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Changes in biomass of finfish and squid from the Gulf of Maine to Cape Hatteras 1963-1974, as determined from research vessel survey data

by

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Introduction

Clark and Brown (ICNAF Res.Doc. 75/65, 1975) evaluated changes in biomass of finfish plus squid in ICNAF Subarea 5 and Statistical Area 6 (Fig. 1) from United States RV ALBATROSS IV autumn bottom trawl survey data. Indices of total biomass were computed by multiplying yearly abundance indices for species and species groups by weighting factors derived from their catchability coefficients and summing these products by year. Estimates of catchability coefficients used in that document have since been refined, and additional indices and catchability coefficients have been calculated by transforming original survey data to log (catch + 1) values. Yearly estimates of finfish and squid biomass in SA 5 and 6 have been computed for the 1963-1974 period using both sets of data.

This working paper reviews the methodology used to estimate stratified mean catch per tow indices from ALBATROSS IV research surveys, describes the calculations of the catchability coefficients, and presents current yearly estimates of biomass during the period 1963-1974 for finfish and squid in SA 5 and 6.

Methods

Autumn bottom trawl survey data have been collected by the US National Marine Fisheries Service RV ALBATROSS IV since 1963; the RV DELAWARE II has also participated infrequently. In all of these surveys, both vessels have used the standard "36 Yankee" trawl with a 1.25 cm stretched mesh cod end liner; this trawl measures 10-12 M along the footrope and 2 M in height at the center of the headrope, and is equipped with rollers to make it suitable for use on rough bottom (Edwards, 1968).

The area sampled in these cruises extends from Nova Scotia to Cape Hatteras. The basic sampling design used is the stratified random design as given by Cochran (1953); thus, the survey area has been apportioned into strata (Fig. 1) with boundaries determined primarily on the basis of depth (Grosslein, 1968).

During the 1963-1966 period, only strata from the New Jersey coast northward (1-42, Fig. 1) were sampled; in autumn, 1967, additional strata (61-76, Fig. 1) were added to cover the mid-Atlantic region. An additional section covering part of the Scotian Shelf was also added in 1968 but is not considered in this study.

The field and laboratory procedures followed in the bottom trawl survey program, and the statistical principles involved, have been discussed in detail by Grosslein (1968, 1971) and will only be mentioned briefly here. It should be noted, however, that sampling stations are allocated to strata roughly in proportion to the area of each stratum and are assigned to specific locations within strata at random. In all cases, one 30-minute tow is taken at each station at an average speed of 3.5 knots. After each tow, numbers captured and total weight are recorded for each species. At the completion of each cruise, data are summarized, audited, and transferred to magnetic tape. Thus, a considerable volume of data relative to biomass levels (numbers and weight) is available for evaluation of trends in biomass levels in recent years.

Following procedures given by Cochran (1953, p. 66), the stratified mean catch per tow in terms of numbers or weight is calculated by

$$\bar{y}_{st} = 1/N \sum_h N_h \bar{y}_h$$

where $\bar{y}_{st}$ = stratified mean catch per tow,

N = total area of all strata in the set,

N_h = area of the h^{th} stratum, and

$\bar{y}_h$ = mean catch per haul in the h^{th} stratum.

We used stratified mean weight per tow in preference to numbers as an index of biomass decline due to its convenience when working with different species groups and the high degree of variability in numbers associated with fluctuations in recruitment. Indices were calculated both as stratified mean weight per tow and as log (mean weight per tow + 1) values. Estimates[1] of stratified mean catch per tow in original units were then computed from the relation $E\bar{y}$ = antilog ($\bar{y}$ + 1.1513s^2) (Bliss, 1963), where $E\bar{y}$ represents the expected mean value and $\bar{y}$ and s^2 represent the sample mean and variance in logarithmic units, respectively.

To compensate for catchability differences we developed "catchability coefficients" for the species and species groups in Tables 1-4 for use as weighting factors. To compute these values, annual estimates of stock size (weight at beginning of year i) were required. In the case of silver hake, herring, and mackerel these were available from virtual population analyses in previous assessments (ICNAF 1974, 1975; Anderson, 1975a and b), while annual estimates for haddock and red hake had also been computed in previous studies (Hennemuth, 1969; Anderson, 1974; Clark, 1975) from average weight or mean weight at age data and the relationship

$$C_i = N_i \, F_i/Z_i \, (1-e^{-Z_i}) \qquad (1)$$

[1]For transformed data.

where C_i = landings (number) in year i;

N_i = stock size (number) at the beginning of year i;

F_i = instantaneous rate of fishing mortality in year i, and

Z_i = instantaneous total mortality rate in year i.

In the case of yellowtail, we assumed an F of 1.0 for the southern New England stock in 1967-1968 (M = 0.2 in all cases) based on earlier assessment work (Brown and Hennemuth, 1971), and calculated stock size using (1); 1964-1966 values were assumed to be similar to the 1967-1968 average as commercial abundance indices were stable throughout this period. We then obtained values for succeeding years by adjusting the 1967-1968 average by stock abundance indices based on pre-recruit survey catches (Brown and Hennemuth, 1971; Parrack, 1974). For an estimate of SA 6 stock size, we obtained an average figure for the 1963-1966 period by multiplying average stock size for southern New England by the ratio of mean survey abundance indices between the SA 6 and southern New England stock areas and the ratio of the actual bottom areas considered; the remaining values were obtained using stock abundance values (Parrack, 1974) as above. Values for each stock were then combined by year to permit computation of a combined catchability coefficient for these areas. For the Georges Bank stock, we assumed an F of 0.8 in 1964 and 1965 (Brown and Hennemuth, 1971), calculated stock sizes by (1), and projected stock size values for later years by regressing commercial abundance values for this stock (Brown and Hennemuth, 1971; Parrack, 1974) on time (years) and using the empirical values so obtained to adjust the initial 1964-1965 average. The Cape Cod stock was considered to have been relatively stable in recent years; we computed an average value by assuming an F of 0.8 (similar to Georges Bank) and added the resulting estimate to each Georges Bank stock estimate to permit computation of combined coefficients as above.

Analytical assessments for the remaining species and stocks have yet to be completed and we therefore obtained average stock size estimates from equation (1) using estimates of F and M and historical catch data. In the case of "other finfish" we computed a value for 1967 (chosen to be in the middle of the period) using (1) assuming F = 0.4 and M = 0.2; we then calculated commercial abundance estimates from historical catch data and total effort estimates (adjusted for learning) for SA 5 and 6 (Brown *et al.*, 1975) and predicted stock size from a regression of these abundance indices against time, as above. We then computed "catchability coefficients" for each species or species group in Tables 1 through 4 (and in the case of silver hake, red hake, yellowtail, and herring, for each individual stock for which TAC's are established [ICNAF, 1975]) by dividing both untransformed and transformed estimates of stratified mean catch per tow values in year i by stock size at the beginning of year i + 1 (or by the computed average stock size value). For species for which catchability coefficients had been calculated for individual stocks (herring, silver and red hake, and yellowtail) analyses of variance revealed differences (P<.10) in the computed coefficients between stocks in all cases. We therefore considered individual stocks separately in computing biomass declines.

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For each of the sets of catchability coefficients obtained above, deviations from the arithmetic mean were plotted against time; in cases in which trends appeared to exist, linear regressions were fitted to the data to evaluate the degree of relationship. In the case of haddock, a significant ($P<0.01$) negative trend was obtained for both untransformed and transformed data, which could have resulted from: 1) underestimates of stock size in later years, or 2) actual differences in catchability associated with changing availability as stock size decreased. A plot of numbers captured per tow by year during the period of study suggested that actual differences in catchability may have occurred; accordingly, we divided the period into two units (1963-1968 and 1969-1974) for the purpose of calculating weighting factors. The dividing line was arbitrarily taken as the point in which the percentage of tows containing five haddock or less reached 90%.

After obtaining the desired sets of catchability coefficients for the species and stocks described above, we obtained weighting coefficients by calculating the arithmetic means for both transformed and untransformed data

$$\frac{\sum_{i=1,n}^{i} \frac{C_i}{S_{i+1}}}{n}$$

where C_i represents stratified mean catch per tow in year i, S_{i+1} represents stock size in year$_{i+1}$ (note that year$_{i+1}$ was used here as surveys were taken in autumn of year i), and n = number of years. Results are presented in Tables 5 and 6. Estimates of finfish and squid biomass for SA 5 and 6 were then obtained by dividing yearly abundance indices for the species and species groups in Tables 1-4 by their respective weighting coefficients (note that we obtained values by stock in the case of yellowtail, silver and red hake, and herring) and summing over all species by year.

Results and Discussion

Estimates of finfish and squid biomass for SA 5 and 6 as described under Methods are given in Tables 7 and 8. Downward trends are evident in all sets examined; for the data of Table 7 (1967-1974, middle Atlantic, southern New England, Georges Bank, and Gulf of Maine strata, Fig. 1) comparisons between averages for "all data" for 1967-1968 and 1973-1974 reveal a 67% decline for both linear and retransformed values, while for "herring and mackerel excluded data" the corresponding figures were 18% and 21%, respectively. For the data of Table 8 (1963-1974, southern New England, Georges Bank, and Gulf of Maine strata, Fig. 1) comparisons between averages for "all data" for 1963-1965 and 1972-1974 reveal declines of 47% and 46% for linear and retransformed values, respectively, while for values in which herring and mackerel were excluded the corresponding values were 32% and 35%. By combining the data of Tables 7 and 8 (Figs. 2 and 3) and taking averages for 1963-1965 and 1972-1974, declines of 51% and 36% are obtained for all data and data for herring and mackerel excluded (linear scale, Fig. 2), while for retransformed values the corresponding figures are 44% and 43% (Fig. 3).

To examine short-term changes in abundance, linear regressions of biomass against time were calculated for each successive three-year period, *i.e.* 1963-1965, 1964-1966, . . . 1972-1974, for the data in Figs. 2 and 3 (Table 9). The yearly ratio of change was estimated from the difference between the expected values estimated at successive midpoints in these regressions (these values are equivalent to that obtained by moving averages of three of x-1, x, x+1) except for 1963 and 1974 when the expected values were estimated by the first and last regressions, respectively. Values with mackerel and herring catches excluded decline rapidly in the first part of the period, but tend to level off in the latter 1960's. However, a 21-22% decline occurred between 1973 and 1974. When mackerel and herring are included (all data), biomass increased in the early 1960's, but declined rapidly in the latter 1960's. The pattern of changes is erratic during this period for linear values, giving major declines between certain years and minimum declines between others. The retransformed values are more consistent, showing large declines (18-29% per year) in the period 1968-1970, with lesser declines (2-13%) from 1971-1973. In both cases, however, the rate of decline increased in 1974, being 28% for the linear data and 33% for the retransformed data, respectively.

The overall estimates of average percent decline per year ranged from 4.8-5.9% for all species combined, and 6.0-6.5% for data excluding herring and mackerel. A 6% decline per year is equivalent to a total decline of 49% for the period 1963-1974.

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Table 1. Stratified mean catch per tow (kg) for selected species of finfish and squid, ALBATROSS IV autumn bottom trawl survey data, 1967-1974, Middle Atlantic, southern New England, Georges Bank, and Gulf of Maine (strata 61-76, 1-30, and 36-40).

Species	Year							
	1967	1968	1969	1970	1971	1972	1973	1974
Cod	4.5	5.0	4.4	5.1	4.6	6.4	6.4	2.9
Haddock	8.1	5.8	3.8	4.0	2.4	2.2	3.3	1.3
Redfish	8.2	13.6	7.9	11.1	7.9	8.3	5.7	7.7
Silver hake	2.3	2.5	1.8	2.0	2.4	3.6	2.6	1.9
Red hake	1.0	1.6	1.8	1.3	1.7	2.6	1.6	0.7
Pollock	1.2	1.9	4.2	1.2	2.2	2.7	2.1	1.8
Yellowtail	4.8	5.6	5.2	4.2	2.9	7.9	1.6	1.0
Other flounder	4.6	5.4	5.1	5.1	3.5	4.3	4.2	3.5
Herring	0.3	0.1	0.1	0.0[1]	0.3	0.1	0.0[1]	0.0[1]
Mackerel	0.3	0.2	1.1	0.0[1]	0.0[1]	0.1	0.0[1]	0.0[1]
Other finfish[2]	81.3	47.2	89.2	49.4	33.6	43.4	54.5	27.4
Short-finned squid	0.2	0.3	0.1	0.3	0.4	0.3	0.3	0.4
Long-finned squid	2.8	5.1	6.8	2.2	2.1	4.6	7.6	5.8
Total finfish and squid	119.6	94.3	131.5	85.9	64.0	86.5	89.9	54.4

[1]Less than 0.05.
[2]Does not include data for tunas, sharks, swordfish, American eel, or white perch.

Table 2. Stratified mean catch per tow (retransformed, kg)[1] for selected species of finfish and squid, ALBATROSS IV autumn bottom trawl survey data, 1967-1974, Middle Atlantic, southern New England, Georges Bank, and Gulf of Maine (strata 61-76, 1-30, and 36-40).

Species	Year							
	1967	1968	1969	1970	1971	1972	1973	1974
Cod	0.8	0.6	0.6	0.7	0.5	0.8	0.6	0.4
Haddock	1.2	0.8	0.6	0.6	0.4	0.4	0.4	0.2
Redfish	0.7	0.7	0.7	0.8	0.7	0.8	0.7	0.6
Silver hake	0.8	0.9	0.7	0.7	0.8	1.2	1.0	0.6
Red hake	0.3	0.4	0.4	0.3	0.5	0.6	0.3	0.2
Yellowtail	0.9	0.8	0.8	0.6	0.5	0.5	0.2	0.2
Other flounder	1.8	2.2	1.9	1.7	1.5	1.8	1.7	1.5
Pollock	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.1
Herring	0.1	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]
Mackerel	0.1	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]
Other finfish[3]	18.7	18.9	19.0	15.6	11.5	18.6	19.7	11.2
Short-finned squid	0.1	0.1	0.0[2]	0.1	0.2	0.1	0.3	0.1
Long-finned squid	0.5	0.9	1.1	0.6	0.5	0.8	1.8	1.4

[1]Individual values computed according to the relation $E\overline{y}$ = antilog $(\overline{y} + 1.1513s^2)$ where $\overline{y}$ and s^2 represent the stratified mean catch per tow and its variance, respectively, on the transformed scale.
[2]Less than 0.05.
[3]Does not include data for tunas, sharks, swordfish, American eel, or white perch.

Table 3. Stratified mean catch per tow (kg) for selected species of finfish and squid, ALBATROSS IV autumn bottom trawl survey data, 1963-1974, southern New England, Georges Bank, and Gulf of Maine areas (strata 1-30 and 36-40).

Species	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Cod	8.5	7.6	5.6	4.8	5.7	6.4	5.6	6.4	5.7	8.1	8.0	3.6
Haddock	31.6	31.2	22.9	10.5	10.2	7.4	4.7	5.1	3.1	2.8	4.2	1.6
Redfish	10.3	23.1	5.8	12.4	10.4	17.1	10.0	14.0	10.0	10.5	7.2	10.0
Silver hake	13.8	4.1	6.1	3.3	2.7	2.9	2.2	2.4	2.9	4.4	3.2	2.4
Red hake	6.7	2.3	2.7	1.6	1.2	1.8	2.1	1.6	2.0	3.2	2.0	0.8
Pollock	4.1	3.6	1.9	1.8	1.5	2.3	5.3	1.5	2.7	3.4	2.7	2.2
Yellowtail	6.6	6.5	4.5	3.2	5.2	5.6	5.6	5.3	3.6	9.8	2.1	1.2
Other flounder	8.8	6.1	6.7	9.2	4.6	5.6	5.8	6.3	4.0	5.1	4.8	4.0
Herring	1.0	0.1	0.5	1.2	0.4	0.1	0.1	0.1	0.3	0.1	0.0[1]	0.1
Mackerel	0.0[1]	0.0[1]	0.1	0.1	0.4	0.2	1.4	0.1	0.1	0.2	0.1	0.1
Other finfish	75.8	89.7	62.5	63.3	50.4	45.9	97.5	55.7	33.7	49.5	60.0	30.6
Short-finned squid	-[3]	0.0[1,4]	0.1[4]	0.1[4]	0.2	0.4	0.1	0.3	0.4	0.3	0.4	0.5
Long-finned squid	-[3]	0.5[4]	0.8[4]	1.0[4]	0.8	4.0	6.2	1.5	2.0	2.5	6.7	4.5
Total finfish and squid	167.2	174.8	120.2	112.5	93.7	99.7	146.6	100.3	70.5	99.9	101.4	61.6

[1]Less than 0.05.
[2]Does not include data for tunas, sharks, swordfish, American eel, or white perch.
[3]Data not recorded.
[4]Squid catches for 1964-1966 prorated by species according to relative percentages caught in later years.

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Table 4. Stratified mean catch per tow (retransformed, kg)[1] for selected species of finfish and squid, ALBATROSS IV autumn bottom trawl survey data, 1967-1974, Middle Atlantic, southern New England, Georges Bank, and Gulf of Maine (strata 1-30 and 36-40).

Species	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
						Year						
Cod	1.1	0.7	0.8	0.7	1.2	0.9	0.8	1.0	0.7	1.1	0.9	0.6
Haddock	5.6	4.3	3.4	1.7	1.9	1.1	0.8	0.8	0.5	0.5	0.5	0.3
Redfish	1.0	0.8	0.7	1.2	1.0	1.1	1.0	1.2	1.1	1.1	1.0	0.9
Silver hake	3.4	1.8	2.4	1.4	0.9	1.1	0.9	0.9	1.2	1.7	1.4	0.9
Red hake	1.6	0.7	0.8	0.6	0.4	0.4	0.5	0.4	0.6	0.7	0.5	0.2
Yellowtail	1.2	0.8	0.7	0.7	1.0	0.9	0.9	0.8	0.6	0.6	0.3	0.3
Other flounder	4.1	3.0	3.4	4.8	1.9	2.4	2.2	2.4	1.8	2.3	2.0	1.8
Pollock	0.6	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.4	0.4	0.2
Herring	0.3	0.0[2]	0.2	0.3	0.1	0.1	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]
Mackerel	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.1	0.0[2]	0.1	0.0[2]	0.0[2]	0.0[2]	0.0[2]	0.0[2]
Other finfish[3]	41.6	26.3	25.8	35.0	17.1	20.3	20.9	22.7	13.5	23.1	22.5	13.6
Short-finned squid	-[4]	0.0[2,5]	0.0[2,5]	0.1[5]	0.1	0.2	0.0[2]	0.1	0.1	0.1	0.2	0.1
Long-finned squid	-[4]	0.1[5]	0.2[5]	0.3[5]	0.2	0.5	0.8	0.4	0.4	0.4	1.3	1.0

[1]Individual values computed according to the relation $E\overline{y} = \text{antilog}(\overline{y} + 1.1513s^2)$ where $\overline{y}$ and s^2 represent the stratified mean catch per tow and its variance, respectively, on the transformed scale.
[2]Less than 0.05.
[3]Does not include data for tunas, sharks, swordfish, American eel, or white perch.
[4]Data not recorded.
[5]Data for 1964-1966 prorated according to species composition of the catch in later years.

Table 5. Weighting coefficients calculated by stock from linear and transformed data, 1967-1974, Middle Atlantic, southern New England, Georges Bank, and Gulf of Maine area (strata 61-76, 1-30, and 36-40).

Species and Stock[2]	Linear Scale		Logarithmic[1] Scale	
	Weighting Coefficient[3]	Coefficient[4] of Variation	Weighting Coefficient[3]	Coefficient[4] of Variation
Cod	4.26	0.23	0.55	0.23
Haddock[5]	7.03, 5.01	0.05, 0.37	0.98, 0.74	0.04, 0.41
Redfish	13.30	0.27	1.09	0.07
Silver hake				
5Y	8.72	0.80	4.45	>1.00
5Ze	0.73	0.29	0.66	0.80
5Zw-6	1.35	0.29	0.45	0.38
Red hake				
5Ze	6.65	0.65	2.45	0.76
5Zw-6	2.35	0.73	0.49	0.69
Pollock	3.42	0.28	0.42	0.33
Yellowtail				
5Ze	15.46	0.24	3.63	0.19
5Zw-6	21.18	0.82	2.64	0.23
Other flounders	11.10	0.18	4.37	0.12
Herring				
5Y	0.13	>1.00	0.02	0.57
5Z-6	0.01	>1.00	0.00[6]	0.69
Mackerel	0.02	>1.00	0.00[6]	0.53
Other finfish	12.81	0.32	4.12	0.23
Short-finned squid	0.30	0.36	0.12	0.33
Long-finned squid	5.25	0.46	1.09	0.51

[1]Expected stratified mean catch per tow values computed from transformed data according to the relation $E\bar{y} = \text{antilog}\,(\bar{y} + 1.1513s^2)$, where $\bar{y}$ and s^2 represent the mean and variance, respectively, on the transformed scale.

[2]Weighting coefficients calculated by individual stock for silver hake, red hake, yellowtail, and herring.

[3]Weighting coefficients calculated as $\dfrac{\sum_{i}^{i=1,n} C_i/S_{i+1}}{n}$ where C_i = stratified mean catch per tow in year$_i$ and S_{i+1} = stock size at the beginning of the following year. All values x 10^8.

[4]Coefficient of variation calculated over all years.

[5]Weighting coefficients computed separately for 1967-1968 and 1969-1974 data due to apparent changes in catchability.

[6]Less than 0.005.

Table 6. Weighting coefficients calculated by stock from linear and transformed data, southern New England, Georges Bank, and Gulf of Maine area (strata 1-30 and 36-40).

Species and Stock[2]	Linear Scale Weighting Coefficient[3]	Linear Scale Coefficient[4] of Variation	Logarithmic[1] Scale Weighting Coefficient[3]	Logarithmic[1] Scale Coefficient[4] of Variation
Cod	5.49	0.22	0.71	0.33
Haddock[5]	10.67, 6.31	0.33, 0.38	1.72, 0.89	0.37, 0.53
Redfish	17.66	0.40	1.53	0.15
Silver hake				
5Y	7.95	0.79	3.69	>1.00
5Ze	0.82	0.49	0.33	0.32
5Zw-6	2.14	0.30	1.00	0.44
Red hake				
5Ze	6.56	0.69	2.22	0.74
5Zw-6	3.44	0.73	1.02	0.57
Pollock	5.15	0.42	0.64	0.36
Yellowtail				
5Ze	15.44	0.29	3.73	0.32
5Zw-6	28.50	>1.00	5.43	0.51
Other flounders	12.70	0.22	5.69	0.27
Herring				
5Y	0.18	>1.00	0.05	>1.00
5Z-6	0.03	>1.00	0.01	1.00
Mackerel	0.01	>1.00	0.00[6]	0.59
Other finfish	12.56	0.31	4.93	0.24
Short-finned squid	0.26	0.62	0.10	0.60
Long-finned squid	3.13	0.81	0.57	0.73

[1]Expected stratified mean catch per tow values computed from transformed data according to the relation $E\bar{y} = \text{antilog}\,(\bar{y} + 1.1513s^2)$, where $\bar{y}$ and s^2 represent the mean and variance, respectively, on the transformed scale.

[2]Weighting coefficients calculated by individual stock for silver hake, red hake, yellowtail, and herring.

[3]Weighting coefficients calculated as $\dfrac{\sum_{i}^{i=1,n} C_i/S_{i+1}}{n}$ where C_i = stratified mean catch per tow in year_i and S_{i+1} = stock size at the beginning of the following year. All values x 10^8.

[4]Coefficient of variation calculated over all years.

[5]Weighting coefficients computed separately for 1963-1968 and 1969-1974 data due to apparent changes in catchability.

[6]Less than 0.005.

Table 7. Stock size estimates[1] (MT x 10^{-3}) for Subarea 5 and Statistical Area 6, 1967-1974, Middle Atlantic, southern New England, Georges Bank, and Gulf of Maine area (strata 61-76, 1-30, and 36-40).

	Computed by: Linear Weighting Coefficients		Computed by: Retransformed Weighting Coefficients	
Year	All Data	Data for herring & mackerel excluded	All Data	Data for herring & mackerel excluded
1967	7517.4	1650.2	8246.8	1488.2
1968	3782.5	1745.9	5387.3	1690.5
1969	9555.4	1825.7	4441.1	1402.1
1970	2035.7	1499.1	2915.7	1350.8
1971	3121.6	1301.8	3086.7	1227.0
1972	2998.7	1755.9	3612.0	1548.1
1973	1947.7	1698.7	2701.1	1521.8
1974	1730.9	1079.6	1822.5	983.4

[1]Individual values represent cumulative sums computed by multiplying stratified mean catch per tow (MT) for each species or species group in Tables 1 and 3 by the reciprocal of its weighting coefficient (Table 5) and summing these values by year. (Individual stock estimates were computed for silver and red hake, yellowtail, and herring.)

Table 8. Stock size estimates[1] (MT x 10^{-3}) for Subarea 5 and Statistical Area 6, 1963-1974, southern New England, Georges Bank, and Gulf of Maine area (strata 1-30 and 36-40).

	Computed by Linear Weighting Coefficients		Computed by Retransformed Weighting Coefficients	
Year	All Data	Data for herring & mackerel excluded	All Data	Data for herring & mackerel excluded
1963	6214.7	2962.4	6444.6	2918.9
1964	2613.1	2212.6	2447.6	1934.5
1965	4863.9	1917.8	5511.6	2277.9
1966	8167.4	1553.1	8728.5	2003.1
1967	5994.7	1366.2	6682.3	1462.8
1968	3356.6	1751.3	4184.4	1813.9
1969	11416.9	1935.0	3894.5	1534.0
1970	2103.3	1572.6	2935.6	1665.6
1971	2584.6	1297.7	2723.8	1416.1
1972	3106.2	1842.0	3330.7	1744.1
1973	2209.5	1848.4	2803.2	1753.1
1974	1905.5	1166.1	1700.5	1137.6

[1]Individual values represent cumulative sums computed by multiplying stratified mean catch per tow (MT) for each species or species group in Tables 2 and 4 by the reciprocal of its weighting coefficient (Table 6) and summing resulting values by year. (Individual stock estimates were computed for silver and red hake, yellowtail, and herring.)

Table 9. Yearly rate of change in finfish and squid biomass in ICNAF SA 5 and 6.

	Linear values						Retransformed values					
	All data			Data for herring and mackerel excluded			All data			Data for herring and mackerel excluded		
Year at midpoint	Predicted[1] stock size MT x 10^3	Slope[2]	%[3] change	Predicted[1] stock size MT x 10^3	Slope[2]	%[3] change	Predicted[1] stock size MT x 10^3	Slope[2]	%[3] change	Predicted[1] stock size MT x 10^3	Slope[2]	%[3] change
1963	5240			2886			5268			2698		
1964	4564	- 676	-13	2364	- 522	-18	4802	- 467	-09	2377	- 321	-12
1965	5215	2777	+14	1895	- 330	-20	5563	3141	+16	2072	34	-13
1966	6849	1327	+31	1707	- 134	-10	7496	1368	+35	1923	- 395	-07
1967	6489	-2192	-05	1650	97	-03	7454	-1671	-01	1727	- 156	-10
1968	6952	1019	+07	1741	88	+06	6025	-1903	-19	1527	- 43	-12
1969	5125	- 874	-26	1690	- 124	-03	4248	-1236	-29	1431	- 170	-03
1970	4904	-3217	-04	1542	- 262	-09	3481	- 677	-18	1327	- 88	-10
1971	2719	482	-45	1519	129	-02	3205	348	-03	1375	99	+04
1972	2590	- 587	-01	1586	199	+04	3133	- 193	-02	1432	143	+04
1973	2226	- 634	-17	1512	- 338	-05	2712	- 894	-13	1351	- 283	-05
1974	1592		-28	1174		-22	1818		-33	1069		-21
	(1731)[4]		$\bar{x}$=-5.9	(1080)[4]		$\bar{x}$=-6.0	(1823)[4]		$\bar{x}$=-4.8	(983)[4]		$\bar{x}$=-6.5

[1]Calculated from $\hat{Y}_{ij} = a+bx_{ij}$ where i = year. The subscript i assumes values of 1, 2, and 3 for x within each j^{th} repetitive grouping of three year periods, i.e. 1963-1965, 1964-1966, . . . 1972-1974. Stock size is predicted from the fitted line for the year indicated.

[2]Equivalent to b for the regression in which the year indicated is the midpoint.

[3]$\hat{Y}_{2,J} - \hat{Y}_{2,J-1}$ except for 1963 where value is $\hat{Y}_{1,1} - \hat{Y}_{2,1}$ and for 1974 where value is $\hat{Y}_{2,10} - \hat{Y}_{3,10}$.

[4]Observed value.

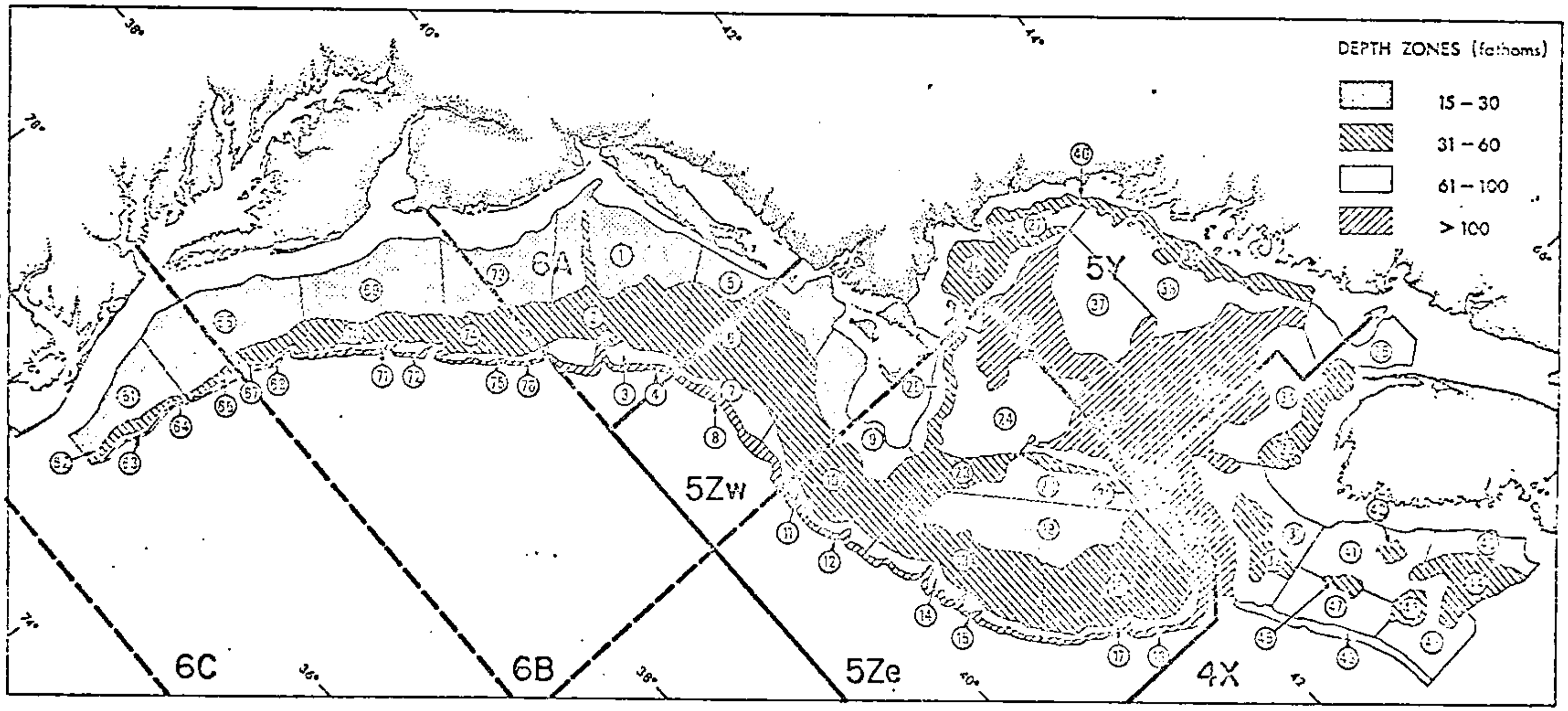

Figure 1. Northwest Atlantic area delineated into strata (by depth zones) with ICNAF division boundaries superimposed.

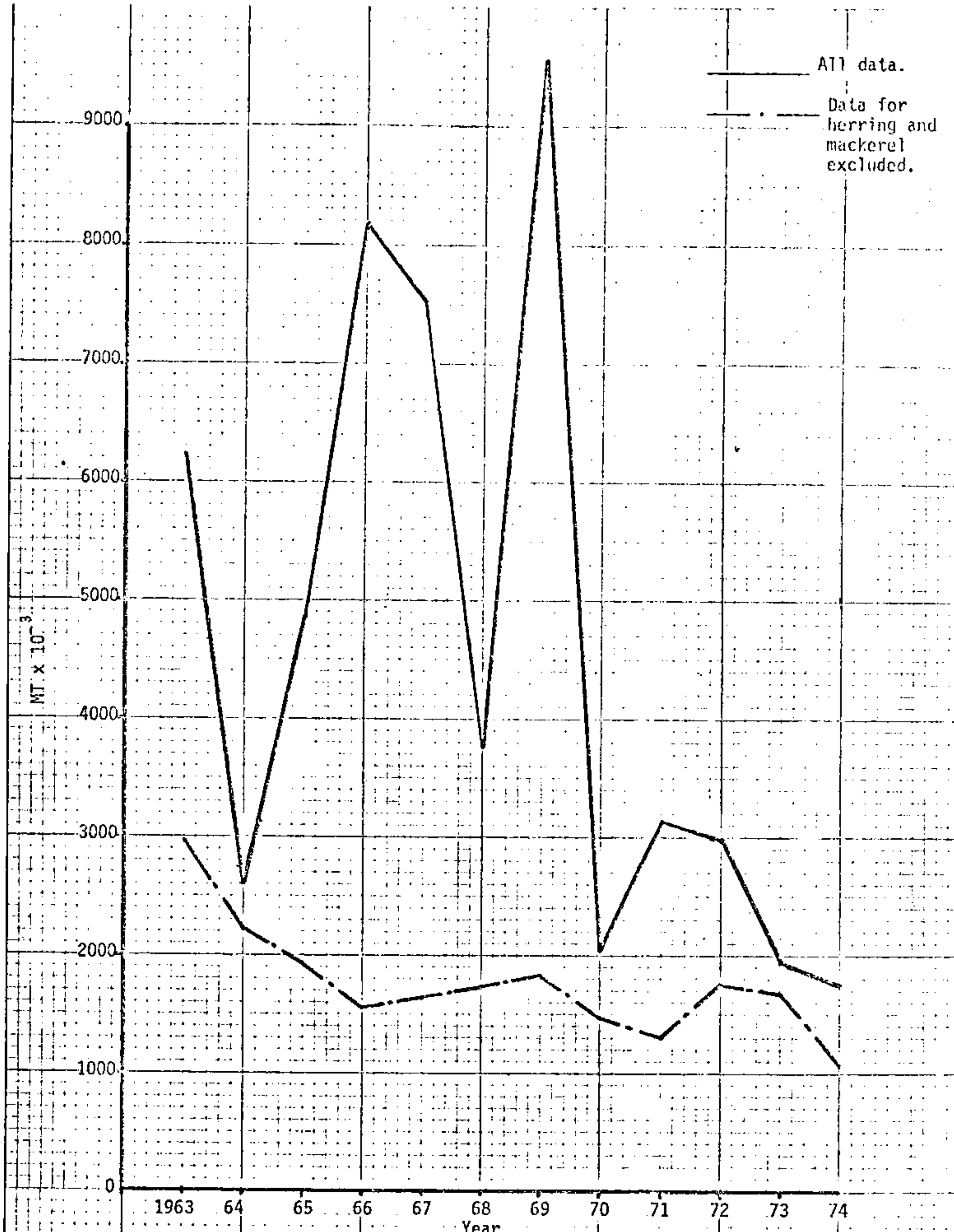

Figure 2. Estimated fishable biomass by year, Subarea 5 and Statistical Area 6, linear data. Curves were plotted by combining stock size estimates for 1963-1966 (Table 8) with stock size estimates for 1967-1974 (Table 7).

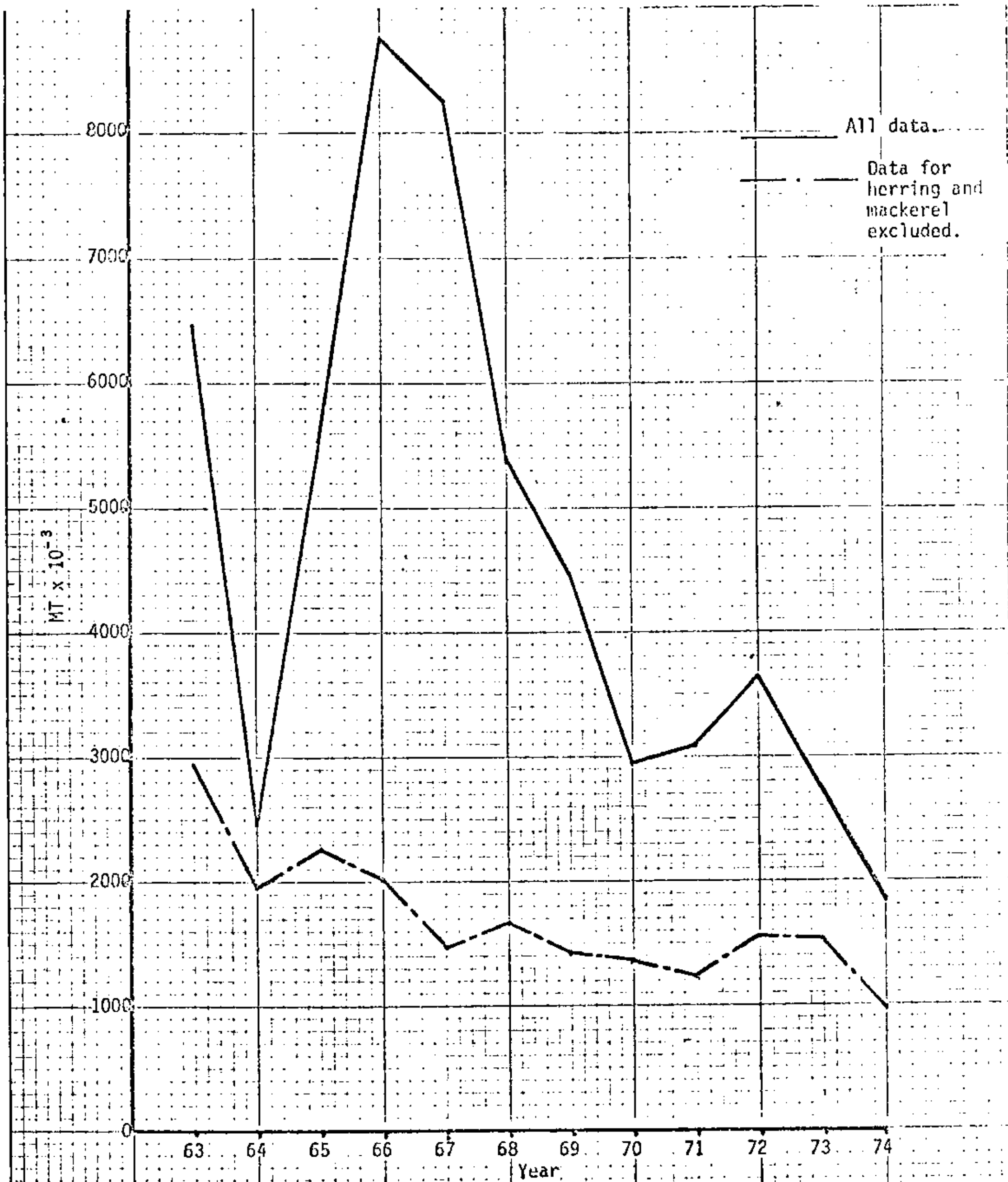

Figure 3. Estimated fishable biomass by year, Subarea 5 and Statistical Area 6, retransformed data. Curves were plotted by combining stock size estimates for 1963-1966 (Table 8) with stock size estimates for 1967-1974 (Table 7).