3	3	6	6	6	6	6	6	4	6	6	5
25	648	2	4	5	4	4	7	7	6	7	4	4	4	4	4	3
26	188	N/S	2	7	8	9	9	9	13	13	14	14	14	13	14	12
27	451	1	9	12	12	11	12	12	10	10	12	20	19	19	20	17
28	149	1	2	2	2	2	3	3	7	6	6	10	10	10	10	10
29	1096	6	4	5	8	8	8	8	6	8	6	6	6	6	6	5
30	669	1	6	14	14	14	14	14	15	15	15	15	15	15	15	14
31	932	7	15	24	24	24	25	24	24	24	24	24	24	23	24	24
32	627	3	12	2	2	2	5	5	4	3	4	4	4	4	4	N/S
33	363	1	4	2	2	4	7	7	10	10	10	7	10	10	10	10
34	203	N/S	3	4	4	4	7	7	10	14	10	13	14	14	14	14
35	601	2	1	7	7	6	5	5	5	5	6	9	10	10	10	10
36	694	3	1	2	2	2	2	2	2	2	2	2	2	2	2	N/S
NY Bight (22-31, 33-35)	6802	28	101	116	120	121	117	134	136	142	137	152	154	154	157	148
Mid-Atlantic	8427	43	112	164	166	167	161	185	193	203	201	224	225	226	229	216

Appendix Table 2. Number of tows accomplished in USA sea scallop research vessel surveys on Georges Bank, 1975, 1977-1990.

Stratum	Area (sq. mi.)	Year														
		1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
45	392	3	3	2	2	N/S	2	2	2	3	3	3	3	3	3	N/S
46	416	3	N/S	4	4	N/S	5	6	6	6	6	6	6	6	6	6
47	871	13	4	9	9	4	9	9	9	9	10	N/S	12	12	12	12
48	1109	2	3	3	3	3	3	3	4	4	9	N/S	9	9	9	N/S
49	244	3	8	7	5	5	5	6	6	7	9	9	7	9	8	6
50	150	5	4	4	4	5	5	8	12	12	12	15	16	16	15	9
51	139	4	N/S	7	7	7	7	8	12	12	12	12	11	12	12	10
52	307	4	6	3	3	5	5	6	6	6	7	12	11	12	12	7
53	268	5	4	1	3	N/S	5	6	6	6	7	7	7	7	7	7
54	278	7	2	7	5	4	6	6	6	6	7	7	7	7	6	10
55	364	14	2	4	7	10	9	6	6	5	7	N/S	9	10	10	10
56	209	1	1	N/S	2	2	2	3	3	3	3	N/S	3	3	3	N/S
So. Channel (46-47, 49-55)	3037	58	30	46	47	40	56	61	69	69	77	68	86	91	88	76
57	184	N/S	3	4	1	1	1	3	3	3	3	3	3	3	3	N/S
58	300	3	2	2	2	2	2	4	4	4	4	8	8	8	8	8
59	538	8	9	13	10	10	9	10	8	8	12	12	12	12	12	12
60	816	10	10	3	8	8	8	8	8	8	12	12	12	12	11	12
So. East Part (58-60)	1654	21	21	18	20	20	19	22	20	20	28	32	32	32	31	32
61	576	N/S	6	3	N/S	18	N/S	7	7	7	8	8	8	8	N/S	8
62	701	N/S	11	18	13	20	N/S	9	9	9	-	-	-	-	-	-
621	547	-	-	-	-	-	-	-	-	-	12	12	12	12	N/S	12
622	154	-	-	-	-	-	-	-	-	-	4	5	6	6	N/S	6
63	694	15	15	12	37	44	15	10	10	10	-	-	-	-	-	-
631	340	-	-	-	-	-	-	-	-	-	7	7	7	7	N/S	7
632	354	-	-	-	-	-	-	-	-	-	7	12	8	8	N/S	7
64	988	7	22	36	36	174	56	14	14	14	16	107	16	16	N/S	16
65	164	8	3	8	16	16	12	12	15	14	-	-	-	-	-	-
651	102	-	-	-	-	-	-	-	-	-	10	12	12	12	N/S	12
652	62	-	-	-	-	-	-	-	-	-	6	5	10	10	N/S	9
66	266	6	12	4	11	12	15	14	14	14	-	-	-	-	-	-
661	117	-	-	-	-	-	-	-	-	-	10	12	12	12	N/S	12
662	149	-	-	-	-	-	-	-	-	-	8	17	7	8	N/S	3
71	146	4	N/S	3	21	4	3	4	4	5	6	6	5	6	N/S	6
72	504	4	N/S	N/S	3	8	N/S	5	4	4	6	6	6	6	N/S	N/S
73	501	2	N/S	N/S	2	9	N/S	5	4	4	5	6	6	6	N/S	N/S
74	433	7	2	N/S	16	15	N/S	5	5	5	8	7	9	8	N/S	8
USA No. Edge & Peak[1]	2765	-	-	-	-	-	-	-	-	-	67	70	71	71	N/S	65
CAN No. Edge & Peak[1]	1707	-	-	-	-	-	-	-	-	-	41	146	47	48	N/S	41
Total No. Edge & Peak	4472	51	71	76	153	311	101	80	82	82	108	216	118	119	N/S	106
USA Georges Bank[2]	7456	-	-	-	-	-	-	-	-	-	172	170	189	194	N/S	173
Total Georges Bank	9163	130	122	140	220	371	176	163	171	171	213	316	236	242	119	214

[1] USA No. Edge & Peak: Strata 61,621,631,651,661,71,72,74; CAN No. Edge & Peak: Strata 622,632,64,652,662.

[2] USA Georges Bank; Combined South Channel, Southeast Part, and USA No. Edge & Peak regions.

Appendix Table 3. Standardized mean number of sea scallops per tow, by stratum, and standardized stratified mean number of sea scallops per tow by region, from USA sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1163	0.0	0.0	25.4	N/S	N/S	N/S	1.0	0.0	0.0	8.7	0.0	0.7	0.0	N/S	N/S
2	175	3.0	N/S	9.8	N/S	0.5	0.0	5.5	40.0	0.0	0.3	0.0	1.0	1.7	N/S	N/S
3	126	933.0	2.0	5.3	N/S	0.5	2.5	0.0	1.5	1.0	1.0	0.0	0.0	0.7	N/S	N/S
4	117	11.5	0.0	0.0	N/S	N/S	0.5	1.5	0.0	0.5	0.0	0.0	0.0	4.8	N/S	N/S
5	453	0.0	0.5	22.5	1.5	0.0	0.0	0.0	7.7	0.0	0.7	0.0	0.0	0.0	N/S	N/S
6	62	N/S	N/S	92.0	72.0	58.0	12.5	4.5	34.0	10.4	12.2	10.6	0.4	4.5	71.4	35.3
7	46	N/S	10.0	30.0	12.0	29.0	3.0	3.7	42.3	20.8	4.8	3.0	4.6	27.0	1.4	256.7
8	74	N/S	N/S	N/S	10.0	0.0	0.0	1.5	2.0	3.5	0.0	0.0	0.0	3.3	0.0	N/S
VA - NC (6-7)	108	N/S	10.0	65.6	46.4	45.6	8.5	4.1	37.5	14.8	9.0	7.4	2.2	14.1	41.6	129.6
9	2171	24.4	12.0	4.3	130.0	11.4	9.1	7.0	5.5	4.8	23.5	7.8	14.0	7.0	N/S	N/S
10	152	80.5	N/S	134.6	165.8	148.0	26.2	18.0	47.4	14.9	36.6	228.1	132.8	73.4	177.0	39.6
11	229	41.7	55.3	113.0	64.9	78.1	14.8	16.5	44.6	12.6	42.4	246.8	105.8	62.3	89.5	54.3
12	204	0.0	2.0	0.5	0.0	0.5	3.0	5.3	5.3	5.0	0.8	1.5	1.5	8.8	0.8	N/S
13	1127	82.3	45.0	34.8	4.4	5.6	0.8	0.3	0.0	0.8	0.8	0.3	1.0	21.0	N/S	N/S
14	219	72.0	48.0	68.9	53.7	61.7	13.7	23.8	33.1	18.2	159.7	267.8	195.8	142.1	148.2	135.0
15	394	113.0	60.5	127.0	113.4	97.9	21.7	40.4	57.8	53.3	62.6	194.6	88.9	114.3	311.8	87.3
16	211	1.0	13.0	0.0	0.0	23.0	1.5	97.0	15.1	8.0	5.9	5.0	3.4	5.4	3.6	N/S
17	749	13.0	12.7	1.5	4.7	6.3	2.3	1.3	0.8	1.8	1.3	11.7	19.0	0.7	N/S	N/S
18	249	22.5	N/S	108.0	48.7	40.7	10.9	10.7	7.7	42.2	84.6	127.2	91.7	149.6	224.7	98.1
19	274	13.5	65.5	66.2	102.2	273.0	26.2	47.6	53.4	68.0	237.5	203.5	92.3	129.8	220.3	211.6
20	120	N/S	0.0	N/S	3.0	50.0	10.0	8.0	0.0	2.0	5.7	6.0	4.3	1.0	1.0	N/S
Delmarva (10-11, 14-15, 18-19)	1517	60.2	58.2	103.1	90.0	117.0	19.0	28.6	42.2	39.1	106.2	206.9	112.4	115.0	210.3	108.6
21	1650	2.8	0.9	0.4	9.3	0.8	1.3	4.0	0.5	6.8	9.3	0.3	5.0	5.3	N/S	N/S
22	312	11.0	73.2	21.1	16.8	10.2	3.1	4.7	4.9	10.4	21.3	25.9	118.1	136.9	102.4	35.0
23	714	99.0	99.9	106.4	66.2	77.4	63.8	32.8	25.9	64.5	96.0	185.6	199.1	357.9	574.3	698.9
24	476	88.3	2.4	8.0	6.3	9.7	3.7	20.2	7.5	29.8	8.0	1.3	0.8	23.8	26.7	6.8
25	648	41.0	19.0	9.2	17.0	8.5	39.6	14.3	6.2	9.3	19.0	14.8	71.0	54.5	54.8	4.0
26	188	N/S	60.0	42.6	19.0	42.1	89.8	104.0	25.4	64.8	72.2	65.9	423.7	186.6	256.2	24.8
27	451	22.0	164.4	94.5	32.3	35.3	35.0	38.2	21.2	63.5	232.1	266.0	372.6	611.6	1350.7	903.9
28	149	0.0	30.0	34.0	2.5	0.5	18.5	118.3	10.6	39.5	107.5	19.0	37.1	52.4	87.9	101.3
29	1096	8.8	29.0	17.4	14.9	24.0	6.0	2.3	19.7	23.4	16.3	50.2	22.5	19.8	22.3	46.4
30	669	23.0	106.0	106.4	16.9	35.6	37.3	30.0	31.2	21.9	52.1	84.1	196.8	240.5	192.2	89.2
31	932	222.9	70.1	95.4	20.0	33.0	53.3	46.3	30.0	34.0	157.8	195.1	190.4	291.7	329.1	392.2
32	627	0.0	2.1	2.5	1.5	1.0	1.0	1.8	0.8	13.0	0.8	2.3	0.0	8.0	8.0	N/S
33	363	240.0	25.3	88.5	25.5	40.3	126.0	61.3	47.3	23.8	67.2	56.6	241.5	63.2	14.6	35.2
34	203	N/S	102.3	73.0	44.0	70.5	93.3	123.1	210.0	150.1	74.8	205.5	159.2	202.6	138.8	78.6
35	601	4.0	0.0	11.3	10.7	9.3	3.8	9.0	0.0	27.2	112.8	92.6	38.3	28.8	81.8	11.2
36	694	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	N/S
NY Bight (22-31, 33-35)	6802	74.1	58.1	56.0	22.9	30.6	37.8	31.8	25.5	35.8	78.3	102.5	140.5	176.4	250.4	213.9
Mid-Atlantic	8427	71.4	57.9	64.6	35.3	46.3	34.1	30.9	28.7	36.1	82.5	120.0	133.6	163.2	240.5	193.8

Appendix Table 4 . Standardized mean number of pre-recruit (<70 mm shell height) sea scallops per tow by stratum, and standardized stratified mean number of pre-recruit sea scallops per tow by region from USA sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1163	0.0	0.0	20.6	N/S	N/S	N/S	1.0	0.0	0.0	5.3	0.0	0.7	0.0	N/S	N/S
2	175	2.5	N/S	8.6	N/S	0.5	0.0	5.0	34.5	0.0	0.3	0.0	1.0	1.7	N/S	N/S
3	126	756.0	0.5	4.0	N/S	0.0	2.0	0.0	1.5	1.0	0.0	0.0	0.0	0.7	N/S	N/S
4	117	11.5	0.0	0.0	N/S	N/S	0.5	1.5	0.0	0.5	0.0	0.0	0.0	4.3	N/S	N/S
5	453	0.0	0.5	13.3	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	N/S	N/S
6	62	N/S	N/S	20.0	40.5	3.0	1.5	0.3	19.5	0.0	2.2	9.2	0.0	3.3	62.0	3.0
7	46	N/S	0.0	9.0	1.0	11.5	0.0	0.7	34.3	0.5	1.0	0.8	0.2	2.8	0.2	81.7
8	74	N/S	N/S	N/S	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	2.3	0.0	N/S
VA - NC (6-7)	108	N/S	0.0	15.3	23.7	6.6	0.9	0.4	25.8	0.2	1.7	5.6	0.1	3.1	35.7	36.5
9	2171	16.0	1.7	3.3	67.6	3.0	3.8	0.6	3.5	0.5	17.8	5.8	7.3	3.7	N/S	N/S
10	152	69.0	N/S	39.0	79.6	68.0	5.4	4.6	32.1	2.6	22.6	181.1	42.8	38.0	122.6	10.5
11	229	34.0	4.3	52.6	4.9	36.0	1.0	3.0	34.3	3.0	24.4	225.6	47.3	31.6	44.5	20.8
12	204	0.0	0.0	0.0	0.0	0.0	0.5	1.7	1.3	0.3	0.0	0.8	1.0	7.3	0.8	N/S
13	1127	49.8	0.0	1.0	0.6	2.0	0.2	0.0	0.0	0.5	0.0	0.3	0.3	11.3	N/S	N/S
14	219	33.0	6.0	9.4	12.7	36.4	3.4	4.5	19.4	2.7	131.7	128.7	112.3	98.4	102.2	60.7
15	394	65.0	19.5	29.9	28.3	68.2	4.7	20.4	36.7	28.6	35.3	101.4	47.8	83.9	118.3	14.6
16	211	1.0	0.0	0.0	0.0	22.5	0.5	75.3	3.6	3.7	3.5	1.1	0.6	3.1	1.8	N/S
17	749	6.5	1.3	0.0	2.0	0.3	1.0	0.3	0.3	0.0	0.0	9.0	9.0	0.7	N/S	N/S
18	249	13.5	N/S	22.6	5.6	25.7	1.4	0.9	1.7	17.2	68.9	61.7	51.2	101.8	133.4	7.9
19	274	1.5	7.0	14.3	36.8	230.8	11.6	16.6	26.3	47.0	137.9	89.8	24.7	80.8	147.8	53.9
20	120	N/S	0.0	N/S	0.0	49.0	9.0	6.3	0.0	0.7	3.0	1.0	0.7	0.7	0.7	N/S
Delmarva (10-11, 14-15, 18-19)	1517	36.2	10.7	27.3	25.4	81.1	4.7	10.0	25.7	19.8	70.3	123.5	52.9	75.9	113.1	27.7
21	1650	2.0	0.4	0.4	1.5	0.0	0.2	1.5	0.0	3.0	5.5	0.0	4.5	2.0	N/S	N/S
22	312	9.0	0.4	1.5	9.7	4.7	0.3	0.8	0.3	6.3	13.8	17.1	95.1	74.3	69.5	10.7
23	714	64.0	4.2	5.8	18.2	54.6	29.1	20.8	15.1	49.2	72.1	109.0	109.6	100.2	406.9	326.1
24	476	21.3	0.5	0.7	4.3	7.0	1.3	11.3	2.5	19.7	0.7	0.3	0.3	23.2	23.0	1.2
25	648	32.5	0.3	0.2	0.5	2.5	29.0	4.0	2.5	3.9	5.3	4.8	60.8	33.0	40.0	2.3
26	188	N/S	0.0	0.7	5.6	17.2	70.0	24.0	10.5	25.8	48.7	17.2	390.6	41.2	183.4	6.2
27	451	8.0	2.9	1.7	5.6	14.6	17.8	17.7	6.5	45.1	165.3	124.6	286.6	349.7	984.9	571.9
28	149	0.0	1.5	6.5	2.5	0.0	8.5	81.3	1.9	26.8	70.8	2.0	13.5	40.9	70.5	36.2
29	1096	4.3	0.3	3.8	2.4	11.6	1.4	0.8	9.0	7.1	3.3	33.0	13.2	3.5	10.3	30.2
30	669	15.0	3.5	11.1	4.1	12.0	22.5	4.5	17.6	7.1	23.7	52.2	111.2	101.5	97.9	43.4
31	932	111.7	2.1	2.2	4.4	13.0	33.2	7.4	6.7	13.9	122.7	82.7	117.8	127.1	210.9	261.0
32	627	0.0	0.1	1.5	0.0	0.5	1.0	0.8	0.0	5.0	0.3	0.0	0.0	7.8	6.3	N/S
33	363	139.0	0.3	4.0	5.0	16.3	31.3	11.3	16.9	5.3	17.2	21.1	179.2	16.5	2.0	21.7
34	203	N/S	1.3	0.5	8.0	42.5	29.0	50.7	126.6	56.7	19.6	133.1	62.3	55.7	37.8	30.7
35	601	0.0	0.0	0.4	1.1	3.2	1.5	2.2	0.0	2.8	41.2	54.3	23.4	16.6	44.7	2.6
36	694	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	N/S
NY Bight (22-31, 33-35)	6802	39.4	1.5	3.3	5.3	15.4	18.9	10.9	11.6	17.5	47.4	53.2	94.4	75.9	168.6	121.1
Mid-Atlantic	8427	38.8	2.7	7.8	9.1	27.1	16.1	10.6	14.3	17.7	51.0	65.2	85.8	74.9	156.9	103.2

ppendix Table 5. Standardized mean number of harvestable-size [$\geq$70 mm shell height] sea scallops per tow by stratum, and standardized stratified mean number of harvestable-size sea scallops per tow by region from USA sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977 - 1990.

tratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1163	0.0	0.0	4.8	N/S	N/S	N/S	0.0	0.0	0.0	3.3	0.0	0.0	0.0	N/S	N/S
2	175	0.5	N/S	1.2	N/S	0.0	0.0	0.5	5.5	0.0	0.0	0.0	0.0	0.0	N/S	N/S
3	126	177.0	1.5	1.3	N/S	0.5	0.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	N/S	N/S
4	117	0.0	0.0	0.0	N/S	N/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	N/S	N/S
5	453	0.0	0.0	9.3	0.8	0.0	0.0	0.0	4.3	0.0	0.7	0.0	0.0	0.0	N/S	N/S
6	62	N/S	N/S	72.0	31.5	55.0	11.0	4.3	14.5	10.4	10.0	1.4	0.4	1.2	9.4	32.3
7	46	N/S	10.0	21.0	11.0	17.5	3.0	3.0	8.0	20.3	3.8	2.2	4.4	24.3	1.2	175.0
8	74	N/S	N/S	N/S	18.0	0.0	0.0	1.5	2.0	3.0	0.0	0.0	0.0	1.0	0.0	N/S
A - NC (6-7)	108	N/S	10.0	50.3	22.8	39.0	7.6	3.7	11.7	14.6	7.4	1.7	2.1	11.0	5.9	93.1
9	2171	8.4	10.3	1.0	62.4	8.4	5.4	6.4	2.0	4.3	5.8	2.0	6.8	3.3	N/S	N/S
10	152	11.5	N/S	95.6	85.4	80.0	20.8	13.4	15.3	12.3	14.0	47.0	90.0	35.4	54.4	29.1
11	229	7.7	51.0	60.4	60.0	42.1	13.8	13.5	10.4	9.6	18.0	21.1	58.5	30.6	45.0	33.5
12	204	0.0	2.0	0.5	0.0	0.5	2.5	3.7	4.0	4.8	0.8	0.8	0.5	1.5	0.0	N/S
13	1127	32.5	45.0	33.8	3.8	3.6	0.6	0.3	0.0	0.3	0.8	0.0	0.7	1.8	N/S	N/S
14	219	39.0	42.0	59.4	41.0	25.3	10.3	19.3	13.8	15.5	28.0	139.2	83.5	43.7	46.0	74.3
15	394	48.0	41.0	97.1	85.2	29.7	17.0	20.0	21.1	24.7	27.3	93.2	41.1	30.4	193.4	72.7
16	211	0.0	13.0	0.0	0.0	0.5	1.0	21.7	11.6	4.3	2.4	3.9	2.9	2.3	1.9	N/S
17	749	6.5	11.3	1.5	2.7	6.0	1.3	1.0	0.5	1.8	1.3	2.7	10.0	0.0	N/S	N/S
18	249	9.0	N/S	85.4	43.1	15.0	9.4	9.9	6.0	25.0	15.8	65.5	40.5	47.8	91.3	90.2
19	274	12.0	58.5	51.8	65.4	42.2	14.6	31.0	27.1	21.0	99.6	113.7	67.6	49.1	72.6	157.7
20	120	N/S	0.0	N/S	3.0	1.0	1.0	1.7	0.0	1.3	2.7	5.0	3.7	0.3	0.3	N/S
Delmarva (10-11, 14-15, 18-19)	1517	24.1	47.5	75.9	64.5	35.8	14.3	18.6	16.4	19.2	35.8	83.5	59.4	39.1	97.2	80.9
21	1650	0.8	0.5	0.0	7.8	0.8	1.2	2.5	0.5	3.8	3.8	0.3	0.5	3.3	N/S	N/S
22	312	2.0	72.8	19.6	7.2	5.5	2.8	3.9	4.6	4.1	7.5	8.8	23.0	63.6	32.9	24.3
23	714	35.0	95.7	100.6	48.1	22.8	34.7	12.1	10.8	15.3	23.9	76.6	89.6	257.7	167.4	372.8
24	476	67.0	1.8	7.3	2.0	2.7	2.3	8.8	5.0	10.2	7.3	1.0	0.5	0.7	3.7	5.6
25	648	8.5	18.8	9.0	16.5	6.0	10.6	10.3	3.7	5.4	13.8	10.0	10.3	21.5	14.8	1.7
26	188	N/S	60.0	41.9	13.4	24.9	19.8	80.0	14.9	39.1	23.5	48.7	33.1	145.4	72.9	18.6
27	451	14.0	161.6	92.8	26.8	20.6	17.3	20.6	14.7	18.4	66.8	141.4	86.1	261.9	365.8	332.0
28	149	0.0	28.5	27.5	0.0	0.5	10.0	37.0	8.7	12.7	36.7	17.0	23.6	11.5	17.4	65.1
29	1096	4.5	28.8	13.6	12.5	12.4	4.6	1.5	10.7	16.3	13.0	17.2	9.3	16.3	12.0	16.2
30	669	8.0	102.5	95.2	12.7	23.6	14.8	25.5	13.6	14.8	28.3	31.9	85.6	139.1	94.3	45.9
31	932	111.1	68.0	93.2	15.6	20.0	20.0	39.0	23.2	20.2	35.1	112.4	72.7	164.7	118.2	131.2
32	627	0.0	2.0	1.0	1.5	0.5	0.0	1.0	0.8	8.0	0.5	2.3	0.0	0.3	1.8	N/S
33	363	101.0	25.0	84.5	20.5	24.0	94.8	50.0	30.4	18.5	50.0	35.4	62.3	46.7	12.6	13.5
34	203	N/S	101.0	72.5	36.0	28.0	64.3	72.4	83.4	93.4	55.2	72.4	96.9	146.9	101.0	47.9
35	601	4.0	0.0	10.9	9.6	6.2	2.3	6.8	0.0	24.4	71.7	38.2	14.9	12.2	37.1	8.6
36	694	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/S
NY Bight (22-31, 33-35)	6802	34.7	56.7	52.7	17.6	15.2	19.0	20.9	14.0	18.4	30.9	49.3	46.0	100.5	81.8	92.8
Mid-Atlantic	8427	32.6	55.1	56.8	26.2	19.2	18.0	20.3	14.4	18.5	31.5	54.8	47.9	88.3	83.6	90.6

ppendix Table 6. Standardized mean meat weight (g) of sea scallops per tow by stratum, and standardized stratified mean meat weight of sea scallops per tow by region from USA sea scallop research vessel surveys in the Mid-Atlantic, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1163	0	0	100	N/S	N/S	N/S	4	0	0	40	0	2	0	N/S	N/S
2	175	12	N/S	39	N/S	1	0	16	146	0	0	0	4	6	N/S	N/S
3	126	4943	18	19	N/S	5	14	0	4	2	16	0	0	2	N/S	N/S
4	117	30	0	0	N/S	N/S	1	2	0	1	0	0	0	18	N/S	N/S
5	453	0	1	137	10	0	0	0	208	0	30	0	0	0	N/S	N/S
6	62	N/S	N/S	1530	554	932	309	131	538	206	333	70	16	33	344	459
7	46	N/S	227	660	218	171	61	102	349	345	93	46	61	476	13	1617
8	74	N/S	N/S	N/S	278	0	0	21	46	86	0	0	0	23	0	N/S
VA - NC (6-7)	108	N/S	227	1159	411	608	204	119	458	265	231	60	35	222	203	952
9	2171	145	266	19	1045	150	168	147	82	110	191	52	109	107	N/S	N/S
10	152	472	N/S	1834	1225	1127	448	331	456	347	380	1167	1186	766	967	424
11	229	203	856	1226	924	743	407	435	468	211	408	883	830	637	718	412
12	204	0	34	9	0	14	39	105	137	76	10	9	7	38	1	N/S
13	1127	467	1411	1142	142	116	24	7	0	3	11	1	15	241	N/S	N/S
14	219	767	1102	1634	888	700	205	446	490	325	444	1824	1372	887	917	990
15	394	1191	966	2178	1133	711	404	551	569	478	552	1376	636	615	2246	829
16	211	5	279	0	0	39	13	455	188	76	46	38	31	53	21	N/S
17	749	346	288	27	40	230	72	48	17	87	35	47	190	0	N/S	N/S
18	249	169	N/S	1781	934	398	207	346	205	547	286	980	680	911	1385	1028
19	274	160	849	1158	845	1282	301	573	502	434	1271	1479	999	875	1016	1652
20	120	N/S	0	N/S	39	63	24	28	0	18	68	48	41	2	6	N/S
Delmarva (10-11, 14-15, 18-19)	1517	555	941	1672	991	808	329	467	459	406	584	1299	899	768	1332	930
21	1650	14	10	1	297	17	25	61	18	138	82	10	19	63	N/S	N/S
22	312	59	1404	506	194	137	72	109	130	177	165	212	583	1128	714	402
23	714	632	1707	2269	1086	571	528	373	296	379	545	1100	1347	3053	2347	4016
24	476	1282	19	72	23	39	25	105	85	178	121	9	10	22	71	51
25	648	342	501	233	566	176	269	210	75	144	294	324	348	419	367	50
26	188	N/S	1208	1017	350	630	494	908	302	641	410	756	1190	1778	1208	334
27	451	315	2425	1797	561	473	270	387	420	419	1163	1705	1407	3294	4301	4386
28	149	0	547	249	2	3	107	541	110	237	574	174	286	227	347	677
29	1096	107	723	480	380	415	140	45	271	287	265	473	174	572	343	521
30	669	237	1012	2135	302	626	382	442	395	315	472	652	1286	1946	1402	751
31	932	1912	1206	1874	375	428	408	567	509	315	714	1493	1060	2007	1501	1886
32	627	0	27	31	17	5	5	17	14	123	8	33	0	8	32	N/S
33	363	2751	533	2134	472	510	1100	865	611	245	646	595	1226	719	216	330
34	203	N/S	1401	1402	732	536	793	1134	1445	1192	780	1428	1286	1818	1268	790
35	601	163	0	192	271	149	27	87	0	279	936	700	268	226	594	135
36	694	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N/S
NY Bight (22-31, 33-35)	6802	717	1029	1158	439	378	321	350	317	318	530	776	761	1357	1146	1232
Mid-Atlantic	8427	686	1012	1251	538	458	321	368	344	333	536	861	777	1237	1167	1174

Appendix Table 7. Standardized mean number of sea scallops per tow, by stratum, and standardized stratified mean number of sea scallops per tow by region, from USA sea scallop research vessel surveys on Georges Bank, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
45	392	34.3	0.0	0.0	0.0	N/S	0.0	0.0	17.0	0.0	11.3	0.0	0.0	0.0	2.3	N/S
46	416	41.0	N/S	20.3	9.0	N/S	84.4	12.7	0.5	19.7	27.8	29.2	21.0	50.3	46.0	110.5
47	871	41.8	20.8	16.7	50.2	27.3	43.9	33.7	48.7	35.0	87.3	N/S	53.3	34.9	6.1	186.8
48	1109	24.5	0.0	0.0	0.3	0.0	2.3	45.0	12.3	33.3	25.3	N/S	1.7	0.6	6.3	N/S
49	244	83.3	213.8	123.6	178.0	174.4	50.2	24.5	34.7	34.9	48.3	43.0	73.1	6.7	5.1	900.2
50	150	849.6	862.8	323.8	1171.3	1133.6	177.2	1787.4	259.9	127.5	318.4	870.1	1135.9	150.6	94.2	1519.3
51	139	18.5	N/S	151.0	20.4	20.3	147.1	3158.0	673.6	63.1	82.4	481.3	610.6	378.3	275.3	1032.2
52	307	8.8	3.8	4.7	4.0	4.0	28.2	90.2	34.0	4.8	243.3	43.4	117.1	99.5	40.0	248.9
53	268	3.0	141.3	173.0	32.7	N/S	35.6	27.2	33.7	20.0	35.1	57.7	114.7	30.6	26.4	21.1
54	278	65.3	262.0	12.9	31.2	50.0	24.7	94.0	52.2	20.2	32.1	92.0	105.6	31.1	50.3	159.9
55	364	6.3	0.5	0.8	1.4	12.1	0.3	4.0	26.2	20.8	39.9	N/S	7.1	89.4	1.2	31.4
56	209	0.0	9.0	N/S	3.5	0.5	3.0	0.0	2.3	6.7	6.7	N/S	0.0	13.0	8.0	N/S
So. Channel (46-47, 49-55)	3037	75.8	95.4	57.4	95.0	109.9	52.0	266.8	74.8	31.3	87.6	152.3	140.7	68.5	36.8	308.7
57	184	N/S	2.3	6.8	1.0	0.0	0.0	0.0	1.7	5.7	3.0	3.0	1.0	7.3	2.7	N/S
58	300	5.7	8.5	9.5	11.5	6.0	2.5	1.5	6.3	1.5	18.5	35.3	20.9	3.8	3.5	1.1
59	538	59.0	63.9	58.9	30.3	108.0	33.8	11.8	38.1	29.1	18.7	40.5	27.2	34.9	69.0	15.9
60	816	40.4	19.3	17.0	34.4	54.6	19.0	13.1	14.1	15.6	23.3	60.6	101.5	11.2	25.1	9.4
So. East Part (58-60)	1654	40.2	30.4	29.3	28.9	63.2	20.8	10.6	20.5	17.5	20.9	49.5	62.7	17.5	35.5	10.0
61	576	N/S	54.3	153.3	N/S	29.3	N/S	11.4	11.0	18.3	20.5	31.5	37.8	33.6	N/S	243.8
62	701	N/S	157.3	242.6	141.6	287.5	N/S	66.2	105.0	105.1	-	-	-	-	-	-
621	547	-	-	-	-	-	-	-	-	-	83.7	170.9	372.6	304.3	N/S	747.8
622	154	-	-	-	-	-	-	-	-	-	222.0	194.6	345.7	192.3	N/S	292.0
63	694	77.4	208.7	416.8	370.3	1605.5	62.5	63.8	39.6	39.4	-	-	-	-	-	-
631	340	-	-	-	-	-	-	-	-	-	15.7	45.6	2.9	3.4	N/S	7.9
632	354	-	-	-	-	-	-	-	-	-	269.6	80.1	338.9	317.6	N/S	222.7
64	988	470.6	606.4	878.4	486.8	1117.0	970.0	237.5	156.4	1297.3	844.9	1147.2	468.5	430.0	N/S	977.0
65	164	452.3	2217.3	1001.4	739.1	6513.3	1030.8	236.4	245.0	301.4	-	-	-	-	-	-
651	102	-	-	-	-	-	-	-	-	-	355.3	309.8	285.3	393.2	N/S	87.4
652	62	-	-	-	-	-	-	-	-	-	1574.8	511.4	1142.3	725.4	N/S	1069.0
66	266	259.8	1783.2	773.0	415.5	129.8	1214.1	297.8	219.9	332.9	-	-	-	-	-	-
661	117	-	-	-	-	-	-	-	-	-	198.0	194.7	190.2	178.8	N/S	72.5
662	149	-	-	-	-	-	-	-	-	-	276.9	1475.8	1291.1	256.6	N/S	490.3
71	146	129.8	N/S	1102.7	448.3	326.0	334.0	86.3	32.3	46.8	32.3	107.7	88.4	298.2	N/S	163.7
72	504	12.5	N/S	N/S	102.7	62.4	N/S	17.4	7.5	15.3	5.8	13.0	52.3	14.8	N/S	N/S
73	501	129.8	N/S	N/S	60.0	0.2	N/S	2.4	0.0	0.3	4.6	1.0	0.0	1.5	N/S	N/S
74	433	34.1	0.0	N/S	229.3	4.0	N/S	10.2	29.0	22.4	9.1	3.1	12.3	118.5	N/S	6.4
USA No. Edge & Peak[1]	2765	-	-	-	-	-	-	-	-	-	48.4	74.2	116.6	126.7	N/S	263.7
CAN No. Edge & Peak[1]	1707	-	-	-	-	-	-	-	-	-	646.3	845.6	524.7	380.8	N/S	719.6
Total No. Edge & Peak	4472	219.7	450.9	550.6	329.9	809.4	683.1	106.2	85.3	347.8	276.7	368.6	272.4	223.7	N/S	459.8
USA Georges Bank[2]	7456	-	-	-	-	-	-	-	-	-	58.3	90.2	114.5	78.8	N/S	223.0
Total Georges Bank	9163	126.3	252.6	263.7	188.9	469.7	249.6	142.2	70.1	183.3	167.9	252.9	190.9	135.1	N/S	320.9

[1] USA No. Edge & Peak: Strata 61,621,631,651,661,71,72,74; CAN No. Edge & Peak: Strata 622,632,64,652,662.

[2] USA Georges Bank: Combined South Channel, Southeast Part, and USA No. Edge & Peak regions.

Appendix Table 8. Standardized mean number of pre-recruit (<70 mm shell height) sea scallops per tow, by stratum, and standardized stratified mean number of pre-recruit sea scallops per tow by region from USA sea scallop research vessel surveys on Georges Bank, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
45	392	16.7	0.0	0.0	0.0	N/S	0.0	0.0	5.0	0.0	9.7	0.0	0.0	0.0	0.3	N/S
46	416	8.7	N/S	7.3	2.0	N/S	11.8	5.2	0.3	5.0	15.0	20.2	10.5	46.0	33.5	68.2
47	871	2.2	0.0	0.7	16.4	11.0	13.6	16.0	27.0	16.9	53.7	N/S	29.5	22.6	0.8	147.7
48	1109	0.8	0.0	0.0	0.0	0.0	0.0	10.7	11.3	5.5	14.1	N/S	1.1	0.3	3.0	N/S
49	244	73.3	18.4	9.1	17.8	137.8	4.2	11.0	20.2	23.0	28.0	29.8	20.1	2.6	1.9	824.4
50	150	740.4	46.3	7.5	2.5	922.0	58.4	1429.9	96.0	77.7	217.3	721.1	658.6	23.8	49.6	1462.7
51	139	2.5	N/S	110.3	1.7	4.7	120.0	2712.8	46.4	14.3	55.1	417.1	469.2	77.9	215.7	995.8
52	307	3.5	0.8	2.0	1.3	0.0	6.0	68.0	1.7	0.5	20.1	13.5	49.7	40.8	13.9	153.5
53	268	0.0	0.3	2.0	0.0	N/S	4.2	6.5	6.7	0.2	8.1	28.6	87.7	8.9	7.0	3.2
54	278	3.7	20.5	0.0	0.4	14.0	3.3	57.5	11.5	8.3	15.1	50.9	65.1	14.6	26.3	65.5
55	364	0.1	0.0	0.0	0.3	4.5	0.0	1.2	7.3	7.2	26.6	N/S	2.6	70.9	0.2	10.5
56	209	0.8	5.0	N/S	2.5	0.5	0.5	0.0	1.7	5.3	6.3	N/S	0.0	11.7	4.0	N/S
So. Channel (46-47, 49-55)	3037	45.1	6.2	7.7	6.8	79.8	15.5	213.8	19.0	13.6	40.3	115.3	84.6	32.5	21.8	258.8
57	184	N/S	0.8	0.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.7	0.0	0.7	1.0	N/S
58	308	2.3	0.8	0.8	2.5	4.5	0.0	0.3	2.5	0.5	15.3	30.5	15.1	0.9	1.4	0.8
59	538	2.3	2.6	6.3	10.8	27.1	1.6	0.9	24.6	8.6	8.0	20.6	13.2	2.0	56.8	1.5
60	816	1.3	4.8	0.3	7.5	24.1	1.9	0.9	5.8	3.4	7.6	33.8	32.5	1.3	9.9	2.0
So. East Part (58-60)	1654	1.8	3.2	2.2	7.7	21.5	1.4	0.8	11.3	4.6	9.1	28.9	23.1	1.4	23.6	1.6
61	576	N/S	0.2	1.3	N/S	9.4	N/S	0.1	1.3	5.3	2.1	17.9	25.1	15.0	N/S	22.9
62	701	N/S	7.4	55.1	31.1	205.4	N/S	7.9	60.4	75.2	-	-	-	-	-	-
621	547	-	-	-	-	-	-	-	-	-	46.9	97.2	199.5	146.9	N/S	231.7
622	154	-	-	-	-	-	-	-	-	-	138.8	55.6	223.2	75.3	N/S	142.5
63	694	13.8	46.9	133.2	43.6	1386.8	22.7	37.5	14.1	22.2	-	-	-	-	-	-
631	340	-	-	-	-	-	-	-	-	-	6.3	22.6	1.3	0.1	N/S	3.2
632	354	-	-	-	-	-	-	-	-	-	108.7	40.4	243.3	176.8	N/S	110.0
64	988	192.1	97.9	374.0	179.9	853.6	320.7	78.1	94.1	1165.9	193.9	433.7	303.8	149.8	N/S	653.1
65	164	284.8	156.0	126.8	139.1	6032.4	294.8	122.3	197.3	179.8	-	-	-	-	-	-
651	102	-	-	-	-	-	-	-	-	-	168.4	259.8	138.2	238.0	N/S	26.1
652	62	-	-	-	-	-	-	-	-	-	664.0	364.6	254.6	246.0	N/S	469.3
66	266	39.3	347.6	74.3	49.6	51.4	862.2	167.1	114.3	211.0	-	-	-	-	-	-
661	117	-	-	-	-	-	-	-	-	-	97.7	133.8	123.8	101.5	N/S	6.7
662	149	-	-	-	-	-	-	-	-	-	167.1	1167.0	428.1	167.3	N/S	11.3
71	146	59.8	N/S	592.7	43.2	106.5	110.0	24.3	14.8	13.6	13.8	71.3	49.0	202.5	N/S	43.4
72	504	0.5	N/S	N/S	11.7	6.1	N/S	9.4	0.3	0.3	0.8	4.5	16.8	6.8	N/S	N/S
73	501	105.5	N/S	N/S	4.5	0.2	N/S	1.8	0.0	0.0	0.4	0.7	0.0	0.5	N/S	N/S
74	433	6.9	0.0	N/S	5.8	0.1	N/S	2.8	11.2	7.4	0.8	0.0	7.6	54.9	N/S	1.0
USA No. Edge & Peak[1]	2765	-	-	-	-	-	-	-	-	-	21.8	45.6	62.0	65.8	N/S	66.9
CAN No. Edge & Peak[1]	1707	-	-	-	-	-	-	-	-	-	186.0	379.5	293.0	153.7	N/S	431.7
Total No. Edge & Peak	4472	83.8	66.1	177.8	72.0	665.7	277.4	40.9	48.3	293.8	84.5	173.0	150.2	99.4	N/S	223.8
USA Georges Bank[2]	7456	-	-	-	-	-	-	-	-	-	26.5	61.3	62.6	37.9	N/S	135.2
Total Georges Bank	9163	51.7	34.4	79.7	36.6	377.4	97.2	91.0	31.9	148.7	56.2	129.8	105.5	59.5	N/S	193.6

[1] USA No. Edge & Peak: Strata 61,621,631,651,661,71,72,74; CAN No. Edge & Peak: Strata 622,632,64,652,662.

[2] USA Georges Bank; Combined South Channel, Southeast Part, and USA No. Edge & Peak regions.

Appendix Table 9. Standardized mean number of harvestable-size (≥70 mm shell height) sea scallops per tow, by stratum, and standardized stratified mean number of harvestable-size sea scallops per tow by region from USA sea scallop research vessel surveys on Georges Bank, 1975, 1977 - 1990.

Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
45	392	17.7	0.0	0.0	0.0	N/S	0.0	0.0	12.0	0.0	1.7	0.0	0.0	0.0	2.0	N/S
46	416	32.3	N/S	13.0	7.0	N/S	72.6	7.5	0.2	14.7	12.8	9.0	10.5	4.3	12.5	42.3
47	871	39.6	20.8	16.0	33.8	16.3	30.3	17.7	21.7	18.1	33.6	N/S	23.8	12.3	5.2	39.1
48	1109	24.5	0.0	0.0	0.3	0.0	2.3	34.3	1.0	27.8	11.2	N/S	0.6	0.2	3.3	N/S
49	244	18.8	203.4	114.4	160.2	36.6	46.0	13.5	14.5	11.9	20.3	13.2	53.0	4.1	3.3	75.8
50	150	109.2	316.5	316.3	1168.8	211.6	118.8	357.5	163.9	49.7	101.2	148.9	477.3	126.8	44.6	56.6
51	139	16.0	N/S	40.7	18.7	15.6	27.1	445.3	627.2	48.8	27.3	64.2	141.5	300.4	59.7	36.4
52	307	5.3	3.0	2.7	2.7	4.0	22.2	22.2	32.3	4.3	223.1	29.9	67.4	58.7	26.1	95.4
53	268	3.0	141.0	171.0	32.7	N/S	31.4	20.7	27.0	19.8	27.0	29.1	27.0	21.7	19.4	17.9
54	278	61.6	241.5	12.9	30.8	36.0	21.3	36.5	40.7	11.8	17.0	41.1	41.4	16.6	24.0	94.4
55	364	6.2	0.5	0.8	1.1	7.6	0.3	2.8	18.8	13.6	13.3	N/S	4.6	18.5	1.0	20.9
56	209	0.0	4.0	N/S	1.0	0.0	2.5	0.0	0.7	1.3	0.3	N/S	0.0	1.3	4.0	N/S
So. Channel (46-47, 49-55)	3037	29.9	89.1	49.7	88.2	30.2	36.5	53.0	55.8	17.7	47.4	37.0	56.1	36.1	15.1	49.9
57	184	N/S	2.3	5.3	1.0	0.0	0.0	0.0	1.7	4.3	3.0	2.3	1.0	6.7	1.7	N/S
58	300	3.3	0.5	9.5	9.0	1.5	2.5	1.3	3.8	1.0	3.3	4.8	5.8	2.9	2.1	0.3
59	538	56.8	61.3	52.6	19.5	80.9	32.2	10.9	13.5	20.5	10.7	19.9	14.0	32.9	12.2	14.4
60	816	39.1	14.5	16.7	26.9	30.5	17.1	12.3	8.4	12.3	15.7	26.8	69.0	9.9	15.2	7.4
So. East Part (58-60)	1654	38.4	27.2	27.1	21.2	41.6	19.4	9.8	9.2	12.9	11.8	20.6	39.6	16.1	11.8	8.4
61	576	N/S	54.2	152.0	N/S	19.9	N/S	11.3	9.7	13.0	18.4	13.6	12.6	18.6	N/S	220.9
62	701	N/S	149.9	187.5	110.5	82.1	N/S	58.3	44.6	29.9	-	-	-	-	-	-
621	547	-	-	-	-	-	-	-	-	-	36.8	73.8	173.1	157.4	N/S	516.1
622	154	-	-	-	-	-	-	-	-	-	83.3	139.0	122.5	117.0	N/S	149.5
63	694	64.4	161.7	283.6	326.7	218.7	39.7	25.5	25.5	17.2	-	-	-	-	-	-
631	340	-	-	-	-	-	-	-	-	-	9.4	23.0	1.6	3.3	N/S	4.7
632	354	-	-	-	-	-	-	-	-	-	160.9	39.7	85.6	140.9	N/S	112.7
64	988	278.4	508.5	504.4	306.9	263.4	649.3	159.4	62.3	131.4	651.0	713.5	164.7	280.2	N/S	323.9
65	164	168.3	2061.3	875.4	600.0	480.9	736.1	114.1	47.7	121.6	-	-	-	-	-	-
651	102	-	-	-	-	-	-	-	-	-	186.9	50.0	141.2	155.2	N/S	61.3
652	62	-	-	-	-	-	-	-	-	-	910.8	146.8	887.7	479.4	N/S	599.7
66	266	220.5	1435.6	698.8	365.9	78.3	351.9	130.7	105.6	121.9	-	-	-	-	-	-
661	117	-	-	-	-	-	-	-	-	-	100.3	60.8	66.5	77.3	N/S	65.8
662	149	-	-	-	-	-	-	-	-	-	109.8	308.8	863.0	89.4	N/S	479.0
71	146	69.3	N/S	510.0	405.0	219.5	224.0	62.0	17.5	33.2	18.5	36.3	39.4	95.7	N/S	120.3
72	504	12.0	N/S	N/S	91.0	56.3	N/S	8.0	7.3	15.0	5.0	8.5	35.5	8.0	N/S	N/S
73	501	23.5	N/S	N/S	55.5	0.0	N/S	0.6	0.0	0.3	4.2	0.3	0.0	1.0	N/S	N/S
74	433	27.3	0.0	N/S	223.5	3.9	N/S	7.4	17.8	15.0	8.4	3.1	4.8	63.6	N/S	5.4
USA No. Edge & Peak[1]	2765	-	-	-	-	-	-	-	-	-	26.6	28.6	54.6	60.9	N/S	196.8
CAN No. Edge & Peak[1]	1707	-	-	-	-	-	-	-	-	-	460.3	466.0	231.7	227.2	N/S	287.9
Total No. Edge & Peak	4472	135.8	384.8	372.9	257.9	143.7	405.7	65.4	37.1	54.0	192.2	195.6	122.2	124.4	N/S	236.0
USA Georges Bank[2]	7456	-	-	-	-	-	-	-	-	-	31.8	28.9	51.9	40.8	N/S	87.8
Total Georges Bank	9163	74.6	218.3	184.0	152.3	92.3	152.4	51.2	38.3	34.6	111.6	123.0	85.4	75.6	N/S	127.3

[1] USA No. Edge & Peak: Strata 61,621,631,651,661,71,72, 74; CAN No. Edge & Peak: Strata 622,632,64,652,662.

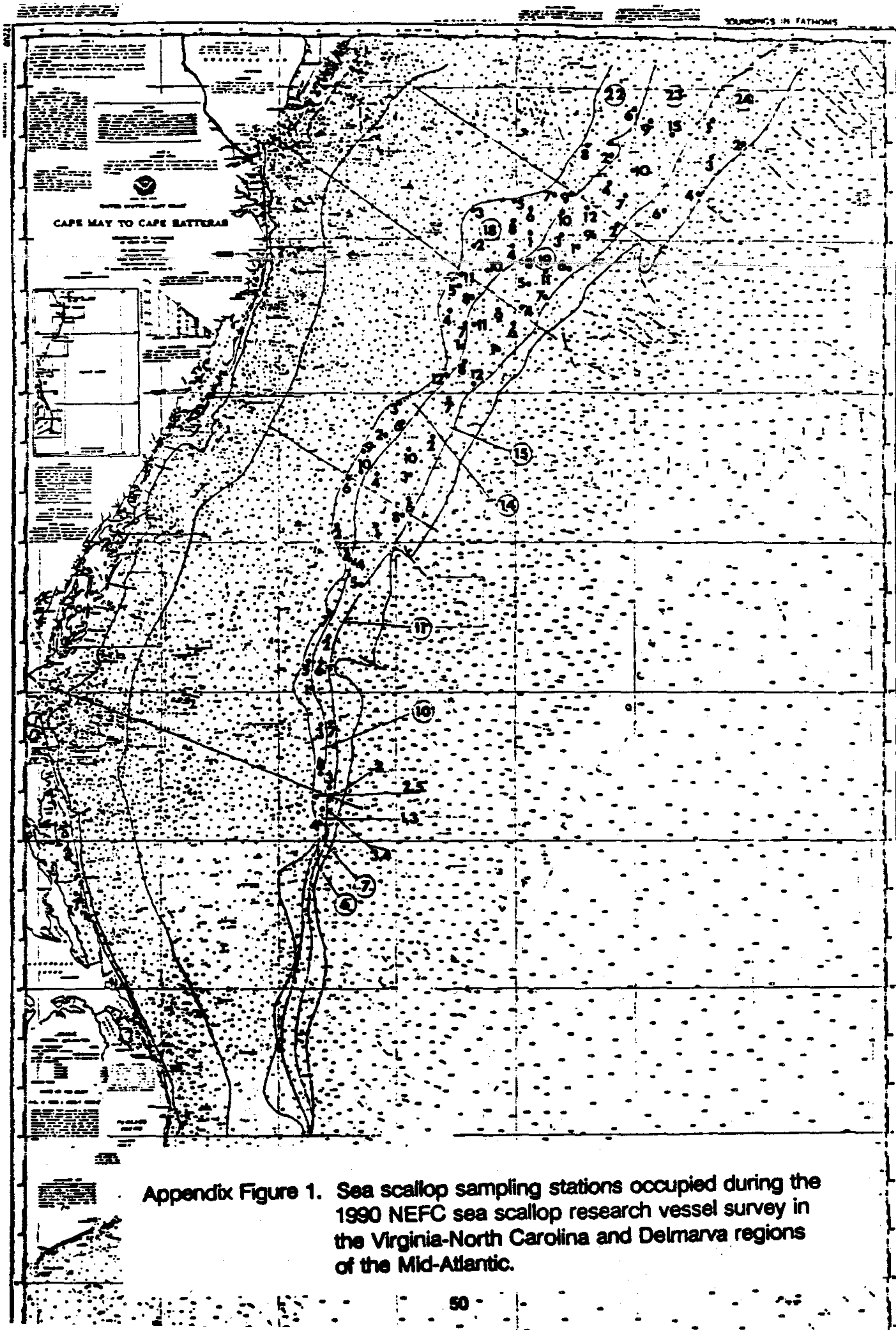
[2] USA Georges Bank: Combined South Channel, Southeast Part, and USA No. Edge & Peak regions.

Appendix Table 10. Standardized mean meat weight (g) of sea scallops per tow, by stratum, and standardized stratified mean meat weight of sea scallops per tow by region from USA sea scallop research vessel surveys on Georges Bank, 1975, 1977 - 1990.

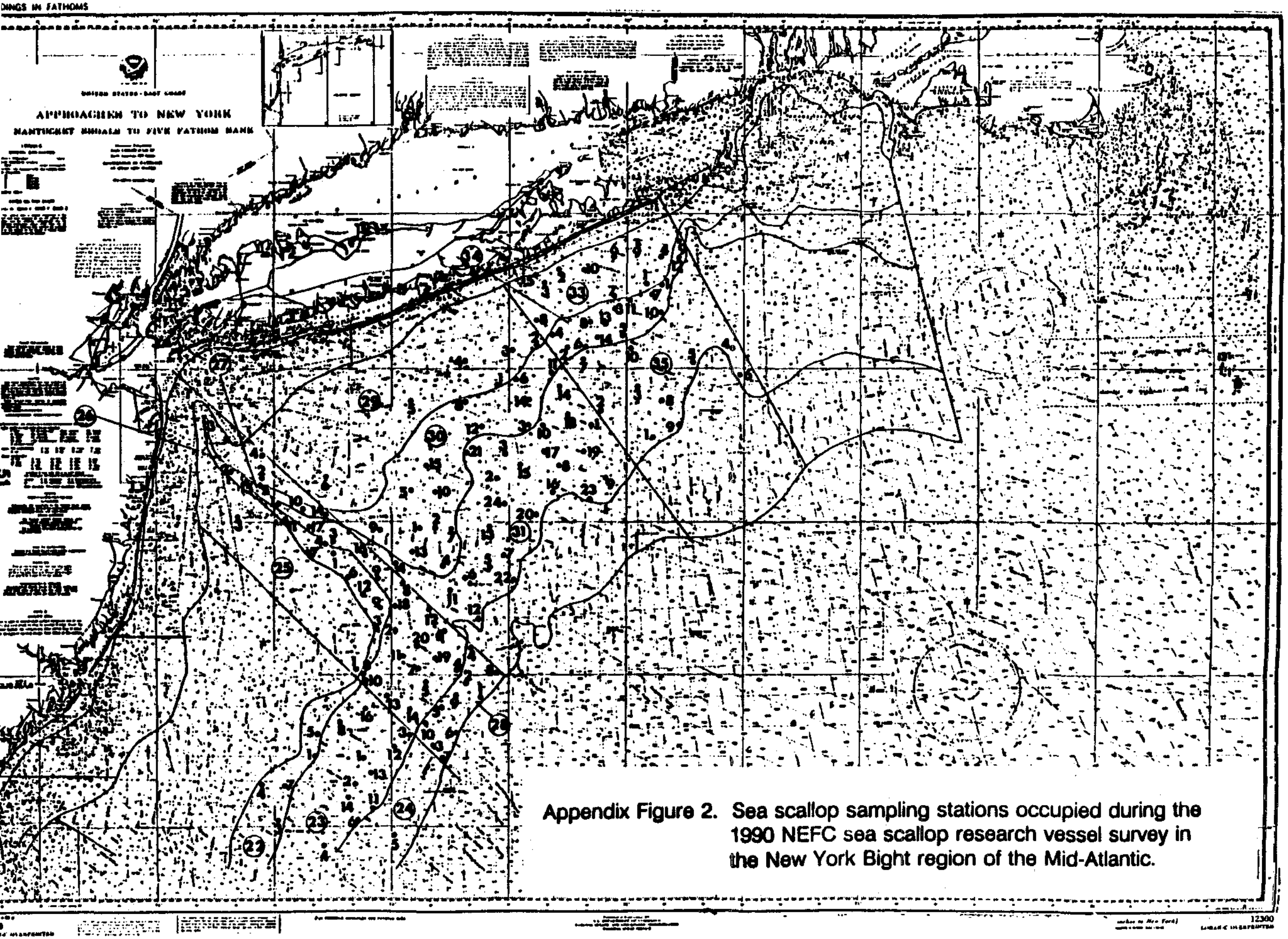
Stratum	Area (sq. mi.)	Year 1975	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
45	392	556	0	0	0	N/S	0	0	289	0	46	0	0	0	21	N/S
46	416	1029	N/S	454	312	N/S	1283	208	10	363	190	183	288	171	289	632
47	871	1114	872	533	1045	450	469	482	597	416	750	N/S	581	276	202	834
48	1109	878	0	0	12	0	70	745	25	535	209	N/S	7	3	62	N/S
49	244	568	3293	2360	4162	1082	1440	206	365	254	383	355	490	82	74	3032
50	150	3571	3945	5717	12907	3154	1380	6901	2084	778	1729	2964	5638	1516	811	3089
51	139	646	N/S	1043	558	454	663	9261	6177	709	562	1436	2326	3017	1236	1448
52	307	163	102	59	38	159	516	491	693	109	3244	614	1033	782	496	1446
53	268	100	4559	4277	959	N/S	599	727	617	608	709	821	820	494	330	355
54	278	1669	5188	563	1183	882	495	1015	699	315	499	945	777	291	511	1519
55	364	235	20	27	36	239	20	84	428	278	417	N/S	103	564	37	318
56	209	0	53	N/S	10	0	61	0	27	31	12	N/S	0	20	41	N/S
So. Channel (46-47, 49-55)	3837	918	1957	1173	1541	668	677	1165	827	387	869	820	891	539	331	1143
57	184	N/S	96	282	13	0	0	0	84	189	123	71	54	117	101	N/S
58	300	113	5	424	161	16	51	55	136	25	139	99	86	33	41	8
59	538	1345	1557	1732	824	1396	786	418	506	433	249	616	287	689	433	232
60	816	1145	368	596	858	571	398	345	170	192	267	496	1125	189	299	149
So. East Part (58-60)	1654	1023	689	934	720	739	461	316	273	240	238	463	664	323	296	150
61	576	N/S	1724	4864	N/S	794	N/S	396	347	528	401	406	423	337	N/S	2020
62	701	N/S	3022	4303	2689	1933	N/S	953	870	670	-	-	-	-	-	-
621	547	-	-	-	-	-	-	-	-	-	610	1257	2360	1959	N/S	5437
622	154	-	-	-	-	-	-	-	-	-	1420	2392	1841	1725	N/S	2000
63	694	1355	2343	5849	5003	5068	757	559	509	419	-	-	-	-	-	-
631	340	-	-	-	-	-	-	-	-	-	193	466	33	86	N/S	139
632	354	-	-	-	-	-	-	-	-	-	1918	913	1826	2097	N/S	1938
64	988	4038	7373	10240	5964	4421	6466	2373	1315	2885	6481	9976	3084	3782	N/S	5213
65	164	3658	22843	15856	7960	12587	7683	1632	1108	1546	-	-	-	-	-	-
651	102	-	-	-	-	-	-	-	-	-	2250	1633	1884	1985	N/S	777
652	62	-	-	-	-	-	-	-	-	-	9178	3013	9670	6083	N/S	8103
66	266	3230	16857	14687	8948	1327	5329	2195	1500	1833	-	-	-	-	-	-
661	117	-	-	-	-	-	-	-	-	-	1412	1183	949	1566	N/S	944
662	149	-	-	-	-	-	-	-	-	-	1992	5960	10875	1428	N/S	6719
71	146	1596	N/S	10007	6194	2732	2619	948	554	639	383	1030	603	1794	N/S	1413
72	504	348	N/S	N/S	1876	1408	N/S	176	158	365	101	216	763	161	N/S	N/S
73	501	820	N/S	N/S	677	1	N/S	7	0	2	99	4	0	25	N/S	N/S
74	433	740	0	N/S	3217	60	N/S	157	307	308	258	95	81	1186	N/S	134
USA No. Edge & Peak[1]	2765	-	-	-	-	-	-	-	-	-	450	610	852	918	N/S	2052
CAN No. Edge & Peak[1]	1787	-	-	-	-	-	-	-	-	-	4784	6809	3630	3125	N/S	4480
Total No. Edge & Peak	4472	2228	5299	7910	4666	2963	4417	1068	746	1133	2104	2976	1913	1760	N/S	3097
USA Georges Bank[2]	7456	-	-	-	-	-	-	-	-	-	574	632	826	632	N/S	1202
Total Georges Bank	9163	1471	3298	4020	2801	1892	1841	964	688	725	1358	1962	1348	1096	N/S	1849

[1] USA No. Edge & Peak: Strata 61,621,631,651,661,71,72,74; CAN No. Edge & Peak: Strata 622,632,64,652,662.

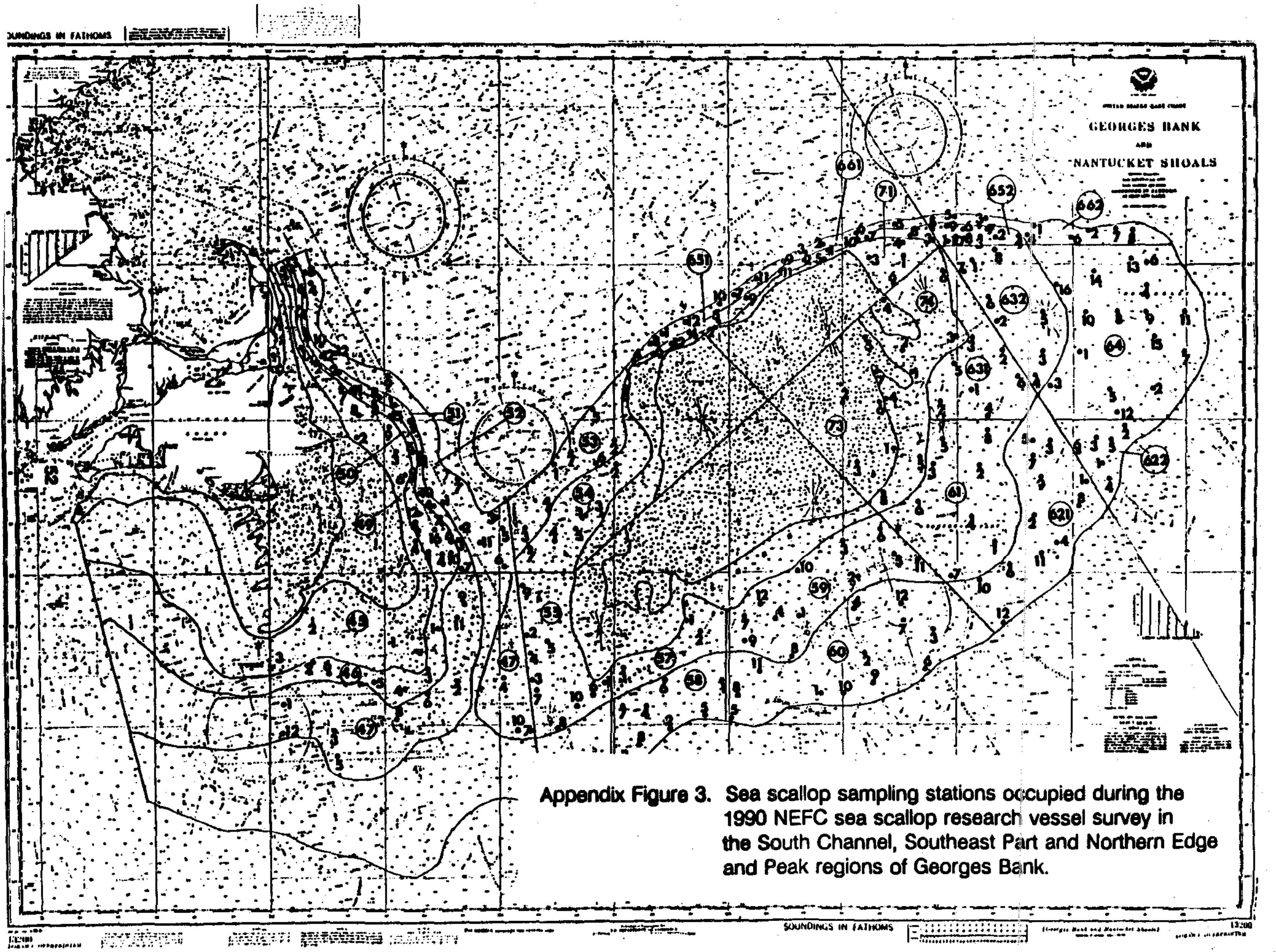
[2] USA Georges Bank: Combined South Channel, Southeast Part, and USA No. Edge & Peak regions.



Appendix Figure 1. Sea scallop sampling stations occupied during the 1990 NEFC sea scallop research vessel survey in the Virginia-North Carolina and Delmarva regions of the Mid-Atlantic.



Appendix Figure 2. Sea scallop sampling stations occupied during the 1990 NEFC sea scallop research vessel survey in the New York Bight region of the Mid-Atlantic.



Appendix Figure 3. Sea scallop sampling stations occupied during the 1990 NEFC sea scallop research vessel survey in the South Channel, Southeast Part and Northern Edge and Peak regions of Georges Bank.

Papers of the Northeast Regional
Stock Assessment Workshops

Stock Assessment of Atlantic Butterfish, *Peprilus triacanthus*, in the Northwest Atlantic

by

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/4

SAW/12/SARC/2

I. Introduction

A. Stock Definition

Atlantic butterfish (*Peprilus triacanthus*) range from Newfoundland to Florida and are present in commercially significant amounts between Cape Hatteras and Southern New England. The commercially exploited butterfish population is assumed to constitute a unit stock in waters north of Cape Hatteras. The portion of the stock north of Cape Hatteras migrates inshore and northward during the summer and returns to offshore waters in the winter due to temperature preferences (Murawski et al. 1978).

B. History of the Fishery

Butterfish have been landed by domestic fishermen since the 1800's. Historical fishery data indicate that from 1920 to 1962 the domestic harvest averaged 3,500 m.t. per year. Figure 1 and Table 1 show Butterfish landings in the Northwest Atlantic Ocean from 1965 to 1990. Foreign catches began in the 1960's and the average catch per year increased to an average of 5,000 m.t. from 1963 to 1967. Foreign catches increased in the late 1960's and early 1970's and as a result, average annual landings rose to 11,655 m.t. from 1968 to 1976 (Murawski and Waring 1979). Overall, landings have dropped since 1976. From 1977 to 1986, butterfish landings averaged 6,310 m.t. per year. Since 1986 the directed foreign fishery has been curtailed, and butterfish landings from 1987 to 1990 have decreased to an average of 3,044 m.t. per year.

C. Current Fishing Activity

Domestic butterfish landings totaled 2,395 m.t. in 1990. Landings decreased by 25% from 3,192 m.t. in 1989. A total of 1,199 and 1196 m.t., were landed in NAFO subareas 5 and 6 during 1990, respectively. Overall, butterfish landings decreased by 32% and 17% in subareas 5 and 6 from 1989, respectively.

Table 2 shows 1990 landings by area and month. Figure 2 shows the breakdown of 1990 landings by market category. The small and unclassified market categories comprised the majority of landings in 1990. In comparison to 1989, landings of small butterfish decreased by 56% while landings of medium, large, and jumbo butterfish increased by 8%, 90%, and 205%, respectively.

The spatial distribution of butterfish landings in 1990 was similar to that in 1989. Figure 3 shows domestic landings by U.S. statistical area (Figure 4) from 1982 to 1990. In 1990, the majority of butterfish were landed in statistical areas 53, 61, and 62 (Table 2, Figure 4).

Table 3 shows catch per unit effort (CPUE) statistics for the directed domestic butterfish fishery during 1982-1990, where directed effort is defined as total landings (m.t.) per total days fished for vessels over 5 G.R.T. that land over 50% butterfish in a trip. Directed trips have decreased in the late 1980's, and the number of directed trips in 1990 was less than 1/3 the average for the 1982-1990 period. Similarly, directed CPUE for butterfish has decreased in the late 1980's, and CPUE in 1990 is roughly 1/2 the average for the 1982-1990 period. Overall, 1989 and 1990 were similar in terms of directed CPUE, although there were more directed trips in 1989.

D. Current Management Plan

Butterfish are managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1990, the maximum optimum yield and the allowable biological catch for Butterfish was 16,000 m.t. and the domestic allowable harvest was 10,000 m.t. (MAFMC 1989, see also Murawski and Waring 1979). Similar regulations are in effect for 1991 (MAFMC 1990A).

Overfishing for butterfish is proposed to be defined as occurring when the three year moving average of pre-recruits from the NEFC fall bottom trawl survey falls within the lowest quartile of this time series (MAFMC 1990B). Using this definition, butterfish would have been overfished in 1990 if the average of the pre-recruit indices from 1988, 1989, and 1990 fell below the 6th lowest value of the pre-recruit index (Table 4).

E. Reference to Previous Assessments

This assessment uses the methodology and data sources of recent butterfish assessments (NEFC 1990).

I. Data Sources

A. Commercial Fishery Data

Landings data for 1989 and 1990 were collected from Joint Venture, general canvas, and NMFS weighout data. Data for 1965-88 were collected from the Report of the 10th SAW (NEFC 1990).

B. Research Survey Data

Research survey data for 1990 were collected from the NEFC survey database. Survey data for 1968-89 were collected from the Report of the 10th SAW (NEFC 1990).

II. Analysis

A. Abundance and Mortality

Indices of relative abundance for butterfish are the stratified mean number per tow and mean weight per tow obtained in the annual NEFC autumn bottom trawl survey. Table 4 shows these indices for 1968-90. The stratified mean number per tow index was disaggregated to a mean number per tow at age (Table 4) using an age length key derived from 1990 autumn bottom trawl survey data.

The 1990 pre-recruit index (stratified mean number of age 0 per tow) was 201% of the mean age 0 index for the 1968-1990 period. However, the 1990 recruit index (stratified mean number of age 1+ per tow) was only 85% of the mean age 1+ index. The pattern of high pre-recruit indices has continued since 1988 (Table 4). Although there was a 42% decline in the butterfish recruit index (Age 1+) from 1989, this index is still at a high level in comparison to the early 1970's and the decline is a result of high mortality on the 1987 and 1988 year classes (Table 5).

Estimates of total instantaneous mortality (Z) for butterfish derived from stratified mean number per tow at age data (Table 4) are presented in Table 3. Overall, the 1990 mortality rate estimates are higher than the 1978-90 means (Table 5), although abundance indices are at or above their average levels for the period 1968-1990 (Table 4).

B. Biological Reference Points

The three year moving average of the pre-recruit index provides a reference point for butterfish abundance, and this moving average was 314.293 for 1990. This is 429% of the 6th lowest pre-recruit index (73.2 in 1972) indicating that butterfish were not overfished under the proposed overfishing definition. Further, it is impossible for butterfish to be overfished in 1991 and 1992 under this definition because of high pre-recruit indices in 1989 and 1990 (332.31 and 328.29) in comparison to minimum potential values of the 6th lowest pre-recruit indices in 1991 and 1992 (at least 47.73 and 41.28, respectively).

III. Discussion

Relatively high total mortality estimates for the 1987 to 1989 year classes (Table 5) may be the result of increased natural predation and discarding. Butterfish are substantial food source for a number of finfish including haddock (*Melanogrammus aeglefinus*), silver hake (*Merluccius bilnearis*), and bluefish (*Pomatomus saltatrix*) (Murawski et al. 1978), although the amount of natural mortality due to large pelagics has not been estimated (NEFC 1990). Butterfish co-occur with *Loligo pealei* (Lange and Waring unpublished data) and discarding of butterfish in directed Loligo fisheries during 1989 may have negatively impacted older age classes. Nonetheless, given the high level of pre-recruit abundance and decreased directed effort, higher estimates of butterfish mortality rates in 1990 are not likely to significantly affect commercial availability 1991.

High pre-recruit indices over the past three years suggest that butterfish reproduction remains strong in the Northwest Atlantic. In addition, relatively large butterfish catches (1684 pounds) were observed in the 1991 NEFC Spring bottom trawl survey (NEFC 1991) in comparison to 1990 (243 pounds) and 1989 (347 pounds) surveys suggesting that levels of abundance may be even higher in 1991. Low CPUE during the 1988-1990 period is likely the result of decreased directed effort towards a patchily distributed species and not decreased availability.

Overall, it appears that the butterfish population is at a relatively high level of abundance in comparison to the period of heavy exploitation in the 1970's (Figure 1, Table 4). Provided that the proposed definition of overfishing is approved, butterfish will not be overfished in 1991 and 1992. In conclusion, Atlantic butterfish stock abundances are probably sufficient to support catches at the OY level (16,000 m.t.) and butterfish are presently an underexploited resource in the Northwest Atlantic.

IV. Literature Cited

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Figure 1. Butterfish Landings in NAFO Subareas 5 and 6 1965-1990

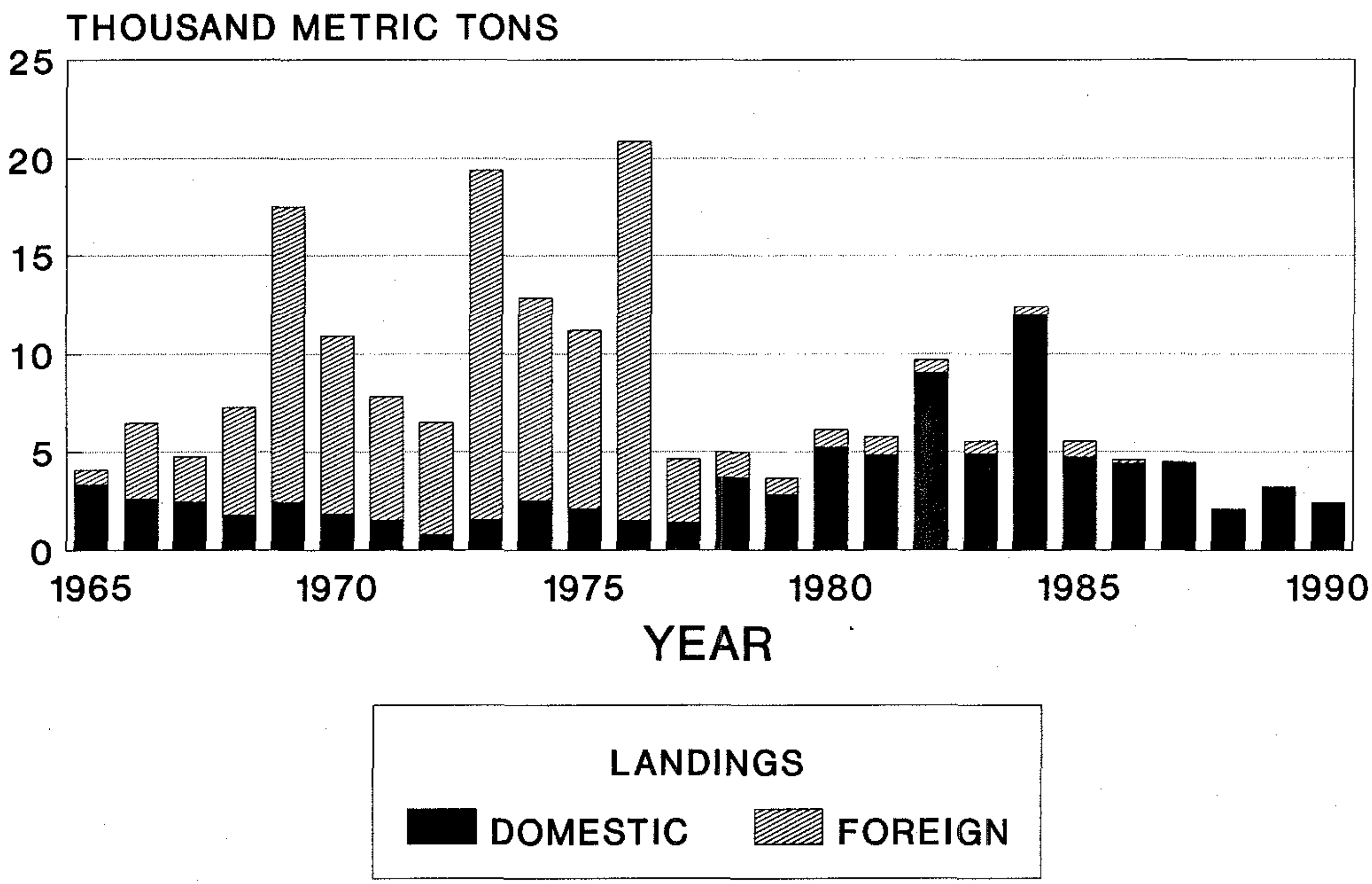
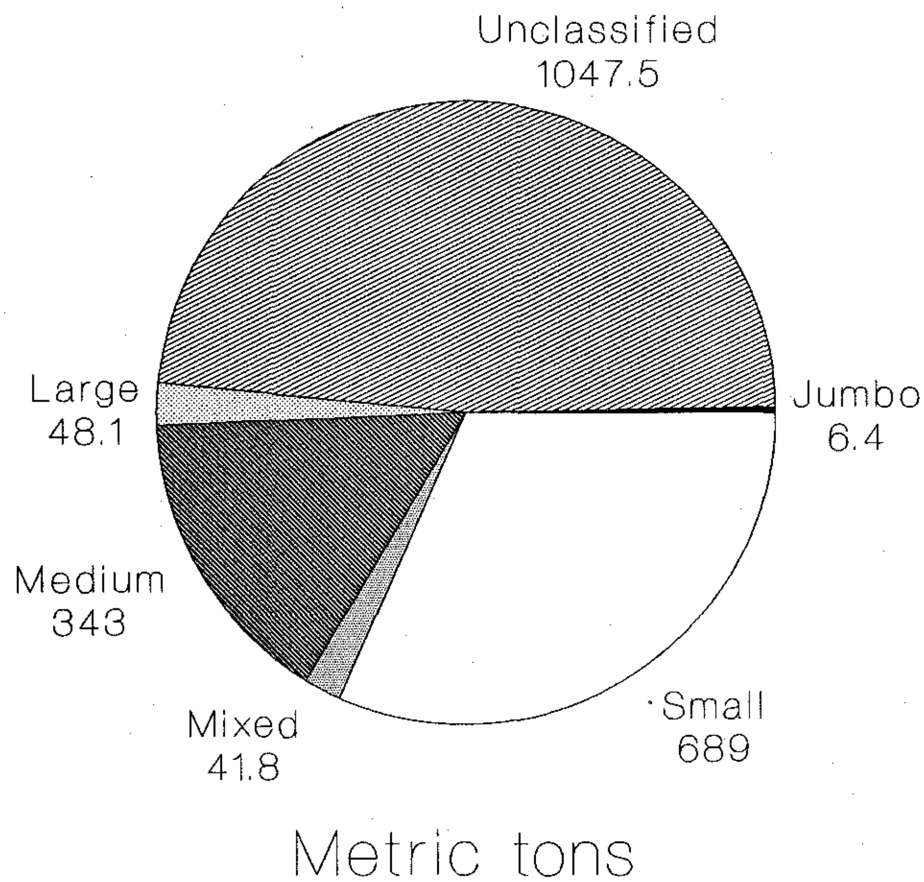
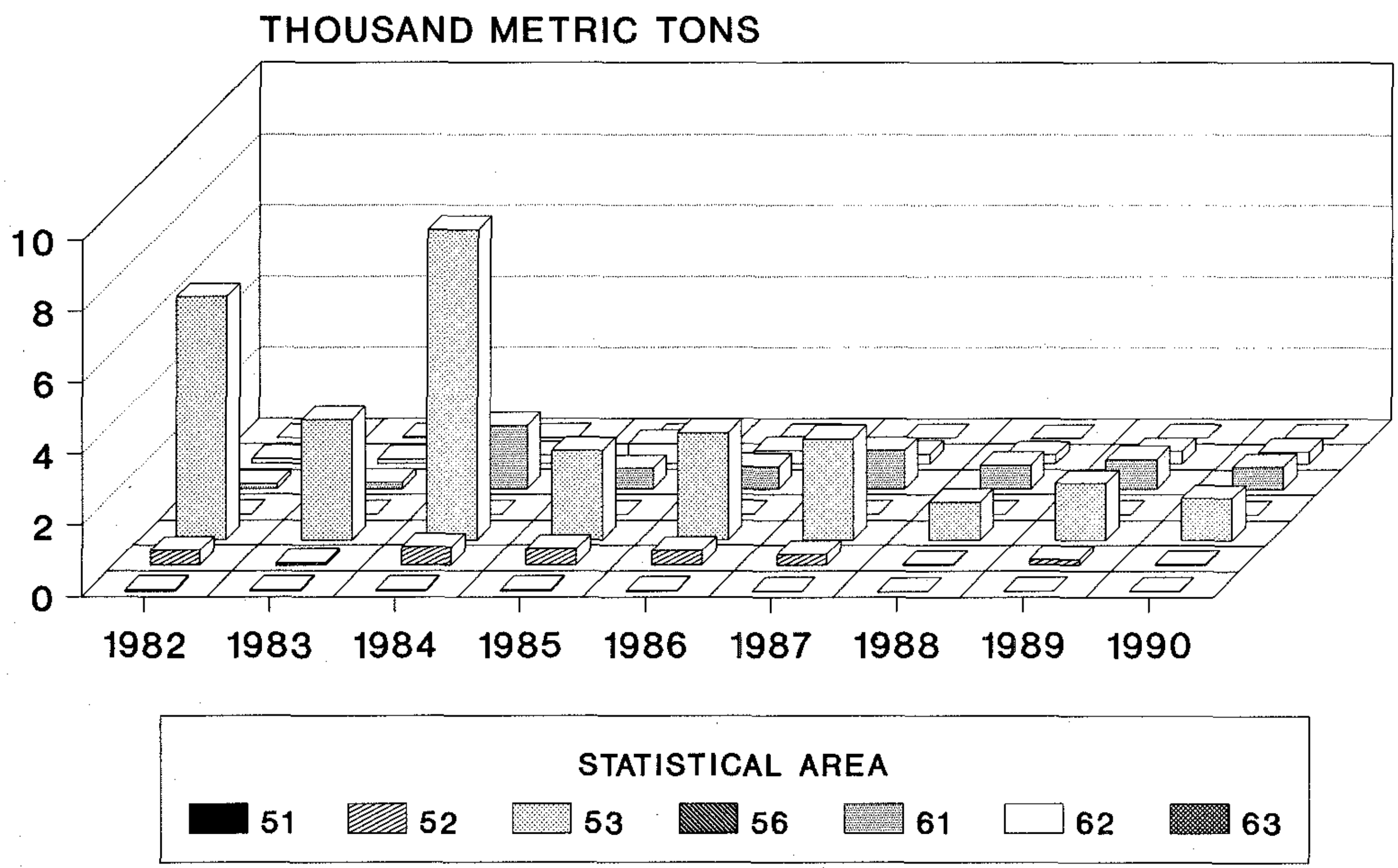


Figure 2. Domestic Butterfish Landings By Market Category in 1990



Small Category includes Landings of Super Small and Super-super Small Market Categories

Figure 3. Domestic Butterfish Landings By Area 1982-1990



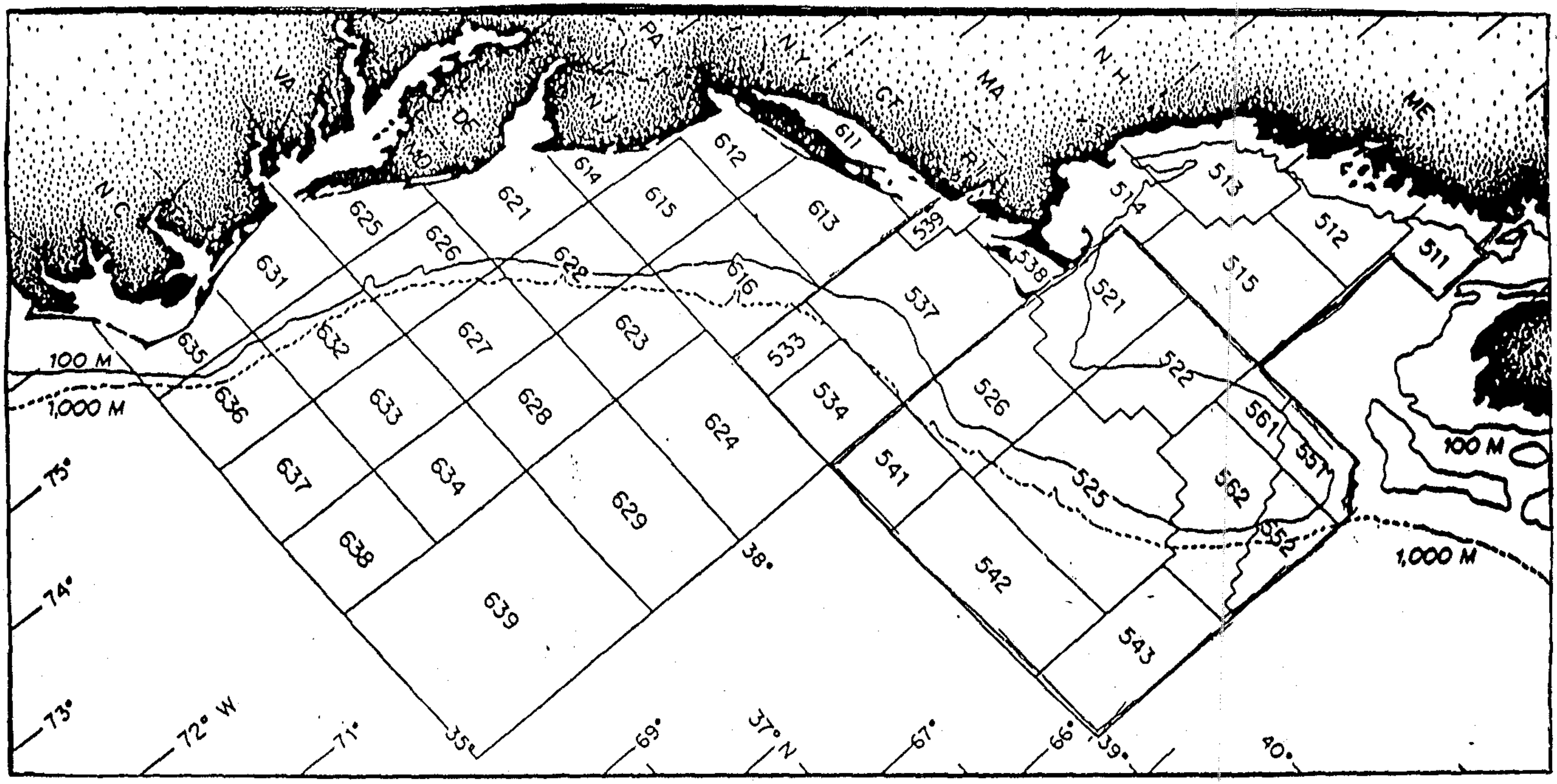


Figure 4. Statistical areas used for reporting Butterfish landings.

Table 1. Domestic and foreign landings (m.t.) of butterfish from Northwest Atlantic Fishing Organization subareas 5 and 6, 1965-1990.

Year	Domestic	Foreign	Total
1965	3,340	749	4,089
1966	2,615	3,865	6,480
1967	2,452	2,316	4,768
1968	1,804	5,437	7,241
1969	2,438	15,073	17,511
1970	1,869	9,028	10,897
1971	1,570	6,238	7,853
1972	819	5,671	6,490
1973	1,557	17,847	19,454
1974	2,528	10,337	12,865
1975	2,088	9,077	11,165
1976	1,528	10,353	11,881
1977	1,448	3,205	4,653
1978	3,676	1,326	5,002
1979	2,831	840	3,671
1980	5,356	879	6,235
1981	4,855	936	5,791
1982	9,060	631	9,691
1983	4,905	630	5,535
1984	11,972	429	12,401
1985	4,739	804	5,543
1986	4,418	164	4,582
1987	4,508	0	4,508
1988	2,083	0	2,083
1989	3,192	1	3,193
1990	2,395	3	2,398

Table 2. 1990 Butterfish landings (metric tons) by month and U.S. statistical area from NMFS weighout data

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0.0	0.0	0.0	0.0	1.2	0.0	1.9	0.0	1.6	1.0	0.0	0.0	5.8
52	8.3	1.4	0.0	0.4	6.2	4.5	3.5	0.8	0.8	0.4	0.6	0.9	27.7
53	270.8	85.3	46.1	23.6	41.3	60.8	29.3	119.7	194.0	136.7	67.4	88.4	1163.5
56	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
61	169.1	116.6	47.8	13.4	14.5	16.6	11.0	18.1	59.6	104.3	28.3	25.9	625.3
62	60.2	18.8	74.4	5.7	8.6	9.7	2.0	16.1	36.8	44.3	54.2	10.8	341.5
63	2.4	0.5	0.2	0.0	0.1	0.0	0.0	0.0	0.1	0.3	4.8	3.6	12.0
TOTALS	510.8	222.6	168.5	43.0	72.2	91.6	47.8	154.8	292.9	287.0	155.3	129.5	2176.0

1990 Butterfish landings (metric tons) by NAFO subarea from Joint Venture and general canvas data

SUBAREA	LANDINGS
5	1.8
6	217.7
TOTALS	219.5

Table 3. Catch per unit effort (metric tons/day fished) from the directed[1] butterfish fishery, 1982-1990.

Year	CPUE	Directed trips
1982	19.86	608
1983	13.24	351
1984	24.92	802
1985	15.17	301
1986	16.47	189
1987	17.69	278
1988	5.15	87
1989	7.09	151
1990	7.07	85
Average	14.07	317

[1]Directed effort is defined as trips by vessels over 5 G.R.T. that land over 50% butterfish

Table 4. Butterfish abundance indices derived from NEFC autumn bottom trawl survey data. Indices are stratified mean number and mean weight (kg.) of Butterfish per tow.

Stratified mean number per tow at age

Year	Age 0	1	2	3	4	Total	Age 1+	Mean weight (kg)
1968	41.28	50.59	1.64	0.10	0	93.61	52.3	7.7
1969	39.48	18.82	2.12	0.16	0	60.58	21.1	3.9
1970	26.43	11.24	0.86	0.10	0	38.63	12.2	2.3
1971	208.85	8.76	0.70	0.24	0	218.55	9.6	4.3
1972	73.20	8.34	0.31	0.05	0	81.90	8.7	2.7
1973	119.10	27.73	1.50	0.07	0	148.40	29.3	6.1
1974	82.13	15.96	1.74	0.37	0	100.20	18.0	3.8
1975	26.34	17.54	1.71	0.15	0	45.74	19.4	2.3
1976	110.63	26.50	2.12	0.33	0	139.58	29.0	5.8
1977	47.73	32.78	6.22	0.24	0	86.97	39.3	5.2
1978	134.96	7.96	10.18	1.05	0	154.15	19.2	4.3
1979	231.51	73.01	4.85	0.18	0	309.55	78.1	12.1
1980	233.19	80.42	18.82	0.73	0.04	333.20	100.0	15.2
1981	234.55	47.14	12.88	0.29	0.01	294.87	60.3	7.0
1982	80.31	26.12	4.73	0.14	0.14	111.44	30.7	4.7
1983	358.77	78.49	10.70	3.25	0.07	451.28	92.5	12.8
1984	268.60	79.55	11.07	2.79	0	362.01	93.4	11.4
1985	286.26	85.69	12.40	2.27	0.09	386.71	100.4	15.2
1986	140.16	29.75	12.19	1.96	0.33	184.39	44.3	6.8
1987	78.59	31.55	7.17	0.25	0	117.56	39.0	4.7
1988	282.28	21.59	13.29	0.20	0	317.36	35.1	7.3
1989	332.31	49.95	15.05	1.03	0	398.34	66.0	12.2
1990	328.29	33.35	3.89	0.95	0	366.57	38.3	8.9
Mean	163.69	37.51	6.79	0.73	0.03	208.76	45.1	7.2

Table 5. Total mortality rates (Z) for butterfish derived from NEFC fall survey abundance indices (Table 3), 1968-1990.

	AGE			
Year	0/1	1/2	2/ 3	3/4
1968/69	.78	3.17	2.33	-
1969/70	1.26	3.09	3.05	-
1970/71	1.10	2.78	1.28	-
1971/72	3.22	3.34	2.64	-
1972/73	.97	1.72	1.49	-
1973/74	2.01	2.77	1.40	-
1974/75	1.54	2.23	2.45	-
1975/76	.01	2.11	1.65	-
1976/77	1.22	1.45	2.18	-
1977/78	1.79	1.17	1.78	-
1978/79	.61	.50	4.03	-
1979/80	1.06	1.36	1.88	1.50
1980/81	1.60	1.83	4.17	4.29
1981/82	2.20	2.30	4.52	.73
1982/83	.02	.89	.38	.69
1983/84	1.51	1.96	1.34	-
1984/85	1.14	1.86	1.58	3.43
1985/86	2.26	1.95	1.84	1.93
1986/87	1.49	1.42	3.89	-
1987/88	1.29	0.86	3.57	-
1988/89	1.73	0.36	2.55	-
1989/90	2.30	2.55	2.76	-
68/77 MEAN	1.39	2.38	2.03	
78/90 MEAN	1.43	1.49	2.71	

Papers of the Northeast Regional
Stock Assessment Workshops

Stock Assessment of the Northwest Atlantic Mackerel Stock

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Appendix to CRD-91-03

SAW 12

Spring 1991

Research Document SAW12/5

SAW/12/SARC/1

I. Introduction

A. Stock Definition

Atlantic mackerel, (Scomber scombrus), is a fast swimming, pelagic schooling species distributed in the Northwest Atlantic between Labrador and North Carolina. There are two major spawning components of this population, a southern group, that spawns primarily in the Mid-Atlantic Bight during April and May, and a northern group that spawns in the Gulf of St. Lawrence in June and July. Both groups winter between Sable Island (off Nova Scotia) and Cape Hatteras in waters generally warmer than 7°C, with extensive northerly (spring) and southerly (Autumn) to and from spawning and summering grounds.

B. History of the Fishery

Mackerel are subjected to seasonal fisheries, both commercial and recreational, throughout most of their distributional range. US commercial catches have occurred mainly between January and May in southern waters and between May and December in coastal Gulf of Maine waters. US recreational catches occur mainly between April and October in areas of seasonal occurrence. Catches in Canadian waters off Nova Scotia and Newfoundland have typically been between May and November. Catches by other countries, principally during the intensive fishery conducted between 1968-77, occurred during December and April from Georges Bank to Cape Hatteras.

C. Management

Mackerel in the Northwest Atlantic were managed by nationally allocated catch quotas between 1973-77 by ICNAF. Since implementation of the MFCMA on March 1, 1977, mackerel in US waters have been managed by the NMFS, initially under a PMP and since February 1980 under the Mid-Atlantic Fishery Management Council's Squid, Mackerel, Butterfish FMP. Management is based on allowable biological catch (ABC) limits obtained from projections of $F_{0.1}$ catch, and maintenance of a minimum spawning stock biomass at 600,000 mt.

D. Recent Fishery

Mackerel landings increased beginning in the late 1960s, and peaked at 436,000 mt in 1973 (Table 1). Landings declined steadily to about 28,000 mt in 1978, increased gradually to roughly 83,000 mt in 1988 and declined to about 61,000 mt in 1990 (Table 1).

II. Data Sources

A. Commercial Landings

U.S. Commercial landings data were obtained from the NMFS weighout data base, and the NMFS Foreign Fishery Observer Program (Anderson 1984; Overholtz and Parry 1985: NEFC 1987) (Table 1). Data for the Canadian component of landings were obtained from Department of Fisheries and Oceans, Canada.

B. Recreational landings

Recreational landings information were obtained from catch interview sampling records from the NMFS National Marine Recreational Fishery Statistics Survey. Data from all waves that contained mackerel were used to estimate total annual recreational catch. The method used was a summation of A and B1 components from the survey to obtain estimated weight landed for 1979-90.

C. Catch-at-age

U.S. catch-at-age data for 1988-90 were obtained by applying sample length frequency data, usually on a month-country basis, to landings data to produce estimates of catch-at-length. Seasonal age data were applied to these estimates to obtain catch-at age by country (Table 2). Previous assessment data were used for the earlier years of the analysis (Anderson 1984; Overholtz and Parry 1985; NEFC 1987). Recreational length samples were applied to recreational catch data when available, mainly for 1988-90. Canadian catch-at-age data were obtained from Department of Fisheries and Oceans, Canada. Mean weight-at-age data were obtained from a length weight equation utilizing data from the catch-at-age analysis for 1988-90 and other sources for previous years (Anderson 1984; Overholtz and Parry 1985; NEFC 1987) (Table 3).

D. Research Survey Data

Mean catch per tow data (weight and number)were obtained from NEFC spring research surveys for 1968-90 (Table 4). Data were transformed and smoothed to stabilize variation due to the highly patchy distribution of mackerel. Catch per tow-at-age data were calculated for 1968-90 for use as a tuning index in Adapt runs (Table 5).

III. Analysis

A. ADAPT Run

Catch-at-age data from commercial and research sources were used in ADAPT runs to estimate fishing mortality and stock size for 1962-90. A final ADAPT run was chosen to represent the current assessment (Table 6).

B. Partial Recruitment

A Separable VPA run was performed and these results were compared with partial recruitment from the ADAPT run. The PR vector from the ADAPT run was judged to be most useful and was used in subsequent analyses.

C. Yield per Recruit

Available data (Table 7) were used in a Y/R analysis to estimate fishing mortality reference points for the Northwest Atlantic mackerel stock. Reference levels of F were $F_{0.1}$=0.27, F_{med}=0.25, and F_{max}=0.96.

D. Fishing Mortality

Fishing mortality ranged between 0.1 and 0.8 without a trend in the 1960s, increased in the early 1970s to a peak for that decade of 0.4 in 1973, and declined steadily until 1980 when it reached a low of 0.04. F remained relatively low throughout the 1980s and reached a series low of 0.02 in 1990 (Table 8).

E. Stock Numbers, Biomass, and Recruitment

Stock size increased in the 1980s due to the recruitment of several large (1982,1987,1988) and moderately large (1981,1984,1985,1986,1989) year classes during this decade (Table 9; Figure 1). Stock biomass increased steadily during the 1980s, peaking at roughly 3.0 million mt in 1990 (Table 10).

F. Stock Projections

Stock projections based on a geometric mean recruitment (1980-89) and geometric mean PR vector (1985-89) were performed for 1992-93. Projections were based on a status quo F of 0.02 in 1991-92 or $F_{0.1}$ for 1992, and mean recruitment, + and -, 1 standard deviation. Results suggest that if current F is maintained landings will range from 40,000 - 100,000 mt and SSB from 2.7-3.7 million mt (Table 11). At a reference level equal to $F_{0.1}$, landings would range from 579,000 - 611,000 mt and SSB from 1.9 - 2.1 million mt (Table 11).

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Table 1. Mackerel catches and landings (mt) from NAFO SA 2-6 for 1960-1990.

Year	USA Commercial	USA Recreational	Canada	Other Countries	Commercial Total	Grand Total
1960	1396	2478	5957	0	7353	9831
1961	1361	-	5459	11	6831	6831
1962	938	-	6865	175	7978	7978
1963	1320	-	6473	1299	9092	9092
1964	1644	-	10960	801	13405	13405
1965	1998	4292	11590	2945	16533	20825
1966	2724	-	12821	7951	23496	23496
1967	3891	-	11243	19047	34181	34181
1968	3929	-	20819	65747	90495	90495
1969	4364	-	17364	114189	135917	135917
1970	4049	16039	19959	210864	234872	250911
1971	2406	-	24496	355892	382794	382794
1972	2006	-	22360	391464	415830	415830
1973	1336	-	38514	396759	436609	436609
1974	1042	-	44655	321837	367534	367534
1975	1974	5190	36258	271719	309951	315141
1976	2712	-	33065	223275	259052	259052
1977	1377	-	22765	56067	80209	80209
1978	1605	-	25899	841	28345	28345
1979	1990	3588	30612	440	33042	36630
1980	2683	2364	22296	566	25545	27909
1981	2941	8505	19355	5361	27657	36162
1982	3330	1162	16383	6647	26360	27522
1983	3805	3280	19806	5955	29566	32846
1984	5954	2618	18233	15045	39232	41850
1985	6632	3287	30906	32409	69947	73234
1986	9637	3943	31097	25355	66089	70032
1987	12310	5567	22173	35094	69577	75144
1988	12309	4204	23288	42858	78455	82659
1989	14556	2251	18659	36823	70038	72289
1990	31261	2000	18200	9126	58587	60587
1991[1]	24164	2000	18000	5349	47513	49513

1 preliminary

Table 2. Mackerel commercial and recreational catch at age (millions of fish) from NAFO SA 2-6 during 1962-90[1].

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total	Mean age
1962	-	16.1	2.8	15.2	3.8	1.2	1.6	1.4	0.8	0.4	0.1	0.3	-	-	-	43.7	2.8
1963	-	1.1	4.2	1.3	26.3	6.0	0.3	0.2	0.2	0.2	0.1	0.1	-	-	-	40.0	4.1
1964	-	12.9	7.0	4.1	4.0	19.4	4.1	3.9	0.7	0.8	0.2	-	-	-	-	57.1	3.8
1965	-	9.0	3.6	2.9	4.0	5.2	19.5	4.2	4.0	0.7	-	-	-	-	-	53.1	4.7
1966	-	24.0	11.5	5.3	2.6	4.7	7.9	21.8	0.5	0.2	-	-	-	-	-	78.5	3.9
1967	1.8	0.8	26.7	19.8	3.5	3.3	5.1	6.1	32.3	0.3	-	-	-	-	-	99.7	4.8
1968	1.1	141.4	61.5	59.3	38.1	14.3	6.6	0.7	1.0	6.1	0.1	-	-	-	-	330.2	2.3
1969	4.0	7.1	262.1	160.7	65.8	5.7	3.0	2.0	3.1	2.2	8.3	-	-	-	-	524.0	2.8
1970	4.8	193.5	54.5	522.1	162.9	27.6	7.0	5.3	9.9	10.0	3.8	2.8	-	-	-	1,004.2	3.0
1971	2.4	74.6	294.2	127.4	558.9	203.5	34.6	8.9	3.6	4.3	8.1	7.2	-	-	-	1,327.7	3.6
1972	3.6	22.1	85.7	256.2	182.6	390.4	87.3	24.0	4.2	8.2	3.8	5.6	-	-	-	1,073.7	4.2
1973	4.0	161.8	283.2	285.1	233.6	192.4	197.2	31.2	11.0	4.1	3.8	1.6	-	-	-	1,409.0	3.6
1974	2.0	95.9	242.2	264.4	101.5	114.3	111.8	108.3	25.7	6.4	2.5	0.8	-	-	-	1,075.8	3.8
1975	3.7	373.7	431.4	113.7	100.8	58.6	67.8	51.9	50.5	12.5	2.3	1.0	-	-	-	1,267.9	2.8
1976	-	12.5	353.5	272.5	85.7	52.4	27.3	40.5	34.6	22.6	13.4	1.4	-	-	-	916.4	3.5
1977	-	2.0	27.0	101.0	54.0	12.0	9.9	5.6	6.3	3.8	3.6	0.3	0.3	-	-	225.8	3.8
1978	-	0.1	0.2	4.7	17.4	13.3	8.4	4.7	2.2	4.5	1.5	4.6	0.6	0.6	-	62.8	5.9
1979	-	0.4	0.6	1.3	7.1	18.6	13.1	6.2	2.6	2.2	2.3	0.7	1.9	0.6	1.0	58.6	6.2
1980	-	1.2	10.9	1.0	1.0	6.9	13.8	4.7	2.0	1.0	1.0	1.6	0.5	1.3	0.8	47.7	5.6
1981	+	10.4	4.8	8.7	2.0	2.8	7.9	13.1	5.6	2.7	0.9	0.4	0.4	0.7	0.8	61.2	5.1
1982	+	3.6	9.9	2.7	8.4	1.2	2.7	4.4	8.1	2.6	1.3	0.6	0.3	0.7	1.3	47.8	5.4
1983	-	2.2	14.2	4.5	1.4	6.8	0.7	1.3	4.8	11.8	5.3	1.2	0.7	0.4	0.8	56.0	5.9
1984	-	0.5	44.0	29.7	3.4	1.2	4.7	0.6	0.6	3.4	7.8	2.9	0.9	0.6	1.6	102.0	4.1
1985	-	3.4	1.9	140.9	33.7	2.7	0.8	3.2	0.2	0.5	2.4	4.5	2.4	0.6	1.2	198.6	3.7
1986	-	1.5	12.3	6.7	93.9	23.1	1.9	0.5	3.5	0.2	0.7	1.5	2.4	0.7	0.7	149.6	4.4
1987	-	10.0	16.6	14.5	7.8	112.2	17.9	2.7	0.4	2.2	0.3	0.5	1.0	1.6	0.5	188.1	4.7
1988	-	2.5	13.7	10.6	11.9	11.0	110.2	22.3	2.6	1.2	0.9	0.7	1.1	1.1	1.8	190.8	5.7
1989	+	2.5	15.6	11.2	7.5	6.7	2.3	87.0	4.6	0.8	0.4	0.5	0.2	0.3	0.4	140.0	5.9
1990	+	3.1	22.9	33.7	9.6	8.1	4.7	0.2	52.5	2.3	0.5	0.3	0.2	0.2	0.3	138.4	5.2

1 includes estimated recreational catches for 1961-1964, 1966-1969, 1971-1974, 1976-1978.

Table 3. Commercial mean weight-at-age for Atlantic mackerel from 1962 to 1990 landings.

	age													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1962[1]	.130	.208	.289	.365	.433	.491	.541	.581	.614	.641	.662	.000	.000	.000
1963	.120	.192	.264	.334	.395	.448	.492	.529	.559	.583	.602	.000	.000	.000
1964	.116	.188	.262	.332	.395	.450	.495	.533	.564	.588	.000	.000	.000	.000
1965	.123	.200	.278	.352	.419	.477	.525	.565	.598	.000	.000	.000	.000	.000
1966	.128	.209	.294	.374	.447	.509	.562	.605	.641	.000	.000	.000	.000	.000
1967	.123	.202	.283	.360	.428	.489	.540	.581	.615	.000	.000	.000	.000	.000
1968	.148	.241	.335	.425	.506	.576	.634	.683	.722	.753	.000	.000	.000	.000
1969	.131	.214	.300	.382	.456	.520	.574	.618	.654	.683	.000	.000	.000	.000
1970	.107	.179	.253	.324	.389	.444	.491	.530	.562	.587	.608	.000	.000	.000
1971	.110	.181	.256	.327	.391	.446	.494	.532	.564	.589	.610	.000	.000	.000
1972	.123	.210	.300	.386	.464	.533	.590	.638	.677	.708	.733	.000	.000	.000
1973	.113	.189	.269	.345	.414	.473	.524	.565	.600	.628	.650	.000	.000	.000
1974	.111	.190	.273	.352	.425	.487	.541	.585	.621	.649	.673	.000	.000	.000
1975	.104	.176	.252	.326	.393	.451	.500	.540	.573	.600	.621	.000	.000	.000
1976	.097	.168	.244	.316	.382	.440	.489	.530	.563	.590	.611	.000	.000	.000
1977	.114	.198	.288	.375	.454	.524	.582	.631	.671	.703	.729	.749	.000	.000
1978	.192	.285	.425	.463	.509	.582	.625	.659	.673	.697	.717	.797	.705	.000
1979	.190	.272	.531	.567	.579	.603	.652	.714	.752	.769	.822	.809	.842	.830
1980	.146	.376	.548	.609	.617	.635	.672	.705	.781	.743	.785	.773	.775	.778
1981	.114	.315	.523	.577	.643	.660	.674	.707	.723	.756	.772	.812	.780	.801
1982	.152	.340	.541	.606	.666	.743	.737	.722	.719	.740	.790	.811	.798	.829
1983	.098	.257	.479	.593	.628	.659	.712	.709	.705	.727	.735	.752	.744	.805
1984	.098	.162	.338	.525	.625	.657	.696	.715	.705	.709	.726	.755	.775	.770
1985	.111	.260	.277	.416	.558	.644	.677	.665	.737	.717	.715	.739	.731	.782
1986	.079	.234	.349	.366	.452	.581	.640	.729	.777	.750	.738	.717	.776	.781
1987	.107	.210	.316	.404	.411	.505	.502	.706	.747	.680	.750	.736	.781	.775
1988	.100	.222	.343	.408	.453	.484	.584	.694	.755	.815	.762	.775	.790	.761
1989	.100	.231	.375	.414	.474	.509	.529	.631	.753	.803	.816	.825	.801	.893
1990	.104	.206	.332	.450	.477	.528	.625	.572	.659	.718	.828	.806	.808	.853

1. Data for 1962-1983 are from Anderson (1984).

Table 4. Mackerel stratified mean wt and number per tow from NEFC spring research surveys for stratas 1-25 and 61-76 for 1968-1990 for standard and log transformed data. Smoothed values were obtained from a IMA model.

	STANDARD		SMOOTHED		LOG		SMOOTHED	
YEAR	WT	NUMBER	WT	NUMBER	WT	NUMBER	WT	NUMBER
68	5.609	70.869	1.147	10.016	1.669	15.253	0.413	2.289
69	0.055	0.484	0.935	5.944	0.031	0.178	0.345	1.601
70	2.200	9.356	1.098	6.886	0.871	2.528	0.393	1.694
71	3.145	12.668	1.179	7.350	0.887	2.773	0.404	1.662
72	1.542	8.490	1.116	6.786	0.603	2.260	0.375	1.480
73	6.746	20.973	1.013	5.902	0.382	1.199	0.328	1.218
74	0.656	2.241	0.720	3.661	0.335	1.129	0.281	1.004
75	0.242	3.540	0.519	2.588	0.167	0.986	0.235	0.811
76	0.254	1.800	0.412	1.683	0.141	0.541	0.206	0.630
77	0.081	0.287	0.348	1.075	0.071	0.195	0.189	0.505
78	0.345	0.970	0.354	0.976	0.193	0.429	0.197	0.483
79	0.089	0.172	0.362	0.888	0.080	0.146	0.205	0.473
80	0.202	0.559	0.444	1.251	0.140	0.310	0.242	0.578
81	2.470	5.872	0.602	2.187	0.744	1.565	0.306	0.794
82	0.854	5.167	0.678	2.936	0.359	0.998	0.345	0.960
83	0.135	0.884	0.743	3.386	0.112	0.551	0.387	1.153
84	2.611	16.228	1.015	5.588	0.883	2.463	0.510	1.591
85	2.232	8.242	1.227	6.939	0.924	2.685	0.626	2.021
86	1.264	4.178	1.482	8.231	0.443	1.196	0.730	2.434
87	7.492	35.231	1.828	11.699	3.208	11.531	0.909	3.351
88	4.133	16.792	1.881	12.392	2.056	5.560	0.961	3.655
89	1.100	12.273	1.749	12.104	0.668	3.841	0.922	3.684
90[1]	1.548	10.748	1.723	11.780	0.824	3.645		

1 preliminary

Table 5. Catch per tow at age (NUMBERS) for Atlantic mackerel from Spring groundfish surveys for stratas 1-25, 61-76 for 1968-1990. Values are log retransformed.

	AGE													
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14
68	12.9400	0.4150	0.1894	0.0523	0.0164	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
69	0.0297	0.1418	0.0167	0.0058	0.0003	0.0007	0.0005	0.0009	0.0004	0.0004	0.0000	0.0000	0.0000	0.0000
70	0.2795	0.1845	1.3910	0.6115	0.1812	0.0617	0.0549	0.0877	0.0827	0.0447	0.0026	0.0000	0.0000	0.0000
71	0.3282	0.9409	0.4383	1.1250	0.3929	0.0621	0.0141	0.0073	0.0062	0.0048	0.0035	0.0000	0.0000	0.0000
72	0.8719	0.3077	0.5929	0.2261	0.3254	0.0583	0.0112	0.0011	0.0018	0.0004	0.0000	0.0000	0.0000	0.0000
73	0.3514	0.3398	0.1758	0.2338	0.1262	0.2846	0.1821	0.1524	0.0460	0.0367	0.0033	0.0291	0.0181	0.0150
74	0.3478	0.1796	0.2358	0.0478	0.0985	0.0599	0.2084	0.0912	0.0590	0.0117	0.0115	0.0000	0.0000	0.0000
75	0.6544	0.2298	0.0409	0.0226	0.0064	0.0073	0.0043	0.0039	0.0034	0.0000	0.0000	0.0000	0.0000	0.0000
76	0.0959	0.3871	0.0710	0.0135	0.0024	0.0006	0.0028	0.0004	0.0019	0.0003	0.0003	0.0000	0.0000	0.0000
77	0.0095	0.0472	0.0850	0.0453	0.0154	0.0052	0.0028	0.0070	0.0038	0.0054	0.0010	0.0075	0.0000	0.0000
78	0.0502	0.1097	0.1032	0.1943	0.0958	0.0284	0.0110	0.0027	0.0148	0.0000	0.0164	0.0000	0.0013	0.0000
79	0.0105	0.0037	0.0072	0.0126	0.0495	0.0144	0.0103	0.0057	0.0057	0.0190	0.0042	0.0156	0.0030	0.0064
80	0.0234	0.1877	0.0066	0.0048	0.0233	0.0489	0.0110	0.0107	0.0070	0.0017	0.0096	0.0000	0.0107	0.0064
81	0.3355	0.1371	0.4294	0.0476	0.0463	0.1613	0.4041	0.2302	0.1385	0.0704	0.0673	0.0844	0.0769	0.1031
82	0.4323	0.1950	0.0215	0.0979	0.0182	0.0102	0.0245	0.0965	0.0440	0.0266	0.0156	0.0122	0.0200	0.0092
83	0.2357	0.2873	0.0222	0.0016	0.0036	0.0006	0.0002	0.0014	0.0022	0.0004	0.0008	0.0006	0.0002	0.0000
84	0.2598	1.8014	0.6055	0.0415	0.0050	0.0432	0.0036	0.0025	0.0161	0.0470	0.0153	0.0075	0.0041	0.0098
85	0.3382	0.0846	1.8513	0.2348	0.0277	0.0107	0.0469	0.0032	0.0097	0.0416	0.0666	0.0405	0.0119	0.0258
86	0.1301	0.4497	0.0778	0.5908	0.1177	0.0080	0.0014	0.0196	0.0004	0.0019	0.0184	0.0101	0.0054	0.0116
87	1.4842	1.7945	0.8742	0.3719	2.9450	0.4967	0.1427	0.0156	0.1383	0.0058	0.0406	0.0412	0.1202	0.0482
88	0.6336	0.4577	0.3666	0.3357	0.3748	1.7688	0.4428	0.0513	0.0478	0.0405	0.0426	0.0764	0.0519	0.0118
89	1.5826	1.6407	0.0707	0.2841	0.0087	0.0108	0.0666	0.0086	0.0050	0.0044	0.0060	0.0020	0.0029	0.0029
90	1.3003	1.3849	0.5010	0.0157	0.0129	0.0059	0.0004	0.0762	0.0094	0.0043	0.0026	0.0014	0.0045	0.0029

Table 6: ADAPT Run for Atlantic Mackerel

```
ADAPT        Run Number 96          1991 6 14 10 37 58
NORTHWEST ATL MACKEREL
MOD2

Output option selected for input parameters:  full
Output option selected for results:  full


INPUT PARAMETERS AND OPTIONS SELECTED
-------------------------------------

Natural mortality is 0.2

Oldest age (not in the plus group) is 10

For all yrs prior to the terminal year (1990), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age 10:    4 5 6 7 8 9
This method for estimating F on the oldest age is generally used
when a flat-topped partial recruitment curve is thought to be
characteristic of the stock.

F for age 11+ is then calculated from the following
ratios of F[age 11+] to F[age 10]
      1962    1.0000
      1963    1.0000
      1964    1.0000
      1965    1.0000
      1966    1.0000
      1967    1.0000
      1968    1.0000
      1969    1.0000
      1970    1.0000
      1971    1.0000
      1972    1.0000
      1973    1.0000
      1974    1.0000
      1975    1.0000
      1976    1.0000
      1977    1.0000
      1978    1.0000
      1979    1.0000
      1980    1.0000
      1981    1.0000
      1982    1.0000
      1983    1.0000
      1984    1.0000
      1985    1.0000
      1986    1.0000
      1987    1.0000
      1988    1.0000
      1989    1.0000
      1990    1.0000
Stock size of the 11+ group is then calculated
using the following method:  CATCHEQ

Partial recruitment estimate for 1990
         1    0.1244
         2    0.6219
         3    0.8781
         4    1.0000
         5    1.0000
         6    1.0000
         7    1.0000
         8    1.0000
         9    1.0000
        10    1.0000

Objective function is    SUM w*( LOG(OBS) - LOG(PRED) )**2
```

Indices normalized (by dividing by mean observed value)
before tuning to VPA stocksizes

The residuals for years prior to the terminal year are downweighted
using the following algorithm: NONE

All biomass estimates (including SSB) reflect mean stock sizes

Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 3	1.0000000E3	0.0000000E0	1.0000000E6
N 4	2.5000000E2	0.0000000E0	1.0000000E6
N 5	1.2500000E2	0.0000000E0	1.0000000E6
N 6	1.5000000E3	0.0000000E0	1.0000000E6
N 7	3.0000000E2	0.0000000E0	1.0000000E6
N 8	2.5000000E1	0.0000000E0	1.0000000E6
N 9	5.0000000E0	0.0000000E0	1.0000000E6
N10	2.0000000E1	0.0000000E0	1.0000000E6
q AGE 1	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 2	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 3	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 4	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 5	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 6	1.0000000E-2	0.0000000E0	1.0000000E0
q AGE 7	1.0000000E-2	0.0000000E0	1.0000000E0

The following indices of abundance are available:

1	AGE 1
2	AGE 2
3	AGE 3
4	AGE 4
5	AGE 5
6	AGE 6
7	AGE 7
8	AGE 8
9	AGE 9
10	AGE 10
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Indices that will be used in this run are: 1 2 3 4 5 6 7

Indices (before transformation) by index & yr; with index means

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	2795.0000	3282.0000
2 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	1845.0000	9409.0000
3 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	13910.0000	4383.0000
4 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	6115.0000	11250.0000
5 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	1812.0000	3929.0000
6 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	617.0000	621.0000
7 ■	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	-999.0000	549.0000	141.0000

■	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1 ■	8719.0000	3514.0000	3478.0000	6544.0000	959.0000	95.0000	502.0000	105.0000	234.0000	3355.0000	4323.0000
2 ■	3077.0000	3398.0000	1796.0000	2298.0000	3871.0000	472.0000	1097.0000	37.0000	1877.0000	1371.0000	1950.0000
3 ■	5929.0000	1758.0000	2358.0000	409.0000	710.0000	850.0000	1032.0000	72.0000	66.0000	4294.0000	215.0000
4 ■	2261.0000	2338.0000	478.0000	226.0000	135.0000	453.0000	1943.0000	126.0000	48.0000	476.0000	979.0000
5 ■	3254.0000	1262.0000	985.0000	64.0000	24.0000	154.0000	958.0000	495.0000	233.0000	463.0000	182.0000

6 ■	583.0000	2846.0000	599.0000	73.0000	6.0000	52.0000	284.0000	144.0000	489.0000	1613.0000	102.0000
7 ■	112.0000	1821.0000	2084.0000	43.0000	28.0000	28.0000	110.0000	103.0000	110.0000	4041.0000	245.0000

■	1983	1984	1985	1986	1987	1988	1989	1990	999999999
1 ■	2357.0000	2598.0000	3382.0000	1301.0000	14842.0000	6336.0000	15826.0000	13003.0000	4645.2381
2 ■	2873.0000	18014.0000	846.0000	4497.0000	17945.0000	4577.0000	16407.0000	13849.0000	5309.8095
3 ■	222.0000	6055.0000	18513.0000	778.0000	8742.0000	3666.0000	707.0000	5010.0000	3794.2381
4 ■	16.0000	415.0000	2348.0000	5908.0000	3719.0000	3357.0000	2841.0000	157.0000	2170.9048
5 ■	36.0000	50.0000	277.0000	1177.0000	29450.0000	3748.0000	87.0000	129.0000	2322.3333
6 ■	6.0000	432.0000	107.0000	80.0000	4967.0000	17688.0000	108.0000	59.0000	1498.8571
7 ■	2.0000	36.0000	469.0000	14.0000	1427.0000	4428.0000	666.0000	4.0000	783.8571

SUMMARY OF WEIGHTING USED IN THE OBJECTIVE FUNCTION

EXOGENOUS WEIGHTS BY INDEX AND YR (omega)

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
7 ■	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
7 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

■	1984	1985	1986	1987	1988	1989	1990
1 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
7 ■	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

DOWNWEIGHTS BY YEAR (delta)

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
■	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

■	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
■	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

INTERATIVE RE-WEIGHTS BY INDEX (chi)

■	1	2	3	4	5	6	7
■	0.1766	0.2340	0.2177	0.1307	0.0987	0.0870	0.0553

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - MOD2

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766
2 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340
3 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177
4 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307
5 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987
6 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766	0.1766
2	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340	0.2340
3	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177	0.2177
4	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307	0.1307
5	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987	0.0987
6	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870	0.0870
7	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553

CATCH AT AGE - MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	16.1	1.1	12.9	9.0	24.0	0.8	141.4	7.1	193.5	74.6	22.1	161.8	95.9	373.7	12.5	2.0	0.1
2	2.8	4.2	7.0	3.6	11.5	26.7	61.5	262.1	54.5	294.2	85.7	283.2	242.2	431.4	353.5	27.0	0.2
3	15.2	1.3	4.1	2.9	5.3	19.8	59.3	160.7	522.1	127.4	256.2	285.1	264.4	113.7	272.5	101.0	4.7
4	3.8	26.3	4.0	4.0	2.6	3.5	38.1	65.8	162.9	558.9	182.6	233.6	101.5	100.8	85.7	54.0	17.4
5	1.2	6.0	19.4	5.2	4.7	3.3	14.3	5.7	27.6	203.5	390.4	192.4	114.3	58.6	52.4	12.0	13.3
6	1.6	0.3	4.1	19.5	7.9	5.1	6.6	3.0	7.0	34.6	87.3	197.2	111.8	67.8	27.3	9.9	8.4
7	1.4	0.2	3.9	4.2	21.8	6.1	0.7	2.0	5.3	8.9	24.0	31.2	108.3	51.9	40.5	5.6	4.7
8	0.8	0.2	0.7	4.0	0.5	32.3	1.0	3.1	9.9	3.6	4.2	11.0	25.7	50.5	34.6	6.3	2.2
9	0.4	0.2	0.8	0.7	0.2	0.3	6.1	2.2	10.0	4.3	8.2	4.1	6.4	12.5	22.6	3.8	4.5
10	0.1	0.1	0.2	0.0	0.0	0.0	0.1	8.3	3.8	8.1	3.8	3.8	2.5	2.3	13.4	3.6	1.5
11	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.8	7.2	5.6	1.6	0.8	1.0	1.4	0.6	5.8
1+	43.7	40.0	57.1	53.1	78.5	97.9	329.1	520.0	999.4	1325.3	1070.1	1405.0	1073.8	1264.2	916.4	225.8	62.8

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.4	1.2	10.4	3.6	2.2	0.6	3.4	1.5	10.0	2.5	2.5	3.1
2	0.6	10.9	4.8	9.9	14.2	44.0	1.9	12.3	16.5	13.7	15.6	22.9
3	1.3	1.0	8.7	2.7	4.5	29.7	140.9	6.7	14.5	10.6	11.2	33.7
4	7.1	1.0	2.0	8.4	1.4	3.4	33.7	93.9	7.8	11.9	7.5	9.6
5	18.6	6.9	2.8	1.2	6.8	1.2	2.7	23.1	112.2	11.0	6.7	8.1
6	13.1	13.8	7.9	2.7	0.7	4.6	0.8	1.9	17.9	110.2	2.3	4.7
7	6.2	4.7	13.1	4.4	1.3	0.6	3.2	0.5	2.7	22.3	87.0	0.2
8	2.6	2.0	5.6	8.1	4.8	0.6	0.3	3.5	0.4	2.6	4.6	52.5
9	2.2	1.0	2.7	2.6	11.8	3.4	0.5	0.2	2.2	1.2	0.8	2.3
10	2.3	1.0	0.9	1.3	5.3	7.8	2.4	0.7	0.3	0.9	0.4	0.5
11	4.2	4.2	2.3	2.9	3.1	5.9	8.7	5.3	3.6	4.7	1.4	1.0
1+	58.6	47.7	61.2	47.8	56.1	101.8	198.5	149.6	188.1	191.6	140.0	138.6

CAA summary for ages 1 1 2 11 1 11

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	16	1	13	9	24	1	141	7	194	75	22	162	96	374	13	2	0	0	1	10	4	2	1
2	28	39	44	44	55	97	188	513	806	1251	1048	1243	978	891	904	224	63	58	47	51	44	54	101
1	44	40	57	53	79	98	329	520	999	1325	1070	1405	1074	1264	916	226	63	59	48	61	48	56	102

	1985	1986	1987	1988	1989	1990
1	3	1	10	3	3	3
2	195	148	178	189	138	136
1	199	150	188	192	140	139

WT AT AGE (MID-YR) (1000s MT)- MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.130	0.120	0.116	0.123	0.128	0.123	0.148	0.131	0.107	0.110	0.123	0.113	0.111	0.104	0.097	0.114	0.192	0.190	0.146	0.114
2	0.208	0.192	0.188	0.200	0.209	0.202	0.241	0.214	0.179	0.181	0.210	0.189	0.190	0.176	0.168	0.198	0.285	0.272	0.376	0.315
3	0.289	0.264	0.262	0.278	0.294	0.283	0.335	0.300	0.253	0.256	0.300	0.269	0.273	0.252	0.244	0.288	0.425	0.531	0.548	0.523
4	0.365	0.334	0.332	0.352	0.374	0.360	0.425	0.382	0.324	0.327	0.386	0.345	0.352	0.326	0.316	0.375	0.463	0.567	0.609	0.577
5	0.433	0.395	0.395	0.419	0.447	0.428	0.506	0.456	0.389	0.391	0.464	0.414	0.425	0.393	0.382	0.454	0.509	0.579	0.617	0.643
6	0.491	0.448	0.450	0.477	0.509	0.489	0.576	0.520	0.444	0.446	0.533	0.473	0.487	0.451	0.440	0.524	0.582	0.603	0.635	0.660
7	0.541	0.492	0.495	0.525	0.562	0.540	0.634	0.574	0.491	0.494	0.590	0.524	0.541	0.500	0.489	0.582	0.625	0.652	0.672	0.674
8	0.581	0.529	0.533	0.565	0.605	0.581	0.683	0.618	0.530	0.532	0.638	0.565	0.585	0.540	0.530	0.631	0.659	0.714	0.705	0.707
9	0.614	0.559	0.564	0.598	0.641	0.615	0.722	0.654	0.562	0.564	0.677	0.600	0.621	0.573	0.563	0.671	0.673	0.752	0.781	0.723

10	0.641	0.583	0.588	0.580	0.580	0.580	0.753	0.683	0.587	0.589	0.708	0.628	0.649	0.600	0.590	0.703	0.697	0.769	0.743	0.756
11	0.663	0.608	0.750	0.750	0.750	0.750	0.750	0.750	0.608	0.610	0.733	0.650	0.673	0.622	0.611	0.739	0.724	0.821	0.779	0.791

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.152	0.098	0.098	0.111	0.079	0.107	0.100	0.100	0.104
2	0.340	0.257	0.162	0.260	0.234	0.210	0.222	0.231	0.206
3	0.541	0.479	0.338	0.277	0.349	0.316	0.343	0.375	0.332
4	0.606	0.593	0.525	0.416	0.366	0.404	0.408	0.414	0.450
5	0.666	0.628	0.625	0.558	0.452	0.411	0.453	0.474	0.477
6	0.743	0.659	0.657	0.644	0.581	0.505	0.484	0.509	0.528
7	0.737	0.712	0.696	0.677	0.640	0.502	0.584	0.529	0.625
8	0.722	0.709	0.715	0.665	0.729	0.706	0.694	0.631	0.572
9	0.719	0.705	0.705	0.737	0.777	0.747	0.755	0.753	0.659
10	0.740	0.727	0.709	0.717	0.750	0.680	0.815	0.803	0.718
11	0.812	0.758	0.747	0.732	0.739	0.763	0.771	0.836	0.827

WT AT AGE (JAN 1) (1000s MT)- MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.107	0.096	0.088	0.094	0.102	0.088	0.123	0.112	0.082	0.080	0.099	0.087	0.088	0.082	0.068	0.072	0.161	0.135	0.099	0.066
2	0.185	0.158	0.150	0.152	0.160	0.161	0.172	0.178	0.153	0.139	0.152	0.152	0.147	0.140	0.132	0.139	0.180	0.229	0.267	0.214
3	0.269	0.234	0.224	0.229	0.242	0.243	0.260	0.269	0.233	0.214	0.233	0.238	0.227	0.219	0.207	0.220	0.290	0.389	0.386	0.443
4	0.351	0.311	0.296	0.304	0.322	0.325	0.347	0.358	0.312	0.288	0.314	0.322	0.308	0.298	0.282	0.302	0.365	0.491	0.569	0.562
5	0.426	0.380	0.363	0.373	0.397	0.400	0.427	0.440	0.385	0.356	0.390	0.400	0.383	0.372	0.353	0.379	0.437	0.518	0.591	0.626
6	0.491	0.440	0.422	0.434	0.462	0.468	0.497	0.513	0.450	0.417	0.457	0.468	0.449	0.438	0.416	0.447	0.514	0.554	0.606	0.638
7	0.547	0.491	0.471	0.486	0.518	0.524	0.557	0.575	0.505	0.468	0.513	0.528	0.506	0.493	0.470	0.506	0.572	0.616	0.637	0.654
8	0.592	0.535	0.512	0.529	0.564	0.571	0.607	0.626	0.552	0.511	0.561	0.577	0.554	0.540	0.515	0.555	0.619	0.668	0.678	0.689
9	0.630	0.570	0.546	0.565	0.602	0.610	0.648	0.668	0.589	0.547	0.600	0.619	0.592	0.579	0.551	0.596	0.652	0.704	0.747	0.714
10	0.627	0.598	0.573	0.572	0.589	0.610	0.681	0.702	0.620	0.575	0.632	0.652	0.624	0.610	0.581	0.629	0.684	0.719	0.747	0.768
11	0.663	0.608	0.750	0.750	0.750	0.750	0.750	0.750	0.608	0.610	0.733	0.650	0.673	0.622	0.611	0.739	0.724	0.821	0.779	0.791

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.117	0.076	0.060	0.076	0.048	0.074	0.066	0.070	0.075	0.087
2	0.197	0.198	0.126	0.160	0.161	0.129	0.154	0.152	0.144	0.144
3	0.413	0.404	0.295	0.212	0.301	0.272	0.268	0.289	0.277	0.296
4	0.563	0.566	0.501	0.375	0.318	0.375	0.359	0.377	0.411	0.398
5	0.620	0.617	0.609	0.541	0.434	0.388	0.428	0.440	0.444	0.493
6	0.691	0.662	0.642	0.634	0.569	0.478	0.446	0.480	0.500	0.512
7	0.697	0.727	0.677	0.667	0.642	0.540	0.543	0.506	0.564	0.557
8	0.698	0.723	0.713	0.680	0.703	0.672	0.590	0.607	0.550	0.693
9	0.713	0.713	0.707	0.726	0.719	0.738	0.730	0.723	0.645	0.595
10	0.731	0.723	0.707	0.711	0.743	0.727	0.780	0.779	0.735	0.673
11	0.812	0.758	0.747	0.732	0.739	0.763	0.771	0.836	0.827	0.827

PERCENT MATURE (females) - MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	1986	1987	1988	1989	1990
1	0	0	0	0	0
2	50	50	50	50	50
3	100	100	100	100	100
4	100	100	100	100	100
5	100	100	100	100	100
6	100	100	100	100	100
7	100	100	100	100	100
8	100	100	100	100	100

9	100	100	100	100	100
10	100	100	100	100	100
11	100	100	100	100	100

SEX RATIO (Percent Female) - MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
6	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
9	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
10	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
11	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

	1986	1987	1988	1989	1990
1	50	50	50	50	50
2	50	50	50	50	50
3	50	50	50	50	50
4	50	50	50	50	50
5	50	50	50	50	50
6	50	50	50	50	50
7	50	50	50	50	50
8	50	50	50	50	50
9	50	50	50	50	50
10	50	50	50	50	50
11	50	50	50	50	50

RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES	26.543943
ORTHOGONALITY OFFSET.........	0.001153
MEAN SQUARE RESIDUALS	0.201090

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 3	3.27636E3	2.44942E3	1.33761E0	0.75
N 4	1.72224E3	1.07120E3	1.60777E0	0.62
N 5	3.94879E2	2.28922E2	1.72495E0	0.58
N 6	5.22263E2	2.82967E2	1.84567E0	0.54
N 7	3.44715E2	1.86062E2	1.85269E0	0.54
N 8	1.14902E2	6.29760E1	1.82454E0	0.55
N 9	7.10585E2	3.96757E2	1.79098E0	0.56
N10	1.73273E2	1.02496E2	1.69054E0	0.59
q AGE 1	6.39123E-4	1.94227E-4	3.29060E0	0.30
q AGE 2	8.19745E-4	2.25175E-4	3.64048E0	0.27
q AGE 3	8.72619E-4	2.44412E-4	3.57029E0	0.28
q AGE 4	1.18481E-3	3.92185E-4	3.02104E0	0.33
q AGE 5	9.32819E-4	3.43566E-4	2.71511E0	0.37
q AGE 6	1.31787E-3	5.13363E-4	2.56713E0	0.39
q AGE 7	2.40766E-3	1.12482E-3	2.14048E0	0.47

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.11	0.12	0.12	0.13	0.12	0.19	0.16	-0.27	-0.29	-0.16	-0.14	-0.13	-0.12	-0.11
0.11	1.00	0.14	0.15	0.16	0.15	0.23	0.20	-0.28	-0.30	-0.29	-0.17	-0.16	-0.15	-0.13
0.12	0.14	1.00	0.15	0.17	0.17	0.21	0.21	-0.30	-0.31	-0.30	-0.26	-0.18	-0.17	-0.15
0.12	0.15	0.15	1.00	0.16	0.18	0.23	0.23	-0.31	-0.32	-0.32	-0.28	-0.25	-0.19	-0.17
0.13	0.16	0.17	0.16	1.00	0.19	0.25	0.25	-0.32	-0.34	-0.34	-0.30	-0.27	-0.27	-0.19
0.12	0.15	0.17	0.18	0.19	1.00	0.28	0.25	-0.31	-0.33	-0.33	-0.28	-0.26	-0.26	-0.22
0.19	0.23	0.21	0.23	0.25	0.28	1.00	0.29	-0.49	-0.51	-0.51	-0.45	-0.43	-0.43	-0.38
0.16	0.20	0.21	0.23	0.25	0.25	0.29	1.00	-0.40	-0.43	-0.43	-0.38	-0.36	-0.36	-0.31
-0.27	-0.28	-0.30	-0.31	-0.32	-0.31	-0.49	-0.40	1.00	0.43	0.41	0.35	0.32	0.31	0.27

-0.29	-0.30	-0.31	-0.32	-0.34	-0.33	-0.51	-0.43	0.43	1.00	0.44	0.37	0.34	0.33	0.28
-0.16	-0.29	-0.30	-0.32	-0.34	-0.33	-0.51	-0.43	0.41	0.44	1.00	0.37	0.34	0.33	0.28
-0.14	-0.17	-0.26	-0.28	-0.30	-0.28	-0.45	-0.38	0.35	0.37	0.37	1.00	0.30	0.29	0.25
-0.13	-0.16	-0.18	-0.25	-0.27	-0.26	-0.43	-0.36	0.32	0.34	0.34	0.30	1.00	0.27	0.23
-0.12	-0.15	-0.17	-0.19	-0.27	-0.26	-0.43	-0.36	0.31	0.33	0.33	0.29	0.27	1.00	0.23
-0.11	-0.13	-0.15	-0.17	-0.19	-0.22	-0.38	-0.31	0.27	0.28	0.28	0.25	0.23	0.23	1.00

SUMMMARY OF RESIDUALS

Index 1 AGE 1
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	-0.5080	0.3442	0.4203	-0.3582	-0.7987	2208
1971	-0.3474	-0.2747	0.4203	-0.0305	-0.0681	1189
1972	0.6297	-0.2381	0.4203	0.3647	0.8133	1233
1973	-0.2791	-0.4834	0.4203	0.0859	0.1915	965
1974	-0.2894	0.0914	0.4203	-0.1601	-0.3569	1714
1975	0.3427	0.2640	0.4203	0.0331	0.0738	2037
1976	-1.5777	-1.2692	0.4203	-0.1297	-0.2892	440
1977	-3.8897	-2.4659	0.4203	-0.5984	-1.3345	133
1978	-2.2250	-3.4724	0.4203	0.5243	1.1691	49
1979	-3.7896	-2.0794	0.4203	-0.7188	-1.6029	196
1980	-2.9883	-2.8805	0.4203	-0.0453	-0.1010	88
1981	-0.3254	-2.0051	0.4203	0.7059	1.5743	211
1982	-0.0719	-0.2010	0.4203	0.0543	0.1210	1280
1983	-0.6785	1.0956	0.4203	-0.7456	-1.6626	4680
1984	-0.5811	-1.1803	0.4203	0.2518	0.5616	481
1985	-0.3174	-0.3297	0.4203	0.0052	0.0115	1125
1986	-1.2727	-0.1437	0.4203	-0.4745	-1.0582	1355
1987	1.1616	-0.6070	0.4203	0.7433	1.6576	853
1988	0.3104	0.6222	0.4203	-0.1310	-0.2922	2915
1989	1.2258	1.0473	0.4203	0.0750	0.1673	4459
1990	1.0293	-0.2763	0.4203	0.5487	1.2236	1187

Partial variance for this index is 0.195522

Index 2 AGE 2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	-1.0571	0.2175	0.4838	-0.6166	-1.3750	1516
1971	0.5721	0.2584	0.4838	0.1518	0.3385	1580
1972	-0.5456	-0.3043	0.4838	-0.1167	-0.2603	900
1973	-0.4464	-0.3551	0.4838	-0.0442	-0.0985	855
1974	-1.0840	-0.7133	0.4838	-0.1793	-0.3999	598
1975	-0.8375	-0.0670	0.4838	-0.3728	-0.8312	1141
1976	-0.3160	0.0905	0.4838	-0.1967	-0.4385	1335
1977	-2.4203	-1.2731	0.4838	-0.5550	-1.2376	342
1978	-1.5770	-2.4257	0.4838	0.4106	0.9155	108
1979	-4.9664	-3.4319	0.4838	-0.7423	-1.6553	39
1980	-1.0399	-2.0655	0.4838	0.4962	1.1065	155
1981	-1.3540	-2.8722	0.4838	0.7344	1.6378	69
1982	-1.0017	-2.0111	0.4838	0.4883	1.0889	163
1983	-0.6142	-0.1602	0.4838	-0.2196	-0.4898	1039
1984	1.2216	1.1386	0.4838	0.0401	0.0895	3809
1985	-1.8368	-1.1344	0.4838	-0.3398	-0.7578	392
1986	-0.1661	-0.2888	0.4838	0.0594	0.1324	914
1987	1.2178	-0.1026	0.4838	0.6387	1.4244	1101
1988	-0.1485	-0.5738	0.4838	0.2057	0.4588	687
1989	1.1282	0.6675	0.4838	0.2229	0.4970	2378
1990	0.9587	1.0929	0.4838	-0.0649	-0.1448	3639

Partial variance for this index is 0.177821

Index 3 AGE 3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3

SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	1.2991	0.7660	0.4666	0.2487	0.5547	2465
1971	0.1442	0.0084	0.4666	0.0634	0.1413	1156
1972	0.4464	-0.0942	0.4666	0.2522	0.5624	1043
1973	-0.7693	-0.7332	0.4666	-0.0169	-0.0376	551
1974	-0.4757	-0.9448	0.4666	0.2189	0.4881	445
1975	-2.2275	-1.2291	0.4666	-0.4658	-1.0388	335
1976	-1.6760	-0.6135	0.4666	-0.4957	-1.1055	621
1977	-1.4960	-0.2415	0.4666	-0.5853	-1.3053	900
1978	-1.3020	-1.4604	0.4666	0.0739	0.1648	266
1979	-3.9646	-2.5713	0.4666	-0.6501	-1.4497	88
1980	-4.0516	-3.5926	0.4666	-0.2141	-0.4775	32
1981	0.1237	-2.2754	0.4666	1.1194	2.4962	118
1982	-2.8706	-3.0704	0.4666	0.0932	0.2079	53
1983	-2.8386	-2.1972	0.4666	-0.2992	-0.6673	127
1984	0.4674	-0.3221	0.4666	0.3683	0.8214	830
1985	1.5850	0.9727	0.4666	0.2857	0.6371	3031
1986	-1.5845	-1.2846	0.4666	-0.1399	-0.3121	317
1987	0.8347	-0.4428	0.4666	0.5960	1.3292	736
1988	-0.0344	-0.2536	0.4666	0.1023	0.2281	889
1989	-1.6802	-0.7315	0.4666	-0.4427	-0.9871	551
1990	0.2780	0.5181	0.4666	-0.1121	-0.2499	1924

Partial variance for this index is 0.19193

Index 4 AGE 4
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	1.0356	-0.1300	0.3615	0.4214	0.9396	741
1971	1.6452	0.5862	0.3615	0.3828	0.8537	1517
1972	0.0407	-0.0520	0.3615	0.0335	0.0747	801
1973	0.0742	-0.2935	0.3615	0.1329	0.2964	629
1974	-1.5133	-1.0754	0.3615	-0.1583	-0.3530	288
1975	-2.2624	-1.3880	0.3615	-0.3161	-0.7049	211
1976	-2.7776	-1.5226	0.3615	-0.4537	-1.0117	184
1977	-1.5670	-0.8139	0.3615	-0.2722	-0.6071	374
1978	-0.1109	-0.2066	0.3615	0.0346	0.0771	686
1979	-2.8466	-1.3798	0.3615	-0.5302	-1.1824	212
1980	-3.8117	-2.4800	0.3615	-0.4814	-1.0735	71
1981	-1.5175	-3.5427	0.3615	0.7321	1.6325	24
1982	-0.7964	-2.2536	0.3615	0.5268	1.1747	89
1983	-4.9103	-3.0072	0.3615	-0.6879	-1.5341	42
1984	-1.6546	-2.1261	0.3615	0.1704	0.3800	101
1985	0.0784	-0.2598	0.3615	0.1222	0.2726	651
1986	1.0012	1.0353	0.3615	-0.0123	-0.0275	2377
1987	0.5383	-1.2046	0.3615	0.6300	1.4050	253
1988	0.4359	-0.3570	0.3615	0.2866	0.6391	591
1989	0.2690	-0.1590	0.3615	0.1547	0.3450	720
1990	-2.6267	-0.6467	0.3615	-0.7157	-1.5961	442

Partial variance for this index is 0.191328

Index 5 AGE 5
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	-0.2481	-1.9988	0.3142	0.5500	1.2265	145
1971	0.5258	-0.9050	0.3142	0.4495	1.0025	434
1972	0.3373	-0.2747	0.3142	0.1923	0.4288	814
1973	-0.6099	-0.7996	0.3142	0.0596	0.1329	482
1974	-0.8577	-1.0805	0.3142	0.0700	0.1561	364
1975	-3.5914	-1.8709	0.3142	-0.5406	-1.2054	165
1976	-4.5723	-2.3184	0.3142	-0.7081	-1.5791	106
1977	-2.7134	-2.2654	0.3142	-0.1407	-0.3138	111
1978	-0.8855	-1.3520	0.3142	0.1466	0.3268	277
1979	-1.5458	-0.6753	0.3142	-0.2735	-0.6098	546
1980	-2.2993	-1.8562	0.3142	-0.1392	-0.3104	168

1981	-1.6126	-2.9505	0.3142	0.4203	0.9374	56
1982	-2.5463	-4.0557	0.3142	0.4742	1.0575	19
1983	-4.1668	-2.7920	0.3142	-0.4319	-0.9632	66
1984	-3.8383	-3.4813	0.3142	-0.1122	-0.2501	33
1985	-2.1263	-2.5991	0.3142	0.1485	0.3312	80
1986	-0.6796	-0.7478	0.3142	0.0214	0.0478	508
1987	2.5401	0.5464	0.3142	0.6264	1.3968	1851
1988	0.4786	-1.6864	0.3142	0.6802	1.5169	199
1989	-3.2844	-0.8133	0.3142	-0.7763	-1.7312	475
1990	-2.8905	-0.6103	0.3142	-0.7164	-1.5976	582

Partial variance for this index is 0.216006

Index 6 AGE 6
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	-0.8876	-2.8162	0.2949	0.5688	1.2685	45
1971	-0.8811	-2.1351	0.2949	0.3699	0.8248	90
1972	-0.9443	-1.1921	0.2949	0.0731	0.1630	230
1973	0.6412	-0.6134	0.2949	0.3701	0.8252	411
1974	-0.9172	-1.0705	0.2949	0.0452	0.1008	260
1975	-3.0220	-1.2502	0.2949	-0.5226	-1.1654	217
1976	-5.5207	-2.0478	0.2949	-1.0243	-2.2842	98
1977	-3.3612	-2.5200	0.2949	-0.2481	-0.5533	61
1978	-1.6635	-2.2256	0.2949	0.1658	0.3697	82
1979	-2.3426	-1.2607	0.2949	-0.3191	-0.7116	215
1980	-1.1201	-0.5629	0.2949	-0.1643	-0.3665	432
1981	0.0734	-1.7613	0.2949	0.5411	1.2067	130
1982	-2.6875	-2.8609	0.2949	0.0512	0.1141	43
1983	-5.5207	-3.9673	0.2949	-0.4582	-1.0217	14
1984	-1.2440	-2.7459	0.2949	0.4430	0.9878	49
1985	-2.6396	-3.3695	0.2949	0.2153	0.4800	26
1986	-2.9304	-2.4856	0.2949	-0.1312	-0.2926	63
1987	1.1981	-0.6476	0.2949	0.5444	1.2140	397
1988	2.4682	0.6229	0.2949	0.5442	1.2137	1415
1989	-2.6303	-1.5768	0.2949	-0.3107	-0.6929	157
1990	-3.2349	-0.6810	0.2949	-0.7533	-1.6798	384

Partial variance for this index is 0.220956

Index 7 AGE 7
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1970	-0.3561	-2.3333	0.2351	0.4649	1.0367	40
1971	-1.7155	-2.6364	0.2351	0.2165	0.4828	30
1972	-1.9457	-2.1776	0.2351	0.0545	0.1216	47
1973	0.8429	-1.1005	0.2351	0.4569	1.0190	138
1974	0.9778	-0.7206	0.2351	0.3993	0.8905	202
1975	-2.9030	-1.0718	0.2351	-0.4306	-0.9602	142
1976	-3.3320	-1.1615	0.2351	-0.5104	-1.1381	130
1977	-3.3320	-1.8340	0.2351	-0.3522	-0.7855	66
1978	-1.9637	-2.2544	0.2351	0.0683	0.1524	44
1979	-2.0295	-1.9257	0.2351	-0.0244	-0.0544	61
1980	-1.9637	-0.9033	0.2351	-0.2493	-0.5560	168
1981	1.6400	-0.1953	0.2351	0.4315	0.9623	342
1982	-1.1630	-1.4111	0.2351	0.0584	0.1301	101
1983	-5.9711	-2.5092	0.2351	-0.8140	-1.8151	34
1984	-3.0807	-3.6159	0.2351	0.1258	0.2806	11
1985	-0.5136	-2.4349	0.2351	0.4517	1.0074	36
1986	-4.0252	-2.9944	0.2351	-0.2424	-0.5405	21
1987	0.5991	-2.1248	0.2351	0.6405	1.4282	50
1988	1.7315	-0.3035	0.2351	0.4785	1.0670	307
1989	-0.1629	0.9458	0.2351	-0.2607	-0.5813	1069
1990	-5.2779	-1.1825	0.2351	-0.9629	-2.1473	127

Partial variance for this index is 0.21407

Standardized residuals by index & yr; with row/column/grand means

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.7987	-0.0681	0.8133	0.1915	-0.3569	0.0738	-0.2892
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-1.3750	0.3385	-0.2603	-0.0985	-0.3999	-0.8312	-0.4385
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5547	0.1413	0.5624	-0.0376	0.4881	-1.0388	-1.1055
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9396	0.8537	0.0747	0.2964	-0.3530	-0.7049	-1.0117
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2265	1.0025	0.4288	0.1329	0.1561	-1.2054	-1.5791
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2685	0.8248	0.1630	0.8252	0.1008	-1.1654	-2.2842
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0367	0.4828	0.1216	1.0190	0.8905	-0.9602	-1.1381
**	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.4075	0.5108	0.2719	0.3327	0.0751	-0.8332	-1.1209

■	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	-1.3345	1.1691	-1.6029	-0.1010	1.5743	0.1210	-1.6626	0.5616	0.0115	-1.0582	1.6576	-0.2922	0.1673	1.2236
2	-1.2376	0.9155	-1.6553	1.1065	1.6378	1.0889	-0.4898	0.0895	-0.7578	0.1324	1.4244	0.4588	0.4970	-0.1448
3	-1.3053	0.1648	-1.4497	-0.4775	2.4962	0.2079	-0.6673	0.8214	0.6371	-0.3121	1.3292	0.2281	-0.9871	-0.2499
4	-0.6071	0.0771	-1.1824	-1.0735	1.6325	1.1747	-1.5341	0.3800	0.2726	-0.0275	1.4050	0.6391	0.3450	-1.5961
5	-0.3138	0.3268	-0.6098	-0.3104	0.9374	1.0575	-0.9632	-0.2501	0.3312	0.0478	1.3968	1.5169	-1.7312	-1.5976
6	-0.5533	0.3697	-0.7116	-0.3665	1.2067	0.1141	-1.0217	0.9878	0.4800	-0.2926	1.2140	1.2137	-0.6929	-1.6798
7	-0.7855	0.1524	-0.0544	-0.5560	0.9623	0.1301	-1.8151	0.2806	1.0074	-0.5405	1.4282	1.0670	-0.5813	-2.1473
**	-0.8767	0.4536	-1.0380	-0.2541	1.4924	0.5563	-1.1648	0.4101	0.2832	-0.2929	1.4079	0.6902	-0.4262	-0.8845

■	*******
1	0.0000
2	0.0000
3	0.0000
4	0.0000
5	0.0000
6	0.0000
7	0.0000
**	0.0000

Percent of total sum of squares by index & yr; with row/column sums

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.50	0.03	0.10	0.00	0.06	1.35	1.04	1.95	0.01	1.88	0.01
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.09	0.05	0.01	0.12	0.52	0.15	1.16	0.64	2.08	0.93	2.03	0.90
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.02	0.24	0.00	0.18	0.82	0.93	1.29	0.02	1.59	0.17	4.72	0.03
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.55	0.00	0.07	0.09	0.38	0.78	0.28	0.00	1.06	0.87	2.02	1.05
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	0.76	0.14	0.01	0.02	1.10	1.89	0.07	0.08	0.28	0.07	0.67	0.85
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.52	0.02	0.52	0.01	1.03	3.95	0.23	0.10	0.38	0.10	1.10	0.01
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.18	0.01	0.79	0.60	0.70	0.98	0.47	0.02	0.00	0.23	0.70	0.01
**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.99	2.11	0.97	1.42	1.12	4.55	8.73	4.85	1.90	7.34	2.39	13.12	2.86

■	1983	1984	1985	1986	1987	1988	1989	1990	*******
1	2.09	0.24	0.00	0.85	2.08	0.06	0.02	1.13	13.89
2	0.18	0.01	0.43	0.01	1.54	0.16	0.19	0.02	12.63
3	0.34	0.51	0.31	0.07	1.34	0.04	0.74	0.05	13.63
4	1.78	0.11	0.06	0.00	1.50	0.31	0.09	1.93	13.59
5	0.70	0.05	0.08	0.00	1.48	1.74	2.27	1.93	15.35
6	0.79	0.74	0.17	0.06	1.12	1.12	0.36	2.14	15.70
7	2.50	0.06	0.77	0.22	1.55	0.86	0.26	3.49	15.21
**	8.39	1.71	1.83	1.22	10.59	4.29	3.93	10.69	100.00

Partial variance (and proportion of total) by index

■	1	2	3	4	5	6	7	************
**	0.19552164	0.17782099	0.19193019	0.19132816	0.21600624	0.22095637	0.21406976	1.40763336
**	0.13890097	0.12632621	0.13634956	0.13592187	0.15345348	0.15697012	0.15207778	1.00000000

STOCK NUMBERS (Jan 1) - MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	303	207	236	295	683	2003	4999	2087	2541	1352	1372	1154	1943	2454	492	148	54	216	97	238	1414
2	181	234	168	182	234	538	1639	3965	1702	1905	1039	1104	798	1504	1671	391	119	44	176	79	185
3	518	145	187	131	146	181	416	1287	3009	1344	1293	773	647	434	841	1048	296	97	35	135	60
4	32	410	118	150	105	114	130	287	908	1991	985	827	375	291	253	442	767	238	79	28	102
5	17	23	312	93	119	84	90	72	175	596	1125	642	466	215	147	129	313	612	189	63	21
6	5	13	13	238	71	93	65	61	54	119	304	567	351	278	123	73	95	244	484	148	49
7	3	2	10	7	177	51	72	48	47	38	66	170	286	186	166	76	51	70	188	384	114
8	5	1	2	5	2	125	36	58	37	34	23	32	111	136	106	99	57	37	52	150	303
9	2	4	1	1	0	1	73	29	45	21	25	15	16	67	66	55	76	45	28	41	118
10	1	1	3	0	0	0	1	55	22	28	14	13	9	8	44	33	42	58	35	22	31
11	2	1	0	0	0	0	0	0	16	24	20	5	3	3	5	6	161	106	146	56	69

	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	5164	531	1243	1496	946	3218	4921	1311	0
2	1154	4226	434	1015	1224	766	2632	4027	1071
3	143	932	3420	354	820	987	614	2141	3276
4	47	113	736	2673	283	658	798	493	1722
5	76	37	89	572	2103	225	528	647	395
6	16	56	29	71	448	1621	174	426	522
7	38	13	42	23	56	350	1227	141	345
8	89	30	10	31	19	44	267	926	115
9	240	69	24	8	23	15	33	214	711
10	94	186	53	19	6	16	11	27	173
11	55	140	193	145	74	86	39	53	64

Summaries for ages 1 1 2 11 1 11

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	303	207	236	295	683	2003	4999	2087	2541	1352	1372	1154	1943	2454	492	148	54	216	97	238
2	765	835	815	806	854	1188	2524	5861	6016	6100	4894	4148	3062	3124	3421	2354	1977	1552	1412	1106
1	1068	1042	1051	1102	1538	3191	7523	7948	8556	7452	6266	5302	5006	5578	3913	2502	2030	1768	1510	1344

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	1414	5164	531	1243	1496	946	3218	4921	1311	0
2	1052	1953	5803	5031	4911	5055	4767	6324	9094	8394
1	2466	7117	6333	6274	6407	6001	7984	11245	10405	8394

FISHING MORTALITY - MOD2

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151
2	0.0173	0.0201	0.0471	0.0221	0.0559	0.0564	0.0423	0.0759	0.0360	0.1872	0.0956	0.3335	0.4086	0.3812	0.2663	0.0793
3	0.0330	0.0099	0.0245	0.0247	0.0411	0.1289	0.1714	0.1485	0.2129	0.1106	0.2471	0.5232	0.6004	0.3416	0.4431	0.1126
4	0.1417	0.0735	0.0382	0.0300	0.0277	0.0344	0.3905	0.2921	0.2210	0.3714	0.2291	0.3741	0.3552	0.4832	0.4699	0.1450
5	0.0826	0.3474	0.0712	0.0638	0.0446	0.0446	0.1920	0.0913	0.1909	0.4737	0.4840	0.4026	0.3163	0.3577	0.5016	0.1082
6	0.4811	0.0266	0.4258	0.0949	0.1305	0.0624	0.1181	0.0558	0.1548	0.3888	0.3820	0.4846	0.4336	0.3141	0.2806	0.1629
7	0.6725	0.0991	0.5597	1.0910	0.1461	0.1409	0.0109	0.0475	0.1321	0.3012	0.5152	0.2270	0.5418	0.3678	0.3137	0.0846
8	0.1799	0.1831	0.5893	2.8080	0.3389	0.3351	0.0308	0.0608	0.3484	0.1246	0.2264	0.4737	0.2963	0.5268	0.4494	0.0726
9	0.2364	0.0621	4.0148	3.9359	3.0219	0.3505	0.0963	0.0877	0.2838	0.2499	0.4608	0.3608	0.5631	0.2292	0.4765	0.0792
10	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264
11	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0021	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0019	0.0152	0.0707	0.0697	0.0608	0.0137	0.0116	0.0049	0.0135	0.0150	0.0200	0.0066	0.0063
3	0.0177	0.0149	0.0318	0.0741	0.0509	0.0354	0.0358	0.0466	0.0212	0.0197	0.0119	0.0204	0.0176
4	0.0254	0.0335	0.0142	0.0821	0.0951	0.0336	0.0338	0.0519	0.0396	0.0309	0.0202	0.0104	0.0218
5	0.0481	0.0342	0.0413	0.0501	0.0648	0.1038	0.0365	0.0340	0.0456	0.0608	0.0556	0.0141	0.0139

6	0.1028	0.0611	0.0320	0.0608	0.0624	0.0489	0.0947	0.0307	0.0301	0.0452	0.0781	0.0147	0.0123
7	0.1082	0.1028	0.0280	0.0384	0.0435	0.0386	0.0539	0.0882	0.0241	0.0546	0.0729	0.0816	0.0016
8	0.0433	0.0804	0.0436	0.0422	0.0300	0.0611	0.0224	0.0344	0.1315	0.0241	0.0682	0.0192	0.0647
9	0.0679	0.0556	0.0401	0.0763	0.0247	0.0558	0.0561	0.0233	0.0289	0.1142	0.0937	0.0269	0.0119
10	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210
11	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210

Avg F for ages 1 1 2 11 1 11

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151	0.0021
2	0.2189	0.0992	0.5933	0.8244	0.3990	0.1407	0.1427	0.1228	0.2010	0.2993	0.3372	0.3984	0.4297	0.3808	0.4024	0.1097	0.0496
1	0.2045	0.0907	0.5451	0.7526	0.3663	0.1280	0.1326	0.1119	0.1907	0.2778	0.3082	0.3775	0.3957	0.3629	0.3684	0.1011	0.0453

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0487	0.0366	0.0586	0.0528	0.0520	0.0440	0.0416	0.0417	0.0475	0.0545	0.0276	0.0192
1	0.0445	0.0345	0.0577	0.0482	0.0473	0.0401	0.0381	0.0380	0.0442	0.0497	0.0251	0.0177

Avg F (weighted by N) for ages 1 1 2 11 1 11

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151	0.0021
2	0.0423	0.0544	0.0679	0.0796	0.0747	0.0983	0.0895	0.1031	0.1636	0.2647	0.2795	0.4055	0.4406	0.3799	0.3495	0.1113	0.0360
1	0.0475	0.0448	0.0666	0.0675	0.0591	0.0369	0.0511	0.0770	0.1412	0.2281	0.2222	0.3539	0.2913	0.2939	0.3092	0.1056	0.0351

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0425	0.0372	0.0522	0.0477	0.0313	0.0196	0.0439	0.0340	0.0399	0.0453	0.0247	0.0167
1	0.0376	0.0356	0.0517	0.0220	0.0089	0.0180	0.0358	0.0263	0.0355	0.0274	0.0141	0.0150

Avg F (wt by catch) for ages 1 1 2 11 1 11

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151	0.0021
2	0.1162	0.1082	0.2156	0.4767	0.1125	0.1692	0.1695	0.1280	0.2033	0.3172	0.3398	0.4183	0.4597	0.3864	0.3698	0.1163	0.0516
1	0.0956	0.1054	0.1810	0.4017	0.0902	0.1678	0.1103	0.1263	0.1810	0.3029	0.3332	0.3895	0.4237	0.3267	0.3651	0.1154	0.0515

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0509	0.0424	0.0562	0.0562	0.0498	0.0302	0.0477	0.0396	0.0507	0.0641	0.0569	0.0337
1	0.0506	0.0416	0.0551	0.0522	0.0479	0.0300	0.0470	0.0392	0.0486	0.0633	0.0559	0.0330

BACKCALCULATED PARTIAL RECRUITMENT

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0.09	0.02	0.02	0.01	0.01	0.00	0.08	0.01	0.25	0.13	0.03	0.32	0.09	0.35	0.06	0.09	0.02	0.02	0.19	0.60	0.03	0.00	0.01	0.03
2	0.03	0.06	0.01	0.01	0.02	0.16	0.11	0.26	0.10	0.40	0.19	0.64	0.68	0.72	0.53	0.49	0.02	0.15	1.00	0.85	0.64	0.13	0.12	0.05
3	0.05	0.03	0.01	0.01	0.01	0.37	0.44	0.51	0.61	0.23	0.48	1.00	1.00	0.65	0.88	0.69	0.16	0.14	0.45	0.90	0.54	0.34	0.38	0.53
4	0.21	0.21	0.01	0.01	0.01	0.10	1.00	1.00	0.63	0.78	0.44	0.72	0.59	0.92	0.94	0.89	0.23	0.33	0.20	1.00	1.00	0.32	0.36	0.59
5	0.12	1.00	0.02	0.02	0.01	0.13	0.49	0.31	0.55	1.00	0.94	0.77	0.53	0.68	1.00	0.66	0.44	0.33	0.58	0.61	0.68	1.00	0.38	0.38
6	0.72	0.08	0.11	0.02	0.04	0.18	0.30	0.19	0.44	0.82	0.74	0.93	0.72	0.60	0.56	1.00	0.95	0.59	0.45	0.74	0.66	0.47	1.00	0.35
7	1.00	0.29	0.14	0.28	0.05	0.40	0.03	0.16	0.38	0.64	1.00	0.43	0.90	0.70	0.63	0.52	1.00	1.00	0.40	0.47	0.46	0.37	0.57	1.00
8	0.27	0.53	0.15	0.71	0.11	0.96	0.08	0.21	1.00	0.26	0.44	0.91	0.49	1.00	0.90	0.45	0.40	0.78	0.62	0.51	0.32	0.59	0.24	0.39
9	0.35	0.18	1.00	1.00	1.00	1.00	0.25	0.30	0.81	0.53	0.89	0.69	0.94	0.44	0.95	0.49	0.63	0.54	0.57	0.93	0.26	0.54	0.59	0.26
10	0.26	0.24	0.02	0.02	0.03	0.36	0.48	0.63	0.62	0.83	0.71	0.77	0.65	0.77	0.82	0.78	0.37	0.44	0.46	0.56	0.50	0.62	0.50	0.58
11	0.26	0.24	0.02	0.02	0.03	0.36	0.48	0.63	0.62	0.83	0.71	0.77	0.65	0.77	0.82	0.78	0.37	0.44	0.46	0.56	0.50	0.62	0.50	0.58

	1986	1987	1988	1989	1990
1	0.01	0.10	0.01	0.01	0.04
2	0.10	0.13	0.21	0.08	0.10
3	0.16	0.17	0.13	0.25	0.27
4	0.30	0.27	0.22	0.13	0.34
5	0.35	0.53	0.59	0.17	0.22

6 ■	0.23	0.40	0.83	0.18	0.19
7 ■	0.18	0.48	0.78	1.00	0.02
8 ■	1.00	0.21	0.73	0.24	1.00
9 ■	0.22	1.00	1.00	0.33	0.18
10 ■	0.31	0.48	0.67	0.50	0.32
11 ■	0.31	0.48	0.67	0.50	0.32

MEAN BIOMASS (1000s MT)

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1 ■	34.7	22.4	24.1	32.4	77.8	223.3	660.4	247.3	236.2	130.8	151.7	109.0	190.3	211.9	42.7	15.1
2 ■	33.8	40.3	28.0	32.6	43.1	95.8	350.9	741.5	271.4	285.9	189.0	161.6	113.6	200.8	224.3	67.6
3 ■	133.5	34.6	44.0	32.7	38.0	43.6	116.5	325.9	623.7	295.8	312.9	148.1	121.6	84.5	151.4	259.2
4 ■	9.8	119.9	34.8	47.1	35.1	36.7	41.8	86.6	240.1	496.0	309.3	217.1	101.4	68.7	58.2	140.2
5 ■	6.3	6.9	108.0	34.2	47.2	31.8	37.9	28.6	56.5	169.6	377.9	199.5	154.6	64.9	40.3	50.5
6 ■	1.6	5.1	4.4	98.3	30.9	40.1	32.3	28.0	20.2	40.0	122.8	194.3	126.7	98.0	43.1	32.0
7 ■	1.1	1.0	3.5	2.1	84.2	23.5	41.0	24.2	19.8	14.7	27.8	72.4	109.3	71.1	63.6	38.6
8 ■	2.6	0.6	0.6	0.8	0.9	56.4	22.2	31.6	15.2	15.4	11.9	13.2	51.1	52.3	41.2	54.9
9 ■	1.0	1.8	0.1	0.1	0.0	0.5	45.9	16.5	19.9	9.8	12.2	6.9	7.1	31.4	27.0	32.3
10 ■	0.4	0.7	1.4	0.0	0.0	0.0	0.4	31.0	10.4	12.3	7.4	6.0	4.2	3.5	19.4	20.1
11 ■	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	7.9	11.2	11.2	2.6	1.4	1.5	2.1	3.5
1+■	226.1	234.0	249.1	280.4	357.3	551.7	1349.2	1561.2	1521.4	1481.4	1534.0	1130.8	981.3	888.6	713.1	714.2

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	9.3	37.2	12.8	24.0	194.5	458.6	47.1	124.9	107.1	91.2	291.5	445.9	123.4
2 ■	30.7	10.7	58.1	21.7	55.5	267.1	617.1	102.0	213.8	231.2	152.6	549.3	749.6
3 ■	113.1	46.5	17.3	61.6	28.8	61.0	280.7	839.6	110.7	232.6	305.0	206.8	638.7
4 ■	317.8	120.4	43.0	14.1	53.7	24.7	52.9	270.8	869.9	102.2	241.0	298.1	198.9
5 ■	141.2	315.9	103.4	36.1	12.4	41.3	20.6	44.5	229.4	761.0	89.9	225.3	277.8
6 ■	47.7	129.7	274.4	86.1	32.3	9.5	32.0	16.8	36.7	200.5	684.7	79.8	202.8
7 ■	27.2	39.5	113.1	230.3	74.6	24.1	7.8	24.6	13.3	24.9	179.1	565.7	79.6
8 ■	33.6	23.2	32.4	94.1	195.1	55.8	19.2	5.8	19.5	11.7	26.5	151.1	465.3
9 ■	44.7	29.8	19.5	25.7	75.7	149.5	42.9	15.8	5.4	14.4	9.7	22.4	127.2
10 ■	25.9	39.5	23.1	14.8	20.2	60.0	116.9	33.8	12.8	3.7	11.8	7.9	17.1
11 ■	103.6	76.8	101.5	39.6	49.3	36.5	92.9	124.8	95.0	49.8	58.2	28.7	39.3
1+■	894.9	869.3	798.7	648.0	792.2	1188.1	1329.9	1603.5	1713.5	1723.3	2050.0	2581.0	2919.8

Summaries for ages 1 1 2 11 1 11

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1 ■	35	22	24	32	78	223	660	247	236	131	152	109	190	212	43	15	9	37	13	24	195	459
2 ■	191	212	225	248	280	328	689	1314	1285	1351	1382	1022	791	677	670	699	886	832	786	624	598	729
1 ■	226	234	249	280	357	552	1349	1561	1521	1481	1534	1131	981	889	713	714	895	869	799	648	792	1188

■	1984	1985	1986	1987	1988	1989	1990
1 ■	47	125	107	91	291	446	123
2 ■	1283	1479	1606	1632	1758	2135	2796
1 ■	1330	1604	1714	1723	2050	2581	2920

CATCH BIOMASS (1000s MT)

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1 ■	2.1	0.1	1.5	1.1	3.1	0.1	21.0	0.9	20.8	8.2	2.7	18.4	10.7	39.0	1.2	0.2	0.0	0.1
2 ■	0.6	0.8	1.3	0.7	2.4	5.4	14.9	56.3	9.8	53.5	18.1	53.9	46.4	76.5	59.8	5.4	0.1	0.2
3 ■	4.4	0.3	1.1	0.8	1.6	5.6	20.0	48.4	132.8	32.7	77.3	77.5	73.0	28.9	67.1	29.2	2.0	0.7
4 ■	1.4	8.8	1.3	1.4	1.0	1.3	16.3	25.3	53.1	184.2	70.9	81.2	36.0	33.2	27.3	20.3	8.1	4.0
5 ■	0.5	2.4	7.7	2.2	2.1	1.4	7.3	2.6	10.8	80.3	182.9	80.3	48.9	23.2	20.2	5.5	6.8	10.8
6 ■	0.8	0.1	1.9	9.3	4.0	2.5	3.8	1.6	3.1	15.6	46.9	94.2	54.9	30.8	12.1	5.2	4.9	7.9
7 ■	0.8	0.1	2.0	2.2	12.3	3.3	0.4	1.2	2.6	4.4	14.3	16.4	59.2	26.2	19.9	3.3	2.9	4.1
8 ■	0.5	0.1	0.4	2.4	0.3	18.9	0.7	1.9	5.3	1.9	2.7	6.3	15.1	27.6	18.5	4.0	1.5	1.9
9 ■	0.2	0.1	0.5	0.4	0.1	0.2	4.4	1.4	5.7	2.4	5.6	2.5	4.0	7.2	12.8	2.6	3.0	1.7
10 ■	0.1	0.1	0.1	0.0	0.0	0.0	0.1	5.7	2.2	4.8	2.7	2.4	1.6	1.4	8.0	2.5	1.0	1.8
11 ■	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.7	4.4	4.1	1.0	0.5	0.6	0.9	0.4	4.2	3.4
1+■	11.5	13.1	17.7	20.6	26.9	38.7	88.8	145.3	247.8	392.5	428.2	434.1	350.5	294.5	247.8	78.6	34.5	36.5

■	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	0.2	1.2	0.5	0.2	0.1	0.4	0.1	1.1	0.3	0.3	0.3
2 ■	4.1	1.5	3.4	3.7	7.1	0.5	2.9	3.5	3.0	3.6	4.7
3 ■	0.5	4.6	1.5	2.2	10.1	39.1	2.3	4.6	3.6	4.2	11.2
4 ■	0.6	1.2	5.1	0.8	1.8	14.1	34.4	3.2	4.9	3.1	4.3
5 ■	4.3	1.8	0.8	4.3	0.8	1.5	10.5	46.2	5.0	3.2	3.9
6 ■	8.8	5.2	2.0	0.5	3.0	0.5	1.1	9.1	53.5	1.2	2.5
7 ■	3.2	8.8	3.3	0.9	0.4	2.2	0.3	1.4	13.1	46.2	0.1
8 ■	1.4	4.0	5.9	3.4	0.4	0.2	2.6	0.3	1.8	2.9	30.1
9 ■	0.8	2.0	1.9	8.3	2.4	0.4	0.2	1.6	0.9	0.6	1.5
10 ■	0.7	0.7	1.0	3.9	5.5	1.7	0.5	0.2	0.7	0.3	0.4
11 ■	3.3	1.8	2.4	2.3	4.4	6.4	3.9	2.7	3.6	1.2	0.8
1+■	27.9	32.7	27.6	30.5	36.0	66.9	58.8	73.8	90.4	66.7	59.9

Summaries for ages 1 1 2 11 1 11

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1 ■	2	0	2	1	3	0	21	1	21	8	3	18	11	39	1	0	0	0	0	1	1	0	0	0
2 ■	9	13	16	20	24	39	68	144	227	384	425	416	340	255	247	78	35	36	28	32	27	30	36	67
1 ■	12	13	18	21	27	39	89	145	248	393	428	434	350	295	248	79	35	36	28	33	28	31	36	67

■	1986	1987	1988	1989	1990
1 ■	0	1	0	0	0
2 ■	59	73	90	66	60
1 ■	59	74	90	67	60

Mean SSB - females (1000s MT)

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1 ■	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 ■	8.4	10.1	7.0	8.1	10.8	24.0	87.7	185.4	67.9	71.5	47.2	40.4	28.4	50.2	56.1	16.9	7.7
3 ■	66.8	17.3	22.0	16.4	19.0	21.8	58.2	163.0	311.8	147.9	156.4	74.0	60.8	42.2	75.7	129.6	56.5
4 ■	4.9	60.0	17.4	23.6	17.6	18.4	20.9	43.3	120.1	248.0	154.6	108.6	50.7	34.3	29.1	70.1	158.9
5 ■	3.2	3.4	54.0	17.1	23.6	15.9	18.9	14.3	28.3	84.8	189.0	99.8	77.3	32.4	20.2	25.3	70.6
6 ■	0.8	2.5	2.2	49.2	15.5	20.0	16.2	14.0	10.1	20.0	61.4	97.2	63.3	49.0	21.5	16.0	23.8
7 ■	0.6	0.5	1.7	1.0	42.1	11.7	20.5	12.1	9.9	7.3	13.9	36.2	54.7	35.6	31.8	19.3	13.6
8 ■	1.3	0.3	0.3	0.4	0.4	28.2	11.1	15.8	7.6	7.7	6.0	6.6	25.5	26.2	20.6	27.5	16.8
9 ■	0.5	0.9	0.1	0.1	0.0	0.3	22.9	8.2	10.0	4.9	6.1	3.4	3.6	15.7	13.5	16.2	22.4
10 ■	0.2	0.3	0.7	0.0	0.0	0.0	0.2	15.5	5.2	6.1	3.7	3.0	2.1	1.7	9.7	10.0	12.9
11 ■	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	4.0	5.6	5.6	1.3	0.7	0.8	1.0	1.8	51.8
1+■	87.3	95.7	105.5	115.9	129.0	140.3	256.7	471.6	574.7	603.9	643.9	470.5	367.1	288.1	279.2	332.6	435.1

■	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 ■	2.7	14.5	5.4	13.9	66.8	154.3	25.5	53.5	57.8	38.1	137.3	187.4
3 ■	23.3	8.6	30.8	14.4	30.5	140.3	419.8	55.3	116.3	152.5	103.4	319.4
4 ■	60.2	21.5	7.0	26.9	12.4	26.4	135.4	434.9	51.1	120.5	149.0	99.5
5 ■	158.0	51.7	18.0	6.2	20.6	10.3	22.2	114.7	380.5	45.0	112.6	138.9
6 ■	64.8	137.2	43.0	16.1	4.7	16.0	8.4	18.4	100.3	342.4	39.9	101.4
7 ■	19.7	56.6	115.1	37.3	12.0	3.9	12.3	6.7	12.5	89.5	282.9	39.8
8 ■	11.6	16.2	47.0	97.6	27.9	9.6	2.9	9.7	5.9	13.3	75.6	232.7
9 ■	14.9	9.8	12.8	37.9	74.8	21.4	7.9	2.7	7.2	4.9	11.2	63.6
10 ■	19.8	11.5	7.4	10.1	30.0	58.4	16.9	6.4	1.9	5.9	3.9	8.6
11 ■	38.4	50.7	19.8	24.7	18.3	46.5	62.4	47.5	24.9	29.1	14.3	19.7
1+■	413.4	378.4	306.5	284.9	298.0	487.2	713.8	749.8	758.2	841.1	930.2	1210.8

MEAN STOCK NUMBERS - MOD2

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1 ■	267	187	208	263	608	1815	4462	1888	2208	1189	1233	965	1714	2037	440	133	49	196	88	211	1280	4680
2 ■	162	210	149	163	206	474	1456	3465	1516	1580	900	855	598	1141	1335	342	108	39	155	69	163	1039
3 ■	462	131	168	118	129	154	348	1086	2465	1156	1043	551	445	335	621	900	266	88	32	118	53	127
4 ■	27	359	105	134	94	102	98	227	741	1517	801	629	288	211	184	374	686	212	71	24	89	42
5 ■	15	17	273	82	106	74	75	63	145	434	814	482	364	165	106	111	277	546	168	56	19	66

6	3	11	10	206	61	82	56	54	45	90	230	411	260	217	98	61	82	215	432	130	43	14
7	2	2	7	4	150	43	65	42	40	30	47	138	202	142	130	66	44	61	168	342	101	34
8	4	1	1	1	1	97	33	51	29	29	19	23	87	97	78	87	51	32	46	133	270	79
9	2	3	0	0	0	1	64	25	35	17	18	11	11	55	48	48	66	40	25	36	105	212
10	1	1	2	0	0	0	1	45	18	21	10	10	6	6	33	29	37	51	31	20	27	83
11	2	1	0	0	0	0	0	0	13	18	15	4	2	2	3	5	143	94	130	50	61	48

	1984	1985	1986	1987	1988	1989	1990
1	481	1125	1355	853	2915	4459	1187
2	3809	392	914	1101	687	2378	3639
3	830	3031	317	736	889	551	1924
4	101	651	2377	253	591	720	442
5	33	80	508	1851	199	475	582
6	49	26	63	397	1415	157	384
7	11	36	21	50	307	1069	127
8	27	9	27	17	38	239	814
9	61	21	7	19	13	30	193
10	165	47	17	5	14	10	24
11	124	171	129	65	75	34	48

Time stamp at end of run 1991 6 14 10 40 25

Table 7: Input data for Yield per Recruit analysis for Atlantic mackerel.

Age	Fish Mort Pattern	M	Proportion Mature	Average Weight Stock	Average Weight Catch
	Yield per Recruit Input Parameters				
1	0.04	0.2	0.0	0.098	0.104
2	0.24	0.2	0.5	0.221	0.206
3	0.49	0.2	1.0	0.343	0.332
4	0.61	0.2	1.0	0.408	0.450
5	1.0	0.2	1.0	0.453	0.477
6	1.0	0.2	1.0	0.521	0.528
7	1.0	0.2	1.0	0.576	0.625
8	1.0	0.2	1.0	0.666	0.666
9	1.0	0.2	1.0	0.738	0.738
10	1.0	0.2	1.0	0.753	0.753
11+	1.0	0.2	1.0	0.779	0.779

Table 8: Fishing mortality at age for Atlantic mackerel estimated by ADAPT.

FISHING MORTALITY

■	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.0605	0.0059	0.0622	0.0342	0.0396	0.0004	0.0318	0.0038	0.0879	0.0629	0.0180	0.1684	0.0561	0.1843	0.0285	0.0151
2	0.0173	0.0201	0.0471	0.0221	0.0559	0.0564	0.0423	0.0759	0.0360	0.1872	0.0956	0.3335	0.4086	0.3812	0.2663	0.0793
3	0.0330	0.0099	0.0245	0.0247	0.0411	0.1289	0.1714	0.1485	0.2129	0.1106	0.2471	0.5232	0.6004	0.3416	0.4431	0.1126
4	0.1417	0.0735	0.0382	0.0300	0.0277	0.0344	0.3905	0.2921	0.2210	0.3714	0.2291	0.3741	0.3552	0.4832	0.4699	0.1450
5	0.0826	0.3474	0.0712	0.0638	0.0446	0.0446	0.1920	0.0913	0.1909	0.4737	0.4840	0.4026	0.3163	0.3577	0.5016	0.1082
6	0.4811	0.0266	0.4258	0.0949	0.1305	0.0624	0.1181	0.0558	0.1548	0.3888	0.3820	0.4846	0.4336	0.3141	0.2806	0.1629
7	0.6725	0.0991	0.5597	1.0910	0.1461	0.1409	0.0109	0.0475	0.1321	0.3012	0.5152	0.2270	0.5418	0.3678	0.3137	0.0846
8	0.1799	0.1831	0.5893	2.8080	0.3389	0.3351	0.0308	0.0608	0.3484	0.1246	0.2264	0.4737	0.2963	0.5268	0.4494	0.0726
9	0.2364	0.0621	4.0148	3.9359	3.0219	0.3505	0.0963	0.0877	0.2838	0.2499	0.4608	0.3608	0.5631	0.2292	0.4765	0.0792
10	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264
11	0.1724	0.0849	0.0814	0.0867	0.0917	0.1270	0.1874	0.1839	0.2149	0.3926	0.3658	0.4024	0.3910	0.4033	0.4114	0.1264

■	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.0021	0.0020	0.0137	0.0495	0.0028	0.0005	0.0013	0.0030	0.0011	0.0117	0.0009	0.0006	0.0026
2	0.0019	0.0152	0.0707	0.0697	0.0608	0.0137	0.0116	0.0049	0.0135	0.0150	0.0200	0.0066	0.0063
3	0.0177	0.0149	0.0318	0.0741	0.0509	0.0354	0.0358	0.0466	0.0212	0.0197	0.0119	0.0204	0.0176
4	0.0254	0.0335	0.0142	0.0821	0.0951	0.0336	0.0338	0.0519	0.0396	0.0309	0.0202	0.0104	0.0218
5	0.0481	0.0342	0.0413	0.0501	0.0648	0.1038	0.0365	0.0340	0.0456	0.0608	0.0556	0.0141	0.0139
6	0.1028	0.0611	0.0320	0.0608	0.0624	0.0489	0.0947	0.0307	0.0301	0.0452	0.0781	0.0147	0.0123
7	0.1082	0.1028	0.0280	0.0384	0.0435	0.0386	0.0539	0.0882	0.0241	0.0546	0.0729	0.0816	0.0016
8	0.0433	0.0804	0.0436	0.0422	0.0300	0.0611	0.0224	0.0344	0.1315	0.0241	0.0682	0.0192	0.0647
9	0.0679	0.0556	0.0401	0.0763	0.0247	0.0558	0.0561	0.0233	0.0289	0.1142	0.0937	0.0269	0.0119
10	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210
11	0.0405	0.0449	0.0322	0.0460	0.0477	0.0644	0.0474	0.0510	0.0412	0.0552	0.0623	0.0408	0.0210

Table 9: Stock numbers (millions: Jan 1) for Atlantic mackerel estimated by ADAPT.

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	303	207	236	295	683	2003	4999	2087	2541	1352	1372	1154	1943	2454	492	148	54	216	97	238	1414
2	181	234	168	182	234	538	1639	3965	1702	1905	1039	1104	798	1504	1671	391	119	44	176	79	185
3	518	145	187	131	146	181	416	1287	3009	1344	1293	773	647	434	841	1048	296	97	35	135	60
4	32	410	118	150	105	114	130	287	908	1991	985	827	375	291	253	442	767	238	79	28	102
5	17	23	312	93	119	84	90	72	175	596	1125	642	466	215	147	129	313	612	189	63	21
6	5	13	13	238	71	93	65	61	54	119	304	567	351	278	123	73	95	244	484	148	49
7	3	2	10	7	177	51	72	48	47	38	66	170	286	186	166	76	51	70	188	384	114
8	5	1	2	5	2	125	36	58	37	34	23	32	111	136	106	99	57	37	52	150	303
9	2	4	1	1	0	1	73	29	45	21	25	15	16	67	66	55	76	45	28	41	118
10	1	1	3	0	0	0	1	55	22	28	14	13	9	8	44	33	42	58	35	22	31
11	2	1	0	0	0	0	0	0	16	24	20	5	3	3	5	6	161	106	146	56	69

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	5164	531	1243	1496	946	3218	4921	1311	0
2	1154	4226	434	1015	1224	766	2632	4027	1071
3	143	932	3420	354	820	987	614	2141	3276
4	47	113	736	2673	283	658	798	493	1722
5	76	37	89	572	2103	225	528	647	395
6	16	56	29	71	448	1621	174	426	522
7	38	13	42	23	56	350	1227	141	345
8	89	30	10	31	19	44	267	926	115
9	240	69	24	8	23	15	33	214	711
10	94	186	53	19	6	16	11	27	173
11	55	140	193	145	74	86	39	53	64

Table 10: Mean Biomass of Atlantic mackerel (000's MT) estimated by ADAPT.

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	34.7	22.4	24.1	32.4	77.8	223.3	660.4	247.3	236.2	130.8	151.7	109.0	190.3	211.9	42.7	15.1
2	33.8	40.3	28.0	32.6	43.1	95.8	350.9	741.5	271.4	285.9	189.0	161.6	113.6	200.8	224.3	67.6
3	133.5	34.6	44.0	32.7	38.0	43.6	116.5	325.9	623.7	295.8	312.9	148.1	121.6	84.5	151.4	259.2
4	9.8	119.9	34.8	47.1	35.1	36.7	41.8	86.6	240.1	496.0	309.3	217.1	101.4	68.7	58.2	140.2
5	6.3	6.9	108.0	34.2	47.2	31.8	37.9	28.6	56.5	169.6	377.9	199.5	154.6	64.9	40.3	50.5
6	1.6	5.1	4.4	98.3	30.9	40.1	32.3	28.0	20.2	40.0	122.8	194.3	126.7	98.0	43.1	32.0
7	1.1	1.0	3.5	2.1	84.2	23.5	41.0	24.2	19.8	14.7	27.8	72.4	109.3	71.1	63.6	38.6
8	2.6	0.6	0.6	0.8	0.9	56.4	22.2	31.6	15.2	15.4	11.9	13.2	51.1	52.3	41.2	54.9
9	1.0	1.8	0.1	0.1	0.0	0.5	45.9	16.5	19.9	9.8	12.2	6.9	7.1	31.4	27.0	32.3
10	0.4	0.7	1.4	0.0	0.0	0.0	0.4	31.0	10.4	12.3	7.4	6.0	4.2	3.5	19.4	20.1
11	1.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	7.9	11.2	11.2	2.6	1.4	1.5	2.1	3.5
1+	226.1	234.0	249.1	280.4	357.3	551.7	1349.2	1561.2	1521.4	1481.4	1534.0	1130.8	981.3	888.6	713.1	714.2

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	9.3	37.2	12.8	24.0	194.5	458.6	47.1	124.9	107.1	91.2	291.5	445.9	123.4
2	30.7	10.7	58.1	21.7	55.5	267.1	617.1	102.0	213.8	231.2	152.6	549.3	749.6
3	113.1	46.5	17.3	61.6	28.8	61.0	280.7	839.6	110.7	232.6	305.0	206.8	638.7
4	317.8	120.4	43.0	14.1	53.7	24.7	52.9	270.8	869.9	102.2	241.0	298.1	198.9
5	141.2	315.9	103.4	36.1	12.4	41.3	20.6	44.5	229.4	761.0	89.9	225.3	277.8
6	47.7	129.7	274.4	86.1	32.3	9.5	32.0	16.8	36.7	200.5	684.7	79.8	202.8
7	27.2	39.5	113.1	230.3	74.6	24.1	7.8	24.6	13.3	24.9	179.1	565.7	79.6
8	33.6	23.2	32.4	94.1	195.1	55.8	19.2	5.8	19.5	11.7	26.5	151.1	465.3
9	44.7	29.8	19.5	25.7	75.7	149.5	42.9	15.8	5.4	14.4	9.7	22.4	127.2
10	25.9	39.5	23.1	14.8	20.2	60.0	116.9	33.8	12.8	3.7	11.8	7.9	17.1
11	103.6	76.8	101.5	39.6	49.3	36.5	92.9	124.8	95.0	49.8	58.2	28.7	39.3
1+	894.9	869.3	798.7	648.0	792.2	1188.1	1329.9	1603.5	1713.5	1723.3	2050.0	2581.0	2919.8

Table 11: Mackerel catch and stock size projections (in 000's MT) for three levels of recruitment and two fishing mortality rates.

	1991 (F=F90)			1992			1993
Recruitment	F	Land.	SSB	F	Land.	SSB	SSB
LOW= 305	0.02	38	3028	F90 = 0.02	41	2943	2702
	0.02	38	3028	F0.1=0.27	579	2557	1891
MID=1096	0.02	38	3028	F90 =0.02	42	3008	2930
	0.02	38	3028	F0.1=0.27	611	2688	2114
HIGH=3942	0.02	38	3028	F90 =0.02	96	3240	3748
	0.02	38	3028	F0.1=027	587	2619	2093

Mackerel Recruitment Age 1
62-89 year classes

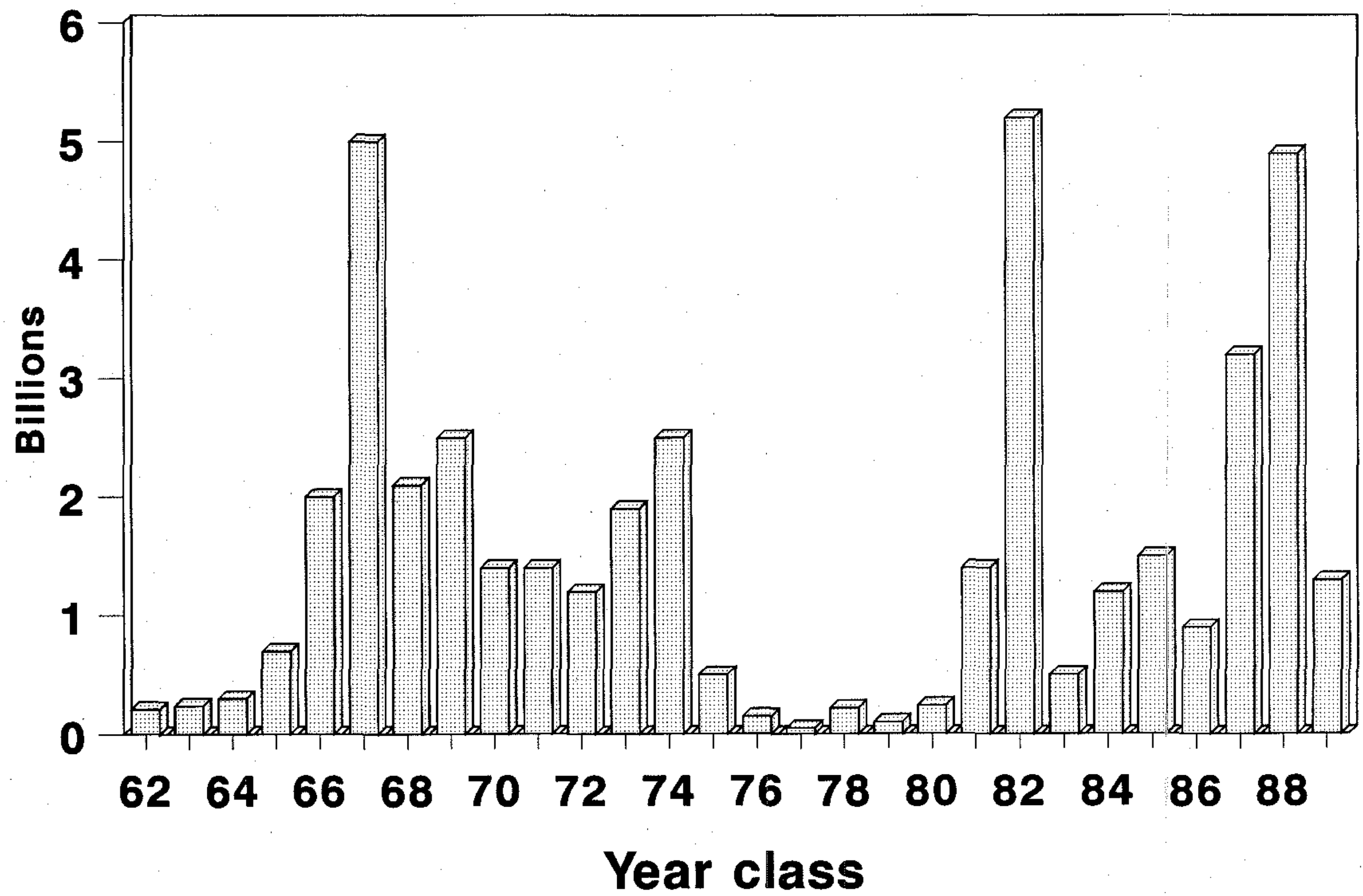

Figure 1: Recruitment (age 1) for Atlantic mackerel 1962-89.

Papers of the Northeast Regional
Stock Assessment Workshops

Stock Assessment of Short-finned Squid, *Illex Illecebrosus*, in the Northwest Atlantic

by

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/6

I. Introduction

A. Stock Definition

The short-finned squid (*Illex illecebrosus*) population is assumed to constitute a unit stock throughout its range of commercial exploitation from Cape Hatteras to Newfoundland. Illex migrate offshore in late autumn and return to nearshore waters in the summer to feed. Illex appear to have a cross-over life cycle where squid hatched in the winter spawn in the summer of the following year, and squid hatched in the summer spawn in the winter of the following year (Mesnil 1977; Lange and Sissewine 1981). Although the location of spawning grounds have not been determined, it is likely that most spawning takes place south of Cape Hatteras (Black et al. 1987).

History of the Fishery

Domestic landings of Illex began in the 1800's as a bait fishery. From 1928 to 1967, annual squid landings from Maine to North Carolina (including *Loligo pealei*) averaged roughly 2,000 m.t. Directed foreign fishing for Illex began in 1972, and from 1972 to 1982 total Illex landings averaged 19,000 m.t. From 1983 to 1990, Illex landings have averaged 8,000 m.t. Table 1 and Figure 1 show domestic and foreign landings of Illex from 1963 to 1990. Since 1982 directed foreign effort has been curtailed, and at present, the Illex fishery is an entirely domestic fishery.

B. Current Fishing Activity

Domestic landings were a record 11,316 m.t. in 1990. This is an increase of 66% over 1989 landings and is 55% above the average domestic landings from 1982-1990. Domestic Illex landings in NAFO subareas 5 and 6 were 1,003 and 10,313 m.t.during 1990, respectively. This represents an increase of 957% and 54% over 1989 landings in subareas 5 and 6, respectively. Table 2 and Figure 2 show Illex landings by U.S. statistical area and month for 1990. Overall, 1990 landings increased in all areas except area 53 with the majority of landings (81%) occurring south of Delaware Bay (areas 621-632). In comparison to 1989 when virtually all (99%) of the landings taken from June to September, the 1990 season extended into November with roughly 16% of the total landings taken in October and November (Table 2).

A total of 340.6 m.t. of squid were landed in 1990 without being identified as Illex or Loligo squid. Of this total, 251.2 m.t. were likely to be Illex based on a proration of unclassified squid by area and month (Appendix 1).

Table 3 and Figures 4 and 5 show Illex catch per unit effort (CPUE) statistics for total and directed effort, where directed effort is defined as total landings (m.t.) per total days fished in trips by vessels over 5 G.R.T. that land over 95% Illex. In comparison to 1989, directed effort increased by 187% in 1990, while directed CPUE fell by 45%. The decrease in CPUE in 1990 is likely the result of the substantial increase in directed and total effort (Table 3) reducing availible concentrations of *Illex* and the extension of the fishing season into November. The increase in directed and total effort for *Illex* is likely to be the result of enhanced export opportunities for U.S. *Illex* in the world squid market (MAFMC 1990A).

C. Current Management Plan

Illex are managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1990, the maximum optimum yield and the allowable biological catch for *Illex* were 30,000 and 22,500 m.t., respectively. The domestic allowable harvest was 15,000 m.t. (MAFMC 1989). For 1991, the domestic allowable harvest has been increased to 18,000 m.t. (MAFMC 1990A).

Overfishing for *Illex* is defined to occur when the three year moving average of pre-recruits from the NEFC fall bottom trawl survey falls within the lowest quartile of this time series (MAFMC 1990B). Using this definition, *Illex* would have been overfished in 1990 if the average of the pre-recruit indices from 1988, 1989, and 1990 fell below the 6th lowest value of the pre-recruit index (Table 4).

D. Reference to Previous Assessments

The previous definition of directed CPUE for *Illex* was restricted to trips in areas 622 through 636 (NEFC 1990, see Figure 21). In 1990, significant *Illex* catches were made in areas 525, 526, 615, 616, and 621 so the directed CPUE index for *Illex* was redefined to be the total landings per day fished for trips landing more than 95% *Illex* in any statistical area.

II. Data Sources

A. Commercial Fishery Data

Landings data for 1989 and 1990 were collected from Joint Venture, general canvass, and NMFS weighout databases. Landings data for 1963-1988 were collected from the Report of the 10th SAW (NEFC 1990). Effort data used in CPUE calculations for 1982-1990 were collected from NMFS weighout databases.

B. Research Survey Data

Research survey data for 1967-1990 were collected from the NEFC survey database.

III. Analysis

A. Abundance and Mortality

Indices of relative abundance for *Illex* are the stratified mean number per tow of all sizes and pre-recruits ($\leq$ 10 cm.) obtained in the NEFC autumn bottom trawl survey. Table 4 shows these indices for 1967-1990.

The 1990 all sizes index is 74% above the 1967-1990 mean, while the pre-recruit index is equal to the 1967-1990 mean. In comparison to 1989, the 1990 all sizes increased by 10%, while the pre-recruit index dropped by 37%. Over the 24 year span of fall survey data, the *Illex* all sizes index has remained at either relatively high (1975 to 1981 and 1987 to present) or relatively low (1967 to 1974 and 1982 to 1986) levels (Table 4). The all sizes index is positively correlated with directed (r=0.70) and total (r=0.67) CPUE indices from 1982 to 1990. This suggests that the all sizes index provides a rough measure of population abundance and subsequent availability to domestic commercial effort.

Total instantaneous mortality rates for *Illex* are not presented because the relative amount of *Illex* mortality due to predation is unknown, but is likely to be substantial given the mid-level position of *Illex* in the food web (Ennis and Collins 1978). Further, the relative amount of *Illex* mortality due to cannibalism is unknown, but may be substantial for smaller individuals (Maurer and Bowman 1985).

B. Biological Reference Points

At present, conservative biological reference points are necessary for *Illex* given their short life-span. The three year moving average of the pre-recruit index provides one reference point for *Illex* production, and this moving average was 1.256 for 1990. This is 417% of the 6th lowest pre-recruit index (0.301 in 1971) indicating that *Illex* were not overfished relative to the MAFMC definition. Further, it will be impossible for *Illex* to be overfished in 1991 and 1992 because of high pre-recruit indices in 1989 and 1990 (1.938 and 1.179) in comparison to minimum potential value of the 6th lowest pre-recruit index in 1991 and 1992 (at least 0.233 and 0.157, respectively).

IV. Discussion

It is likely that *Illex* abundance will remain high in 1991 given that the 1990 all sizes and pre-recruit indices are at above average and average levels, respectively, and that the all sizes abundance index appears to remain at either high or low levels for several consecutive years. It is interesting that the only recorded shift in *Illex* abundance from high to low in 1982 followed the highest value of the all sizes index (61.9) and the lowest value of the pre-recruit ratio (0.01). However, it is not clear whether conditions in 1990 were sufficiently similar to those in 1981 to predict whether such a shift will occur in 1991. Nonetheless, domestic Illex landings in 1990 were below those of the foreign distant water fleets during the 1972-1982 period when Illex abundance shifted from low to high levels and then back to low levels, so the portion of the Illex resource available in U.S. waters is presently underexploited relative to its historic yields. In the future, increased marketing opportunities for Illex may lead to overfishing. However relative to the MAFMC definition, overfishing cannot occur for at least 2 years.

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Table 1. Annual short-finned squid landings (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the domestic and foreign fleets, 1963-90.

Year	Domestic	Foreign	Total
1963	810	0	810
1964	358	2	360
1965	444	78	522
1966	452	118	570
1967	707	285	992
1968	678	2,593	3,271
1969	562	975	1,537
1970	408	2,418	2,826
1971	455	159	614
1972	472	17,169	17,641
1973	530	18,625	19,155
1974	148	20,480	20,628
1975	107	17,819	17,926
1976	229	24,707	24,936
1977	1,024	23,771	24,795
1978	385	17,310	17,695
1979	1,780	15,742	17,522
1980	349	17,529	17,878
1981	631	14,723	15,354
1982	5,902	12,350	18,252
1983	9,944	1,776	11,720
1984	9,547	676	10,223
1985	4,997	1,053	6,050
1986	5,176	250	5,422
1987	10,260	0	10,260
1988	1,966	1	1,967
1989	6,802	0	6,802
1990	11,316	0	11,316

Table 2. 1990 Illex landings by month and U.S. statistical area from NMFS weighout data

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
512	0	0	0	0	0	0	0	0.5	0	0	0	0	0.5	0.0%
513	0	0	0	0	0	0	0	0.4	0	0.1	0.1	0	0.5	0.0%
522	0	0	0	0	0	0	0	0.7	0	0	0	0	0.7	0.0%
525	0	0	0	0	161.3	0.3	0	0	0	0	0	0	161.7	1.4%
526	0	0	0	0	0	0	0	0	816.9	0	0	0	816.9	7.2%
537	0	0	0	0	0	0	0	21.9	0	0	0.9	0	22.7	0.2%
538	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
613	0	0	0	0	0	0	0	0	0.1	1.5	0	0	1.6	0.0%
615	0	0	0	0	0	0	0	0	461.9	0	0	0	461.9	4.1%
616	0	0	0	0	0	0	0.3	448.9	139.5	87.2	0	0	675.9	6.0%
621	0	0	0	0	0	0	0	0	0	0	223.8	30.3	254.1	2.3%
622	0	0	0	0	29.4	994.8	2724.0	1869.8	1442.9	1265.2	0.1	1.6	8327.8	73.6%
626	0	0	0	0	0	24.0	145.4	49.2	89.3	182.3	31.2	0.9	522.2	4.6%
632	0	0	0	0	0	0	0	32.7	0	0	36.5	0	69.2	0.6%
TOTALS	0	0	0	0	190.8	1019.2	2869.7	2423.9	2950.6	1536.3	292.4	32.8	11315.7	
PERCENT	0.0%	0.0%	0.0%	0.0%	1.7%	9.0%	25.4%	21.4%	26.1%	13.6%	2.6%	0.3%		

Table 3. Directed and total catch per unit effort (m.t./day fished) for Illex during 1982-1990 in the domestic fishery

	Directed		Total	
Year	CPUE	Days Fished	CPUE	Days Fished
1982	33.0	98.0	6.0	589.3
1983	21.9	58.8	5.8	245.0
1984	50.6	63.7	14.3	229.9
1985	27.8	49.6	13.0	187.5
1986	44.6	85.3	15.2	289.1
1987	55.6	115.0	24.6	282.6
1988	52.9	26.1	12.3	158.6
1989	65.0	99.0	39.9	170.5
1990	35.5	283.8	25.6	441.8
Average	43.0	97.7	17.4	288.3

Table 4. Short-finned squid abundance and pre-recruit indices from NEFC autumn surveys, 1967-1990.

Year	Mean Number Per Tow[1] Total	Pre-Recruit	Pre-Recruit Ratio[2]
1967	2.1	0.1	0.03
1968	2.3	0.2	0.07
1969	0.8	0.1	0.17
1970	3.4	1.5	0.43
1971	1.9	0.3	0.16
1972	3.5	1.1	0.30
1973	1.3	0.1	0.05
1974	3.0	1.8	0.60
1975	12.4	6.2	0.50
1976	28.7	0.6	0.02
1977	15.8	1.1	0.07
1978	29.4	5.1	0.17
1979	32.1	2.6	0.08
1980	17.1	0.7	0.04
1981	61.9	0.4	0.01
1982	4.7	1.3	0.24
1983	2.8	0.2	0.08
1984	6.4	0.4	0.07
1985	2.0	0.3	0.17
1986	3.2	0.5	0.16
1987	30.0	1.3	0.04
1988	24.0	0.7	0.03
1989	22.2	1.9	0.09
1990	24.5	1.2	0.05
Average	14.1	1.2	0.15

[1] Stratified mean number per tow of all size individuals (total) and of pre-recruits (≤10cm), Mid-Atlantic to Georges Bank.

[2] Ratio of pre-recruits to total mean numbers per tow.

Figure 1. Illex landings 1963-1990 from Cape Hatteras to the Gulf of Maine

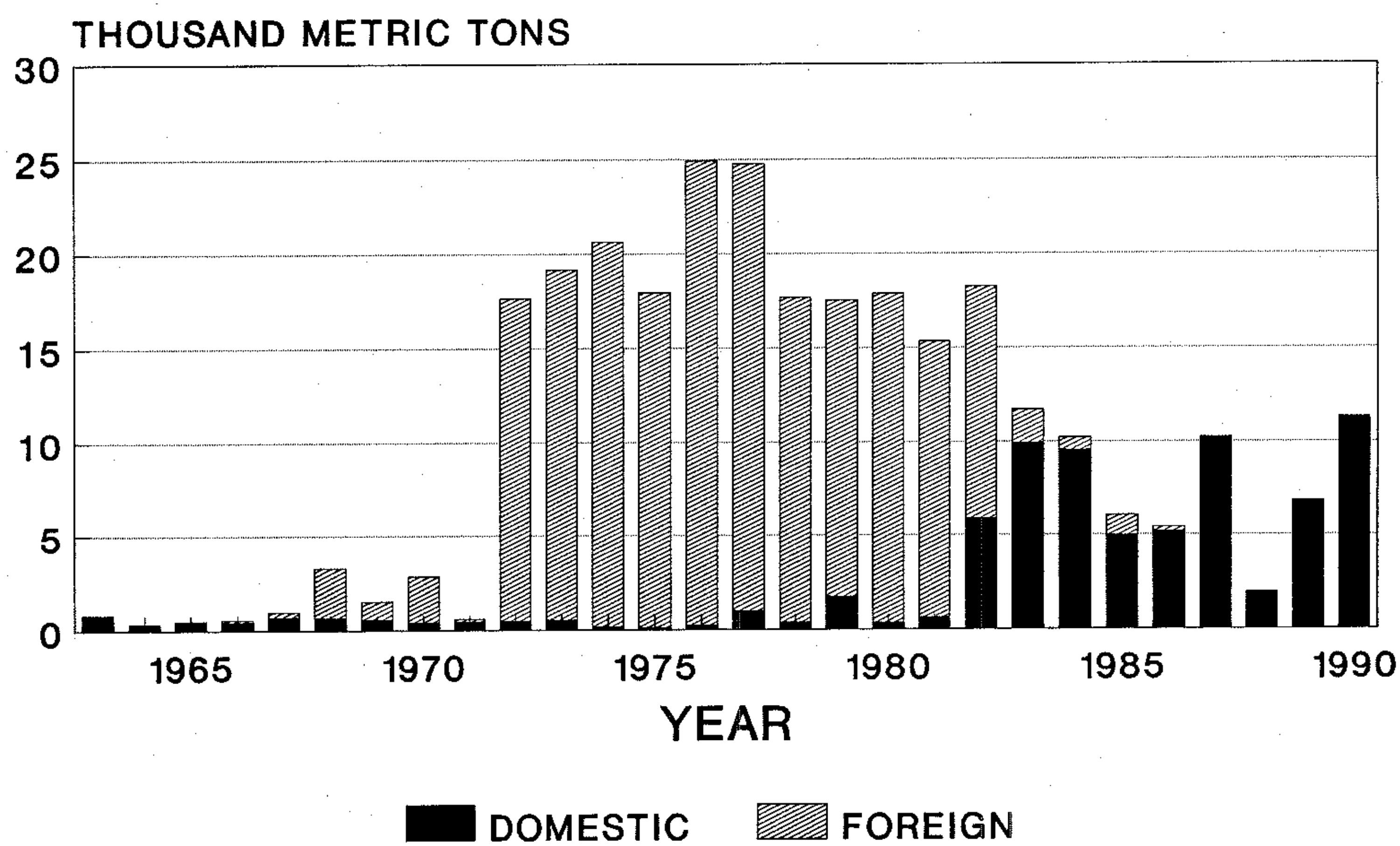
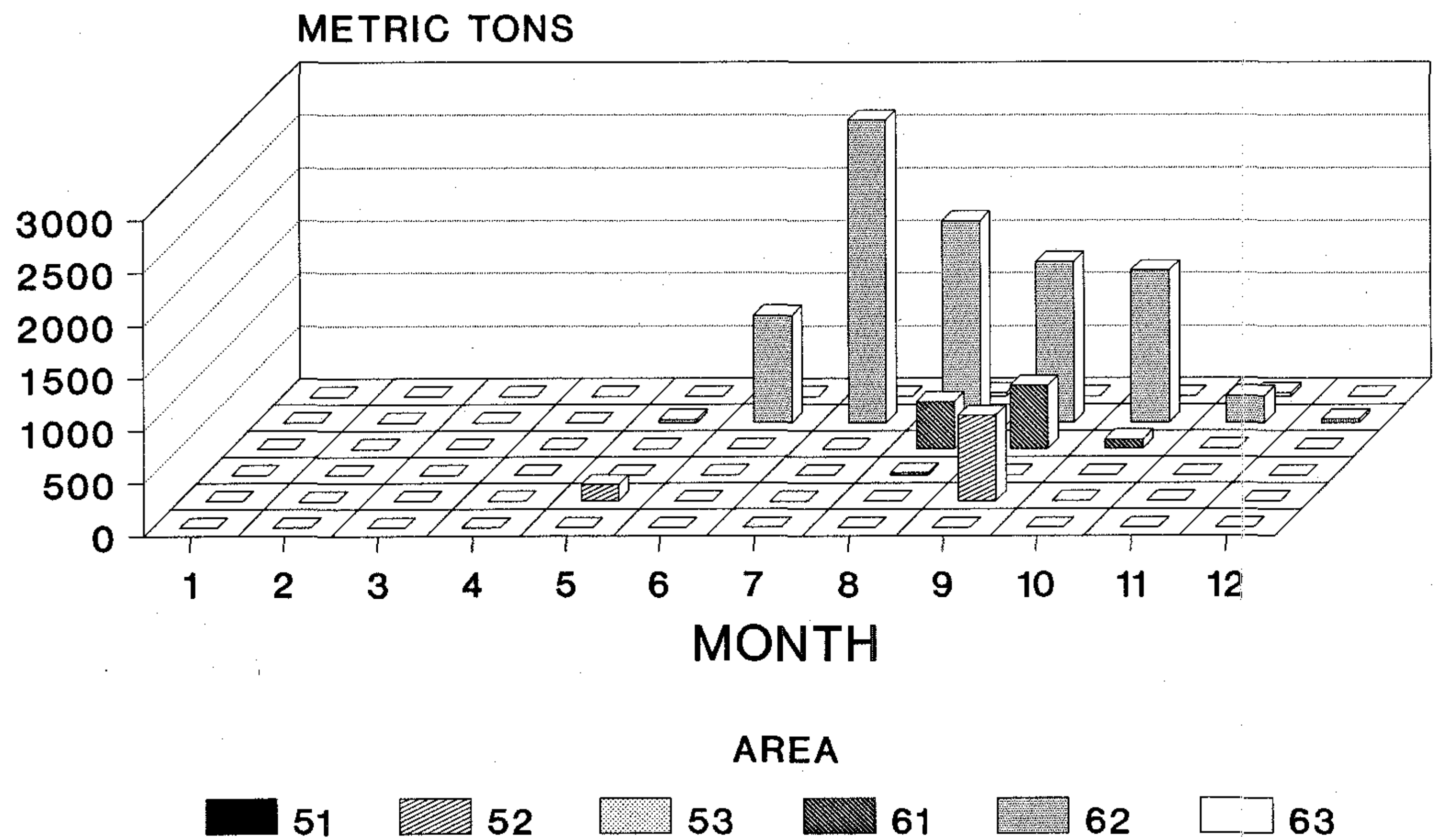


Figure 2. 1990 Illex landings

By area and month



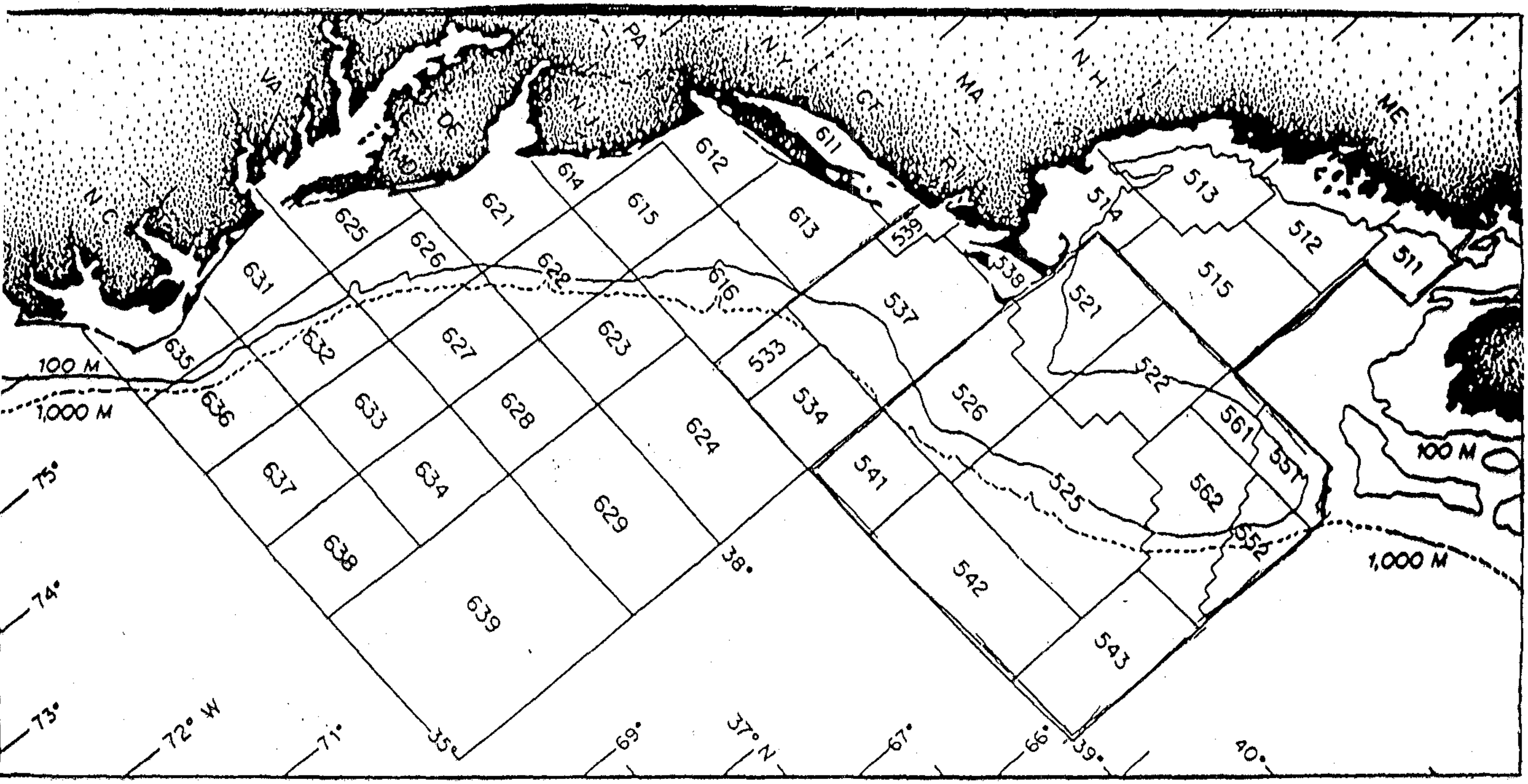
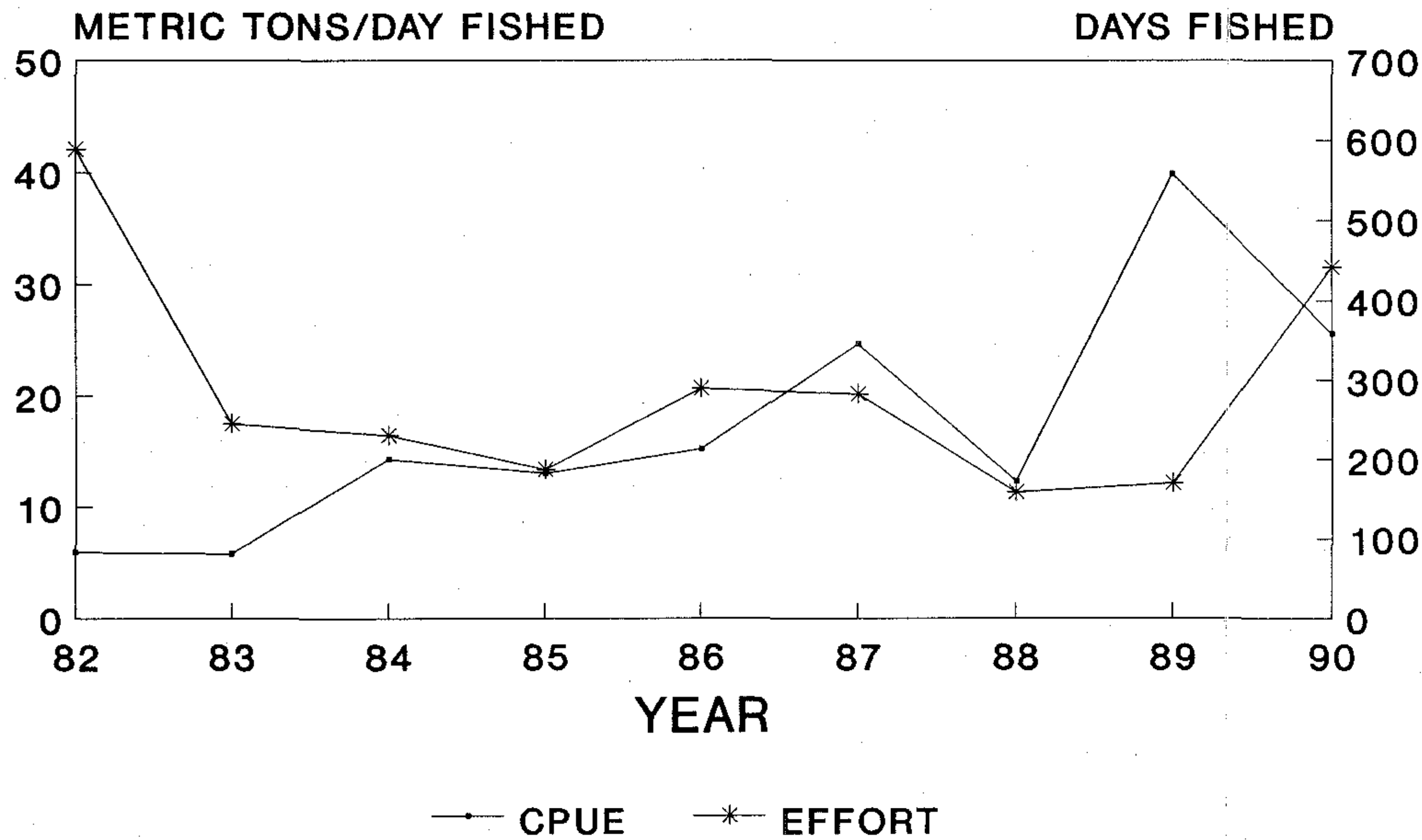


Figure 3. Statistical areas used for reporting Illex landings.

Figure 4. Illex CPUE 1982-1990

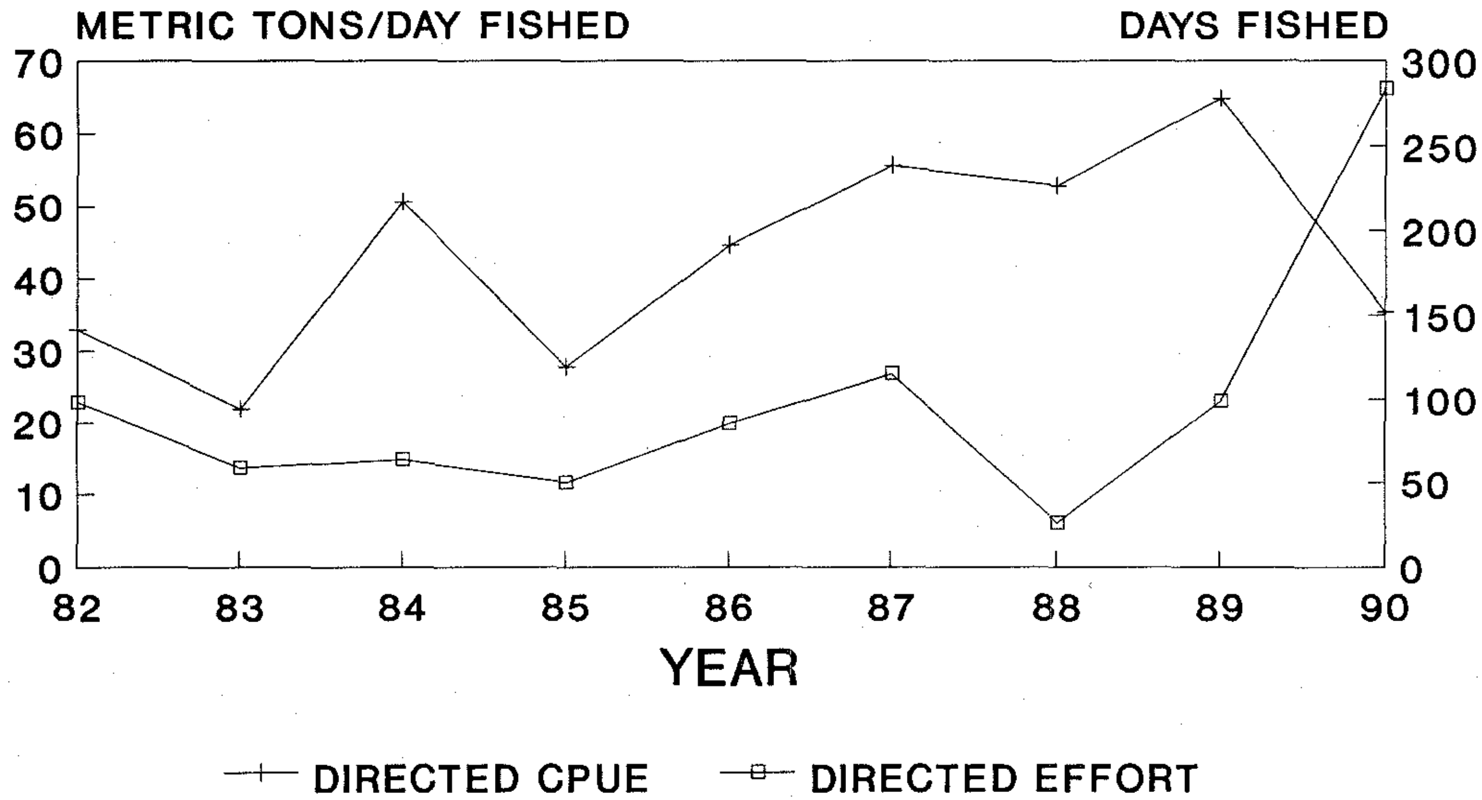
All trips



Includes all trips that landed Illex

Figure 5. Illex CPUE 1982-1990

Directed trips



Directed trips are defined as trips where more than 95% of the total landings were Illex

Appendix 1. Proration of unclassified squid to Illex squid.

Unclassified squid landings in 1990 (TOTALS IN 100'S LBS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0	0	1	0	926	21	8	3	3	11	27	28	1027
52	0	0	0	0	0	5	20	83	0	0	0	5	113
53	0	32	0	120	0	19	0	0	0	0	2	0	173
61	96	160	0	0	0	0	0	0	0	0	0	0	256
62	109	37	96	169	538	1270	4	1	5	3707	3	0	5938
63	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	205	229	97	289	1464	1315	32	87	8	3718	32	33	7507

Illex proportion of total Loligo and Illex landings by month and statistical area in 1990 determines the proportion of unclassified squid assigned to Illex

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.950	0.000	0.025	0.077	0.000	0.289
52	0.000	0.000	0.000	0.000	0.949	0.121	0.000	0.070	0.998	0.000	0.000	0.000	0.858
53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.091	0.000	0.000	0.002	0.000	0.003
61	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.574	0.731	0.103	0.000	0.000	0.189
62	0.000	0.000	0.000	0.000	0.248	0.784	0.925	0.960	0.947	0.930	0.469	0.115	0.759
63	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.690	0.000	0.000	0.250	0.000	0.210
TOTAL	0.000	0.000	0.000	0.000	0.093	0.462	0.711	0.787	0.738	0.479	0.203	0.028	0.431

Unclassified squid landings assigned to Illex (TOTALS IN 100'S OF POUNDS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0	0	1[1]	0	926[1]	0	8[1]	2.8	0	0.3	2.1	0	940.2
52	0	0	0	0	0	0.60	0	5.85	0	0	0	0	6.45
53	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00
61	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	133.6	996.1	3.7	1.0	4.7	3446.9	1.4	0	4587.4
63	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	0	1059.7	996.6	11.7	9.7	4.7	3447.2	3.5	0	5534.1

Unclassifed squid assigned to Illex (TOTALS IN METRIC TONS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0.00	0.00	0.05[1]	0.00	42.0[1]	0.00	0.36[1]	0.13	0.00	0.01	0.09	0.00	42.65
52	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.27	0.00	0.00	0.00	0.00	0.29
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	6.06	45.18	0.17	0.04	0.21	156.3	0.06	0.00	208.08
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	0.00	0.00	0.05	0.00	48.07	45.21	0.53	0.44	0.21	156.4	0.16	0.00	251.02

[1]No Loligo or Illex squid were landed in the Gulf of Maine in these months. Unclassified squid landed in these months are assigned to Illex based on the more northerly distribution of Illex in the Northwest Atlantic.

Papers of the Northeast Regional
Stock Assessment Workshops

Stock Assessment of Long-Finned Squid, *Loligo pealei*, in the Northwest Atlantic

by

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/7

SAW/12/SARC/7

I. Introduction

A. Stock Definition

Long-finned squid (*Loligo pealei*) range from Nova Scotia to the northern coast of South America. Loligo are assumed to constitute a unit stock throughout their range of commercial exploitation in the Northwest Atlantic from Nova Scotia to Cape Hatteras. North of Cape Hatteras, Loligo migrate offshore during late autumn to overwinter and migrate inshore during the spring or summer with larger squid moving inshore before smaller squid. In general, differences in migratory timing can be attributed to the cross-over life cycle of Loligo (Mesnil 1977). In this cross-over pattern, most spring-spawned hatchlings return to spawn in the summer of the following year, whereas hatchlings spawned in late-summer return to spawn in the spring two years later.

B. History of the Fishery

The domestic fishery for Loligo off the Northeastern United States began in the late 1800's with squid being mostly used for bait. From 1928 to 1967, annual squid landings from Maine to North Carolina (including *Illex illecebrosus* landings) averaged roughly 2,000 m.t. A directed foreign fishery for Loligo developed in 1967, and foreign fishing fleets exploited Loligo throughout the 1970's and early 1980's. Table 1 and Figure 1 show annual Loligo landings in the Northwest Atlantic from 1963-1990. Annual landings averaged 19,900 m.t. from 1967 to 1986. Since 1986, foreign fishing has been curtailed, and domestic landings have averaged 17,300 m.t. At present, the Loligo fishery is an entirely domestic fishery.

C. Current Fishing Activity

Domestic landings totaled 15,469 m.t. in 1990. This is a decrease of 33% from the record level of domestic landings in 1989 (Table 1). Loligo landings in NAFO subareas 5 and 6 were 6,901 and 8,568 m.t. during 1990, respectively. This represents a decrease of 37% and 29% over 1989 landings in subareas 5 and 6, respectively.

Table 2 and Figure 2 show Loligo landings by area and month for 1990. Overall, landings were lower in all areas during 1990 in comparison to 1989. In particular, 1990 landings in areas 52, 53, 61, and 62 dropped to 162, 6737, 4879, and 2892 m.t. from 2411, 8516, 7722, and 3891 m.t. in 1989, respectively. Tables 3.1 to 3.5, and Figure 4 show the breakdown of 1990 landings by market category. In comparison to 1989, landings of large, small, and unclassified Loligo fell by 16%, 86%, and 26%, respectively, while no medium Loligo were landed in 1989.

A total of 340.6 m.t. of squid were landed in 1990 without being identified as Loligo or Illex squid. Of this total, 89.4 m.t. were likely to be Loligo based on a proration of unclassifed squid landings by area and month (Appendix 1).

Table 4 shows catch per unit effort (CPUE) statistics for the directed domestic Loligo fishery during 1982-1990, where directed effort is defined as total landings (m.t.) per total days fished in trips by vessels over 5 G.R.T. that land over 75% Loligo. In 1990, directed CPUE decreased by 41% to 6.92 m.t./day fished, and the number of directed trips fell by 24% to 848 trips. The 1990 CPUE index is the 2nd lowest for the 1982-1990 period and follows 2 years with relatively high CPUE indices (Table 3). The number of directed trips in 1990 was higher than the 1982-1990 average ~~reflecting an increase in the number of directed trips since 1988.~~

The domestic fishery for Loligo has changed over the past decade as directed foreign fishing activity has ceased. Figure 5 shows domestic CPUE for 1982-1990 for all trips that landed Loligo excluding negligible landings in area 56 (northeast peak of Georges Bank). In particular, CPUE has increased in areas 61 and 62 in recent years (Figure 5), while CPUE has remained relatively steady in area 53 and fluctuated in areas 51, 52, and 63. An examination of average CPUE (Figure 6), where CPUE is averaged over all trips landing Loligo, shows a similar pattern. Loligo has also been retained as a higher percentage of total landed weight in trips that land Loligo within areas 61 and 62 during the late 1980's (Figure 7). Overall, the increase in CPUE in areas 61 and 62, the recent increase in the number of directed trips, and a higher landings ratio in areas 61 and 62 may indicate a shift in fishing effort from other species to Loligo in the Mid-Atlantic region.

D. Current Management Plan

Loligo are managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1990, the maximum optimum yield and the allowable biological catch for Loligo were 44,000 and 37,000 m.t.,respectively. The domestic allowable harvest was 26,000 m.t. (MAFMC 1989). For 1991, the domestic allowable harvest has been increased to 31,000 m.t. (MAFMC 1990A).

Overfishing for Loligo is defined to occur when the three year moving average of pre-recruits from the NEFC fall bottom trawl survey falls within the lowest quartile of this time series (MAFMC 1990B). Using this definition, Loligo would have been overfished in 1990 if the average of the pre-recruit indices from 1988, 1989, and 1990 fell below the 6th lowest value of the pre-recruit index (Table 4).

E. Reference to Previous Assessments

The previous definition of directed CPUE for Loligo was restricted to trips in areas 537 through 636 (NEFC 1990, see Table 23). In 1989, there were significant Loligo landings in area 526 so the CPUE index for Loligo was redefined to be the total landings per day fished for trips landing more than 75% Loligo in any statistical area.

II. Data Sources

A. Commercial Fishery Data

Landings data for 1989 and 1990 were collected from Joint Venture, general canvass, and NMFS weighout databases. Landings data for 1963-1988 were collected from the Report of the 10th SAW (NEFC 1990). Effort data used in CPUE calculations for 1982-1990 were collected from NMFS weighout databases.

B. Research Survey Data

Research survey data for 1967-1990 were collected from the NEFC survey database.

III. Analysis

A. Abundance and Mortality

Indices of relative abundance for *Loligo* are the stratified mean number per tow of all sizes, pre-recruits (≤ 8 cm), and recruits (> 8 cm) obtained in the NEFC autumn bottom trawl survey. Table 5 shows these indices for 1967-1990.

The 1990 all sizes, pre-recruit, and recruit indices are 24%, 55%, and 16% above the 1967-1990 means, respectively. In comparison to 1989, the 1990 all sizes and recruit indices dropped by 11% and 35%, respectively, while the 1990 pre-recruit index increased by 1%. In general, these indices show that population abundance remains relatively high in comparison to periods of heavy exploitation by foreign distant water fleets (Figure 1 and Table 5).

Total instantaneous mortality rates for *Loligo* are not presented because the relative amount of *Loligo* mortality due to predation is unknown, but is likely to be substantial given the mid-level position of *Loligo* in the food web. Further, natural instantaneous mortality rates probably fluctuate seasonally in relation to predator abundance, and the relative amount of *Loligo* mortality due to cannibalism is unknown.

B. Biological Reference Points

At present, conservative biological reference points are a necessity for *Loligo* given their cross-over life cycle and short life-span. The three year moving average of the pre-recruit index provides a reference point for *Loligo* abundance, and this moving average was 289.2 for 1990. This is 185% of the 6th lowest pre-recruit index (156.5 in 1979) indicating that *Loligo* were not overfished under the MAFMC overfishing definition. Further, it will be impossible for *Loligo* to be overfished in 1991 because of high pre-recruit indices in 1989 and 1990 (271.9 and 275.7) in comparison to minimum potential value of the 6th lowest pre-recruit index in 1991 (at least 152.2).

C. Prospects for 1991

It is likely that the abundance of the fishable Loligo population is related to the value of the fall recruit index, although in some years environmental conditions may perturb this relation. For the period 1982-1990, the Loligo recruit index (stratified mean number per tow of individuals with dorsal mantle length > 8 cm) and the directed CPUE index have been moderately correlated (r=0.514). Figure 8 shows that the relation between the recruit index and the directed CPUE index for 1982-1990 is variable.

Regression analyses were performed to investigate the utility of the fall pre-recruit index and the stratified mean bottom temperature as predictors of the fall recruit index (Appendix 2). The cross correlation between the recruit and temperature series was significant at lag 4 (Part 1), while the cross correlation between the recruit and the pre-recruit series was not significant at any lag (Part 2). A regression analysis of the fall recruit series during the period 1967 to 1990 on the temperature series (Part 3), the temperature series lagged 4 years (Part 4), and the pre-recruit series lagged 1 year (Part 5) showed that the recruit index is only slightly dependent on temperature and the pre-recruit series alone. Multiple regression analyses of the dependence of the recruit series on the temperature series and the pre-recruit series lagged by 1 year (Part 6) had limited utility as a predictive model. Similarly, multiple regression analyses of the dependence of the recruit series on the temperature series lagged by 4 years and the pre-recruit series lagged by 1 year (Part 7) also had limited utility as a predictive model. In contrast however, the regression analysis of the dependence of the recruit series on year (Part 8) had the highest adjusted R^2 and indicated that there has been a significant increasing trend in the Loligo fall recruit series during 1967 to 1990.

Time series methods were also applied to the series of fall recruit indices to develop a predictive model for this index. Standard model identification procedures (Box and Jenkins 1970) were applied and numerous models were examined. The recruit series was log-transformed to stabilize its variance and then differenced to remove its time trend. For the transformed and differenced series, the best fit was obtained with an AR(2) model with no lag 1 parameter (Appendix 3). Model parameters were estimated using the recruit series from 1967-1988 to provide an in-sample forecast of the 1989 recruit index for comparison with the observed value (Part 1), and model parameters were estimated using the recruit series from 1967-1989 to provide an in-sample forecast of the 1990 recruit index for comparison with the observed value (Part 2). Model parameters were then re-estimated using the recruit series from 1967-1990 to provide an out-of-sample forecast for 1991 (Part 3). Table 6 shows the results of the in-sample and out-of-sample forecasts.

Confidence intervals for the in-sample forecasts show that the AR(2) model estimates are not very precise. This is due to the relatively small number of data points in the recruit series. Nonetheless, the 1989 and 1990 in-sample forecasts are reasonably accurate (Table 6). For the out-of-sample forecast, the relatively lower values of the predicted recruit index and the 95% confidence limits indicate that directed CPUE in 1991 is likely to be at or below that observed in recent years.

IV. Discussion

Fall survey indices indicate that the Loligo population is at relatively high levels of abundance (Table 5) in comparison to the period of heaviest exploitation in the 1970's. However, high population abundance does not necessarily imply that commercial availability of Loligo will be correspondingly high. Annual fluctuations in temperature distribution and other oceanographic variables can decrease Loligo availability to commerical fishing by increasing the spatial dispersion of the population and by altering the spatio-temporal pattern of the annual inshore/offshore migration. Preliminary landings figures for Loligo in the first quarter of 1991 are roughly 1/2 of first quarter landings in 1990. However, April landings in 1991 are above those observed in 1990 indicating either a shift in fishing activity for Loligo or seasonal shifts in Loligo availability in 1991. In summary, in spite of relatively high population abundance, it is likely that in 1991 Loligo landings and directed CPUE will be at or below levels seen in recent years.

V. Literature Cited

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Mesnil, B. 1977. Growth and life cycly of squid, *Loligo pealei* and *Illex illecebrosus*, from the Northwest Atlantic. NAFO Research Document 76/VI/65.

Mid-Atlantic Fishery Management Council. 1989. 1990 Allowable biological catch, optimum yield, domestic annual harvest, domestic annual processing, joint venture processing, and total allowable level of foreign fishing recommendations for Loligo, Illex, and Butterfish. MAFMC. Dover, DE.

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Figure 1. Loligo landings in the NW Atlantic 1963-1990

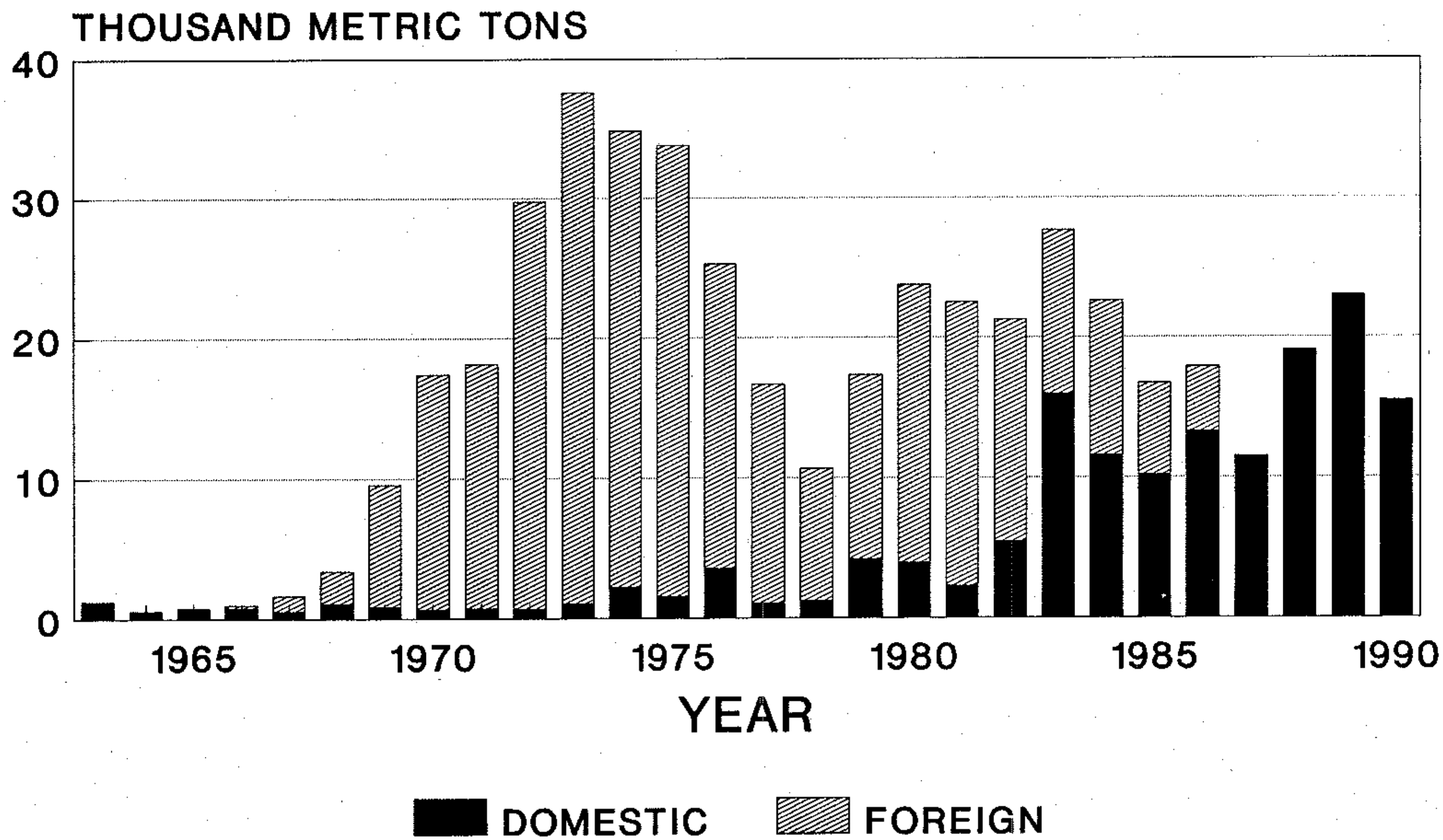
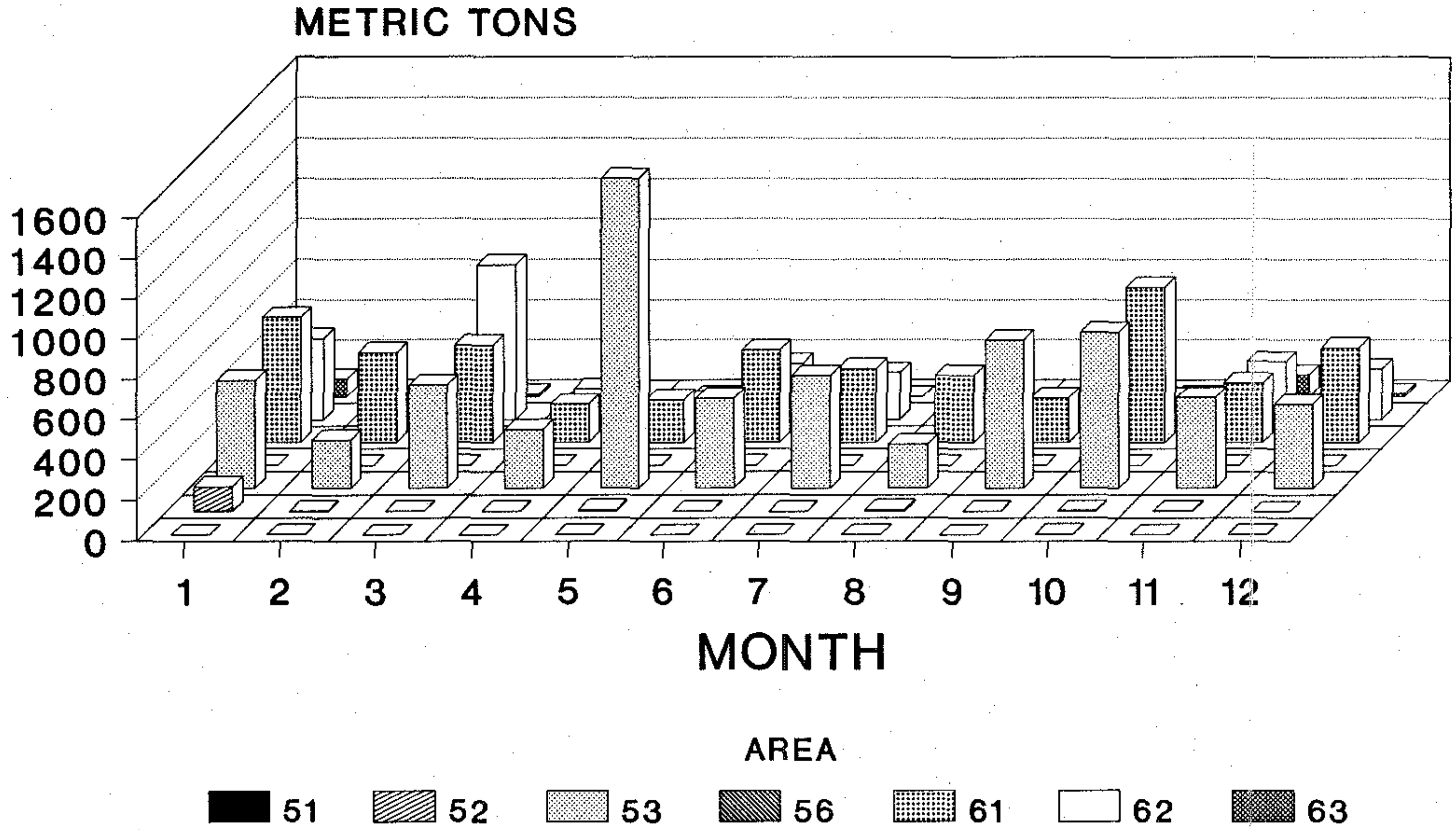


Figure 2. 1990 Loligo landings
By area and month



EXCLUDES GENERAL CANVASS AND JV DATA

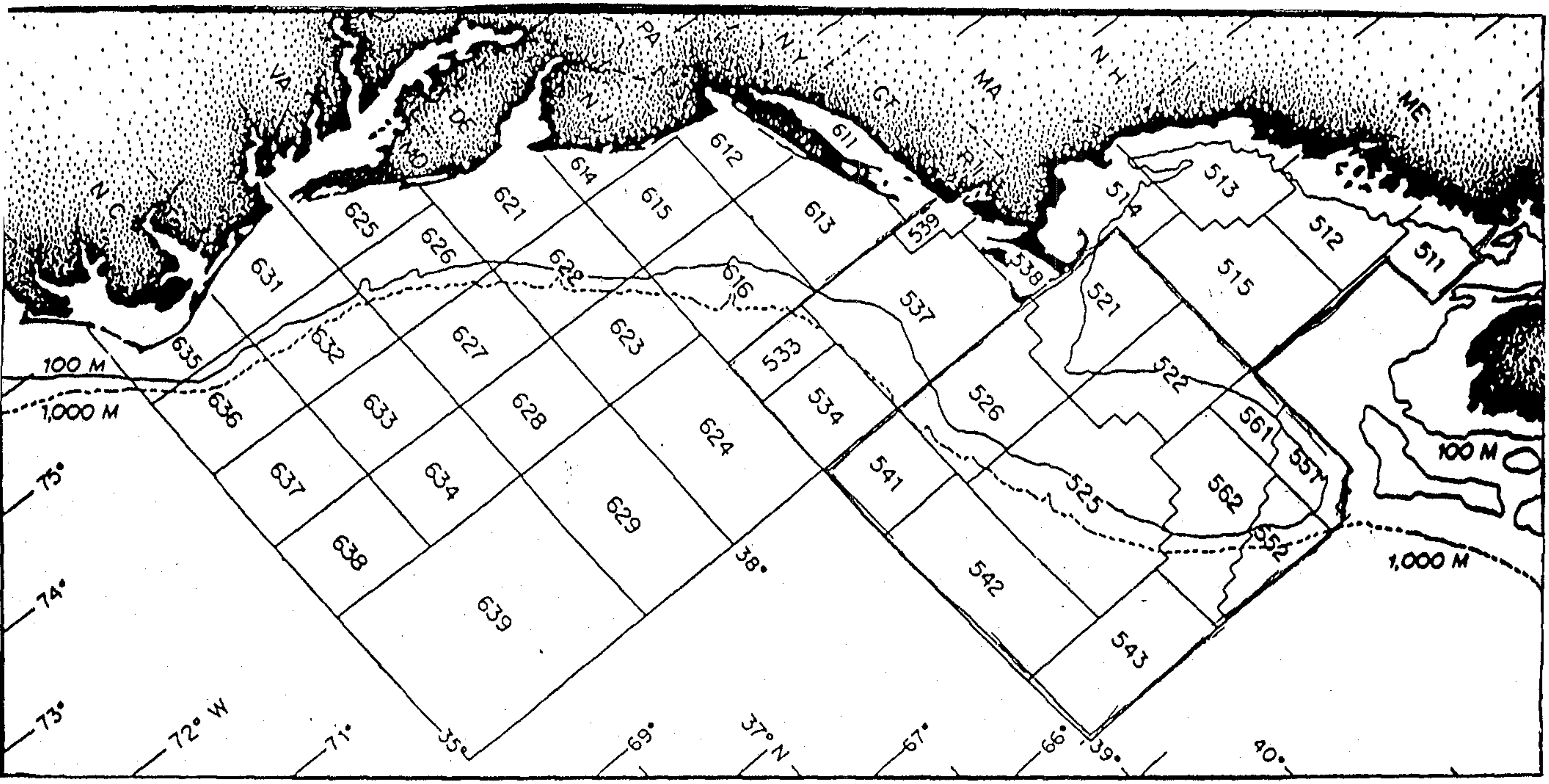
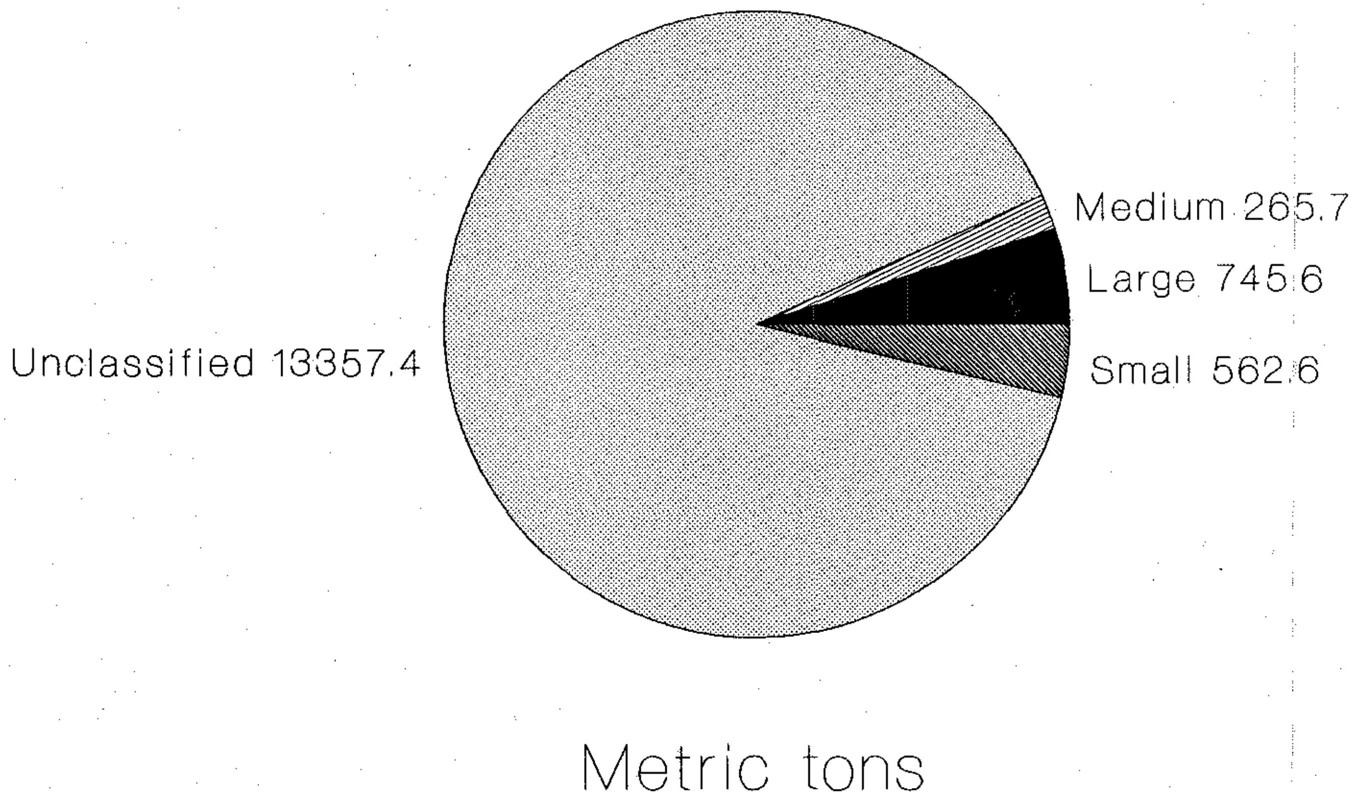


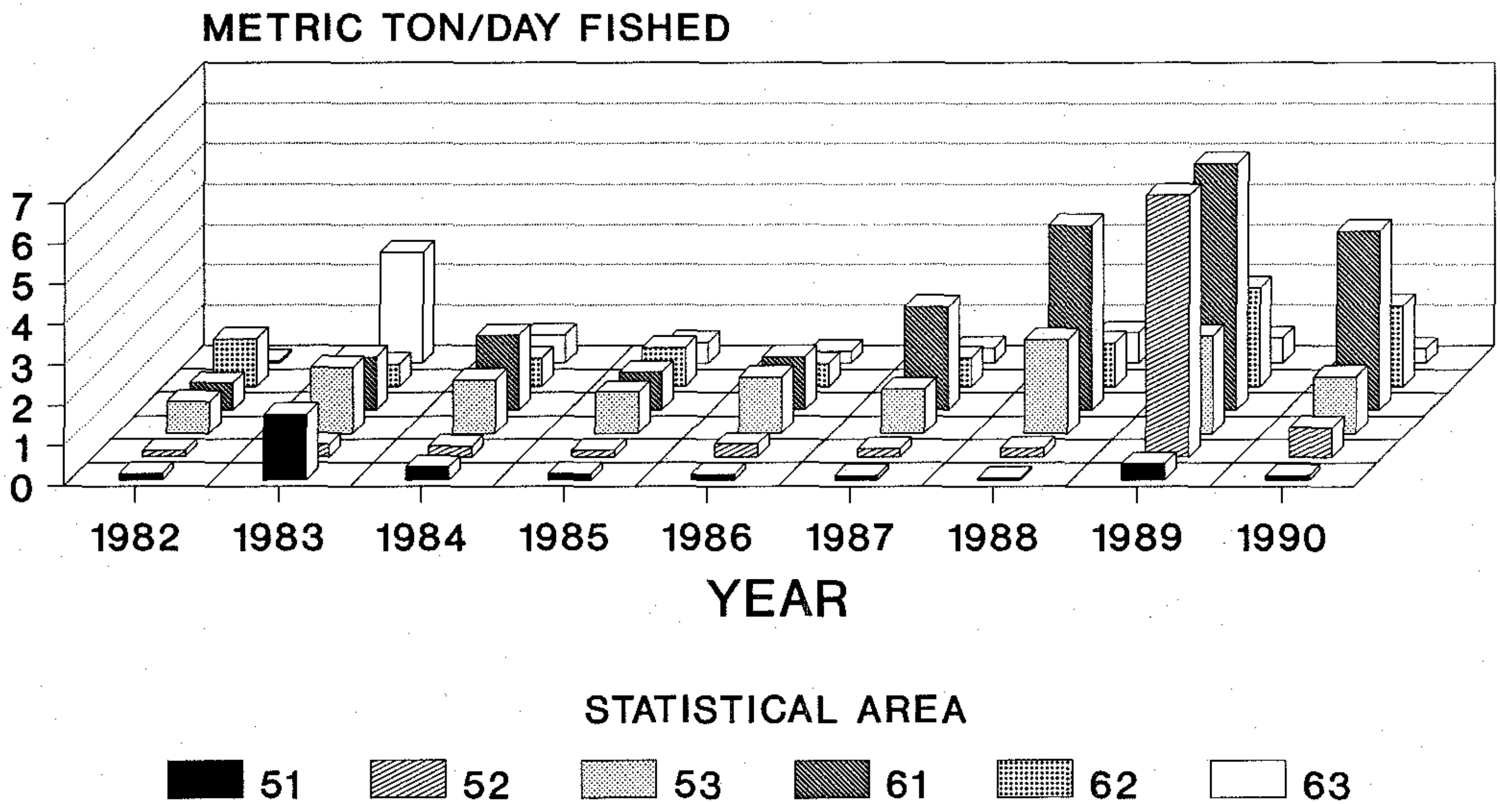
Figure 3. Statistical areas used for reporting Loligo landings.

Figure 4. Domestic Loligo Landing
By Market Category in 1990



Excludes general canvas and JV data
Large category includes extra-large
Small category includes super-small

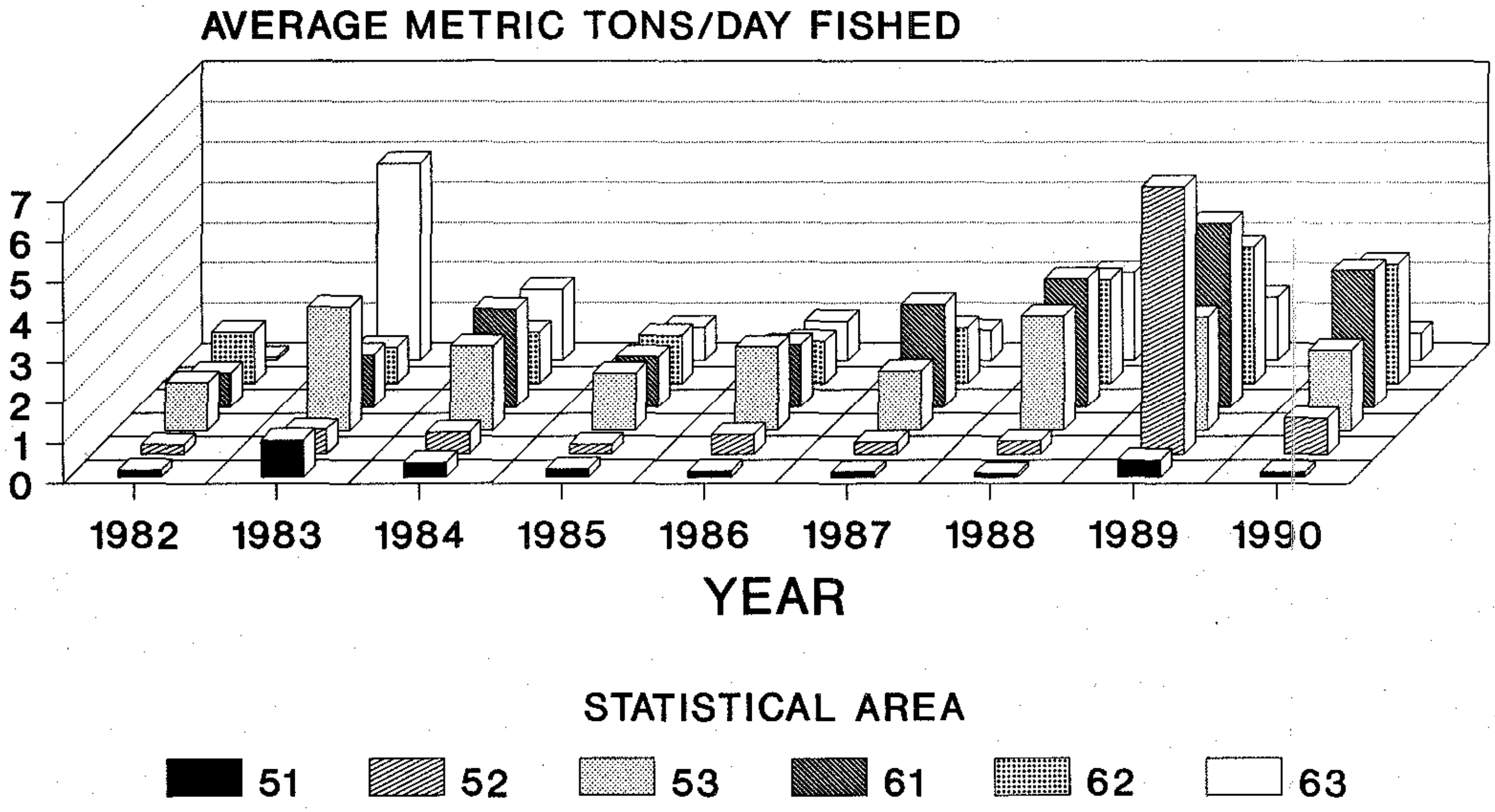
Figure 5. Loligo CPUE by area
Domestic fishery 1982-1990



EXCLUDES TRIPS TO AREA 56
CPUE IS TOTAL LANDINGS
DIVIDED BY TOTAL DAYS FISHED

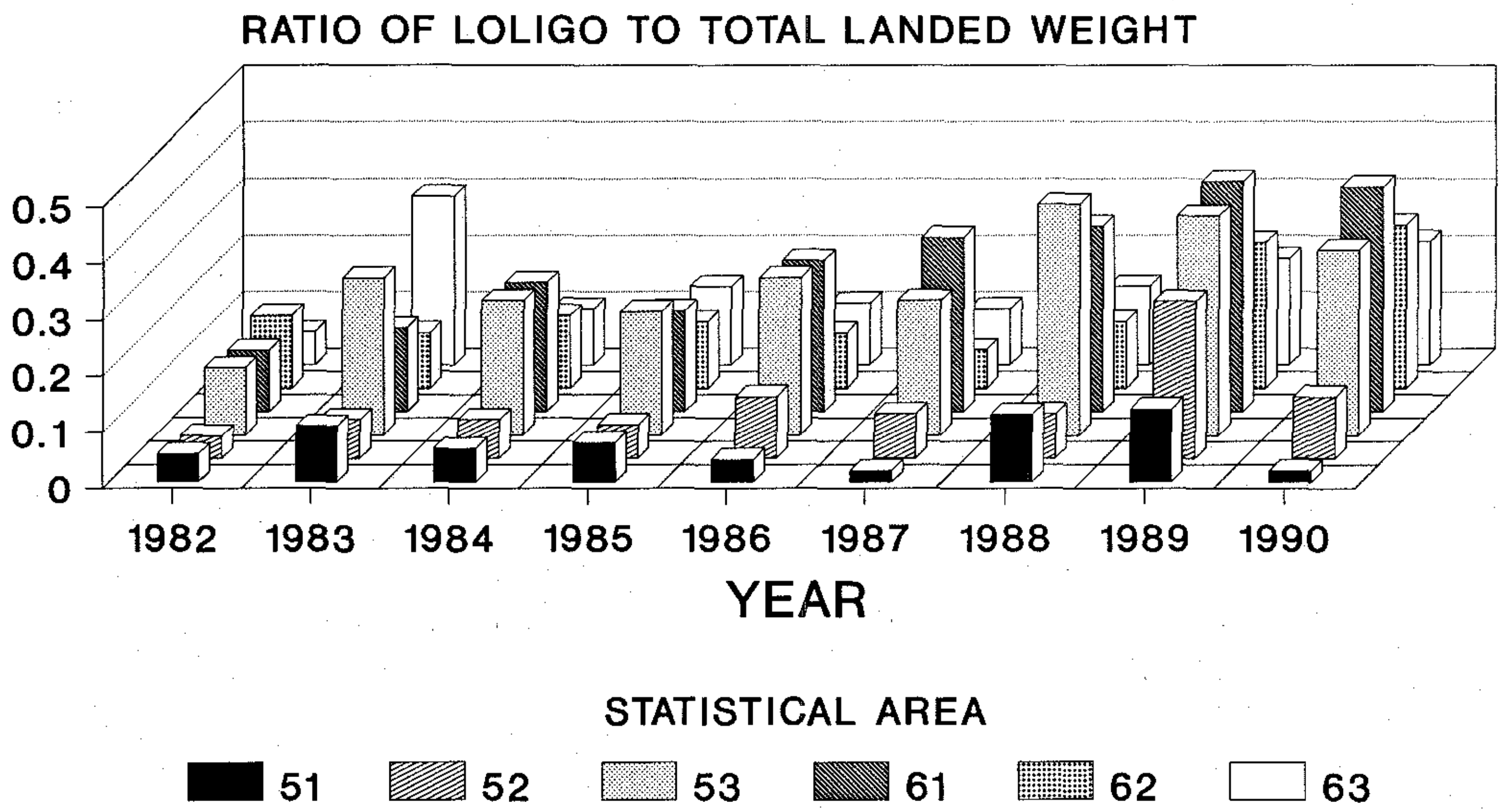
Figure 6. Average Loligo CPUE

Domestic fishery 1982-1990



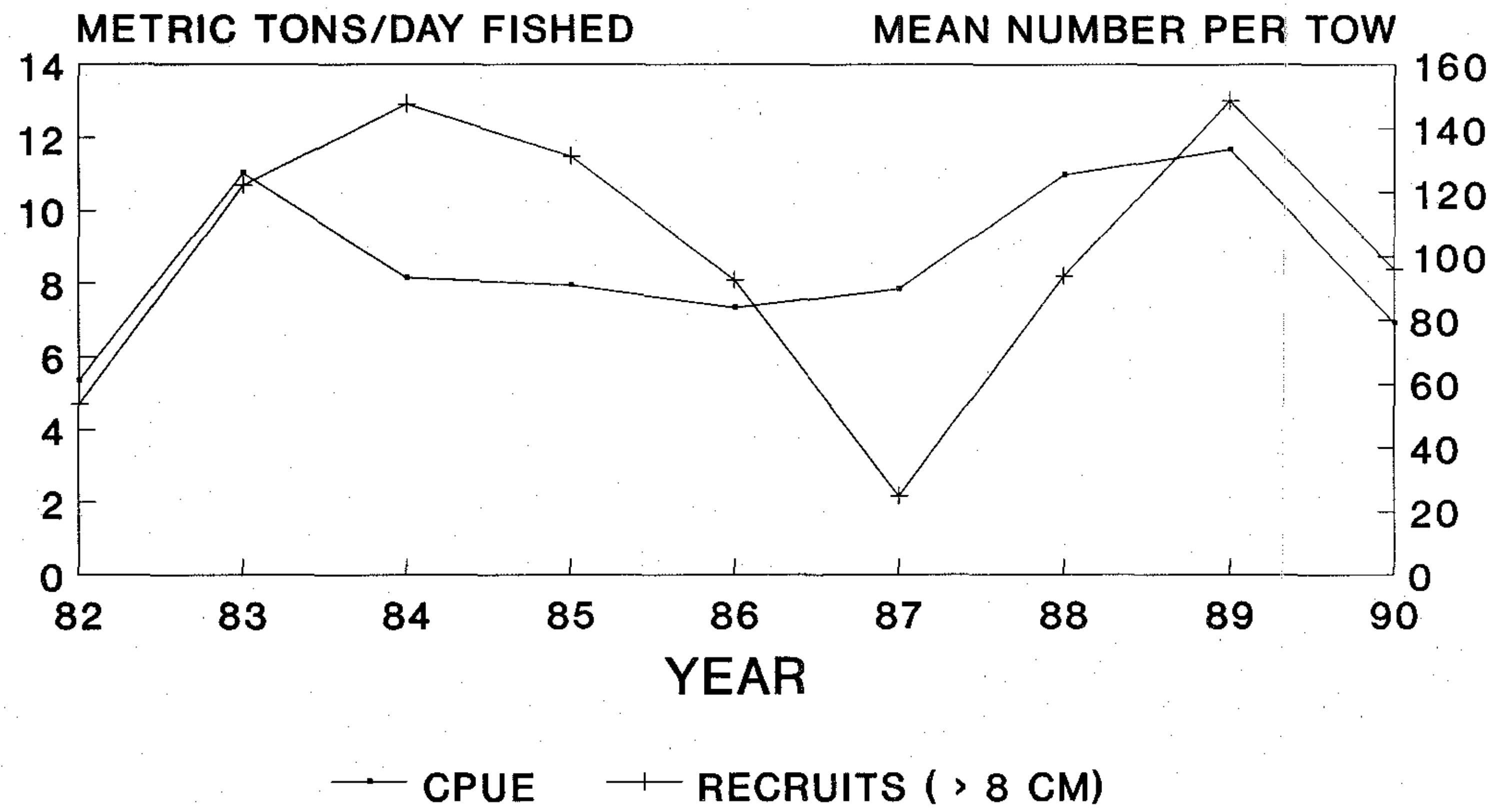
INCLUDES ALL TRIPS LANDING LOLIGO
EXCLUDES AREA 56
CPUE IS AVERAGED OVER TRIPS

Figure 7. Loligo landings ratio
Domestic fishery 1982-1990



INCLUDES ALL TRIPS LANDING LOLIGO
EXCLUDES AREA 56
RATIO IS AVERAGED OVER ALL TRIPS

Figure 8. Loligo CPUE
DIRECTED DOMESTIC FISHERY 1982-1990



Directed effort is based on trips where over 75% of the landings are Loligo

Table 1. Annual *Loligo* squid catches (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the domestic[1] and foreign fleets, 1963-90.

Year	Domestic	Foreign	Total
1963	1,294	0	1,294
1964	576	2	578
1965	709	99	808
1966	772	226	948
1967	547	1,130	1,167
1968	1,084	2,327	3,411
1969	899	8,643	9,542
1970	653	16,732	17,385
1971	727	17,442	18,169
1972	725	29,009	29,734
1973	1,105	36,508	37,613
1974	2,274	32,576	34,850
1975	1,621	32,180	33,801
1976	3,602	21,682	25,284
1977	1,088	15,586	16,674
1978	1,291	9,355	10,646
1979	4,252	13,068	17,320
1980	3,996	19,750	23,746
1981	2,316	20,212	22,528
1982	5,464	15,805	21,269
1983	15,943	11,720	27,663
1984	11,592	11,031	22,623
1985	10,155	6,549	16,704
1986	13,292	4,598	17,890
1987	11,475	2	11,477
1988	19,072	3	19,075
1989	23,007	5	23,012
1990	15,469	0	15,469

[1]Includes joint venture catches made by domestic catcher vessels

Table 2. 1990 Loligo landings (metric tons) by month and U.S. statistical area
from NMFS weighout data

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
514	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.05	0.00	1.77	0.54	0.05	2.45	0.02%
521	0.00	0.00	0.00	0.05	2.04	0.05	0.00	0.00	0.00	0.00	0.59	0.00	2.72	0.02%
522	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.76	0.18	0.00	0.00	0.00	5.94	0.04%
525	0.00	0.00	0.32	0.09	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72	0.01%
526	122.47	4.63	1.77	1.68	5.31	2.27	2.31	3.22	1.36	3.40	2.54	0.41	151.36	1.01%
533	0.00	0.00	0.00	12.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.11	0.08%
537	536.69	239.54	513.47	159.48	114.90	232.01	526.03	198.86	682.11	626.82	303.14	316.15	4449.25	29.80%
538	0.00	0.00	0.00	53.07	1123.10	192.05	19.73	4.04	4.94	9.30	7.58	0.00	1413.89	9.47%
539	0.14	0.00	0.00	67.86	301.78	22.95	15.79	15.20	50.85	142.16	141.84	102.87	861.46	5.77%
562	0.00	0.00	0.00	0.00	0.27	0.00	0.14	0.05	0.00	0.00	0.00	0.00	0.41	0.00%
611	0.27	0.00	0.95	2.90	54.20	28.26	34.06	38.33	21.95	21.36	23.50	38.92	264.72	1.77%
612	17.96	4.49	0.00	0.05	75.43	273.92	48.08	150.00	5.72	162.43	86.27	119.84	944.11	6.32%
613	25.63	14.83	37.60	73.84	70.58	150.32	285.13	142.52	192.91	446.34	146.10	130.73	1716.49	11.50%
614	0.00	3.36	0.00	0.00	0.86	6.03	0.36	0.82	0.23	0.86	0.05	0.00	12.61	0.08%
615	0.00	0.00	0.00	0.95	11.97	0.00	0.00	0.00	0.00	38.24	14.38	0.00	65.54	0.44%
616	579.24	424.29	445.79	112.40	0.00	0.00	0.00	1.04	0.00	104.10	25.27	182.89	1875.11	12.56%
621	15.10	1.72	2.86	1.00	43.14	160.44	84.32	25.67	1.63	2.59	205.66	140.66	684.79	4.59%
622	265.71	119.07	479.18	138.03	45.50	119.75	139.16	10.52	59.38	95.62	73.44	84.55	1629.80	10.92%
623	48.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.22	0.32%
625	2.59	0.00	101.20	0.36	0.36	0.00	0.00	0.00	0.00	0.14	0.27	0.05	104.92	0.70%
626	73.39	29.08	185.84	12.38	0.05	0.05	9.21	43.73	24.09	10.89	8.85	26.35	423.93	2.84%
631	1.72	3.36	6.08	0.00	0.00	0.00	0.00	0.00	0.00	0.09	3.18	4.49	18.91	0.13%
632	84.01	14.61	5.35	0.00	0.00	0.00	0.00	14.70	0.00	4.58	92.03	9.34	224.66	1.50%
635	1.77	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	0.01%
636	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.29	0.00	14.29	0.10%
TOTALS	1774.91	859.06	1780.40	636.25	1850.80	1188.14	1164.33	654.49	1045.35	1670.67	1149.50	1157.30	14931.24	
PERCENT	11.89%	5.75%	11.92%	4.26%	12.40%	7.96%	7.80%	4.38%	7.00%	11.19%	7.70%	7.75%		

1990 Loligo landings (metric tons) by NAFO subarea from Joint Venture
and general canvass data

SUBAREA	LANDINGS
5	0
6	537.4
TOTALS	537.4

Table 3.1. 1990 Landings (m.t.) of unclassified Loligo squid by month and U.S. statistical area

CATEGORY UNCLASSIFIED LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
514	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	1.77	0.54	0.05	2.40	0.02%
521	0.00	0.00	0.00	0.00	1.36	0.05	0.00	0.00	0.00	0.00	0.59	0.00	2.00	0.01%
522	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.44	0.18	0.00	0.00	0.00	5.62	0.04%
525	0.00	0.00	0.32	0.09	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.01%
526	119.98	4.49	0.91	1.27	5.31	1.86	2.13	3.13	1.36	2.81	2.31	0.36	145.92	1.09%
533	0.00	0.00	0.00	12.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.11	0.09%
537	474.28	213.37	448.15	116.12	113.13	214.87	472.64	188.83	669.19	587.77	258.00	277.69	4034.03	30.20%
538	0.00	0.00	0.00	50.53	981.98	188.79	19.60	4.04	4.49	8.12	6.62	0.00	1264.16	9.46%
539	0.14	0.00	0.00	61.19	300.55	21.36	14.83	14.70	49.08	130.54	114.90	81.60	788.89	5.91%
562	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.05	0.00	0.00	0.00	0.00	0.27	0.00%
611	0.27	0.00	0.95	2.86	52.89	27.85	33.70	38.15	21.86	21.00	22.73	38.78	261.00	1.95%
612	17.96	4.49	0.00	0.05	75.43	273.92	48.08	150.00	5.72	162.43	86.27	119.84	944.11	7.07%
613	25.63	14.83	35.11	70.72	70.58	150.32	285.13	141.70	192.10	437.63	135.49	130.41	1689.59	12.65%
614	0.00	3.36	0.00	0.00	0.86	6.03	0.36	0.82	0.23	0.86	0.05	0.00	12.61	0.09%
615	0.00	0.00	0.00	0.95	11.97	0.00	0.00	0.00	0.00	38.24	14.38	0.00	65.54	0.49%
616	528.89	373.67	384.06	94.66	0.00	0.00	0.00	1.04	0.00	104.10	25.27	171.05	1682.78	12.60%
621	15.10	1.72	2.86	1.00	43.14	160.44	84.32	25.67	1.63	2.59	4.54	5.17	348.18	2.61%
622	249.43	119.07	479.18	101.15	45.50	116.07	97.89	3.22	4.63	28.35	73.44	84.55	1402.46	10.50%
623	45.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.95	0.34%
625	2.59	0.00	101.20	0.36	0.36	0.00	0.00	0.00	0.00	0.14	0.27	0.05	104.92	0.79%
626	73.39	29.08	47.13	11.48	0.05	0.05	9.21	43.73	24.09	10.89	8.85	26.35	284.31	2.13%
631	1.72	3.36	6.08	0.00	0.00	0.00	0.00	0.00	0.00	0.09	3.18	4.49	18.91	0.14%
632	84.01	14.61	5.35	0.00	0.00	0.00	0.00	14.70	0.00	4.58	92.03	9.34	224.66	1.68%
635	1.77	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	0.01%
636	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.29	0.00	14.29	0.11%
TOTALS	1641.10	782.08	1511.28	524.53	1703.60	1161.65	1068.03	635.26	974.54	1541.90	863.73	949.73	13357.31	
PERCENT	12.29%	5.86%	11.31%	3.93%	12.75%	8.70%	8.00%	4.76%	7.30%	11.54%	6.47%	7.11%		

Table 3.2. 1990 Landings (m.t.) of large Loligo squid by month and U.S. statistical area

CATEGORY LARGE LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
521	0.00	0.00	0.00	0.05	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.10%
522	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.32	0.04%
525	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.13%
526	2.31	0.14	0.86	0.41	0.00	0.41	0.18	0.09	0.00	0.59	0.23	0.05	5.26	0.74%
537	37.88	7.94	49.44	41.87	1.77	15.51	52.25	9.84	11.93	38.78	40.69	38.46	346.41	48.61%
538	0.00	0.00	0.00	2.45	61.69	2.81	0.09	0.00	0.45	0.82	0.95	0.00	69.31	9.73%
539	0.00	0.00	0.00	6.67	1.18	1.00	0.95	0.41	1.54	11.07	24.90	21.27	69.06	9.69%
562	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.02%
611	0.00	0.00	0.00	0.05	1.18	0.41	0.36	0.18	0.09	0.36	0.41	0.14	3.22	0.45%
613	0.00	0.00	2.49	2.45	0.00	0.00	0.00	0.82	0.82	8.66	10.61	0.32	26.17	3.67%
616	38.87	44.50	22.09	4.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.84	121.83	17.10%
621	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.86	9.66	32.52	4.56%
622	1.77	0.00	0.00	7.03	0.00	1.18	11.29	0.00	0.00	2.18	0.00	0.00	23.41	3.28%
623	2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27	0.32%
626	0.00	0.00	10.07	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.98	1.54%
TOTALS	83.10	52.57	84.96	66.50	67.59	21.32	65.14	11.66	14.83	62.46	100.65	81.74	712.59	
PERCENT	11.66%	7.38%	11.92%	9.33%	9.48%	2.99%	9.14%	1.64%	2.08%	8.77%	14.12%	11.47%		

Table 3.3. 1990 Landings (m.t.) of small Loligo squid by month and U.S. statistical area

CATEGORY SMALL LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
537	5.90	6.12	4.76	0.00	0.00	0.05	0.00	0.00	0.91	0.27	4.40	0.00	22.41	4.38%
538	0.00	0.00	0.00	0.00	17.96	0.00	0.00	0.00	0.00	0.36	0.00	0.00	18.37	3.59%
539	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.23	0.41	1.86	0.00	2.54	0.50%
611	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.36	0.07%
613	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.01%
616	8.21	0.00	17.64	8.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.02	6.65%
621	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	136.71	98.34	235.05	45.94%
622	11.16	0.00	0.00	19.01	0.00	0.95	12.79	1.54	33.61	36.88	0.00	0.00	115.94	22.66%
626	0.00	0.00	82.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.92	16.21%
TOTALS	25.27	6.12	105.32	27.12	17.96	1.04	12.79	1.54	34.75	37.97	143.34	98.34	511.65	
PERCENT	4.94%	1.20%	20.59%	5.30%	3.51%	0.20%	2.50%	0.30%	6.79%	7.42%	28.01%	19.22%		

Table 3.4. 1990 Landings (m.t.) of medium Loligo squid by month and U.S. statistical area

CATEGORY MEDIUM LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
514	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02%
526	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.07%
537	18.64	12.11	11.11	1.50	0.00	1.59	1.13	0.18	0.09	0.00	0.05	0.00	46.40	17.46%
538	0.00	0.00	0.00	0.09	33.66	0.45	0.05	0.00	0.00	0.00	0.00	0.00	34.25	12.89%
539	0.00	0.00	0.00	0.00	0.05	0.54	0.00	0.09	0.00	0.14	0.18	0.00	1.00	0.38%
611	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.05%
613	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.26%
616	3.27	6.12	22.00	4.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.42	13.71%
621	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.55	27.49	69.04	25.98%
622	3.36	0.00	0.00	10.84	0.00	1.09	9.71	0.00	1.41	5.49	0.00	0.00	31.84	11.98%
626	0.00	0.00	45.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.72	17.21%
TOTALS	25.45	18.28	78.83	18.10	33.84	3.67	10.89	0.27	1.50	5.62	41.78	27.49	265.71	
PERCENT	9.58%	6.88%	29.67%	6.81%	12.73%	1.38%	4.10%	0.10%	0.56%	2.12%	15.72%	10.34%		

Table 3.5. 1990 Landings (m.t.) of super small Loligo squid by month and U.S. statistical area

CATEGORY SUPER SMALL LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
622	0.00	0.00	0.00	0.00	0.00	0.09	3.36	5.76	19.73	22.00	0.00	0.00	50.94
PERCENT	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	6.59%	11.31%	38.74%	43.19%	0.00%	0.00%	

Table 3.6. 1990 Landings (m.t.) extra large Loligo squid by month and U.S. statistical area

CATEGORY EXTRA LARGE LOLIGO SQUID

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS	PERCENT
538	0.00	0.00	0.00	0.00	27.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.81	84.20%
622	0.00	0.00	0.00	0.00	0.00	0.36	4.13	0.00	0.00	0.73	0.00	0.00	5.22	15.80%
TOTALS	0.00	0.00	0.00	0.00	27.81	0.36	4.13	0.00	0.00	0.73	0.00	0.00	33.02	
PERCENT	0.00%	0.00%	0.00%	0.00%	84.20%	1.10%	12.50%	0.00%	0.00%	2.20%	0.00%	0.00%		

Table 4. Catch per unit effort (metric tons/day fished) from the directed[1] domestic Loligo fishery, 1982-1990.

Year	CPUE	Directed trips
1982	5.35	202
1983	11.04	949
1984	8.16	591
1985	7.96	507
1986	7.34	796
1987	7.85	612
1988	10.98	1120
1989	11.69	1115
1990	6.92	848
Average	8.59	749

[1]Directed effort is defined as trips by vessels over 5 G.R.T. that land over 75% Loligo

Table 5. Total and pre-recruit (≤8 cm) stratified mean numbers per tow[1] of *Loligo* squid from the NEFC autumn bottom trawl surveys (mid-Atlantic to Georges Bank), 1967-90.

Year	All sizes	Pre-recruit	Recruit
1967	134.5	116.9	18.5
1968	176.5	159.9	16.6
1969	237.3	217.4	19.9
1970	85.6	79.3	6.3
1971	163.3	161.5	1.8
1972	271.4	258.5	12.9
1973	372.0	353.9	18.1
1974	251.7	233.3	18.4
1975	614.4	593.3	21.1
1976	410.9	302.5	108.4
1977	388.5	297.7	90.8
1978	144.2	93.4	50.8
1979	193.7	156.5	37.2
1980	364.1	279.8	84.3
1981	226.2	161.8	64.4
1982	310.4	256.6	53.8
1983	373.4	251.1	122.3
1984	299.8	152.2	147.6
1985	442.2	310.8	131.4
1986	453.0	360.4	92.6
1987	56.7	32.0	24.7
1988	413.7	320.0	93.7
1989	420.6	271.9	148.7
1990	371.6	275.7	95.9
Average	299.0	237.3	61.7

[1] Stratified mean number per tow of all sizes and of individuals ≤8 cm dorsal mantle length.

Table 6. In-sample forecasts of recruit index for 1989 and 1990 and out-of-sample forecast of recruit index for 1991.

Year	Lower 95% C.I.	Estimate	Upper 95% C.I.	Observed value
1989	35.8	173.7	841.4	148.7
1990	22.1	103.3	483.4	95.9
1991	19.7	88.9	401.0	

Appendix 1. Proration of unclassified squid to <u>Loligo</u> squid.

Unclassified squid landings in 1990 (TOTALS IN 100'S LBS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0	0	1	0	926	21	8	3	3	11	27	28	1027
52	0	0	0	0	0	5	20	83	0	0	0	5	113
53	0	32	0	120	0	19	0	0	0	0	2	0	173
61	96	160	0	0	0	0	0	0	0	0	0	0	256
62	109	37	96	169	538	1270	4	1	5	3707	3	0	5938
63	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	205	229	97	289	1464	1315	32	87	8	3718	32	33	7507

<u>Loligo</u> proportion of total <u>Loligo</u> and <u>Illex</u> landings by month and statistical area in 1990 determines the proportion of unclassified squid assigned to <u>Loligo</u>

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0	1	0	0	0	1	0	0.05	0	0.975	0.923	1	0.710
52	1	1	1	1	0.050	0.879	1	0.929	0.001	1	1	1	0.141
53	1	1	1	1	1	1	1	0.908	1	1	0.998	1	0.996
61	1	1	1	1	1	1	0.999	0.425	0.268	0.897	1	1	0.810
62	1	1	1	1	0.751	0.215	0.075	0.039	0.052	0.070	0.530	0.884	0.241
63	1	1	1	0	0	0	0	0.310	0	1	0.750	1	0.789
TOTALS	1	1	1	1	0.906	0.538	0.288	0.212	0.261	0.520	0.797	0.972	0.568

Unclassified squid landings assigned to *Loligo* (TOTALS IN 100'S OF POUNDS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0	0	0	0	0	21	0	0.15	0	10.72	24.92	28	84.79
52	0	0	0	0	0	4.39	20	77.15	0	0	0	5	106.55
53	0	32	0	120	0	19	0	0	0	0	1.99	0	172.99
61	96	160	0	0	0	0	0	0	0	0	0	0	256
62	109	37	96	169	404.32	273.95	0.30	0.03	0.26	260.10	1.59	0	1351.57
63	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	205	229	96	289	404.32	318.35	20.30	77.34	0.26	270.82	28.51	33	1971.92

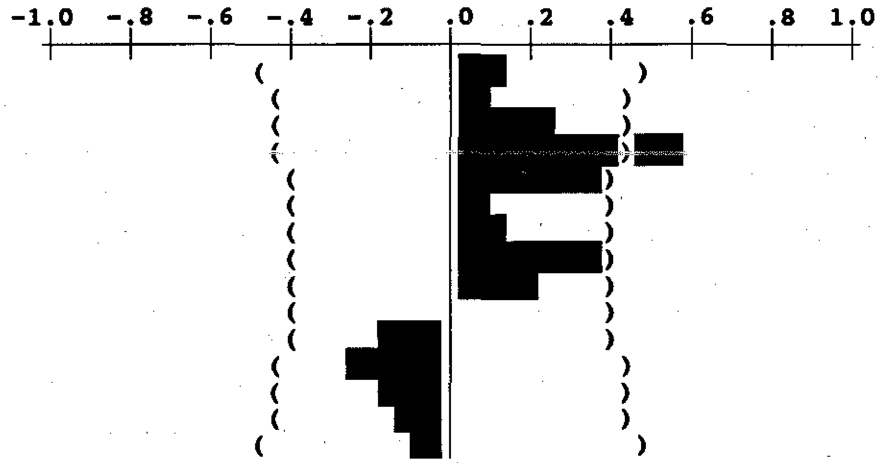
Unclassifed squid assigned to *Loligo* (TOTALS IN METRIC TONS)

AREA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
51	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.01	0.00	0.49	1.13	1.27	3.85
52	0.00	0.00	0.00	0.00	0.00	0.20	0.91	3.50	0.00	0.00	0.00	0.23	4.83
53	0.00	1.45	0.00	5.44	0.00	0.86	0.00	0.00	0.00	0.00	0.09	0.00	7.85
61	4.35	7.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.61
62	4.94	1.68	4.35	7.67	18.34	12.43	0.01	0.00	0.01	11.80	0.07	0.00	61.31
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTALS	9.30	10.39	4.35	13.11	18.34	14.44	0.92	3.51	0.01	12.28	1.29	1.50	89.44

Appendix 2. Results of regression analyses to predict the <u>Loligo</u> fall recruit series (RECRUIT) for 1967-1990 using stratified mean temperature (TEMP) and the <u>Loligo</u> fall prerecruit series (PRE).

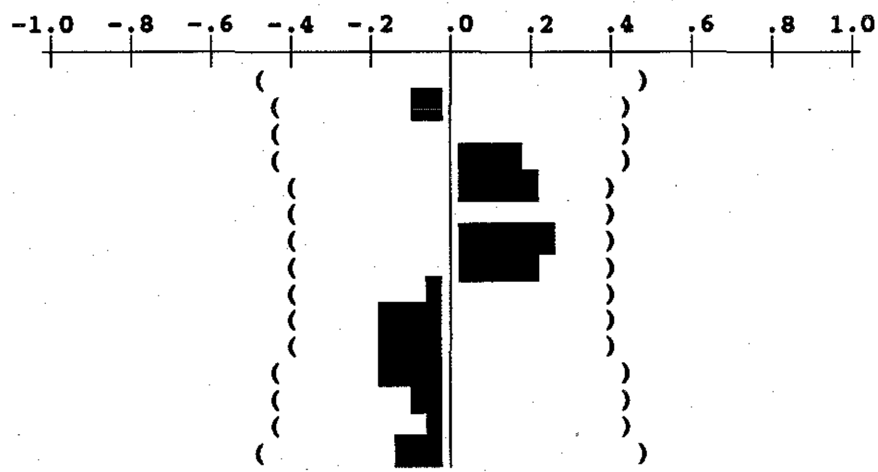
PART 1. PLOT OF CROSS CORRELATIONS BETWEEN RECRUIT AND TEMP SERIES

LAG	CORR	SE
-7	.153	.243
-6	.094	.236
-5	.247	.229
~~-4~~	~~.578~~	~~.224~~
-3	.412	.218
-2	.103	.213
-1	.160	.209
0	.415	.204
1	.214	.209
2	.010	.213
3	-.165	.218
4	-.243	.224
5	-.182	.229
6	-.129	.236
7	-.096	.243



PART 2. PLOT OF CROSS CORRELATIONS BETWEEN RECRUIT AND PRE SERIES

LAG	CORR	SE
-7	-.017	.243
-6	-.110	.236
-5	.000	.229
-4	.169	.224
-3	.234	.218
-2	.013	.213
-1	.260	.209
0	.221	.204
1	-.065	.209
2	-.163	.213
3	-.166	.218
4	-.196	.224
5	-.088	.229
6	-.061	.236
7	-.130	.243



PART 3. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON TEMP

DEP VAR: RECRUIT N: 24 MULTIPLE R: .415 SQUARED MULTIPLE R: .172
ADJUSTED SQUARED MULTIPLE R: .135 STANDARD ERROR OF ESTIMATE: 44.418

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-131.410	90.722	0.000	.	-1.448	0.162
TEMP	16.748	7.830	0.415	.100E+01	2.139	0.044

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	9027.249	1	9027.249	4.575	0.044
RESIDUAL	43405.976	22	1972.999		

PART 4. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON TEMP LAGGED BY 4 YEARS

---

3 CASES DELETED DUE TO MISSING DATA.

DEP VAR: RECRUIT N: 21 MULTIPLE R: .446 SQUARED MULTIPLE R: .199
ADJUSTED SQUARED MULTIPLE R: .157 STANDARD ERROR OF ESTIMATE: 44.039

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-131.813	92.491	0.000	.	-1.425	0.170
TEMP4	17.277	7.959	0.446	.100E+01	2.171	0.043

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	9138.015	1	9138.015	4.712	0.043
RESIDUAL	36849.151	19	1939.429		

PART 5. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON PRE LAGGED BY 1 YEAR

---

1 CASES DELETED DUE TO MISSING DATA.

DEP VAR: RECRUIT N: 23 MULTIPLE R: .266 SQUARED MULTIPLE R: .071
ADJUSTED SQUARED MULTIPLE R: .026 STANDARD ERROR OF ESTIMATE: 47.269

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	38.424	22.195	0.000	.	1.731	0.098
PRE1	0.107	0.084	0.266	.100E+01	1.264	0.220

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	3567.496	1	3567.496	1.597	0.220
RESIDUAL	46920.602	21	2234.314		

PART 6. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON PRE LAGGED BY 1 YEAR AND TEMP (NO LAG)

---

1 CASES DELETED DUE TO MISSING DATA.

DEP VAR: RECRUIT N: 23 MULTIPLE R: .397 SQUARED MULTIPLE R: .157
ADJUSTED SQUARED MULTIPLE R: .073 STANDARD ERROR OF ESTIMATE: 46.118

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-128.572	118.332	0.000	.	-1.087	0.290
TEMP	15.386	10.718	0.323	0.8334120	1.435	0.167
PRE1	0.054	0.090	0.134	0.8334120	0.596	0.558

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	7950.248	2	3975.124	1.869	0.180
RESIDUAL	42537.850	20	2126.892		

PART 7. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON PRE LAGGED BY 1 YEAR AND TEMP LAGGED BY 4 YEARS

3 CASES DELETED DUE TO MISSING DATA.

DEP VAR: RECRUIT N: 21 MULTIPLE R: .496 SQUARED MULTIPLE R: .246
ADJUSTED SQUARED MULTIPLE R: .162 STANDARD ERROR OF ESTIMATE: 43.892

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-155.731	94.897	0.000	.	-1.641	0.118
TEMP4	17.517	7.936	0.452	0.9991839	2.207	0.041
PRE1	0.086	0.081	0.217	0.9991839	1.062	0.302

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	11309.296	2	5654.648	2.935	0.079
RESIDUAL	34677.870	18	1926.548		

PART 8. REGRESSION ANALYSIS OF RECRUIT DEPENDENCE ON YEAR

DEP VAR: RECRUIT N: 24 MULTIPLE R: .741 SQUARED MULTIPLE R: .549
ADJUSTED SQUARED MULTIPLE R: .529 STANDARD ERROR OF ESTIMATE: 32.785

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-9837.019	1912.795	0.000	.	-5.143	0.000
YEAR	5.003	0.967	0.741	.100E+01	5.175	0.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	28786.011	1	28786.011	26.781	0.000
RESIDUAL	23647.214	22	1074.873		

Appendix 3. Results of time series analyses using the log-transformed, differenced Loligo fall recruit series.

Part 1. In-sample forecast of Loligo recruit index in 1989.

```
                                      ARIMA PROCEDURE

                             NAME OF VARIABLE        =      LSUR
                             PERIOD(S) OF DIFFERENCING=1.
                             MEAN OF WORKING SERIES=           0
                             STANDARD DEVIATION     =  0.848276
                             NUMBER OF OBSERVATIONS=          21
                                      AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1       STD
  0   0.719572   1.00000  |                   |********************|          0
  1 -0.0999379  -0.13889  |           .    ***|        .           |   0.218218
  2  -0.238429  -0.33135  |           .*******|        .           |   0.222387
  3 0.00366766   0.00510  |          .        |         .          |    0.24477
  4   0.145566   0.20230  |          .        |****     .          |   0.244775
  5  -0.118854  -0.16517  |          .     ***|         .          |   0.252611
  6   -0.17682  -0.24573  |          .   *****|         .          |   0.257703
  7  0.0360098   0.05004  |         .         |*         .         |   0.268629
  8   0.207675   0.28861  |         .         |******    .         |   0.269072
  9 -0.0501108  -0.06964  |         .        *|          .         |   0.283431
 10 -0.0864415  -0.12013  |         .       **|          .         |   0.284244
 11 -.00772165  -0.01073  |         .         |          .         |   0.286652
 12  0.0578202   0.08035  |         .         |**        .         |   0.286671
 13 -0.0638789  -0.08877  |        .        **|           .        |   0.287741
 14 -0.0478288  -0.06647  |        .         *|           .        |   0.289042
 15 -0.0779685  -0.10835  |        .        **|           .        |   0.289769
 16   0.224814   0.31243  |        .          |******     .        |   0.291692
 17 0.00179422   0.00249  |        .          |           .        |   0.307215
 18 -0.0766075  -0.10646  |        .        **|           .        |   0.307215
 19  0.0184304   0.02561  |        .          |*          .        |   0.308967
 20 -0.0109657  -0.01524  |        .          |           .        |   0.309068
                          '.' MARKS TWO STANDARD ERRORS
```

```
                    ARIMA: MAXIMUM LIKELIHOOD ESTIMATION

                                        APPROX.
             PARAMETER     ESTIMATE    STD ERROR   T RATIO  LAG
             AR1,1        -0.385767     0.234997     -1.64   2

             VARIANCE  ESTIMATE =  0.648208
             STD ERROR ESTIMATE =  0.805114
             AIC                =   51.7887
             SBC                =   52.8332
             NUMBER OF RESIDUALS=        21

                        CORRELATIONS OF THE ESTIMATES

                                        AR1,1
                              AR1,1     1.000

                       AUTOCORRELATION CHECK OF RESIDUALS

        TO    CHI                            AUTOCORRELATIONS
       LAG  SQUARE DF   PROB
         6    2.47  5  0.781 -0.180 -0.006 -0.093  0.031 -0.200 -0.083
        12    4.47 11  0.954 -0.061  0.202 -0.037 -0.033 -0.071  0.017
        18   18.54 17  0.355 -0.100  0.037 -0.161  0.305  0.035 -0.115
                       AUTOCORRELATION PLOT OF RESIDUALS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1         STD
  0   0.648208     1.00000  |                    |********************|           0
  1   -0.11637    -0.17953  |           .    ****|        .           |    0.218218
  2 -.00377017    -0.00582  |           .        |        .           |    0.225141
  3 -0.0603663    -0.09313  |           .      **|        .           |    0.225148
  4  0.0203348     0.03137  |           .        |*       .           |    0.226975
  5  -0.129696    -0.20008  |           .    ****|        .           |    0.227182
  6 -0.0536136    -0.08271  |           .      **|        .           |    0.235423
  7 -0.0395169    -0.06096  |           .       *|        .           |    0.236803
  8   0.130965     0.20204  |          .         |****     .          |    0.237549
  9 -0.0239626    -0.03697  |          .        *|         .          |    0.245596
 10 -0.0215116    -0.03319  |          .        *|         .          |    0.245861
 11 -0.0457554    -0.07059  |          .        *|         .          |    0.246074
 12  0.0110288     0.01701  |          .         |         .          |    0.247036
 13 -0.0650829    -0.10040  |          .       **|         .          |    0.247092
 14  0.0236888     0.03655  |          .         |*        .          |    0.249027
 15  -0.104604    -0.16137  |          .      ***|         .          |    0.249283
 16   0.197751     0.30507  |          .         |******   .          |    0.254209
 17  0.0226431     0.03493  |         .          |*         .         |    0.271083
 18 -0.0746385    -0.11515  |         .        **|          .         |    0.271297
```

MODEL FOR VARIABLE LSUR
DATA HAVE BEEN CENTERED.
NO MEAN TERM IN THIS MODEL.
PERIODS OF DIFFERENCING= 1.

AUTOREGRESSIVE FACTORS
FACTOR 1
1+0.385767B**(2)

FORECASTS FOR VARIABLE LSUR

OBS	FORECAST	STD ERROR	LOWER 95%	UPPER 95%	ACTUAL	RESIDUAL
--------FORECAST BEGINS--------						
23	5.1571	0.8051	3.5791	6.7351		

AUTOREGRESSIVE MODEL LAG 2

UNIVARIATE

VARIABLE=RESIDUAL RESIDUAL: ACTUAL-FORECAST

MOMENTS

N	21	SUM WGTS	21
MEAN	0.00262551	SUM	0.0551357
STD DEV	0.805314	VARIANCE	0.648531
SKEWNESS	0.048283	KURTOSIS	0.00670456
USS	12.9708	CSS	12.9706
CV	30672.7	STD MEAN	0.175734
T:MEAN=0	0.0149403	PROB>|T|	0.988228
SGN RANK	-1.5	PROB>|S|	0.972273
NUM ^= 0	21		
W:NORMAL	0.95778	PROB<W	0.476

EXTREMES

LOWEST	HIGHEST
-1.4735	0.610116
-1.2983	0.66897
-1.29	1.09108
-0.496681	1.41853
-0.487146	1.53568

QUANTILES(DEF=4)

100% MAX	1.53568	99%	1.53568
75% Q3	0.548469	95%	1.52397
50% MED	0.0114398	90%	1.35304
25% Q1	-0.43589	10%	-1.2966
0% MIN	-1.4735	5%	-1.456
		1%	-1.4735
RANGE	3.00923		
Q3-Q1	0.984359		
MODE	-1.4735		

Part 2. In-sample forecast of <u>Loligo</u> recruit index in 1990.

```
                                  ARIMA PROCEDURE

                         NAME OF VARIABLE      =     LSUR
                         PERIOD(S) OF DIFFERENCING=1.
                         MEAN OF WORKING SERIES=        0
                         STANDARD DEVIATION    = 0.832633
                         NUMBER OF OBSERVATIONS=       22
                                  AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1          STD
  0   0.693278     1.00000 |                    |********************|           0
  1 -0.0736066    -0.10617 |           .      **|        .           |    0.213201
  2  -0.251131    -0.36224 |           . *******|        .           |    0.215591
  3 -.00516019    -0.00744 |          .         |         .          |    0.241677
  4   0.132962     0.19179 |          .         |****     .          |    0.241688
  5  -0.112785    -0.16268 |          .      ***|         .          |    0.248509
  6   -0.15677    -0.22613 |          .    *****|         .          |    0.253304
  7  0.0294203     0.04244 |          .         |*        .          |    0.262319
  8   0.191549     0.27629 |         .          |******    .         |    0.262631
  9 -0.0345681    -0.04986 |         .         *|          .         |    0.275527
 10 -0.0886166    -0.12782 |         .       ***|          .         |    0.275937
 11 -0.0190247    -0.02744 |         .         *|          .         |    0.278615
 12  0.0497455     0.07175 |         .          |*         .         |    0.278738
 13 -0.0343535    -0.04955 |         .         *|          .         |    0.279576
 14 -0.0442908    -0.06389 |         .         *|          .         |    0.279975
 15 -0.0753368    -0.10867 |         .        **|          .         |    0.280637
 16   0.219843     0.31711 |         .          |******    .         |    0.282543
 17  0.0357406     0.05155 |        .           |*          .        |    0.298282
 18 -0.0940724    -0.13569 |        .        ***|           .        |    0.298687
 19 -.00297146    -0.00429 |        .           |           .        |    0.301476
 20 -.00986285    -0.01423 |        .           |           .        |    0.301479
 21 -.00335011    -0.00483 |        .           |           .        |    0.301509
                           '.' MARKS TWO STANDARD ERRORS
```

ARIMA: MAXIMUM LIKELIHOOD ESTIMATION

PARAMETER	ESTIMATE	APPROX. STD ERROR	T RATIO	LAG
AR1,1	-0.370597	0.212285	-1.75	2

VARIANCE ESTIMATE =	0.619817
STD ERROR ESTIMATE =	0.787285
AIC =	53.182
SBC =	54.2731
NUMBER OF RESIDUALS=	22

CORRELATIONS OF THE ESTIMATES

	AR1,1
AR1,1	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.70	5	0.746	-0.189	-0.002	-0.087	0.032	-0.200	-0.098
12	4.84	11	0.939	-0.057	0.210	-0.042	-0.030	-0.068	0.022
18	17.60	17	0.414	-0.116	0.033	-0.164	0.313	0.022	-0.096

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1        STD
  0   0.619817    1.00000  |                    |********************|          0
  1  -0.117304   -0.18926  |           .    ****|        .           |   0.213201
  2 -0.0013938   -0.00225  |           .        |        .           |   0.220705
  3 -0.0541129   -0.08730  |           .      **|        .           |   0.220706
  4   0.019743    0.03185  |           .        |*       .           |    0.22227
  5  -0.123932   -0.19995  |           .    ****|        .           |   0.222478
  6 -0.0606094   -0.09779  |           .      **|        .           |   0.230501
  7 -0.0353782   -0.05708  |           .       *|        .           |   0.232379
  8   0.130381    0.21035  |           .        |****    .           |   0.233016
  9  -0.026003   -0.04195  |          .        *|         .          |   0.241493
 10 -0.0188286   -0.03038  |          .        *|         .          |   0.241824
 11 -0.0418868   -0.06758  |          .        *|         .          |   0.241998
 12  0.0137078    0.02212  |          .         |         .          |   0.242854
 13 -0.0716368   -0.11558  |          .       **|         .          |   0.242945
 14  0.0203166    0.03278  |          .         |*        .          |   0.245432
 15  -0.101511   -0.16378  |          .      ***|         .          |   0.245631
 16   0.193874    0.31279  |          .         |******   .          |   0.250545
 17  0.0139363    0.02248  |         .          |          .         |   0.267708
 18 -0.0596359   -0.09622  |         .        **|          .         |   0.267794
```

MODEL FOR VARIABLE LSUR
DATA HAVE BEEN CENTERED.
NO MEAN TERM IN THIS MODEL.
PERIODS OF DIFFERENCING= 1.

AUTOREGRESSIVE FACTORS
FACTOR 1
1+0.370597B**(2)

FORECASTS FOR VARIABLE LSUR

OBS	FORECAST	STD ERROR	LOWER 95%	UPPER 95%	ACTUAL	RESIDUAL
--------FORECAST BEGINS--------						
24	4.6378	0.7873	3.0948	6.1809		

AUTOREGRESSIVE MODEL LAG 2

UNIVARIATE

VARIABLE=RESIDUAL RESIDUAL: ACTUAL-FORECAST

MOMENTS

N	22	SUM WGTS	22
MEAN	-0.0270442	SUM	-0.594972
STD DEV	0.786996	VARIANCE	0.619363
SKEWNESS	0.0893635	KURTOSIS	0.17039
USS	13.0227	CSS	13.0066
CV	-2910	STD MEAN	0.167788
T:MEAN=0	-0.16118	PROB>|T|	0.873492
SGN RANK	-11.5	PROB>|S|	0.721
NUM ^= 0	22		
W:NORMAL	0.950857	PROB<W	0.384

EXTREMES

LOWEST	HIGHEST
-1.4946	0.591422
-1.3194	0.616316
-1.3156	1.07361
-0.514733	1.4132
-0.507237	1.51266

QUANTILES(DEF=4)

100% MAX	1.51266	99%	1.51266
75% Q3	0.502495	95%	1.49774
50% MED	-0.0564313	90%	1.31132
25% Q1	-0.434508	10%	-1.3183
0% MIN	-1.4946	5%	-1.4683
		1%	-1.4946
RANGE	3.00722		
Q3-Q1	0.937004		
MODE	-1.4946		

Part 3. Out-of-sample forecast for 1990.

```
                              ARIMA PROCEDURE

                    NAME OF VARIABLE        =      LSUR
                    PERIOD(S) OF DIFFERENCING=1.
                    MEAN OF WORKING SERIES=           0
                    STANDARD DEVIATION      =  0.821566
                    NUMBER OF OBSERVATIONS=          23
                              AUTOCORRELATIONS

LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1         STD
  0   0.674971     1.00000  |                    |********************|          0
  1 -0.0787392    -0.11666  |            .     **|       .            |   0.208514
  2  -0.269238    -0.39889  |            ********|       .            |   0.211333
  3  0.0275965     0.04089  |          .         |*        .          |   0.241863
  4   0.139944     0.20733  |          .         |****     .          |   0.242163
  5  -0.102005    -0.15112  |          .      ***|         .          |   0.249762
  6  -0.151192    -0.22400  |          .     ****|         .          |   0.253706
  7  0.0121794     0.01804  |          .         |         .          |   0.262164
  8   0.189679     0.28102  |          .         |******   .          |   0.262218
  9 -0.0258337    -0.03827  |         .         *|          .         |      0.275
 10  -0.102134    -0.15132  |         .       ***|          .         |   0.275232
 11 -.00943781    -0.01398  |         .          |          .         |   0.278825
 12   0.063382     0.09390  |         .          |**        .         |   0.278856
 13  -0.026493    -0.03925  |         .         *|          .         |   0.280227
 14 -0.0774481    -0.11474  |         .        **|          .         |   0.280466
 15 -0.0736626    -0.10913  |         .        **|          .         |     0.2825
 16    0.21068     0.31213  |         .          |******    .         |   0.284327
 17   0.027069     0.04010  |        .           |*          .        |   0.298854
 18   -0.13498    -0.19998  |        .       ****|           .        |   0.299088
 19  0.0254309     0.03768  |        .           |*          .        |   0.304846
 20  0.0192235     0.02848  |        .           |*          .        |   0.305049
 21 -.00544658    -0.00807  |        .           |           .        |   0.305164
 22 0.00394098     0.00584  |        .           |           .        |   0.305173
                           '.' MARKS TWO STANDARD ERRORS
```

AUTOCORRELATION CHECK FOR WHITE NOISE

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	8.49	6	0.204	-0.117	-0.399	0.041	0.207	-0.151	-0.224
12	13.07	12	0.364	0.018	0.281	-0.038	-0.151	-0.014	0.094
18	27.61	18	0.068	-0.039	-0.115	-0.109	0.312	0.040	-0.200

ARIMA: MAXIMUM LIKELIHOOD ESTIMATION

ESTIMATES DID NOT IMPROVE AFTER HIGH RIDGE.
ESTIMATES MIGHT NOT HAVE CONVERGED.

PARAMETER	ESTIMATE	APPROX. STD ERROR	T RATIO	LAG
AR1,1	-0.377907	0.196477	-1.92	2

VARIANCE ESTIMATE = 0.590723
STD ERROR ESTIMATE = 0.768585
AIC = 54.4496
SBC = 55.5851
NUMBER OF RESIDUALS= 23

CORRELATIONS OF THE ESTIMATES

	AR1,1
AR1,1	1.000

AUTOCORRELATION CHECK OF RESIDUALS

TO LAG	CHI SQUARE	DF	PROB	AUTOCORRELATIONS					
6	2.71	5	0.745	-0.190	0.001	-0.082	0.036	-0.198	-0.091
12	4.88	11	0.937	-0.060	0.209	-0.042	-0.031	-0.068	0.022
18	16.72	17	0.474	-0.116	0.028	-0.169	0.305	0.018	-0.106

AUTOCORRELATION PLOT OF RESIDUALS

```
LAG COVARIANCE CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1        STD
  0   0.590723    1.00000  |                    |********************|          0
  1   -0.11216   -0.18987  |            .   ****|       .            |   0.208514
  2 .000607435    0.00103  |           .        |        .           |   0.215901
  3 -0.0483199   -0.08180  |           .      **|        .           |   0.215901
  4  0.0215154    0.03642  |           .        |*       .           |   0.217244
  5  -0.116844   -0.19780  |           .    ****|        .           |   0.217509
  6 -0.0540229   -0.09145  |           .      **|        .           |   0.225194
  7 -0.0357341   -0.06049  |           .       *|        .           |   0.226803
  8    0.12357    0.20918  |           .        |****    .           |   0.227504
  9 -0.0246578   -0.04174  |           .       *|        .           |   0.235718
 10 -0.0183816   -0.03112  |           .       *|        .           |   0.236039
 11  -0.040028   -0.06776  |           .       *|        .           |   0.236217
 12  0.0128353    0.02173  |           .        |        .           |   0.237061
 13 -0.0685609   -0.11606  |           .      **|        .           |   0.237148
 14  0.0165021    0.02794  |          .         |*        .          |   0.239605
 15 -0.0997313   -0.16883  |          .      ***|         .          |   0.239746
 16   0.180182    0.30502  |          .         |******   .          |   0.244861
 17  0.0105019    0.01778  |          .         |         .          |   0.260858
 18 -0.0627557   -0.10624  |          .       **|         .          |   0.260911
                           '.' MARKS TWO STANDARD ERRORS
```

INVERSE AUTOCORRELATIONS

```
LAG CORRELATION -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  1    0.34247  |            .       |*******.            |
  2    0.13383  |            .       |***    .            |
  3    0.12263  |            .       |**     .            |
  4    0.20590  |            .       |****   .            |
  5    0.34088  |            .       |*******.            |
  6    0.26672  |            .       |*****  .            |
  7    0.11000  |            .       |**     .            |
  8   -0.05002  |            .      *|       .            |
  9    0.06499  |            .       |*      .            |
 10    0.13555  |            .       |***    .            |
 11    0.11907  |            .       |**     .            |
```

FORECASTS FOR VARIABLE LSUR

OBS	FORECAST	STD ERROR	LOWER 95%	UPPER 95%	ACTUAL	RESIDUAL
--------FORECAST BEGINS--------						
25	4.4875	0.7686	2.9811	5.9939		

AUTOREGRESSIVE MODEL LAG 2

UNIVARIATE

VARIABLE=RESIDUAL RESIDUAL: ACTUAL-FORECAST

MOMENTS

N	23	SUM WGTS	23
MEAN	0.00197316	SUM	0.0453826
STD DEV	0.768766	VARIANCE	0.591001
SKEWNESS	0.0947333	KURTOSIS	0.307348
USS	13.0021	CSS	13.002
CV	38961.3	STD MEAN	0.160299
T:MEAN=0	0.0123092	PROB>|T|	0.99029
SGN RANK	-6	PROB>|S|	0.867148
NUM ^= 0	23		
W:NORMAL	0.947029	PROB<W	0.324

EXTREMES

LOWEST	HIGHEST
-1.4641	0.62072
-1.2889	0.661979
-1.283	1.10232
-0.485744	1.43606
-0.477266	1.54404

QUANTILES(DEF=4)

100% MAX	1.54404	99%	1.54404
75% Q3	0.499874	95%	1.52245
50% MED	-0.0334884	90%	1.30256
25% Q1	-0.377625	10%	-1.2866
0% MIN	-1.4641	5%	-1.4291
		1%	-1.4641
RANGE	3.00819		
Q3-Q1	0.877498		
MODE	-1.4641		

MISSING VALUE	.
COUNT	2
% COUNT/NOBS	8.00

Papers of the Northeast Regional
Stock Assessment Workshops

Bootstrap Estimators of Discard Rates Using Domestic Sea Sampling Data

by

Jon Brodziak

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Woods Hole, MA

Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/8

ABSTRACT---Two bootstrap estimators of discard rates are examined: the ratio of total discards to total time spent fishing for a given set of tows (aggregate ratio) and the average discard per tow (average rate). The estimators are applied to tow data collected by the NEFC Domestic Sea Sampling Program in 1989 for the purpose of estimating discard and catch rates for Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Yellowtail flounder (*Limanda ferruginea*) in the large mesh otter trawl fishery operating in the Gulf of Maine. Comparisons of the estimators indicate that the aggregate ratio estimator should outperform the average rate estimator. When applied to the Sea sampling data however, both estimators underestimate total catches of Cod and Yellowtail. The magnitude of the underestimates suggests that the estimates of total discard for Cod and Yellowtail are probably conservative and may indicate that the Sea sampling data are not representative of fishing effort directed at these species. In contrast, quarterly discard estimates for Haddock appear reasonable based on the concordance between actual and estimated catches and on the relatively small mean squared errors for the Haddock discard rate. Overall, it is recommended that the Sea sampling data be used cautiously to estimate discard rates on a quarterly basis.

INTRODUCTION

It is necessary to account for the amount of fish discarded by fishermen in order to assess the effect of fishing effort on future recruitment of commercially exploited species. Discard estimates obtained in dockside interviews depend on the captain's recollection and may be unreliable due to fatigue, poor memory, lack of interest in the discarded catches, and so on. Discard estimates obtained by directly observing fishing operations at sea (as is done in the Domestic Sea Sampling Program) are likely to be very accurate for the individual fishing trip. Yet since relatively few fishing trips can be sampled by observers, data collected by observers may not be representative of the discarding practices of the entire fleet.

In general, considerable variation in fishing vessel performance can be expected due to differences in vessel size, fishing gear, fishing area, crew experience, and luck. It is desirable to reduce variability in vessel performance as much as possible for the purpose of estimating discard rates. This can be accomplished by organizing data collected from the fishing fleet into more or less homogeneous units since observer records can be categorized according to gear type, area of capture, and time of capture. In this study, discard rates of three species, Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), and Yellowtail flounder (*Limanda ferruginea*), are estimated for one fishery, the Gulf of Maine large mesh (mesh $\geq$ 5.5 inches) otter trawl fishery of 1989.

The estimation of a discard rate requires that a time interval be specified for which the rate will apply. In this study, quarterly samples of observed tows for the Gulf of Maine large mesh otter trawl fishery for 1989 are treated as independent and identically distributed draws from the set of all tows within this fishery. The assumption that tows are independent requires that the autocorrelation between tows within a trip should be similar in magnitude and sign to the crosscorrelation between tows across different trips and vessels.

Nonparametric estimation methods can be applied to estimate target parameters (e.g. discard rates of Cod, Haddock, and Yellowtail) when the joint distribution of the these parameters is unknown. In this study, a nonparametric method called the "bootstrap" is used to estimate discard rates as well as to estimate the bias and variance of these rates (Efron 1982).

METHODS

It is usually necessary to estimate parameters to describe the distribution a random variable within a given population. In this study, the (vector-valued) random variable of interest is the weight of Cod, Haddock, and Yellowtail, discarded per quarter in the Gulf of Maine large mesh otter trawl fishery, the population is the set of all tows made by vessels in this fishery, but the distribution of the random variable is unknown. To begin, assume that all tows are independent and identically distributed. That is, $T_1, T_2, \ldots, T_n$ are iid draws from F, where F is an unspecified distribution and T_j denotes a single tow ($j=1,\ldots,n$). Additional assumptions are unnecessary since the samples are drawn from an unspecified distribution (cf. Efron 1982).

Suppose that $D(\underline{T},F)$ denotes the random variable of interest that depends on the (unordered) set of tows $\underline{T}$. For example, D might be the amount (pounds) of Cod discarded in a fishery. Based on an observed sample of tows $\underline{t}$, one estimates a parameter (or set of parameters) to describe the distribution of D. One might want to know the expectation of D,

(i) What is $E_F[D(\underline{T},F)]$?

Alternatively, one might want to know the probability that D is very large, say greater than 100000,

(ii) What is $Pr_F\{ D(\underline{T},F) > 100000 \}$?

To understand how the bootstrap can handle either (i) or (ii), it is useful to consider the bootstrap as a computational procedure (algorithm). For question (i), the bootstrap algorithm to estimate $E_F[D(\underline{T},F)]$ based on an observed tow sample $\underline{t}$ of size n consists of 3 steps:

(1) Fit the empirical probability distribution, denoted by F, to the observed tow sample $\underline{t}$. That is, F assigns probability 1/n to t_j for j=1,...,n

(2) Create a bootstrap sample $\underline{T}$ from F of size n, where $T_1, T_2, \ldots, T_n$ are iid from F. Then compute $D(\underline{T}, F)$ based on this bootstrapped sample.

(3.i) Independently repeat step (2) a large number of times B, obtaining B bootstrapped estimates of D, denoted by $D_1, D_2, \ldots, D_B$. Then calculate

$$E_F[D] = \frac{1}{B} \sum_{b=1}^{B} D_b$$

The bootstrap algorithm for (ii) is identical to that for (i), except that step (3.i) changes to

(3.ii) Independently repeat step (2) B times and, for each bootstrapped sample, record whether D_b is greater than 100000. Then calculate

$$Pr_F\{D > 100000\} = \frac{\text{Number of times } D_b > 100000}{B}$$

For the bootstrap to work well, the underlying (unknown) distribution F should reflect a sampling unit for which the iid assumption makes sense. For the Gulf of Maine large mesh otter trawl fishery, sampling units were defined by quarter of tow observation. This definition allows quarterly length frequency data to be applied to the estimates of weight discarded.

Defining the estimators

Two estimators that apply tow by tow data to compute discard rates with the bootstrap are examined: the ratio of total discards to total time spent fishing for a given set of tows (aggregate ratio) and the average discard per tow (average rate). Both estimators consider discards per unit time so that potential problems with the ratio of discard to catch can be avoided (i.e. tows with positive discards but no landed catch). If discard rates do not fluctuate widely on a tow by tow basis, the sample average should adequately describe the central tendency of the distribution of discard rates. Alternatively, if discard rates fluctuate substantially, possibly because some tows are stopped prematurely when discard rates are high, it may be better to use the aggregate ratio. Regardless of which estimator is chosen, an estimate of the total discard within a quarter is calculated as the sum of the quarterly estimated discard rate times the total amount of time spent fishing by the entire fleet in that quarter.

To define the estimators, suppose that a bootstrap sample $\underline{T}$ consisting of a total of n tows has been generated, where $\underline{T} = \{T_1, T_2, \ldots, T_n\}$. Let D_j be the discarded weight and L_j be the tow duration in days fished during the jth tow in $\underline{T}$.

Aggregate ratio estimator, R

One way to estimate the weight discarded per unit time is to <u>aggregate</u> the tow samples first by computing the total amount discarded and the total tow duration for the bootstrap sample, and then to compute the discard rate as the ratio of these amounts. This leads to the aggregate ratio estimator, denoted by R,

$$R = \frac{\sum_{i=1}^{n} D_i}{\sum_{j=1}^{n} L_i}$$

The aggregate ratio estimator calculates discard rate as the ratio of the expectation of two random variables: total weight discarded and total days fished. Notice also that if all tows were sampled, the estimate of total discard would be exact.

Average rate estimator, R_{avg}

Another way to estimate the weight of discarded fish per unit time is to use the <u>average</u> of the observed discard per tow duration for the bootstrapped sample. This leads to the average rate estimator, denoted by R_{avg},

$$R_{avg} = \frac{1}{n} \sum_{i=1}^{n} \frac{D_i}{L_i}$$

The average rate estimator computes the discard rate as the expectation of the ratio of discarded weight to days fished. Note that if all tows were sampled, then the estimate of total discard would probably not be exact. Thus, R_{avg} is inferior to R in the sense that R_{avg} is not necessarily a consistent estimator of total discard.

Comparison of the precision of R and R_{avg}

An analytic comparison of the precision of the R and R_{avg} estimators can be made in certain cases. Suppose that, for every tow T_j, the tow duration L_j is observed without error and that the discarded weight is observed with an error e_j, where the e_j are independent and normally distributed with mean 0 and variance v. That is, assume that $D_1 + e_1$, $D_2 + e_2, \ldots, D_n + e_n$ are observed, where $e_1, e_2, \ldots, e_n$ are iid Normal(0,v) random variables.

It can be shown that the distribution of observational errors, E and E_{avg}, of the actual values, R and R_{avg}, respectively, are

$$E \sim Normal\left(O, \frac{Vn}{\left(\sum_{j=1}^{n} L_j\right)^2}\right) \qquad E_{avg} \sim Normal\left(O, V\sum_{j=1}^{n}\left(\frac{1}{L_j}\right)^2\right)$$

The variance of E is smaller than that of E_{avg}, so large observational errors are more likely if the average rate estimator rather than the aggregate ratio estimator is used.

RESULTS

Sea sampling data used for this study were collected from the large mesh otter trawl fishery operating in the Gulf of Maine for 1989. Observer data for this fishery consisted of 279 tow records from 39 trips (2,15,17, and 5 trips from quarters 1,2,3, and 4, respectively). For all bootstrapped estimates, the number of bootstrap replications (e.g. B) is 10000. Separate bootstrap samples are used to estimate the discard and catch rates of Cod, Haddock, and Yellowtail; this amounts to assuming that the distributions of discard and catch rates for these species are independent. Table 1 summarizes the sampling coverage for the Gulf of Maine large mesh otter trawl fishery in 1989 relative to total commercial effort.

Empirical comparisons of the estimators

While the aggregate ratio estimator is likely to be more robust than the average rate estimator, a direct comparison of the performance of the estimators may reveal potential bias in either. To perform an empirical comparison, the total observed catches in each quarter based on the observed sample of 279 tows are compared to the total estimated catches of Cod, Haddock, and Yellowtail flounder, respectively, in Tables 2.1, 2.2, and 2.3.

Table 2.1 shows that the R_{avg} estimator overestimates the catch of Cod in quarters 1 and 2, and overestimates the total Cod catch by 7408 pounds. The R_{avg} estimator also overestimates Cod discards in all quarters, and overestimates the total Cod discard by 784 pounds. In contrast, the R estimator performs well and its estimates are closer to the actual Cod catch and discard statistics. Although the R estimator overestimates Cod catch and discard by 76 and 14 pounds, respectively, the R overestimates are an order of magnitude smaller than the R_{avg} overestimates.

Table 2.2 shows that both estimators provide reasonable estimates of the total catch of Haddock, although the quarterly R_{avg} estimates are more variable. The quarterly estimates also show that the R estimator accurately estimates the Haddock discards, while the R_{avg} estimator overestimates discards in quarters 1 and 4.

Table 2.3 shows that the R_{avg} estimator overestimates the quarter 2 catch of Yellowtail flounder, and that both estimators produce reasonably accurate estimates of the observed Yellowtail discard. The R estimator underestimates the total Yellowtail catch by only 6 pounds. In comparison, the R_{avg} estimator overestimates the Yellowtail catch by 416 pounds, roughly 2 orders of magnitude larger than the R estimate. The Sea sampling data for quarter 1 do not adequately represent fishery impacts on Yellowtail (0 catch observed in 2 trips out of a total of 491 trips) since the total Yellowtail catch in the Gulf of Maine was 166,500 pounds for quarter 1 of 1989. Nonetheless, this comparison shows that the R estimator provides more reliable estimates of the observed catch and discard within the Sea sampling data.

Another comparison of the R and R_{avg} estimators was performed based on the estimated catch per day fished and total days fished by quarter (Table 1) to estimate the total catch for the three species. Actual catches in each quarter (based on all trips in the CFDBS) are compared to estimated catches of Cod, Haddock, and Yellowtail flounder, respectively, in Tables 2.4, 2.5, and 2.6.

Table 2.4 shows that the R and R_{avg} estimator perform poorly when estimating the Cod catch in quarters 3 and 4. In quarters 1 and 2, the R_{avg} estimator produces adequate estimates of Cod catch, while the R estimator underestimates the catch. For both estimators however, the approximate 95% confidence interval about the catch estimate does not contain the actual catch. Nonetheless, it is surprising that the R_{avg} estimator outperforms the R estimator in quarters 1 and 2 given the results of the other comparison for Cod (Table 2.1).

Table 2.5 shows that, while a few quarterly catch estimates for Haddock are reasonably accurate (R quarter 1; R_{avg} quarter 2), most estimates differ substantially from the actual statistics (R quarters 2,3,4; R_{avg} quarters 1,3,4). This is unexpected given the good performance of both estimators in the other comparison for Haddock (Table 2.2). Regardless, the catch estimates for Haddock are more accurate than those for Cod (Table 2.4) and Yellowtail (Table 2.6) and both estimators produce approximate 95% confidence intervals that contain the actual Haddock catch.

Table 2.6 shows that both estimators perform poorly for Yellowtail flounder in quarters 1,3, and 4, while reasonably accurate catch estimates are obtained in quarter 2. Both estimators produce approximate 95% confidence intervals that do not contain the actual Yellowtail catch, and the total catch is grossly underestimated using either estimator. Again, this is unexpected given the performance of the estimators, especially the R estimator, in the other comparison with Yellowtail (Table 2.3).

Discard estimates

Estimates of the total discard of Cod, Haddock, and Yellowtail flounder in the Gulf of Maine large mesh otter trawl fishery are calculated using the R and R_{avg} estimators. The mean squared error (variance + bias^2) of the estimated discard rates provides another comparison of estimator performance; the estimator with the lower mean squared error (MSE) should provide a better estimate (with respect to the squared difference between the estimate and the true value) of the discard rate. Tables 3.1, 3.2, and 3.3 show the discard estimates for Cod, Haddock, and Yellowtail flounder, respectively. Tables 4.1, 4.2, and 4.3 show the bias and standard deviation estimates for the discard rates of Cod, Haddock, and Yellowtail, respectively.

DISCUSSION

Discarding of Cod (Table 3.1) in the Gulf of Maine large mesh otter trawl fishery occurs throughout the year and peaks in quarter 4. The standard deviation of Cod discards is also largest in quarter 4. The estimated total discard of Cod is 307,075 pounds using the R estimator, and 392,324 pounds using the R_{avg} estimator. The approximate 95% confidence interval for the total amount discarded is (184160,426990) using the R estimator, while it is (247404,537244) using the R_{avg} estimator. The MSE of the R estimator is lower than that of the R_{avg} estimator in all quarters. Overall, the higher MSE for the R_{avg} estimator indicates that R_{avg} estimates of discard rate are more likely to vary around the true value. Estimates of the total discard as a percentage of total estimated catch are 12% for both estimators (12.3% and 12.4% for R and R_{avg}, respectively). The total catch of Cod (5,214,079 pounds) is underestimated using both estimators (R estimate is 2,500,858 pounds, R_{avg} estimate is 3,158,770 pounds). Neither estimator produces an approximate 95% confidence interval that contains the actual catch. The underestimates of total Cod catch may be due to a lack of sampling trips directed at Cod in quarters 3 and 4 (Table 2.4).

Discarding of Haddock (Table 3.2) peaks in quarters 1 and 4, and is negligible in quarters 2 and 3. Standard deviation and bias estimates for Haddock discards are also largest in quarters 1 and 4. The estimated total discard of Haddock is 11,134 pounds using the R estimator and 14,721 pounds using the R_{avg} estimator. The approximate 95% confidence intervals for the total amount of Haddock discarded are (0,25689) and (0,33012) for the R and R_{avg} estimators, respectively. Since the MSE for the R estimator is lower than that of the R_{avg} estimator in quarters 1 and 4, more reliable estimates can be expected using the R estimator. The estimates of total discard as a percentage of total estimated catch are 6.2% using the R estimator and 7.8% using the R_{avg} estimator. The total Haddock catch (162,424 pounds) is overestimated by both estimators (R estimate is 178,320 pounds, R_{avg} estimate is 189,325 pounds), yet both produce approximate 95% confidence intervals that contain the actual catch.

Discarding of Yellowtail flounder (Table 3.3) peaks in quarter 2, and is negligible in quarters 1, 3, and 4. The standard deviation and bias estimates for Yellowtail discards are also largest in quarter 2. The estimated total discard of Yellowtail is 9,410 pounds using the R estimator and 8,416 pounds using the R_{avg} estimator. The approximate 95% confidence intervals for the total amount of Yellowtail discarded are (3065,15754) and (3400,13432) for the R and R_{avg} estimators, respectively. The estimates of total discard as a percentage of total estimated catch are 10.4% using the R estimator and 6.7% using the R_{avg} estimator. Since the MSE for the R_{avg} estimator is lower than that of the R estimator in quarters 2 and 3, more reliable estimates might be expected from the R_{avg} estimator under the assumption of representative sampling. Since the total Yellowtail catch (464,053 pounds) is grossly underestimated by both estimators (R estimate is 85,228 pounds, R_{avg} estimate is 116,930 pounds) however, and since neither estimator produces an approximate 95% confidence interval that contains the actual catch, the quarterly estimates of Yellowtail discard for this fleet are suspect, despite the relatively small estimates of bias and standard deviation (Table 4.3).

While the comparison of the estimators using the Sea sampling alone (Tables 2.1, 2.2, and 2.3) suggests that the R estimator is superior, the consistency check based on the total catch estimates (Tables 2.4, 2.5 and 2.6) shows that both estimators underestimate total catch for Cod and Yellowtail. This suggests that the quarterly Sea sampling data may not be representative of large mesh otter trawl trips directed at Cod and Yellowtail in the Gulf of Maine. Nonetheless, the total discard estimates for Cod and Yellowtail (Tables 3.1 and .3) are likely to be conservative since both estimators understate the total catch.

Discard rates are consistently higher for Cod than for Haddock and Yellowtail (Tables 3.1, 3.2, and 3.3). Bias and standard deviation estimates for the Cod discard rate are also larger than those for Yellowtail and Haddock, although Haddock discard rates (Tables 3.2 and 4.2) have relatively large variances. Bias does not appear to be a serious problem for either estimator because standard deviation estimates are an order of magnitude larger than bias estimates (Tables 4.1, 4.2, and 4.3). Estimated discard rates for Haddock appear reasonable based on the concordance of the actual and estimated total catch (Table 3.2) as well as the their relatively small bias and MSE (Table 4.2). Nonetheless, it is recommended that the Sea sampling data be used cautiously to estimate discard rates on a quarterly basis.

REFERENCES

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Monograph 38. S.I.A.M. Philadelphia, PA.

Table 1. Sampling coverage for Gulf of Maine large mesh otter trawl trips in 1989

Quarter	#Trips	Total Days Fished	Sampled D. F.	% D.F. Sampled	Sampled Trips(Tows)
1	491	1,037	9.42	0.9%	2 (61)
2	563	943	12.63	1.3%	15 (96)
3	421	806	16.73	2.1%	17 (89)
4	413	915	6.05	0.7%	5 (33)
Total	1,888	3,701	44.83	1.2%	39 (279)

Table 2.1. Comparison of actual Cod catch and discard to R and R_{avg} estimates for observed tows

	CATCH (pounds)			DISCARD (pounds)		
Quarter	Actual	R	R_{avg}	Actual	R	R_{avg}
1	7,578	7,616	10,307	290	292	387
2	13,433	13,463	17,522	850	852	1,074
3	4,000	4,004	4,289	1,276	1,278	1,378
4	3,060	3,064	3,361	981	989	1,342
Total	28,071	28,147	35,479	3,397	3,411	4,181

Table 2.2. Comparison of actual Haddock catch and discard to R and R_{avg} estimates for observed tows

	CATCH (pounds)			DISCARD (pounds)		
Quarter	Actual	R	R_{avg}	Actual	R	R_{avg}
1	289	292	497	67	67	78
2	250	249	186	2	2	1
3	2,169	2,170	2,059	4	4	4
4	152	152	143	22	22	39
Total	2,860	2,863	2,885	95	95	122

Table 2.3. Comparison of actual Yellowtail flounder catch and discard to R and R_{avg} estimates for observed tows

	CATCH (pounds)			DISCARD (pounds)		
Quarter	Actual	R	R_{avg}	Actual	R	R_{avg}
1	0	0	0	0	0	0
2	1,042	1,046	1,456	102	102	101
3	68	68	75	18	18	16
4	35	25	30	1	1	1
Total	1,145	1,139	1,561	121	121	118

Table 2.4. Comparison of actual and estimated Cod catch (pounds) in all trips using the R and R_{avg} estimators

Quarter	Actual Catch	R Catch/DF	R Catch	R_{avg} Catch/DF	R_{avg} Catch
1	1,119,936	808.4	838,311	1094.1	1,134,582
2	1,354,482	1066.4	1,005,615	1387.9	1,308,790
3	1,266,226	239.6	193,118	256.4	206,658
4	1,473,435	506.9	463,814	556.0	508,740
Total	5,214,079	-	2,500,858	-	3,158,770
S.E. of total			351,921		430,147

Table 2.5. Comparison of actual and estimated Haddock catch (pounds) for all trips using the R and R_{avg} estimators

Quarter	Actual Catch	R Catch/DF	R Catch	R_{avg} Catch/DF	R_{avg} Catch
1	36,636	31.0	32,147	52.7	54,650
2	11,805	19.7	18,577	14.7	13,862
3	71,756	129.7	104,538	123.1	99,219
4	42,227	25.2	23,058	23.6	21,594
Total	162,424	-	178,320	-	189,325
S.E. of total			31,275		37,868

Table 2.6. Comparison of actual and estimated Yellowtail catch (pounds) for all trips using the R and R_{avg} estimators

Quarter	Actual Catch	R Catch/DF	R Catch	R_{avg} Catch/DF	R_{avg} Catch
1	166,500	0	0	0	0
2	93,098	82.8	78,080	115.3	108,728
3	8,966	4.1	3,305	4.5	3,627
4	195,489	4.2	3,843	5.0	4,575
Total	464,053	-	85,228	-	116,930
S.E. of total			17,015		23,161

Table 3.1. Cod discard estimates (in pounds)

Quarter	MSE R	MSE R_{avg}	Discard/Day Fished R	Discard/Day Fished R_{avg}	Total Discard R	Total Discard R_{avg}
1	292.4	342.3	31.0	41.1	32,109	42,575
2	185.0	256.0	67.5	85.1	63,671	80,244
3	338.6	364.8	76.4	82.4	61,563	66,390
4	3637.5	5535.4	163.6	222.0	149,732	203,115
Total	-	-	-	-	307,075	392,324
% of Actual Catch (5,214,079)					5.9%	7.5%
% of Estimate (R 2,500,858; R_{avg} 3,158,770)					12.3%	12.4%

Table 3.2. Haddock discard estimates (in pounds)

Quarter	MSE R	MSE R_{avg}	Discard/Day Fished R	Discard/Day Fished R_{avg}	Total Discard R	Total Discard R_{avg}
1	42.3	55.8	7.2	8.3	7,417	8,583
2	0.0	0.0	0.2	0.1	149	105
3	0.0	0.0	0.2	0.2	193	196
4	11.6	33.6	3.7	6.4	3,375	5,837
Total	-	-	-	-	11,134	14,721
% of Actual Catch (162,424)					6.9%	9.1%
% of Estimate (R 178,320; R_{avg} 189,325)					6.2%	7.8%

Table 3.3. Yellowtail flounder discard estimates (in pounds)

Quarter	MSE R	MSE R_{avg}	Discard/Day Fished R	Discard/Day Fished R_{avg}	Total Discard R	Total Discard R_{avg}
1	0.0	0.0	0.0	0.0	0	0
2	11.6	7.3	8.1	8.0	8,392	7,520
3	0.3	0.1	1.1	1.0	866	775
4	0.0	0.0	0.2	0.1	152	121
Total	-	-	-	-	9,410	8,416
% of Actual Catch (464,053)					2.0%	1.8%
% of Estimated Catch (R 85,228; R_{avg} 116,930)					11.0%	7.2%

Table 4.1. Bias and standard deviation estimates for Cod discard rates (in pounds per day fished)

	Bias		Standard Deviation	
Quarter	R	R_{avg}	R	R_{avg}
1	0.18	0.01	17.1	18.5
2	0.19	-0.03	13.6	16.0
3	0.11	-0.01	18.4	19.1
4	1.71	0.09	60.3	74.4
Standard error of total amount discarded			61,181	73,939

Table 4.2. Bias and standard deviation estimates for Haddock discard rates (in pounds per day fished)

	Bias		Standard Deviation	
Quarter	R	R_{avg}	R	R_{avg}
1	0.04	-0.01	6.5	7.4
2	-0.00	0.00	0.1	0.1
3	0.00	0.00	0.2	0.2
4	0.05	-0.02	3.4	5.8
Standard error of total amount discarded			7,426	9,332

Table 4.3. Bias and standard deviation estimates for Yellowtail flounder discard rates (in pounds per day fished)

	Bias		Standard Deviation	
Quarter	R	R_{avg}	R	R_{avg}
1	0.00	0.00	0.0	0.0
2	0.01	0.01	3.4	2.7
3	-0.00	-0.00	0.5	0.3
4	0.00	0.00	0.2	0.1
Standard error of total amount discarded			3,237	2,559

Papers of the Northeast Regional
Stock Assessment Workshops

Cod Discards in the Gulf of Maine Shrimp Fishery

An Exploration of the Sea Sampling Database

by

Susan E. Wigley

Northeast Fisheries Science Center
Woods Hole, MA

Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/9

ABSTRACT

Various methods of estimating commercial discard rates from data collected by the Northeast Fisheries Center Domestic Sea Sampling Program (NEFC DSSP) during 1989-90 were evaluated, using as an example the discarding of Atlantic cod (*Gadus morhua*) in the fishery for Northern shrimp (*Pandalus borealis*) in the Gulf of Maine. Ratio estimators based on the amount of cod discarded to the amount of shrimp or cod landed observed in sea-sampled trips were derived, and discard estimates were generated both on a monthly and seasonal basis. Monthly estimates were generally lower than seasonal estimates, reflecting a temporal aspect to the discarding problem noted by other studies. A multiple regression model was developed in which observed values for tow duration, the amount of shrimp landed, and an interaction term involving month and the ratio of cod caught to shrimp landed explained 63% of the variation in cod discards in sea-sampled shrimp tows. In addition, length frequencies of discarded and kept cod were examined.

INTRODUCTION

The Eleventh NEFC Stock Assessment Workshop (SAW) recommended that the Sea Sampling Analysis Working Group (WG # 28) present results at the Twelfth SAW Plenary Session of an evaluation of the "properties of estimates of discard from current sea sampling data and estimates of sample size needed to achieve specified precision levels for discard estimates. Target examples may include the northern shrimp fishery and all Atlantic cod stocks" (NEFC 1990). The analyses which follow below were undertaken to provide discard estimates for Atlantic cod in all Gulf of Maine fisheries to be included in future analytical assessments of the Gulf of Maine cod stock. A portion of this work was presented to the SAW/12 Stock Assessment Review Committee (SARC) during 3-8 June 1991. The SARC's recommendation was that the multiple regression methodology be expanded to incorporate variance estimates, and that results be reported to the 12th SAW Plenary Session. Thus, what follows is intended to supplement as well as complement analyses provided by the Sea Sampling Analysis Working Group.

METHODS

Data collected for individual observed tows in the Northern shrimp fishery during sea-sampled trips by the NEFC Domestic Sea Sampling Program (DSSP) in 1989-90 provided the basis for estimates of cod discarding. Analyses for 1989 include data collected during January-May 1989, while 1990 analyses include data collected during December 1989-May 1990, corresponding to the shrimp fishery. Tows were assigned to one of three areas devised (S. Clark, NEFC, personal communication) to characterize local fishing fleets (i.e. Gloucester, Portland, and Other

Maine).

Simple ratio estimators (Snedecor and Cochran, 1980) based on: 1) the amount of cod discarded to the amount of shrimp landed observed in sea-sampled tows, and 2) the amount of cod discarded to the amount of cod landed in sea-sampled tows were derived. Since previous work (S. Clark, NEFC, personal communication) suggested a seasonal nature to discarding in the shrimp fishery, monthly ratio estimators were developed in addition to an estimator for entire six-month (December-May) regulated shrimp season. Estimates of cod discards were calculated by applying all ratio estimators to total shrimp landings or to total cod landings (as regulated by-catch in the shrimp fishery) data contained in the NEFC commercial weighout data base.

A multiple regression model (Neter and Wasserman, 1974) was developed to evaluate the effects of month, area, tow duration, amount of shrimp landed, and the amount of cod caught in observed sea sample tows upon discard rates. Numerous versions of the model were evaluated, including those which used combinations of the independent variables above as interaction terms. Criteria for model selection included regression significance, minimized residual sum of squares, minimal multicollinearity among variables, and model interpretability.

Length frequencies obtained from sea sampled tows for discarded and kept cod were summarized over 3 cm intervals by month and year.

RESULTS AND DISCUSSION

Sea sampling coverage of, and cod landings associated with, the Northern shrimp fishery is presented by month and area for 1989 and 1990 in Table 1; shrimp landings are summarized by month and area in Table 2. Sea sampling coverage of this fishery was less than 1% (Table 3). Mean values from sea sampled tows for tow duration, shrimp landed, and cod landed and discarded are presented by month in Table 4 and Appendix Tables 1 and 2.

Ratio estimates were derived based upon cod discarded as a function of: 1) shrimp landed and 2) cod landed in the shrimp fishery observed in sea sampled tows. Estimates for 1989 and 1990 are presented in Table 5. Since ratio estimators are examined in more detail in another Sea Sampling Working Group analysis, they will not be discussed any further in this study.

Results of various multiple regression models are presented in Table 6. Based upon model selection criteria, a model incorporating tow duration, shrimp landed, and an interaction term involving month and the ratio of cod caught to shrimp landed in observed sea sampled tows was chosen (Tables 6-8). Even though it produced the highest R-squared, a model based only upon total cod caught was rejected due to its lack of utility in a predictive sense. Estimates of cod discarded and 95% confidence intervals are presented for 1989 and 1990 in Table 9. Plots of residuals revealed no discernible patterns (Figures 1 and 2).

Examination of length frequency data indicate that in 1989 age 2 fish comprised the majority on discards during January and February, after which the discarding shifted to age 3 fish

(Figures 3-7), perhaps reflecting the seasonal movement of the shrimp fleets following shrimp inshore as they spawn and then offshore following egg-shedding (S. Clark, NEFC, personal communication). In 1990, discarding of the strong 1987 year class as age 3 fish continued, with negligible discarding of younger fish occurring (Figure 8).

Estimates of cod discards obtained from the multiple regression model were considerably lower than those generated by the ratio estimators. Given annual fluctuations in both shrimp and cod abundances, it is likely that models based only upon sea sampling data would need to be re-evaluated each year. The apparent decrease in 1990 discards from 1989 is attributed less to the implementation of a separator trawl regulation for the entire 1990 shrimp season than to the variability in 1987 and 1988 year class strengths.

ACKNOWLEDGEMENTS

I wish to thank David Ham of the Northeast Regional Office for his collaboration in the length frequency analyses presented in this study.

REFERENCES

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Northeast Fisheries Center. 1990. Report of the eleventh NEFC stock assessment workshop Fall 1990. NEFC Ref. Doc. No. 90-09, 121 p.

Snedecor, G.W., and W.G. Cochran. 1980. Statistical methods. The Iowa State University Press, Ames, IA, 507 p.

Table 1. USA commercial cod landings (MT, live weight) from the Gulf of Maine shrimp fishery, () is the number of observed tows in the sea sampling database for the corresponding month and area.

Year	Area	Jan		Feb		Mar		Apr		May		Jun	Dec		Total	
1989	512	0.0		0.2		0.1		0.0		0.0		0.3	8.2		8.8	
	513	110.4	7	23.3	16	35.1	11	25.9	28	3.4	11	0.0	36.2	11	234.4	84
	514	3.5	5	0.3	8	0.5		0.3	5	0.0	3	0.0	0.9	9	5.5	30
	Total	113.9	12	23.9	24	35.7	11	26.2	33	3.4	14	0.3	45.3	20	248.8	114
1990	512	0.5		0.1		0.0		0.1		0.0		0.0	0.4		1.2	
	513	52.2	18	18.1	17	14.4	16	56.7	5	21.3	11	0.0	23.7	9	186.4	76
	514	1.8	3	8.0		0.0	5	0.0	1	0.0		0.0	2.9	3	12.8	12
	Total	54.6	21	26.2	17	14.4	21	56.9	6	21.3	11	0.0	27.0	12	200.4	88

Table 2. USA commercial shrimp landings (MT, live weight) from the Gulf of Maine shrimp fishery by month and area.

Year	Area	Jan	Feb	Mar	Apr	May	Jun	Dec	Total
1989	511	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3
	512	63.5	80.3	22.4	0.5	0.1	0.0	30.3	196.9
	513	912.6	772.2	309.2	366.3	141.2	0.0	648.1	3149.6
	514	69.1	25.7	2.8	8.8	0.0	0.0	20.2	126.5
	Total	1045.3	878.3	334.3	375.6	141.3	0.0	698.5	3473.3
1990	512	62.0	36.6	61.2	52.0	2.5	0.0	9.5	223.8
	513	1163.9	725.5	670.4	618.1	385.0	0.8	391.5	3955.3
	514	76.5	15.5	3.6	0.0	0.8	0.0	29.2	125.7
	Total	1302.5	777.6	735.2	670.1	388.4	0.8	430.1	4304.8

Table 3. Coverage of sea sampling trips conducted in the Gulf of Maine shrimp fishery relative to the number commercial shrimp trips during 1989 and 1990.

	1989	1990
Sea Sampled trips	40	31
Sea Sampled observed tows	114	88
Commercial trips	9113	8968
Percent coverage	0.44%	0.35%

Table 4. Summary of monthly means from the sea sampled Gulf of Maine shrimp fishery in 1989 and 1990 (observed tows only; December values from the previous year).

		Dec	Jan	Feb	Mar	Apr	May
number of tows	89		12	24	11	33	14
	90	20	21	17	21	6	11
mean shrimp landed (pounds)	89		357.5	338.7	465.9	401.4	428.8
	90	330.2	591.4	656.2	244.0	411.7	532.5
mean cod landed (pounds)	89		20.6	0.6	87.4	41.2	22.3
	90	19.8	21.2	21.6	3.3	37.5	51.5
mean cod discarded (pounds)	89		8.4	5.8	78.7	40.9	50.3
	90	18.7	45.2	39.2	3.8	75.8	197.4
mean cod caught (pounds)	89		29.0	6.4	166.1	82.2	72.6
	90	38.5	66.4	60.9	7.0	113.3	248.9

Table 5. Ratio estimates of discarded cod (in pounds) from the Gulf of Maine shrimp fishery.

METHOD 1: COD DISCARDED AS A FUNCTION OF SHRIMP LANDED

Discard = (SS mean cod discard / SS mean shrimp landed) * shrimp landed

1) using seasonal means:

	1989 Jan89-May89	1990 Dec89-May90
discard estimate	528,625	1,048,636
discard rate	8.6%	10.4%

2) using monthly means:

1989	Dec	Jan	Feb	Mar	Apr	May	Total
discard est.		54,257	33,307	124,535	84,511	36,544	333,155
discard rate		2.4%	1.7%	16.9%	10.2%	11.7%	
1990							
discard est.	87,278	219,408	102,505	27,201	272,136	322,822	944,132
discard rate	5.6%	7.6%	5.9%	1.7%	18.4%	37.7%	

Table 5, continued.

METHOD 2: COD DISCARDED AS A FUNCTION OF COD LANDED

Discard = SS mean cod discard / SS mean cod landed) * cod landed

1) using seasonal means:

	1989 Jan89-May89	1990 Dec89-May90
discard estimate	484,713	1,069,145
discard rate	108%	222%

2) using monthly means:

1989	Dec	Jan	Feb	Mar	Apr	May	Total
discard est.		102,685	504,064	70,924	57,391	16,904	751,968
discrad rate		40.9%	956.6%	90.1%	99.4%	225.5%	

1990	Dec	Jan	Feb	Mar	Apr	May	Total
discard est.	94,573	256,707	104,678	36,326	253,673	179,992	831,377
discard rate	94.7%	213.3%	181.2%	114.4%	202.2%	383.3%	

Table 6. Criteria used for the selection of a multiple regression model and the various model forms evaluated using 1989 sea sample data.

Criteria for model selection:

1) significant regression
2) highest R^2
3) lowest MSE
and last but not least 4) interpretability

Models examined using 1989 data:

Independent variables	Significance	R^2
total	**	.80
kept	**	.26
shrimp	NS	.03
shrimp, **month*(kept/shrimp)**	**	.21
shrimp, **kept/shrimp**	**	.19
shrimp, **tow**	**	.23
tow, shrimp, **month*(kept/shrimp)*area**	**	.31
shrimp, kept/shrimp, **month*(kept/shrimp)**	**	.34
shrimp, kept/shrimp, month*(kept/shrimp), **tow**	**	.32
shrimp, **tow**, **month*(kept/shrimp)**, month*area	**	.32
tow, shrimp, **month*(kept/shrimp)**	**	.32
tow, shrimp, month*area	**	.24
shrimp, area, **kept/shrimp**	**	.20
tow,shrimp,month*(total/shrimp)*area	**	.62
TOW, SHRIMP, MONTH*(TOTAL/SHRIMP)	**	.63

Note: **tow** duration
shrimp landed
cod **kept**
total cod caught
Steve Clark's **areas**

Variables in bold indicate significant regression coefficient at $p < 0.05$ level.

Table 7. Results and associated statistics of selected multiple regression model using Jan-May 1989 sea sample data.

THE DOMESTIC SEA SAMPLING PROGRAM 21:48 TUESDAY, JULY 9, 1991
OBSERVED TOWS IN THE GULF OF MAINE
FROM SHRIMP GEAR (058) 1989 SHRIMP SEASON

X'X INVERSE, B, SSE

INVERSE	INTERCEP	TOW	SHR	MORAT1	DISC
INTERCEP	0.2663776	-0.00877074	-.0000243095	0.01482697	-53.1541
TOW	-0.00877074	0.000345721	-.0000017126	-0.000892302	1.416484
SHR	-.0000243095	-.0000017126	1.75861E-07	.00000498325	0.03701314
MORAT1	0.01482697	-0.000892302	.00000498325	0.01335163	38.9742
DISC	-53.1541	1.416484	0.03701314	38.9742	106296.3

DEP VARIABLE: DISC

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	180757.75870	60252.58623	48.181	0.0001
ERROR	85	106296.28625	1250.54454		
C TOTAL	88	287054.04494			

ROOT MSE	35.36304	R-SQUARE	0.6297
DEP MEAN	29.76404	ADJ R-SQ	0.6166
C.V.	118.8113		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	-53.1541	18.25149546	-2.912	0.0046
TOW	1	1.41648435	0.65752529	2.154	0.0340
SHR	1	0.03701314	0.01482978	2.496	0.0145
MORAT1	1	38.97420425	4.08617322	9.538	0.0001

COVARIANCE OF ESTIMATES

COVB	INTERCEP	TOW	SHR	MORAT1
INTERCEP	333.1171	-10.9682	-0.0304001	18.54179
TOW	-10.9682	0.4323395	-0.00214167	-1.11586
SHR	-0.0304001	-0.00214167	0.0002199223	0.00623177
MORAT1	18.54179	-1.11586	0.00623177	16.69681

CORRELATION OF ESTIMATES

CORRB	INTERCEP	TOW	SHR	MORAT1
INTERCEP	1.0000	-0.9140	-0.1123	0.2486
TOW	-0.9140	1.0000	-0.2196	-0.4153
SHR	-0.1123	-0.2196	1.0000	0.1028
MORAT1	0.2486	-0.4153	0.1028	1.0000

Table 8. Results and associated statistics of selected multiple regression model using Dec89-May 1990 sea sample data.

THE DOMESTIC SEA SAMPLING PROGRAM 21:55 TUESDAY, JULY 9, 1991

OBSERVED TOWS IN THE GULF OF MAINE

FROM SHRIMP GEAR (058) 1990 SHRIMP SEASON

X'X INVERSE, B, SSE

INVERSE	INTERCEP	TOW	SHR	MORAT1	DISC
INTERCEP	0.1364358	-0.00419823	-0.00016408	0.0007376401	-2.9946
TOW	-0.00419823	0.0001748551	-.0000148896	-0.000157414	0.1038184
SHR	-0.00016408	-.0000148896	.00001300354	-.0000076906	0.01860886
MORAT1	0.0007376401	-0.000157414	-.0000076906	0.008383316	6.471271
DISC	-2.9946	0.1038184	0.01860886	6.471271	892.1575

DEP VARIABLE: DISC

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	5458.32670	1819.44223	185.583	0.0001
ERROR	91	892.15751029	9.80392868		
C TOTAL	94	6350.48421			

ROOT MSE	3.131123	R-SQUARE	0.8595
DEP MEAN	3.926316	ADJ R-SQ	0.8549
C.V.	79.74709		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	-2.9946	1.15654949	-2.589	0.0112
TOW	1	0.10381837	0.0414037	2.507	0.0139
SHR	1	0.01860886	0.01129096	1.648	0.1028
MORAT1	1	6.47127142	0.28668700	22.573	0.0001

COVARIANCE OF ESTIMATES

COVB	INTERCEP	TOW	SHR	MORAT1
INTERCEP	1.337607	-0.0411591	-0.00160863	0.007231771
TOW	-0.0411591	0.001714267	-0.000145977	-0.00154328
SHR	-0.00160863	-0.000145977	0.0001274857	-.0000753984
MORAT1	0.007231771	-0.00154328	-.0000753984	0.08218944

Table 9. Multiple linear regression estimates of discarded cod (in pounds) from the Gulf of Maine shrimp fishery.

COD DISCARD = $\alpha + \beta_1$(TOW DURATION) + β_2(SHRIMP LANDED) + β_3(MONTH*(COD CAUGHT/SHRIMP LANDED))

	1989		1990	
R^2	0.63		0.86	
Significance	<0.01		<0.01	
	$\hat{Y}_h$	$s^2(\hat{Y}_h)$	$\hat{Y}_h$	$s^2(\hat{Y}_h)$
Dec			34,653	137,121.6
Jan	85,257	529,636.5	64,629	476,801.9
Feb	71,632	373,914.9	38,599	169,936.0
Mar	27,319	54,184.2	36,476	151,909.8
Apr	30,659	68,383.3	33,314	126,198.2
May	11,567	9,710.1	19,428	42,394.6
Total	226,434	1,035,829.0	192,446	1,104,362.2
95% CI	+ 1,995		+ 2,060	

$$s^2(\hat{Y}_h) = MSE(1 + X_h'(X'X)^{-1})X_h)$$

THE DOMESTIC SEA SAMPLING PROGRAM
OBSERVED TOWS IN THE GULF OF MAINE
FROM SHRIMP GEAR (058)
1989 SHRIMP SEASON

PLOT OF RESID*DISC   LEGEND: A = 1 OBS, B = 2 OBS, ETC.

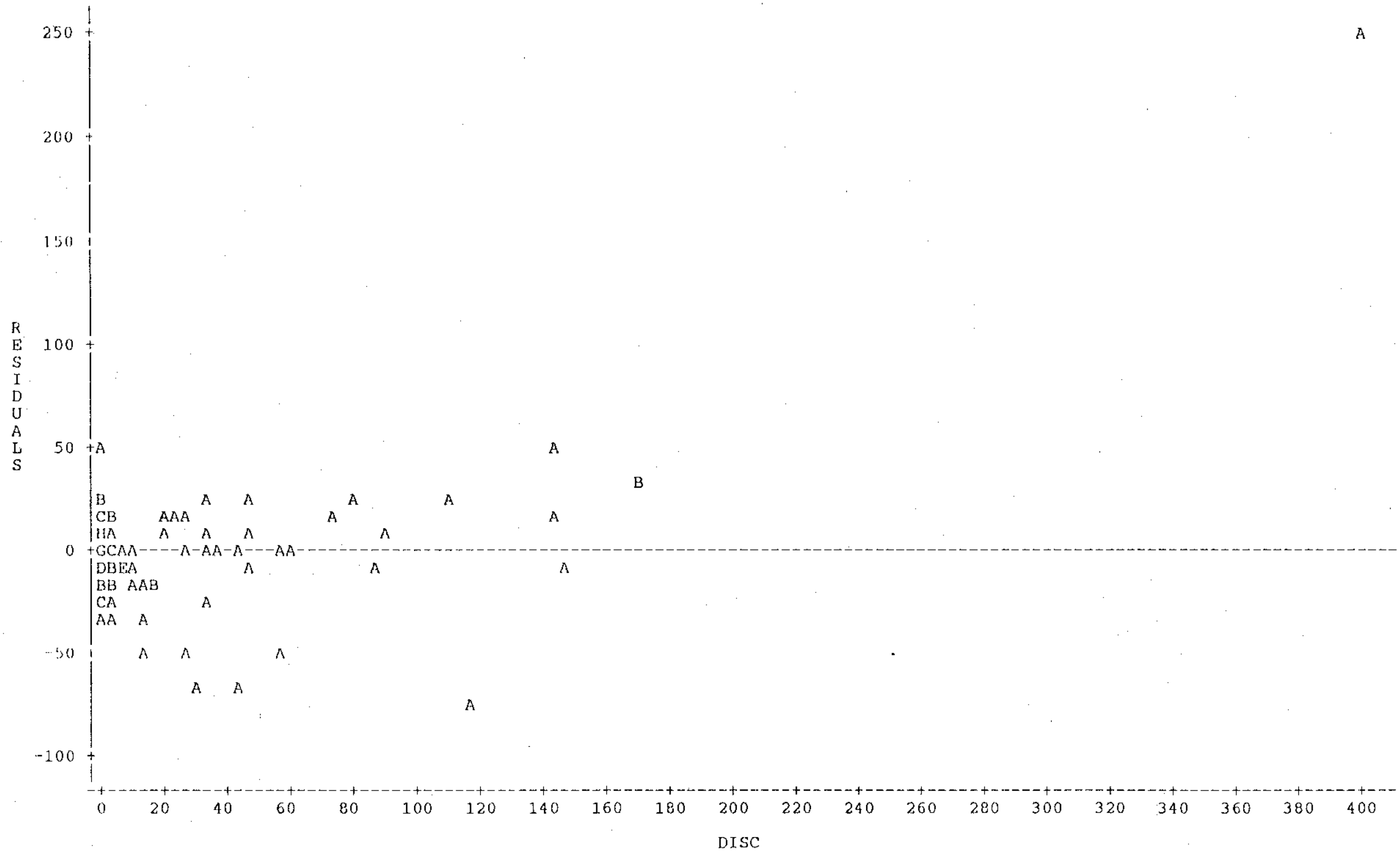

Figure 1. Residuals obtained from multiple regression modelling between predicted and observed cod discards (in pounds) in the 1989 Gulf of Maine shrimp fishery.

THE DOMESTIC SEA SAMPLING PROGRAM
OBSERVED TOWS IN THE GULF OF MAINE
FROM SHRIMP GEAR (058)
1990 SHRIMP SEASON

PLOT OF RESID*DISC   LEGEND: A = 1 OBS, B = 2 OBS, ETC.

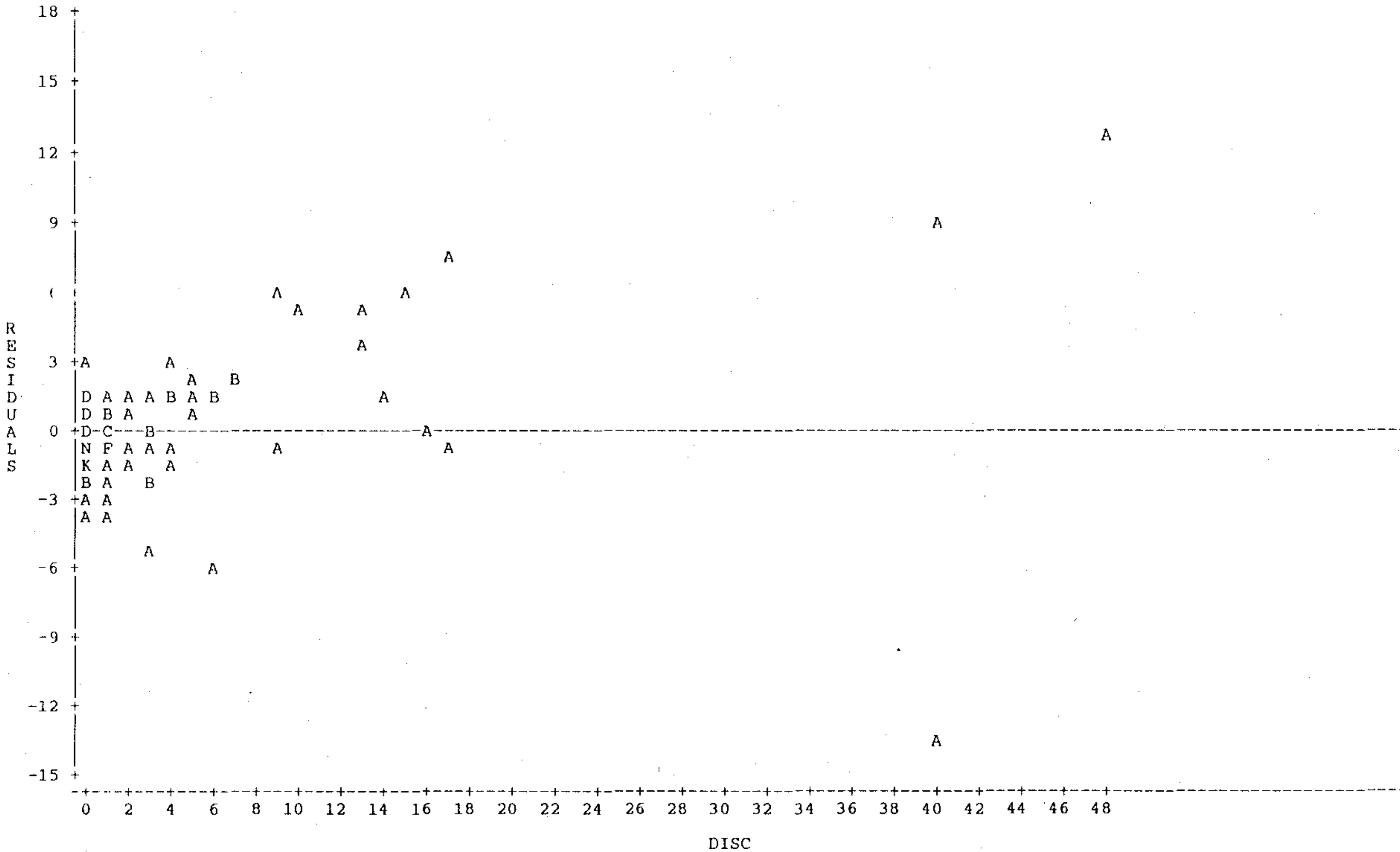

Figure 2. Residuals obtained from multiple regression modelling between predicted and observed cod discards (in pounds) in the 1990 Gulf of Maine shrimp fishery.

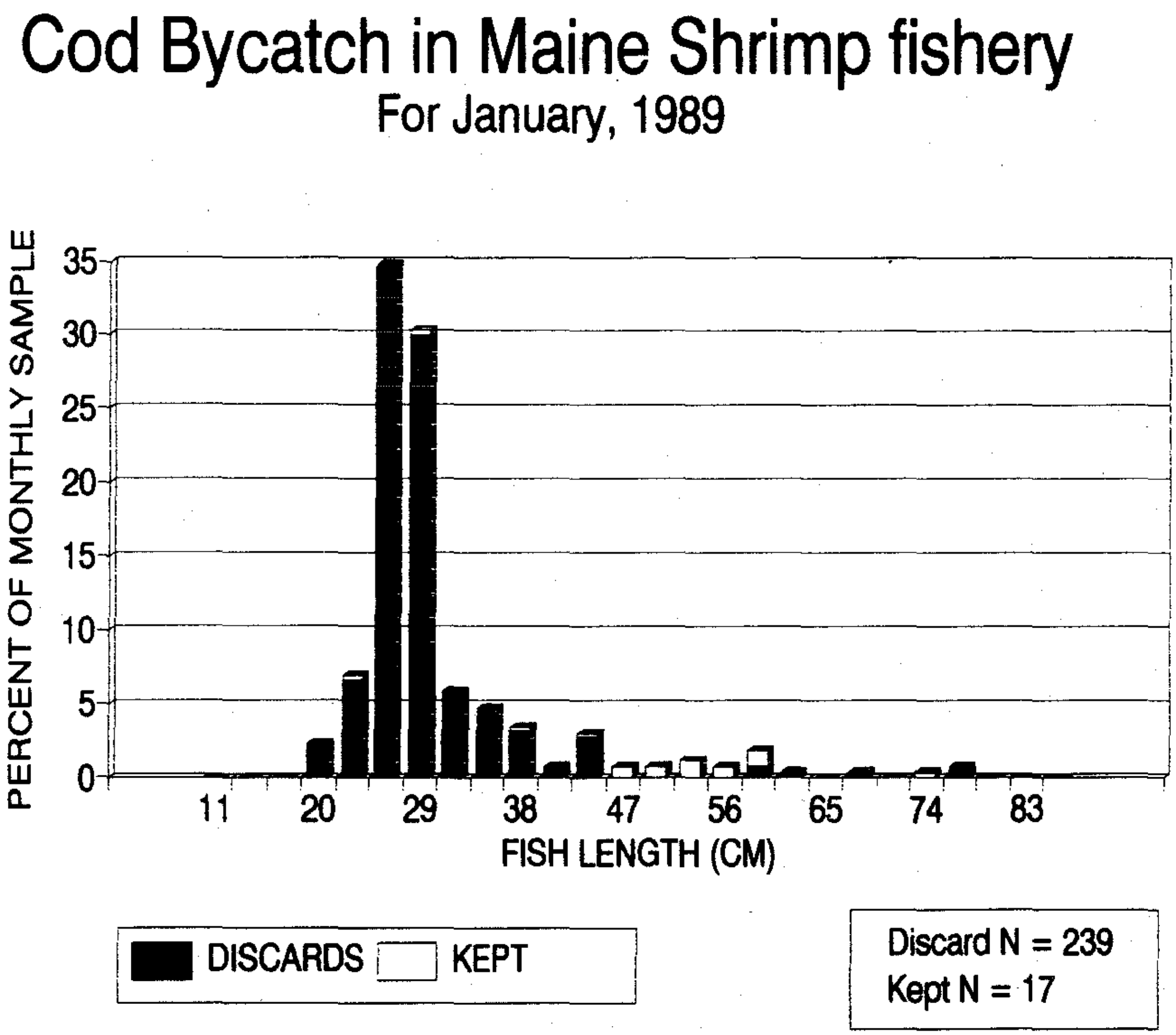

Figure 3. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery in January, 1989.

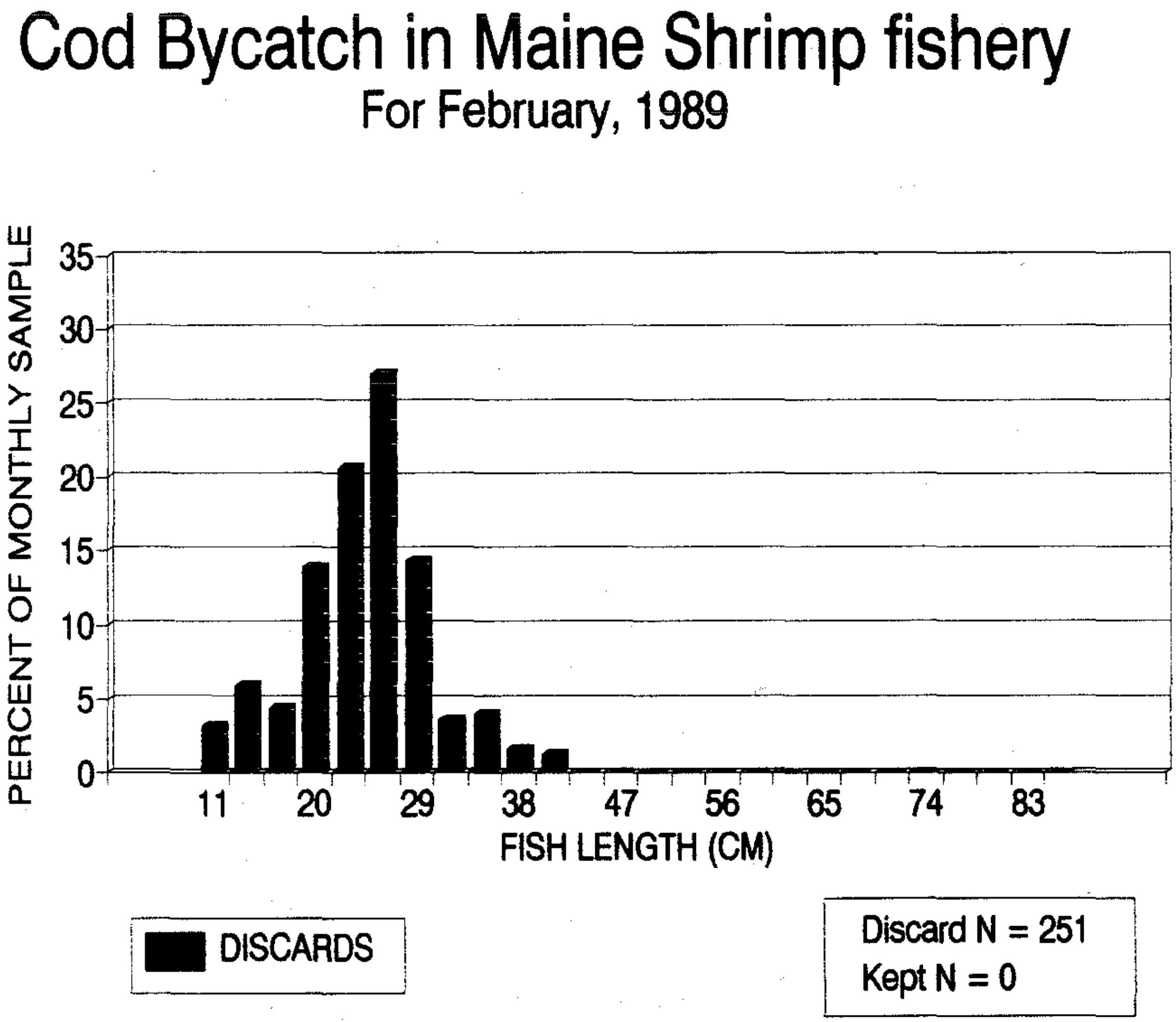

Figure 4. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery in February, 1989.

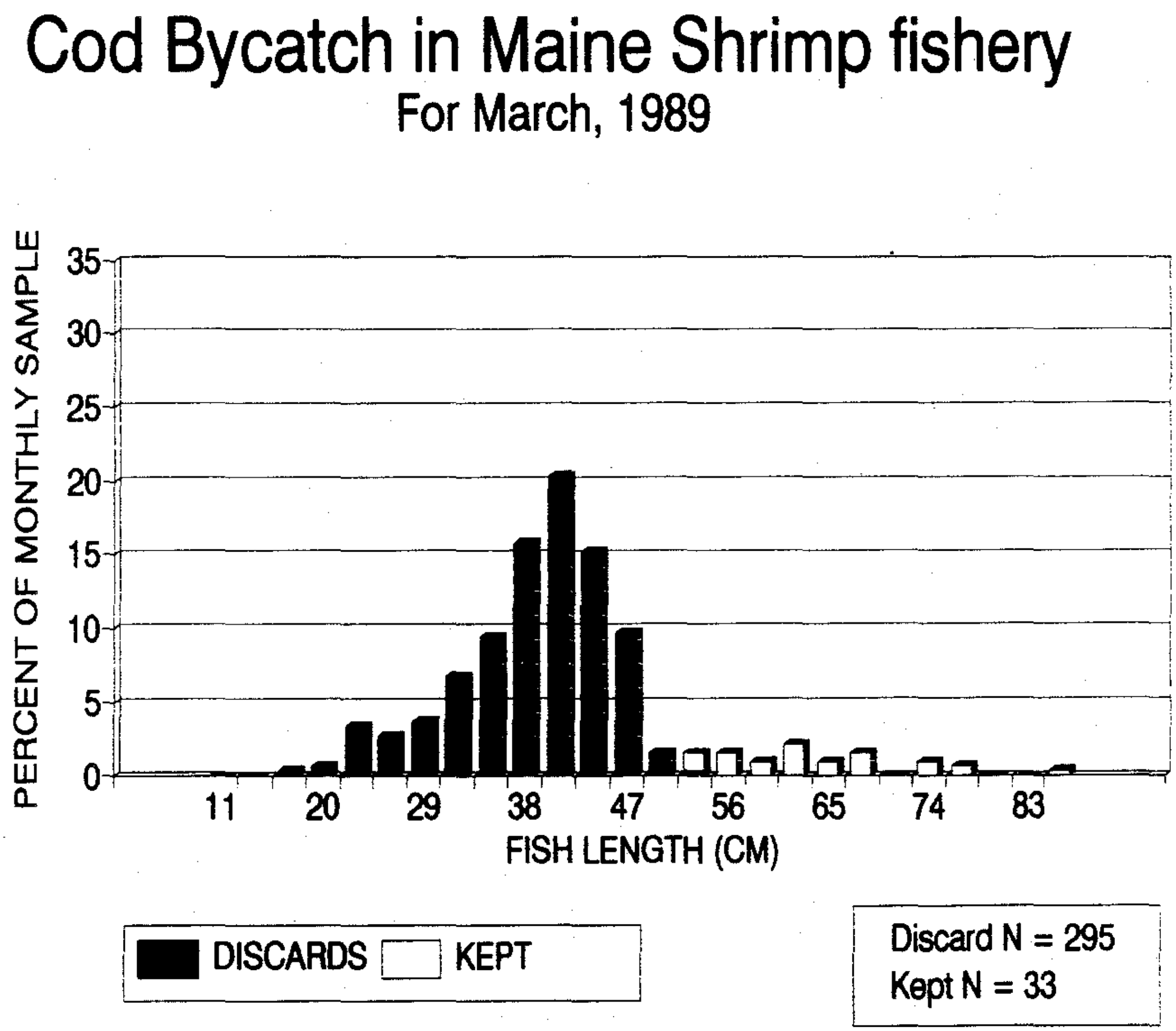

Figure 5. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery in March, 1989.

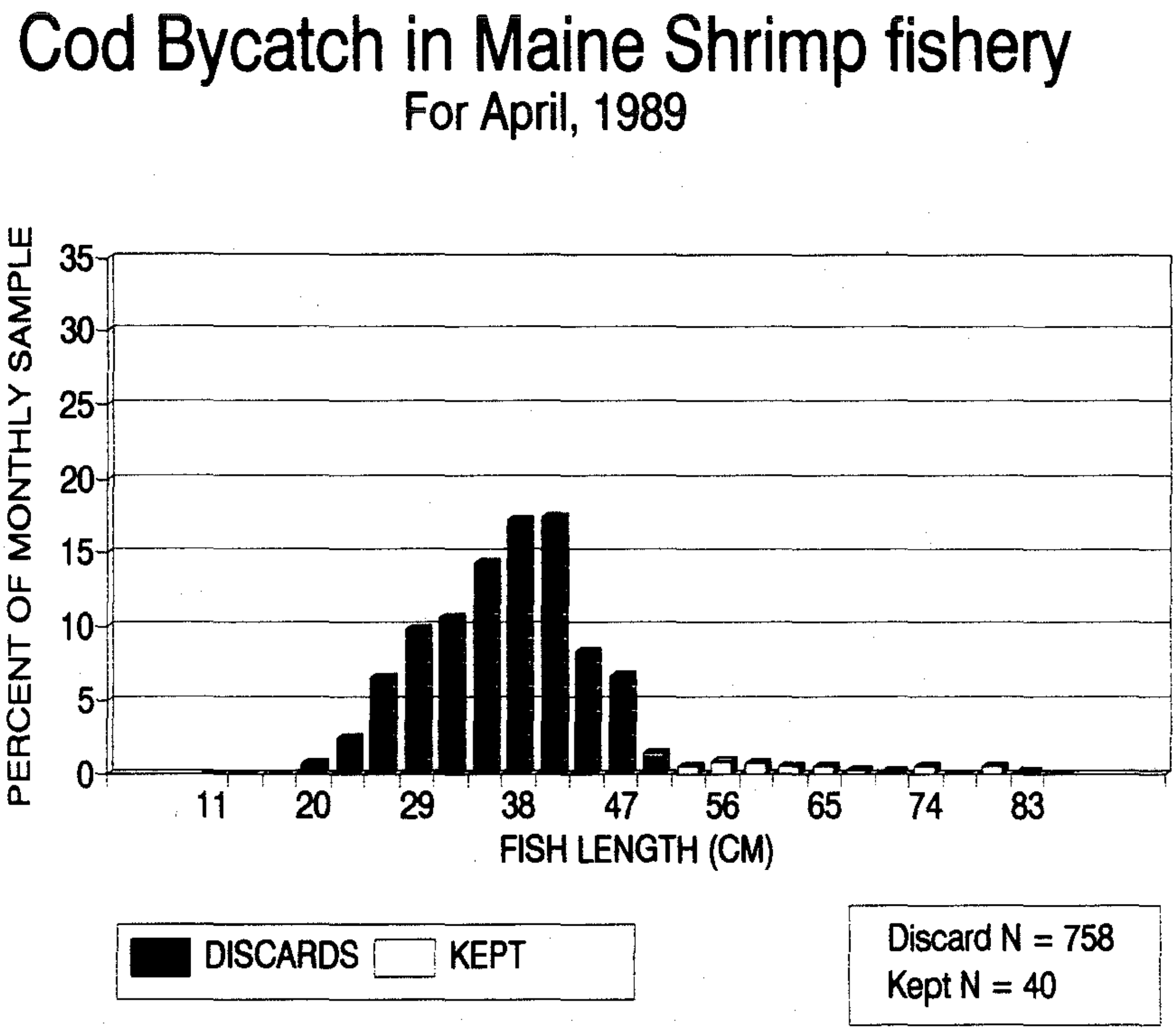

Figure 6. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery in April, 1989.

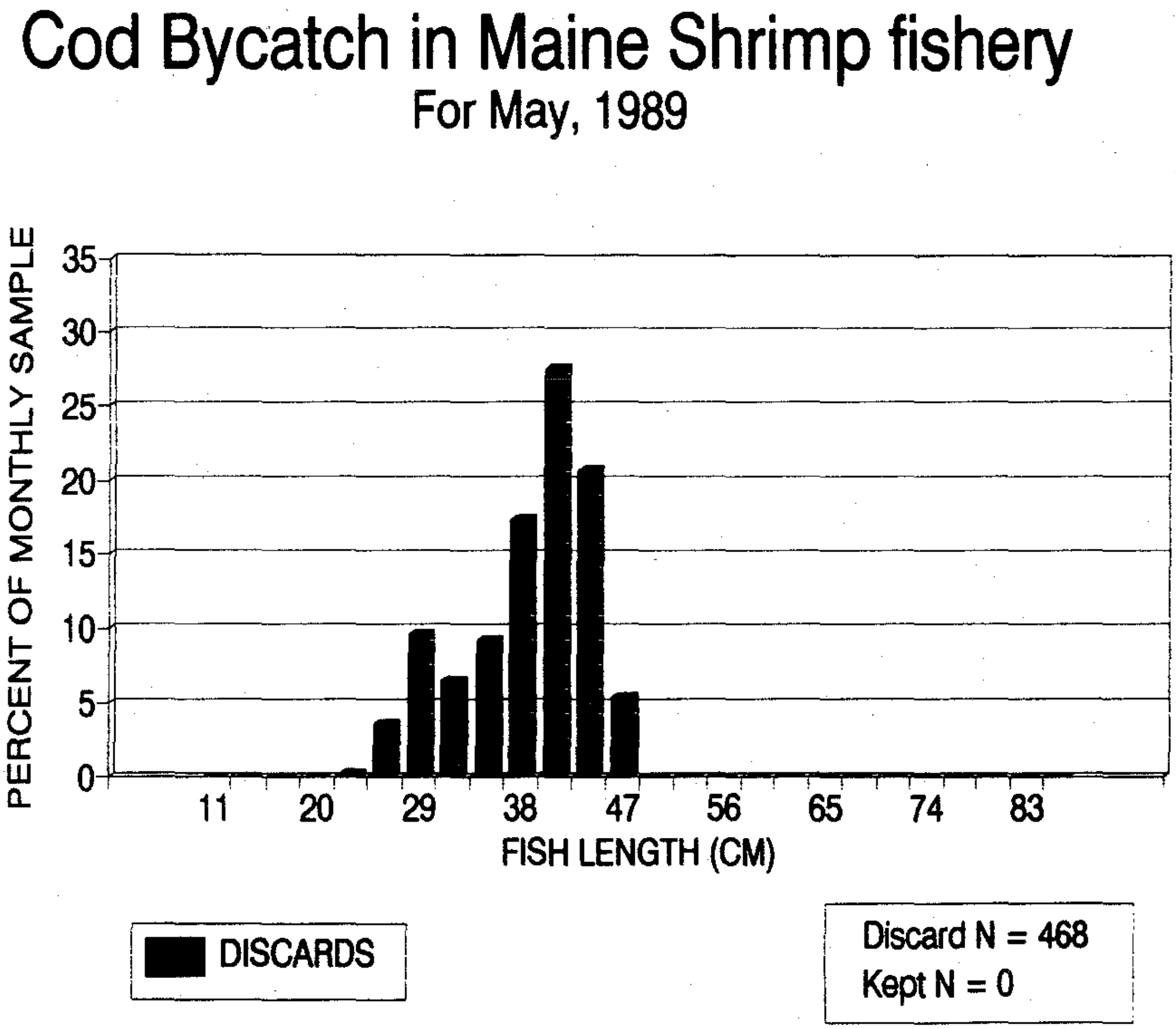

Figure 7. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery in May, 1989.

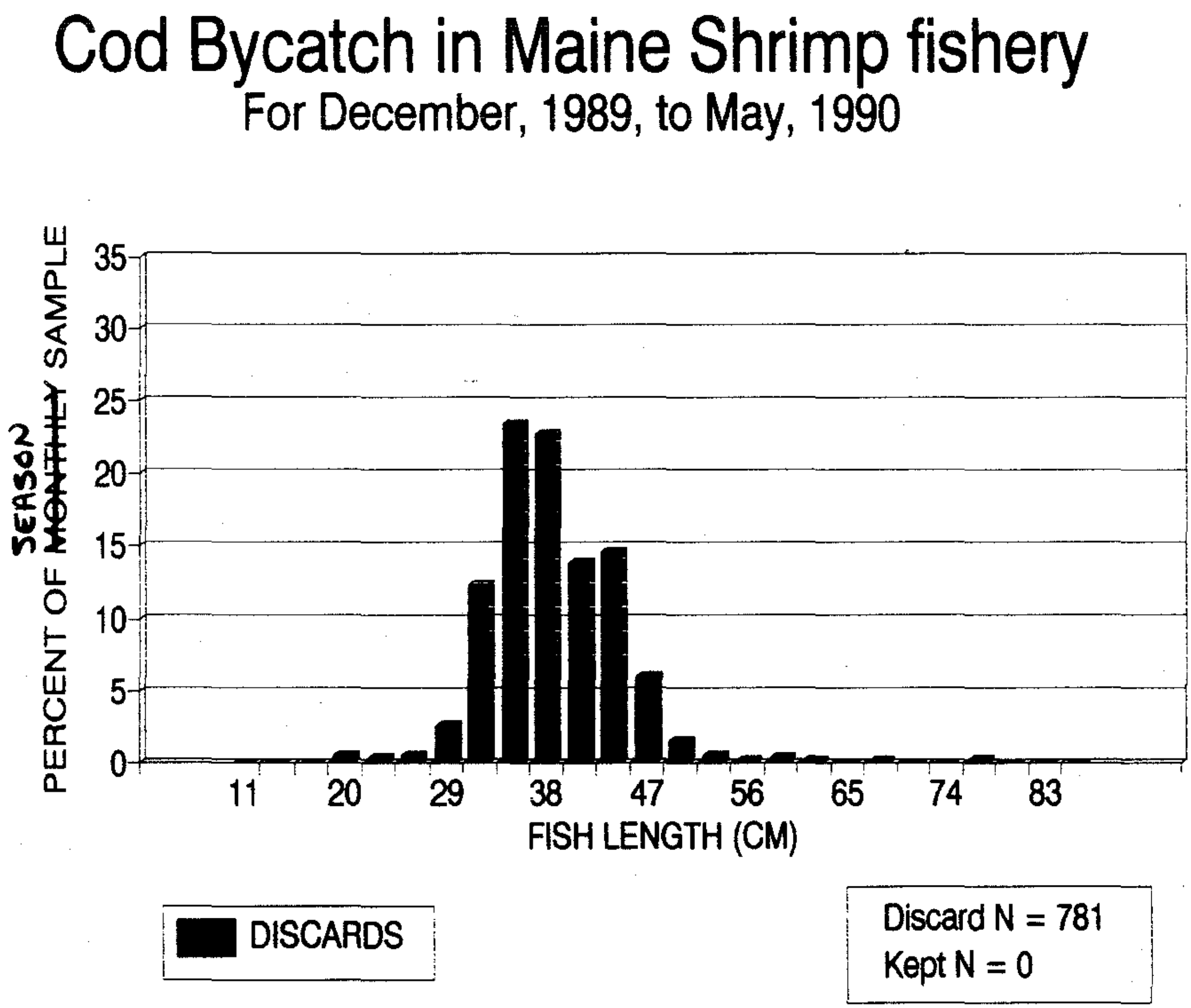

Figure 8. Cod by-catch (total length, summarized over 3 cm intervals) in the Gulf of Maine shrimp fishery from December, 1989 to May 1990.

Appendix Table 1. Monthly means and associated statistics for NEFC sea sampled observed tows during Jan-May 1989 (month equals month within Dec-May seasonal fishery; tow equals tow duration in tenths of hours; shrimp equals shrimp landed; kept, discard, and total refer to cod captured in shrimp tows; ratio equals total cod caught/shrimp landed; and month*ratio is an interaction term).

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
4 TOW			93	29.204	6.332	0.6566	0.21683	2.000	-4.30	42.000	2.02	40.000
	MONTH	*2	12	26.500	3.873	1.1180	0.14615	20.000	-1.68	31.000	1.16	11.000
		*3	23	26.304	8.594	1.7920	0.32672	2.000	-2.83	38.000	1.36	36.000
		*4	11	32.091	4.571	1.3781	0.14243	25.000	-1.55	42.000	2.17	17.000
		*5	34	30.529	5.142	0.8818	0.16842	23.000	-1.46	40.000	1.84	17.000
		*6	13	30.923	5.377	1.4913	0.17388	24.000	-1.29	40.000	1.69	16.000
5 SHRIMP			93	391.710	260.696	27.0329	0.66553	0.000	-1.50	1400.000	3.87	1400.000
	MONTH	*2	12	357.500	308.527	89.0639	0.86301	0.000	-1.16	1000.000	2.08	1000.000
		*3	23	338.696	235.233	49.0495	0.69453	90.000	-1.06	1000.000	2.81	910.000
		*4	11	465.909	143.802	43.3580	0.30865	200.000	-1.85	650.000	1.28	450.000
		*5	34	401.441	299.929	51.4374	0.74713	100.000	-1.01	1400.000	3.33	1300.000
		*6	13	428.846	233.150	64.6642	0.54367	100.000	-1.41	800.000	1.59	700.000
6 KEPT			93	31.333	53.907	5.5899	1.72044	0.000	-0.58	235.000	3.78	235.000
	MONTH	*2	12	20.583	19.934	5.7544	0.96844	0.000	-1.03	54.000	1.68	54.000
		*3	23	0.609	1.672	0.3486	2.74631	0.000	-0.36	6.000	3.23	6.000
		*4	11	87.364	83.669	25.2271	0.95771	0.000	-1.04	235.000	1.76	235.000
		*5	34	41.235	62.172	10.6624	1.50773	0.000	-0.66	217.000	2.83	217.000
		*6	13	22.308	16.660	4.6207	0.74684	0.000	-1.34	50.000	1.66	50.000
7 DISCARD			93	33.849	63.768	6.6125	1.88388	0.000	-0.53	400.000	5.74	400.000
	MONTH	*2	12	8.417	14.469	4.1769	1.71911	0.000	-0.58	48.000	2.74	48.000
		*3	23	5.826	11.808	2.4621	2.02670	0.000	-0.49	45.000	3.32	45.000
		*4	11	78.727	113.708	34.2841	1.44432	2.000	-0.67	400.000	2.83	398.000
		*5	34	40.971	69.952	11.9967	1.70737	0.000	-0.59	294.000	3.62	294.000
		*6	13	50.308	45.408	12.5939	0.90261	0.000	-1.11	143.000	2.04	143.000
8 TOTAL			93	65.183	103.584	10.7412	1.58913	0.000	-0.63	444.000	3.66	444.000
	MONTH	*2	12	29.000	29.970	8.6515	1.03344	0.000	-0.97	102.000	2.44	102.000
		*3	23	6.435	12.048	2.5123	1.87240	0.000	-0.53	45.000	3.20	45.000
		*4	11	166.091	134.376	40.5159	0.80905	20.000	-1.09	400.000	1.74	380.000
		*5	34	82.206	128.068	21.9634	1.55789	0.000	-0.64	444.000	2.83	444.000
		*6	13	72.615	53.677	14.8874	0.73920	0.000	-1.35	178.000	1.96	178.000
9 RATIO			89	0.148	0.211	0.0223	1.41879	0.000	-0.70	0.927	3.70	0.927
	MONTH	*2	11	0.080	0.072	0.0218	0.90651	0.000	-1.10	0.229	2.05	0.229
		*3	23	0.031	0.097	0.0202	3.08101	0.000	-0.32	0.467	4.49	0.467
		*4	10	0.372	0.328	0.1038	0.88236	0.040	-1.01	0.927	1.69	0.887
		*5	32	0.159	0.193	0.0342	1.21770	0.000	-0.82	0.569	2.12	0.569
		*6	13	0.217	0.222	0.0615	1.02349	0.000	-0.98	0.811	2.68	0.811
10 MONTH*RATIO			89	0.686	1.014	0.1075	1.47767	0.000	-0.68	4.866	4.12	4.866
	MONTH	*2	11	0.160	0.145	0.0437	0.90651	0.000	-1.10	0.457	2.05	0.457
		*3	23	0.094	0.291	0.0606	3.08101	0.000	-0.32	1.400	4.49	1.400
		*4	10	1.488	1.313	0.4153	0.88236	0.160	-1.01	3.709	1.69	3.549
		*5	32	0.793	0.966	0.1708	1.21770	0.000	-0.82	2.846	2.12	2.846
		*6	13	1.299	1.330	0.3688	1.02349	0.000	-0.98	4.866	2.68	4.866

Appendix Table 2. Monthly means and associated statistics for NEFC sea sampled observed tows during Dec 1989 - May 1990 (month equals month within Dec-May seasonal fishery; tow equals tow duration in tenths of hours; shrimp equals shrimp landed; kept, discard, and total refer to cod captured in shrimp tows; ratio equals total cod caught/shrimp landed; and month*ratio is an interaction term).

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN	COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
4 TOW			96	28.271	8.261	0.8431	0.29220	1.000	-3.30	45.000	2.03	44.000
	MONTH	*1	21	26.619	9.718	2.1207	0.36509	1.000	-2.64	38.000	1.17	37.000
		*2	21	29.619	7.566	1.6511	0.25545	20.000	-1.27	43.000	1.77	23.000
		*3	17	31.000	7.475	1.8129	0.24113	11.000	-2.68	45.000	1.87	34.000
		*4	21	25.619	8.015	1.7491	0.31287	10.000	-1.95	43.000	2.17	33.000
		*5	6	23.500	8.361	3.4132	0.35577	13.000	-1.26	30.000	0.78	17.000
		*6	10	32.700	4.923	1.5567	0.15054	25.000	-1.56	41.000	1.69	16.000
5 SHRIMP			96	452.385	300.115	30.6304	0.66341	15.000	-1.46	1500.000	3.49	1485.000
	MONTH	*1	21	330.190	162.651	35.4933	0.49260	15.000	-1.94	600.000	1.66	585.000
		*2	21	591.429	332.859	72.6359	0.56281	200.000	-1.18	1400.000	2.43	1200.000
		*3	17	656.176	397.006	96.2882	0.60503	75.000	-1.46	1500.000	2.13	1425.000
		*4	21	244.048	166.828	36.4048	0.68359	75.000	-1.01	775.000	3.18	700.000
		*5	6	411.667	152.501	62.2584	0.37045	210.000	-1.32	620.000	1.37	410.000
		*6	10	532.500	151.148	47.7973	0.28385	255.000	-1.84	775.000	1.60	520.000
6 KEPT			96	21.219	29.288	2.9892	1.38031	0.000	-0.72	137.000	3.95	137.000
	MONTH	*1	21	19.762	21.945	4.7888	1.11048	0.000	-0.90	100.000	3.66	100.000
		*2	21	21.190	33.719	7.3581	1.59123	0.000	-0.63	137.000	3.43	137.000
		*3	17	21.647	23.979	5.8158	1.10773	0.000	-0.90	75.000	2.22	75.000
		*4	21	3.286	6.206	1.3543	1.88878	0.000	-0.53	20.000	2.69	20.000
		*5	6	37.500	44.017	17.9699	1.17379	5.000	-0.74	105.000	1.53	100.000
		*6	10	51.500	36.366	11.5000	0.70614	5.000	-1.28	100.000	1.33	95.000
7 DISCARD			96	47.052	94.496	9.6445	2.00833	0.000	-0.50	505.000	4.85	505.000
	MONTH	*1	21	18.714	24.558	5.3591	1.31228	0.000	-0.76	91.000	2.94	91.000
		*2	21	45.190	52.015	11.3506	1.15102	0.000	-0.87	170.000	2.40	170.000
		*3	17	39.235	50.879	12.3400	1.29677	0.000	-0.77	171.000	2.59	171.000
		*4	21	3.762	5.224	1.1400	1.38867	0.000	-0.72	18.000	2.73	18.000
		*5	6	75.833	68.750	28.0671	0.90659	0.000	-1.10	164.000	1.28	164.000
		*6	10	197.400	218.120	68.9757	1.10497	10.000	-0.86	505.000	1.41	495.000
8 TOTAL			96	68.271	112.672	11.4995	1.65036	0.000	-0.61	590.000	4.63	590.000
	MONTH	*1	21	38.476	36.863	8.0441	0.95807	0.000	-1.04	150.000	3.03	150.000
		*2	21	66.381	70.591	15.4042	1.06342	6.000	-0.86	238.000	2.43	232.000
		*3	17	60.882	66.858	16.2154	1.09815	0.000	-0.91	236.000	2.62	236.000
		*4	21	7.048	9.510	2.0753	1.34945	0.000	-0.74	35.000	2.94	35.000
		*5	6	113.333	100.703	41.1118	0.88855	5.000	-1.08	224.000	1.10	219.000
		*6	10	248.900	239.984	75.8895	0.96418	15.000	-0.97	590.000	1.42	575.000
9 RATIO			95	0.149	0.224	0.0229	1.50168	0.000	-0.67	1.358	5.41	1.358
	MONTH	*1	21	0.122	0.134	0.0292	1.09720	0.000	-0.91	0.615	3.69	0.615
		*2	21	0.154	0.187	0.0409	1.21849	0.004	-0.80	0.657	2.69	0.653
		*3	17	0.130	0.213	0.0517	1.63305	0.000	-0.61	0.813	3.20	0.813
		*4	21	0.045	0.061	0.0134	1.34927	0.000	-0.74	0.201	2.55	0.201
		*5	6	0.251	0.196	0.0799	0.78119	0.013	-1.22	0.506	1.30	0.493
		*6	9	0.409	0.465	0.1549	1.13578	0.038	-0.80	1.358	2.04	1.321
10 MONTH*RATIO			95	0.517	1.138	0.1168	2.20253	0.000	-0.45	8.150	6.71	8.150
	MONTH	*1	21	0.122	0.134	0.0292	1.09720	0.000	-0.91	0.615	3.69	0.615
		*2	21	0.308	0.375	0.0818	1.21849	0.009	-0.80	1.314	2.69	1.306
		*3	17	0.391	0.639	0.1550	1.63305	0.000	-0.61	2.438	3.20	2.438
		*4	21	0.182	0.245	0.0535	1.34927	0.000	-0.74	0.805	2.55	0.805
		*5	6	1.253	0.979	0.3997	0.78119	0.063	-1.22	2.530	1.30	2.467
		*6	9	2.456	2.789	0.9296	1.13578	0.225	-0.80	8.150	2.04	7.925

Papers of the Northeast Regional
Stock Assessment Workshops

By-catch and Discard Patterns in the Gulf of Maine Northern Shrimp Fishery

by

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Appendix to CRD-91-03 SAW 12

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INTRODUCTION

The northern shrimp (*Pandalus borealis* Krøyer) supports a small but locally important fishery in the western Gulf of Maine. Currently fishermen from three states- Maine, New Hampshire and Massachusetts- participate. Commercial landings have fluctuated considerably, increasing to an average of about 11,400 metric tons (t) from 1969-1972 before declining to negligible levels in the late 1970's. During the 1980's landings again increased to over 5,000 t in 1987 and have since declined somewhat; the 1990 total was 4,400 t. Historically the bulk of the catch has been landed by vessels fishing out of smaller ports along the central Maine coast between Portland and Rockland (Figure 1).

This fishery has been managed by seasonal closures and mesh regulations under the Interstate Fisheries Management program of the Atlantic States Marine Fisheries Commission. Under a "Statement of Policy" drafted by the Commission in 1980, fishing is allowed within a "window" of 183 days (December-May). Since 1986 the fishery has been open throughout the entire December-May period, e.g., the 1990 fishing season extended from December 1, 1989 to May 31, 1990. Distinct seasonal peaks in effort and landings occur in midwinter, particularly along the Central Maine coast, reflecting increased availability associated with onshore movement of ovigerous females. Mesh regulations require use of trawls with stretched mesh sizes of not less than 1.75 inches (44 mm) in the body and codend.

Substantial increases in effort in this fishery in recent years, coupled with use of small mesh gear, has led to concern about potential mortality and loss of yield due to by-catch and discard of juvenile finfish in directed shrimping operations. Until recently, discard data for this fishery have been limited; but there is sufficient information from earlier sea sampling programs to indicate that fishery-related impacts can be significant. In shrimp trawl gear trials conducted in 1974 by-catch of finfish of all sizes consistently exceeded catches of shrimp (McInnes 1986). MacIsaac and Diodati (1978) reported average finfish discard of 22-27 percent of the total catch (shrimp and finfish included) based on interview data for Gloucester and Portland vessels during 1976 and 1977. Howell and Langan (1987) observed high discard rates for several flatfish species in sea sampling trips aboard shrimp vessels in the western Gulf of Maine in 1983. Brunenmeister and Burns (MS 1987) analyzed data for sixteen sea sampling trips between 1983 and 1987 by NMFS port agents and concluded that annual losses in yield of up to 7% or $1.4 million could result from discard of American plaice and winter flounder alone. A total discard of 1900 t of selected flatfish and roundfish species was estimated for 1988 based on data for ten sea sampling trips (McCarthy MS 1989).

Until 1989, no resources were available to support a comprehensive sea sampling program and the number of trips made was limited. In 1989, however, the Northeast Fisheries Science Center (NEFSC) developed and implemented the Domestic Sea Sampling Program under contract with the Manomet Bird Observatory which has provided greatly expanded coverage of this fishery. The 1989, 1990 and 1991 fishing seasons have been covered and data are now available for a variety of analyses, e.g., total numbers and weights discarded by species, area and season.

The purposes of this study were:

1) To complete a preliminary evaluation of discard of Multispecies Plan finfish in the Gulf of Maine northern shrimp fishery; and

2) To evaluate discard patterns by area and season to provide a basis for future sampling work.

METHODS

Data on total catch and effort for the northern shrimp trawl fishery (gear code 058) were extracted from Northeast Fisheries Science Center (NEFSC) weighout and interview data files. Sea sampling data was extracted from NEFSC Domestic Sea Sampling Program data files. We include by-catch and discard data for the thirteen finfish species now included in the New England Fishery Management Council's Multispecies Plan for Atlantic Groundfish (hereafter termed MSP), i.e. cod, haddock, redfish, silver hake or whiting, red hake, white hake, pollock, American plaice, winter flounder, witch flounder, yellowtail, sand dab, and ocean pout.

To determine if area/season patterns could be identified in the data, we plotted the locations of all tows sampled in the western Gulf of Maine during the 1989-1991 fishing seasons. The resulting plot indicated three centers of activity (Figure 2), which were delineated for subsequent analysis as follows:

Area 1	Central Maine	Lat. ≥ 43° 12' Long. ≤ 69° 50'
Area 2	Southern Maine	Lat. ≥ 43° 12' Long. > 69° 50'
Area 3	New Hampshire-Massachusetts	Lat. < 43° 12'

The "Central Maine" region is fished primarily by vessels operating out of ports east of Portland; the "Southern Maine" region is fished primarily by Portland vessels, and the "New Hampshire-Massachusetts region is fished primarily by vessels operating out of Gloucester and smaller ports north to the New Hampshire border (Figure 1). There is support for such an arrangement both from seasonal differences in landings and effort trends and from anecdotal information suggesting that discard amounts and species composition also differ between these areas.

We derived and plotted average total bycatch estimates and percentages by weight relative to total northern shrimp landings by area and month for the 1989-1991 fishing seasons as an initial proxy for discard. Here we assumed that by-catch trends should reflect finfish availability and hence discard potential. We also summarized total MSP discard for sea sampled trips by year and area to assess its importance relative to amounts of finfish and shrimp actually landed. We also calculated total discard estimates for each area/month combination for the 1990 and 1991 seasons by multiplying estimates of discard per day fished from the sea sample data by estimates of total days fished from NEFSC weighout data files.

RESULTS AND DISCUSSION

Average total bycatch of MSP species and corresponding percentages by weight relative to shrimp landings for the 1989-1991 seasons are given in Figure 3. For each area there is a clear tendency for bycatch to be high early in the season, to decline significantly during mid-winter, and then to increase again in April and May. This is thought to reflect differences in finfish availability associated with seasonal shifts in directed effort. Total amounts of bycatch were lowest for the Central Maine area, as were percentages by weight. Bycatch tended to be much higher in the remaining two areas. Totals were highest off Southern Maine in December through February and off New Hampshire and Massachusetts in March through May. Monthly percentages by weight relative to shrimp landings increased consistently from Central Maine to Massachusetts (Figure 3).

Data from the NEFSC Domestic Sea Sampling Program reveal species differences between areas in the relative proportions discarded; but there is a general tendency for discard to exceed landings by weight for finfish, often substantially so (Table 1). This is particularly true for cod, American plaice and whiting. Average percentages by weight relative to shrimp catch for all MSP species over the 1989-1991 fishing seasons were as follows: Central Maine, 47%, Southern Maine, 64%, and New Hampshire-Massachusetts, 47%. This pattern is not consistent with the bycatch trends indicated in Figure 3; but the observed proportions of discard relative to total landings of shrimp and finfish do appear adequate to document the potential magnitude of the problem.

Total discard estimates are given by area and month for the 1990 and 1991 fishing seasons in Table 2 (similar estimates for 1989 were not developed due to gaps in seasonal coverage). There seems to be a general tendency for discard amounts and rates (discard per day fished) to decline in midwinter and then to increase later as observed for by-catch data (Figure 3) although considerable variability is evident in observed trends between areas and years. Total discard estimates by area were not consistent with the bycatch analyses results, however, as amounts for Central Maine were intermediate between the remaining two areas in both years. The magnitude of the drop in total estimated discard between the two years i.e. from 5.7 to 2.7 million pounds (Table 3) was also unexpected although directed effort (number of trips) did decline between 1990 and 1991.

Further refinement of discard estimates in this fishery will likely require both more intensive sampling and more consistent and representative sampling by area and season. Effort data (days fished) for sea sampled trips during the 1990 and 1991 seasons indicate that on average less than one-half of one percent of the total effort was in fact covered under this program, and in some cases intensity was considerably less. Estimates can also obviously be improved by insuring consistent monthly coverage throughout the season. This is particularly true for the Gulf of Maine shrimp fishery where discard rates are very likely to change with shifts in directed effort by area. Also, the distribution of sea sampled tows for the three years (Figure 2) suggests that there was relatively little coverage of inshore areas (particularly off Central Maine) where discard rates might be expected to be relatively low. This could have resulted in significant upward bias for discard estimates for the Central Maine component of the fishery. Additional sampling in future seasons, with particular reference to inshore and offshore areas off Central Maine, is needed to resolve this question.

To summarize, results of this project agree with previous studies in indicating that the impact of the Gulf of Maine shrimp fishery on demersal finfish resources is significant, although additional work is needed to generate definitive estimates. Development of such estimates on a species by species basis will in our opinion require both more intensive sampling and representative sampling strategies to account for differences in by-catch and discard trends by area and season.

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Table 1. Multispecies landings and discard (lbs) observed during sea sampling trips made under the NEFSC Domestic Sea Sampling Program in the Gulf of Maine northern shrimp fishery, 1989-1991 fishing seasons.[1]

	Central ME			Southern ME			NH-MA		
Species	K[2]	D	%D[3]	K	D	%D	K	D	%D
1989									
Cod	145	51	26	1,268	1,135	47	1,289	1,793	58
Am plaice	110	83	43	205	1,072	84	691	2,512	78
Other fldr	49	62	56	96	151	61	441	215	33
Hakes	115	705	86	150	524	78	1,837	2,515	58
Whiting	50	690	93	157	476	75	2,026	7,356	78
Other	0	45	100	75	74	50	1,023	224	18
Shrimp	2,640	-	-	6,600	-	-	26,845	-	-
1990									
Cod	340	652	66	564	1,289	70	1,208	2,676	69
Am plaice	118	1,119	90	247	1,687	87	318	2,925	90
Other fldr	77	349	82	106	255	71	211	249	54
Hakes	75	839	92	1,578	903	36	2,375	1,503	40
Whiting	0	672	100	747	2,819	79	2,904	2,870	50
Other	44	57	56	106	320	75	309	792	72
Shrimp	7,375	-	-	9,820	-	-	27,014	-	-
1991									
Cod	3,082	949	24	475	1,473	76	1,658	1,175	41
Am plaice	364	1,563	81	43	336	89	646	3,205	83
Other fldr	162	561	78	272	408	60	866	905	51
Hakes	1,000	1,430	59	58	580	91	1,590	2,803	64
Whiting	157	1,414	90	39	381	91	1,428	4,543	76
Other	51	194	79	151	291	66	397	1,865	82
Shrimp	14,316	-	-	11,115	-	-	32,265	-	-

[1]Seasons for each year include the preceding December, e.g., 1990 fishing season extends from December 1989 to May 1990. No adjustments have been made for months for which there was no coverage e.g., December of 1988.
[2]K=kept; D=discarded
[3]Expressed as percent of total caught.

Table 2. Estimates of multispecies discard per day fished (lbs), total days fished, and total discard, (000's lbs) for the Gulf of Maine northern shrimp fishery during the 1990 and 1991 fishing seasons.[1]

Area	Dec	Jan	Feb	Mar	Apr	May	Total
1990							
Central ME							
D/DF[2]	2,262	1,613	806	469	(469)	(469)	
TDF	249.7	422.3	302.2	459.7	228.8	28.7	
TD	565	681	244	216	(107)[3]	(13)	1,826
Southern ME							
D/DF	5,410	1,869	1,412	728	4,790	(4,790)	
TDF	196.6	273.8	229.0	194.0	138.4	117.3	
TD	1,064	512	323	141	663	(562)	3,265
NH-MA							
D/DF	788	1,634	3,148	1,394	613	2,288	
TDF	45.6	118.7	61.1	43.5	58.6	36.2	
TD	36	194	192	61	36	83	602
						Total =	5,693
1991							
Central ME							
D/DF	4,484	1,143	218	149	1,136	(1,136)	
TDF	110.9	248.1	395.1	225.8	55.1	17.6	
TD	497	284	86	34	61	(20)	983
Southern ME							
D/DF	(2,220)	2,220	641	134	(134)	(134)	
TDF	194.9	271.6	166.1	112.4	100.2	43.3	
TD	(433)	603	106	15	(13)	(6)	1,176
NH-MA							
D/DF	2,090	1,617	964	1,225	1,179	1,296	
TDF	71.8	113.5	100.6	57.2	33.6	45.0	
TD	150	184	97	70	40	58	599
						Total =	2,758

[1]Seasons for each year include the preceding December, e.g., 1990 fishing season extended from December 1989 to May 1990.
[2]D/DF=Discard per day fished (lbs), TDF=total days fished, and TD=total discard (000's lbs).
[3]( )Sea sampling data not available; estimate calculated using D/DF value for adjacent month.

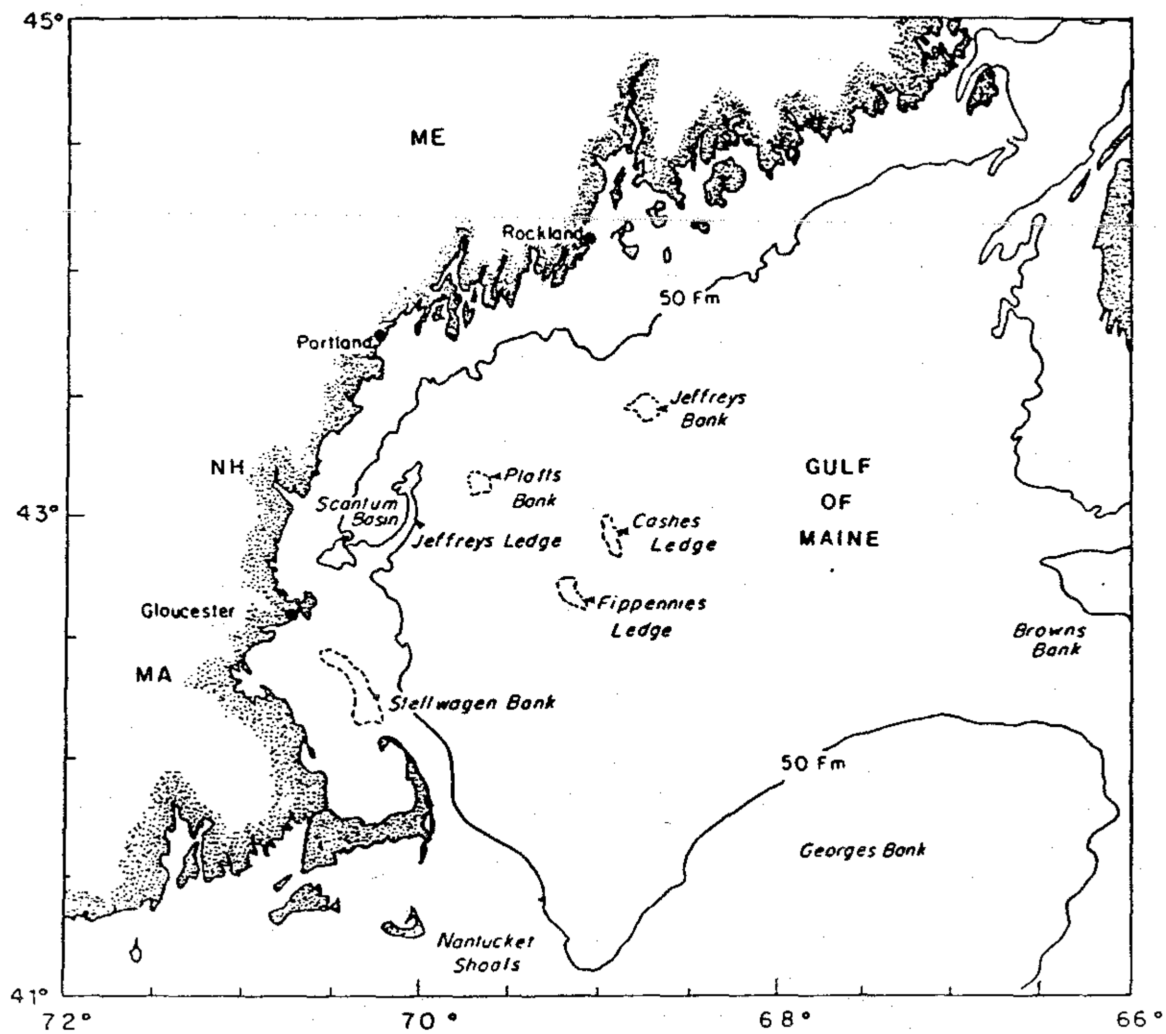

Figure 1. Gulf of Maine indicating areas mentioned in this report.

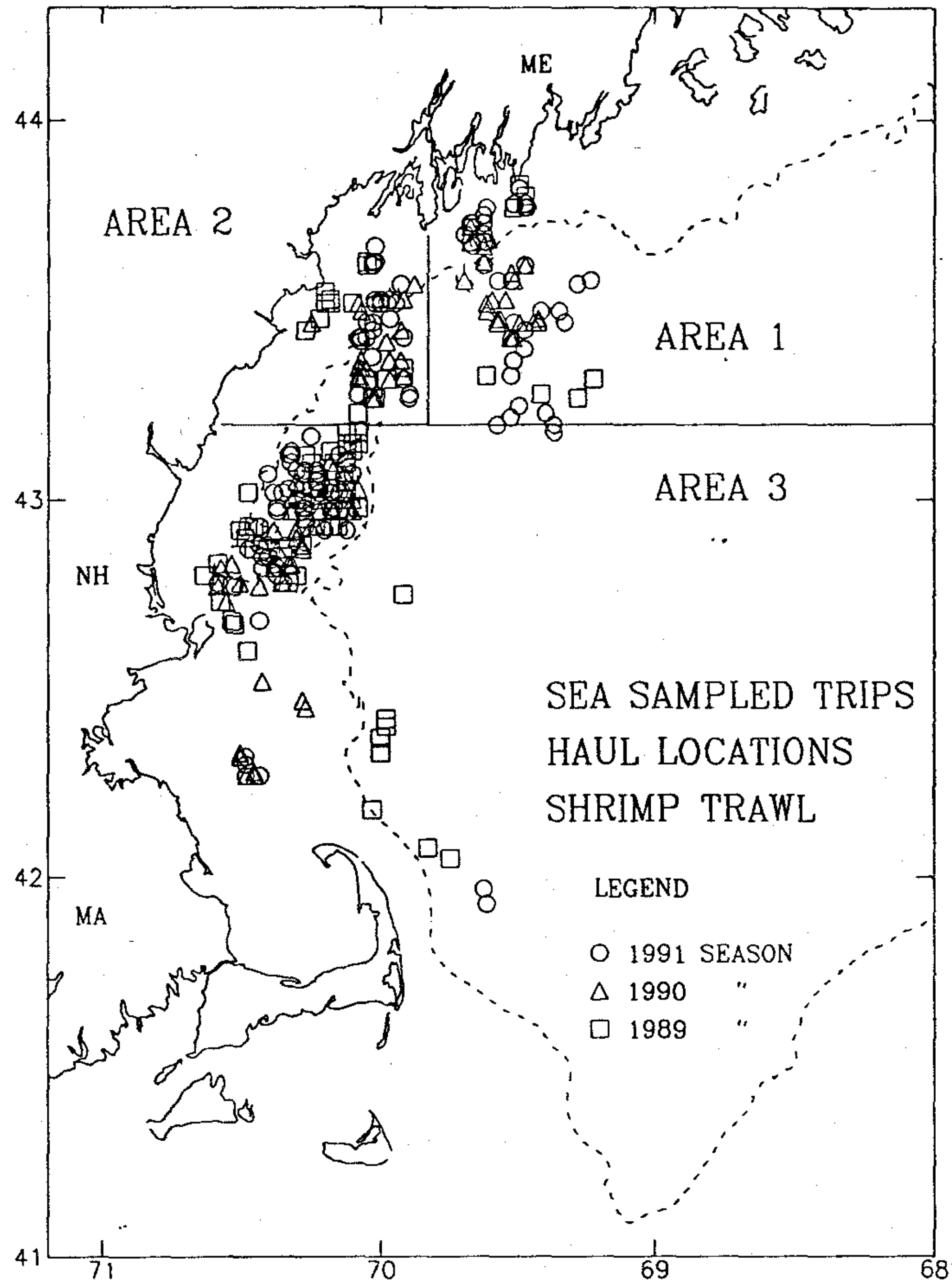

Figure 2. Location of tows sampled in the Gulf of Maine northern shrimp fishery during the NEFSC Sea Sampling program 1989-1991.

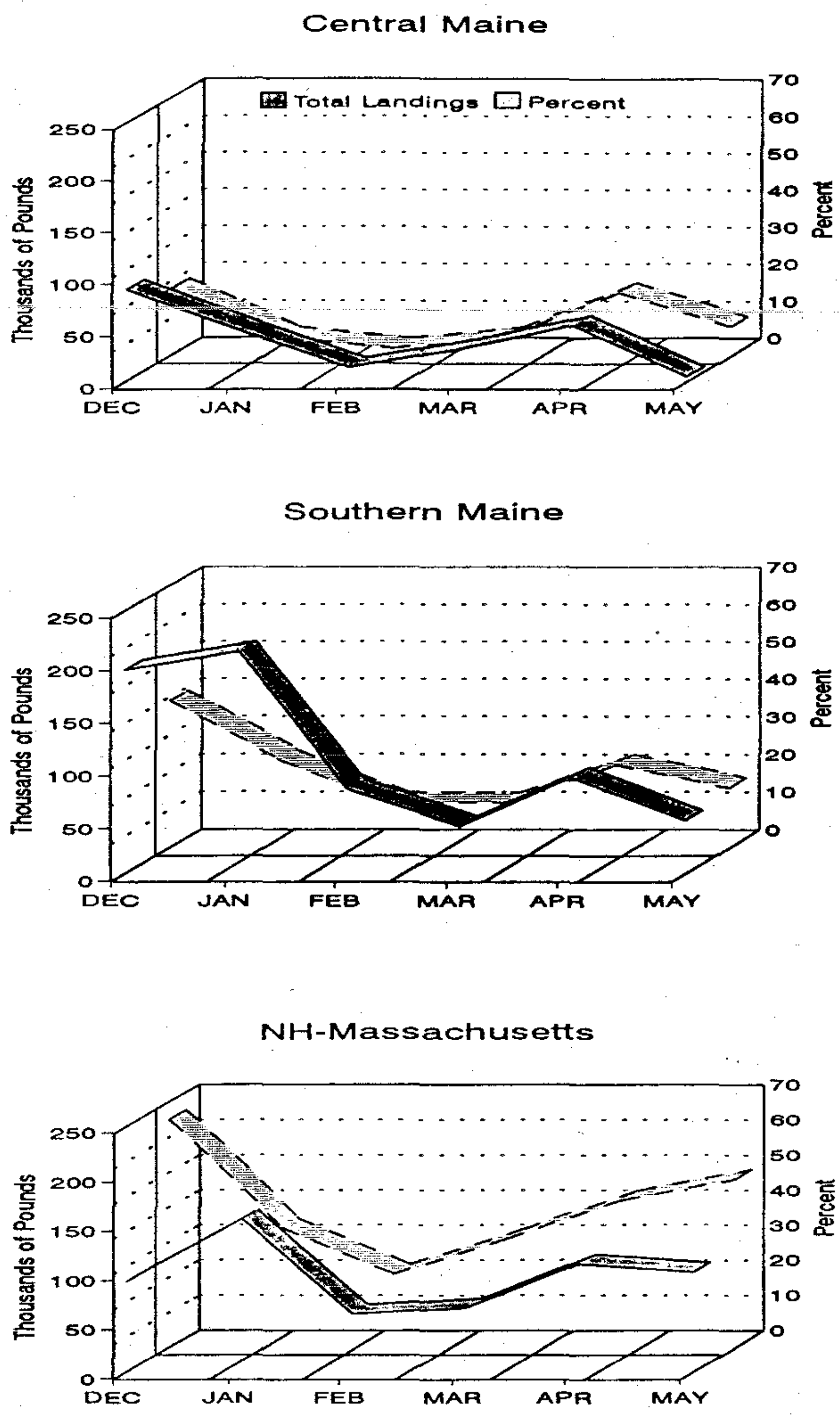

Figure 3. Average landings (000's lbs) and percentages by weight relative to shrimp for Multispecies Plan Finfish bycatch in the Gulf of Maine northern shrimp fishery, 1989-1991 seasons.

Papers of the Northeast Regional
Stock Assessment Workshops

Exploratory Analysis of Four Methods for Estimating Discards from Sea Sampling Data

by

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/11

Abstract:

Four estimators, based on different assumptions, were applied to the sea sampling data for the purpose of estimating total weight of cod discarded by various fisheries operating in the Gulf of Maine during 1989. Through comparisons of the results obtained between the different estimators and with known characteristics of the entire commercial catch, problems with the estimators and assumptions are indicated. From these preliminary analyses, it appears that no single estimator can be recommended for all fisheries operating in the Gulf of Maine, as different assumptions were apparently violated for each estimator-fishery combination. Cluster sampling estimators appear to have a lower coefficient of variation than regression estimators, but large discrepancies between predicted and actual catch with cluster sampling estimators clearly indicate that caution must be used in applying these estimators.

Introduction:

Discarding of fish caught during commercial fishery operations has been identified as a significant source of mortality for numerous species of fish in the northwest Atlantic Ocean. In order to estimate the biomass, number and size distribution of fish discarded in the major commercial fisheries off the northeastern United States, the National Marine Fisheries Service has instituted a program of sampling catch and landings by commercial boats at sea. The "sea sampling program" as it is commonly referred to has collected information on over 650 commercial fishing trips during 1989 and 1990.

This paper explores a number of statistical methods for estimating the biomass of fish discarded in a fishery. This information is required before the total number of fish or number of fish at age discarded can be estimated. Future development of these methods will consider the length and age composition of the discarded portion of the catch. In this paper, four different formulae for estimating the total weight of fish discarded were tested. To simplify analysis, I concentrated on four of the Gulf of Maine fisheries (large-mesh otter trawl; small mesh otter trawl; gillnet; shrimp) and estimated the total biomass of Atlantic cod (Gadus morhua) discarded in each fishery.

Some of the essential characteristics of the sea sampling data are:

1. On each fishing trip, the catch and discard by species are observed for some, but not necessarily all tows.

2. Each trip constitutes a cluster sample (in the statistical sense) and as such, the tows observed within a trip are not independent, random samples of all tows performed by the fishery.

Because of these characteristics of the sampling design, estimates of discard rate made by assuming simple random or stratified random sampling are potentially biased, and tend to underestimate the true variability of estimates. Accordingly, the estimators presented in this paper are based on the clustered nature of the observations.

Methods:

The first estimator tested assumed that the basic observational unit consisted of random samples of tows within trips, with a random selection of trips among the entire population of trips within a fishery. This assumption implies that a "traditional" cluster sample estimator (with subsampling within clusters) is applicable. For the purposes of this paper, only interviewed trips were considered since these are the only trips where the number of tows per trip is known from the commercial fishery database.

The form of the estimator is as follows:

$$D = \frac{N}{n} \Sigma \hat{Y}_i$$

$$\hat{Y}_i = M_i \times \bar{Y}_i$$

$$\bar{Y}_i = \frac{\sum Discard}{m_i}$$

The variance of estimates is obtained by:

$$\frac{N^2}{n}(1-f_1) \; \Sigma \; \frac{(\hat{Y}_i - \hat{\bar{Y}})^2}{n-1} \; + \; \frac{N}{n} \sum \frac{M_i^2(1-f_{2_i}) S_{2\,i}^2}{m_i}$$

Where,

N = # *Trips in Fishery*
n = # *of Trips Sampled*
M_i = # *of Tows in Trip*$_i$
m_i = # *of Observed Tows in Trip*$_i$
$\bar{Y}_i$ = *Mean Discard/ Tow in Trip*$_i$
$S_{2\,i}^2$ = *Variance of Discard/ Tow in Trip*
D = *Total discard*
$\hat{Y}_i$ = *Estimated total discard in trip*$_i$
$\hat{\bar{Y}}$ = *Estimated Population Mean Discard/ Trip* = $\frac{\textit{Estimated Total Discard}}{\textit{Number Trips in Fishery}}$

The second estimator is also based on the assumption that observed tows are a random sample of tows within a trip, again with trips a random sample of all trips. This estimator, however, is based on the number of days fished and takes the form of a ratio estimator:

$$D = \frac{N \text{ days fished in fishery}}{n \text{ days fished sampled}} \sum \text{days fished} * \frac{\text{discard}}{\text{day fished}}$$

$$= N \text{ days fished in fishery} * \frac{\Sigma \text{ discard}}{\Sigma \text{ days fished}}$$

This is equivalent to Cochran's (1977) formula, Pg. 303:

$$\hat{Y}_R = M_o \frac{\Sigma \hat{Y}_i}{\Sigma M_i}$$

Where,

$$\hat{Y}_i = \text{days fished in trip}_i * \frac{\text{discard}}{\text{day fished}}$$

M_o = Number of days fished in fishery
M_i = Number of days fished in $trip_i$

Since this is a ratio estimator, it is biased (Cochran 1977) and the mean square error (MSE) is more appropriate than the variance of the estimator as a measure of precision.

$$MSE(\hat{Y}_R) \doteq \frac{N_2}{n}(1-f_1)\ \Sigma M_i^2 - \frac{(\bar{Y}_i - \hat{Y}_R^*)^2}{n-1} + \frac{N}{n} \sum \frac{M_i^2(1-f_{2_i})^2 S_{2_i}}{m_i}$$

where,

$$\hat{Y}_R^* = \frac{\Sigma \hat{Y}_i}{\Sigma M_i} = \frac{\hat{Y}_R}{M_o}$$

N = # *days fished in fishery*
n = # *days in sample* $= \sum M_i$
M_i = # *days fished in trip total*
m_i = # *days fished observed in trip*

$$f_{2_i} = \frac{m_i}{M_i}$$

$$\bar{Y}_i = \frac{discard}{day\ fished}\ in\ trip_i = \frac{\Sigma\ discard}{\Sigma\ days\ fished} \qquad (observed\ in\ trip)$$

The third estimator used was a regression estimator. This assumes that the tows sampled are an independent random sample of all tows made in the fishery with respect to the relationship between cod caught and cod discarded. Regression estimators in general have a bias of order 1/n if the assumptions of a linear relationship between the two variables is met as well as equal variance of the dependant variable across the range of the independent variable. Note that ratio estimators are a subset of regression estimators where the intercept is zero. Thus, a regression estimator was used as a generalization of ratio estimators of the form discard/kept or discard/total catch.

$$\bar{Y}_{lr} = \bar{Y} + b\,(\bar{X} - \bar{x})$$

Where,

$\bar{Y}$ = *mean discard/ DF* $= \frac{\Sigma\ discard}{\Sigma\ DF}$
$\bar{x}$ = *mean of auxillary variate in sample*
$\bar{X}$ = *population mean of auxillary variate* $= \frac{\sum catch}{\sum DF}$
b = *slope of linear regression between x and y*

The variance of this estimator is approximated by:

$$V(\bar{Y}_{1r}) = \frac{1-f}{n\,(n-2)} \sum \left[(Y_i - \bar{Y}) - b\,(X_i - \bar{x})\right]^2$$

or

$$\frac{1-f}{n\,(n-2)} \sum (Y_i - \bar{Y})^2 - \frac{\Sigma\left[(Y_i - \bar{Y})\,(X_i - \bar{x})\right]^2}{\Sigma\,(X_i - \bar{X})^2}$$

or if n is large

$$V(\bar{Y}_{1r}) = \frac{1}{n-1} \sum \left[(Y_i - \bar{Y}) - b(X_i - \bar{x})\right]^2$$

The final estimator is of the same form as the above regression estimator, except that the basic sampling unit is taken to be the trip and not the individul tows. Accordingly,

$\bar{Y}$ = *discard/ trip*

$\bar{x}$ = *catch/ trip*

$$\bar{X} = \frac{\sum catch}{\#\ trips}$$

Results and Discussion:

Before applying any of the estimators, the information in the sea sampling database had to be merged (crossed) in order to get trip and net characteristics, and catch and discard by species associated with each tow. After this, each trip had to be classified into one of the four main fisheries we are concerned with. Namely, these fisheries are:

1. Large mesh otter trawls
2. Small mesh otter trawls
3. Sink gill nets
4. Shrimp trawls

A difficulty encountered was that each estimator requires knowledge of the population total number of trips, days fished or catch. Thus, it is necessary to group the individual tows within a sea sampling trip into a single trip or several sub-trips that mimics the way commercial fishermen would report their trip or sub-trip in the weighout database. To accomplish this, I classified all tows within division 51 within a trip as "Gulf of Maine". Any tows taken in division 52 were classified in a separate sub-trip. Within the Gulf of Maine portion of any otter trawl trip, each tow was classified as small mesh or large mesh. If the percentage of small mesh or large mesh tows was less than 15% of the total number of tows, those tows were reclassified as the other mesh type. Thus, if a trip had 90% of the tows taken with large mesh gear, and 10% of the tows with small mesh gear, the entire trip was classified as large mesh. On the other hand, if a trip had 80% large mesh tows and 20% small mesh tows, then a sub-trip was created for the small mesh portion of the trip. The choice of 15% as a cut off point was arbitrary.

Estimates of total discards are presented in table 1 for each fishery using each of the four estimators. An important point to note is that using the cluster sampling methods, the total catch of Gulf of Maine cod within a fishery can also be estimated from the sea sampling data. This provides a useful diagnostic measure, in that if the assumptions underlying the estimator are met, the predicted total catch should be relatively close to the actual catch reported.

Using the first cluster sampling estimator, estimates obtained for the total catch showed large deviations from the known total catch. Thus, by inference, the total discard of cod is also likely to deviate from the actual (but unknown) total discard. Unfortunately, the direction of the deviations were not consistent between fisheries. The lack of agreement between predicted and actual catch for each fishery implies that sampling of tows within a trip or trips was not random. Similar deviations between actual and estimated catch using the second cluster sampling estimator were obtained. In this case, the lack of agreement implies that the catch per unit effort differed between the trips or tows sampled at sea and the population as a whole. The second cluster sampling estimator could not be applied to the gill net fishery because fishing effort (days fished) are recorded differently between the sea sampling and commercial weighout databases.

Except for the shrimp fishery, the two cluster sampling estimators produced similar estimates of total discard. The predicted catch, however, differed sharply between the two methods for all fisheries except for the large mesh otter trawl fishery. Comparing the variance estimates produced from each of the two cluster sampling estimators, it appears that the first cluster sampling estimator yields a lower CV for the same data set. Thus, if the model assumptions could be met, it appears that the first cluster sampling estimator would be preferable in this situation.

The two regression estimators produced similar estimates of total discard for all fisheries except for the shrimp fishery. Coefficients of variation for total discard were generally larger for both of the regression estimators compared to the cluster sampling estimators. Unfortunately, no comparison with known population totals can be made to determine if the assumptions of the regression estimators were met.

As a guide for the evaluation of future sampling plans, the standard error and coefficient of variation (CV) for the first cluster sampling estimator for various sample sizes was computed (Figures 1-4). The relationship between standard error and sample size was approximated from data collected during 1989 based on the formula:

$$SE = \sqrt{\frac{s^2}{n}}$$

It should be noted that this formula is not exact for cluster sampling designs or stratified designs, but is intended as an approximate guide for determining appropriate sample sizes for meeting prescribed levels of precision. The relationship between sample size and CV was similar in each fishery. For example, at a sample size of 100 trips, the CV is approximately 30% for the large mesh otter trawl fishery, 22% for the shrimp fishery, 30% for the gill net fishery, and 26% for the small mesh otter trawl fishery. It is important to note, however, that the standard errors achievable for each fishery with a given sample size varies widely. Thus, <u>for the purpose of estimating total discard of cod in the Gulf of Maine</u>, sampling effort should clearly be emphasized for the large mesh otter trawl fishery and the shrimp fishery. Sampling these fisheries more intensively would increase the precision of estimates of cod discarded in all fisheries in the Gulf of Maine, but may affect the precision of estimates of other characteristics of the fishery (i.e., marine mammal kill total).

References

Cochran, W. G. 1977. Sampling techniques. John Wiley and Sons, New York.

Table 1. Estimates of total discard and catch of Atlantic cod in the Gulf of Maine, 1989 from sea-sampled trips. The actual total catch in interviewed trips is presented as a diagnostic measure for the accuracy of estimates obtained from the sea-sampling database.

FISHERY	ESTIMATOR	ESTIMATED TOTAL LBS DISCARDED	DISCARD STANDARD ERROR	ESTIMATED CATCH (LBS)	CATCH STANDARD ERROR	ACTUAL CATCH (LBS)	SAMPLE SIZE TRIPS	TOWS
LARGE	CLUSTER 1	236,010	103,491	2,082,674	324,492	5,214,079	39	235
MESH	CLUSTER 2	329,607	130,364	2,173,548	500,055	5,214,079		
OTTER	REGRESSION 1	546,348	446,521	-	-	-		
TRAWL	REGRESSION 2	646,708	207,784	-	-	-		
SMALL	CLUSTER 1	9,729	1,911	100,856	18,239	53,013	155	496
MESH	CLUSTER 2	9,970	3,737	16,267	3,550	53,013		
OTTER	REGRESSION 1	12,490	14,095	-	-	-		
TRAWL	REGRESSION 2	7,899	18,244	-	-	-		
GILL NET	CLUSTER 1	33,540	10,708	968,641	168,615	174,452	84	262
QUARTERS	CLUSTER 2	-	-	-	-	174,452		
3 AND 4	REGRESSION 1	24,987	49,536	-	-	-		
	REGRESSION 2	3,195	55,041	-	-	-		
SHRIMP	CLUSTER 1	98,608	31,774	96,587	24,167	42,068	40	130
	CLUSTER 2	474,569	193,573	494,340	147,052	42,068		
	REGRESSION 1	206,965	604,373	-	-	-		
	REGRESSION 2	41,048	98,302	-	-	-		

Figure 1. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the large mesh otter trawl fishery in the Gulf of Maine, based on 1989 data.

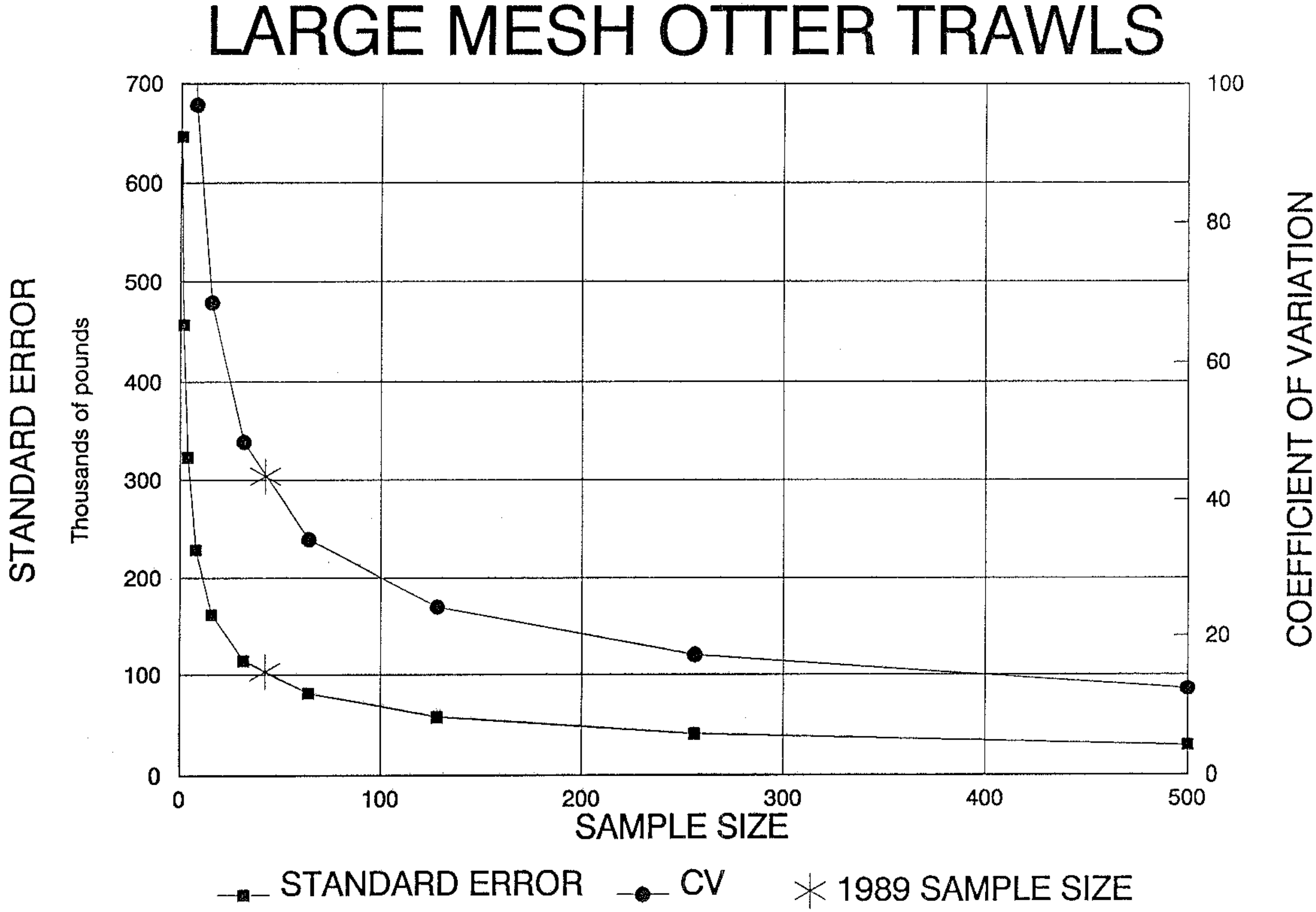


Figure 2. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the shrimp fishery in the Gulf of Maine, based on 1989 data.

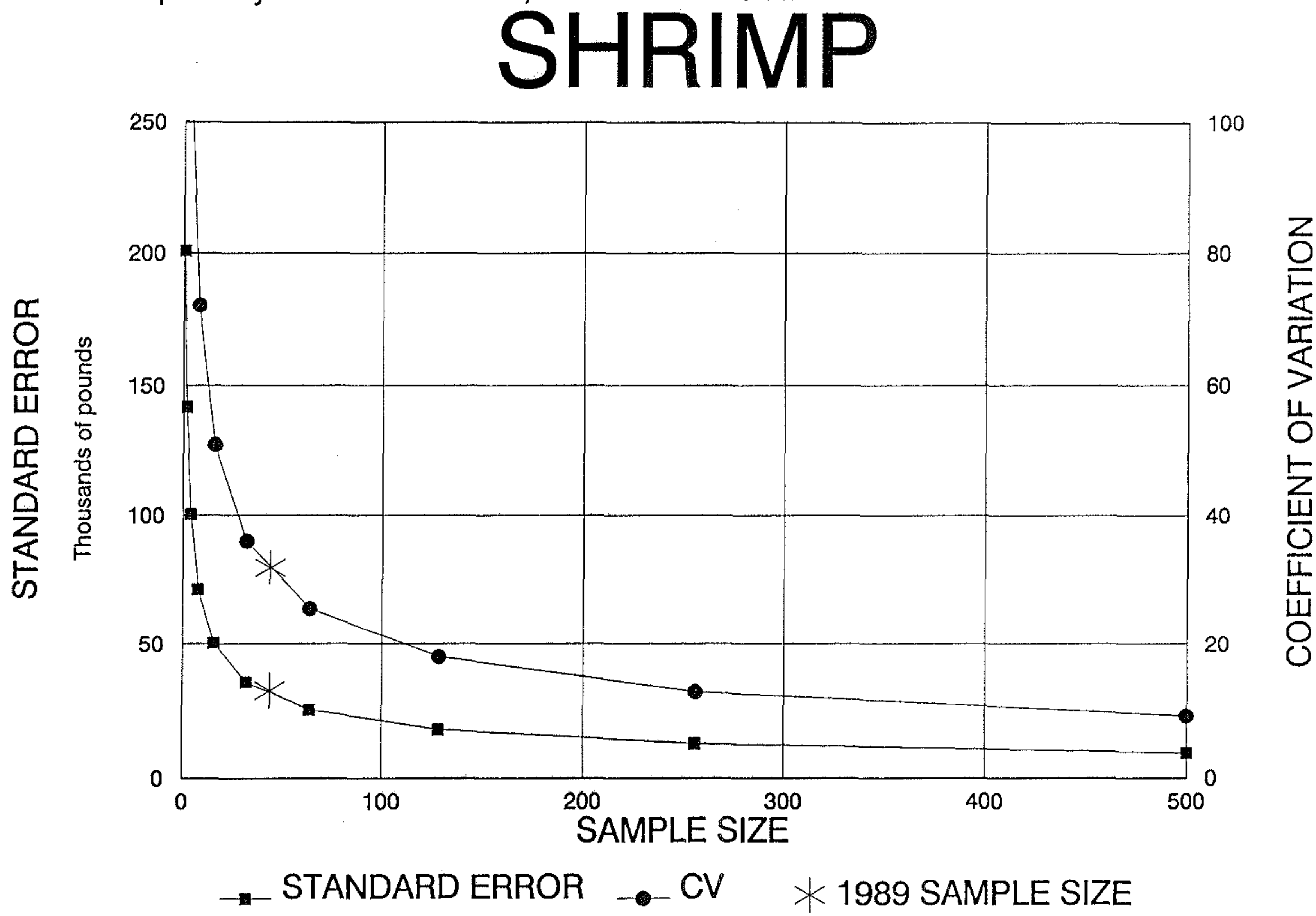


Figure 3. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the gillnet fishery in the Gulf of Maine, based on 1989 data.

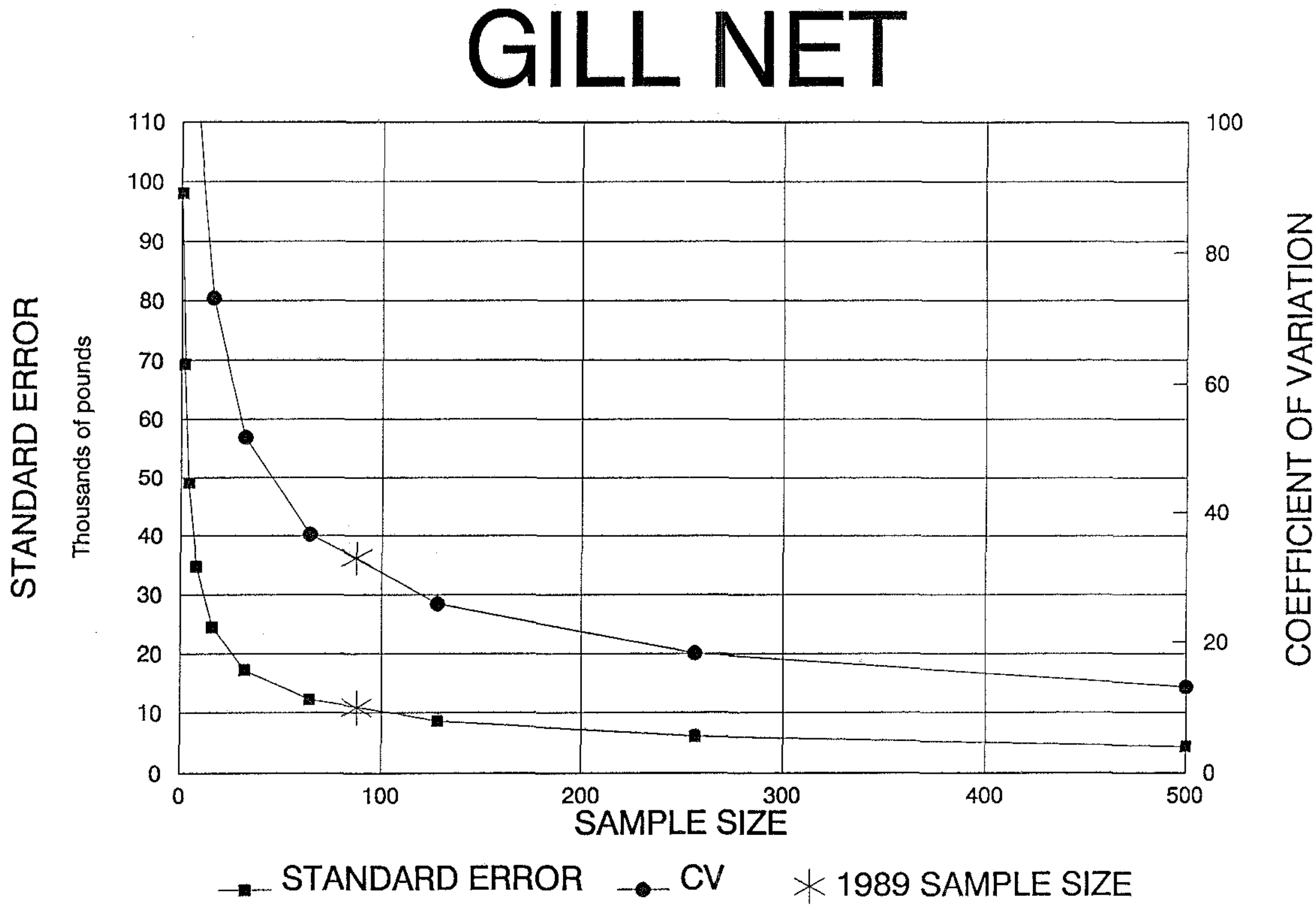
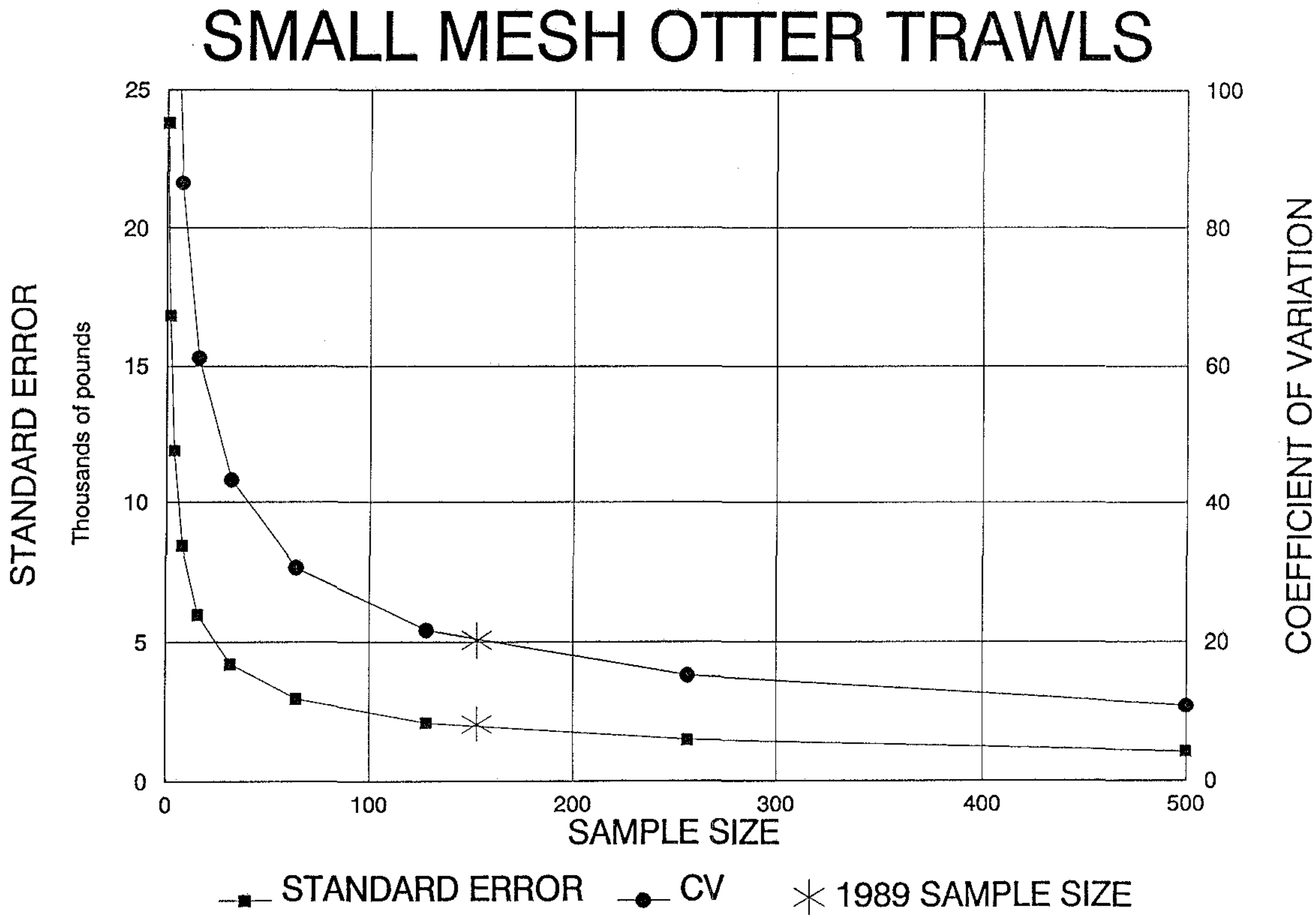


Figure 4. Approximate standard and coefficient of variation obtainable with different sample sizes (trips) for the small mesh otter trawl fishery in the Gulf of Maine, based on 1989 data.



Papers of the Northeast Regional
Stock Assessment Workshops

An Assessment of the Southern New England and Georges Bank Yellowtail Flounder Stocks

by

Ramon J. Conser, Loretta O'Brien,
and William J. Overholtz[1]

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Appendix to CRD-91-03 SAW 12

Spring 1991 Research Document SAW12/12

Papers of the Northeast Regional Stock Assessment Workshop

Stock Assessment of the Georges Bank and Southern New England Yellowtail Flounder Stocks

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Appendix to CRD-91-12
Summer 1991

SAW 12
Research Document #12

I. Introduction

A. Stock Definition

The yellowtail flounder (Pleuronectes ferrugineus), ranges from Labrador to Chesapeake Bay. Off the USA coast, commercially important concentrations are found on Georges Bank, off Cape Cod, and in Southern New England, generally at depths between 37 and 73 m. Tagging studies and other information indicate that Southern New England and Georges Bank yellowtail flounder form relatively discrete groups, although some intermingling occurs. Spawning by this species occurs during spring and summer, peaking in May.

B. History of the Fishery

Yellowtail flounder have been an important component of USA demersel landings since the early 1930s (Royce et al.1959). After substantial increases and declines in total landings during the decades of the 30s, 40s, and 50s, total landings peaked at 57,500 mt in 1969 with the influx of foreign fishing effort that occurred at this time. Landings declined steadily to 11,300 mt in 1978, and the increased to an average of 16,000 mt for 1979-1981.

C. Management

Yellowtail flounder were managed with nationally allocated catch quotas under the International Commission for Northwest Atlantic Fisheries in 1971-1976 and then under the FMP for Atlantic groundfish from 1977-1982, when MFCMA restrictions were put in place by the New England Fishery Management Council (NEFMC). From March, 1982 to September, 1986 the species was managed under the Interim Plan. The USA fishery for yellowtail flounder is currently managed under the New England Fishery Management Council's Multispecies FMP.

D. Recent Fishery

Landings for both stocks peaked in 1983 with the recruitment of several good year classes, and then declined precipitously for the rest of the 1980s. An increase in landings occurred in 1990 with recruitment of the 1987 year class.

II. Data Sources

A. Commercial Landings

USA commercial landings data for 1973-1990 were obtained from the NMFS weighout data base for the Southern New England and Georges Bank yellowtail flounder stocks (Table 1).

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discard at length was converted to discards-at-age by applying age data (ages 1-3) and this was expanded to total discard by using total landings for the quarter.

c. Survey Expansion Method

Two methods were used when there were no sea sampling or interview data available. If commercial landings at ages 1-3 were available, then survey length frequencies for a given length range for these age groups were compared to commercial lengths-at-age, and raised by the appropriate proportions. Landed fractions were then subtracted from the total estimate to give discards-at-age.

The other method involved a similar proportional approach for estimating age 1 and 2 discard when only age 2 or 3 catch was available respectively. An assumption of relative proportionality was made to calculate the unknown discards from the ratio of survey catch to commercial catch at age for the known ages to the survey catch of the younger age group without a landings estimate for a given length range.

d. Discard Estimation

Estimates of quarterly discard-at-age were smoothed by fitting a logistic retention rate model by nonlinear least squares. The smoothed retention rate estimates were used in calculating discard catch-at-age. Examination of residuals from the three sources of discard data suggest that there was no consistent bias introduced from any of the methods. The estimated catch-at-age, including discards for both stocks, is given in Table 2A and 2B. Corresponding weights-at-age are shown in Table 3.

D. Research Survey Data

Stratified mean number and weight per tow indices were estimated for yellowtail flounder from the Georges Bank (strata 13-21) and Southern New England (strata 5,6,9,10) areas for the 1968-1990 spring and the 1963-1990 autumn bottom trawl surveys (Tables 4A,4B). The 1963-1988 indices were re-estimated primarily because the historical age and maturation data (1963-1981) had recently been processed using post-1982 auditing procedures and was considered to be the best available data.

Abundance and biomass indices were also estimated for yellowtail flounder from NEFC offshore scallop surveys (Table 4C). Age length keys from the 1982-1990 autumn bottom trawl surveys were applied to yellowtail flounder length frequency samples from the NEFC 1982-1990 scallop surveys. Stratified mean number per tow indices were estimated for the 1982-1990 surveys and stratified mean weight per tow indices were estimated for only the 1982-1985 surveys.

In previous assessments, the spring bottom trawl indices had discard at length was converted to discards-at-age by applying age data (ages 1-3) and this was expanded to total discard by using total landings for the quarter.

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In previous assessments, the spring bottom trawl indices had yellowtail flounder stock. Reference levels of fishing mortality were Fo.1 = 0.25, Fmax = 0.63, and F20% = 0.58.

D. Fishing Mortality

1. Southern New England

Fishing mortality (age 7+) fluctuated at high levels in the 1980s reaching a series high of 2.2 in 1984 (Table 5). F remained at relatively high levels in the late 1980s and rose to 1.6 in 1990.

2. Georges Bank

Fishing mortality also reached a series high in 1984 of 2.1 on the Georges Bank stock, fluctuating at relatively high levels during the entire 1973-1990 series (Table 6). F averaged about 0.8 in 1990.

E. Stock Numbers, Biomass, and Recruitment

Southern New England

Stock size remained at moderate levels in the 1970s, increased greatly in the early 1980s due to recruitment from the 1980 and 1981 year classes, and declined through the rest of the 80s until the large 1987 year class began recruiting in 1988 (Table 5). Stock size declined steadily in the late 1980s, reaching a 1973-1990 low of 12 million fish in 1991. Both the 1980 and 1987 year-classes were relatively large when compared to the 1973-1990 average, but these cohorts contributed relatively little to rebuilding the stock since they were heavily fished and discarded at age 1-3. Stock biomass declined in the 1970s, increased in the early 1980s, declined to series lows during the 1985-1987 period, and increased again in 1988.

2. Georges Bank

Stock size for the Georges Bank stock declined in the 1970s, increased in 1981 with the recruitment of the 1980 year-class and declined steadily with some minor fluctuations to a 1973-1990 low of only 6 million fish in 1990 (Table 6). Recruitment had been rather moderate and steady in the 1970s and early 1980s for this stock, but declined greatly in the 1980s. Stock biomass declined somewhat in the 1970s, and then declined greatly in the 1980s to about 15-25% of levels found in the early 1970s.

F. Stock Projections

1. Southern New England

Stock projections based on a geometric mean recruitment (1980-1989) and geometric mean PR vector (1985-1989) were estimated for 1992-93. Projections, including discards, were based on a status yellowtail flounder stock. Reference levels of fishing mortality were Fo.1 = 0.25, Fmax = 0.63, and F20% = 0.58.

D. Fishing Mortality

1. Southern New England

Fishing mortality (age 7+) fluctuated at high levels in the 1980s reaching a series high of 2.2 in 1984 (Table 5). F remained at relatively high levels in the late 1980s and rose to 1.6 in 1990.

2. Georges Bank

Fishing mortality also reached a series high in 1984 of 2.1 on the Georges Bank stock, fluctuating at relatively high levels during the entire 1973-1990 series (Table 6). F averaged about 0.8 in 1990.

E. Stock Numbers, Biomass, and Recruitment

Southern New England

Stock size remained at moderate levels in the 1970s, increased greatly in the early 1980s due to recruitment from the 1980 and 1981 year classes, and declined through the rest of the 80s until the large 1987 year class began recruiting in 1988 (Table 5). Stock size declined steadily in the late 1980s, reaching a 1973-1990 low of 12 million fish in 1991. Both the 1980 and 1987 year-classes were relatively large when compared to the 1973-1990 average, but these cohorts contributed relatively little to rebuilding the stock since they were heavily fished and discarded at age 1-3. Stock biomass declined in the 1970s, increased in the early 1980s, declined to series lows during the 1985-1987 period, and increased again in 1988.

2. Georges Bank

Stock size for the Georges Bank stock declined in the 1970s, increased in 1981 with the recruitment of the 1980 year-class and declined steadily with some minor fluctuations to a 1973-1990 low of only 6 million fish in 1990 (Table 6). Recruitment had been rather moderate and steady in the 1970s and early 1980s for this stock, but declined greatly in the 1980s. Stock biomass declined somewhat in the 1970s, and then declined greatly in the 1980s to about 15-25% of levels found in the early 1970s.

F. Stock Projections

1. Southern New England

Stock projections based on a geometric mean recruitment (1980-1989) and geometric mean PR vector (1985-1989) were estimated for 1992-93. Projections, including discards, were based on a status

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Table 2A. Landings, discards, and total catch-at-age for the Southern New England yellowtail stock, 1973-1990.

SNE ANNUAL LANDINGS AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	28	130	591	0	66	21	19	119	0	56	57	45	166	39	72	0	0	0
2	2570	1764	2351	1397	2038	3209	4972	4557	2732	17413	13823	2623	3984	5926	1371	1153	5213	415
3	7169	3922	1496	897	3931	1487	8253	6323	6418	12788	33241	13901	1495	2883	2015	504	1269	18476
4	4630	5053	974	246	392	1025	1031	3618	2448	1740	3346	6587	1313	561	803	406	279	1352
5	1716	2501	1257	337	205	165	427	472	884	405	376	740	774	324	139	99	42	68
6	1515	950	550	391	253	34	96	117	129	78	129	244	136	119	47	17	3	5
7	258	1021	308	166	123	43	24	19	14	7	35	7	27	21	7	6	0	0
8+	56	196	164	188	161	28	0	12	0	0	7	13	4	1	1	0	0	0

SNE ANNUAL DISCARDS AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	160	728	8249	214	5376	8677	185	869	38	113	2469	465	1532	342	1165	5899	0	130
2	2486	26568	1426	5203	2733	10101	14253	5441	4013	17716	4607	3108	67	5016	1828	828	19109	361
3	1131	793	1	14	41	7	119	18	318	906	5374	941	1	0	77	5	25	20295
4	42	45	10	0	0	0	0	0	0	4	17	74	10	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SNE ANNUAL CATCH AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	188	858	8840	214	5442	8698	204	987	38	170	2526	511	1698	381	1238	5899	0	130
2	5056	28333	3777	6600	4770	13310	19224	9998	6745	35130	18430	5731	4051	10942	3198	1981	24321	775
3	8300	4716	1497	911	3972	1494	8371	6341	6736	13693	38615	14842	1496	2883	2092	509	1294	38771
4	4673	5098	984	246	392	1025	1031	3618	2448	1745	3364	6661	1323	561	803	407	279	1352
5	1716	2501	1257	337	205	165	427	472	884	405	376	740	774	324	139	99	42	68
6	1515	950	550	391	253	34	96	117	129	78	129	244	136	119	47	17	3	5
7	258	1021	308	166	123	43	24	19	14	7	35	7	27	21	7	6	0	0
8+	56	196	164	188	161	28	0	12	0	0	7	13	4	1	1	0	0	0

Table 2A. Landings, discards, and total catch-at-age for the Southern New England yellowtail stock, 1973-1990.

SNE ANNUAL LANDINGS AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	28	130	591	0	66	21	19	119	0	56	57	45	166	39	72	0	0	0
2	2570	1764	2351	1397	2038	3209	4972	4557	2732	17413	13823	2623	3984	5926	1371	1153	5213	415
3	7169	3922	1496	897	3931	1487	8253	6323	6418	12788	33241	13901	1495	2883	2015	504	1269	18476
4	4630	5053	974	246	392	1025	1031	3618	2448	1740	3346	6587	1313	561	803	406	279	1352
5	1716	2501	1257	337	205	165	427	472	884	405	376	740	774	324	139	99	42	68
6	1515	950	550	391	253	34	96	117	129	78	129	244	136	119	47	17	3	5
7	258	1021	308	166	123	43	24	19	14	7	35	7	27	21	7	6	0	0
8+	56	196	164	188	161	28	0	12	0	0	7	13	4	1	1	0	0	0

SNE ANNUAL DISCARDS AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	160	728	8249	214	5376	8677	185	869	38	113	2469	465	1532	342	1165	5899	0	130
2	2486	26568	1426	5203	2733	10101	14253	5441	4013	17716	4607	3108	67	5016	1828	828	19109	361
3	1131	793	1	14	41	7	119	18	318	906	5374	941	1	0	77	5	25	20295
4	42	45	10	0	0	0	0	0	0	4	17	74	10	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SNE ANNUAL CATCH AT AGE (1000s) - Ages 1 thru 8+ 30/ 5/91

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	188	858	8840	214	5442	8698	204	987	38	170	2526	511	1698	381	1238	5899	0	130
2	5056	28333	3777	6600	4770	13310	19224	9998	6745	35130	18430	5731	4051	10942	3198	1981	24321	775
3	8300	4716	1497	911	3972	1494	8371	6341	6736	13693	38615	14842	1496	2883	2092	509	1294	38771
4	4673	5098	984	246	392	1025	1031	3618	2448	1745	3364	6661	1323	561	803	407	279	1352
5	1716	2501	1257	337	205	165	427	472	884	405	376	740	774	324	139	99	42	68
6	1515	950	550	391	253	34	96	117	129	78	129	244	136	119	47	17	3	5
7	258	1021	308	166	123	43	24	19	14	7	35	7	27	21	7	6	0	0
8+	56	196	164	188	161	28	0	12	0	0	7	13	4	1	1	0	0	0

Table 3. Weight at age matrices.

WT AT AGE (MID-YR) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.210	0.203	0.218	0.228	0.215	0.234	0.189	0.206	0.140	0.226	0.175	0.182	0.183	0.186	0.247	0.270	0.311	0.301
2	0.298	0.308	0.290	0.303	0.284	0.296	0.301	0.281	0.262	0.263	0.262	0.239	0.264	0.285	0.268	0.293	0.337	0.327
3	0.381	0.359	0.385	0.427	0.385	0.402	0.366	0.384	0.343	0.354	0.341	0.298	0.370	0.335	0.361	0.398	0.389	0.378
4	0.420	0.429	0.439	0.528	0.521	0.543	0.476	0.499	0.484	0.502	0.499	0.388	0.428	0.470	0.412	0.501	0.546	0.461
5	0.430	0.477	0.436	0.533	0.529	0.710	0.590	0.690	0.619	0.661	0.671	0.497	0.541	0.598	0.542	0.664	0.736	0.800
6	0.506	0.476	0.469	0.568	0.484	0.791	0.684	0.891	0.664	0.821	0.829	0.652	0.620	0.617	0.595	0.936	0.959	0.884
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781

WT AT AGE (JAN 1) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.173	0.170	0.185	0.204	0.183	0.206	0.155	0.183	0.102	0.210	0.150	0.151	0.147	0.155	0.227	0.242	0.303	0.284	0.185
2	0.272	0.254	0.243	0.257	0.254	0.252	0.265	0.230	0.232	0.192	0.243	0.205	0.219	0.228	0.223	0.269	0.302	0.319	0.319
3	0.359	0.327	0.344	0.352	0.342	0.338	0.329	0.340	0.310	0.305	0.299	0.279	0.297	0.297	0.321	0.327	0.338	0.357	0.335
4	0.394	0.404	0.397	0.451	0.472	0.457	0.437	0.427	0.431	0.415	0.420	0.364	0.357	0.417	0.372	0.425	0.466	0.423	0.400
5	0.409	0.448	0.432	0.484	0.528	0.608	0.566	0.573	0.556	0.566	0.580	0.498	0.458	0.506	0.505	0.523	0.607	0.661	0.502
6	0.466	0.452	0.473	0.498	0.508	0.647	0.697	0.725	0.677	0.713	0.740	0.661	0.555	0.578	0.596	0.712	0.798	0.807	0.968
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781	0.781

WT AT AGE (MID-YR) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.198	0.200	0.211	0.185	0.197	0.182	0.139	0.138	0.091	0.213	0.215	0.208	0.236	0.234	0.212	0.220	0.223	0.211
2	0.375	0.378	0.340	0.339	0.364	0.337	0.356	0.354	0.389	0.313	0.296	0.240	0.363	0.343	0.338	0.351	0.355	0.337
3	0.464	0.500	0.492	0.545	0.527	0.513	0.462	0.495	0.493	0.487	0.440	0.378	0.497	0.540	0.523	0.557	0.543	0.419
4	0.527	0.609	0.554	0.636	0.634	0.684	0.649	0.656	0.603	0.650	0.604	0.500	0.647	0.664	0.666	0.688	0.725	0.588
5	0.603	0.680	0.618	0.741	0.782	0.793	0.728	0.813	0.707	0.748	0.736	0.642	0.733	0.823	0.680	0.855	0.883	0.699
6	0.689	0.725	0.687	0.814	0.865	0.899	0.835	1.054	0.798	1.052	0.952	0.738	0.819	0.864	0.938	1.054	1.026	0.798
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

WT AT AGE (JAN 1) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.143	0.153	0.166	0.132	0.151	0.130	0.087	0.082	0.049	0.181	0.203	0.157	0.196	0.195	0.165	0.173	0.181	0.162
2	0.325	0.274	0.261	0.267	0.259	0.258	0.255	0.222	0.232	0.169	0.251	0.227	0.275	0.285	0.281	0.273	0.279	0.274
3	0.405	0.433	0.431	0.430	0.423	0.432	0.395	0.420	0.418	0.435	0.371	0.334	0.345	0.443	0.424	0.434	0.437	0.386
4	0.464	0.532	0.526	0.559	0.588	0.600	0.577	0.551	0.546	0.566	0.542	0.469	0.495	0.574	0.600	0.600	0.635	0.565
5	0.550	0.599	0.613	0.641	0.705	0.709	0.706	0.726	0.681	0.672	0.692	0.623	0.605	0.730	0.672	0.755	0.779	0.712
6	0.645	0.661	0.683	0.709	0.801	0.838	0.814	0.876	0.805	0.862	0.844	0.737	0.725	0.796	0.879	0.847	0.937	0.839
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

Table 3. Weight at age matrices.

WT AT AGE (MID-YR) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.210	0.203	0.218	0.228	0.215	0.234	0.189	0.206	0.140	0.226	0.175	0.182	0.183	0.186	0.247	0.270	0.311	0.301
2	0.298	0.308	0.290	0.303	0.284	0.296	0.301	0.281	0.262	0.263	0.262	0.239	0.264	0.285	0.268	0.293	0.337	0.327
3	0.381	0.359	0.385	0.427	0.385	0.402	0.366	0.384	0.343	0.354	0.341	0.298	0.370	0.335	0.361	0.398	0.389	0.378
4	0.420	0.429	0.439	0.528	0.521	0.543	0.476	0.499	0.484	0.502	0.499	0.388	0.428	0.470	0.412	0.501	0.546	0.461
5	0.430	0.477	0.436	0.533	0.529	0.710	0.590	0.690	0.619	0.661	0.671	0.497	0.541	0.598	0.542	0.664	0.736	0.800
6	0.506	0.476	0.469	0.568	0.484	0.791	0.684	0.891	0.664	0.821	0.829	0.652	0.620	0.617	0.595	0.936	0.959	0.884
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781

WT AT AGE (JAN 1) in kg. - SOUTHERN NEW ENGLAND

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.173	0.170	0.185	0.204	0.183	0.206	0.155	0.183	0.102	0.210	0.150	0.151	0.147	0.155	0.227	0.242	0.303	0.284	0.185
2	0.272	0.254	0.243	0.257	0.254	0.252	0.265	0.230	0.232	0.192	0.243	0.205	0.219	0.228	0.223	0.269	0.302	0.319	0.319
3	0.359	0.327	0.344	0.352	0.342	0.338	0.329	0.340	0.310	0.305	0.299	0.279	0.297	0.297	0.321	0.327	0.338	0.357	0.335
4	0.394	0.404	0.397	0.451	0.472	0.457	0.437	0.427	0.431	0.415	0.420	0.364	0.357	0.417	0.372	0.425	0.466	0.423	0.400
5	0.409	0.448	0.432	0.484	0.528	0.608	0.566	0.573	0.556	0.566	0.580	0.498	0.458	0.506	0.505	0.523	0.607	0.661	0.502
6	0.466	0.452	0.473	0.498	0.508	0.647	0.697	0.725	0.677	0.713	0.740	0.661	0.555	0.578	0.596	0.712	0.798	0.807	0.968
7	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781	0.781

WT AT AGE (MID-YR) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.198	0.200	0.211	0.185	0.197	0.182	0.139	0.138	0.091	0.213	0.215	0.208	0.236	0.234	0.212	0.220	0.223	0.211
2	0.375	0.378	0.340	0.339	0.364	0.337	0.356	0.354	0.389	0.313	0.296	0.240	0.363	0.343	0.338	0.351	0.355	0.337
3	0.464	0.500	0.492	0.545	0.527	0.513	0.462	0.495	0.493	0.487	0.440	0.378	0.497	0.540	0.523	0.557	0.543	0.419
4	0.527	0.609	0.554	0.636	0.634	0.684	0.649	0.656	0.603	0.650	0.604	0.500	0.647	0.664	0.666	0.688	0.725	0.588
5	0.603	0.680	0.618	0.741	0.782	0.793	0.728	0.813	0.707	0.748	0.736	0.642	0.733	0.823	0.680	0.855	0.883	0.699
6	0.689	0.725	0.687	0.814	0.865	0.899	0.835	1.054	0.798	1.052	0.952	0.738	0.819	0.864	0.938	1.054	1.026	0.798
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

WT AT AGE (JAN 1) in kg. - GEORGE'S BANK

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.143	0.153	0.166	0.132	0.151	0.130	0.087	0.082	0.049	0.181	0.203	0.157	0.196	0.195	0.165	0.173	0.181	0.162
2	0.325	0.274	0.261	0.267	0.259	0.258	0.255	0.222	0.232	0.169	0.251	0.227	0.275	0.285	0.281	0.273	0.279	0.274
3	0.405	0.433	0.431	0.430	0.423	0.432	0.395	0.420	0.418	0.435	0.371	0.334	0.345	0.443	0.424	0.434	0.437	0.386
4	0.464	0.532	0.526	0.559	0.588	0.600	0.577	0.551	0.546	0.566	0.542	0.469	0.495	0.574	0.600	0.600	0.635	0.565
5	0.550	0.599	0.613	0.641	0.705	0.709	0.706	0.726	0.681	0.672	0.692	0.623	0.605	0.730	0.672	0.755	0.779	0.712
6	0.645	0.661	0.683	0.709	0.801	0.838	0.814	0.876	0.805	0.862	0.844	0.737	0.725	0.796	0.879	0.847	0.937	0.839
7	1.082	1.001	0.675	0.857	1.025	0.939	0.955	1.224	0.833	1.057	1.005	0.971	0.733	1.015	0.790	0.939	1.254	1.207

Table 4b. Stratified mean catch per tow in numbers and weight (kg) for Southern New England yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

	Age Group										
Autumn	0	1	2	3	4	5	6	7	8+	Total No/tow	Total Wt/tow
1963	0.046	16.228	16.531	12.262	4.779	0.541	0.124	0.000	0.082	50.593	16.842
1964	0.000	18.466	26.190	4.804	7.132	3.265	0.908	0.000	0.000	60.764	19.030
1965	0.258	10.845	17.533	6.370	1.754	1.776	0.127	0.000	0.074	38.735	12.675
1966	0.885	35.496	10.710	1.947	1.022	0.189	0.000	0.000	0.000	50.248	9.431
1967	0.276	18.440	25.540	11.243	1.587	0.387	0.065	0.131	0.000	57.668	14.057
1968	0.000	9.250	10.944	18.738	1.183	0.094	0.000	0.000	0.000	40.208	10.062
1969	0.000	11.870	9.741	27.755	5.206	0.093	0.041	0.041	0.000	54.747	14.401
1970	0.037	4.227	5.521	16.341	10.624	2.514	0.426	0.073	0.000	39.763	10.965
1971	0.000	6.351	10.900	6.244	15.138	2.694	0.216	0.161	0.000	41.703	9.186
1972	0.000	4.209	16.496	19.716	18.847	12.288	1.680	0.044	0.000	73.279	20.114
1973	0.000	1.415	1.303	1.823	1.344	1.017	0.866	0.174	0.000	7.940	2.264
1974	0.206	0.997	1.678	0.554	2.275	0.956	0.401	0.195	0.076	7.337	2.141
1975	0.000	1.624	0.423	0.218	0.270	0.274	0.000	0.085	0.000	2.895	0.715
1976	0.000	2.977	6.009	0.719	0.072	0.114	0.296	0.347	0.155	10.687	2.962
1977	0.044	1.696	2.194	0.798	0.051	0.044	0.109	0.075	0.000	5.010	1.501
1978	0.000	3.131	7.328	0.434	0.378	0.041	0.009	0.076	0.031	11.427	3.057
1979	0.000	1.730	4.371	2.446	0.374	0.041	0.040	0.000	0.000	9.001	2.565
1980	0.000	1.411	4.345	1.159	0.411	0.000	0.000	0.000	0.000	7.326	1.957
1981	0.000	4.536	8.625	1.354	0.322	0.077	0.059	0.000	0.000	14.973	3.789
1982	0.000	2.139	24.075	7.109	0.840	0.335	0.000	0.000	0.000	34.497	8.126
1983	0.000	3.756	14.718	8.261	0.718	0.060	0.000	0.041	0.000	27.554	6.515
1984	0.000	0.589	1.817	1.967	0.540	0.000	0.000	0.000	0.000	4.912	1.365
1985	0.000	1.198	0.526	0.189	0.144	0.000	0.000	0.000	0.000	2.057	0.438
1986	0.000	0.972	1.982	0.429	0.103	0.000	0.000	0.000	0.000	3.485	0.883
1987	0.113	1.515	0.674	0.558	0.047	0.037	0.000	0.037	0.000	2.981	0.607
1988	0.000	1.484	0.457	0.203	0.229	0.056	0.000	0.000	0.000	2.430	0.496
1989	0.000	0.000	9.416	1.647	0.077	0.000	0.000	0.000	0.000	11.140	2.359
1990	0.000	0.000	0.114	2.818	0.318	0.000	0.000	0.000	0.000	3.250	0.974

Stratified mean catch per tow in numbers and weight (kg) for George Bank yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

1963	0.000	12.067	6.472	9.202	1.523	0.406	0.230	0.028	0.191	30.120	9.991
1964	0.000	1.411	7.970	6.041	4.916	2.205	0.314	0.078	0.023	22.957	10.643
1965	0.014	0.933	4.573	4.480	3.164	1.478	0.133	0.233	0.031	15.038	7.113
1966	1.160	7.190	3.915	1.697	0.686	0.075	0.042	0.000	0.000	14.765	3.116
1967	0.050	7.489	7.634	2.212	0.825	0.253	0.062	0.050	0.000	18.575	5.918
1968	0.000	9.657	9.792	4.720	0.628	0.774	0.048	0.000	0.000	25.618	8.231
1969	1.054	6.644	8.509	4.799	1.362	0.453	0.122	0.149	0.000	23.092	7.249
1970	0.780	3.779	4.207	2.577	1.600	0.370	0.052	0.014	0.000	13.378	3.890
1971	0.025	2.973	5.696	4.020	1.843	0.452	0.192	0.020	0.020	15.240	4.972
1972	0.777	1.987	5.348	3.954	1.717	0.551	0.229	0.000	0.000	14.563	4.944
1973	0.100	2.044	4.506	4.184	2.413	0.997	0.341	0.141	0.025	14.751	5.070
1974	1.011	3.789	2.339	1.249	0.869	0.377	0.204	0.107	0.000	9.945	2.866
1975	0.358	3.791	2.058	0.719	0.469	0.274	0.027	0.000	0.025	7.720	1.817
1976	0.000	0.275	1.581	0.389	0.096	0.100	0.027	0.000	0.055	2.523	1.178
1977	0.000	0.901	2.098	1.601	0.600	0.110	0.054	0.035	0.016	5.414	2.556
1978	0.037	4.591	1.235	0.750	0.394	0.135	0.011	0.000	0.023	7.177	2.154
1979	0.017	1.274	1.941	0.307	0.118	0.134	0.037	0.062	0.007	3.896	1.373
1980	0.077	0.739	4.938	5.874	0.658	0.211	0.157	0.060	0.032	12.745	6.072
1981	0.038	1.538	2.265	1.583	0.485	0.117	0.081	0.013	0.000	6.118	2.367
1982	0.000	1.987	1.791	1.303	0.347	0.073	0.000	0.000	0.000	5.501	1.773
1983	0.000	0.089	1.872	1.569	0.388	0.056	0.010	0.000	0.031	4.015	1.665
1984	0.027	0.542	0.328	0.251	0.199	0.074	0.024	0.000	0.015	1.459	0.463
1985	0.010	1.418	0.553	0.178	0.062	0.073	0.000	0.000	0.000	2.293	0.732
1986	0.000	0.289	1.154	0.351	0.084	0.000	0.000	0.000	0.000	1.878	0.849
1987	0.000	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.011	0.019	0.213	0.107	0.032	0.000	0.000	0.000	0.000	0.382	0.174
1989	0.027	0.292	2.344	0.910	0.081	0.078	0.000	0.000	0.000	3.732	1.149
1990	0.215	0.000	0.384	1.785	0.329	0.017	0.000	0.000	0.000	2.730	0.852

Table 4b. Stratified mean catch per tow in numbers and weight (kg) for Southern New England yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

	Age Group										
Autumn	0	1	2	3	4	5	6	7	8+	Total No/tow	Total Wt/tow
1963	0.046	16.228	16.531	12.262	4.779	0.541	0.124	0.000	0.082	50.593	16.842
1964	0.000	18.466	26.190	4.804	7.132	3.265	0.908	0.000	0.000	60.764	19.030
1965	0.258	10.845	17.533	6.370	1.754	1.776	0.127	0.000	0.074	38.735	12.675
1966	0.885	35.496	10.710	1.947	1.022	0.189	0.000	0.000	0.000	50.248	9.431
1967	0.276	18.440	25.540	11.243	1.587	0.387	0.065	0.131	0.000	57.668	14.057
1968	0.000	9.250	10.944	18.738	1.183	0.094	0.000	0.000	0.000	40.208	10.062
1969	0.000	11.870	9.741	27.755	5.206	0.093	0.041	0.041	0.000	54.747	14.401
1970	0.037	4.227	5.521	16.341	10.624	2.514	0.426	0.073	0.000	39.763	10.965
1971	0.000	6.351	10.900	6.244	15.138	2.694	0.216	0.161	0.000	41.703	9.186
1972	0.000	4.209	16.496	19.716	18.847	12.288	1.680	0.044	0.000	73.279	20.114
1973	0.000	1.415	1.303	1.823	1.344	1.017	0.866	0.174	0.000	7.940	2.264
1974	0.206	0.997	1.678	0.554	2.275	0.956	0.401	0.195	0.076	7.337	2.141
1975	0.000	1.624	0.423	0.218	0.270	0.274	0.000	0.085	0.000	2.895	0.715
1976	0.000	2.977	6.009	0.719	0.072	0.114	0.296	0.347	0.155	10.687	2.962
1977	0.044	1.696	2.194	0.798	0.051	0.044	0.109	0.075	0.000	5.010	1.501
1978	0.000	3.131	7.328	0.434	0.378	0.041	0.009	0.076	0.031	11.427	3.057
1979	0.000	1.730	4.371	2.446	0.374	0.041	0.040	0.000	0.000	9.001	2.565
1980	0.000	1.411	4.345	1.159	0.411	0.000	0.000	0.000	0.000	7.326	1.957
1981	0.000	4.536	8.625	1.354	0.322	0.077	0.059	0.000	0.000	14.973	3.789
1982	0.000	2.139	24.075	7.109	0.840	0.335	0.000	0.000	0.000	34.497	8.126
1983	0.000	3.756	14.718	8.261	0.718	0.060	0.000	0.041	0.000	27.554	6.515
1984	0.000	0.589	1.817	1.967	0.540	0.000	0.000	0.000	0.000	4.912	1.365
1985	0.000	1.198	0.526	0.189	0.144	0.000	0.000	0.000	0.000	2.057	0.438
1986	0.000	0.972	1.982	0.429	0.103	0.000	0.000	0.000	0.000	3.485	0.883
1987	0.113	1.515	0.674	0.558	0.047	0.037	0.000	0.037	0.000	2.981	0.607
1988	0.000	1.484	0.457	0.203	0.229	0.056	0.000	0.000	0.000	2.430	0.496
1989	0.000	0.000	9.416	1.647	0.077	0.000	0.000	0.000	0.000	11.140	2.359
1990	0.000	0.000	0.114	2.818	0.318	0.000	0.000	0.000	0.000	3.250	0.974

Stratified mean catch per tow in numbers and weight (kg) for George Bank yellowtail flounder in NEFC offshore autumn bottom trawl surveys, 1963-1990.

1963	0.000	12.067	6.472	9.202	1.523	0.406	0.230	0.028	0.191	30.120	9.991
1964	0.000	1.411	7.970	6.041	4.916	2.205	0.314	0.078	0.023	22.957	10.643
1965	0.014	0.933	4.573	4.480	3.164	1.478	0.133	0.233	0.031	15.038	7.113
1966	1.160	7.190	3.915	1.697	0.686	0.075	0.042	0.000	0.000	14.765	3.116
1967	0.050	7.489	7.634	2.212	0.825	0.253	0.062	0.050	0.000	18.575	5.918
1968	0.000	9.657	9.792	4.720	0.628	0.774	0.048	0.000	0.000	25.618	8.231
1969	1.054	6.644	8.509	4.799	1.362	0.453	0.122	0.149	0.000	23.092	7.249
1970	0.780	3.779	4.207	2.577	1.600	0.370	0.052	0.014	0.000	13.378	3.890
1971	0.025	2.973	5.696	4.020	1.843	0.452	0.192	0.020	0.020	15.240	4.972
1972	0.777	1.987	5.348	3.954	1.717	0.551	0.229	0.000	0.000	14.563	4.944
1973	0.100	2.044	4.506	4.184	2.413	0.997	0.341	0.141	0.025	14.751	5.070
1974	1.011	3.789	2.339	1.249	0.869	0.377	0.204	0.107	0.000	9.945	2.866
1975	0.358	3.791	2.058	0.719	0.469	0.274	0.027	0.000	0.025	7.720	1.817
1976	0.000	0.275	1.581	0.389	0.096	0.100	0.027	0.000	0.055	2.523	1.178
1977	0.000	0.901	2.098	1.601	0.600	0.110	0.054	0.035	0.016	5.414	2.556
1978	0.037	4.591	1.235	0.750	0.394	0.135	0.011	0.000	0.023	7.177	2.154
1979	0.017	1.274	1.941	0.307	0.118	0.134	0.037	0.062	0.007	3.896	1.373
1980	0.077	0.739	4.938	5.874	0.658	0.211	0.157	0.060	0.032	12.745	6.072
1981	0.038	1.538	2.265	1.583	0.485	0.117	0.081	0.013	0.000	6.118	2.367
1982	0.000	1.987	1.791	1.303	0.347	0.073	0.000	0.000	0.000	5.501	1.773
1983	0.000	0.089	1.872	1.569	0.388	0.056	0.010	0.000	0.031	4.015	1.665
1984	0.027	0.542	0.328	0.251	0.199	0.074	0.024	0.000	0.015	1.459	0.463
1985	0.010	1.418	0.553	0.178	0.062	0.073	0.000	0.000	0.000	2.293	0.732
1986	0.000	0.289	1.154	0.351	0.084	0.000	0.000	0.000	0.000	1.878	0.849
1987	0.000	0.113	0.390	0.396	0.053	0.079	0.000	0.000	0.000	1.031	0.509
1988	0.011	0.019	0.213	0.107	0.032	0.000	0.000	0.000	0.000	0.382	0.174
1989	0.027	0.292	2.344	0.910	0.081	0.078	0.000	0.000	0.000	3.732	1.149
1990	0.215	0.000	0.384	1.785	0.329	0.017	0.000	0.000	0.000	2.730	0.852

Table 5. Adapt Results for Southern New England Yellowtail Flounder.

ADAPT Run Number 126 1991 5 31 23 13 1
YELLOWTAIL FLOUNDER - SOUTHERN NEW ENGLAND STOCK
SNE

Output option selected for input parameters: full
Output option selected for results: full

INPUT PARAMETERS AND OPTIONS SELECTED

Natural mortality is 0.2

Oldest age (not in the plus group) is 6

For all yrs prior to the terminal year (1990), backcalculated stock sizes for the following ages used to estimate total mortality (Z) for age 6: 3 4 5 6
This method for estimating F on the oldest age is generally used when a flat-topped partial recruitment curve is thought to be characteristic of the stock.

F for age 7+ is then calculated from the following ratios of F[age 7+] to F[age 6]

1973	1.0000
1974	1.0000
1975	1.0000
1976	1.0000
1977	1.0000
1978	1.0000
1979	1.0000
1980	1.0000
1981	1.0000
1982	1.0000
1983	1.0000
1984	1.0000
1985	1.0000
1986	1.0000
1987	1.0000
1988	1.0000
1989	1.0000
1990	1.0000

Stock size of the 7+ group is then calculated using the following method: CATCHEQ

Partial recruitment estimate for 1990

1	0.0200
2	0.3500
3	1.0000
4	1.0000
5	1.0000
6	1.0000

Objective function is SUM w*(LOG(OBS) - LOG(PRED))**2

Indices normalized (by dividing by mean observed value) before tuning to VPA stocksizes

The residuals for years prior to the terminal year are downweighted using the following algorithm: NONE

All biomass estimates (including SSB) reflect mean stock sizes

Initial estimates of parameters for the Marquardt algorithm and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 2	5.0000000E0	0.0000000E0	1.0000000E6

Table 5. Adapt Results for Southern New England Yellowtail Flounder.

ADAPT Run Number 126 1991 5 31 23 13 1
YELLOWTAIL FLOUNDER - SOUTHERN NEW ENGLAND STOCK
SNE

Output option selected for input parameters: full
Output option selected for results: full

INPUT PARAMETERS AND OPTIONS SELECTED

Natural mortality is 0.2

Oldest age (not in the plus group) is 6

For all yrs prior to the terminal year (1990), backcalculated stock sizes for the following ages used to estimate total mortality (Z) for age 6: 3 4 5 6
This method for estimating F on the oldest age is generally used when a flat-topped partial recruitment curve is thought to be characteristic of the stock.

F for age 7+ is then calculated from the following ratios of F[age 7+] to F[age 6]

1973	1.0000
1974	1.0000
1975	1.0000
1976	1.0000
1977	1.0000
1978	1.0000
1979	1.0000
1980	1.0000
1981	1.0000
1982	1.0000
1983	1.0000
1984	1.0000
1985	1.0000
1986	1.0000
1987	1.0000
1988	1.0000
1989	1.0000
1990	1.0000

Stock size of the 7+ group is then calculated using the following method: CATCHEQ

Partial recruitment estimate for 1990

1	0.0200
2	0.3500
3	1.0000
4	1.0000
5	1.0000
6	1.0000

Objective function is SUM W*(LOG(OBS) - LOG(PRED))**2

Indices normalized (by dividing by mean observed value) before tuning to VPA stocksizes

The residuals for years prior to the terminal year are downweighted using the following algorithm: NONE

All biomass estimates (including SSB) reflect mean stock sizes

Initial estimates of parameters for the Marquardt algorithm and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 2	5.0000000E0	0.0000000E0	1.0000000E6

Table 5. (Continued)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
7	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
9	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
10	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
11	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
12	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
13	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

	1984	1985	1986	1987	1988	1989	1990
1	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
7	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
8	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
9	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
10	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
11	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
12	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
13	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

DOWNWEIGHTS BY YEAR (delta)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	1990
	1.0000

INTERATIVE RE-WEIGHTS BY INDEX (chi)

	1	2	3	4	5	6	7	8	9	10	11	12	13
	0.0227	0.0621	0.1065	0.0678	0.0926	0.0636	0.1121	0.0498	0.0562	0.0564	0.0785	0.1270	0.1046

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227
2	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621
3	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065
4	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678
5	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562
10	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564
11	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785
12	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270
13	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046

	1990
1	0.0227
2	0.0621

Table 5. (Continued)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
7	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
8	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
9	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	1.00000000
10	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
11	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
12	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
13	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

	1984	1985	1986	1987	1988	1989	1990
1	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
2	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
3	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
6	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
7	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
8	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
9	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
10	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
11	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
12	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
13	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

DOWNWEIGHTS BY YEAR (delta)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	1990
	1.0000

INTERATIVE RE-WEIGHTS BY INDEX (chi)

	1	2	3	4	5	6	7	8	9	10	11	12	13
	0.0227	0.0621	0.1065	0.0678	0.0926	0.0636	0.1121	0.0498	0.0562	0.0564	0.0785	0.1270	0.1046

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227	0.0227
2	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621	0.0621
3	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065
4	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678	0.0678
5	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926	0.0926
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636	0.0636
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121	0.1121
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498	0.0498
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562	0.0562
10	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564	0.0564
11	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785
12	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270	0.1270
13	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046	0.1046

	1990
1	0.0227
2	0.0621

Table 5. (Continued)

1	■	0.173	0.170	0.185	0.204	0.183	0.206	0.155	0.183	0.102	0.210	0.150	0.151	0.147	0.155	0.227	0.242	0.303	0.284	0.185
2	■	0.272	0.254	0.243	0.257	0.254	0.252	0.265	0.230	0.232	0.192	0.243	0.205	0.219	0.228	0.223	0.269	0.302	0.319	0.319
3	■	0.359	0.327	0.344	0.352	0.342	0.338	0.329	0.340	0.310	0.305	0.299	0.279	0.297	0.297	0.321	0.327	0.338	0.357	0.335
4	■	0.394	0.404	0.397	0.451	0.472	0.457	0.437	0.427	0.431	0.415	0.420	0.364	0.357	0.417	0.372	0.425	0.466	0.423	0.400
5	■	0.409	0.448	0.432	0.484	0.528	0.608	0.566	0.573	0.556	0.566	0.580	0.498	0.458	0.506	0.505	0.523	0.607	0.661	0.502
6	■	0.466	0.452	0.473	0.498	0.508	0.647	0.697	0.725	0.677	0.713	0.740	0.661	0.555	0.578	0.596	0.712	0.798	0.807	0.968
7	■	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781	0.781

PERCENT MATURE (females) - SNE

	■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	■	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
2	■	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
3	■	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
4	■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5	■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) - SNE

	■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
6	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7	■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

BEGIN MARQUARDT ALGORITHM

```
LAMBDA      1.00000E-2
RSS         2.14332E1
NPHI        2.14332E1

par
  5.00000E0      5.00000E0      5.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.
     00000E-1      1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1

LAMBDA      1.00000E-1
RSS         1.86672E1
NPHI        1.86672E1

par
  4.29367E0      4.57161E0      4.81027E-1     8.37098E-2     8.77089E-2     9.51844E-2     1.07781E-1     1.09722E-1     9.
     45559E-2      8.94882E-2     1.02713E-1     1.21446E-1     9.00670E-2     9.07399E-2     1.02419E-1     1.11374E-1

LAMBDA      1.00000E0
RSS         1.64508E1
NPHI        1.64508E1

par
  3.75344E0      4.21706E0      4.64536E-1     7.16714E-2     7.81674E-2     9.11066E-2     1.15288E-1     1.19280E-1     8.
     99727E-2      8.11542E-2     1.05198E-1     1.44908E-1     8.21361E-2     8.32896E-2     1.04629E-1     1.22733E-1

LAMBDA      1.00000E1
RSS         1.47888E1
NPHI        1.47888E1

par
  3.34825E0      3.91916E0      4.53044E-1     6.32009E-2     7.11741E-2     8.78715E-2     1.21936E-1     1.27896E-1     8.
     63185E-2      7.49223E-2     1.07246E-1     1.68202E-1     7.61766E-2     7.76536E-2     1.06469E-1     1.33108E-1
```

Table 5. (Continued)

1 ■	0.173	0.170	0.185	0.204	0.183	0.206	0.155	0.183	0.102	0.210	0.150	0.151	0.147	0.155	0.227	0.242	0.303	0.284	0.185
2 ■	0.272	0.254	0.243	0.257	0.254	0.252	0.265	0.230	0.232	0.192	0.243	0.205	0.219	0.228	0.223	0.269	0.302	0.319	0.319
3 ■	0.359	0.327	0.344	0.352	0.342	0.338	0.329	0.340	0.310	0.305	0.299	0.279	0.297	0.297	0.321	0.327	0.338	0.357	0.335
4 ■	0.394	0.404	0.397	0.451	0.472	0.457	0.437	0.427	0.431	0.415	0.420	0.364	0.357	0.417	0.372	0.425	0.466	0.423	0.400
5 ■	0.409	0.448	0.432	0.484	0.528	0.608	0.566	0.573	0.556	0.566	0.580	0.498	0.458	0.506	0.505	0.523	0.607	0.661	0.502
6 ■	0.466	0.452	0.473	0.498	0.508	0.647	0.697	0.725	0.677	0.713	0.740	0.661	0.555	0.578	0.596	0.712	0.798	0.807	0.968
7 ■	0.611	0.518	0.515	0.603	0.612	0.677	0.679	1.182	0.476	0.956	0.838	0.724	0.867	0.804	0.905	0.937	1.278	0.781	0.781

PERCENT MATURE (females) - SNE

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
2 ■	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
3 ■	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
4 ■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
5 ■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6 ■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7 ■	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) - SNE

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
6 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7 ■	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

```
BEGIN MARQUARDT ALGORITHM
-------------------------

LAMBDA        1.00000E-2
RSS           2.14332E1
NPHI          2.14332E1

par
   5.00000E0      5.00000E0      5.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.
      00000E-1       1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1     1.00000E-1

LAMBDA        1.00000E-1
RSS           1.86672E1
NPHI          1.86672E1

par
   4.29367E0      4.57161E0      4.81027E-1     8.37098E-2     8.77089E-2     9.51844E-2     1.07781E-1     1.09722E-1     9.
      45559E-2       8.94882E-2     1.02713E-1     1.21446E-1     9.00670E-2     9.07399E-2     1.02419E-1     1.11374E-1

LAMBDA        1.00000E0
RSS           1.64508E1
NPHI          1.64508E1

par
   3.75344E0      4.21706E0      4.64536E-1     7.16714E-2     7.81674E-2     9.11066E-2     1.15288E-1     1.19280E-1     8.
      99727E-2       8.11542E-2     1.05198E-1     1.44908E-1     8.21361E-2     8.32896E-2     1.04629E-1     1.22733E-1

LAMBDA        1.00000E1
RSS           1.47888E1
NPHI          1.47888E1

par
   3.34825E0      3.91916E0      4.53044E-1     6.32009E-2     7.11741E-2     8.78715E-2     1.21936E-1     1.27896E-1     8.
      63185E-2       7.49223E-2     1.07246E-1     1.68202E-1     7.61766E-2     7.76536E-2     1.06469E-1     1.33108E-1
```

Table 5. (Continued)

RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES 6.937270
ORTHOGONALITY OFFSET......... 0.002193
MEAN SQUARE RESIDUALS 0.039416

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	1.17692E0	8.95988E-1	1.31354E0	0.76
N 3	2.01502E0	8.92080E-1	2.25879E0	0.44
N 5	3.07185E-1	1.95898E-1	1.56808E0	0.64
qSPR AGE1	1.97382E-2	6.60608E-3	2.98788E0	0.33
qSPR AGE2	2.93992E-2	5.57889E-3	5.26973E0	0.19
qSPR AGE3	6.19448E-2	8.96114E-3	6.91261E0	0.14
qSPR AGE4	2.17189E-1	3.92722E-2	5.53033E0	0.18
qSPR 5+	2.63505E-1	4.32425E-2	6.09365E0	0.16
qSCAL AG1	5.82729E-2	1.62800E-2	3.57942E0	0.28
qSCAL AG2	3.52224E-2	7.19523E-3	4.89525E0	0.20
qSCAL AG3	1.31747E-1	3.97720E-2	3.31255E0	0.30
qSCAL 4+	8.51019E-1	2.41722E-1	3.52065E0	0.28
qFALL AG1	3.71971E-2	7.81745E-3	4.75821E0	0.21
qFALL AG2	3.98292E-2	6.75395E-3	5.89717E0	0.17
qFALL AG3	1.27593E-1	1.71242E-2	7.45100E0	0.13
qFALL 4+	3.11264E-1	4.57702E-2	6.80057E0	0.15

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.05	0.02	-0.13	-0.01	-0.00	-0.00	-0.00	-0.30	-0.01	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00
0.05	1.00	0.04	-0.07	-0.10	-0.00	-0.00	-0.00	-0.15	-0.21	-0.01	-0.01	-0.00	-0.13	-0.01	-0.01
0.02	0.04	1.00	-0.02	-0.05	-0.09	-0.05	-0.05	-0.07	-0.11	-0.16	-0.15	-0.04	-0.07	-0.18	-0.15
-0.13	-0.07	-0.02	1.00	0.01	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.01	0.00	0.00
-0.01	-0.10	-0.05	0.01	1.00	0.00	0.00	0.00	0.02	0.03	0.01	0.01	0.00	0.02	0.01	0.01
-0.00	-0.00	-0.09	0.00	0.00	1.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01
-0.00	-0.00	-0.05	0.00	0.00	0.00	1.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
-0.00	-0.00	-0.05	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
-0.30	-0.15	-0.07	0.05	0.02	0.01	0.00	0.00	1.00	0.04	0.01	0.01	0.00	0.02	0.01	0.01
-0.01	-0.21	-0.11	0.02	0.03	0.01	0.01	0.01	0.04	1.00	0.02	0.02	0.00	0.03	0.02	0.02
-0.00	-0.01	-0.16	0.00	0.01	0.01	0.01	0.01	0.01	0.02	1.00	0.02	0.01	0.01	0.03	0.02
-0.00	-0.01	-0.15	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	1.00	0.01	0.01	0.03	0.02
-0.00	-0.00	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	1.00	0.00	0.01	0.01
-0.01	-0.13	-0.07	0.01	0.02	0.01	0.00	0.00	0.02	0.03	0.01	0.01	0.00	1.00	0.01	0.01
-0.00	-0.01	-0.18	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.03	0.03	0.01	0.01	1.00	0.03
-0.00	-0.01	-0.15	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.03	1.00

SUMMMARY OF RESIDUALS

Index 1 SPR AGE1
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.8319	-0.1841	0.1507	0.1531	0.7711	42.145
1974	0.2699	-1.7030	0.1507	0.2973	1.4974	9.228
1975	-0.0098	-0.5627	0.1507	0.0833	0.4197	28.861
1976	-3.0946	-1.3674	0.1507	-0.2603	-1.3110	12.907
1977	-1.0152	-0.0630	0.1507	-0.1435	-0.7227	47.568
1978	1.6550	0.0340	0.1507	0.2443	1.2303	52.417
1979	1.0015	-0.5210	0.1507	0.2294	1.1556	30.090
1980	-0.4252	-0.1888	0.1507	-0.0356	-0.1794	41.945
1981	-0.8649	0.9184	0.1507	-0.2687	-1.3536	126.927
1982	-0.9341	0.0482	0.1507	-0.1480	-0.7456	53.167
1983	-2.4015	-1.2482	0.1507	-0.1738	-0.8753	14.541
1985	-0.3758	-0.8790	0.1507	0.0758	0.3819	21.036
1986	-3.0946	-2.0768	0.1507	-0.1534	-0.7725	6.349
1988	-0.9156	0.8566	0.1507	-0.2671	-1.3451	119.319
1989	-1.5238	-2.5258	0.1507	0.1510	0.7605	4.053
1990	-2.0327	-3.4670	0.1507	0.2161	1.0887	1.581

Table 5. (Continued)

RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES	6.937270
ORTHOGONALITY OFFSET.........	0.002193
MEAN SQUARE RESIDUALS	0.039416

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	1.17692E0	8.95988E-1	1.31354E0	0.76
N 3	2.01502E0	8.92080E-1	2.25879E0	0.44
N 5	3.07185E-1	1.95898E-1	1.56808E0	0.64
qSPR AGE1	1.97382E-2	6.60608E-3	2.98788E0	0.33
qSPR AGE2	2.93992E-2	5.57889E-3	5.26973E0	0.19
qSPR AGE3	6.19448E-2	8.96114E-3	6.91261E0	0.14
qSPR AGE4	2.17189E-1	3.92722E-2	5.53033E0	0.18
qSPR 5+	2.63505E-1	4.32425E-2	6.09365E0	0.16
qSCAL AG1	5.82729E-2	1.62800E-2	3.57942E0	0.28
qSCAL AG2	3.52224E-2	7.19523E-3	4.89525E0	0.20
qSCAL AG3	1.31747E-1	3.97720E-2	3.31255E0	0.30
qSCAL 4+	8.51019E-1	2.41722E-1	3.52065E0	0.28
qFALL AG1	3.71971E-2	7.81745E-3	4.75821E0	0.21
qFALL AG2	3.98292E-2	6.75395E-3	5.89717E0	0.17
qFALL AG3	1.27593E-1	1.71242E-2	7.45100E0	0.13
qFALL 4+	3.11264E-1	4.57702E-2	6.80057E0	0.15

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.05	0.02	-0.13	-0.01	-0.00	-0.00	-0.00	-0.30	-0.01	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00
0.05	1.00	0.04	-0.07	-0.10	-0.00	-0.00	-0.00	-0.15	-0.21	-0.01	-0.01	-0.00	-0.13	-0.01	-0.01
0.02	0.04	1.00	-0.02	-0.05	-0.09	-0.05	-0.05	-0.07	-0.11	-0.16	-0.15	-0.04	-0.07	-0.18	-0.15
-0.13	-0.07	-0.02	1.00	0.01	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.01	0.00	0.00
-0.01	-0.10	-0.05	0.01	1.00	0.00	0.00	0.00	0.02	0.03	0.01	0.01	0.00	0.02	0.01	0.01
-0.00	-0.00	-0.09	0.00	0.00	1.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01
-0.00	-0.00	-0.05	0.00	0.00	0.00	1.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
-0.00	-0.00	-0.05	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01
-0.30	-0.15	-0.07	0.05	0.02	0.01	0.00	0.00	1.00	0.04	0.01	0.01	0.00	0.02	0.01	0.01
-0.01	-0.21	-0.11	0.02	0.03	0.01	0.01	0.01	0.04	1.00	0.02	0.02	0.00	0.03	0.02	0.02
-0.00	-0.01	-0.16	0.00	0.01	0.01	0.01	0.01	0.01	0.02	1.00	0.02	0.01	0.01	0.03	0.02
-0.00	-0.01	-0.15	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	1.00	0.01	0.01	0.03	0.02
-0.00	-0.00	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	1.00	0.00	0.01	0.01
-0.01	-0.13	-0.07	0.01	0.02	0.01	0.00	0.00	0.02	0.03	0.01	0.01	0.00	1.00	0.01	0.01
-0.00	-0.01	-0.18	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.03	0.03	0.01	0.01	1.00	0.03
-0.00	-0.01	-0.15	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.03	1.00

SUMMMARY OF RESIDUALS

Index 1 SPR AGE1
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.8319	-0.1841	0.1507	0.1531	0.7711	42.145
1974	0.2699	-1.7030	0.1507	0.2973	1.4974	9.228
1975	-0.0098	-0.5627	0.1507	0.0833	0.4197	28.861
1976	-3.0946	-1.3674	0.1507	-0.2603	-1.3110	12.907
1977	-1.0152	-0.0630	0.1507	-0.1435	-0.7227	47.568
1978	1.6550	0.0340	0.1507	0.2443	1.2303	52.417
1979	1.0015	-0.5210	0.1507	0.2294	1.1556	30.090
1980	-0.4252	-0.1888	0.1507	-0.0356	-0.1794	41.945
1981	-0.8649	0.9184	0.1507	-0.2687	-1.3536	126.927
1982	-0.9341	0.0482	0.1507	-0.1480	-0.7456	53.167
1983	-2.4015	-1.2482	0.1507	-0.1738	-0.8753	14.541
1985	-0.3758	-0.8790	0.1507	0.0758	0.3819	21.036
1986	-3.0946	-2.0768	0.1507	-0.1534	-0.7725	6.349
1988	-0.9156	0.8566	0.1507	-0.2671	-1.3451	119.319
1989	-1.5238	-2.5258	0.1507	0.1510	0.7605	4.053
1990	-2.0327	-3.4670	0.1507	0.2161	1.0887	1.581

Table 5. (Continued)

1984	0.1772	0.6330	0.2604	-0.1187	-0.5979	8.671
1985	-2.1885	-0.8375	0.2604	-0.3518	-1.7722	1.993
1986	-1.7617	-1.6910	0.2604	-0.0184	-0.0927	0.849
1987	-2.5220	-1.4948	0.2604	-0.2675	-1.3474	1.033
1988	-1.9905	-2.1895	0.2604	0.0518	0.2610	0.516
1989	-3.1351	-2.3857	0.2604	-0.1952	-0.9830	0.424
1990	0.9120	-0.9011	0.2604	0.4722	2.3784	1.870

Partial variance for this index is 0.039608

Index 5 SPR 5+
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5 6 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	2.2004	0.7404	0.3044	0.4444	2.2383	7.957
1974	0.9274	0.6919	0.3044	0.0717	0.3610	7.580
1975	0.0829	0.1698	0.3044	-0.0265	-0.1333	4.498
1976	-0.5702	-0.3290	0.3044	-0.0734	-0.3698	2.731
1977	-1.2634	-1.1102	0.3044	-0.0466	-0.2348	1.250
1978	-1.1912	-1.7614	0.3044	0.1736	0.8742	0.652
1979	-2.4280	-1.4090	0.3044	-0.3101	-1.5621	0.927
1980	-1.0896	-1.3328	0.3044	0.0740	0.3728	1.001
1981	-0.8046	-1.0415	0.3044	0.0721	0.3631	1.339
1982	-0.9091	-1.5689	0.3044	0.2008	1.0115	0.790
1983	-2.0245	-1.3166	0.3044	-0.2154	-1.0851	1.017
1984	-0.9793	-0.9929	0.3044	0.0041	0.0207	1.406
1985	-1.2652	-1.0465	0.3044	-0.0666	-0.3353	1.333
1986	-2.8783	-1.7754	0.3044	-0.3357	-1.6907	0.643
1988	-2.7255	-3.1925	0.3044	0.1422	0.7161	0.156
1990	-3.9861	-3.6295	0.3044	-0.1085	-0.5467	0.101

Partial variance for this index is 0.039523

Index 6 SCAL AG1
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.1022	1.0308	0.2522	-0.2342	-1.1795	48.105
1983	0.5242	-0.3651	0.2522	0.2243	1.1296	11.911
1984	-0.9449	-0.4239	0.2522	-0.1314	-0.6618	11.232
1985	0.2038	0.0605	0.2522	0.0362	0.1821	18.230
1986	-0.6274	-1.1256	0.2522	0.1256	0.6327	5.568
1987	0.1310	-0.7544	0.2522	0.2233	1.1247	8.070
1988	0.9344	1.8138	0.2522	-0.2218	-1.1170	105.261
1989	-1.1398	-1.5415	0.2522	0.1013	0.5103	3.673
1990	-3.0175	-2.5285	0.2522	-0.1233	-0.6212	1.369

Partial variance for this index is 0.033979

Index 7 SCAL AG2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	1.0009	0.9818	0.3349	0.0064	0.0323	75.779
1983	-0.3040	0.0356	0.3349	-0.1137	-0.5728	29.420
1984	-1.9140	-1.6527	0.3349	-0.0875	-0.4408	5.438
1985	-1.5904	-1.4266	0.3349	-0.0548	-0.2762	6.817
1986	-0.8045	-1.3161	0.3349	0.1713	0.8629	7.614
1987	-2.3319	-2.4253	0.3349	0.0313	0.1576	2.511
1988	-2.9337	-1.7224	0.3349	-0.4056	-2.0431	5.072
1989	1.4791	0.9199	0.3349	0.1873	0.9433	71.231
1990	-1.5931	-2.3857	0.3349	0.2654	1.3368	2.613

Partial variance for this index is 0.041704

Table 5. (Continued)

1984	0.1772	0.6330	0.2604	-0.1187	-0.5979	8.671
1985	-2.1885	-0.8375	0.2604	-0.3518	-1.7722	1.993
1986	-1.7617	-1.6910	0.2604	-0.0184	-0.0927	0.849
1987	-2.5220	-1.4948	0.2604	-0.2675	-1.3474	1.033
1988	-1.9905	-2.1895	0.2604	0.0518	0.2610	0.516
1989	-3.1351	-2.3857	0.2604	-0.1952	-0.9830	0.424
1990	0.9120	-0.9011	0.2604	0.4722	2.3784	1.870

Partial variance for this index is 0.039608

Index 5 SPR 5+
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5 6 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	2.2004	0.7404	0.3044	0.4444	2.2383	7.957
1974	0.9274	0.6919	0.3044	0.0717	0.3610	7.580
1975	0.0829	0.1698	0.3044	-0.0265	-0.1333	4.498
1976	-0.5702	-0.3290	0.3044	-0.0734	-0.3698	2.731
1977	-1.2634	-1.1102	0.3044	-0.0466	-0.2348	1.250
1978	-1.1912	-1.7614	0.3044	0.1736	0.8742	0.652
1979	-2.4280	-1.4090	0.3044	-0.3101	-1.5621	0.927
1980	-1.0896	-1.3328	0.3044	0.0740	0.3728	1.001
1981	-0.8046	-1.0415	0.3044	0.0721	0.3631	1.339
1982	-0.9091	-1.5689	0.3044	0.2008	1.0115	0.790
1983	-2.0245	-1.3166	0.3044	-0.2154	-1.0851	1.017
1984	-0.9793	-0.9929	0.3044	0.0041	0.0207	1.406
1985	-1.2652	-1.0465	0.3044	-0.0666	-0.3353	1.333
1986	-2.8783	-1.7754	0.3044	-0.3357	-1.6907	0.643
1988	-2.7255	-3.1925	0.3044	0.1422	0.7161	0.156
1990	-3.9861	-3.6295	0.3044	-0.1085	-0.5467	0.101

Partial variance for this index is 0.039523

Index 6 SCAL AG1
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.1022	1.0308	0.2522	-0.2342	-1.1795	48.105
1983	0.5242	-0.3651	0.2522	0.2243	1.1296	11.911
1984	-0.9449	-0.4239	0.2522	-0.1314	-0.6618	11.232
1985	0.2038	0.0605	0.2522	0.0362	0.1821	18.230
1986	-0.6274	-1.1256	0.2522	0.1256	0.6327	5.568
1987	0.1310	-0.7544	0.2522	0.2233	1.1247	8.070
1988	0.9344	1.8138	0.2522	-0.2218	-1.1170	105.261
1989	-1.1398	-1.5415	0.2522	0.1013	0.5103	3.673
1990	-3.0175	-2.5285	0.2522	-0.1233	-0.6212	1.369

Partial variance for this index is 0.033979

Index 7 SCAL AG2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	1.0009	0.9818	0.3349	0.0064	0.0323	75.779
1983	-0.3040	0.0356	0.3349	-0.1137	-0.5728	29.420
1984	-1.9140	-1.6527	0.3349	-0.0875	-0.4408	5.438
1985	-1.5904	-1.4266	0.3349	-0.0548	-0.2762	6.817
1986	-0.8045	-1.3161	0.3349	0.1713	0.8629	7.614
1987	-2.3319	-2.4253	0.3349	0.0313	0.1576	2.511
1988	-2.9337	-1.7224	0.3349	-0.4056	-2.0431	5.072
1989	1.4791	0.9199	0.3349	0.1873	0.9433	71.231
1990	-1.5931	-2.3857	0.3349	0.2654	1.3368	2.613

Partial variance for this index is 0.041704

Table 5. (Continued)

1980	-0.1410	-0.4005	0.2801	0.0727	0.3661	16.821
1981	0.5446	0.0693	0.2801	0.1332	0.6707	26.909
1982	1.5711	1.1047	0.2801	0.1307	0.6582	75.779
1983	1.0790	0.1585	0.2801	0.2579	1.2988	29.420
1984	-1.0129	-1.5298	0.2801	0.1448	0.7293	5.438
1985	-2.2525	-1.3037	0.2801	-0.2658	-1.3388	6.817
1986	-0.9259	-1.1932	0.2801	0.0749	0.3771	7.614
1987	-2.0046	-2.3024	0.2801	0.0834	0.4202	2.511
1988	-2.3931	-1.5995	0.2801	-0.2223	-1.1198	5.072
1989	0.6324	1.0428	0.2801	-0.1150	-0.5791	71.231
1990	-3.7816	-2.2628	0.2801	-0.4255	-2.1430	2.613

Partial variance for this index is 0.038031

Index 12 FALL AG3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.0039	0.5491	0.3563	-0.1943	-0.9785	13.572
1974	-1.1872	-0.5650	0.3563	-0.2217	-1.1166	4.455
1975	-2.1198	-1.7351	0.3563	-0.1371	-0.6905	1.382
1976	-0.9265	-1.6919	0.3563	0.2727	1.3737	1.443
1977	-0.8222	-0.6911	0.3563	-0.0467	-0.2354	3.927
1978	-1.4313	-0.9604	0.3563	-0.1678	-0.8450	3.000
1979	0.2979	0.2100	0.3563	0.0313	0.1578	9.669
1980	-0.4490	-0.1622	0.3563	-0.1022	-0.5147	6.664
1981	-0.2935	-0.2577	0.3563	-0.0128	-0.0643	6.057
1982	1.3648	0.3633	0.3563	0.3568	1.7974	11.271
1983	1.5150	1.1425	0.3563	0.1327	0.6685	24.567
1984	0.0799	-0.0442	0.3563	0.0442	0.2228	7.499
1985	-2.2626	-1.5913	0.3563	-0.2392	-1.2047	1.596
1986	-1.4429	-1.2094	0.3563	-0.0832	-0.4191	2.339
1987	-1.1800	-1.7274	0.3563	0.1951	0.9825	1.393
1988	-2.1911	-2.4136	0.3563	0.0793	0.3993	0.701
1989	-0.0976	-1.0704	0.3563	0.3466	1.7458	2.687
1990	0.4395	1.1521	0.3563	-0.2539	-1.2789	24.803

Partial variance for this index is 0.039474

Index 13 FALL 4+
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 4 5 6 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	1.4309	1.3109	0.3235	0.0388	0.1955	11.917
1974	1.5686	1.0560	0.3235	0.1658	0.8351	9.236
1975	-0.2568	0.2872	0.3235	-0.1759	-0.8862	4.281
1976	0.1907	-0.2998	0.3235	0.1586	0.7991	2.381
1977	-1.0697	-0.8764	0.3235	-0.0625	-0.3149	1.337
1978	-0.4187	-0.6438	0.3235	0.0728	0.3668	1.688
1979	-0.5806	-0.5600	0.3235	-0.0067	-0.0336	1.835
1980	-0.6823	0.0156	0.3235	-0.2258	-1.1371	3.263
1981	-0.5741	-0.3490	0.3235	-0.0728	-0.3667	2.266
1982	0.3681	-0.4496	0.3235	0.2645	1.3322	2.049
1983	0.0071	-0.0106	0.3235	0.0057	0.0289	3.179
1984	-0.4094	0.2900	0.3235	-0.2262	-1.1394	4.294
1985	-1.7311	-0.6608	0.3235	-0.3462	-1.7438	1.659
1986	-2.0662	-1.4747	0.3235	-0.1913	-0.9637	0.735
1987	-1.9051	-1.7863	0.3235	-0.0384	-0.1936	0.538
1988	-1.0484	-2.4954	0.3235	0.4680	2.3574	0.265
1989	-2.3571	-2.5668	0.3235	0.0678	0.3416	0.247
1990	-0.9389	-1.2595	0.3235	0.1037	0.5223	0.912

Partial variance for this index is 0.039605

Table 5. (Continued)

1980	-0.1410	-0.4005	0.2801	0.0727	0.3661	16.821
1981	0.5446	0.0693	0.2801	0.1332	0.6707	26.909
1982	1.5711	1.1047	0.2801	0.1307	0.6582	75.779
1983	1.0790	0.1585	0.2801	0.2579	1.2988	29.420
1984	-1.0129	-1.5298	0.2801	0.1448	0.7293	5.438
1985	-2.2525	-1.3037	0.2801	-0.2658	-1.3388	6.817
1986	-0.9259	-1.1932	0.2801	0.0749	0.3771	7.614
1987	-2.0046	-2.3024	0.2801	0.0834	0.4202	2.511
1988	-2.3931	-1.5995	0.2801	-0.2223	-1.1198	5.072
1989	0.6324	1.0428	0.2801	-0.1150	-0.5791	71.231
1990	-3.7816	-2.2628	0.2801	-0.4255	-2.1430	2.613

Partial variance for this index is 0.038031

Index 12 FALL AG3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.0039	0.5491	0.3563	-0.1943	-0.9785	13.572
1974	-1.1872	-0.5650	0.3563	-0.2217	-1.1166	4.455
1975	-2.1198	-1.7351	0.3563	-0.1371	-0.6905	1.382
1976	-0.9265	-1.6919	0.3563	0.2727	1.3737	1.443
1977	-0.8222	-0.6911	0.3563	-0.0467	-0.2354	3.927
1978	-1.4313	-0.9604	0.3563	-0.1678	-0.8450	3.000
1979	0.2979	0.2100	0.3563	0.0313	0.1578	9.669
1980	-0.4490	-0.1622	0.3563	-0.1022	-0.5147	6.664
1981	-0.2935	-0.2577	0.3563	-0.0128	-0.0643	6.057
1982	1.3648	0.3633	0.3563	0.3568	1.7974	11.271
1983	1.5150	1.1425	0.3563	0.1327	0.6685	24.567
1984	0.0799	-0.0442	0.3563	0.0442	0.2228	7.499
1985	-2.2626	-1.5913	0.3563	-0.2392	-1.2047	1.596
1986	-1.4429	-1.2094	0.3563	-0.0832	-0.4191	2.339
1987	-1.1800	-1.7274	0.3563	0.1951	0.9825	1.393
1988	-2.1911	-2.4136	0.3563	0.0793	0.3993	0.701
1989	-0.0976	-1.0704	0.3563	0.3466	1.7458	2.687
1990	0.4395	1.1521	0.3563	-0.2539	-1.2789	24.803

Partial variance for this index is 0.039474

Index 13 FALL 4+
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 4 5 6 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	1.4309	1.3109	0.3235	0.0388	0.1955	11.917
1974	1.5686	1.0560	0.3235	0.1658	0.8351	9.236
1975	-0.2568	0.2872	0.3235	-0.1759	-0.8862	4.281
1976	0.1907	-0.2998	0.3235	0.1586	0.7991	2.381
1977	-1.0697	-0.8764	0.3235	-0.0625	-0.3149	1.337
1978	-0.4187	-0.6438	0.3235	0.0728	0.3668	1.688
1979	-0.5806	-0.5600	0.3235	-0.0067	-0.0336	1.835
1980	-0.6823	0.0156	0.3235	-0.2258	-1.1371	3.263
1981	-0.5741	-0.3490	0.3235	-0.0728	-0.3667	2.266
1982	0.3681	-0.4496	0.3235	0.2645	1.3322	2.049
1983	0.0071	-0.0106	0.3235	0.0057	0.0289	3.179
1984	-0.4094	0.2900	0.3235	-0.2262	-1.1394	4.294
1985	-1.7311	-0.6608	0.3235	-0.3462	-1.7438	1.659
1986	-2.0662	-1.4747	0.3235	-0.1913	-0.9637	0.735
1987	-1.9051	-1.7863	0.3235	-0.0384	-0.1936	0.538
1988	-1.0484	-2.4954	0.3235	0.4680	2.3574	0.265
1989	-2.3571	-2.5668	0.3235	0.0678	0.3416	0.247
1990	-0.9389	-1.2595	0.3235	0.1037	0.5223	0.912

Partial variance for this index is 0.039605

Table 5. (Continued)

STOCK NUMBERS (Jan 1) in millions - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	42.145	9.228	28.861	12.907	47.568	52.417	30.090	41.945	126.927	53.167	14.541	12.668	21.036	6.349
2	15.231	34.335	6.779	15.631	10.374	34.021	35.045	24.451	33.449	103.885	43.376	9.619	9.909	15.686
3	19.879	7.895	2.475	2.132	6.826	4.177	15.811	11.298	10.972	21.282	53.267	18.837	2.690	4.447
4	10.104	8.765	2.197	0.671	0.922	1.994	2.068	5.370	3.512	2.889	5.034	8.671	1.993	0.849
5	3.811	4.045	2.564	0.909	0.327	0.400	0.706	0.760	1.123	0.661	0.786	1.078	1.072	0.434
6	3.443	1.567	1.048	0.961	0.439	0.082	0.178	0.192	0.195	0.119	0.175	0.304	0.213	0.177
7+	0.703	1.968	0.885	0.861	0.484	0.170	0.043	0.049	0.021	0.011	0.056	0.024	0.047	0.032
1+	95.316	67.803	44.809	34.072	66.939	93.261	83.941	84.065	176.200	182.013	117.235	51.201	36.960	27.974

	1987	1988	1989	1990	1991
1	9.583	119.319	4.053	1.581	0.000
2	4.854	6.726	92.353	3.318	1.177
3	2.941	1.080	3.714	53.605	2.015
4	1.033	0.516	0.424	1.870	8.806
5	0.187	0.119	0.054	0.094	0.307
6	0.063	0.028	0.007	0.006	0.015
7+	0.011	0.009	0.000	0.000	0.001
1+	18.671	127.797	100.605	60.475	12.322

Summaries for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	42.145	9.228	28.861	12.907	47.568	52.417	30.090	41.945	126.927	53.167	14.541	12.668	21.036	6.349
2+	53.171	58.576	15.948	21.165	19.372	40.844	53.851	42.120	49.273	128.847	102.694	38.534	15.925	21.625
3+	37.941	24.240	9.169	5.535	8.998	6.823	18.806	17.669	15.824	24.962	59.319	28.914	6.015	5.939
4+	18.062	16.345	6.695	3.402	2.172	2.646	2.995	6.371	4.852	3.679	6.051	10.077	3.325	1.492
5+	7.957	7.580	4.498	2.731	1.250	0.652	0.927	1.001	1.339	0.790	1.017	1.406	1.333	0.643

	1987	1988	1989	1990	1991
1	9.583	119.319	4.053	1.581	0.000
2+	9.089	8.477	96.552	58.894	12.322
3+	4.235	1.751	4.199	55.576	11.145
4+	1.293	0.671	0.485	1.971	9.130
5+	0.261	0.156	0.061	0.101	0.324

FISHING MORTALITY - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0049	0.1085	0.4132	0.0185	0.1352	0.2026	0.0075	0.0264	0.0003	0.0035	0.2132	0.0456	0.0934	0.0686	0.1540
2	0.4571	2.4300	0.9566	0.6285	0.7097	0.5663	0.9320	0.6013	0.2521	0.4680	0.6341	1.0743	0.6012	1.4739	1.3028
3	0.6189	1.0791	1.1046	0.6385	1.0304	0.5032	0.8798	0.9683	1.1346	1.2416	1.6153	2.0463	0.9536	1.2601	1.5414
4	0.7155	1.0293	0.6831	0.5185	0.6353	0.8391	0.8011	1.3650	1.4705	1.1010	1.3409	1.8906	1.3239	1.3123	1.9630
5	0.6885	1.1501	0.7809	0.5271	1.1806	0.6069	1.1037	1.1582	2.0440	1.1289	0.7509	1.4202	1.5996	1.7347	1.7053
6	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614
7+	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614

	1988	1989	1990
1	0.0562	0.0000	0.0953
2	0.3939	0.3440	0.2988
3	0.7357	0.4862	1.6062
4	2.0590	1.3026	1.6062
5	2.6044	1.9363	1.6062
6	1.1001	0.5629	1.6062
7+	1.1001	0.5629	1.6062

Table 5. (Continued)

STOCK NUMBERS (Jan 1) in millions - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	42.145	9.228	28.861	12.907	47.568	52.417	30.090	41.945	126.927	53.167	14.541	12.668	21.036	6.349
2	15.231	34.335	6.779	15.631	10.374	34.021	35.045	24.451	33.449	103.885	43.376	9.619	9.909	15.686
3	19.879	7.895	2.475	2.132	6.826	4.177	15.811	11.298	10.972	21.282	53.267	18.837	2.690	4.447
4	10.104	8.765	2.197	0.671	0.922	1.994	2.068	5.370	3.512	2.889	5.034	8.671	1.993	0.849
5	3.811	4.045	2.564	0.909	0.327	0.400	0.706	0.760	1.123	0.661	0.786	1.078	1.072	0.434
6	3.443	1.567	1.048	0.961	0.439	0.082	0.178	0.192	0.195	0.119	0.175	0.304	0.213	0.177
7+	0.703	1.968	0.885	0.861	0.484	0.170	0.043	0.049	0.021	0.011	0.056	0.024	0.047	0.032
1+	95.316	67.803	44.809	34.072	66.939	93.261	83.941	84.065	176.200	182.013	117.235	51.201	36.960	27.974

	1987	1988	1989	1990	1991
1	9.583	119.319	4.053	1.581	0.000
2	4.854	6.726	92.353	3.318	1.177
3	2.941	1.080	3.714	53.605	2.015
4	1.033	0.516	0.424	1.870	8.806
5	0.187	0.119	0.054	0.094	0.307
6	0.063	0.028	0.007	0.006	0.015
7+	0.011	0.009	0.000	0.000	0.001
1+	18.671	127.797	100.605	60.475	12.322

Summaries for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	42.145	9.228	28.861	12.907	47.568	52.417	30.090	41.945	126.927	53.167	14.541	12.668	21.036	6.349
2+	53.171	58.576	15.948	21.165	19.372	40.844	53.851	42.120	49.273	128.847	102.694	38.534	15.925	21.625
3+	37.941	24.240	9.169	5.535	8.998	6.823	18.806	17.669	15.824	24.962	59.319	28.914	6.015	5.939
4+	18.062	16.345	6.695	3.402	2.172	2.646	2.995	6.371	4.852	3.679	6.051	10.077	3.325	1.492
5+	7.957	7.580	4.498	2.731	1.250	0.652	0.927	1.001	1.339	0.790	1.017	1.406	1.333	0.643

	1987	1988	1989	1990	1991
1	9.583	119.319	4.053	1.581	0.000
2+	9.089	8.477	96.552	58.894	12.322
3+	4.235	1.751	4.199	55.576	11.145
4+	1.293	0.671	0.485	1.971	9.130
5+	0.261	0.156	0.061	0.101	0.324

FISHING MORTALITY - SNE

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0049	0.1085	0.4132	0.0185	0.1352	0.2026	0.0075	0.0264	0.0003	0.0035	0.2132	0.0456	0.0934	0.0686	0.1540
2	0.4571	2.4300	0.9566	0.6285	0.7097	0.5663	0.9320	0.6013	0.2521	0.4680	0.6341	1.0743	0.6012	1.4739	1.3028
3	0.6189	1.0791	1.1046	0.6385	1.0304	0.5032	0.8798	0.9683	1.1346	1.2416	1.6153	2.0463	0.9536	1.2601	1.5414
4	0.7155	1.0293	0.6831	0.5185	0.6353	0.8391	0.8011	1.3650	1.4705	1.1010	1.3409	1.8906	1.3239	1.3123	1.9630
5	0.6885	1.1501	0.7809	0.5271	1.1806	0.6069	1.1037	1.1582	2.0440	1.1289	0.7509	1.4202	1.5996	1.7347	1.7053
6	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614
7+	0.6663	1.1086	0.8674	0.5971	1.0122	0.6099	0.9013	1.1219	1.3043	1.2742	1.6797	2.1900	1.2190	1.3595	1.7614

	1988	1989	1990
1	0.0562	0.0000	0.0953
2	0.3939	0.3440	0.2988
3	0.7357	0.4862	1.6062
4	2.0590	1.3026	1.6062
5	2.6044	1.9363	1.6062
6	1.1001	0.5629	1.6062
7+	1.1001	0.5629	1.6062

Table 5. (Continued)

MEAN BIOMASS (1000s MT)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	8.002	1.612	4.703	2.643	8.690	10.097	5.136	7.733	16.103	10.872	2.084	2.044	3.336	1.036	1.993
2	3.327	3.731	1.165	3.220	1.935	7.034	6.314	4.727	7.050	19.930	7.708	1.300	1.800	2.170	0.673
3	5.171	1.599	0.532	0.616	1.512	1.206	3.539	2.559	2.078	3.990	8.377	2.235	0.591	0.783	0.503
4	2.780	2.164	0.641	0.253	0.326	0.674	0.622	1.354	0.826	0.811	1.281	1.410	0.438	0.206	0.174
5	1.086	1.059	0.712	0.344	0.094	0.195	0.233	0.287	0.277	0.242	0.341	0.265	0.269	0.115	0.045
6	1.165	0.416	0.302	0.376	0.123	0.045	0.074	0.095	0.067	0.051	0.065	0.075	0.071	0.055	0.016
7	0.288	0.568	0.280	0.358	0.172	0.079	0.018	0.032	0.005	0.005	0.021	0.007	0.022	0.013	0.004
1+	21.819	11.149	8.336	7.811	12.850	19.329	15.935	16.786	26.406	35.901	19.878	7.336	6.526	4.378	3.409

	1988	1989	1990
1	28.420	1.142	0.412
2	1.486	24.005	0.854
3	0.279	1.045	9.376
4	0.102	0.120	0.399
5	0.026	0.016	0.035
6	0.015	0.005	0.003
7	0.005	0.000	0.000
1+	30.334	26.334	11.078

Summaries for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	8.002	1.612	4.703	2.643	8.690	10.097	5.136	7.733	16.103	10.872	2.084	2.044	3.336	1.036	1.993	28.420
2	13.816	9.538	3.633	5.168	4.161	9.232	10.799	9.054	10.303	25.029	17.793	5.292	3.190	3.342	1.416	1.913
3	10.490	5.806	2.468	1.948	2.226	2.198	4.485	4.327	3.253	5.099	10.085	3.992	1.390	1.172	0.743	0.427
4	5.319	4.207	1.935	1.331	0.714	0.992	0.946	1.768	1.175	1.109	1.708	1.758	0.799	0.389	0.240	0.148
5	2.539	2.043	1.295	1.079	0.389	0.318	0.324	0.414	0.349	0.298	0.427	0.347	0.362	0.183	0.066	0.046

	1989	1990
1	1.142	0.412
2	25.191	10.666
3	1.186	9.812
4	0.141	0.436
5	0.021	0.038

CATCH BIOMASS (1000s MT)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0.040	0.175	1.944	0.049	1.175	2.046	0.039	0.204	0.005	0.038	0.444	0.093	0.312	0.071	0.307	1.597
2	1.521	9.067	1.114	2.024	1.373	3.983	5.885	2.842	1.778	9.327	4.888	1.396	1.082	3.198	0.877	0.585
3	3.200	1.726	0.588	0.394	1.558	0.607	3.113	2.478	2.357	4.954	13.532	4.573	0.563	0.987	0.775	0.205
4	1.989	2.228	0.438	0.131	0.207	0.565	0.498	1.849	1.215	0.893	1.718	2.666	0.580	0.270	0.342	0.211
5	0.748	1.218	0.556	0.181	0.111	0.118	0.257	0.332	0.566	0.273	0.256	0.377	0.430	0.199	0.077	0.069
6	0.777	0.461	0.262	0.225	0.125	0.027	0.067	0.106	0.087	0.065	0.110	0.165	0.086	0.075	0.029	0.016
7	0.192	0.630	0.243	0.214	0.174	0.048	0.016	0.036	0.007	0.007	0.035	0.014	0.027	0.017	0.008	0.005
1+	8.465	15.504	5.145	3.217	4.721	7.394	9.875	7.847	6.015	15.557	20.982	9.285	3.080	4.818	2.414	2.689

	1989	1990
1	0.000	0.039
2	8.257	0.255
3	0.508	15.059
4	0.156	0.641
5	0.032	0.056
6	0.003	0.004
7	0.000	0.000
1+	8.956	16.054

Table 5. (Continued)

MEAN BIOMASS (1000s MT)

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	8.002	1.612	4.703	2.643	8.690	10.097	5.136	7.733	16.103	10.872	2.084	2.044	3.336	1.036	1.993
2 ■	3.327	3.731	1.165	3.220	1.935	7.034	6.314	4.727	7.050	19.930	7.708	1.300	1.800	2.170	0.673
3 ■	5.171	1.599	0.532	0.616	1.512	1.206	3.539	2.559	2.078	3.990	8.377	2.235	0.591	0.783	0.503
4 ■	2.780	2.164	0.641	0.253	0.326	0.674	0.622	1.354	0.826	0.811	1.281	1.410	0.438	0.206	0.174
5 ■	1.086	1.059	0.712	0.344	0.094	0.195	0.233	0.287	0.277	0.242	0.341	0.265	0.269	0.115	0.045
6 ■	1.165	0.416	0.302	0.376	0.123	0.045	0.074	0.095	0.067	0.051	0.065	0.075	0.071	0.055	0.016
7 ■	0.288	0.568	0.280	0.358	0.172	0.079	0.018	0.032	0.005	0.005	0.021	0.007	0.022	0.013	0.004
1+■	21.819	11.149	8.336	7.811	12.850	19.329	15.935	16.786	26.406	35.901	19.878	7.336	6.526	4.378	3.409

■	1988	1989	1990
1 ■	28.420	1.142	0.412
2 ■	1.486	24.005	0.854
3 ■	0.279	1.045	9.376
4 ■	0.102	0.120	0.399
5 ■	0.026	0.016	0.035
6 ■	0.015	0.005	0.003
7 ■	0.005	0.000	0.000
1+■	30.334	26.334	11.078

Summaries for ages 1 1 2 7 3 7 4 7 5 7

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	8.002	1.612	4.703	2.643	8.690	10.097	5.136	7.733	16.103	10.872	2.084	2.044	3.336	1.036	1.993	28.420
2 ■	13.816	9.538	3.633	5.168	4.161	9.232	10.799	9.054	10.303	25.029	17.793	5.292	3.190	3.342	1.416	1.913
3 ■	10.490	5.806	2.468	1.948	2.226	2.198	4.485	4.327	3.253	5.099	10.085	3.992	1.390	1.172	0.743	0.427
4 ■	5.319	4.207	1.935	1.331	0.714	0.992	0.946	1.768	1.175	1.109	1.708	1.758	0.799	0.389	0.240	0.148
5 ■	2.539	2.043	1.295	1.079	0.389	0.318	0.324	0.414	0.349	0.298	0.427	0.347	0.362	0.183	0.066	0.046

■	1989	1990
1 ■	1.142	0.412
2 ■	25.191	10.666
3 ■	1.186	9.812
4 ■	0.141	0.436
5 ■	0.021	0.038

CATCH BIOMASS (1000s MT)

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	0.040	0.175	1.944	0.049	1.175	2.046	0.039	0.204	0.005	0.038	0.444	0.093	0.312	0.071	0.307	1.597
2 ■	1.521	9.067	1.114	2.024	1.373	3.983	5.885	2.842	1.778	9.327	4.888	1.396	1.082	3.198	0.877	0.585
3 ■	3.200	1.726	0.588	0.394	1.558	0.607	3.113	2.478	2.357	4.954	13.532	4.573	0.563	0.987	0.775	0.205
4 ■	1.989	2.228	0.438	0.131	0.207	0.565	0.498	1.849	1.215	0.893	1.718	2.666	0.580	0.270	0.342	0.211
5 ■	0.748	1.218	0.556	0.181	0.111	0.118	0.257	0.332	0.566	0.273	0.256	0.377	0.430	0.199	0.077	0.069
6 ■	0.777	0.461	0.262	0.225	0.125	0.027	0.067	0.106	0.087	0.065	0.110	0.165	0.086	0.075	0.029	0.016
7 ■	0.192	0.630	0.243	0.214	0.174	0.048	0.016	0.036	0.007	0.007	0.035	0.014	0.027	0.017	0.008	0.005
1+■	8.465	15.504	5.145	3.217	4.721	7.394	9.875	7.847	6.015	15.557	20.982	9.285	3.080	4.818	2.414	2.689

■	1989	1990
1 ■	0.000	0.039
2 ■	8.257	0.255
3 ■	0.508	15.059
4 ■	0.156	0.641
5 ■	0.032	0.056
6 ■	0.003	0.004
7 ■	0.000	0.000
1+■	8.956	16.054

Table 5. (Continued)

DERIVATION OF WEIGHTS FOR SNE RUN 126

Index	Sample Var	Unadjusted Wt	Wt (adj)	Old Wt (adj)	New Wt (adj)
1	1.741433	0.574240	0.022708	1.000000	0.022708
2	0.636397	1.571347	0.062137	1.000000	0.062137
3	0.371367	2.692752	0.106481	1.000000	0.106481
4	0.583040	1.715149	0.067823	1.000000	0.067823
5	0.426851	2.342737	0.092640	1.000000	0.092640
6	0.621859	1.608081	0.063589	1.000000	0.063589
7	0.352664	2.835561	0.112128	1.000000	0.112128
8	0.793531	1.260190	0.049833	1.000000	0.049833
9	0.703971	1.420513	0.056172	1.000000	0.056172
10	0.700693	1.427159	0.056435	1.000000	0.056435
11	0.503922	1.984433	0.078472	1.000000	0.078472
12	0.311467	3.210615	0.126959	1.000000	0.126959
13	0.377967	2.645730	0.104622	1.000000	0.104622

The following codes define the indices of abundance:

1	SPR AGE1
2	SPR AGE2
3	SPR AGE3
4	SPR AGE4
5	SPR 5+
6	SCAL AG1
7	SCAL AG2
8	SCAL AG3
9	SCAL 4+
10	FALL AG1
11	FALL AG2
12	FALL AG3
13	FALL 4+

Table 5. (Continued)

DERIVATION OF WEIGHTS FOR SNE RUN 126

Index	Sample Var	Unadjusted Wt	Wt (adj)	Old Wt (adj)	New Wt (adj)
1	1.741433	0.574240	0.022708	1.000000	0.022708
2	0.636397	1.571347	0.062137	1.000000	0.062137
3	0.371367	2.692752	0.106481	1.000000	0.106481
4	0.583040	1.715149	0.067823	1.000000	0.067823
5	0.426851	2.342737	0.092640	1.000000	0.092640
6	0.621859	1.608081	0.063589	1.000000	0.063589
7	0.352664	2.835561	0.112128	1.000000	0.112128
8	0.793531	1.260190	0.049833	1.000000	0.049833
9	0.703971	1.420513	0.056172	1.000000	0.056172
10	0.700693	1.427159	0.056435	1.000000	0.056435
11	0.503922	1.984433	0.078472	1.000000	0.078472
12	0.311467	3.210615	0.126959	1.000000	0.126959
13	0.377967	2.645730	0.104622	1.000000	0.104622

The following codes define the indices of abundance:

1	SPR AGE1
2	SPR AGE2
3	SPR AGE3
4	SPR AGE4
5	SPR 5+
6	SCAL AG1
7	SCAL AG2
8	SCAL AG3
9	SCAL 4+
10	FALL AG1
11	FALL AG2
12	FALL AG3
13	FALL 4+

Table 6. (Continued)

Par.	Initial Est	Lower Bnd	Upper Bnd
N 2	5.0000000E0	0.0000000E0	1.0000000E6
N 3	5.0000000E0	0.0000000E0	1.0000000E6
N 4	1.0000000E0	0.0000000E0	1.0000000E5
N 5	5.0000000E-1	0.0000000E0	1.0000000E6
qSPR AGE2	1.0000000E-1	0.0000000E0	1.0000000E2
qSPR AGE3	1.0000000E-1	0.0000000E0	1.0000000E2
qSPR AGE4	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG1	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG2	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG3	1.0000000E-1	0.0000000E0	1.0000000E2
~~qSCAL 4+~~	~~1.0000000E-1~~	~~0.0000000E0~~	~~1.0000000E2~~
qFALL AG1	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG2	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG3	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG4	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL 5+	1.0000000E-1	0.0000000E0	1.0000000E2

The following indices of abundance are available:

1	SPR AGE1
2	SPR AGE2
3	SPR AGE3
4	SPR AGE4
5	SPR 5+
6	SCAL AG1
7	SCAL AG2
8	SCAL AG3
9	SCAL 4+
10	FALL AG1
11	FALL AG2
12	FALL AG3
13	FALL AG4
14	FALL 5+
15	
16	
17	
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20	
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22	
23	
24	
25	

Indices that will be used in this run are: 2 3 4 6 7 8 9 10 11 12 13 14

Indices (before transformation) by index & yr; with index means

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 ■	4.733	3.223	4.260	6.330	0.972	1.157	2.802	6.731	1.741	3.633	1.529	0.076
3 ■	3.432	2.669	1.246	1.807	1.631	0.735	0.558	8.349	3.015	1.089	2.236	0.663
4 ■	1.541	1.821	0.432	0.450	0.556	0.318	0.475	0.685	1.222	0.986	0.435	0.725
6 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.485	0.183	0.294
7 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.499	0.532	0.118
8 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.195	0.404	0.050
9 ■	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	0.091	0.135	0.102
10 ■	2.044	3.789	3.791	0.275	0.901	4.591	1.274	0.739	1.538	1.987	0.089	0.542
11 ■	4.506	2.339	2.058	1.581	2.098	1.235	1.941	4.938	2.265	1.791	1.872	0.328
12 ■	4.184	1.249	0.719	0.389	1.601	0.750	0.307	5.874	1.583	1.303	1.569	0.251
13 ■	2.413	0.869	0.469	0.096	0.600	0.394	0.118	0.658	0.485	0.347	0.388	0.199
14 ■	1.504	0.688	0.326	0.182	0.215	0.169	0.240	0.460	0.211	0.073	0.097	0.113

Table 6. (Continued)

Par.	Initial Est	Lower Bnd	Upper Bnd
N 2	5.0000000E0	0.0000000E0	1.0000000E6
N 3	5.0000000E0	0.0000000E0	1.0000000E6
N 4	1.0000000E0	0.0000000E0	1.0000000E5
N 5	5.0000000E-1	0.0000000E0	1.0000000E6
qSPR AGE2	1.0000000E-1	0.0000000E0	1.0000000E2
qSPR AGE3	1.0000000E-1	0.0000000E0	1.0000000E2
qSPR AGE4	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG1	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG2	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL AG3	1.0000000E-1	0.0000000E0	1.0000000E2
qSCAL 4+	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG1	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG2	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG3	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL AG4	1.0000000E-1	0.0000000E0	1.0000000E2
qFALL 5+	1.0000000E-1	0.0000000E0	1.0000000E2

The following indices of abundance are available:

1	SPR AGE1
2	SPR AGE2
3	SPR AGE3
4	SPR AGE4
5	SPR 5+
6	SCAL AG1
7	SCAL AG2
8	SCAL AG3
9	SCAL 4+
10	FALL AG1
11	FALL AG2
12	FALL AG3
13	FALL AG4
14	FALL 5+
15	
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18	
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22	
23	
24	
25	

Indices that will be used in this run are: 2 3 4 6 7 8 9 10 11 12 13 14

Indices (before transformation) by index & yr; with index means

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2 ■	4.733	3.223	4.260	6.330	0.972	1.157	2.802	6.731	1.741	3.633	1.529	0.076
3 ■	3.432	2.669	1.246	1.807	1.631	0.735	0.558	8.349	3.015	1.089	2.236	0.663
4 ■	1.541	1.821	0.432	0.450	0.556	0.318	0.475	0.685	1.222	0.986	0.435	0.725
6 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.485	0.183	0.294
7 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.499	0.532	0.118
8 ■	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.195	0.404	0.050
9 ■	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	-4995.000	0.091	0.135	0.102
10 ■	2.044	3.789	3.791	0.275	0.901	4.591	1.274	0.739	1.538	1.987	0.089	0.542
11 ■	4.506	2.339	2.058	1.581	2.098	1.235	1.941	4.938	2.265	1.791	1.872	0.328
12 ■	4.184	1.249	0.719	0.389	1.601	0.750	0.307	5.874	1.583	1.303	1.569	0.251
13 ■	2.413	0.869	0.469	0.096	0.600	0.394	0.118	0.658	0.485	0.347	0.388	0.199
14 ■	1.504	0.688	0.326	0.182	0.215	0.169	0.240	0.460	0.211	0.073	0.097	0.113

Table 6. (Continued)

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - GB_2

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
2 ■	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
3 ■	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025
4 ■	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322
6 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424
7 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762
8 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282
9 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382
10 ■	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259
11 ■	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421
12 ■	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337
13 ■	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429
14 ■	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876

■	1990
2 ■	0.0481
3 ■	0.1025
4 ■	0.1322
6 ■	0.0424
7 ■	0.0762
8 ■	0.0282
9 ■	0.0382
10 ■	0.0259
11 ■	0.1421
12 ■	0.1337
13 ■	0.1429
14 ■	0.0876

CATCH AT AGE INCLUDING DISCARDS (millions) - GB_2

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	0.347	5.425	2.590	0.515	0.330	9.659	0.251	0.309	0.035	0.922	2.178	0.356	2.300	0.270	0.041
2 ■	9.009	12.672	22.674	24.352	6.742	2.248	9.879	5.695	2.228	14.000	7.732	1.914	3.334	5.955	1.819
3 ■	13.545	8.052	6.997	5.087	9.844	3.971	3.396	8.707	5.946	7.061	16.027	4.266	0.815	0.979	2.729
4 ■	9.277	7.398	3.392	1.347	1.721	1.660	1.243	1.419	4.555	3.267	2.317	4.735	0.652	0.348	0.762
5 ■	3.743	3.544	2.084	0.533	0.395	0.460	0.551	0.320	0.796	1.031	0.625	1.591	0.410	0.161	0.131
6 ■	1.259	0.851	0.670	0.432	0.221	0.102	0.140	0.085	0.122	0.061	0.108	0.257	0.060	0.051	0.039
7 ■	0.360	0.625	0.479	0.435	0.255	0.072	0.130	0.014	0.004	0.022	0.018	0.064	0.005	0.023	0.072
1+■	37.540	38.566	38.886	32.701	19.507	18.171	15.588	16.548	13.685	26.365	29.005	13.182	7.577	7.787	5.593

■	1988	1989	1990
1 ■	0.000	1.151	0.000
2 ■	2.154	2.378	2.592
3 ■	1.181	0.683	9.528
4 ■	0.624	0.262	0.741
5 ■	0.166	0.068	0.105
6 ■	0.015	0.012	0.017
7 ■	0.023	0.008	0.003
1+■	4.162	4.561	12.985

CAA summary for ages 1 1 2 7 3 7 4 7 5 7

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	0.347	5.425	2.590	0.515	0.330	9.659	0.251	0.309	0.035	0.922	2.178	0.356	2.300	0.270	0.041
2 ■	37.193	33.141	36.296	32.186	19.177	8.512	15.337	16.239	13.651	25.442	26.828	12.825	5.277	7.517	5.551
3 ■	28.184	20.470	13.622	7.834	12.435	6.264	5.459	10.544	11.423	11.442	19.095	10.912	1.943	1.562	3.733
4 ■	14.639	12.418	6.625	2.748	2.591	2.293	2.063	1.838	5.477	4.382	3.068	6.646	1.127	0.583	1.003
5 ■	5.362	5.020	3.233	1.401	0.870	0.634	0.821	0.418	0.921	1.114	0.751	1.911	0.475	0.235	0.241

Table 6. (Continued)

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - GB_2

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
3	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025	0.1025
4	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424	0.0424
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762	0.0762
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382	0.0382
10	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259
11	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421	0.1421
12	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337
13	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429
14	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876

CATCH AT AGE INCLUDING DISCARDS (millions) - GB_2

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.347	5.425	2.590	0.515	0.330	9.659	0.251	0.309	0.035	0.922	2.178	0.356	2.300	0.270	0.041	0.000	1.151	0.000
2	9.009	12.672	22.674	24.352	6.742	2.248	9.879	5.695	2.228	14.000	7.732	1.914	3.334	5.955	1.819	2.154	2.378	2.592
3	13.545	8.052	6.997	5.087	9.844	3.971	3.396	8.707	5.946	7.061	16.027	4.266	0.815	0.979	2.729	1.181	0.683	9.528
4	9.277	7.398	3.392	1.347	1.721	1.660	1.243	1.419	4.555	3.267	2.317	4.735	0.652	0.348	0.762	0.624	0.262	0.741
5	3.743	3.544	2.084	0.533	0.395	0.460	0.551	0.320	0.796	1.031	0.625	1.591	0.410	0.161	0.131	0.166	0.068	0.105
6	1.259	0.851	0.670	0.432	0.221	0.102	0.140	0.085	0.122	0.061	0.108	0.257	0.060	0.051	0.039	0.015	0.012	0.017
7	0.360	0.625	0.479	0.435	0.255	0.072	0.130	0.014	0.004	0.022	0.018	0.064	0.005	0.023	0.072	0.023	0.008	0.003
1+	37.540	38.566	38.886	32.701	19.507	18.171	15.588	16.548	13.685	26.365	29.005	13.182	7.577	7.787	5.593	4.162	4.561	12.985

CAA summary for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.347	5.425	2.590	0.515	0.330	9.659	0.251	0.309	0.035	0.922	2.178	0.356	2.300	0.270	0.041
2	37.193	33.141	36.296	32.186	19.177	8.512	15.337	16.239	13.651	25.442	26.828	12.825	5.277	7.517	5.551
3	28.184	20.470	13.622	7.834	12.435	6.264	5.459	10.544	11.423	11.442	19.095	10.912	1.943	1.562	3.733
4	14.639	12.418	6.625	2.748	2.591	2.293	2.063	1.838	5.477	4.382	3.068	6.646	1.127	0.583	1.003
5	5.362	5.020	3.233	1.401	0.870	0.634	0.821	0.418	0.921	1.114	0.751	1.911	0.475	0.235	0.241

Table 6. (Continued)

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BEGIN MARQUARDT ALGORITHM
-------------------------


LAMBDA       1.00000E-2
RSS          2.42751E1
NPHI         2.42751E1

par
  5.00000E0       5.00000E0       1.00000E0       5.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1      1.
     00000E-1       1.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1      1.00000E-1


LAMBDA       1.00000E-1
RSS          2.09477E1
NPHI         2.09477E1

par
  3.98507E0       4.45493E0       1.17417E0       5.67177E-1      8.92639E-2      9.71357E-2      1.10023E-1      9.84989E-2      1.
     00605E-1       1.02887E-1      1.16175E-1      8.74381E-2      9.62843E-2      1.02094E-1      1.12926E-1      1.21404E-1


LAMBDA       1.00000E0
RSS          1.82342E1
NPHI         1.82342E1

par
  3.27582E0       4.01570E0       1.34767E0       6.32582E-1      8.07527E-2      9.46422E-2      1.19894E-1      9.71077E-2      1.
     01110E-1       1.05530E-1      1.33063E-1      7.76965E-2      9.30829E-2      1.03998E-1      1.26028E-1      1.44814E-1


LAMBDA       1.00000E1
RSS          1.61585E1
NPHI         1.61585E1

par
  2.80236E0       3.67477E0       1.52124E0       6.96838E-1      7.43934E-2      9.26194E-2      1.28813E-1      9.57708E-2      1.
     01457E-1       1.07746E-1      1.49146E-1      7.05577E-2      9.04955E-2      1.05589E-1      1.38178E-1      1.68106E-1


LAMBDA       1.00000E0
RSS          9.14273E0
NPHI         9.14273E0

par
  7.70832E-1      1.82927E0       2.93666E0       1.20607E0       4.49656E-2      8.29197E-2      1.77188E-1      8.55380E-2      1.
     02312E-1       1.19976E-1      2.41008E-1      3.80656E-2      7.75473E-2      1.14114E-1      2.05626E-1      3.04896E-1


LAMBDA       1.00000E-1
RSS          6.22599E0
NPHI         6.22599E0

par
  6.83151E-1      1.54041E0       3.60576E0       1.44983E0       3.33614E-2      7.49387E-2      2.45505E-1      8.37549E-2      1.
     04158E-1       1.31319E-1      4.01957E-1      2.76741E-2      6.87160E-2      1.21994E-1      3.12154E-1      5.88341E-1


LAMBDA       1.00000E-2
RSS          5.94985E0
NPHI         5.94985E0

par
  6.79403E-1      1.57622E0       3.45182E0       1.40294E0       3.39331E-2      7.47963E-2      2.69479E-1      8.39309E-2      1.
     04648E-1       1.33972E-1      4.92365E-1      2.82605E-2      6.85582E-2      1.23498E-1      3.59603E-1      8.01134E-1


LAMBDA       1.00000E-3
RSS          5.94508E0
NPHI         5.94508E0

par
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Table 6. (Continued)

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BEGIN MARQUARDT ALGORITHM
-------------------------

LAMBDA      1.00000E-2
RSS         2.42751E1
NPHI        2.42751E1

par
   5.00000E0     5.00000E0     1.00000E0     5.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1    1.
      00000E-1     1.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1    1.00000E-1

LAMBDA      1.00000E-1
RSS         2.09477E1
NPHI        2.09477E1

par
   3.98507E0     4.45493E0     1.17417E0     5.67177E-1    8.92639E-2    9.71357E-2    1.10023E-1    9.84989E-2    1.
      00605E-1     1.02887E-1    1.16175E-1    8.74381E-2    9.62843E-2    1.02094E-1    1.12926E-1    1.21404E-1

LAMBDA      1.00000E0
RSS         1.82342E1
NPHI        1.82342E1

par
   3.27582E0     4.01570E0     1.34767E0     6.32582E-1    8.07527E-2    9.46422E-2    1.19894E-1    9.71077E-2    1.
      01110E-1     1.05530E-1    1.33063E-1    7.76965E-2    9.30829E-2    1.03998E-1    1.26028E-1    1.44814E-1

LAMBDA      1.00000E1
RSS         1.61585E1
NPHI        1.61585E1

par
   2.80236E0     3.67477E0     1.52124E0     6.96838E-1    7.43934E-2    9.26194E-2    1.28813E-1    9.57708E-2    1.
      01457E-1     1.07746E-1    1.49146E-1    7.05577E-2    9.04955E-2    1.05589E-1    1.38178E-1    1.68106E-1

LAMBDA      1.00000E0
RSS         9.14273E0
NPHI        9.14273E0

par
   7.70832E-1    1.82927E0     2.93666E0     1.20607E0     4.49656E-2    8.29197E-2    1.77188E-1    8.55380E-2    1.
      02312E-1     1.19976E-1    2.41008E-1    3.80656E-2    7.75473E-2    1.14114E-1    2.05626E-1    3.04896E-1

LAMBDA      1.00000E-1
RSS         6.22599E0
NPHI        6.22599E0

par
   6.83151E-1    1.54041E0     3.60576E0     1.44983E0     3.33614E-2    7.49387E-2    2.45505E-1    8.37549E-2    1.
      04158E-1     1.31319E-1    4.01957E-1    2.76741E-2    6.87160E-2    1.21994E-1    3.12154E-1    5.88341E-1

LAMBDA      1.00000E-2
RSS         5.94985E0
NPHI        5.94985E0

par
   6.79403E-1    1.57622E0     3.45182E0     1.40294E0     3.39331E-2    7.47963E-2    2.69479E-1    8.39309E-2    1.
      04648E-1     1.33972E-1    4.92365E-1    2.82605E-2    6.85582E-2    1.23498E-1    3.59603E-1    8.01134E-1

LAMBDA      1.00000E-3
RSS         5.94508E0
NPHI        5.94508E0

par
```

Table 6. (Continued)

1976	0.9939	0.4107	0.2193	0.1279	0.6657	44.425
1977	-0.8798	-0.6115	0.2193	-0.0588	-0.3061	15.983
1978	-0.7055	-0.9630	0.2193	0.0565	0.2938	11.247
1979	0.1790	0.1025	0.2193	0.0168	0.0873	32.641
1980	1.0554	-0.3064	0.2193	0.2987	1.5542	21.687
1981	-0.2969	-0.4260	0.2193	0.0283	0.1473	19.242
1982	0.4387	0.4453	0.2193	-0.0015	-0.0076	45.991
1983	-0.4267	-0.6214	0.2193	0.0427	0.2221	15.827
1984	-3.4284	-1.9710	0.2193	-0.3196	-1.6634	4.105
1985	-0.0634	-1.4793	0.2193	0.3105	1.6160	6.712
1986	-0.2602	-0.9404	0.2193	0.1492	0.7762	11.504
1987	-2.9071	-1.8982	0.2193	-0.2213	-1.1515	4.415
1988	-2.1423	-1.4257	0.2193	-0.1572	-0.8179	7.081
1989	-1.5465	-0.3558	0.2193	-0.2611	-1.3589	20.640
1990	-3.4153	-1.8173	0.2193	-0.3505	-1.8238	4.786

Partial variance for this index is 0.038575

Index 3 SPR AGE3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.7014	0.8007	0.3202	-0.0318	-0.1655	29.776
1974	0.4500	0.1113	0.3202	0.1084	0.5643	14.944
1975	-0.3118	-0.2398	0.3202	-0.0231	-0.1201	10.520
1976	0.0599	-0.3747	0.3202	0.1392	0.7243	9.191
1977	-0.0425	0.0699	0.3202	-0.0360	-0.1874	14.338
1978	-0.8396	-0.6491	0.3202	-0.0610	-0.3175	6.986
1979	-1.1151	-0.6224	0.3202	-0.1578	-0.8210	7.175
1980	1.5904	0.2854	0.3202	0.4179	2.1746	17.786
1981	0.5719	-0.0591	0.3202	0.2020	1.0514	12.603
1982	-0.4465	0.0272	0.3202	-0.1517	-0.7894	13.739
1983	0.2729	0.6253	0.3202	-0.1128	-0.5872	24.986
1984	-0.9427	-0.8077	0.3202	-0.0432	-0.2251	5.962
1985	-1.8711	-2.1050	0.3202	0.0749	0.3897	1.629
1986	-1.7662	-1.6855	0.3202	-0.0258	-0.1344	2.478
1987	-2.7210	-1.1990	0.3202	-0.4874	-2.5362	4.031
1988	-1.5369	-1.9155	0.3202	0.1212	0.6309	1.969
1989	-0.6710	-1.2453	0.3202	0.1839	0.9570	3.849
1990	-0.2671	0.0981	0.3202	-0.1169	-0.6084	14.747

Partial variance for this index is 0.037297

Index 4 SPR AGE4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.9103	1.4972	0.3635	-0.2134	-1.1103	16.502
1974	1.0772	1.1888	0.3635	-0.0405	-0.2110	12.123
1975	-0.3615	0.2931	0.3635	-0.2380	-1.2383	4.950
1976	-0.3207	-0.4814	0.3635	0.0584	0.3041	2.282
1977	-0.1091	-0.2338	0.3635	0.0453	0.2358	2.923
1978	-0.6678	-0.2654	0.3635	-0.1463	-0.7613	2.832
1979	-0.2666	-0.5517	0.3635	0.1037	0.5394	2.127
1980	0.0995	-0.2761	0.3635	0.1365	0.7106	2.802
1981	0.6783	0.5934	0.3635	0.0309	0.1607	6.684
1982	0.4638	0.2906	0.3635	0.0629	0.3275	4.938
1983	-0.3546	0.2746	0.3635	-0.2287	-1.1903	4.860
1984	0.1563	0.4780	0.3635	-0.1169	-0.6086	5.955
1985	-0.7880	-1.2852	0.3635	0.1808	0.9406	1.021
1986	-2.4045	-1.8239	0.3635	-0.2111	-1.0985	0.596
1987	-1.5395	-1.1728	0.3635	-0.1333	-0.6938	1.143
1988	-0.9410	-1.4920	0.3635	0.2003	1.0424	0.831
1989	-0.5980	-1.9168	0.3635	0.4794	2.4949	0.543
1990	-0.2943	-0.3768	0.3635	0.0300	0.1561	2.533

Partial variance for this index is 0.03581

Table 6. (Continued)

1976	0.9939	0.4107	0.2193	0.1279	0.6657	44.425
1977	-0.8798	-0.6115	0.2193	-0.0588	-0.3061	15.983
1978	-0.7055	-0.9630	0.2193	0.0565	0.2938	11.247
1979	0.1790	0.1025	0.2193	0.0168	0.0873	32.641
1980	1.0554	-0.3064	0.2193	0.2987	1.5542	21.687
1981	-0.2969	-0.4260	0.2193	0.0283	0.1473	19.242
1982	0.4387	0.4453	0.2193	-0.0015	-0.0076	45.991
1983	-0.4267	-0.6214	0.2193	0.0427	0.2221	15.827
1984	-3.4284	-1.9710	0.2193	-0.3196	-1.6634	4.105
1985	-0.0634	-1.4793	0.2193	0.3105	1.6160	6.712
1986	-0.2602	-0.9404	0.2193	0.1492	0.7762	11.504
1987	-2.9071	-1.8982	0.2193	-0.2213	-1.1515	4.415
1988	-2.1423	-1.4257	0.2193	-0.1572	-0.8179	7.081
1989	-1.5465	-0.3558	0.2193	-0.2611	-1.3589	20.640
1990	-3.4153	-1.8173	0.2193	-0.3505	-1.8238	4.786

Partial variance for this index is 0.038575

Index 3 SPR AGE3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.7014	0.8007	0.3202	-0.0318	-0.1655	29.776
1974	0.4500	0.1113	0.3202	0.1084	0.5643	14.944
1975	-0.3118	-0.2398	0.3202	-0.0231	-0.1201	10.520
1976	0.0599	-0.3747	0.3202	0.1392	0.7243	9.191
1977	-0.0425	0.0699	0.3202	-0.0360	-0.1874	14.338
1978	-0.8396	-0.6491	0.3202	-0.0610	-0.3175	6.986
1979	-1.1151	-0.6224	0.3202	-0.1578	-0.8210	7.175
1980	1.5904	0.2854	0.3202	0.4179	2.1746	17.786
1981	0.5719	-0.0591	0.3202	0.2020	1.0514	12.603
1982	-0.4465	0.0272	0.3202	-0.1517	-0.7894	13.739
1983	0.2729	0.6253	0.3202	-0.1128	-0.5872	24.986
1984	-0.9427	-0.8077	0.3202	-0.0432	-0.2251	5.962
1985	-1.8711	-2.1050	0.3202	0.0749	0.3897	1.629
1986	-1.7662	-1.6855	0.3202	-0.0258	-0.1344	2.478
1987	-2.7210	-1.1990	0.3202	-0.4874	-2.5362	4.031
1988	-1.5369	-1.9155	0.3202	0.1212	0.6309	1.969
1989	-0.6710	-1.2453	0.3202	0.1839	0.9570	3.849
1990	-0.2671	0.0981	0.3202	-0.1169	-0.6084	14.747

Partial variance for this index is 0.037297

Index 4 SPR AGE4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.9103	1.4972	0.3635	-0.2134	-1.1103	16.502
1974	1.0772	1.1888	0.3635	-0.0405	-0.2110	12.123
1975	-0.3615	0.2931	0.3635	-0.2380	-1.2383	4.950
1976	-0.3207	-0.4814	0.3635	0.0584	0.3041	2.282
1977	-0.1091	-0.2338	0.3635	0.0453	0.2358	2.923
1978	-0.6678	-0.2654	0.3635	-0.1463	-0.7613	2.832
1979	-0.2666	-0.5517	0.3635	0.1037	0.5394	2.127
1980	0.0995	-0.2761	0.3635	0.1365	0.7106	2.802
1981	0.6783	0.5934	0.3635	0.0309	0.1607	6.684
1982	0.4638	0.2906	0.3635	0.0629	0.3275	4.938
1983	-0.3546	0.2746	0.3635	-0.2287	-1.1903	4.860
1984	0.1563	0.4780	0.3635	-0.1169	-0.6086	5.955
1985	-0.7880	-1.2852	0.3635	0.1808	0.9406	1.021
1986	-2.4045	-1.8239	0.3635	-0.2111	-1.0985	0.596
1987	-1.5395	-1.1728	0.3635	-0.1333	-0.6938	1.143
1988	-0.9410	-1.4920	0.3635	0.2003	1.0424	0.831
1989	-0.5980	-1.9168	0.3635	0.4794	2.4949	0.543
1990	-0.2943	-0.3768	0.3635	0.0300	0.1561	2.533

Partial variance for this index is 0.03581

Table 6. (Continued)

Index is tuned to the sum of mean full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.3830	-0.1679	0.1610	0.0887	0.4616	29.906
1974	1.0002	0.1934	0.1610	0.1299	0.6761	42.917
1975	1.0007	0.3562	0.1610	0.1038	0.5401	50.509
1976	-1.6229	-0.6778	0.1610	-0.1522	-0.7919	17.959
1977	-0.4361	-1.0306	0.1610	0.0957	0.4981	12.621
1978	1.1922	0.1462	0.1610	0.1684	0.8765	40.942
1979	-0.0897	-0.3822	0.1610	0.0471	0.2451	24.137
1980	-0.6343	-0.4997	0.1610	-0.0217	-0.1128	21.461
1981	0.0986	0.3645	0.1610	-0.0428	-0.2228	50.930
1982	0.3547	-0.6759	0.1610	0.1660	0.8637	17.994
1983	-2.7510	-1.8432	0.1610	-0.1462	-0.7607	5.600
1984	-0.9444	-1.5361	0.1610	0.0953	0.4959	7.613
1985	0.0174	-0.9345	0.1610	0.1533	0.7976	13.894
1986	-1.5732	-1.9514	0.1610	0.0609	0.3169	5.026
1987	-2.5122	-1.5042	0.1610	-0.1623	-0.8448	7.860
1988	-4.2952	-0.4370	0.1610	-0.6213	-3.2331	22.849
1989	-1.5629	-1.7952	0.1610	0.0374	0.1946	5.875

Partial variance for this index is 0.038277

Index 11 FALL AG2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.9304	0.3587	0.3769	0.2155	1.1213	20.879
1974	0.2747	0.1781	0.3769	0.0364	0.1894	17.429
1975	0.1467	0.3022	0.3769	-0.0586	-0.3050	19.731
1976	-0.1170	0.6011	0.3769	-0.2707	-1.4086	26.605
1977	0.1659	-0.2939	0.3769	0.1733	0.9020	10.871
1978	-0.3640	-0.4763	0.3769	0.0423	0.2202	9.059
1979	0.0882	0.5173	0.3769	-0.1618	-0.8418	24.467
1980	1.0219	0.1376	0.3769	0.3334	1.7348	16.736
1981	0.2425	0.1134	0.3769	0.0487	0.2533	16.336
1982	0.0077	0.8588	0.3769	-0.3208	-1.6696	34.427
1983	0.0520	-0.3671	0.3769	0.1580	0.8220	10.104
1984	-1.6898	-1.6946	0.3769	0.0018	0.0094	2.679
1985	-1.1674	-1.2333	0.3769	0.0248	0.1292	4.249
1986	-0.4318	-0.7162	0.3769	0.1072	0.5579	7.126
1987	-1.5167	-1.5718	0.3769	0.0208	0.1081	3.029
1988	-2.1215	-1.0120	0.3769	-0.4182	-2.1764	5.301
1989	0.2768	0.1838	0.3769	0.0350	0.1824	17.529
1990	-1.5322	-1.6195	0.3769	0.0329	0.1713	2.888

Partial variance for this index is 0.036815

Index 12 FALL AG3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	1.1644	0.8864	0.3657	0.1016	0.5289	19.645
1974	-0.0445	0.1108	0.3657	-0.0568	-0.2957	9.045
1975	-0.5968	-0.4068	0.3657	-0.0695	-0.3615	5.390
1976	-1.2111	-0.3919	0.3657	-0.2995	-1.5588	5.471
1977	0.2037	-0.1322	0.3657	0.1228	0.6392	7.094
1978	-0.5546	-0.6839	0.3657	0.0473	0.2461	4.086
1979	-1.4478	-0.5544	0.3657	-0.3267	-1.7000	4.650
1980	1.5037	0.3373	0.3657	0.4265	2.2195	11.344
1981	0.1924	0.0104	0.3657	0.0666	0.3465	8.180
1982	-0.0022	0.0538	0.3657	-0.0205	-0.1066	8.544
1983	0.1836	0.4942	0.3657	-0.1136	-0.5911	13.271
1984	-1.6492	-1.0617	0.3657	-0.2148	-1.1180	2.800
1985	-1.9929	-2.0644	0.3657	0.0262	0.1361	1.027
1986	-1.3139	-1.5461	0.3657	0.0849	0.4419	1.725
1987	-1.1932	-1.3853	0.3657	0.0702	0.3655	2.026
1988	-2.5018	-1.9897	0.3657	-0.1873	-0.9745	1.107

Table 6. (Continued)

Index is tuned to the sum of mean full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.3830	-0.1679	0.1610	0.0887	0.4616	29.906
1974	1.0002	0.1934	0.1610	0.1299	0.6761	42.917
1975	1.0007	0.3562	0.1610	0.1038	0.5401	50.509
1976	-1.6229	-0.6778	0.1610	-0.1522	-0.7919	17.959
1977	-0.4361	-1.0306	0.1610	0.0957	0.4981	12.621
1978	1.1922	0.1462	0.1610	0.1684	0.8765	40.942
1979	-0.0897	-0.3822	0.1610	0.0471	0.2451	24.137
1980	-0.6343	-0.4997	0.1610	-0.0217	-0.1128	21.461
1981	0.0986	0.3645	0.1610	-0.0428	-0.2228	50.930
1982	0.3547	-0.6759	0.1610	0.1660	0.8637	17.994
1983	-2.7510	-1.8432	0.1610	-0.1462	-0.7607	5.600
1984	-0.9444	-1.5361	0.1610	0.0953	0.4959	7.613
1985	0.0174	-0.9345	0.1610	0.1533	0.7976	13.894
1986	-1.5732	-1.9514	0.1610	0.0609	0.3169	5.026
1987	-2.5122	-1.5042	0.1610	-0.1623	-0.8448	7.860
1988	-4.2952	-0.4370	0.1610	-0.6213	-3.2331	22.849
1989	-1.5629	-1.7952	0.1610	0.0374	0.1946	5.875

Partial variance for this index is 0.038277

Index 11 FALL AG2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	0.9304	0.3587	0.3769	0.2155	1.1213	20.879
1974	0.2747	0.1781	0.3769	0.0364	0.1894	17.429
1975	0.1467	0.3022	0.3769	-0.0586	-0.3050	19.731
1976	-0.1170	0.6011	0.3769	-0.2707	-1.4086	26.605
1977	0.1659	-0.2939	0.3769	0.1733	0.9020	10.871
1978	-0.3640	-0.4763	0.3769	0.0423	0.2202	9.059
1979	0.0882	0.5173	0.3769	-0.1618	-0.8418	24.467
1980	1.0219	0.1376	0.3769	0.3334	1.7348	16.736
1981	0.2425	0.1134	0.3769	0.0487	0.2533	16.336
1982	0.0077	0.8588	0.3769	-0.3208	-1.6696	34.427
1983	0.0520	-0.3671	0.3769	0.1580	0.8220	10.104
1984	-1.6898	-1.6946	0.3769	0.0018	0.0094	2.679
1985	-1.1674	-1.2333	0.3769	0.0248	0.1292	4.249
1986	-0.4318	-0.7162	0.3769	0.1072	0.5579	7.126
1987	-1.5167	-1.5718	0.3769	0.0208	0.1081	3.029
1988	-2.1215	-1.0120	0.3769	-0.4182	-2.1764	5.301
1989	0.2768	0.1838	0.3769	0.0350	0.1824	17.529
1990	-1.5322	-1.6195	0.3769	0.0329	0.1713	2.888

Partial variance for this index is 0.036815

Index 12 FALL AG3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1973	1.1644	0.8864	0.3657	0.1016	0.5289	19.645
1974	-0.0445	0.1108	0.3657	-0.0568	-0.2957	9.045
1975	-0.5968	-0.4068	0.3657	-0.0695	-0.3615	5.390
1976	-1.2111	-0.3919	0.3657	-0.2995	-1.5588	5.471
1977	0.2037	-0.1322	0.3657	0.1228	0.6392	7.094
1978	-0.5546	-0.6839	0.3657	0.0473	0.2461	4.086
1979	-1.4478	-0.5544	0.3657	-0.3267	-1.7000	4.650
1980	1.5037	0.3373	0.3657	0.4265	2.2195	11.344
1981	0.1924	0.0104	0.3657	0.0666	0.3465	8.180
1982	-0.0022	0.0538	0.3657	-0.0205	-0.1066	8.544
1983	0.1836	0.4942	0.3657	-0.1136	-0.5911	13.271
1984	-1.6492	-1.0617	0.3657	-0.2148	-1.1180	2.800
1985	-1.9929	-2.0644	0.3657	0.0262	0.1361	1.027
1986	-1.3139	-1.5461	0.3657	0.0849	0.4419	1.725
1987	-1.1932	-1.3853	0.3657	0.0702	0.3655	2.026
1988	-2.5018	-1.9897	0.3657	-0.1873	-0.9745	1.107

Table 6. (Continued)

Standardized residuals by index & yr; with row/column/grand means

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 ■	0.8522	0.4698	0.4447	0.6657	-0.3061	0.2938	0.0873	1.5542	0.1473	-0.0076	0.2221	-1.6634	1.6160
3 ■	-0.1655	0.5643	-0.1201	0.7243	-0.1874	-0.3175	-0.8210	2.1746	1.0514	-0.7894	-0.5872	-0.2251	0.3897
4 ■	-1.1103	-0.2110	-1.2383	0.3041	0.2358	-0.7613	0.5394	0.7106	0.1607	0.3275	-1.1903	-0.6086	0.9406
6 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5193	0.7253	0.9056	0.7291
7 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.7437	1.1080	0.8491	-0.7790
8 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1551	0.4079	-0.0564	-1.6414
9 ■	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0643	0.1403	0.0915	-1.1319
10 ■	0.4616	0.6761	0.5401	-0.7919	0.4981	0.8765	0.2451	-0.1128	-0.2228	0.8637	-0.7607	0.4959	0.7976
11 ■	1.1213	0.1894	-0.3050	-1.4086	0.9020	0.2202	-0.8418	1.7348	0.2533	-1.6696	0.8220	0.0094	0.1292
12 ■	0.5289	-0.2957	-0.3615	-1.5588	0.6392	0.2461	-1.7000	2.2195	0.3465	-0.1066	-0.5911	-1.1180	0.1361
13 ■	0.9245	-0.3591	0.4102	-1.4578	1.6560	0.8841	-0.9289	1.7352	-0.1269	-0.2526	-0.4465	-1.1671	-0.6086
14 ■	0.3329	-0.4582	-0.9577	-1.0214	0.3779	0.0817	0.4908	2.0560	0.7789	-1.1793	-0.9263	-0.7485	-0.2186
** ■	0.3682	0.0720	-0.1984	-0.5681	0.4769	0.1905	-0.3662	1.5090	0.2985	-0.2456	-0.0897	-0.2696	0.0299

■	1986	1987	1988	1989	1990********	
2 ■	0.7762	-1.1515	-0.8179	-1.3589	-1.8238	0.0000
3 ■	-0.1344	-2.5362	0.6309	0.9570	-0.6084	-0.0000
4 ■	-1.0985	-0.6938	1.0424	2.4949	0.1561	0.0000
6 ■	0.5919	-1.8622	-1.4360	-0.1731	0.0000	0.0000
7 ■	-0.7833	0.9910	-1.4810	0.1624	0.6763	0.0000
8 ■	-1.5489	0.5153	0.4464	1.0511	0.6710	-0.0000
9 ■	-1.5778	-0.2432	1.2699	1.3926	0.1229	-0.0000
10 ■	0.3169	-0.8448	-3.2331	0.1946	0.0000	0.0000
11 ■	0.5579	0.1081	-2.1764	0.1824	0.1713	0.0000
12 ■	0.4419	0.3655	-0.9745	1.1119	0.6707	-0.0000
13 ■	0.9025	-1.0541	-1.1077	0.7936	0.2032	-0.0000
14 ■	0.0000	1.2007	0.0000	1.3801	-1.1893	-0.0000
** ■	-0.1414	-0.4338	-0.7125	0.6824	-0.0864	-0.0000

Percent of total sum of squares by index & yr; with row/column sums

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990*******	
2 ■	0.45	0.14	0.12	0.28	0.06	0.05	0.00	1.50	0.01	0.00	0.03	1.72	1.62	0.37	0.82	0.42	1.15	2.07	10.81
3 ■	0.02	0.20	0.01	0.33	0.02	0.06	0.42	2.94	0.69	0.39	0.21	0.03	0.09	0.01	4.00	0.25	0.57	0.23	10.46
4 ■	0.77	0.03	0.95	0.06	0.03	0.36	0.18	0.31	0.02	0.07	0.88	0.23	0.55	0.75	0.30	0.67	3.87	0.02	10.04
6 ■	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.33	0.51	0.33	0.22	2.15	1.28	0.02	0.00	5.00
7 ■	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.76	0.45	0.38	0.38	0.61	1.36	0.02	0.28	4.58
8 ■	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.00	1.67	1.49	0.16	0.12	0.69	0.28	4.54
9 ■	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.80	1.55	0.04	1.00	1.20	0.01	4.61
10 ■	0.13	0.28	0.18	0.39	0.15	0.48	0.04	0.01	0.03	0.46	0.36	0.15	0.40	0.06	0.44	6.49	0.02	0.00	10.09
11 ■	0.78	0.02	0.06	1.23	0.51	0.03	0.44	1.87	0.04	1.73	0.42	0.00	0.01	0.19	0.01	2.94	0.02	0.02	10.32
12 ■	0.17	0.05	0.08	1.51	0.25	0.04	1.80	3.06	0.07	0.01	0.22	0.78	0.01	0.12	0.08	0.59	0.77	0.28	9.89
13 ■	0.53	0.08	0.10	1.32	1.70	0.49	0.54	1.87	0.01	0.04	0.12	0.85	0.23	0.51	0.69	0.76	0.39	0.03	10.25
14 ■	0.07	0.13	0.57	0.65	0.09	0.00	0.15	2.63	0.38	0.86	0.53	0.35	0.03	0.00	0.90	0.00	1.18	0.88	9.39
** ■	2.92	0.93	2.08	5.76	2.82	1.51	3.56	14.18	1.25	4.09	3.98	5.07	6.12	5.65	10.20	15.89	9.89	4.09	100.00

Partial variance (and proportion of total) by index

■	2	3	4	6	7	8	9	10	11	12	13
** ■	0.03857508	0.03729693	0.03581003	0.03880881	0.03555295	0.03519078	0.03578186	0.03827650	0.03681528	0.03528779	0.03657936
** ■	0.08726396	0.08437255	0.08100890	0.08779270	0.08042734	0.07960805	0.08094518	0.08658851	0.08328297	0.07982750	0.08274926

■	14***********	
** ■	0.03807517	0.44205056
** ■	0.08613308	1.00000000

Table 6. (Continued)

STOCK NUMBERS (Jan 1) in millions - GB_2

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	33.182	50.313	57.124	20.091	14.102	50.543	26.766	23.844	56.211	20.350	7.420	8.591	16.594	5.691
2	28.209	26.853	36.285	44.425	15.983	11.247	32.641	21.687	19.242	45.991	15.827	4.105	6.712	11.504
3	29.776	14.944	10.520	9.191	14.338	6.986	7.175	17.786	12.603	13.739	24.986	5.962	1.629	2.478
4	16.502	12.123	4.950	2.282	2.923	2.832	2.127	2.802	6.684	4.938	4.860	5.955	1.021	0.596
5	5.865	5.116	3.231	0.983	0.649	0.835	0.817	0.617	1.009	1.351	1.086	1.882	0.591	0.246
6	2.433	1.415	0.982	0.759	0.323	0.175	0.268	0.170	0.216	0.107	0.173	0.324	0.101	0.113
7	0.685	1.019	0.684	0.752	0.364	0.122	0.246	0.027	0.006	0.037	0.028	0.078	0.008	0.050
1+	116.653	111.784	113.775	78.484	48.682	72.740	70.039	66.932	95.972	86.512	54.381	26.896	26.656	20.678

	1987	1988	1989	1990	1991
1	8.694	25.210	7.118	0.830	0.000
2	4.415	7.081	20.640	4.786	0.679
3	4.031	1.969	3.849	14.747	1.573
4	1.143	0.831	0.543	2.533	3.453
5	0.173	0.246	0.115	0.208	1.403
6	0.055	0.023	0.052	0.033	0.075
7	0.101	0.033	0.033	0.005	0.014
1+	18.612	35.393	32.351	23.142	7.197

Summaries for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	33.182	50.313	57.124	20.091	14.102	50.543	26.766	23.844	56.211	20.350	7.420	8.591	16.594	5.691	8.694
2	83.471	61.471	56.652	58.392	34.580	22.197	43.273	43.088	39.761	66.161	46.960	18.305	10.063	14.987	9.918
3	55.262	34.617	20.367	13.967	18.596	10.950	10.632	21.401	20.518	20.171	31.133	14.200	3.351	3.483	5.504
4	25.486	19.673	9.847	4.776	4.259	3.964	3.457	3.615	7.915	6.432	6.147	8.239	1.722	1.005	1.473
5	8.984	7.550	4.897	2.495	1.336	1.132	1.330	0.813	1.231	1.494	1.288	2.284	0.701	0.409	0.330

	1988	1989	1990	1991
1	25.210	7.118	0.830	0.000
2	10.183	25.233	22.312	7.197
3	3.102	4.592	17.526	6.518
4	1.133	0.744	2.779	4.945
5	0.303	0.201	0.245	1.492

FISHING MORTALITY - GB_2

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0116	0.1269	0.0514	0.0287	0.0262	0.2372	0.0104	0.0144	0.0007	0.0514	0.3921	0.0469	0.1663	0.0539	0.0053
2	0.4353	0.7371	1.1731	0.9309	0.6276	0.2496	0.4072	0.3428	0.1369	0.4101	0.7764	0.7241	0.7964	0.8487	0.6074
3	0.6986	0.9050	1.3284	0.9457	1.4220	0.9893	0.7404	0.7787	0.7370	0.8393	1.2341	1.5642	0.8056	0.5740	1.3797
4	0.9711	1.1222	1.4160	1.0569	1.0523	1.0436	1.0376	0.8208	1.3991	1.3141	0.7485	2.1098	1.2233	1.0346	1.3356
5	1.2217	1.4506	1.2480	0.9137	1.1135	0.9368	1.3701	0.8511	2.0488	1.8554	1.0096	2.7215	1.4550	1.2893	1.8015
6	0.8479	1.0926	1.4041	0.9914	1.4078	1.0308	0.8571	0.8039	0.9831	1.0163	1.1759	2.0802	1.0556	0.6968	1.4557
7	0.8479	1.0926	1.4041	0.9914	1.4078	1.0308	0.8571	0.8039	0.9831	1.0163	1.1759	2.0802	1.0556	0.6968	1.4557

	1988	1989	1990
1	0.0000	0.1969	0.0000
2	0.4097	0.1362	0.9126
3	1.0880	0.2182	1.2518
4	1.7739	0.7617	0.3907
5	1.3597	1.0592	0.8212
6	1.3132	0.2877	0.8212
7	1.3132	0.2877	0.8212

Table 6. (Continued)

Avg F for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0116	0.1269	0.0514	0.0287	0.0262	0.2372	0.0104	0.0144	0.0007	0.0514	0.3921	0.0469	0.1663	0.0539	0.0053
2	0.8371	1.0667	1.3290	0.9717	1.1719	0.8801	0.8782	0.7335	1.0480	1.0752	1.0201	1.8800	1.0652	0.8567	1.3393
3	0.9175	1.1326	1.3601	0.9798	1.2807	1.0063	0.9724	0.8117	1.2302	1.2083	1.0688	2.1112	1.1190	0.8583	1.4856
4	0.9722	1.1895	1.3681	0.9883	1.2454	1.0105	1.0305	0.8199	1.3536	1.3005	1.0275	2.2479	1.1974	0.9293	1.5121
5	0.9725	1.2119	1.3521	0.9655	1.3097	0.9995	1.0281	0.8196	1.3384	1.2960	1.1205	2.2939	1.1887	0.8943	1.5710

	1988	1989	1990
1	0.0000	0.1969	0.0000
2	1.2096	0.4584	0.8365
3	1.3696	0.5229	0.8212
4	1.4400	0.5991	0.7136
5	1.3287	0.5448	0.8212

Avg F (weighted by N) for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0116	0.1269	0.0514	0.0287	0.0262	0.2372	0.0104	0.0144	0.0007	0.0514	0.3921	0.0469	0.1663	0.0539	0.0053
2	0.7058	0.9273	1.2342	0.9394	1.0175	0.6200	0.5169	0.5632	0.5926	0.5975	1.0241	1.6837	0.8827	0.8163	1.0394
3	0.8439	1.0749	1.3431	0.9666	1.3526	1.0005	0.8538	0.7865	1.0199	1.0248	1.1501	1.9610	1.0557	0.7091	1.3860
4	1.0137	1.2039	1.3589	1.0067	1.1190	1.0201	1.0893	0.8250	1.4703	1.4211	0.8087	2.2481	1.2921	1.0422	1.4032
5	1.0920	1.3352	1.3011	0.9607	1.2648	0.9614	1.1720	0.8397	1.8568	1.7748	1.0356	2.6087	1.3924	1.0534	1.6375

	1988	1989	1990
1	0.0000	0.1969	0.0000
2	0.6801	0.1669	1.0765
3	1.2973	0.3049	1.1213
4	1.6609	0.7536	0.4287
5	1.3510	0.7316	0.8212

Avg F (wt by catch) for ages 1 1 2 7 3 7 4 7 5 7

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.0116	0.1269	0.0514	0.0287	0.0262	0.2372	0.0104	0.0144	0.0007	0.0514	0.3921	0.0469	0.1663	0.0539	0.0053
2	0.7620	0.9560	1.2374	0.9399	1.1029	0.8026	0.5745	0.6311	0.9388	0.7059	1.0547	1.7967	0.9049	0.8295	1.1321
3	0.8664	1.0915	1.3443	0.9677	1.3605	1.0010	0.8773	0.7868	1.0951	1.0677	1.1674	1.9849	1.0913	0.7561	1.3877
4	1.0215	1.2124	1.3611	1.0084	1.1269	1.0212	1.1028	0.8252	1.4840	1.4358	0.8193	2.2548	1.2980	1.0620	1.4096
5	1.1089	1.3453	1.3035	0.9618	1.2744	0.9626	1.2016	0.8400	1.9034	1.7927	1.0376	2.6140	1.4004	1.1026	1.6434

	1988	1989	1990
1	0.0000	0.1969	0.0000
2	0.8527	0.2200	1.1308
3	1.3277	0.4130	1.1852
4	1.6699	0.7936	0.4525
5	1.3510	0.8889	0.8212

BACKCALCULATED PARTIAL RECRUITMENT

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.01	0.09	0.04	0.03	0.02	0.23	0.01	0.02	0.00	0.03	0.32	0.02	0.11	0.04	0.00	0.00	0.19	0.00
2	0.36	0.51	0.83	0.88	0.44	0.24	0.30	0.40	0.07	0.22	0.63	0.27	0.55	0.66	0.34	0.23	0.13	0.73
3	0.57	0.62	0.94	0.89	1.00	0.95	0.54	0.91	0.36	0.45	1.00	0.57	0.55	0.45	0.77	0.61	0.21	1.00
4	0.79	0.77	1.00	1.00	0.74	1.00	0.76	0.96	0.68	0.71	0.61	0.78	0.84	0.80	0.74	1.00	0.72	0.31
5	1.00	1.00	0.88	0.86	0.78	0.90	1.00	1.00	1.00	1.00	0.82	1.00	1.00	1.00	1.00	0.77	1.00	0.66
6	0.69	0.75	0.99	0.94	0.99	0.99	0.63	0.94	0.48	0.55	0.95	0.76	0.73	0.54	0.81	0.74	0.27	0.66
7	0.69	0.75	0.99	0.94	0.99	0.99	0.63	0.94	0.48	0.55	0.95	0.76	0.73	0.54	0.81	0.74	0.27	0.66

Table 6. (Continued)

MEAN BIOMASS (1000s MT)

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	5.921	8.583	10.657	3.322	2.486	7.451	3.355	2.962	4.635	3.833	1.204	1.583	3.279	1.176	1.666
2 ■	7.830	6.588	6.709	9.019	3.957	3.053	8.710	5.925	6.355	10.776	2.991	0.643	1.542	2.444	1.024
3 ■	9.115	4.523	2.652	2.982	3.738	2.096	2.149	5.615	4.033	4.161	5.839	1.058	0.511	0.932	1.060
4 ■	5.124	4.095	1.360	0.826	1.057	1.108	0.792	1.152	2.011	1.653	1.896	1.161	0.352	0.227	0.389
5 ■	1.887	1.703	1.055	0.440	0.283	0.396	0.300	0.310	0.284	0.429	0.464	0.391	0.212	0.105	0.051
6 ■	1.039	0.576	0.336	0.361	0.139	0.090	0.138	0.113	0.101	0.065	0.089	0.094	0.047	0.064	0.025
7 ■	0.459	0.572	0.230	0.376	0.185	0.066	0.145	0.021	0.003	0.023	0.016	0.030	0.004	0.033	0.039
1+■	31.376	26.641	22.998	17.326	11.845	14.261	15.588	16.097	17.421	20.939	12.499	4.961	5.947	4.982	4.254

■	1988	1989	1990
1 ■	5.027	1.310	0.159
2 ■	1.861	6.223	0.973
3 ■	0.617	1.708	3.260
4 ■	0.249	0.253	1.125
5 ■	0.107	0.058	0.091
6 ■	0.013	0.042	0.016
7 ■	0.016	0.033	0.004
1+■	7.889	9.627	5.627

Summaries for ages 1 1 2 7 3 7 4 7 5 7

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	5.921	8.583	10.657	3.322	2.486	7.451	3.355	2.962	4.635	3.833	1.204	1.583	3.279	1.176	1.666	5.027
2 ■	25.454	18.057	12.341	14.004	9.359	6.809	12.233	13.135	12.787	17.106	11.295	3.378	2.668	3.806	2.588	2.862
3 ■	17.625	11.469	5.632	4.985	5.402	3.756	3.523	7.211	6.432	6.330	8.304	2.735	1.126	1.362	1.564	1.001
4 ■	8.510	6.947	2.981	2.003	1.664	1.660	1.375	1.596	2.399	2.169	2.465	1.676	0.615	0.430	0.504	0.385
5 ■	3.386	2.851	1.621	1.177	0.607	0.552	0.583	0.444	0.388	0.516	0.569	0.515	0.263	0.203	0.115	0.135

■	1989	1990
1 ■	1.310	0.159
2 ■	8.317	5.469
3 ■	2.094	4.495
4 ■	0.386	1.236
5 ■	0.133	0.111

CATCH BIOMASS (1000s MT)

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	0.069	1.089	0.548	0.095	0.065	1.768	0.035	0.043	0.003	0.197	0.472	0.074	0.545	0.063	0.009	0.000
2 ■	3.408	4.856	7.870	8.396	2.484	0.762	3.546	2.031	0.870	4.419	2.322	0.466	1.228	2.075	0.622	0.762
3 ■	6.368	4.093	3.523	2.820	5.316	2.074	1.591	4.373	2.972	3.492	7.206	1.656	0.411	0.535	1.462	0.671
4 ■	4.976	4.596	1.925	0.873	1.112	1.157	0.821	0.945	2.814	2.173	1.419	2.450	0.431	0.235	0.519	0.442
5 ■	2.306	2.471	1.317	0.402	0.315	0.371	0.411	0.264	0.582	0.795	0.468	1.065	0.308	0.136	0.092	0.145
6 ■	0.881	0.629	0.472	0.358	0.196	0.093	0.118	0.091	0.099	0.066	0.105	0.196	0.050	0.045	0.037	0.017
7 ■	0.390	0.625	0.323	0.373	0.261	0.068	0.124	0.017	0.003	0.023	0.018	0.062	0.004	0.023	0.057	0.021
1+■	18.397	18.359	15.977	13.317	9.748	6.292	6.647	7.763	7.343	11.165	12.011	5.968	2.978	3.112	2.798	2.058

■	1989	1990
1 ■	0.258	0.000
2 ■	0.848	0.888
3 ■	0.373	4.080
4 ■	0.193	0.439
5 ■	0.061	0.075
6 ■	0.012	0.013
7 ■	0.010	0.003
1+■	1.754	5.499

Table 6. (Continued)

Summaries for ages 1 1 2 7 3 7 4 7 5 7

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	0.069	1.089	0.548	0.095	0.065	1.768	0.035	0.043	0.003	0.197	0.472	0.074	0.545	0.063	0.009	0.000
2 ■	18.329	17.270	15.429	13.222	9.683	4.524	6.612	7.720	7.340	10.968	11.539	5.894	2.433	3.048	2.789	2.058
3 ■	14.920	12.414	7.559	4.826	7.199	3.762	3.066	5.689	6.470	6.549	9.217	5.428	1.204	0.974	2.167	1.296
4 ■	8.552	8.321	4.037	2.006	1.883	1.688	1.475	1.317	3.498	3.057	2.011	3.772	0.793	0.439	0.705	0.625
5 ■	3.576	3.725	2.111	1.133	0.771	0.532	0.653	0.372	0.684	0.884	0.592	1.323	0.362	0.204	0.186	0.183

■	1989	1990
1 ■	0.258	0.000
2 ■	1.496	5.499
3 ■	0.648	4.611
4 ■	0.276	0.531
5 ■	0.083	0.091

Mean SSB - females (1000s MT)

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1 ■	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 ■	3.445	2.899	2.952	3.968	1.741	1.343	3.832	2.607	2.796	4.741	1.316	0.283	0.679	1.075	0.450	0.819	2.738
3 ■	4.558	2.261	1.326	1.491	1.869	1.048	1.074	2.808	2.016	2.080	2.920	0.529	0.255	0.466	0.530	0.308	0.854
4 ■	2.562	2.048	0.680	0.413	0.528	0.554	0.396	0.576	1.006	0.827	0.948	0.581	0.176	0.114	0.194	0.125	0.126
5 ■	0.944	0.852	0.527	0.220	0.141	0.198	0.150	0.155	0.142	0.214	0.232	0.196	0.106	0.053	0.025	0.053	0.029
6 ■	0.519	0.288	0.168	0.181	0.069	0.045	0.069	0.056	0.050	0.032	0.045	0.047	0.024	0.032	0.013	0.006	0.021
7 ■	0.230	0.286	0.115	0.188	0.093	0.033	0.072	0.010	0.002	0.011	0.008	0.015	0.002	0.017	0.019	0.008	0.017
1+■	12.257	8.633	5.768	6.461	4.442	3.221	5.594	6.212	6.012	7.906	5.468	1.650	1.241	1.756	1.232	1.319	3.785

■	1990
1 ■	0.000
2 ■	0.428
3 ■	1.630
4 ■	0.562
5 ■	0.045
6 ■	0.008
7 ■	0.002
1+■	2.676

MEAN STOCK NUMBERS in millions - GB_2

■	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	29.906	42.917	50.509	17.959	12.621	40.942	24.137	21.461	50.930	17.994	5.600	7.613	13.894	5.026	7.860
2 ■	20.879	17.429	19.731	26.605	10.871	9.059	24.467	16.736	16.336	34.427	10.104	2.679	4.249	7.126	3.029
3 ■	19.645	9.045	5.390	5.471	7.094	4.086	4.650	11.344	8.180	8.544	13.271	2.800	1.027	1.725	2.026
4 ■	9.722	6.725	2.454	1.299	1.667	1.620	1.220	1.756	3.335	2.544	3.139	2.322	0.545	0.342	0.584
5 ■	3.130	2.505	1.707	0.593	0.361	0.499	0.412	0.382	0.402	0.573	0.630	0.610	0.289	0.128	0.075
6 ■	1.508	0.794	0.489	0.444	0.161	0.100	0.165	0.107	0.126	0.062	0.094	0.128	0.058	0.075	0.027
7 ■	0.424	0.572	0.341	0.439	0.181	0.070	0.152	0.017	0.004	0.021	0.015	0.031	0.005	0.033	0.049
1+■	85.215	79.987	80.621	52.810	32.955	56.377	55.204	51.802	79.314	64.164	32.853	16.182	20.066	14.455	13.650

■	1988	1989	1990
1 ■	22.849	5.875	0.752
2 ■	5.301	17.529	2.888
3 ■	1.107	3.145	7.779
4 ■	0.362	0.349	1.913
5 ■	0.125	0.066	0.130
6 ■	0.012	0.041	0.021
7 ■	0.017	0.026	0.003
1+■	29.774	27.031	13.486

Time stamp at end of run 1991 6 5 9 2 31

Table 7. Input Parameters for Yield and Spawning Stock Biomass Per Recruit Calculations for Yellowtail Flounder.

a) Southern New England

Age	F Mort Pattern	Proportion Mature	Average Weights w/Discards	w/out Discards
1	0.06	0.13	0.084	0.263
2	0.47	0.74	0.257	0.302
3	1.0	0.98	0.373	0.372
4	1.0	1.0	0.501	0.478
5	1.0	1.0	0.664	0.668
6	1.0	1.0	0.798	0.798
7+	1.0	1.0	0.941	0.941

Note: Average weights without discards are assumed equal to commercial weight at age for the first 3-5 ages only.

b) Georges Bank

Age	F Mort Pattern	Proportion Mature	Average Weights w/Discards	w/out Discards
1	0.13	0.0	0.112	0.220
2	0.44	0.88	0.362	0.345
3	1.0	1.0	0.577	0.516
4	1.0	1.0	0.666	0.666
5	1.0	1.0	0.730	0.730
6	1.0	1.0	0.860	0.860
7+	1.0	1.0	1.041	1.041

Table 8a

Projections for SNE Yellowtail Flounder

Recruitment	F	Rein.	Land.	Disc.	SSB	F	Rein.	Land.	Disc.	SSB	SSB
	F_{Sq}=1.606	4203	3936	267	2757	F_{Sq}=1.606	1814	1439	375	1487	1390
Low	"	4203	3936	267	2757	$F_{0.1}$=0.218	385	306	79	2226	3490
(8,200)	"	4203	3936	267	2757	$F_{20\%}$=0.493	789	626	163	2050	2820
	"	4303	3945	358	2895	F_{Sq}=1.606	3243	2218	1025	2983	3591
Medium	"	4303	3945	358	2895	$F_{0.1}$=0.218	641	426	215	4151	7983
(22,500)	"	4303	3945	358	2895	$F_{20\%}$=0.493	1335	890	445	3881	6658
	"	4572	3972	600	3266	F_{Sq}=1.606	7080	4310	2770	7001	9502
High	"	4572	3972	600	3266	$F_{0.1}$=0.218	1328	747	581	9322	20049
(60,900)	"	4572	3972	600	3266	$F_{20\%}$=0.493	2801	1598	1203	8798	16966

Table 8b

Projections for Georges Bank Yellowtail Flounder

Recruitment	F	Rein.	Land.	Disc.	SSB	F	Rein.	Land.	Disc.	SSB	SSB
	F_{Sq}=0.821	2395	2256	139	2988	F_{Sq}=0.821	1907	1706	201	3259	4186
Low	"	2395	2256	139	2988	$F_{0.1}$=0.247	692	622	70	3826	6319
(10,600)	"	2395	2256	139	2988	$F_{20\%}$=0.580	1453	1303	150	3484	4946
	"	2531	2292	239	2988	F_{Sq}=0.821	3015	2579	436	5707	8725
Med.	"	2531	2292	239	2988	$F_{0.1}$=0.247	1063	913	150	6547	12667
(23,800)	"	2531	2292	239	2988	$F_{20\%}$=0.580	2272	1946	326	6043	10155
	"	2836	2375	461	2988	F_{Sq}=0.821	5507	4543	964	11218	18936
High	"	2836	2375	461	2988	$F_{0.1}$=0.247	1898	1566	332	12668	26951
(53,500)	"	2836	2375	461	2988	$F_{20\%}$=0.580	4113	3393	720	11803	21877