International Commission for the Northwest Atlantic Fisheries

Serial No. 3527
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ICNAF Res.Doc. 75/48
Corrigendum

ANNUAL MEETING - JUNE 1975

Current status of the Georges Bank (5Ze) haddock stock

by

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Page 4, line 11: Please correct values for equation to read as follows:

to estimate $\log_e N_o$, where

N_t = $\log_e$ stratified mean number/tow at age t

$$\overline{N}_t = \frac{\sum_1^m N_t}{m}$$

t = time in months from age 0

$$\overline{t} = \frac{\sum_1^m t}{m}$$

m = number of observations (survey cruises) and

Z = total mortality coefficient (0.058 on a monthly basis)

(only data for $t \geqslant 19$ months were used to allow for recruitment to the survey trawl)

Page 4, 6th line from bottom: equation should read as follows:

$$\log_e N_t = \log_e N_o - Zt$$

Page 5, 2nd paragraph below table, line 7: The sentence "It is likely, however,......discards." should read as follows:
"It is likely, however, that commercial data for these year-classes have been biased by unrecorded discards."

Page 7, 2nd paragraph of Conclusions and recommendations: This sentence "In conclusion, it is evident.......recover." should read as follows:
"In conclusion, it is evident that no additional fishing should be allowed on this stock and that efforts should be made to reduce F to the lowest possible level if the stock is to recover."

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Current status of the Georges Bank (5Ze[1]) haddock stock

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Introduction

This document reviews recent trends in the Georges Bank (5Ze) haddock fishery. This stock has been recognized as being distinct from the Browns Bank stock (Needler, 1930; Hennemuth *et al.*, 1964; Halliday, 1974) and from two other groups in the 5Y-5Zw area (Grosslein, 1962; Hennemuth, 1969) and is therefore considered as an independent unit in this report. The 5Ze stock has contributed the bulk of all haddock landings from Subarea 5 in recent years; landings from 5Y-5Zw have been relatively small in comparison.

The Georges Bank haddock fishery appears to have been relatively stable during the 1935-1964 period, with landings averaging approximately 47,000 MT annually (Hennemuth, 1969). In 1965 and 1966, however, a considerable increase in fishing effort occurred, due in large measure to recruitment of the outstanding 1963 year-class. This resulted in sharp declines in stock abundance and productivity. Reduced landings during the late 1960's led to attempts by the Commission to reduce fishing mortality by limiting catch; this has been undertaken primarily by establishing quotas although designated areas with relatively high spawning concentrations have also been closed in spring (March, April, and May) beginning in 1970. Continued declines in stock abundance led to the establishment of progressively lower quotas for Subarea 5 (12,000 MT in 1970 and 1971, and 6,000 MT in 1972 and 1973). In 1974 the TAC for Subarea 5 was set at 0, with only incidental catches being allowed. This was intended to keep total catch as low as possible. A TAC of 6,000 MT is in effect for 1975.

Trends in commercial and survey data

Recent catch and effort statistics for the 5Ze haddock stock reflect the Commissions's measures in that effort appears to have declined considerably in recent years (Table 1). On the other hand, available data do not indicate any significant degree of stock recovery, as commercial abundance indices for the US fleet (MT/standard day fished, using US trawlers 216-310 gt as standard) declined from 4.6 in 1967 to 0.8 in 1974 (Table 2). The more recent of these indices (and particularly the 1974 index) are undoubtedly biased downward due to quota limitations, but the observed trend is still believed to reflect trends in stock abundance with reasonable accuracy. Similarly, *Albatross IV* fall survey indices (stratified mean number/tow, Georges Bank strata 13-25, 29 and 30) indicate a decline to a very depressed state. It is therefore evident that 5Ze haddock stock abundance continues at a very low level and that every possible effort should be made to limit fishing mortality.

1/ Subarea 5Z has been divided into Divisions 5Ze and 5Zw since 1968.

Table 1. Catch and effort statistics for Georges Bank (5Ze) haddock, 1967-1973.

Year	US	Landings[1/] Foreign	Total	Total[2/] No. Landed	Effort[3/]
1967	34,728	16,730	51,458	40	11,215
1968	25,197	14,619	39,816	25	11,337
1969	16,443	5,704	22,147	11	7,856
1970	8,400	2,874	11,274	5	5,449
1971	7,301	3,404	10,705	5	5,456
1972	3,866	1,853	5,719	2	2,835
1973	2,776	2,526	5,302	3	4,859
1974[4]	2,317	2,373	4,690	3	6,131

1/ MT, round, fresh as reported for Subarea 5Z-5Ze, ICNAF statistical data.

2/ Millions of fish, computed on the basis of average weight/fish in US landings.

3/ US standard days, using US trawlers of 216-310 gt as standard (adjusted to eliminate effects of closed area and seasons).

4/ All 1974 figures include preliminary landings data for the United States, Canada and the United Kingdom and estimated landings for other nations.

Table 2. Survey and commercial indices of abundance for Georges Bank (5Ze) haddock, 1967-1974, all age classes combined.

Year	Survey Index[1/]	Commercial Index[2/]
1963-1965 average	98.4 (3.36)	5.1
1967	11.9 (1.55)	4.6
1968	5.1 (0.84)	3.5
1969	2.3 (0.73)	2.8
1970	5.2 (0.74)	2.1
1971	2.8 (0.76)	2.0
1972	7.6 (1.23)	2.0
1973	10.0 (0.80)	1.1
1974	2.7 (0.62)	0.8

1/ Stratified mean /number tow, *Albatross IV* fall survey data, strata 13-25, 29 and 30. (Mean ln(x+1) values in parentheses).

2/ Metric tons /standard day fished, using US trawlers 216-310 gt as standard. Standardization calculations were adjusted to eliminate effects of closed areas and seasons.

Age composition of landings

The distribution of numbers of haddock landed at age for the Georges Bank (5Ze) stock is given in Table 3; similar information is given graphically in terms of landings per day in Figure 1. Both sets of data indicate that the strong 1962 and 1963 year-classes have virtually disappeared. These year-classes contributed approximately 75% of the total landings (by weight) for this stock during the 1967-1970 period, but more recently yield from these two -year-classes has declined sharply (to approximately 24% of the total weight landed in both 1973 and 1974). On the other hand, age 1 and 2 fish contributed fully 38% of the total number landed during the 1971-1974 period, up substantially from earlier years in which this figure averaged less than 10%. As mean length and weight at age data for 5Ze haddock indicate a substantial increase in growth rates in recent years (Tables 4 and 5), it appears that this change is the result of a reduction in age at recruitment - a disturbing trend considering the obvious decline in the older elements of the stock. The data of Table 3 and Figure 1 also fail to indicate any significant degree of recruitment from year-classes produced since 1966 in comparison to earlier years.

Table 3. Numbers of Georges Bank (5Ze) haddock ($X10^{-3}$) landed at age by the US commercial fleet, 1967-1974.

Year	1	2	3	4	Age in years 5	6	7	8	9+
1967	301	104	1985	14139	6901	784	652	607	424
1968	-	1800	444	1229	9087	2162	414	269	487
1969	1	6	1292	335	491	4422	1155	166	381
1970	13	71	13	458	146	163	1733	575	355
1971	-	865	145	29	194	174	206	952	628
1972	84	-	309	58	23	81	58	48	800
1973	186	916	3	211	30	16	44	11	298
1974	2	942	327	1	42	2	1	35	137

The above data indicate changes in stock structure which have serious implications relative to stock and recruitment. Hennemuth (1969) was unable to demonstrate a definite relationship between abundance and recruitment for this stock, but the bulk of his observations were made over a period in which stock abundance was relatively stable. Studies on certain other gadoid stocks have, however, demonstrated a tendency for reduced recruitment at low levels of stock abundance (Garrod 1966, 1968) and the fact that all year-classes since 1963 have been weak is certainly suggestive of a similar tendency for 5Ze haddock. In any event, future prospects hardly appear encouraging in view of the obvious decline occurring in the older elements of the stock and the increasing tendency for recruitment at an earlier age (Table 3, Figure 1).

Table 4. Mean length at age (cm) of Georges Bank (5Ze) haddock in U.S. commercial landings, 1964-1974.

Year	1	2	3	4	5	Age in years 6	7	8	9	10	11	12
1964	34.50	41.82	47.18	51.59	54.69	58.58	62.58	65.32	68.75	66.11	73.14	77.22
1965	-	39.40	45.90	51.51	55.34	59.44	62.14	65.87	69.26			
1966	-	38.16	43.77	50.09	56.37	60.26	62.46	66.80	68.83			
1967	39.44	38.51	44.90	48.66	52.76	59.60	61.63	65.40	69.23			
1968	-	43.48	47.42	50.71	53.30	58.29	63.22	65.95	70.07			
1969	34.50	41.61	51.10	54.28	55.98	57.67	62.36	65.82	69.91	71.80	73.12	69.87
1970	39.83	46.00	47.60	55.96	57.84	59.26	61.42	66.09	66.70	71.14	70.55	73.91
1971	-	44.39	48.36	53.27	60.09	63.23	64.93	65.89	68.59	71.65	72.43	73.75
1972	37.75	-	54.17	55.72	59.64	65.65	64.90	66.53	68.17	70.10	71.88	73.90
1973	37.29	45.16	52.50	59.41	62.76	63.58	67.53	71.93	68.89	69.85	76.06	76.73
1974	39.99	45.12	54.34	68.50	65.74	69.50	72.50	70.82	-	73.79	73.74	77.15

Table 5. Mean weight at age (kg, round, fresh) of Georges Bank (5Ze) haddock in U.S. commercial landings, 1964-1974.

Year	1	2	3	4	5	Age in years 6	7	8	9	10	11	12
1964	.49	.87	1.26	1.67	1.99	2.46	3.00	3.42	4.02	3.56	4.85	5.73
1965	-	.73	1.16	1.65	2.06	2.56	2.94	3.52	4.11			
1966	-	.66	1.00	1.52	2.18	2.68	3.00	3.67	4.03			
1967	.73	.68	1.09	1.39	1.78	2.59	2.87	3.44	4.10			
1968	-	.98	1.28	1.58	1.84	2.42	3.10	3.53	4.25			
1969	.49	.86	1.61	1.94	2.14	2.34	2.97	3.51	4.22	4.58	4.85	4.21
1970	.75	1.17	1.30	2.14	2.36	2.54	2.84	3.55	3.66	4.46	4.34	5.01
1971	-	1.05	1.37	1.84	2.65	3.10	3.37	3.52	3.98	4.56	4.71	4.97
1972	.64	-	1.93	2.10	2.60	3.48	3.36	3.63	3.91	4.26	4.60	5.01
1973	.62	1.11	1.75	2.56	3.04	3.15	3.80	4.61	4.04	4.21	5.47	5.62
1974	.74	1.05	1.81	3.41	3.16	3.62	4.22	3.88	-	4.17	4.32	4.77

Estimation of recruitment and stock abundance

Hennemuth (1969) used *Albatross IV* survey data to estimate recruitment by pooling regressions of ln (stratified mean number/tow at age) versus age for the various year-classes to estimate a common slope (Z). Recruitment (number at age 2+) was then obtained by relating the intercept of the year-class in question to that of a year-class for which reliable recruitment estimates had been determined. This method was applicable for year-classes for which a sufficient number of data points were available, but did not appear to give reliable indices in recent years in which zero catches were frequent. However, analyses of commercial data by Gulland's (1965) extension of the virtual population method (Table 6) suggest an average Z value of 0.7 during the 1968-1972 period, essentially equivalent to the value of Z = 0.67 estimated by Hennemuth (1969). We therefore used the relation

$$\overline{N}_t = \log_e N_o - Z\overline{t}$$

to estimate $\log_e N_o$, where

N_t = $\log_e$ stratified mean number/tow at age t

$\overline{N}_t = \dfrac{\sum_{i}^{m} N_t}{m}$

t = time in months from age 0

$\overline{t} = \dfrac{\sum_{1}^{m} t_i}{m}$

m = number of observations (survey cruises) and

Z = total mortality coefficient (0.058 on a monthly basis)

Table 6. Total mortality coefficients (Z) for 5Ze haddock, 1968-1972, derived by virtual population analyses (M = 0.2).[1] (Mean = 0.72)

Year	Year-class 1959	1960	1961	1962	1963	1964	1965	1966	1967
1968	0.74	0.51	0.59	0.66	0.73	0.81	0.52		
1969	0.50	0.53	0.46	0.68	0.73	0.73	0.62	0.86	
1970	0.52	0.60	0.56	0.79	0.72	0.62	0.61	0.89	0.30
1971		0.65	0.79	0.92	0.68	1.26	1.13	0.75	0.48
1972			0.84	1.26	0.73	0.98	1.18	0.67	0.58

[1] Calculations based on US total landings and age composition data.

The value obtained for $\log_e N_o$ for each year-class was then related to the value obtained by Hennemuth (1969) for the base year-class (1959) to estimate recruitment. A comparable estimate may also be obtained by deriving a value for $\log_e N_t$ at age t = 24 months (the point at which the virtual population estimate of 1959 year-class abundance was made) in the equation

$$\log_e N_t = \log_e N_o - Z_t$$

Hennemuth's (1959) values for $\log_e N_o$ (3.31) and Z (0.056) were used to estimate $\log_e N_t$ in the above equation; corresponding estimates for the 1968-1972 year-classes were obtained from fitting the above equation to the observed survey data for each year-class and calculating $\log_e N_t$ at age t = 24 months. These values were then related to the base year-class value, as above. The estimates obtained by this procedure agree reasonably well with those obtained using a common slope of 0.058 (Table 7).

Table 7. Estimated recruitment for the 1968-1972 haddock year-classes on Georges Bank (5Ze) as computed by modification of Hennemuth's (1969) index.

Year class	Survey index[1]	Index relative to 1959 class	Nos. population[2] age 2 X10^6
1968	0.31	0.05	4(1)
1969	0.99	0.10	8(11)
1970	-1.80	0.01	1(1)
1971	1.44	0.15	12(15)
1972	2.25	0.35	28(29)

1 Intercepts of linear regressions of $\log_e$ (mean number tow at age) versus age (19 months+).

2 Figures in parentheses calculated under the assumption that Z varies.

As an additional check on the data of Table 7, recruitment was also estimated by Grosslein's (1969) young-of-year index (Table 8). This method is based on mean numbers of age 0 haddock caught in *Albatross IV* fall survey cruises in designated survey areas. Although it utilizes only one data point, values obtained provide supplementary data and are the only ones available for short-term predictive work.

The data of Tables 7 and 8 agree in indicating poor recruitment since 1967. The 1970 year-class appears to have been the poorest on record, with those of 1968 and 1969 faring little better; prospects appear somewhat more favorable after 1970 although values are still low compared to estimates for the 1935-1961 period (average 54x10^6 recruits). *Albatross IV* survey data and foreign data for the same area (Table 9) agree in indicating the 1972 year-class to be the strongest of these year-classes (and consequently the strongest in years) although this pattern did not hold true for US commercial data (Table 3, Figure 1). It is likely, however, that commercial data for these year-classes has been biased by unrecorded discards.

To obtain estimates of fishable stock, I used the relation

$$C_i = N_i \,(1-e^{-Z})\,\frac{F}{F+M}$$

where C_i = catch in year i

N_i = numbers in population at beginning of year

and Z, F, and M represent the total, fishing, and natural mortality coefficients, respectively.

Hennemuth (1969) estimated an F value of 1.0 for 1968 based on a proportional relationship between effort and mortality. However, virtual population analysis (Table 6) and use of catch-effort data for different pairs of year and age groups (Gulland 1969, Table 10) both agree in suggesting a lower value (0.45 and 0.47 for 1968, respectively). Use of an F value of 0.5, an M of 0.2 and the known catch of 25x10^6 fish in 1968 in the above equation gives an initial population estimate of 70x10^6 fish. Projected estimates of population size from this point based on known removals and estimated recruitment in succeeding years are given in Table 11.

Table 8. Estimated recruitment for 1965-1974 haddock year-classes on Georges Bank (5Ze) computed using Grosslein's (1969) index.

Year class	Survey Index[1]	Index relative to 1959	Nos. in population[2] age 2x10^6
1966	1.67	0.18	15
1967	1.00	0.11	9
1968	1.05	0.12	9
1969	1.07	0.12	10
1970	1.00	0.11	9
1971	1.38	0.15	12
1972	2.05	0.23	18
1973	1.75	0.19	16
1974	1.26	0.14	11

1 Mean of $\log_{10}$ catch/tow+1, antilogged; fall survey data only.

2 Note that the 1966 year-class will recruit in 1968.

Table 9. Summary of stratified mean number/tow for 1970-1974 haddock year-classes obtained in *Albatross IV* and foreign surveys on Georges Bank in 1973 and 1974. All cruises in fall unless otherwise noted.

Year	Vessel	Gear	Year-class 1970	1971	1972	1973	1974
1973	Albatross IV	36' Yankee	0	1.08	6.04	1.77	-
1974	" "	" "	0	0.15	0.66	1.24	0.74
1973	Wieczno	28/32	0	0	0.30	1.19	-
1974	"	"	0	0.00[1]	0.02	2.02	0.42
1973	Belogorsk	41' Yankee	0	0.45	12.96	.88	-
1974	"	" "	0	0.57	5.76	1.97	2.75
1973	W. Herwig[2]	180' Herring	0	5.51	2.40	-	-
1974	"	" "	0	1.57	9.80	3.73	-

[1] Less than 0.01.

[2] Spring.

Table 10. Total mortality coefficients (Z) for 5Ze haddock, 1968-1973, computed for different pairs of year and age groups (catch at age/standard day fished as determined from US age composition data). (Mean of positive values = 0.65.)

Year	Age 3-4	4-5	5-6	6-7	7-8	$\frac{\Sigma 4\text{-}8}{\Sigma 3\text{-}7}$
67-68	0.43	0.39	1.11	0.58	0.84	0.57
68-69	0.08	0.71	0.51	0.42	0.73	0.50
69-70	0.67	0.46	0.74	0.57	0.33	0.55
70-71	-[1]	0.77	-	-	0.51	0.39
71-72	0.26	-	0.21	0.45	0.78	0.37
72-73	0.74	1.00	0.69	0.97	2.01	0.52

[1] Negative values.

Table 11. Stock abundance and recruitment estimates for Georges Bank (5Ze) haddock, 1968-1976.

	1935-1960	1968[1]	1969	Yearly Estimates ($X10^6$) 1970	1971	1972	1973	1974	1975	1976
Population (2+)	145	70	36	24	23	12	20	42	48	48
Removals:										
total	63	35	16	9	9	4	6	10	11	12
fishing	41	25	11	5*	5*	2*	3*	3*	3*	3*
natural	22	10	5	4	4	2	3	7	8	8
Recruits[2] (age 2)	54	15	1	4	8	-	12	28	16	11

[1] Population size estimated with F = 0.5 and M = 0.2 during 1968.

[2] Values for 1968-1974 computed by Hennemuth's (1969) method (see text). Values for 1975 and 1976 computed from Grosslein's (1969) young-of-year index.

* Under regulation; computed on basis of mean weight in US commercial landings.

The data of Table 11 agree with the commercial and survey indices of Table 2 in demonstrating a pronounced decline in stock abundance in recent years. There is some indication that the downward trend may have been reversed in 1973, but it should be emphasized that recruitment estimates for 1973 and 1974 are based on limited data and consequently the observed upswing may not be as great as anticipated. It should also be noted that available recruitment estimates for 1975 and 1976 (Grosslein's young-of-year index, Table 8) are down considerably from the 1974 (Hennemuth-type) estimate (Table 7).

Conclusions and recommendations

The above analyses indicate that the 5Ze haddock fishery is in a very depressed state and is unlikely to recover to its pre-1963 level in the foreseeable future. Reduced recruitment and changes in stock structure in recent years imply that significant recruitment will become increasingly unlikely during the remainder of this decade. It therefore appears likely that even with stringent quota regulations the 5Ze stock will remain considerably below the pre-1963 level.

In conclusion, it is evident that no additional fishing should be allowed on this stock and that effort should be made to reduce F to the lowest possible level if the stock is to recover.

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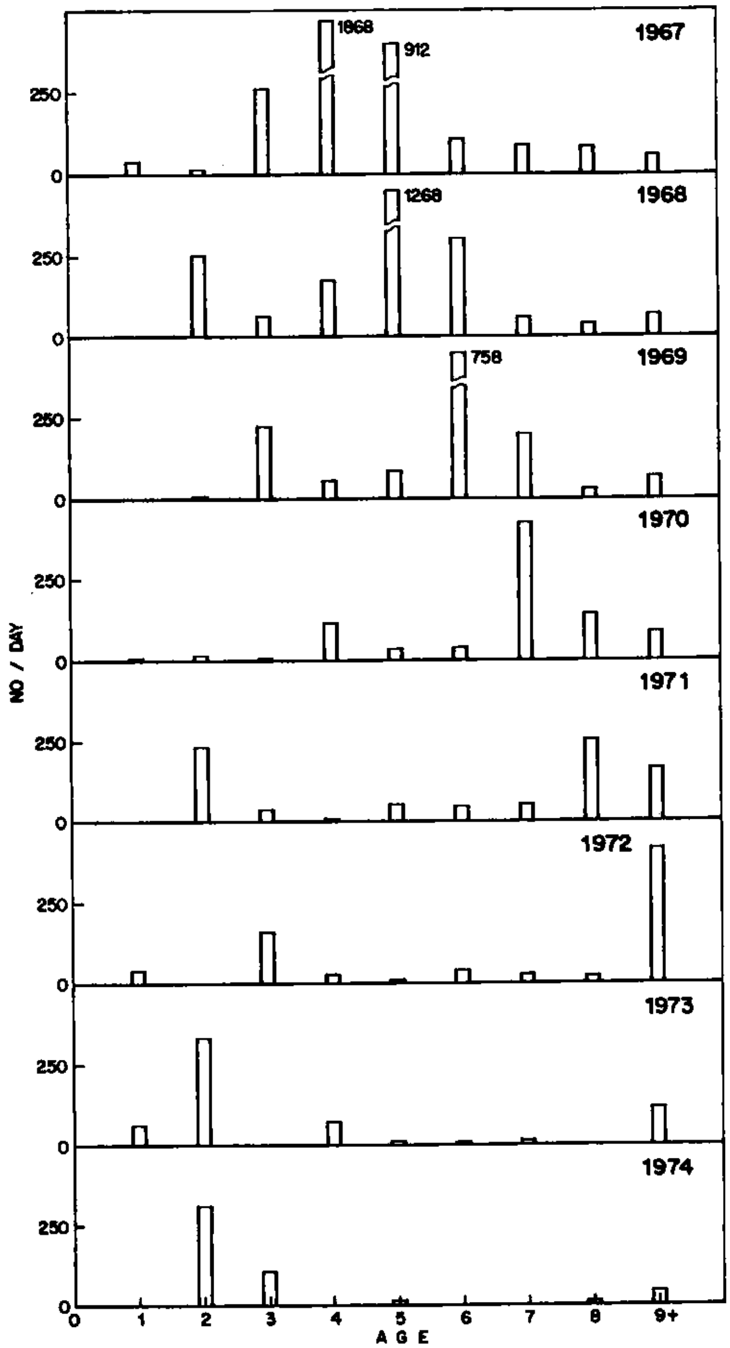

Figure 1. Age composition of US haddock landings from Georges Bank, 1967-1974.