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The 1984 assessment of 5Ze haddock

by

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The annual catches of haddock from NAFO Subdivision 5Ze have declined since 1965, when peak landings of 150,362 t were recorded. During the period 1935-1960, the average annual landings of haddock was 46,000 t. The declining trend since 1965 is attributed to either poor year-classes or prerecruitment overexploitation of strong year-classes. After a moderate increase in landings between 1976 and 1980, catches have once more shown a decline with 11,876 t taken in 1983. Landings during the 1976-79 period were probably underestimated due to discarding and misreporting in the US fishery. Since 1963, Canadian landings have comprised about 23% of the total.

Indicators of stock strength (numbers caught, biomass) calculated from US surveys continue to indicate declining abundance since 1979. Catch-per-unit effort data for tonnage class 4 stern trawlers has also been declining since the late 1970's although this trend is less apparent in TC 5 stern trawlers. Recruitment indices calculated from the survey catch-at-age data indicate that the 1983 year-class may be relatively strong.

A sequential population analysis was conducted for the period 1964-1983, assuming $M = 0.20$ and with fully-recruited F 's (0.40) determined by examination of the relationship between \ln age 3+ population numbers in year $_{t+1}$ (from cohort analysis) vs \ln age 2+ in year $_t$ (from the research surveys). Fishing mortality for the fully recruited ages was greater than the $F_{0.1}$ of 0.26 in recent years and the 2+ population numbers suggest the lowest population level since 1972. However, since there are uncertainties associated with both the catch-at-age matrix and the cohort analysis, interpretation of these results should be made with caution.

RE SUME

Dans la subdivision 5Ze de l'OPANO, les prises annuelles d'aiglefin ont baissé depuis 1965, année où les débarquements ont atteint 150 362 t. De 1935 à 1960, les débarquements d'aiglefin représentaient en moyenne 46 000 t annuellement. La tendance à la baisse qui se manifeste depuis 1965 serait due à la médiocrité des classes d'âges ou à la surexploitation en prérecrutement des classes d'âges fortes. Après une augmentation modérée de 1976 à 1980, les prises ont de nouveau baissé et en 1983 elles étaient de 11 876 t. Il est probable que les débarquements de 1976 à 1979 ont été sous-estimés en raison des rejets et des déclarations erronées du côté américain. Depuis 1963, les débarquements au Canada représentent 23 % du total.

Les indices de l'importance des stocks (nombre de poissons capturés, biomasse) établis d'après les relevés américains dénotent une baisse depuis 1979. La prise par unité d'effort de pêche des chalutiers arrières de catégorie de tonnage n°4 a également baissé depuis la fin des années soixante-dix, mais la tendance est moins apparente qu'avec les chalutiers de catégorie n°5. Les indices de recrutement déterminés d'après l'âge à la capture montrent que la classe d'âge de 1983 pourrait être relativement importante.

On a fait l'analyse de population séquentielle de 1964 à 1983 en supposant un M de 0,20 et en appliquant les valeurs de F au recrutement (0,40) déterminées en étudiant la relation entre le \ln des populations d'âge 3+ de l'année $t + 1$ (d'après l'analyse de cohorte) par comparaison au \ln des populations d'âge 2+ de l'année t (d'après les relevés). La mortalité par pêche pour les âges pleinement recrutés était supérieure à 0,26 valeur du $F_{0.1}$ de ces dernières années et, si l'on en juge par le nombre de poissons dans l'âge 2+, la population serait au plus bas depuis 1972. Il est cependant recommandé d'user de circonspection dans l'interprétation de ces résultats, car la matrice de l'âge à la capture et l'analyse de cohorte comportent un certain degré d'incertitude.

INTRODUCTION

Evaluations of the Georges Bank haddock (Melanogrammus aeglefinus) stock size were conducted in 1969 (Hennemuth 1969), 1975 (Clark 1975) and 1976 (Clark 1976) under the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Since 1977, stock assessments have been carried out every year by the U.S. National Marine Fisheries Service (NMFS) in Woods Hole (Clark and Palmer 1978; Clark and Overholtz 1979; Clark and Essig 1980; Clark et al. 1981, 1982a; Overholtz 1982; Overholtz et al. 1983). In addition, Canada has conducted stock assessments since 1983 (O'Boyle MS 1983).

As noted by O'Boyle, a variety of methods have been used to establish stock size. In 1978 and 1979, Virtual Population Analysis (VPA) was employed. In 1980, it was felt that the unreliability of catch-at-age data in recent years precluded the use of VPA (Clark and Essig 1980). Historical relationships between survey indices and VPA results were applied to current survey results to predict stock size in 1981 and 1982. The exact form of the relationship used varied from one assessment to another. The 1982 assessment also employed a modification of the Delury Method (Collie and Sissenwine MS 1982).

The assessment documented here uses data from NMFS sources to determine stock size using cohort analyses.

STOCK STRUCTURE

The Georges Bank stock of haddock is generally considered a separate stock, distinct from those adjacent on Browns Bank and the Gulf of Maine. In the case of Browns Bank, early workers have postulated the existence of a separate stock there based on growth rate examination (Needler 1930) or vertebrae counts (Vladykov 1935). However, in both cases only average values were reported with no estimates of variance which would permit statistical corroboration. A more convincing study was completed by Schuck and Arnold (1951) who compared data obtained from scale examination and concluded that the growth rate of Georges Bank haddock was significantly greater than that of Browns Bank fish. They further stated that the growth rate differences were due to ecological or hereditary factors and that significant intermigrations during bottom-dwelling life-history stages did not occur.

Possible interchanges of earlier life history stages of haddock were examined and rejected by Walford (1938) who concluded that in 1931 and 1932, the Georges Bank stock did not receive any recruits from other areas. Grosslein and Hennemuth (1973) noted that surface circulation patterns in Georges and Browns Banks tended to result in the retention of planktonic offspring in the regions in which they were spawned, a view also held by Bolz and Lough (1983). However, Grosslein and Hennemuth (1973) also noted generally good correlations between catches of pelagic 0-group haddock on Georges and Browns Banks. Some authors have considered Grosslein and Hennemuth's observation as evidence that mixing of larvae may occur between the two spawning centres. However, as noted by Bourne and Clark (1983),

synchrony of juvenile haddock abundance may simply reflect favourable environmental conditions affecting recruitment uniformly among adjacent stocks.

Tagging studies have indicated that the deep water of the Fundian Channel is an obstacle to the passage of demersal haddock between Browns and Georges Banks (Needler 1930; Schroeder 1942; Grosslein 1962). Similar tagging efforts have indicated little interchange between Georges Bank and the Gulf of Maine stocks (Schroeder 1942; McCracken 1960; Grosslein 1962). However, of the two stocks postulated to occur in the Gulf of Maine (Grosslein 1962), members of one stock sometimes are caught on Georges Bank. However, Georges Bank fish were not caught in the Gulf of Maine (Bourne and Clark 1983).

In summary, the available data suggest that the Georges Bank stock (5Ze) is a discrete stock and is treated as such in this assessment.

HISTORY OF THE FISHERY

The history of the Georges Bank fishery can be partitioned into five more or less distinct periods: a) partial exploitation (up to 1905); b) rapid growth and initial over exploitation (1906-1930); c) recovery, stabilization and full exploitation (1931-1960); d) development of the Soviet and European fishery, over exploitation and collapse (1961-1976) and e) partial recovery (1977-present).

Early History (1880-1960's)

During the period 1880-1903, haddock landings averaged about 24,500 t. Virtually all the catch was taken by New England schooners. Hand lining from deck and later from dories preceded the development of line trawling which remained viable well into the 1920's. Haddock was not as commercially important as cod due to its inferior salting properties and hence was not usually the object of a directed fishery.

The period 1905-1929 was one of rapid growth for the haddock fishery. By the end of the 1920's, haddock had replaced cod as the major New England fishery. The increase in landings was mainly due to advances in gear technology and processing techniques. Otter trawls were first introduced into New England from the European North Sea fishery in 1905. In 1915, less than 25% of the haddock catch was landed by steam otter trawlers. By 1929, over 83% of the total catch was taken by this gear (Herrington 1936). Whereas the development of the otter trawl fishery increased the capacity for exploitation, the introduction of processing techniques in 1924 for the packaging of fresh and frozen haddock fillets provided the industry with new and seemingly inexhaustable markets. Accordingly, haddock catches almost trebled to a record 115,500 t between 1924 and 1929.

In the early thirties, haddock catches declined markedly to 26,000 t in 1934. At least part of the decline was attributed to the removal of tremendous numbers of small haddock. Investigations indicated that up to

80% of the total number of haddock caught by otter trawlers were below market size and presumably discarded (Herrington 1936). However, catches slowly recovered and remained relatively stable at the estimated long term sustainable catch (52,000 t) until the beginning of the 1960's. In 1951, by international agreement, management of fish resources in the area came under the jurisdiction of ICNAF. After thorough study, a minimum mesh size of 114 mm in the body and codend was adopted. This measure undoubtedly reduced wastage of undersized haddock and other groundfish (Graham and Premetz 1955; Clark 1956).

The total annual catches for Georges Bank haddock are presented in Fig. 1. A high rate of exploitation of Georges Bank haddock by European and Soviet fleets began in the early 1960's. Canadian and US effort also increased and an all time record of 150,362 t was landed in 1965 (Fig. 2, Table 1). The USSR alone accounted for over 54% of the total landings (81,882 t). These catches were not sustained for long and within 5 years, the landings had fallen to less than one-tenth the 1965 level. The problem was compounded by poor recruitment in the mid to late 1960's. For the first time in the history of the fishery, a total allowable catch (TAC) was imposed in 1970 under ICNAF. Initially TAC's were set at 12,000 t (1970, 1971) but this was later halved in 1972, 1973, 1975 and 1976. In 1974, it was set at zero with provision for a 6,000 t by-catch. The spawning grounds (Fig. 3) were also closed to all trawlers during the months of March to May and the minimum codend mesh size was increased to 130 mm. Catches declined to a record low in 1974 with 4,290 t being landing. The Canadian catch was 462 t, the lowest since that fishery was established in the early 1960's.

Recent History (1970 - present)

The declaration of a 200 mile economic zone by the US in 1976 and Canada in 1977 marked a major turning point in the participation and management of the fishery. Although much of Georges Bank fell within the Canada/US "disputed zone", management and exploitation of the haddock fishery was completely under the control of the two countries. In the US, management fell under the auspices of the New England Regional Fishery Management Council (NERFMC) and a Fisheries Management Plan (FMP) was implemented in 1977. Initially a TAC system not unlike that adopted by ICNAF was followed. The TAC's were set at levels which would cause speedy recovery of the stock. Optimism in a strong 1975 year-class resulted in the raising of TAC's in 1977 and 1978 but this did not keep pace with the increased catch rates. Since mandatory reporting was in effect, massive discarding and misreporting was practiced during this period. Overholtz et al. 1983 estimated that actual catches in 1977 and 1980 were about twice the reported landings (20,531 vs 10,843 t; 51,084 vs 27,571 t, respectively).

On March 31, 1981, the Interim Plan for Atlantic Groundfish (IPAG) was implemented. Catch quotas were abandoned. Spawning area closures, increased minimum mesh size regulation (to 140 mm), minimum landed size (43 cm) and voluntary reporting were adopted as management strategies.

Total US landings continued to decline from 1981 to 1983 reaching a low of 8,669 t. This was due mainly to poor recruitment in recent years. A breakdown of the US landings by month is given in Table 2.

Since 1963 Canadian landings have averaged about 23% of the total landings. The highest level (% of total) was observed in 1978 (46%). This has stabilized at about 26% in the last 3 years. Trends in Canadian catches follow those of total US landings (Fig. 2). The 1983 Canadian landings (3,208 t) are the lowest since 1977.

The majority of the Canadian catch has been taken by Nova Scotian trawlers, mainly tonnage class (TC) 4, side and TC 4 and 5 stern trawlers (Tables 3 and 4; Fig. 4, 5). Since 1978, the relative contribution of the TC 4 side trawlers has steadily declined and in 1983, no landings were reported. Tonnage class 5 stern trawlers continued to take the majority of the catch although the portion of the landings taken by TC 2 and 3 has increased dramatically since 1977. In 1983, TC 2 and 3 vessels landed 32% of the catch vs 35% for TC 5. Landings by longliners have been relatively low but have increased since 1980 to 815 t in 1983 (25% of the total reported Canadian catch).

AGE COMPOSITION OF LANDINGS

Sampling Frequency of Canadian Landings

Sampling of Canadian landings (1968-1983) has been confined almost exclusively to TC 4 and 5 otter trawlers (Table 3). Sampling intensity in 1983 was relatively poor, consisting of 8 samples from stern trawlers (6 for TC 5, 2 for TC 3).

Construction of the Catch-at-Age Matrix

For the present assessment, the US catch-at-age matrix reported in Overholtz et al. 1983 was taken to represent the total landed catch. As noted by O'Boyle (MS 1983) different procedures were used to estimate age composition depending on whether catches were made using regulation-mesh trawl gear (Canada, Spain, US and Ireland) or small-mesh trawl gear (USSR, Romania and Poland). In the former case, US sampling information was used exclusively, except in 1975 and 1976 when Canadian sampling data from the first half of the year were used. Monthly length frequencies were used to provide length compositions of the corresponding nominal catch. These were then combined for 3-month periods or quarters and the appropriate age-length keys applied to give quarterly catch-at-age compositions which were further combined for yearly estimates (Clark et al. 1982b).

The small-mesh catches were handled differently due to a lack of sampling information. Using 1973 USSR sampling and US survey data, a retention curve for USSR trawls relative to the survey gear was calculated (Pope et al. 1975). This curve was then applied to US spring, summer, and fall survey length frequencies for the 1963-76 period to estimate length frequency composition of small-mesh gear catches. Then, as described above, the catch-at-age matrix was estimated by applying these length frequencies to the appropriate monthly catch, combining over each quarter and applying the appropriate age-length key derived from groundfish survey data. Only in 1966 and 1973 were USSR length frequencies used to determine age-size composition.

Additional attempts were made (Overholtz et al. 1983) to estimate the discarding of the 1975 year-class in 1977 and 1978, the 1972 year-class in 1974 and the 1978 year-class in 1980. Discarding of the 1977 and 1972 year-classes was estimated using data from vessel captain interviews. Two indices were developed and their average taken to estimate the discarding. The first was the ratio of the total trips with haddock landings to trips with discard information, times the reported discarding from the latter. The second was the ratio of discarded to landed fish (from interviewed trips) applied to the total landings. Although discarding of the 1978 year-class in 1980 and 1981 was known from industry reports and sampling trips to be substantial, no interview data were available to estimate the extent of the problem. Hence, an average Z was calculated from NEFC spring and autumn RV survey catch-at-age ($Z = 0.98$) and this was used with VPA calculated age 3 numbers to estimate total catch (31 million fish) at age 2. Discards were then estimated by subtraction.

The Catch-at-Age Matrix

Historically, the 52e haddock fishery has been dominated by 1 or 2 year-classes (Fig. 6). The 1962 and 1963 year-classes largely supported the fishery from 1965 to 1972 while the large 1975 year-class recruited to the fishery with combined landings and discards greater than 19 million fish (Table 5; Fig. 6). More recently, the 1978 year-class has sustained the fishery since 1980. Unfortunately, these strong year-classes have not resulted in a recovery of the stock, as over-exploitation of younger fish has greatly reduced the potential reproduction and yield of the stock. The age composition of total landings (percentage numbers and weight) are shown in Tables 6 and 7, respectively. The mean weight at age of Georges Bank haddock is shown in Table 8 and Fig. 7.

The Canadian catch at age for otter trawls is shown in Table 9 and Fig. 6. Due to the relatively poor sampling intensity, these values should be viewed with caution. Since 1977, the major difference between the Canadian and US catches-at-age has been the relative importance of the 1975 year class. From 1977 to 1982, the year-class has accounted for 91, 86, 69, 15, 15, and 17% (by numbers) of the total US catch. The corresponding values from the Canadian sampling are 24, 40, 62, 5, 11, and 3%. The greatest difference was in 1978 when the Canadian catch accounted for 46% of the total and only 40 vs 91% (US) was attributed to the 1975 year-class. It would appear that only part of this discrepancy can be explained by the lack of adjustment for discarding in the Canadian landings.

In 1983, the 1978 and 1977 year-classes accounted for 43 and 24% (by numbers), respectively, of the Canadian otter trawl landings.

STOCK ABUNDANCE TRENDS

U. S. Groundfish Survey Abundance Indices

Trawl surveys have been conducted by NMFS in the autumn of each year since 1963. In addition to the autumn surveys, summer surveys have been run

sporadically since 1963 and regular spring surveys conducted since 1968. All surveys were of the stratified random design. The survey gear employed was the 'Yankee 36', except in the spring surveys when a modified 'Yankee 41' was used from 1973 to the present.

The trends in the survey data (numbers caught, biomass) continue to indicate declining abundance. As noted by O'Boyle (MS 1983), the relatively high stock size in 1963 declined to low values during the 1968-1974 period (Table 10, Fig. 8). Numbers caught declined before biomass due to the size of the 1963 year-class. Both biomass and numbers caught increased from 1975-1978. Biomass again started to decline in 1978 and according to the 1983 survey results, continues to decline. Numbers caught started to decline in 1980 (Fig. 8) and from the 1983 survey, appeared to be at the 1968-1974 level. The numbers caught-at-age and total mortality (Z) are shown in Table 11.

Canadian Groundfish Survey Abundance Indices

The results of a Canadian groundfish survey on Georges Bank in 1984 indicated higher abundance indices than those recorded from US surveys in 1983 (Table 10). However, the Canadian survey employed different gear (Western IIA) and covered different strata than those of the US surveys (Fig. 9).

Recruitment Indices

O'Boyle (MS 1983) calculated a recruitment index based on U.S. bottom trawl survey catches in year 0 and 1. The index was calculated by normalizing age 0 and 1 survey catches relative to the 1963-82 mean to make catch rates relative and adjust for partial recruitment to the gear. The adjusted catches at age were then averaged across the cohort (i.e. age 0 + 1 catch-at-age for a given year-class/2) and used as the recruitment index (Table 12).

In order of decreasing rank, the top five year-classes from 1963-1982 were 1963, 1975, 1978, 1980 and 1972. The 1983 year-class also appeared relatively strong. However, anecdotal reports of discarding of that year-class have been noted (Overholtz, pers. comm.).

Commercial Catch Rates

Since no 1983 landings were reported for TC 4 side trawlers, only CPUE data for TC 5 stern trawlers are presented (Table 13; Fig. 10). The series indicated relatively low catch rates in the late 1960's to early 1970's, increasing to a peak rate in 1980 and then declining somewhat to present values. Catch-per-unit effort in 1983 was down slightly from 1982 (0.476 vs 0.572 t per hour).

Sequential Population Analysis

Cohort analysis was conducted for the period 1964-83 using $m = 0.2$ and catch-at-age values from Overholtz et al. 1983 plus 1983 catch-at-age from Overholtz (pers. comm.). The relationship of the \ln age 3+ population numbers in year $t+1$ (from cohort analysis) vs \ln age 2+ survey numbers per tow in year t was used to tune the cohort analysis for fully recruited F's. Mortalities for ages 8 and 9+ were recalculated as the arithmetic average of the age 4 to 6 values when the 1983 F's were changed. The final point (1982 RV/1983 cohort) was used in the analysis. A summary of the cohort analysis for different levels of starting F is given in Table 14. The fit (r^2) of the above relationships was relatively insensitive to changes in input F's and hence this criterion was not used to establish a terminal F on fully recruited years. Rather, the pattern in residuals for the final 5 years was used as the determining criterion. Terminal input F's of 0.38-0.42 gave low absolute residuals and a terminal F of 0.40 was chosen. The relationship is presented in Fig. 11.

The relationship between effective effort (total annual catch divided by the catch rate) for Canadian TC 5 stern trawlers and average F for ages 4-6 was initially considered for the determination of terminal F's on fully recruited ages but this was later rejected since this fleet fishes in a relatively restricted area in 5Z.

The terminal F for age 2 fish was determined by multiplying a partial recruitment value obtained from averaging the corresponding values for 1975-79 (the method of O'Boyle, 1981 was used) by the terminal F's for fully recruited ages (0.4). The average partial recruitment values for ages 1 and 2 are indicated in Table 15. The estimated terminal F for age 2 was 0.18. The relationships of \ln age 1 research survey numbers per tow vs \ln age 2 cohort numbers could not be used to tune the cohort analyses for age 2 because of a zero value for 1983 in the research survey index.

The terminal F for age 1 was determined by minimizing the absolute residuals in the relationships of \ln age 2 population numbers vs \ln age 1 research survey numbers per tow. Results of this analysis including the pattern of residuals for a range of F's are given in Table 16. The final cohort run is shown in Table 17.

In summary, average F's for fully recruited ages have been substantially higher than F 0.1 (= 0.26; Overholtz et al. 1983) in recent years, recruitment has been generally poor and the calculated 2+ numbers (January) for 1984 suggest the lowest population level since 1972. However, due to uncertainties in the catch-at-age matrix (Overholtz et al. 1983) and the reliance on a single index of abundance to tune the cohort analyses, conclusions from the above analysis should be made with caution.

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Table 1. Nominal catches (t) of haddock from Georges Bank¹ for 1956-1983². (--- no fishing activity, - no TAC).

Year	USA (%)	Canada ⁶ (%)	USSR (%)	Spain (%)	Others ³ (%)	Total	TAC
1956	51144 (100)	---	---	---	---	51144	-
1957	48561 (100)	---	---	---	---	48561	-
1958	37322 (100)	---	---	---	---	37322	-
1959	36051 (100)	---	---	---	---	36051	-
1960	40800 (100)	77 (<1)	---	---	---	40877	-
1961	46384 (99)	266 (1)	---	---	---	46650	-
1962	49409 (91)	3461 (6)	1134 (2)	---	---	54004	-
1963	44150 (80)	8379 (15)	2317 (4)	---	---	54846	-
1964	46512 (73)	11625 (18)	5483 (9)	2 (<1)	464 (1)	64086	-
1965	52823 (35)	14889 (10)	81882 (54)	10 (<1)	758 (<1)	150362	-
1966	52918 (44)	18292 (15)	48409 (40)	1111 (1)	544 (<1)	121274	-
1967	34728 (67)	13040 (25)	2316 (5)	1355 (3)	30 (<1)	51469	-
1968	25469 (62)	9323 (23)	1397 (3)	3014 (7)	1720 (4)	40923	-
1969	16456 (74)	3990 (18)	65 (<1)	1201 (5)	540 (2)	22252	-
1970	8415 (74)	1978 (18)	103 (1)	782 (7)	22 (<1)	11300	12000
1971	7306 (67)	1630 (15)	374 (3)	1310 (12)	242 (2)	10862	12000
1972	3869 (67)	609 (11)	137 (2)	1098 (19)	20 (<1)	5733	6000
1973	2777 (52)	1563 (29)	602 (11)	386 (7)	3 (<1)	5331 ⁷	6000
1974	2396 (56)	462 (11)	109 (3)	764 (18)	559 (13)	4290 ⁷	-
1975	3989 (74)	1358 (25)	8 (<1)	61 (1)	4 (<1)	5420	6000
1976	2904 (67)	1361 (31)	4 (<1)	46 (1)	9 (<1)	4324 ⁸	6000
1977	7934 (73)	2909 (27)	---	---	---	10843 ⁹	10500
1978	12160 (54)	10179 (46)	---	---	---	22339 ⁹	20000
1979	14279 (73)	5182 (27)	---	---	---	19461 ¹⁰	32000
1980	17470 (63)	10101 (37)	---	---	---	27571 ¹⁰	-
1981	19245 ⁴ (77)	5659 (23)	---	---	3 (<1)	24907 ⁴	-
1982	12649 ⁴ (72)	4931 ⁴ (28)	---	---	---	17580 ⁵	-
1983	8668 ⁴ (73)	3208 ⁴ (27)	---	---	---	11876 ⁴	-

¹Includes NAFO Areas 5Ze, 5Zw, and 5Nk.

²Data Sources ICNAF (1956-1978, NAFO (1979-1983).

³Bulgaria, Cuba, Federal Republic of Germany, France, German Democratic Republic, Ireland, Japan, Poland, Romania, and United Kingdom.

⁴Provisional (incomplete).

⁵Overholtz, W. 1982. USA data for January-November, 1982 (preliminary).

⁶Landings in the Maritimes, Quebec and Newfoundland.

⁷⁻¹⁰Corresponding values corrected for discards are: ⁷6190, ⁸20531, ⁹26281, ¹⁰51084.

Table 2. Monthly breakdown of the 1983 Georges Bank haddock landings by U.S. vessels.

Month	Landings (t)
January	884.7
February	1072.2
March	389.9
April	758.7
May	857.8
June	1675.6
July	736.0
August	592.5
September	513.0
October	341.3
November	485.5
December	361.7
TOTAL	8668.9

Table 3. Nominal catches (t)^a of haddock caught by Canadian (Maritimes and Quebec) fishing vessels on Georges Bank (NAFO Subdivision 5Ze) during 1968-1983. Numbers in parentheses indicate number of samples taken by DFO personnel.

Year	Gear			Total
	Otter trawlers	Longliners	Other	
1968	9169(8)	112	11	9292
1969	3952(2)	23	15	3989
1970	1897(5)	78	2	1978
1971	1477(1)	151	1	1630
1972	410	195(1)	3	609
1973	1459(3)	103	0	1563
1974	373(5)	88	1	462
1975	1246(5)	107	0	1353
1976	1186(8)	156	15	1357
1977	2787(10)	94	28	2909
1978	9494(26)	169	305	9968
1979	4807(14)	271	2	5080
1980	9367(25)	180	69	9616
1981	4639(16) ^b	430(2)	2	5070
1982	4150(17) ^b	685 ^b	0	4835
1983	2386(8) ^{b,c}	815 ^{b,c}	7 ^{b,c}	3208

^aExcludes catches by tonnage class one vessels except for 1983 longliners (27 tons).

^bMaritimes only.

^cProvisional.

Table 4. Nominal catches (t) of haddock caught by Canadian (Maritimes) otter trawlers on Georges Bank (NAFO Subdivision 5Ze) during 1968-1983. (See Fig. 5).

Year	Side Otter Trawlers T.C.				Stern Otter Trawlers T.C.				Total Otter Trawlers
	2	3	4	5	2	3	4	5	
1968	0	173	3463	117	0	0	579	4836	9168
1969	1	7	791	0	0	1	225	2927	3952
1970	0	24	551	0	2	0	133	1187	1897
1971	0	0	495	5	0	0	16	960	1477
1972	0	2	146	0	0	0	2	260	410
1973	0	25	608	0	0	0	60	766	1459
1974	0	0	27	0	0	6	8	332	373
1975	0	1	221	0	0	1	60	963	1246
1976	0	2	193	23	0	2	59	907	1186
1977	5	46	357	0	92	243	18	2025	2787
1978	70	17	2369	0	237	812	351	5639	9494
1979	13	116	1493	0	136	858	627	1564	4807
1980	9	15	1419	1	354	365	950	6254	9367
1981	4	87	387	0	448	483	883	2345	4639
1982	1	25	89	0	189	297	208	3341	4150
1983	16	90	0	0	614	430	107	1129	2386

Table 5. Estimated age composition (numbers in 000's) of haddock in landings (all countries) from Georges Bank (NAFO Division 5Z) during 1963-1983. (see also Fig. 6).

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	2910	10101	9601	114	1150	8	2	46	1	156	2560	46	192	144	1	1	1	8	1	78	1
2	4047	15935	125818	6843	168	2994	11	158	1375	2	2057	(4320)	1034	473	(19585)	761	26	(31000)	1743	1356	87
3	7418	4554	44496	100810	2891	709	1698	16	223	450	3	657	1864	550	187	(14395)	1726	347	10998	1762	393
4	11152	4776	5356	19167	20667	1921	448	570	40	81	386	2	375	880	680	305	7169	975	831	3472	708
5	8198	8722	4391	2768	10338	14519	654	186	289	32	53	70	4	216	515	567	525	6054	937	350	1902
6	2205	5794	6690	2591	1209	3499	5954	214	246	120	30	2	42	1	357	517	410	594	2572	785	267
7	1405	2082	3772	2332	993	677	1574	2308	285	78	77	2	4	23	4	139	315	546	331	1709	222
8	721	1028	1094	1268	917	453	225	746	1469	66	15	53	4	4	39	14	96	153	158	156	874
9+	1096	1332	1366	867	698	842	570	464	928	1236	447	249	88	112	111	67	46	81	94	185	95
TOTAL	39152	54324	202584	136760	39031	25622	11136	4708	4855	2221	5628	(5401)	3607	2403	(21479)	(16766)	10314	(39758)	17665	9853	4549
Nominal Catch (t)	54846	64086	150362	121274	51469	40923	22252	11300	10862	5733	5331	(6190)	5420	4324	(20531)	(26281)	19461	(51084)	24907	17580	11876
Catch ¹ wt. (t)	57731	67823	181774	140715	52065	41018	22336	12376	11998	6464	6790	7295	5545	4304	25980	27023	21100	43424	22126	16761	10352 ²
Ratio	0.95	0.94	0.83	0.86	0.99	1.00	1.00	0.91	0.91	0.89	0.79	0.85	0.98	1.01	0.79	0.97	0.92	1.18	1.13	1.04	1.15

¹Obtained by multiplying numbers caught at age by corresponding mean weight-at-age data in Table 8.

²1982 weights at age (Overholtz pers. comm.) were used.

Table 6. Estimated age composition (percent numbers) of haddock in total landings from Georges Bank (NAFO Division 52e) during 1963-1982. Values have been adjusted to reflect estimates of discards.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	7.43	18.59	4.74	0.08	2.95	0.03	0.02	0.98	0.02	7.02	45.49	0.85	5.32	5.99	0.00	0.01	0.01	0.02	0.01	0.79	0.02
2	10.34	29.33	62.11	5.00	0.43	11.69	0.10	3.36	28.32	0.09	36.55	79.99	28.67	19.68	91.18	4.54	0.25	77.97	9.87	13.76	1.91
3	18.95	8.38	21.96	73.71	7.41	2.77	15.25	0.34	4.59	20.26	0.05	12.16	51.68	22.89	0.87	85.86	16.73	0.87	62.26	17.88	8.64
4	28.48	8.79	2.64	14.02	52.95	7.50	4.02	12.11	0.82	3.65	6.86	0.04	10.40	36.62	3.17	1.82	69.51	2.45	4.70	35.24	15.56
5	20.94	16.06	2.17	2.02	26.49	56.67	5.87	3.95	5.95	1.44	0.94	1.30	0.11	8.99	2.40	3.38	5.09	15.23	5.30	3.55	41.81
6	5.63	10.67	3.30	1.89	3.10	13.66	53.47	4.55	5.07	5.40	0.53	0.04	1.16	0.04	1.66	3.08	3.98	1.49	14.56	7.97	5.87
7	3.59	3.83	1.86	1.71	2.54	2.64	14.13	49.02	5.87	3.51	1.37	0.04	0.11	0.96	0.02	0.83	3.05	1.37	1.87	17.34	4.88
8	1.84	1.89	0.54	0.93	2.35	1.77	2.02	15.85	30.25	2.97	0.27	0.98	0.11	0.17	0.18	0.08	0.93	0.38	0.89	1.58	21.41
9+	2.80	2.45	0.67	0.63	1.79	3.29	5.12	9.86	19.11	55.65	7.94	4.61	2.44	4.66	0.52	0.40	0.45	0.20	0.53	1.88	2.09

Table 7. Estimated age composition (percent weight) of haddock in total landings from Georges Bank (NAFO Division 52e) during 1963-1982. Values have been adjusted to reflect estimates of discards.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	2.87	7.45	3.06	0.05	1.46	0.01	0.00	0.26	0.01	1.50	22.62	0.45	2.15	2.01	0.00	0.00	0.00	0.01	0.00	0.28	0.00
2	6.10	19.50	47.76	3.55	0.23	5.91	0.04	1.62	11.80	0.03	31.20	62.77	18.27	10.88	80.66	2.65	0.12	51.40	5.20	4.29	0.45
3	15.16	7.52	25.21	63.76	5.28	1.81	8.36	0.16	2.43	12.11	0.07	16.39	54.79	17.76	1.04	79.90	10.47	0.96	47.72	11.25	4.10
4	28.40	10.07	3.98	17.16	46.84	6.18	3.39	8.89	0.58	2.56	12.11	0.06	14.95	40.68	5.68	2.30	68.63	4.33	4.62	32.52	10.83
5	23.86	21.09	4.03	3.34	28.20	55.57	5.12	3.29	5.76	1.20	1.88	2.72	0.16	13.35	5.41	5.85	6.24	32.07	6.61	4.78	42.43
6	8.21	17.17	7.32	3.81	4.76	17.91	53.05	4.13	5.76	5.42	1.45	0.10	2.23	0.06	4.41	6.10	6.10	4.02	27.32	10.49	5.83
7	5.72	7.37	4.69	3.78	4.41	3.83	17.76	48.11	6.94	3.69	3.88	0.11	0.29	1.97	0.06	1.73	5.64	4.85	4.23	28.96	6.14
8	3.80	4.00	1.60	2.59	4.68	2.89	3.01	19.47	37.95	3.51	0.85	2.85	0.29	0.43	0.60	0.19	1.72	1.46	2.70	2.98	26.48
9+	5.89	5.83	2.34	1.96	4.16	5.87	9.26	14.06	28.77	69.98	25.94	14.54	6.87	12.85	2.13	1.27	1.06	0.90	1.61	4.46	3.74

Table 8. Mean weights (kg, whole) of haddock by age-group, as observed from samples of USA commercial landings from Georges Bank (NAFO Division 5Z) during 1963-1982. Values in parentheses are estimates based on the mean of the weights for 1963-1979 for that particular age group.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 ^a	1981 ^a	1982 ^a
1	0.57	0.50	0.58	0.58	0.66	0.59	0.52	0.71	(0.6)	0.62	0.60	0.72	0.62	0.50	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)
2	0.87	0.83	0.69	0.73	0.70	0.81	0.78	1.27	1.03	1.03	1.03	1.06	0.98	0.99	1.07	0.94	1.00	0.72	0.67	(0.53)
3	1.18	1.12	1.03	0.89	0.95	1.05	1.10	1.22	1.31	1.74	1.58	1.82	1.63	1.39	1.44	1.5	1.28	1.2	0.96	(1.07)
4	1.47	1.43	1.35	1.26	1.18	1.32	1.69	1.93	1.74	2.04	2.13	2.32	2.21	1.99	2.17	2.04	2.02	1.93	1.23	(1.57)
5	1.68	1.64	1.67	1.70	1.42	1.57	1.75	2.19	2.39	2.42	2.41	2.83	2.20	2.66	2.73	2.79	2.51	2.3	1.56	(2.29)
6	2.15	2.01	1.99	2.07	2.05	2.10	1.99	2.39	2.81	2.92	3.29	3.76	2.94	(2.63)	3.21	3.19	3.14	2.94	2.35	(2.24)
7	2.35	2.40	2.26	2.28	2.31	2.32	2.52	2.58	2.92	3.06	3.42	4.05	4.00	3.69	4.15	3.37	3.78	3.86	2.83	(2.84)
8	3.04	2.64	2.66	2.87	2.66	2.62	2.99	3.23	3.10	3.44	3.86	3.92	4.05	4.67	4.00	3.61	3.79	4.13	3.78	(3.21)
9+	3.10	2.97	3.11	3.18	3.10	2.86	3.63	3.75	3.72	3.66	3.94	4.26	4.33	4.94	4.99	5.11	4.87	4.83	3.79	(4.04)

^aOverholtz (pers. comm.).

Table 9. Estimated age composition (percent numbers) of haddock in landings by Canada from Georges Bank (NAFO Subdivision 5Ze) during 1963-1983. (--- no data). All values based on otter trawl samples.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.0	0.07	0.93	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	0.04	0.0	0.06	0.00
2	0.28	14.72	58.66	1.79	0.00	21.60	0.26	8.21	6.05	---	51.94	25.62	10.33	11.73	23.88	0.36	0.03	47.38	4.84	13.09	0.39
3	11.51	9.20	26.88	63.35	2.86	5.39	6.64	10.17	25.15	---	24.72	62.37	35.12	19.88	58.12	40.19	3.31	43.68	60.40	21.76	17.46
4	39.02	16.45	4.09	21.57	63.87	7.11	13.09	16.67	3.46	---	15.58	6.72	50.98	28.03	9.18	49.18	61.59	2.18	15.19	50.34	23.92
5	20.92	29.68	1.45	4.07	19.24	39.37	13.44	11.98	1.60	---	3.42	3.89	1.80	34.68	5.08	4.66	23.24	5.55	6.71	6.39	43.11
6	12.10	12.40	3.28	3.63	8.33	22.30	54.03	6.41	12.80	---	2.00	0.40	1.10	2.26	3.10	3.98	5.57	0.70	11.44	4.25	6.82
7	10.71	8.65	2.88	3.49	2.64	2.28	7.95	37.34	5.96	---	1.05	0.0	0.44	2.67	0.27	1.24	5.26	0.18	0.25	3.46	4.84
8	3.76	5.25	0.73	1.58	2.18	0.82	2.45	6.61	40.48	---	0.48	0.09	0.0	0.17	0.32	0.31	0.74	0.21	0.62	0.19	1.99
9+	1.68	3.57	1.08	0.43	0.88	1.14	2.13	2.60	4.50	---	0.80	0.91	0.19	0.59	0.05	0.08	0.27	0.08	0.55	0.45	1.34

Table 10. Stratified mean catch per tow in numbers and weight (kg) for haddock in offshore spring, summer, and autumn¹ US bottom trawl surveys on Georges Bank, 1963-1984. (From Clark et al. 1982a; Overholtz 1982 and Overholtz et al. 1983, --- denotes no data available).

Year	Spring ^{1,2}		Summer ^{1,3}		Autumn ¹	
	Nos.	Wt.(kg)	Nos.	Wt.(kg)	Nos.	Wt.(kg)
1963	---	---	76.65	29.49	97.34	52.83
1964	---	---	387.74	119.45	129.70	64.07
1965	---	---	261.65	156.05	68.26	48.20
1966	---	---	---	---	22.32	19.78
1967	---	---	---	---	11.88	16.87
1968	15.56	23.13	---	---	5.06	10.20
1969	8.26	19.05	6.46	12.95	2.28	5.59
1970	6.84	19.28	---	---	5.17	8.94
1971	3.18	5.62	---	---	2.83	3.70
1972	7.26	8.30	---	---	7.62	5.61
1973	25.23	10.18	---	---	9.98	6.48
1974	12.77	11.72	---	---	2.71	2.64
1975	4.18	5.44	---	---	20.78	10.00
1976	55.83	10.41	---	---	47.68	23.68
1977	24.74	17.60	49.29	42.90	19.02	23.13
1978	13.03	20.71	26.43	1.89	20.70	15.18
1979	30.53	13.09	55.56	25.28	42.74	26.87
1980	40.32	35.71	48.54	39.12	24.98	18.47
1981	25.53	31.95	14.00	13.12	11.01	11.77
1982 ⁴	7.10	11.00	---	---	3.47	4.17
1983 ⁴	3.66	8.56	---	---	5.15	3.97
1984 ⁵	13.77	19.88	---	---	---	---

¹Spring and autumn surveys covered strata 13-25, 29, and 30. The summer survey covered strata 13, 16, and 19-25.

²Data for the spring, 1968-1972 and 1982 surveys were adjusted by a factor of 1.7 to account for differences in surface area between the "36 Yankee" and the modified "41 Yankee" trawls (the "41 Yankee" was used in spring during 1973-1981).

³Sampling incomplete in 1978 and 1981 (7 strata sampled).

⁴Preliminary data from U.S. Surveys.

⁵Preliminary data from Canadian groundfish survey in March, 1984. The survey employed a Western IIA trawl and strata 16-22 were completed.

Table 11. Stratified mean catch per tow at age (numbers) for haddock in NEFC offshore spring, summer, and autumn¹ bottom trawl surveys on Georges Bank 1963-1982 (from Clark et al. 1982 and Overholtz et al. 1983).

Year	AGE										TOTALS ² 1+ ²	2+	
	0	1	2	3	4	5	6	7	8	9			0+ ²
<u>Spring</u> ³													
1968	0.0	0.27	3.23	0.53	0.80	7.62	1.92	0.29	0.51	0.37	-	15.54	15.27
1969	0.0	0.02	0.05	0.66	0.17	0.48	4.83	1.17	0.32	0.52	-	8.22	8.20
1970	0.0	0.77	0.29	0.0	0.37	0.53	0.53	2.28	1.12	0.97	-	6.86	6.09
1971	0.0	0.0	1.33	0.29	0.0	0.14	0.14	0.10	0.94	0.26	-	3.20	3.20
1972	0.0	4.61	0.10	0.70	0.14	0.03	0.05	0.15	0.03	1.48	-	7.29	2.68
1973	0.0	20.59	3.25	0.0	0.36	0.06	0.0	0.12	0.01	0.86	-	25.25	4.66
1974	0.0	1.43	8.92	1.92	0.0	0.16	0.0	0.01	0.07	0.25	-	12.76	11.33
1975	0.0	0.63	0.65	2.23	0.42	0.0	0.09	0.06	0.01	0.10	-	4.19	3.56
1976	0.0	54.22	0.20	0.40	0.62	0.29	0.0	0.03	0.0	0.07	-	55.83	1.61
1977	0.0	0.41	22.42	0.28	0.82	0.40	0.30	0.0	0.03	0.08	-	24.74	24.33
1978	0.0	0.05	0.65	10.69	0.24	0.63	0.55	0.11	0.04	0.07	-	13.03	12.98
1979	0.0	24.24	1.06	0.76	3.83	0.22	0.11	0.25	0.04	0.03	-	30.54	6.30
1980	0.0	3.49	31.34	0.34	0.70	3.27	0.45	0.25	0.31	0.16	-	40.31	36.82
1981	0.0	2.70	2.69	15.95	1.79	0.62	1.46	0.20	0.09	0.04	-	25.53	22.83
1982	0.0	0.62	1.25	0.77	3.33	0.34	0.23	0.50	0.00	0.00	-	7.04	6.42
<u>Summer</u> ⁴													
1963	12.72	55.04	4.22	2.15	2.08	1.41	0.40	0.33	0.04	0.25	78.64	65.92	10.88
1964	24.89	320.27	36.61	1.31	0.89	2.02	1.29	0.18	0.13	0.15	387.74	362.85	42.58
1965	0.0	27.58	207.90	19.51	1.65	1.19	1.91	1.34	0.24	0.53	261.65	261.65	234.27
1969	0.74	0.31	0.02	0.51	0.08	0.17	3.40	0.89	0.09	0.25	6.46	5.72	5.41
1977	0.04	3.80	44.41	0.0	0.48	0.23	0.24	0.04	0.0	0.06	49.30	49.26	45.46
1978	25.16	0.11	0.40	0.69	0.01	0.01	0.01	0.01	0.0	0.02	26.42	1.26	1.15
1979	3.35	49.89	0.07	0.54	1.37	0.21	0.08	0.01	0.03	0.03	55.58	52.23	2.34
1980	1.09	5.95	40.23	0.22	0.15	0.87	0.01	0.02	0.0	0.01	48.53	47.44	41.51
1981	2.03	1.77	2.45	7.51	0.14	0.0	0.11	0.0	0.0	0.0	14.01	11.98	10.21
<u>Autumn</u>													
1963	56.33	17.04	6.19	4.57	5.60	3.99	1.37	1.13	0.79	0.31	97.32	40.99	23.95
1964	1.59	75.75	42.78	3.91	1.20	2.56	1.05	0.46	0.17	0.22	129.69	128.10	52.35
1965	0.22	6.82	51.94	6.51	0.72	0.54	0.61	0.54	0.17	0.18	68.25	68.03	61.21
1966	4.12	0.64	1.94	12.34	2.25	0.35	0.33	0.22	0.08	0.05	22.32	18.20	17.56
1967	0.02	4.51	0.24	0.67	4.54	1.09	0.33	0.14	0.22	0.12	11.88	11.86	7.35
1968	0.06	0.04	0.64	0.09	0.22	2.59	0.85	0.18	0.11	0.26	5.04	4.98	4.94
1969	0.26	0.02	0.0	0.19	0.09	0.11	1.02	0.34	0.06	0.18	2.27	2.01	1.99
1970	0.03	2.77	0.14	0.01	0.19	0.18	0.34	0.92	0.32	0.27	5.17	5.14	2.37
1971	1.63	0.0	0.21	0.05	0.01	0.15	0.02	0.06	0.50	0.19	2.82	1.19	1.19
1972	4.53	1.69	0.0	0.35	0.06	0.0	0.06	0.04	0.02	0.87	7.62	3.09	1.40
1973	2.17	6.04	1.08	0.0	0.13	0.03	0.0	0.05	0.01	0.48	9.99	7.82	1.78
1974	0.50	1.19	0.66	0.21	0.0	0.01	0.0	0.0	0.0	0.15	2.72	2.22	1.03
1975	15.76	0.42	0.48	3.26	0.62	0.0	0.02	0.0	0.01	0.20	20.77	5.01	4.59
1976	2.90	43.07	0.35	0.36	0.55	0.20	0.0	0.03	0.07	0.17	47.70	44.80	1.73
1977	0.11	1.75	15.33	0.46	0.47	0.52	0.28	0.03	0.01	0.07	19.03	18.92	17.17
1978	10.82	0.69	0.85	7.59	0.15	0.21	0.37	0.01	0.0	0.01	20.70	9.88	9.19
1979	1.08	37.29	0.03	0.74	3.12	0.21	0.23	0.04	0.01	0.0	42.75	41.67	4.38
1980	9.56	2.22	10.41	0.37	0.15	1.39	0.39	0.38	0.07	0.05	24.99	15.43	13.21
1981	0.31	5.02	1.70	3.03	0.17	0.34	0.43	0.0	0.0	0.01	11.01	10.70	5.68
1982	0.91	0.00	0.89	0.23	0.94	0.09	0.05	0.14	0.01	0.07	3.33	2.42	2.42
1983	3.73	0.11	0.09	0.18	0.24	0.56	0.08	0.01	0.14	0.01	5.15	1.42	1.31

	<u>Spring</u>		<u>Autumn</u>	
	Years	Age 2+ Age 3+	Years	Age 2+ Age 3+
Instantaneous ⁶				
Total Mortality	1973-1976	0.90 0.76	1973-1976	0.69 0.29
(2)	1977-1980	0.62 0.48	1977-1981	0.97 0.76
	1977-1981	0.76 0.82	1977-1983	0.99 0.85

¹Spring and autumn, strata 13-25, 29, and 30; summer, strata 13, 16, and 19-25 (see Fig. 4).

²May not agree exactly with data in Table 2 due to rounding errors.

³Data for 1968-1972 adjusted by a factor of 1.7 to account for differences in surface area between the "36 Yankee" and the modified "41 Yankee" trawls (the modified "41 Yankee" has been used in spring since 1973).

⁴Sampling incomplete in 1978 and 1981 (7 strata sampled).

⁵Preliminary.

⁶Calculated by pooling over age groups, e.g. the spring 1973-1976 value for age 2 and older fish was calculated as $\ln \frac{\text{age 2 and older for 1973-1976}}{\text{age 3 and older for 1974-1977}}$

$\ln \frac{\text{age 1 and older for 1972-1975}}{\text{age 2 and older for 1973-1976}}$. The spring value for age 3 and older fish was calculated as

$\ln \frac{\text{age 3 and older for 1973-1976}}{\text{age 4 and older for 1974-1977}}$ and the corresponding autumn value was calculated as

$\ln \frac{\text{age 2 and older for 1972-1975}}{\text{age 3 and older for 1973-1976}}$

Table 12. Recruitment indices of Georges Bank (NAFO Division 5Ze) haddock for the 1963-1983 year-classes.

Year Class	Age 0+1 Index	Rank
1963	8.975	1
1964	0.500	
1965	0.053	
1966	0.602	
1967	0.004	
1968	0.006	5
1969	0.169	
1970	0.003	
1971	0.233	
1972	0.719	
1973	0.255	2
1974	0.066	
1975	3.662	
1976	0.349	
1977	0.046	
1978	2.921	3
1979	0.212	
1980	1.111	4
1981	0.027	
1982	0.086	
1983*	0.661	

*Based on 0 age-group estimate only.

Table 13. Effective effort and catch per unit effort for Canadian otter trawls TC 5.

Year	Total ¹ Landings	CPUE (t/hr)	(%) ²	Effective ³ Effort (hr)	Average F ⁴ for Ages 4 to 6
1968	40923	0.378	(9.9)	108262	0.541
1969	22252	0.347	(17.2)	64127	0.462
1970	11300	0.267	(24.3)	42322	0.262
1971	10862	0.219	(11.4)	49598	0.447
1972	5733	0.169	(4.2)	33928	0.266
1973	5331	0.229	(47.5)	23279	0.491
1974	4290	0.319	(10.8)	13448	0.072
1975	5420	0.265	(16.7)	20453	0.115
1976	4324	0.348	(34.7)	12425	0.136
1977	10843	0.511	(28.1)	21219	0.263
1978	22339	0.402	(2.5)	55570	0.235
1979	19461	0.638	(19.4)	30503	0.263
1980	27571	0.680	(58.8)	40546	0.380
1981	24907	0.487	(25.3)	51144	0.378
1982	17580	0.572	(22.0)	30734	0.446
1983	11876	0.476	(26.0)	24952	0.380

¹Values for years 1974, 1977, 1978 and 1980 were not adjusted for discarding (see Table 5).

²Percent of landings with effort data.

³Effective effort = $\frac{\text{Total landings}}{\text{TC 5 otter trawl catch/hr}}$

⁴Average F's for ages 4-6 based on cohort present in Table 16.

Table 14. 1975-1984 age 3+ numbers from cohort analyses conducted at different levels of terminal F vs the corresponding 2+ numbers per tow from the previous fall NEFC groundfish survey; ln transformed regression results and ln residuals are also indicated; 3+ numbers for 1984 were calculated using $N_t = N_0 e^{-(F+M)}$ where $M = 0.2$, and the partial F for age 2 was 0.16.

Survey year	Cohort year	2+ Survey	Terminal F															
			0.27		0.30		0.35		0.38		0.40		0.42		0.45		0.50	
			Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals	Cohort 3+	ln Residuals
1974	1975	1.03	11675	0.37	11588	0.40	11477	0.43	11424	0.45	11393	0.46	11365	0.47	11328	0.49	11276	0.52
1975	1976	4.59	14050	-0.66	13900	-0.65	13706	-0.63	13614	-0.62	13561	-0.62	13513	-0.61	13448	-0.61	13358	-0.59
1976	1977	1.73	14753	0.18	14537	0.20	14258	0.22	14126	0.23	14048	0.24	13979	0.24	13886	0.25	13756	0.27
1977	1978	17.17	66243	-0.19	65102	-0.19	63637	-0.20	62945	-0.20	62541	-0.20	62176	-0.20	61691	-0.20	61013	-0.20
1978	1979	9.19	48339	0.01	47205	0.00	45749	-0.01	45061	-0.01	44660	-0.01	44297	-0.01	43815	-0.01	43141	-0.02
1979	1980	4.38	34456	0.27	33333	0.26	31893	0.25	31211	0.24	30815	0.24	30456	0.24	29978	0.24	29312	0.23
1980	1981	13.21	50166	-0.25	48099	-0.28	45446	-0.31	44192	-0.33	43462	-0.34	42802	-0.35	41923	-0.37	40696	-0.38
1981	1982	5.68	32714	0.01	30666	-0.03	28038	-0.10	26795	-0.13	26072	-0.14	25417	-0.16	24547	-0.18	23331	-0.22
1982	1983	2.42	20707	0.25	18896	0.18	16571	0.09	15471	0.04	14831	0.01	14252	-0.02	13482	-0.06	12406	-0.12
1983	1984	1.31	13119	0.29	11669	0.20	9809	0.07	8930	0.00	8418	-0.04	7955	-0.09	7340	-0.15	6481	-0.24
Intercept			8.9711		8.9384		8.920		8.8678		8.8530		8.8390		8.8194		8.7900	
Slope			0.8149		0.8218		0.8318		0.8372		0.8406		0.8438		0.8484		0.8554	
r ²			0.8916		0.8959		0.8993		0.8999		0.9000		0.8997		0.8988		0.8966	

Table 15. Partial recruitment vectors developed in this and other studies.

Age	Overholtz et al. 1983	O'Boyle 1983	This study**
1	*	0.12	0.219
2	0.59	0.78	0.460
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9+	1	1	1

*Not established.

**Averaging of historical partial recruitment values for 1975-1979 (after O'Boyle 1983).

Table 16. 1974-1983 year-class numbers at age 1 from cohort analysis conducted at different levels of terminal F vs the age 0 research numbers per two from the previous fall NEFC bottom survey. Regression was performed on ln transformed values.

Survey year	Cohort year	0 no/tow survey	0.00001		0.00005		0.00008		0.0001		0.0002		0.0004		0.0008	
			Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals	Age 1 cohort no.	ln residuals
1974	1975	0.50	7939	0.36	7939	0.44	7939	0.46	7939	0.48	7939	0.51	7939	0.55	7939	0.58
1975	1976	15.76	105437	0.42	105437	0.50	105437	0.52	105437	0.53	105437	0.56	105437	0.60	105437	0.63
1976	1977	2.90	12951	-0.44	12951	-0.36	12951	-0.34	12951	-0.32	12951	-0.29	12951	-0.26	12951	-0.22
1977	1978	0.11	5555	1.11	5555	1.19	5555	1.22	5555	1.23	5555	1.27	5555	1.30	5555	1.34
1978	1979	10.82	81044	0.43	81044	0.51	81044	0.53	81044	0.54	81044	0.58	81044	0.61	81044	0.64
1979	1980	1.08	9556	-0.02	9556	0.06	9556	0.09	9556	0.10	9556	0.13	9556	0.17	9556	0.20
1980	1981	9.56	3781	-2.54	3781	-2.46	3781	-2.44	3981	-2.43	3981	-2.40	3981	-2.36	3981	-2.33
1981	1982	0.31	796	-1.59	796	-1.51	796	-1.49	796	-1.47	796	-1.44	796	-1.40	796	-1.37
1982	1983	0.91	110334	2.55	22068	1.02	13792	0.58	11034	0.37	5517	-0.29	2759	-0.95	1380	-1.61
Intercept			9.1274		9.047		9.023		9.012		8.978		8.942		8.9083	
Slope			0.7309		0.7326		0.7331		0.7334		0.7341		0.7348		0.7356	
r ²			0.6913		0.7564		0.7659		0.7687		0.7697		0.7594		0.7387	

Table 17. Results of cohort analysis based on a terminal F of 0.40 for fully recruited age, 0.18 for age 2 and 0.0001 for age 1.

POPULATION NUMBERS																			27/ 9/84
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	468969	33034	4072	14029	470	1037	4557	336	8736	19610	10542	7939	105437	12951	5555	81044	9556	3781	796
2	155218	374820	18359	3231	10446	378	848	3690	274	7011	13739	8589	6326	86194	10602	4548	66352	7816	3094
3	22735	112663	193032	8839	2493	5843	299	551	1777	223	3879	7339	6097	4752	52849	7992	3700	26275	4822
4	20113	14493	51979	66824	4621	1400	3248	231	249	1047	180	2581	4322	4494	3721	30244	4981	2715	11560
5	27036	12146	7019	25214	36011	2045	741	2143	153	131	508	145	1774	2743	3064	2771	18275	3196	1471
6	16171	14243	5971	3242	11289	16346	1083	438	1493	96	59	353	115	1257	1779	1996	1793	9484	1769
7	5578	7997	5608	2544	1561	6077	7995	693	136	1114	51	47	251	93	706	989	1263	931	5438
8	3304	2683	3134	2481	1185	665	3551	4458	309	41	842	40	35	185	73	452	525	540	463
9	4281	3350	2143	1889	2202	1685	2209	2816	5791	1218	3957	887	967	525	349	217	278	321	549
	723405	575429	291318	128294	70277	35476	24530	15355	18918	30490	33757	27921	125324	113193	78699	130251	106722	55059	29962
	1983	1984																	
1	11034	21541 ⁰																	
2	581	9034 ¹																	
3	1307	397 ¹																	
4	2354	717 ¹																	
5	6323	1292 ¹																	
6	888	3470 ¹																	
7	738	487 ¹																	
8	2906	405 ¹																	
9	316	1595 ¹																	
	26446	38938																	

FISHING MORTALITY																			27/ 9/84	
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.024	0.387	0.031	0.095	0.019	0.002	0.011	0.003	0.020	0.156	0.005	0.027	0.002	0.000	0.000	0.000	0.001	0.000	0.115	0.000 ²
2	0.120	0.464	0.531	0.059	0.381	0.033	0.231	0.531	0.008	0.392	0.427	0.143	0.086	0.289	0.083	0.006	0.726	0.283	0.662	0.180
3	0.250	0.574	0.861	0.449	0.377	0.387	0.061	0.593	0.328	0.015	0.207	0.329	0.105	0.044	0.358	0.273	0.109	0.621	0.517	0.400
4	0.304	0.525	0.523	0.418	0.615	0.437	0.216	0.213	0.445	0.523	0.012	0.175	0.255	0.183	0.095	0.304	0.244	0.413	0.403	0.400
5	0.441	0.510	0.572	0.604	0.590	0.436	0.325	0.161	0.264	0.594	0.165	0.031	0.145	0.233	0.229	0.235	0.456	0.392	0.305	0.400
6	0.504	0.732	0.653	0.531	0.419	0.515	0.247	0.969	0.093	0.424	0.038	0.141	0.010	0.377	0.387	0.258	0.456	0.356	0.674	0.400
7	0.532	0.737	0.615	0.564	0.653	0.337	0.384	0.606	1.003	0.079	0.044	0.100	0.107	0.048	0.245	0.434	0.650	0.499	0.427	0.400
8	0.417	0.590	0.584	0.518	0.542	0.463	0.262	0.448	0.267	0.513	0.072	0.116	0.136	0.264	0.237	0.265	0.385	0.387	0.461	0.400
9	0.417	0.590	0.584	0.518	0.542	0.463	0.262	0.448	0.267	0.513	0.072	0.116	0.136	0.264	0.237	0.265	0.385	0.387	0.461	0.400
	0.094	0.495	0.747	0.422	0.521	0.432	0.247	0.442	0.149	0.236	0.212	0.160	0.023	0.241	0.277	0.101	0.563	0.455	0.458	0.228

NUMBER OF ITERATIONS : 6

⁰From the relationship $\ln/\text{cohort} = 9.012 \times 0.733 \ln 0 \text{ rv}$

¹From $N_1 e^{-z}$

²Rounded off to 0.0001

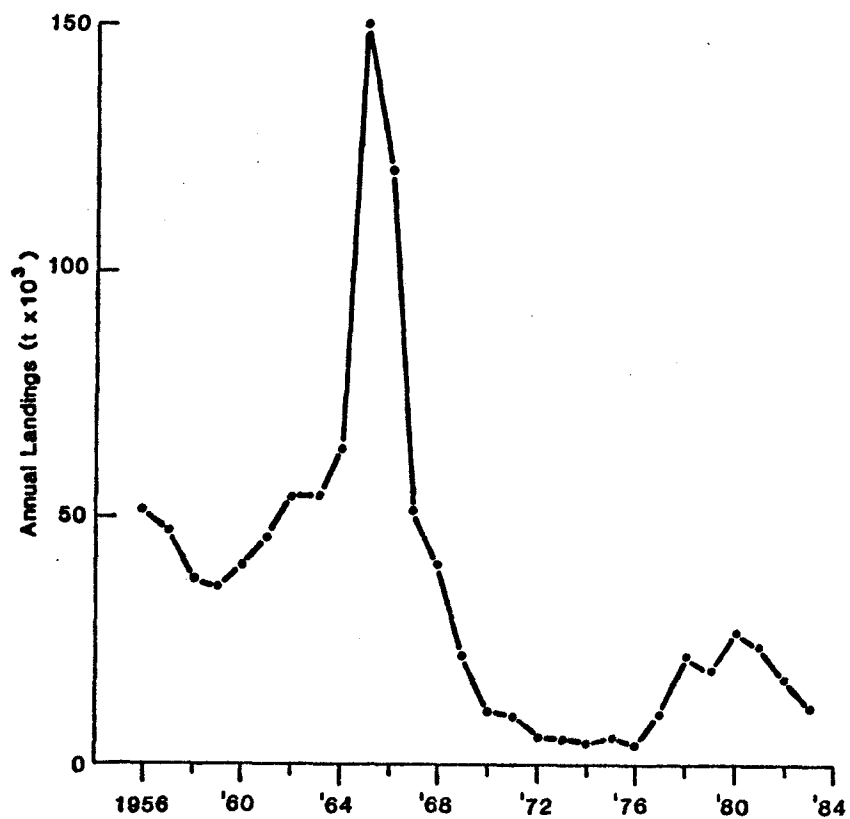


Figure 1. Annual landings (t) by all countries fishing the Georges Bank haddock stock, 1956-1983.

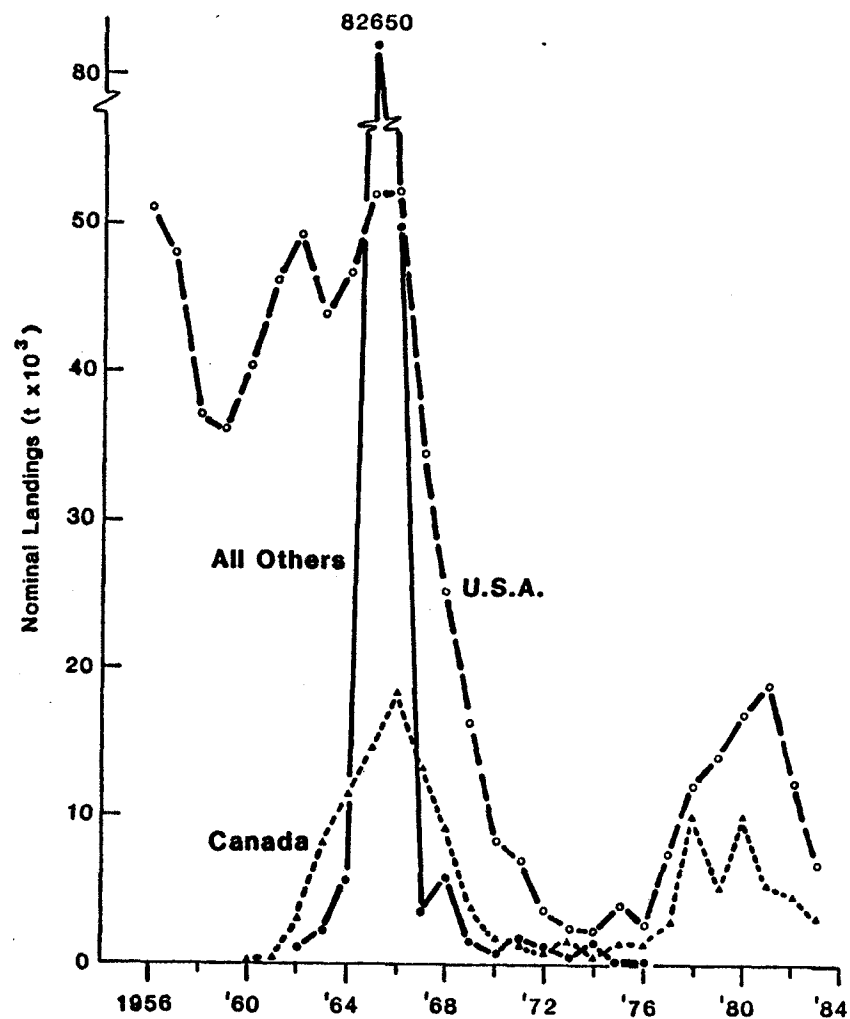


Figure 2. Nominal catches (t) of Georges Bank haddock from 1956-1983.

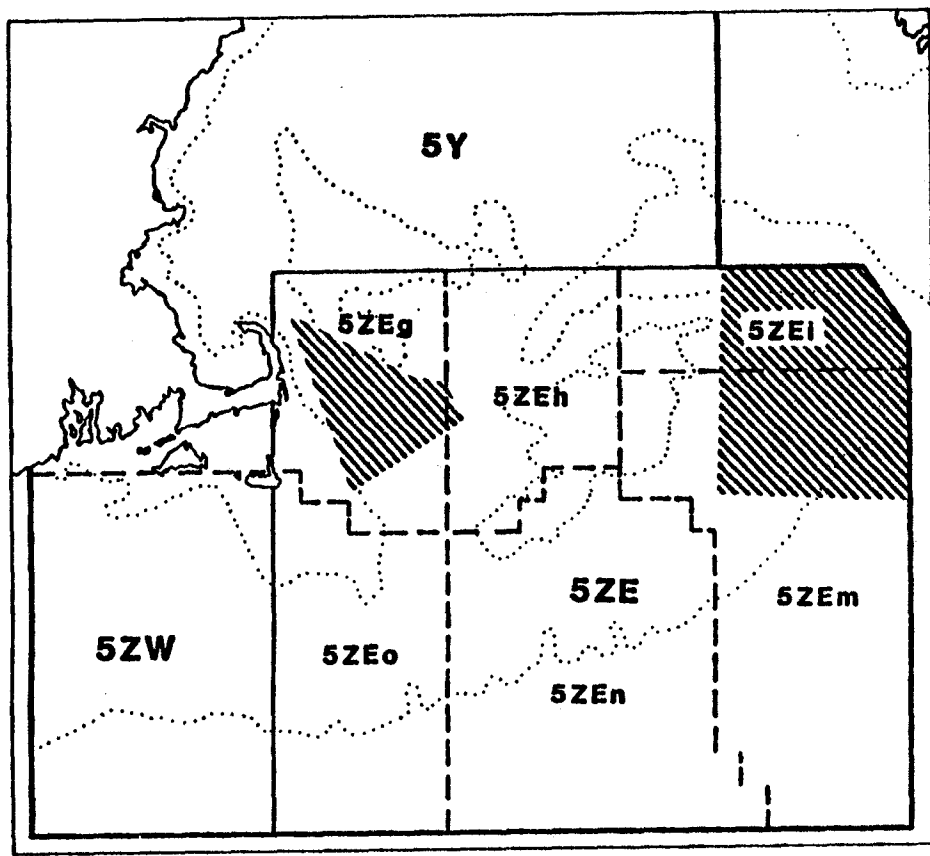


Figure 3. Location of areas seasonally closed to fishing since 1974 to protect haddock spawning on Georges Bank.

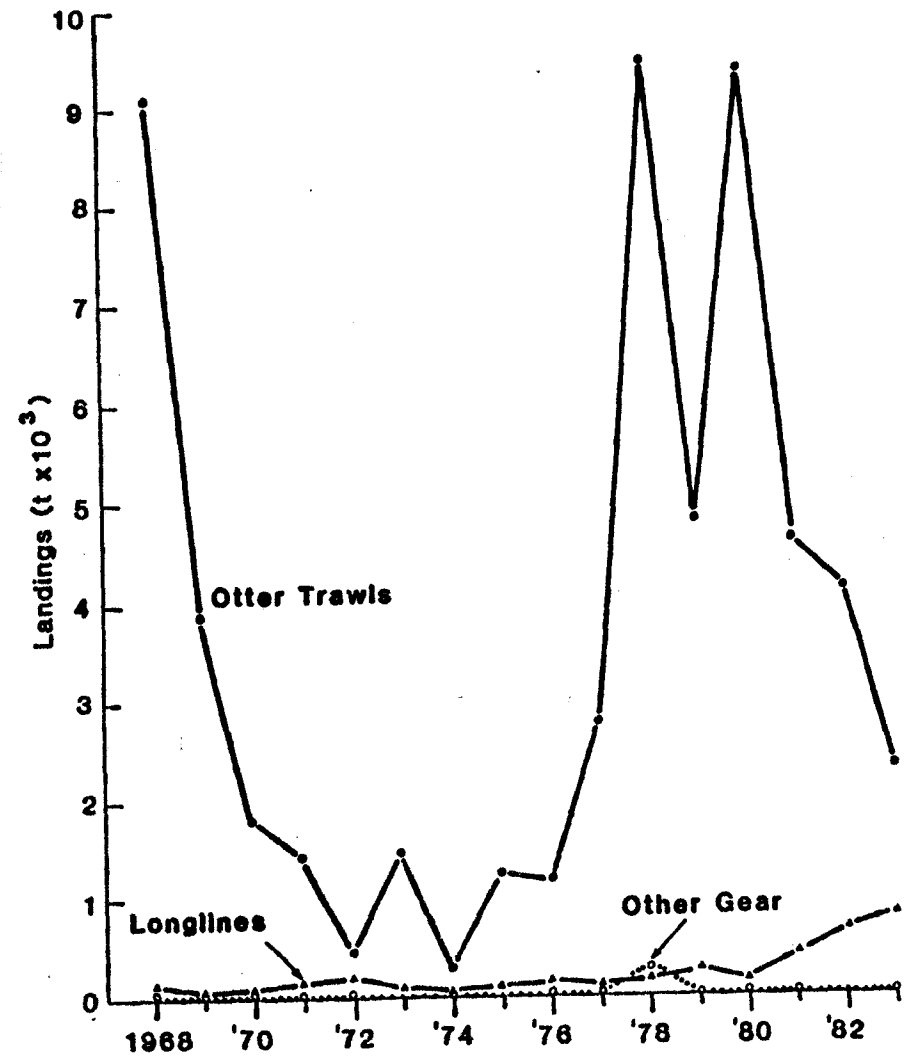


Figure 4. Canadian landings of Georges Bank haddock, by gear type (1968-1983).

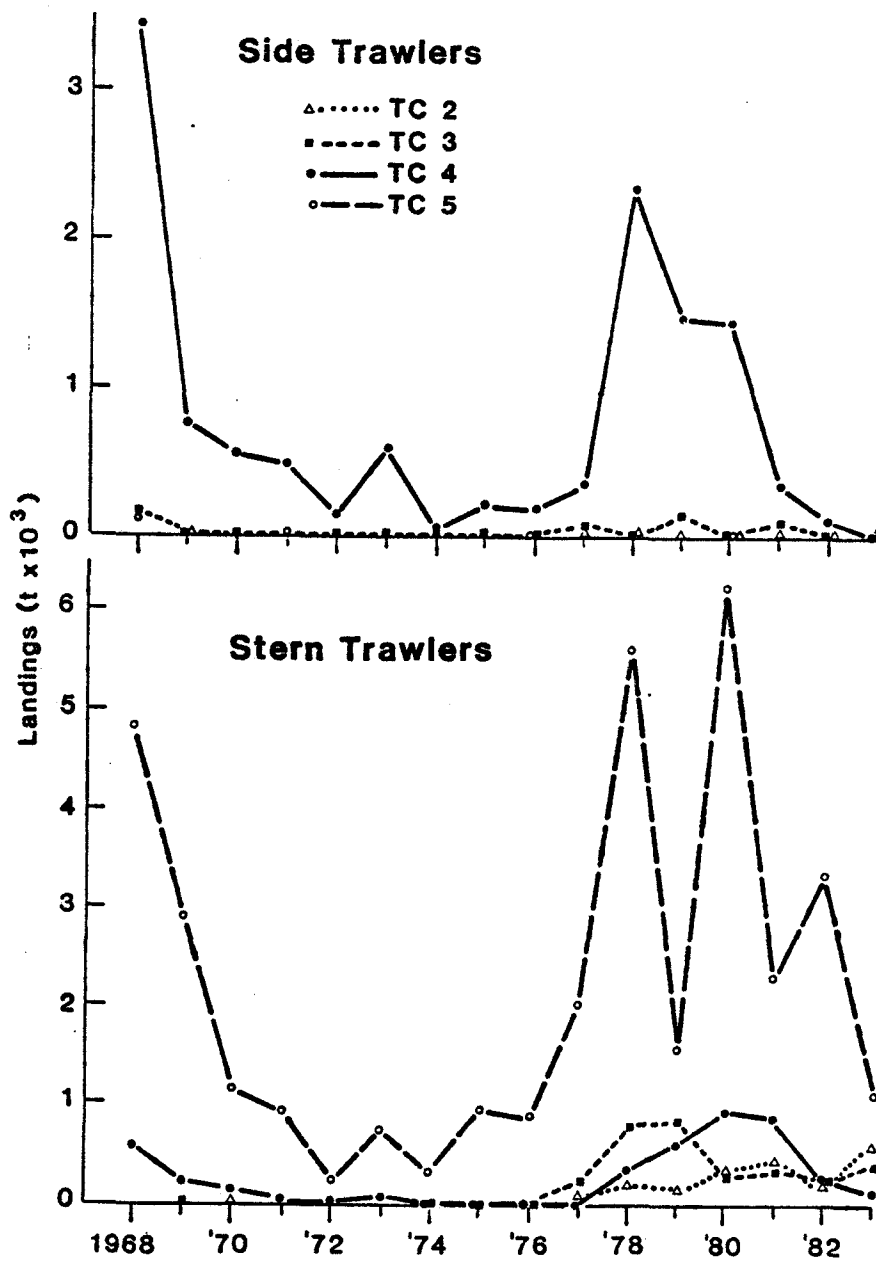


Figure 5. Landings of Georges Bank haddock by Canadian side and stern trawlers, 1968-1983.

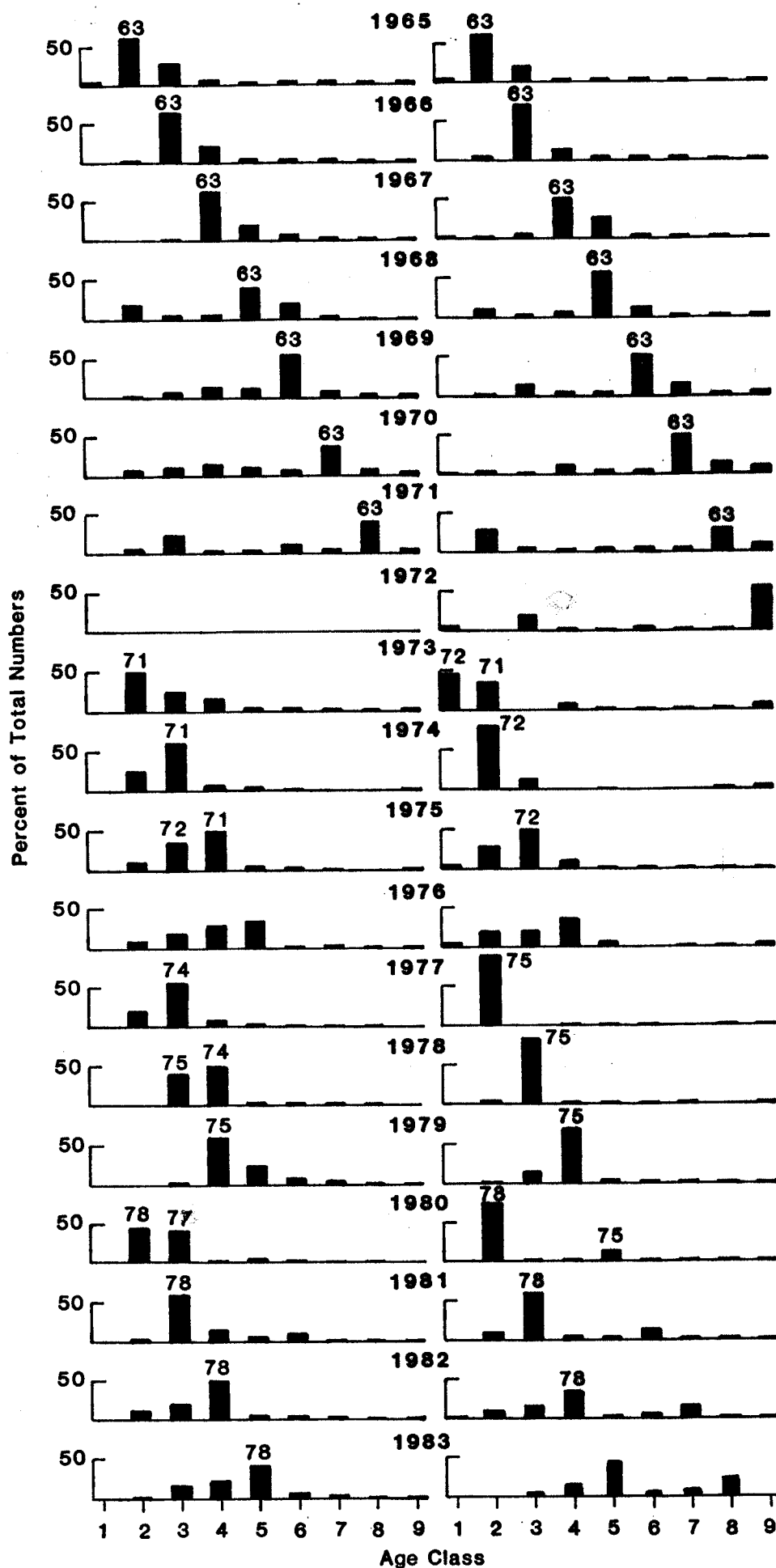


Figure 6. Histograms of percentage age composition of Georges Bank haddock catches, 1965-1983. Canadian data are shown on the left, U.S. on the right.

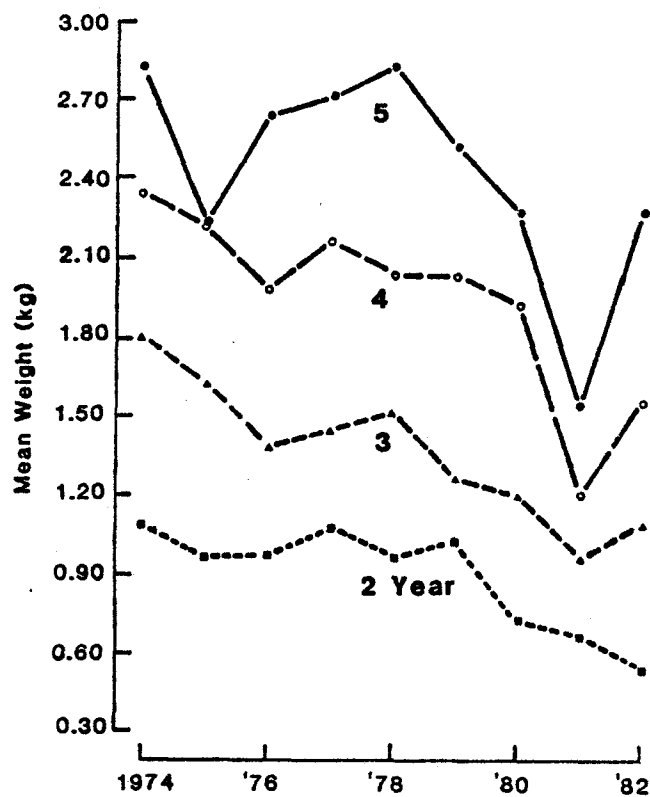


Figure 7. Trends in mean weight-at-age for ages 2-5 Georges Bank haddock, 1974-1982.

Regression equations are:

$$\begin{aligned}
 y &= 121.54 - 0.061(x) & (2\text{-year-olds, } r^2 &= 0.743) \\
 y &= 184.33 - 0.093(x) & (3\text{-year-olds, } r^2 &= 0.874) \\
 y &= 206.67 - 0.104(x) & (4\text{-year-olds, } r^2 &= 0.691) \\
 y &= 167.92 - 0.084(x) & (5\text{-year-olds, } r^2 &= 0.327)
 \end{aligned}$$

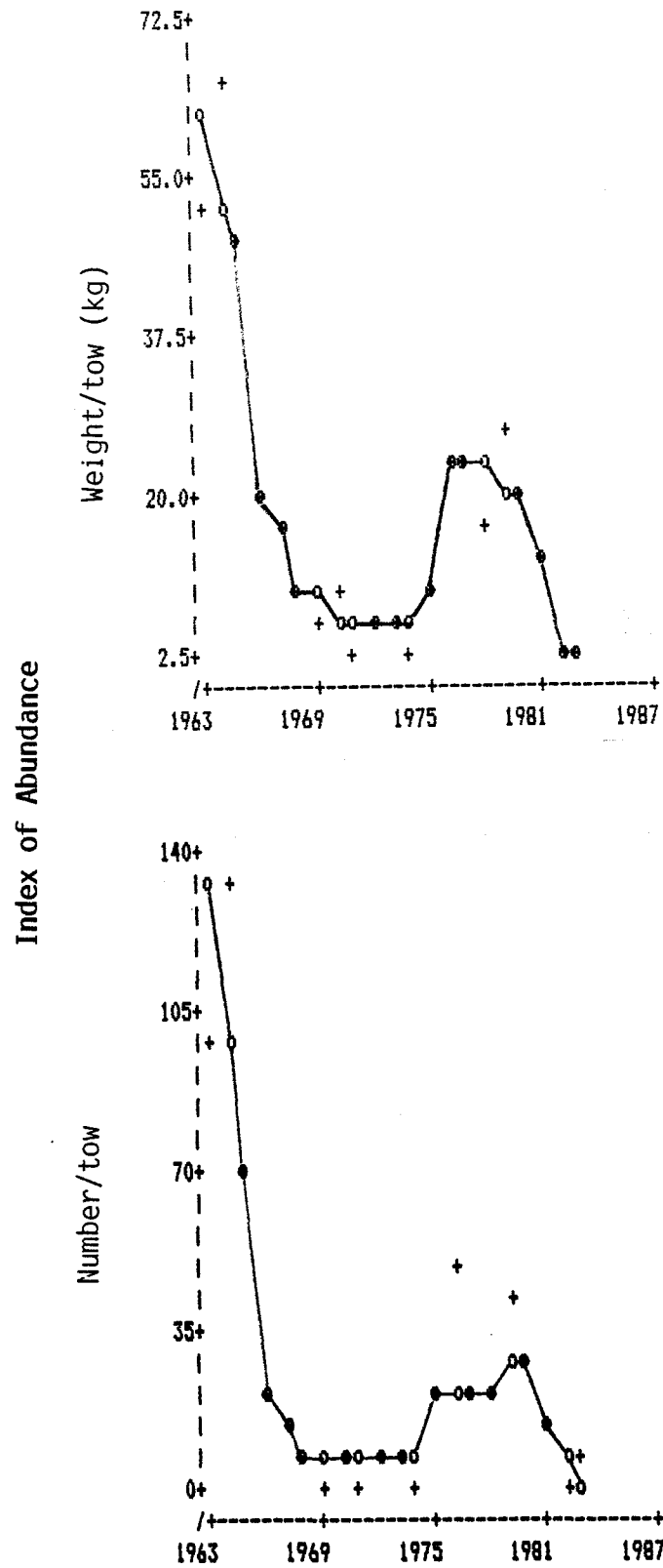


Figure 8. Trends in stratified mean catch (number and weight) per tow of U.S. autumn surveys of Georges Bank during 1963-83. (+ - original data; 0 - smoothed data, using running medians of 3's)

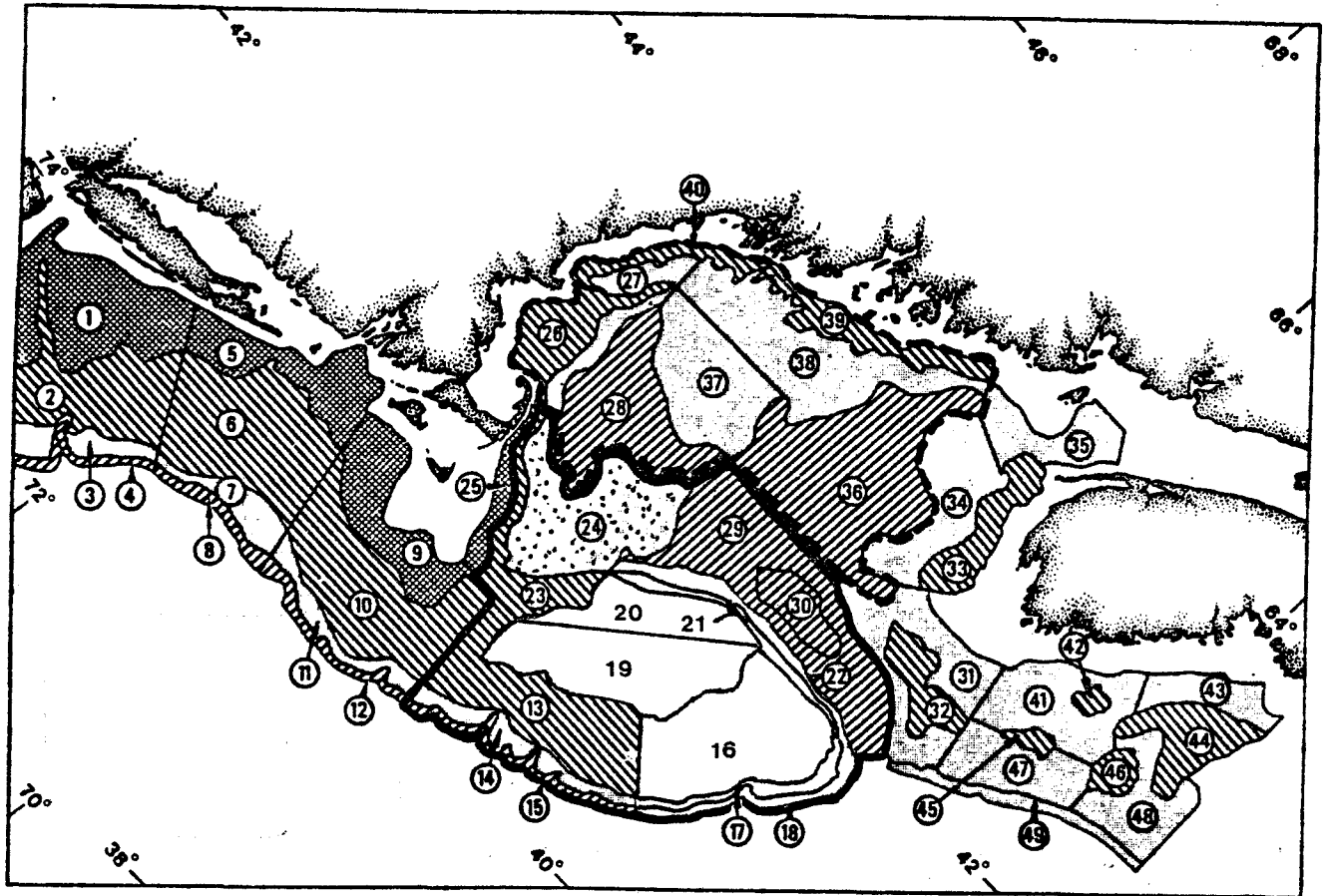


Figure 9. Stratification scheme used for bottom-trawl surveys of Georges Bank. The area outlined includes strata covered by the U.S. groundfish surveys and the area with no shading (strata 16-22) indicates the region covered by the Canadian survey initiated in March 1984.

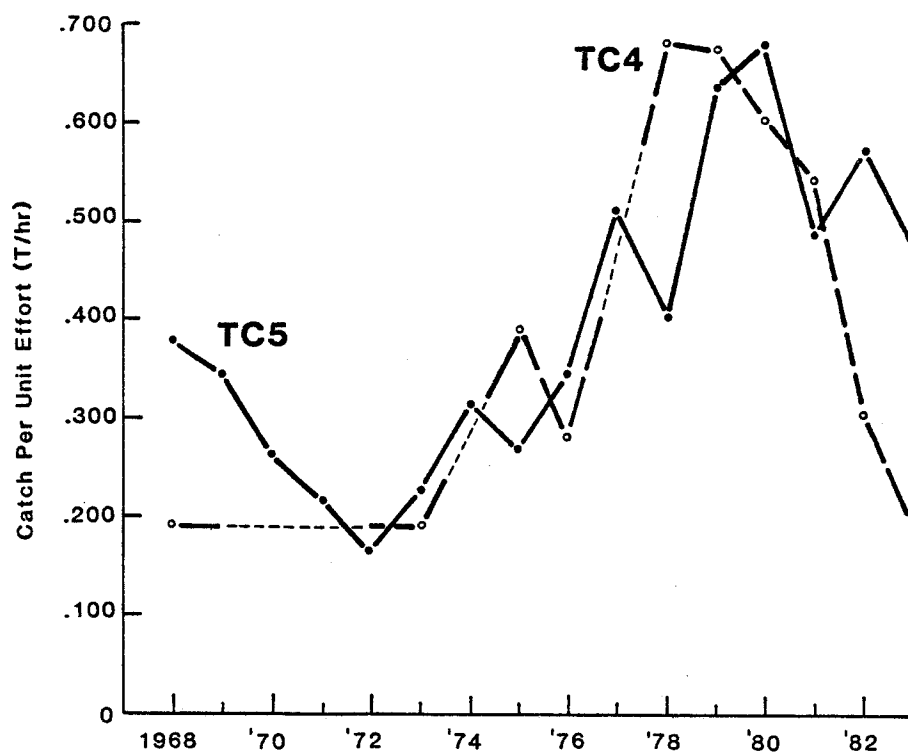


Figure 10. The trend in catch-per-unit effort of Georges Bank haddock by Tonnage Class 4 and 5 stern trawlers, 1968-1983.

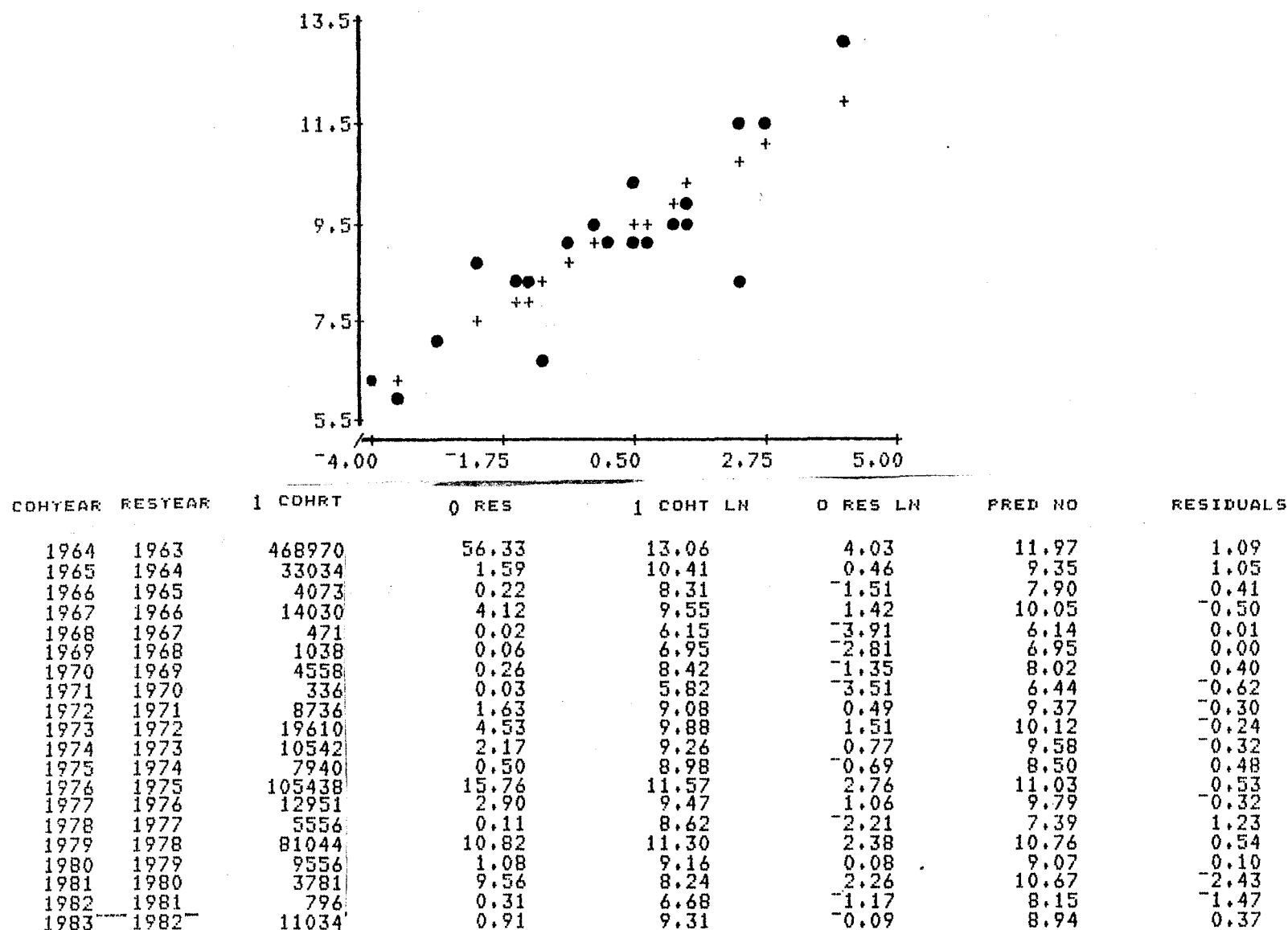


Figure 11. Relationship between \ln numbers for ages 3+ from cohort analysis (Y axis) vs. \ln numbers for ages 2+ from the fall U.S. groundfish survey (X axis). Summary table indicates untransformed, transformed, predicted and residual values (observed-predicted). Cohort analysis was conducted with terminal F's on fully recruited ages of 0.40, $m = 0.2$ and catch-at-age values from Overholtz et al. (1983).