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Georges Bank (Subdiv. 5Ze) Haddock Status Report

by

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Introduction

The Subdiv. 5Ze (Georges Bank) haddock fishery provides a classic example of the adverse effects of overexploitation on physical and economic yield. At an approximate average level of 140,000 MT (corresponding to the 1935-1960 situation), this stock was capable of providing an MSY of 50,000 MT annually (Hennemuth, 1969), thereby representing an important mainstay of the New England fishing industry. Recruitment of the outstanding 1963 year-class in 1965, however, attracted greatly increased effort by distant-water fleets in 1965 and 1966 and resulted in massive overexploitation (landings of 150,000 and 121,000 MT in 1965 and 1966, respectively). Continued unrestricted exploitation throughout the latter part of the 1960's, coupled with poor recruitment, resulted in continued declines in stock abundance and landings (ICNAF, 1970; Table 1) and led to the establishment of a TAC of 12,000 MT for Subarea 5[1] in 1970 and 1971. Evidence for continued declines in stock abundance and continued poor recruitment led to a further reduction in the TAC level to 6,000 MT for 1972 (ICNAF 1972) which continued in effect for 1973. In 1974, the TAC was set at 0, allowing for incidental catch only, under which limitation catches declined to 5,121 MT (Table 1). This form of management (*i.e.* catch limitations) has been continued for 1975 and 1976 under an established TAC of 6,000 MT, recognizing that incidental catches up to this limit are as a rule unavoidable.

The present paper updates available information relative to stock size and recruitment for the Subdiv. 5Ze haddock fishery and discusses the implications of various TAC levels relative to stock size and recruitment.

Commercial landings

Landings for this stock declined continually prior to 1970, when quota limitations were imposed, and under quota management continued to decline until 1975. Since 1970, the USA and Canada have been the primary participants in this fishery and together accounted for 87% of the landings for SA 5 during 1970-1974. USA landings approximated 70% of the total figure during the same period. Increased landings for 1975 compared to the 1974 figure (Table 1) are thought to relate primarily to increases in incidental catch limitations for the USA fishery during that year (which have since been revised downward for 1976) and consequently should not be taken as an indication of increased abundance.

Landings, effort data, and commercial abundance indices for Subdiv. 5Ze haddock are given in Table 2. Commercial abundance indices (catch per standard day fished, using USA trawlers of 216-310 GRT as standard) declined from 4.6 MT per day in 1967 to 1.1 MT per day in 1973 (data for 1974 and 1975 are not comparable due to changes in fishing patterns associated with incidental catch limitations).

[1]Comprising the Subdiv. 5Ze stock and very limited amounts in Subdiv. 5Zw and Div. 5Y.

Catch at age data for the USA fishery from 1967-1973 (numbers per standard day fished) are given in Table 3. These data indicate that from 1967-1972 this fishery has been supported primarily by the 1963 year-class; recruitment since 1963 has been extremely poor. As the 1963 year-class has essentially passed through the fishery, effort is now concentrated on the later, weaker year-classes. The 1972 year-class, which appears to have been the strongest in recent years, accounted for 56% of the total number landed by the USA in 1974 and 1975. However, this year-class appears to have been less than half as strong as the pre-1963 average (see next section).

Research vessel survey data

Trends in *Albatross IV* spring and autumn bottom trawl survey data for Subdiv. 5Ze (strata 13-25, 29, and 30) since 1967 are given in Table 4. For spring data, stratified mean catch per tow values (numbers and weight) decline to a low of 1.87 age 2+ individuals (3.3 kg) per tow in 1971, followed by subsequent upswings to 1974; values again declined in 1975. As a larger trawl (*i.e.* the #41 Yankee) has been used in spring surveys since 1973 and some uncertainty exists regarding the conversion factor used (1.8, Table 4) the magnitude of the increase observed since 1972 is problematical.

Autumn survey data reveal pronounced declines in abundance to a low of 1.20 age 2+ individuals (3.71 kg) per tow in 1971, followed by increases in numbers and weight during 1972 and 1973. The lowest values in the history of the groundfish survey were observed in 1974, but a marked improvement to 4.60 age 2+ individuals (10.01 kg) per tow occurred in 1975. In terms of number, recruitment of the 1972 year-class accounted for 72% of the age 2+ figure. The sharp increase in the total number captured in 1975 (20.78) reflects recruitment of the 1975 year-class, which will be discussed in the following sections.

Estimates of instantaneous total mortality (Z) computed from stratified mean catch per tow at age data (autumn surveys only) are given in Table 5. Apparently due to low catch at age values, estimates fluctuate considerably and no trends are evident. The weighted mean value of Z obtained for 1967-1975 was 0.50 (Table 5).

Recruitment and stock abundance

Recruitment for the stock in recent years has been estimated using indices devised by Grosslein (1969) and Hennemuth (1969). Grosslein's method relates mean catch in numbers[1] of young-of-year haddock in known concentration areas to catches during a base year (1959) for which haddock year-class strength at age 2 is known. Estimates obtained (Table 6) indicate poor recruitment prior to 1975. The index for the current year (3.77) is the highest since 1967 and compares favorably with the 1953-1962 average.

Hennemuth (1969) estimated recruitment by pooling regressions of ln (stratified mean catch per tow, in numbers) against age (months), *viz.*

$$\log_e N_t = \log_e N_o - Zt \qquad (1)$$

where N_t = stratified mean catch per tow at age t, and
t = age (months)

to estimate a common slope (Z). Recruitment (numbers at age 2+) was then estimated by relating the intercepts of year-classes in question to that of a standard for which the total population at age 2+ had been determined. By computing the above regression line for the 1968-1973 year-classes, an average slope of 0.053 was obtained, very close to the pooled value of 0.058 obtained by Hennemuth. Therefore, recruitment was estimated by obtaining a value for $\log_e N_t$ at t = 24 months for each year-class and relating this to the corresponding value obtained from Hennemuth's regression line (Table 7).

The data of Tables 6 and 7 agree in indicating poor recruitment in recent years. The 1972 and 1975 year-classes appear to have been by far the strongest since 1967, although the 1975 estimate is based on only one survey and additional data will be necessary to provide a more definitive estimate. However, data obtained in spring juvenile herring surveys by the *Walther Herwig* (FRG) and the *Anton Dohrn* (GDR) also indicate the 1975 year-class to be a relatively strong one (stratified mean catch per tow in numbers of yearling haddock equalled 148.9 in 1976 compared to the stratified mean 1973-1975 average of 4.1 per tow recorded by the *Walther Herwig*). As survey coverage has improved and vessels were changed in 1976 (although the 180' herring trawl was used in all years) these data are only generally comparable, but they do indicate increased strength of the 1975 year-class as compared to the earlier years.

[1] Ln (mean catch per tow + 1) values, antilogged.

To obtain estimates of fishable stock (numbers of age 2+ fish) the relation

$$C_i = N_i \left(1-e^{-Z_i}\left(\frac{F_i}{F_i + M}\right)\right) \qquad (2)$$

was used, where

C_i = catch in year i;
N_i = population size at the beginning of year i;
F_i = instantaneous fishing mortality in year i;
M = instantaneous natural mortality; and
$Z_i = F_i + M$

Data obtained in the present study indicate that F approximated 0.3-0.4 (Tables 4 and 6) in 1968, although Hennemuth (1969) estimated a much higher figure (F = 1.0) based on a proportional relationship between effort and mortality. Use of F = 0.5, M = 0.2, and an estimated catch of 25 X 10^6 individuals for 1968 in the above equation provides an estimated stock size of 70 X 10^6 fish for 1968. Projected estimates of stock size in numbers from 1968 to 1977 based on known or assumed removals and estimated recruitment are given in Table 7.

Stock size estimates in Table 7 agree with survey data (Table 4) in indicating a decline to an all-time low in the early 1970's, followed by a subsequent upswing. Stock size appears to have reached its lowest point in 1972; since that time, abundance has improved, although it would appear that abundance currently approximates only one-third of the pre-1960 level.

Table 8 provides projected estimates of stock size computed from (2) under varying assumptions of catch and recruitment. It can be seen that if (1) recruitment remains at the assumed 1977 level for several more years, and (2) the existing TAC is maintained, we may expect continued improvement, although 10-12 years would be required to completely rebuild the stock. Recruitment at half the assumed 1977 level, on the other hand, will result in no further increase beyond 1980 even under existing catch levels, while increasing the TAC could lead to substantial declines in abundance. For the present, it is probably more realistic to assume that, on the average, recruitment in future years will be closer to the 1972-1976 average (14 X 10^6, Table 7) than to the 30 X 10^6 figure. If the premise is accepted, it may in turn be inferred that any increase in the existing TAC may cause a reduction in stock size.

Literature cited

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Table 1. Commercial landings of haddock (MT, live) from Subarea 5 and Statistical Area 6 by country, 1967-1975.

					COUNTRY				
Year	Canada	Poland	Romania	Spain	UK	USSR	USA	Other[1]	Total
					Div. 5Y[2]				
1967	589	-	-	-	-	-	4907	-	5496
1968	120	-	-	-	-	-	3437	-	3557
1969	59	-	-	230	-	-	2423	-	2712
1970	38	-	-	63	-	-	1457	-	1558
1971	85	-	-	26	-	-	1194	1	1306
1972	23	-	-	-	-	4	909	-	936
1973	49	-	-	-	-	-	509	-	558
1974	198	-	-	-	9	-	622	-	829
1975[4]	78						1183		1261
					Subdiv. 5Ze[2]				
1967[3]	13040	-	12	1355	3	2316	34728	4	51458
1968	9292	1145	-	2845	-	1308	25197	29	39816
1969	3990	458	-	1201	-	51	16443	4	22147
1970	1978	15	-	782	-	98	8400	1	11274
1971	1630	1	225	1240	-	292	7301	16	10705
1972	609	1	14	1098	-	126	3866	5	5719
1973	1563	-	-	386	-	574	2776	3	5302
1974	462	-	-	764	426	97	2396	-	4145
1975[4]	1353					8	3985		5346
					Total Subarea 5 and Statistical Area 6				
1967	13629	-	12	1355	3	2316	39659	15	56989
1968	9443	1327	402	3014	-	1397	28914	33	44530
1969	4049	458	66	1431	-	65	18892	16	24977
1970	2016	15	-	845	-	103	9874	11	12864
1971	1715	1	225	1336	-	374	8508	17	12176
1972	632	1	14	1098	-	141	4779	5	6670
1973	1612	-	-	386	-	602	3289	3	5892
1974	660	-	-	764	568	111	3018	-	5121
1975[4]	1431					8	5168		6607

[1] Includes landings for Bulgaria, France, FRG, GDR and Japan.
[2] From ICNAF statistical bulletins 17-24.
[3] Landings not allocated by subdivision (5Ze or 5Zw).
[4] From provisional ICNAF statistics for 1976 (incomplete).

Table 2. Catch and effort statistics and commercial abundance indices computed for Georges Bank (Subdiv. 5Ze) haddock, 1967-1973.

Year	Landings (MT, live)	Total no. landed[1] ($x10^6$)	Effort[2]	Commercial abundance index MT/day
1967	51458	38.4	11215	4.6
1968	39816	24.9	11337	3.5
1969	22147	11.1	7856	2.8
1970	11274	4.7	5449	2.1
1971	10705	4.7	5456	2.0
1972	5719	2.2	2835	2.0
1973	5302	3.3	4859	1.1
1974	4145	2.6	-[3]	-[3]
1975[4]	5322	3.2	-[3]	-[3]

[1]Based on mean weight in U.S. landings.

[2]U.S. standard days, using U.S. trawlers of 216-310 GRT as standard. Data adjusted to eliminate effects of closed areas and closed seasons.

[3]Computation of comparable abundance indices and effort values not possible due to incidental catch limitations.

[4]Provisional statistics (incomplete).

Table 3. Catch at age (nos.) for the USA fishery per standard day fished,[1] 1967-1973[2]

Year	1	2	3	4	5	6	7	8	9+
1967	40	14	262	1868	912	104	86	80	56
1968	-	251	62	171	1267	301	58	37	68
1969	-	1	221	57	84	758	198	28	65
1970	3	17	3	113	36	40	427	142	87
1971	-	232	39	8	52	47	55	256	169
1972	44	-	162	30	12	42	30	25	418
1973	73	361	1	83	12	6	17	4	117

[1]Using USA trawlers of 216-310 GRT as standard; data adjusted to eliminate effects of closed areas and seasons.

[2]Figures for 1974 and 1975 not available due to changes in fishing patterns associated with incidental catch limitations.

Table 4. Stratified mean catch per tow in numbers and weight (kg) for haddock from *ALBATROSS IV* spring and autumn bottom trawl surveys in Subdiv. 5Ze (Georges Bank, strata 13-25, 29 and 30), 1967-1975.

Year	Spring Nos.	Spring Nos. (Age 2+)	Spring Wt. (kg)	Autumn Nos.	Autumn Nos. (Age 2+)	Autumn Wt. (kg)
1967	-	-	-	11.40	7.36	16.87
1968	9.15	8.98	13.61	5.06	4.99	10.20
1969	5.15	4.38	10.37	2.28	1.99	5.59
1970	4.02	3.57	11.34	5.17	2.37	8.94
1971	1.87	1.87	3.30	2.83	1.20	3.71
1972	4.27	1.56	4.89	7.62	1.40	5.61
1973	(14.03)[1]	(2.58)	(5.65)	9.98	1.78	6.48
1974	(7.10)	(6.28)	(6.52)	2.71	1.02	2.64
1975	(2.32)	(1.97)	(3.02)	20.78	4.60	10.01

[1]Values in parentheses computed by adjusting stratified mean catch per tow values for the #41 Yankee trawl by a factor of 1.8.

Table 5. Total mortality coefficients (Z) for Subdiv. 5Ze haddock, computed from *Albatross IV* autumn bottom trawl survey data,[1] 1967-1975.

Age Group	67-68	68-69	69-70	70-71	71-72	72-73	73-74	75-75
II	0.98	1.18	-0.93	1.03	-0.51	0.00	1.64	-1.60
III	1.11	0.00	0.05	0.00	-0.18	0.99	0.00	-1.08
IV	0.56	0.69	-0.69	0.24	0.92	0.69	2.56	0.00
V	0.25	0.93	-1.13	2.20	0.92	0.00	2.01	-0.69
VI	1.83	0.92	0.10	1.73	-0.69	0.18	0.00	0.00
VII	0.24	1.10	0.06	0.61	1.10	1.39	2.53	-0.92
VIII	-0.17	1.01	-1.10	0.76	-0.06	0.69	-0.69	-0.92
IX	2.48	1.87	0.69	2.89	-0.51	0.36	0.92	1.61
Z_{4+}[2]	0.48	0.90	-0.12	0.88	-0.06	0.61	1.48	-0.45
							$\bar{Z}_{4+}$[3] =	0.50

[1]Stratified mean catch per tow (numbers) at age.

[2]Computed as $\ln\left(\frac{\Sigma \text{ 4 and older (1967)}}{\Sigma \text{ 5 and older (1968)}}\right)$, etc.

[3]Computed as $\ln\left(\frac{\Sigma \text{ 4 and older (1967+)}}{\Sigma \text{ 5 and older (1968+)}}\right)$.

Table 6. Young-of-year indices for Georges Bank (Subdiv. 5Ze) haddock, 1967-1975, and age 2+ recruitment estimates obtained by relating these values to the 1958-1959 average[1].

Year-class	Young-of-year index[2]	Index relative to 1959	Recruitment estimate (Nos. age 2×10^6)
1953-1962 average	5.20	0.51	42
1967	1.00	0.10	8
1968	1.05	0.10	8
1969	1.07	0.11	9
1970	1.00	0.10	8
1971	1.38	0.14	11
1972	2.05	0.20	16
1973	1.75	0.17	14
1974	1.26	0.12	10
1975	3.77	0.37	30

[1]Assuming an average population size of 81×10^6 fish at age 2 for the 1958 and 1959 year-class as determined by virtual population analysis and a corresponding young-of-year index of 10.1.

[2]All values equivalent to mean of $\log_{10}$ (no. of young-of-year haddock caught/tow +1) values, antilogged, for stations in selected strata.

Table 7. Stock abundance and recruitment estimates for Georges Bank (Subdiv. 5Ze) haddock, 1968-1977.

	Mean 1935-1960[1]	Yearly estimates ($\times 10^{-6}$)									
		1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Stock (2+)	145	70[2]	36	21	24	16	27	55	50	48	66[3]
Removals											
Total	63	35	16	8	9	5	8	12	12	12	14
Fishing[4]	41	25	11	5	5	2	3	3	3	4	4
Natural	22	10	5	3	4	3	5	9	9	8	10
Recruits[5] (2+)	54	15	1	1	11	1	16	36	7	10	30

[1]ICNAF Redbook, 1970.

[2]Estimated assuming F = 0.5 and M = 0.2 during 1968.

[3]Assuming that the current TAC level remains in effect for 1977.

[4]Values computed on the basis of mean weight at age in USA landings.

[5]Values for 1968-1975 computed using Hennemuth's (1969) index; values for 1976-1977 estimated using Grosslein's (1969) index. From Hennemuth's common regression line, $Y_1 = 3.31 - .056\ (24) = 1.97$; Y_2 is estimated at $t = 24$ months from the fitted regression line for a given year-class, and estimated recruitment = $(e^{Y_2 - Y_1}) \times 81 \times 10^6$ fish.

Table 8. Projected stock sizes for Subdiv. 5Ze haddock under varying assumptions of catch and recruitment, 1978-1986.

TAC (MT) 1977+	1978	1980	1982	1984	1986
		Annual recruitment of $15X10^6$			
6	67	65[1]	-	-	-
9	65	61	58	55	54
12	63	56	52	49	47
		Annual recruitment of $30X10^6$			
6	82	103	117	126	133
9	80	98	110	119	124
12	78	93	104	111	116

[1]For a 6000 MT TAC level, recruitment balances natural and fishing mortality at this point.