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An evaluation of the 5Ze haddock population characteristics during the 1963-82 period with yield projected to 1984

by

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Abstract

Annual landings of haddock from NAFO Division 5Ze averaged 46,000 t during 1935-60 with the USA being the main exploiter, although several countries took significant catches in the 1960's. Catches rose to a peak of 150,000 t in 1965 and subsequently declined due to poor recruitment to a low of 4,000 t in 1974. Nominal catch increased to 27,571 t in 1980 but declined again to 18,000 t in 1982.

The reported landings during 1976-79 are probably considerable underestimates of actual catches due to misreporting and discarding in the USA fishery. Thus little reliance can be put on these figures.

Canadian otter trawler catch rates from 1980 to 1982 were approximately twice those observed during 1969-71 when the stock biomass was at its lowest observed level. USA fall research survey abundance indices indicate that the stock biomass rose from a minimum in 1970-74 to a plateau in 1977-80 and has declined thereafter. These surveys also indicate that recent recruitment has been poor, being lower than the long-term average. In fact, since 1977, the fishery has been sustained by only the 1975 and 1978 year classes.

Estimated removals-at-age data for 1976 to the present are unreliable due to the under-reporting of catches. Consequently sequential population analysis was performed on the 1963-75 catch-at-age data and calibrated using the USA fall survey information. The derived calibration factors were then used to estimate 1980-82 population size based on survey catch per tow in recent years. The fully recruited fishing mortality required to take the catch from the 1982 estimated population size was 0.2.

Using the relationship between F and fishing effort for the 1963-75 period, a fishing mortality of 0.27 was calculated corresponding to the 1982 effort calculated from Canadian otter trawler catch rates.

Projections at the two different estimates of F in 1982, using the 1982 partial recruitments and weights-at-age and assuming a 1982 catch of 18,000 t, indicate that the catch in 1984 corresponding to $F_{0.1}$ = 0.25 probably lies in the range of 15-20,000 t.

Résumé

Les débarquements annuels moyens d'aiglefin de la div. 5Ze de l'OPANO ont été de 46 000 t en 1935-60, les E.-U. étant les principaux exploitants, bien que, dans les années 1960, plusieurs pays y aient fait d'importantes pêches. Les prises augmentèrent à un sommet de 150 000 t en 1965 pour ensuite diminuer, par suite d'un mauvais recrutement, à 4 000 t en 1974. Les prises nominales augmentèrent à 27 571 t en 1980, mais diminuèrent de nouveau à 18 000 t en 1982.

Les débarquements signalés en 1976-79 sous-estiment probablement de beaucoup les prises réelles à cause de déclarations inexactes et du rejet de poissons à la mer par les bateaux américains. On ne peut donc pas beaucoup se fier à ces chiffres.

Les taux de capture des chalutiers canadiens entre 1980 et 1982 ont été approximativement le double de ceux observés entre 1969 et 1971, alors que la biomasse du stock était à son plus bas niveau jamais observé. Les relevés d'automne par les navires de recherche américains indiquent une augmentation de la biomasse du stock, depuis un minimum en 1970-74 à un plateau en 1977-80, pour ensuite diminuer. Ces relevés indiquent également que le récent recrutement a été pauvre, inférieur à la moyenne à long terme. En fait, depuis 1977, la pêche a été alimentée seulement par les classes d'âge de 1975 et 1978.

Les estimations de prises par âge entre 1976 et nos jours ne sont pas fiables, à cause de déclarations inexactes. Nous avons donc effectué une analyse de population séquentielle avec les données sur les prises par âge de 1963-75 et calibré à l'aide des données des relevés d'automne par les E.-U. Les facteurs de calibrage ainsi obtenus ont été ensuite utilisés pour estimer l'effectif de la population en 1980-82 à partir des prises par trait des relevés des récentes années. La mortalité par pêche au plein recrutement requise pour prélever la récolte à même la population estimée de 1982 est de 0,2.

En se fondant sur la relation entre F et l'effort de pêche durant la période de 1963-75, on a calculé une mortalité par pêche de 0,27 correspondant à l'effort de 1982 calculé à partir des taux de capture des chalutiers canadiens.

Utilisant la relation entre les deux estimations différentes de F en 1982, ainsi que les recrutements partiels et les poids par âge de 1982, et en supposant des prises de 18 000 t en 1982, on voit que les prises de 1984 correspondant à $F_{0,1} = 0,25$ se situent probablement entre 15 000 et 20 000 t.

Introduction

Under the auspices of ICNAF, evaluations of the Georges Bank haddock stock size were conducted in 1969 (Hennemuth, 1969), 1975 (Clark, 1975), and 1976 (Clark, 1976). 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).

A variety of techniques have been used to establish current 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 the latter years precluded the use of VPA (Clark and Essig, 1980). Thus historical relationships between survey indices and VPA results were applied to current survey results to predict stock size. This method was used in 1981 and 1982. The exact form of the relationship varied from one assessment to another. The 1982 assessment also employed a modification of the Delury Method (Collie and Sissenwine MS, 1982).

All recent assessments point towards a stock with low recruitment in recent years and a population age structure dominated by one or two age groups.

The present assessment uses data provided in the NMFS documents. The techniques used are similar to those employed previously. Only the details are different.

Stock Structure

A complete review of the literature on the Georges Bank stock structure is provided by Clark et al. (1982b). The major points will be presented here.

There is evidence suggesting two and possibly three stocks of haddock in the Georges Bank-Gulf of Maine region. One inhabits Georges Bank east of 69° while the other two reside in the Nantucket Shoals-western Gulf of Maine Area. Available data do not permit evaluation of the degree of intermixing among these stocks. However, it appears during the adult phase, that the Georges Bank population is relatively isolated, from other haddock populations in the surrounding areas. These observations are based on tagging (Needler, 1930; Schroeder, 1942; Halliday and McCracken, 1970; McCracken, 1960; Grosslein, 1962; Bigelow and Schroeder, 1953), age composition, growth analyses (Needler, 1930; Schuck and Arnold, 1951) and analyses of meristics (vertebral count) (Clark and Vladykov, 1960).

Ichthyoplankton data generally confirm the discreteness of the Georges Bank stock (Grosslein, 1962; Colton and St. Onge, 1974; Colton, 1965; Posgay and Marak, 1970). However, Grosslein and Hennemuth (1973) observed a fair degree of year class strength synchrony among stocks on Georges Bank, in the Gulf of Maine and on Browns Bank suggesting that some interchange, such as larval drift, may exist.

For the present assessment, the haddock exploited on Georges Bank are taken to be a discrete stock. This encompasses haddock caught in statistical unit areas 5Zeh, 5Zej, 5Zem, and 5Zen (Figure 1), which are subsets of NAFO subdivision 5Ze. Catch statistics prior to 1968 are reported in 5Z only (5Ze and 5Zw combined); data on a unit area basis are not readily attainable. This analysis assumes all 5Z haddock landings belong to the Georges Bank stock. This bias is unestimatable.

Management History

Prior to 1951, Georges Bank, like the rest of the Northwest Atlantic, was part of the high seas. ICNAF was established in 1951 and evaluations of stock yield were made in that organization until 1977, at which time the USA withdrew. Since that time, management of the resource has been an issue before the New England Regional Fishery Management Council (NERFMC) and with the Canadian Department of Fisheries and Oceans (DFO). Both countries are in jurisdictional dispute over the ownership of the bank, thus no true joint management of the resource, as was the case under ICNAF, has been in effect since 1977.

Under the auspices of ICNAF a variety of regulations were implemented that enhanced the stock's production. The first major regulation was the imposition of the 114 mm codend mesh size in 1953. This was increased to 130 mm in 1974. These regulations substantially reduced discarding.

The entry of the foreign fleets into the fishery during the mid-1960's heavily contributed to near stock collapse and thus led to the imposition by ICNAF, from 1970 onward, of an annual Total Allowable Catch (TAC). Closed areas were also imposed to protect the spawning aggregations.

Since 1977, Canada and the USA have followed different management routes. During 1977-1981 the NERFMC continued with the ICNAF regulations and added some of its own. A series of fisheries management plans (FMP) were tabled which attempted to both optimize stock yield and meet the demands of industry. The dissatisfaction of the latter resulted in a whole new FMP being put into effect in

April, 1982. Quotas were lifted but minimum size, mesh, and closed area regulations were maintained. In essence, the new plan represents an attempt to regulate effort but not catch.

Canada has not pursued an active management policy for the Georges Bank haddock stock since 1977. Management has primarily consisted of an extension of the catch and effort regulations into the 5Ze area. However, the condition of the resource has prompted Canada to undertake a more in-depth evaluation of the situation.

The Landings

Annual Trends

Prior to 1900, haddock were not as commercially important as cod, due to the inferior salting properties of the former. During 1880-1903, annual landings averaged 24,500 t. Until the 1920's catch trends were determined primarily by the fresh fish market. However during the 1920's, change in consumer preference, the introduction of filleting and quick-freeze techniques as well as changes in vessel and gear technology resulted in dramatic increases in landed catch. A peak of 115,500 t was reported landed in 1929 but this subsequently fell to about 26,000 t in 1934, due to declining catch rates. Nominal catches during the 1935-60 period remained relatively constant (Figure 2), with the annual catch averaging about 46,000 t. During this period, exploitation was almost entirely by the USA vessels operating out of New England.

During the 1960's, the addition of fishing effort by the Canadian otter trawler fleet and the European distant water fleet resulted in a sharp increase in catch followed by pronounced declines in stock abundance and productivity. Canada first entered the fishery in 1960 (Table 1) while Soviet participation commenced in 1962. Soviet catches peaked at 81,882 t in 1965 and dropped off dramatically thereafter as effort was directed on other species. The last Soviet catches were reported in 1976. Spain and a number of other European countries were involved in the fishery during the 1964-76 period. Canada and the US are presently the only participants in the exploitation of this resource.

Since 1977, annual landings have averaged about 20,000 t. An interim peak of 27,571 t in 1980 has been followed by a decline to 18,000 t in 1982. During this period, about 30% of the catch was taken by Canada and the rest by the USA.

Canadian effort has been mostly expended in unit areas 5Zej and 5Zem whereas US effort has covered all six unit areas composing NAFO Subdivision 5Ze. A fair degree of US effort has been expended in unit area 5Zeg. This may be directed toward a different stock but data are not available for further catch breakdown.

Since 1976, actual USA catches have been much higher than those reported (Clark et al., 1982a & 1982b, MS 1981). Interview data (corroborated by other industry sources) indicate that, due to the regulations imposed by the Groundfish FMP, substantial amounts of scrod[1] and snapper[1] haddock were routinely discarded and/or misreported as other species. The total amount involved appears to have been substantial, particularly in 1977 and 1980 when the strong 1975 and 1978 year classes recruited to the fishery (Clark et al. 1982b, MS 1981).

Canadian Landings by Gear and Tonnage Class

Canadian fishing effort was and is mainly expended by the otter trawler fleet operating out of Nova Scotia (Table 2). Activity by longliners has been relatively low but increasing since 1980.

Within the otter trawler fleet, the highest landings have been from the tonnage class 5 stern trawlers (Table 3). However, since 1977, catches by the tonnage class 2 and 3 vessels operating out of southwest Nova Scotia have dramatically increased. Landings by the side trawlers are declining due in part to the phasing out of this method of fishing.

Age Composition of the Landings

Sampling Intensity

Canadian sampling (1968-82) has, for the most part, been confined to otter trawlers (Table 2). Prior to 1976, total sampling was sparse but has picked up considerably since that time. Within the otter trawl fleet, only tonnage classes 4 and 5 were sampled.

Sampling of catches by the distant water fleet has been very low. This is unfortunate as this fleet was using small mesh gear (40 mm mesh codend liners).

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[1] By convention, "large" haddock are those weighing more than 1.1 kg (gutted weight); "scrod" haddock range from 0.5 to 1.1 kg. "snapper" haddock average 0.5 to 0.8 kg in commercial landings and are often discarded.

Construction of Catch-At-Age Matrix

The commercial catch-at-age (Tables 4 to 6 and Figure 3) data were taken from Clark et al. (1982a; 1982b).

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, USA sampling information was used exclusively except for 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 compositons 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 USA 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 USA 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, catch-at-age was estimated by applying these length frequencies to the appropriate monthly catch, combining over quarter and applying the appropriate USA survey age-length key. Only in 1966 and 1973 were true USSR length frequencies used to determine age-size composition.

The overall catch-at-age was obtained by combining the large and small mesh gear age-composition matrices.

The Catch-At-Age Matrix

The most notable feature of the fishery is its continued dependence on one or two year classes. From 1965-72, the 1963 year class dominated landings in weight (Table 6a) and numbers (Table 6b). The 1970 and 1971 year classes made some contribution following the demise of the 1963 year class. The 1972 year class supported the fishery until 1976. Then the 1975 year class took over. By 1980 it too had been fished out and the 1978 year class was sustaining the fishery (Figure 3).

The available Canadian sampling data applied to the Canadian landings from 5Ze creates a catch-at-age matrix that is less definitive than the US in its overall description of the fishery (Table 7). The year class strengths are more spread out among the population. There are many pattern differences between the estimated age composition tables (Tables 6a and 7) specifically for 1969, 1970, 1973, 1975, 1977-1979. According to the Canadian sampling, the 1982 fishery is dominated by the 1978 year class followed by the 1979 year class.

There may be a number of reasons for these differences. First, Canadian vessels are operating in only a small area of Georges Bank and are truly exploiting the resident stock. US vessels operate throughout 5Z and sampling may include data from other stocks. Second, during the 1977-80 period high discarding by vessels of both nations (Clark et al., 1981) would add much noise to the data. Third, Canadian and US ageing procedures are different for haddock and could, although unlikely, result in differences.

For the present assessment, the US age-size composition was taken as reflective of the landed catch. No adjustments were made to compensate for the high discarding reported to have taken place during the 1977-1980 period.

Stock Abundance Trends

US Bottom Trawl Surveys Catch Per Tow

Stratified random design bottom trawl surveys have been run by NMFS in the autumn of each year since 1963. Summer surveys have been run sporadically since 1963 while spring surveys have been conducted since 1968. The Yankee 36 trawl was used on all surveys except for spring 1973-present when a modified Yankee 41 trawl was deployed.

Generally, the trends in stock abundance agree for all three survey series (Table 8). The relatively high stock size in 1963 declined dramatically to exceptionally low values during the 1968-1974 period (Table 9, Figure 5). Numbers declined before biomass due to the size of the 1963 year class. Both biomass and numbers increased from 1975-1978. Biomass started to decline in 1978 and, according to the 1982 survey results, continues to decline. Numbers started to decline in 1980 (Figures 5 and 6) and, from the 1982 survey, appear to be at the 1968-1974 level.

Recruitment Indices

The degree of recruitment of each age group to the survey was determined by examining the relationship between the catch rate of successive ages on a cohort by cohort basis. The age 0 to 4 catch rates could be used to develop recruitment indices (Figure 7). Since substantial fishing mortalities occur at ages 2 and above (Clark et al., 1982b) the age 0 and 1 catch rates were chosen for the development of an index.

The index was derived as follows: first the yearly age 0 and 1 catch in numbers per tow were normalized to the 1963-81 mean to make the survey catch rates relative and thus adjust for partial recruitment to the survey gear. Next the age 0 and 1 normalized estimates for each cohort were averaged. This index is provided, along with that of Grosslein (Clark et al., 1982a) in Table 11 and illustrated in Figure 8. In order of size, the five top year classes during 1963-80 are those of 1963, 1972, 1975, 1978, and 1980.

The Grosslein index predicted a much larger 1980 year class. This year class was abundant in the surveys at age 0 and less so at age 1. The Grosslein index depends heavily on the age 0 estimate which might explain the difference observed.

It is worthwhile to note that recruitment to this stock seems periodic with strong year classes occurring about every three years (Figure 8). Following this pattern one would predict the 1981 year class to be good. Unfortunately it appears to be very weak (Table 8) and indeed the autumn 0 group catch rate in 1981 was one of the lowest in the series. Clark et al. (1982a) states that MARMAP ichthyoplankton surveys indicate that the 1982 year class may also be weak. Thus at present the 1979, 1980, 1981 and 1982 year classes all appear to be weak.

Commercial Catch Rates

Two commercial catch rate series were developed, both for the Canadian otter trawl fishery operating on Georges Bank during June-September. The first describes the catch rates for the tonnage class 4 side trawlers while the second depicts the tonnage class 5 stern trawler catch rates (Table 10 and Figure 9).

Both series indicate relatively low catch rates in the late 1960's - early 1970's, followed by increases to the present. This is in general agreement with the trend in the age 2+ stratified mean catch (no.) per tow from the US autumn survey (Figure 6).

Determination of 1982 Population Size

Sequential Population Analysis for 1963-1975

A sequential population analysis for the 1963-82 period could not be undertaken due to uncertainties in the reliability of the 1976-79 catch data. Thus the strategy taken here was to conduct a cohort analysis for the 1963-75 period, tuned with the autumn survey data, to develop population size-abundance index relationships which could be used with the current abundance indices to predict the current population size. The approach is very similar to that employed by Clark et al., (1982b). However this analysis uses both survey and commercial catch rate series to provide an estimate of the 1982 population size.

Three relationships were chosen to tune the cohort analysis:

1. ℓn age 1 population numbers from cohort analysis versus ℓn year class strength index.

2. ℓn age 2 population numbers from cohort analysis versus ℓn year class strength index.

3. ℓn age 3+ population numbers in year t+1 from cohort analysis versus ℓn age 2+ survey numbers per tow in year t.

Age 8 and 9+ fishing mortalities were recalculated as the arithmetic average of the age 4 to 6 values whenever the 1975 fishing mortalities were changed. Starting conditions were obtained from Clark et al., (1982b). The only adjustment was to the age 3 fishing mortality in 1975 when it was determined from the relationships that the size of the 1972 year class at age one was being underestimated.

The final cohort analysis results are given in Table 12. The results of the tuning relationship are provided in Table 14 and Figure 10. All relationships were highly significant ($P < 0.05$).

An additional relationship was developed for the commercial catch rate data. First the total annual catch for the 1968-75 period was divided by the tonnage class 5 stern trawler catch rate for each year to provide an estimate of the effective effort. This was regressed against the average fishing mortality for ages 4 to 6 of each year of the cohort analysis (Table 13). Except for the 1968 and 1973 points, the relationship (Figure 11) was extremely good with a relatively high r^2 (Table 14).

Estimation of 1982 Partial Recruitment

Two partial recruitment series were calculated using the cohort analysis results (Table 12). The first was the average pattern observed over the 1963-69 period while the second summarizes the 1970-75 pattern (Table 15). In both series, full recruitment occurred at age 3. In later years recruitment at age 2 appears to have been generally higher than seen historically. The 1970-75 partial recruitment pattern compares favourably with that provided by Clark et al., (1982a). In the absence of more complete information on the recent fishery, the 1970-75 vector was used in the determination of the 1982 population size and the yield calculations.

Determination of 1982 Population Size and Structure Using Survey Data

Using the three survey relationships provided in Table 14 along with the autumn survey abundance indices given in Table 8, population numbers for ages 1, 2 and 3 plus were estimated for 1980 to 1982. The age 3 to 9+ population numbers at age was further obtained by breaking down the age 3+ estimate across age groups using the 2+ age composition of the autumn survey in the previous year (Table 16).

Three independent estimates of the 1982 population structure were obtained as follows: the 1980 estimates were projected to 1982 using the reported annual landings, the 1979 weights at age and the 1970-75 partial recruitment vector; a similar projection was done with the 1981 population estimate. The resulting estimates for 1982 (Table 17) exhibit a high degree of variability, particularly for ages 4 (1978 year class) and 7 (1975 year class). These have been the largest two year classes in recent years.

The arithmetic mean of the three estimates provides a 1982 estimated population structure based on survey data (Table 17). This vector, considered along with the weights at age and the 1982 reported landings, translates to a fully recruited fishing mortality of 0.2 in 1982.

The use of the survey data provides an opportunity to compare year class size and estimates for 1966 to 1980 from this assessment with those presented previously (Tables 18 and 19).

From a year class size point of view, the present evaluation is more optimistic than that of Clark et al., (1982a; 1982b) but more pessimistic than earlier evaluations. A similar statement can be made regarding the population size. The 1982 population size presented here is about 37% higher than that provided by Clark et al., (1982a; 1982b). Nevertheless, the numbers are very low and this evaluation is in general agreement with earlier ones, providing a rather pessimistic view of the resource.

Determination of 1982 Fishing Mortality Using Commercial Catch Rate Data

A second estimate of the 1982 fishing mortality was obtained through use of the cohort analysis derived fishing mortality effective effort relationship and the 1982 calculated effective effort. A value of 0.267 was obtained which is substantially higher than that derived from the survey data.

Yield-Per-Recruit and Projection

A yield-per-recruit analysis using the 1979 weights at age, the 1970-75 partial recruitment vector and a natural mortality of 0.2 provides an $F_{0.1}$ of 0.26 and an F_{max} of 0.47. The former is the same as that derived by Clark et al., (1982b). Thus the population is presently being exploited either at or below $F_{0.1}$.

Yield to 1984 was projected using the population estimates derived from the survey data. Recruitment was set at the geometric mean of the 1975-82 age one estimates based on the survey data. The fishing level in 1982 was set at 18,000 t while $F_{0.1}$ was taken for 1983 and 1984. The input parameters for the projection are given in Table 20.

Assuming a fully recruited fishing mortality of 0.2 in 1982, yield in 1983 and 1984 should not exceed 20,000 t (Table 21). If the 1982 fishing mortality is nearer to 0.27, the yield in upcoming years should be closer to 15,000 t. The range of yields provided by the most recent U.S. evaluation (Clark et al., 1982a) is 10 - 15,000 t (Table 22). Thus the present evaluation is more optimistic but both are pessimistic relative to the historical situation. In addition, the poor incoming recruitment indicates that yield cannot be expected to increase substantially within the next five years.

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Table 1. Nominal catches (t) of haddock from Georges Bank[1] for 1956-82[2].
(--- no fishing activity, - no TAC)

YEAR	USA	CANADA[6]	USSR	SPAIN	OTHERS[3]	TOTAL	TAC
1956	51144	---	---	---	---	51144	-
1957	48561	---	---	---	---	48561	-
1958	37322	---	---	---	---	37322	-
1959	36051	---	---	---	---	36051	-
1960	40800	77	---	---	---	40877	-
1961	46384	266	---	---	---	46650	-
1962	49409	3461	1134	---	---	54004	-
1963	44150	8379	2317	---	---	54846	-
1964	46512	11625	5483	2	464	64086	-
1965	52823	14889	81882	10	758	150362	-
1966	52918	18292	48409	1111	544	121274	-
1967	34728	13040	2316	1355	30	51469	-
1968	25469	9323	1397	3014	1720	40923	-
1969	16456	3990	65	1201	540	22252	-
1970	8415	1978	103	782	22	11300	12000
1971	7306	1630	374	1310	242	10862	12000
1972	3869	609	137	1098	20	5733	6000
1973	2777	1563	602	386	3	5331	6000
1974	2396	462	109	764	559	4290	-
1975	3989	1358	8	61	4	5420	6000
1976	2904	1361	4	46	9	4324	6000
1977	7934	2909	---	---	---	10843	10500
1978	12160	10179	---	---	---	22339	20000
1979	14279	5182	---	---	---	19461	-
1980	17470	10101	---	---	---	27571	-
1981	18891	5720	---	---	3	24614[4]	-
1982	12567	4775	---	---	---	17342[5]	-

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

[2] Data Sources ICNAF (1956-1978), NAFO (1979-1982).

[3] Bulgaria, Cuba, Feberal Republic of Germany, Franch, German Democratic Republic, Ireland, Ireland, Japan, Poland, Romania, and United Kingdom.

[4] Provisional (incomplete).

[5] Overholtz, W. et al., 1983 (preliminary).

[6] Landings in the Maritimes, Quebec and Newfoundland

Table 2. Nominal catches (t)[1] of haddock caught by Canadian (Maritimes and Quebec) fishing vessels on Georges Bank (NAFO Subdivision 5Ze) during 1968-1982. Numbers in parentheses indicate number of samples taken by DFO personnel.

YEAR	GEAR: OTTER TRAWLERS	GEAR: LONGLINERS	GEAR: OTHER	TOTAL
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)	430(2)	2	5070
1982	4150(17)	685	0	4835

[1] Excludes catches by tonnage class one vessels.

Table 3. Nominal catches (t) of haddock caught by Canadian (Maritimes and Quebec) otter trawlers on Georges Bank (NAFO Subdivision 5Ze) during 1968-1982. (--- no landings)

YEAR	SIDE OTTER TRAWLERS T.C. 2	3	4	5	STERN OTTER TRAWLERS T.C. 2	3	4	5
1968	---	173	3463	117	---	---	579	4836
1969	1	7	791	---	---	1	225	2927
1970	---	24	551	---	2	---	133	1187
1971	---	---	495	5	---	---	16	960
1972	---	2	146	---	---	---	2	260
1973	---	25	608	---	---	---	60	766
1974	---	---	27	---	---	6	8	332
1975	---	1	221	---	---	1	60	963
1976	---	2	193	23	---	2	59	907
1977	5	46	357	---	92	243	18	2025
1978	70	17	2369	---	237	812	351	5639
1979	13	116	1493	---	136	858	627	1564
1980	9	15	1419	1	354	365	950	6254
1981	4	87	387	---	448	483	883	2345
1982	1	25	89	-	189	297	208	3341

Table 4. Estimated age composition (numbers in 000's) of haddock in landings (all countries) from Georges Bank (NAFO Division 5Z) during 1963-1979.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	2910	10101	9601	114	1150	8	2	46	0	156	2560	46	192	144	0	0	0
2	4047	15935	125818	6843	168	2994	11	158	1375	2	2057	1820	1034	473	6130	761	26
3	7418	4554	44496	100810	2891	709	1698	16	223	450	3	657	1864	550	187	11315	1726
4	11152	4776	5356	19167	20667	1921	448	570	40	81	386	2	375	880	680	305	7169
5	8198	8722	4391	2768	10338	14519	654	186	289	32	53	70	4	216	515	567	525
6	2205	5794	6690	2591	1209	3499	5954	214	246	120	30	2	42	0	357	517	410
7	1405	2082	3772	2332	993	677	1574	2308	285	78	77	2	4	23	4	139	315
8	721	1028	1094	1268	917	453	225	746	1469	66	15	53	4	4	39	14	96
9+	1096	1332	1366	867	698	842	570	464	928	1236	447	249	88	112	111	67	46
TOTAL	39152	54324	202584	136760	39031	25622	11136	4708	4855	2221	5628	2901	3607	2402	8023	13685	10313
Nominal Catch (t)	54846	64086	150362	121274	51469	40923	22252	11300	10862	5733	5331	4290	5420	4324	10843	22339	19461
Catch[1] wt. (t)	57731	67823	181774	140715	52065	41018	22336	12376	11998	6464	6790	4647	5545	4287	11582	22403	21100
Ratio	0.95	0.94	0.83	0.86	0.99	1.00	1.00	0.91	0.91	0.89	0.79	0.92	0.98	1.01	0.94	1.00	0.92

[1] Obtained by multiplying numbers caught at age by corresponding mean weight-at-age data in Table 5.

Table 5. Mean weights (kg, whole) of haddock by age-group, as observed from samples of USA commercial landings from Georges Bank (NAFO Division 5Z) during 1963-1979. 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
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)
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
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
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
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
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
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
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
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

Table 6a. Estimated age composition (percent weight) of haddock in total landings from Georges Bank (NAFO Division 5Z) during 1963-1979.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	2.87	7.45	3.06	0.05	1.46	0.01	0.00	0.26	0.00	1.50	22.62	0.71	2.15	2.01	0.00	0.00	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	41.53	18.27	10.88	56.63	3.19	0.12
3	15.16	7.52	25.21	63.76	5.27	1.81	8.36	0.16	2.43	12.11	0.07	25.74	54.79	17.77	2.32	75.76	10.47
4	28.40	10.07	3.98	17.16	46.84	6.18	3.39	8.89	0.58	2.56	12.11	0.10	14.95	40.71	12.74	2.78	68.63
5	23.86	21.09	4.03	3.34	28.19	55.57	5.12	3.29	5.76	1.20	1.88	4.26	0.16	13.36	12.14	7.06	6.24
6	8.21	17.17	7.32	3.81	4.76	17.91	53.05	4.13	5.76	5.42	1.45	0.16	2.23	0.00	9.89	7.36	6.10
7	5.72	7.37	4.69	3.78	4.41	3.83	17.76	48.11	6.94	3.69	3.88	0.17	0.29	1.97	0.14	2.09	5.64
8	3.80	4.00	1.60	2.59	4.68	2.89	3.01	19.47	37.95	3.51	0.85	4.47	0.29	0.43	1.35	0.23	1.72
9+	5.89	5.83	2.34	1.96	4.16	5.87	9.26	14.06	28.77	69.97	25.93	22.84	6.87	12.86	4.78	1.53	1.06

Table 6b. Estimated age composition (percent numbers) of haddock in total landings from Georges Bank (NAFO Division 5Z) during 1963-1979.

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	7.43	15.76	4.74	0.08	2.95	0.03	0.02	0.98	0.00	7.02	45.49	1.59	5.32	6.00	0.00	0.00	0.00
2	10.34	24.87	62.11	5.00	0.43	11.69	0.10	3.36	28.32	0.09	36.55	62.74	28.67	19.69	76.41	5.56	0.25
3	18.95	7.11	21.96	73.71	7.41	2.77	15.25	0.34	4.59	20.26	0.05	22.65	51.68	22.90	2.33	82.68	16.74
4	28.48	7.45	2.64	14.02	52.95	7.50	4.02	12.11	0.82	3.65	6.86	0.07	10.40	36.64	8.48	2.23	69.51
5	20.94	13.61	2.17	2.02	26.49	56.67	5.87	3.95	5.95	1.44	0.94	2.41	0.11	8.99	6.42	4.14	5.09
6	5.63	9.04	3.30	1.89	3.10	13.66	53.47	4.55	5.07	5.40	0.53	0.07	1.16	0.00	4.45	3.78	3.98
7	3.59	3.25	1.86	1.71	2.54	2.64	14.13	49.02	5.87	3.51	1.37	0.07	0.11	0.96	0.05	1.02	3.05
8	1.84	1.60	0.54	0.93	2.35	1.77	2.02	15.85	30.26	2.97	0.27	1.83	0.11	0.17	0.49	0.10	0.93
9+	2.80	2.08	0.67	0.63	1.79	3.29	5.12	9.86	19.11	55.65	7.94	8.58	2.44	4.66	1.38	0.49	0.45

Table 7. Estimated age composition (percent numbers) of haddock in landings by Canada from Georges Bank (NAFO Subdivision 5Ze) during 1963-1982. (--- no data)

AGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
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

Table 8. Stratified mean catch per tow at age (numbers) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys on Georges Bank 1963-1981 (from Clark et al. 1982).

YEAR	AGE 0	1	2	3	4	5	6	7	8	9+	TOTALS 0+[2]	1+[2]	2+
Spring[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
Summer[4]													
1963	12.72	55.04	4.22	2.15	2.08	1.41	0.40	0.33	0.04	0.25	76.64	63.92	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
Autumn													
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[5]	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

	Years	Spring Age 2+	Spring Age 3+	Years	Autumn Age 2+	Autumn Age 3+	Means Age 2+	Means Age 3+
Instantaneous[6] Total Mortality (Z)	1973-1976	0.90	0.76	1973-1976	0.69	0.29	0.79	0.47
	1977-1980	0.67	0.48	1977-1981	0.97	0.76	0.81	0.60

[1] Spring and autumn, strata 13-25, 29, and 30; summer, strata 13, 16, and 19-25 (see Figure 4).
[2] May not agree exactly with data in Table 9 due to rounding errors.
[3] Data 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).
[4] Sampling incomplete in 1978 and 1981 (7 strata sampled).
[5] Preliminary.
[6] Calculated by pooling over age groups, e.g. the spring 1973-1976 value for age 2 and older fish was calculated as $\ln \dfrac{\text{age 2 and older for 1973-1976}}{\text{age 3 and older for 1974-1977}}$ and the corresponding autumn value was calculated as

$$\ln \frac{\text{age 1 and older for 1972-1975}}{\text{age 2 and older for 1973-1976}}$$

Table 9. Stratified mean catch per tow in numbers and weight (kg) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys on Georges Bank, 1963-1982. (From Clark et al, 1982a and Overholtz, 1982). (--- no data)

YEAR	Spring[2]		Summer[3]		Autumn	
	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]	12.53	18.70	-	-	3.47	4.17

[1] Spring and autumn, strata 13-25, 29, and 30; summer, strata 13, 16, and 19-25.

[2] Data for 1968-1972 and 1982 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).

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

[4] Preliminary.

Table 10. Estimates of abundance of Georges Bank (NAFO Division 5Z) haddock during 1963-1982. (--- no data)

	U.S. Research Surveys (Autumn)			Canadian Fishing Activity Otter Trawlers June - September	
	Age 2+	Ages 0+		Side TC 4	Stern TC 5
Year	No/Tow	No/Tow	Kg/Tow	t/hr	t/hr
1963	23.95	97.34	52.83	---	---
1964	52.35	129.70	64.07	---	---
1965	61.21	68.26	48.20	---	---
1966	17.56	22.32	19.78	---	---
1967	7.35	11.88	16.87	---	---
1968	4.94	5.06	10.20	0.208	0.378
1969	1.99	2.28	5.59	0.168	0.347
1970	2.37	5.17	8.94	0.191	0.267
1971	1.19	2.83	3.70	0.158	0.219
1972	1.40	7.62	5.61	---	0.169
1973	1.78	9.98	6.48	0.225	0.229
1974	1.03	2.71	2.64	1.167	0.319
1975	4.59	20.78	10.00	0.266	0.265
1976	1.73	47.68	23.68	0.262	0.348
1977	17.17	19.02	23.13	0.443	0.511
1978	9.19	20.70	15.18	0.633	0.402
1979	4.38	42.74	26.87	0.236	0.638
1980	13.21	24.98	18.47	0.410	0.680
1981	5.68	11.01	11.77	0.391	0.487
1982	-	3.47	4.17	0.440	0.572

Table 11. Recruitment indices of Georges Bank (NAFO Division 5Z) haddock for the 1963-1981 year classes.

Year Class	Age 0+1 Index	Rank	Grosslein Index	Rank
1963	8.255	1	12.6	1
1964	0.448		2.0	
1965	0.048		1.2	
1966	0.556		1.7	
1967	0.004		1.0	
1968	0.006		1.0	
1969	0.149		1.1	
1970	0.003		1.0	
1971	0.216		1.5	
1972	0.661	5	2.1	5
1973	0.239		1.8	
1974	0.062		1.3	
1975	3.314	2	3.8	2
1976	0.326		1.7	
1977	0.041		1.1	
1978	2.629	3	2.3	4
1979	0.194		1.6	
1980	1.041	4	2.8	3
1981	0.053*		1.2	

* Based on 0 age group estimate only.

Table 12. Cohort analysis results for the 1963-1975 period.

POPULATION NUMBERS

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	191564	467682	32834	4044	12910	416	981	4377	69	8790	22155	6781	3046
2	32177	154207	373766	18195	3208	9529	334	802	3542	57	7055	15823	5510
3	32683	22683	111835	192169	8705	2474	5093	263	513	1655	45	3915	11308
4	45267	20047	14450	51301	66118	4511	1384	2633	201	219	948	34	2611
5	28767	26971	12091	6985	24659	35433	1955	728	1640	128	106	427	26
6	9238	16135	14190	5926	3214	10835	15872	1009	428	1081	76	39	286
7	5582	5569	7967	5564	2508	1537	5705	7608	632	128	777	35	30
8	2788	3299	2675	3110	2445	1155	646	3246	4140	260	34	566	27
9+	4238	4275	3340	2126	1861	2146	1637	2019	2616	4867	1011	2660	594
1+	352305	720866	573150	289421	125628	68036	33608	22685	13782	17185	32207	30280	23437

FISHING MORTALITY

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.017	0.024	0.390	0.032	0.104	0.021	0.002	0.012	0.000	0.020	0.137	0.008	0.072
2	0.150	0.121	0.465	0.537	0.060	0.427	0.037	0.246	0.560	0.040	0.389	0.136	0.231
3	0.289	0.251	0.579	0.867	0.457	0.381	0.460	0.070	0.654	0.357	0.077	0.205	0.200
4	0.318	0.306	0.527	0.533	0.424	0.636	0.443	0.273	0.248	0.527	0.598	0.067	0.172
5	0.378	0.442	0.513	0.576	0.622	0.603	0.462	0.332	0.217	0.322	0.808	0.200	0.186
6	0.306	0.506	0.736	0.660	0.537	0.441	0.535	0.267	1.009	0.131	0.572	0.059	0.176
7	0.326	0.533	0.741	0.622	0.576	0.667	0.364	0.408	0.689	1.125	0.116	0.065	0.160
8	0.334	0.418	0.592	0.590	0.528	0.560	0.480	0.291	0.491	0.327	0.659	0.109	0.178
9+	0.334	0.418	0.592	0.590	0.528	0.560	0.480	0.291	0.491	0.327	0.659	0.109	0.178

Table 13. Data used in development of a cohort analysis fishing mortality - effort relationship for the 1968-75 period.

Year	Average F for Ages 4 to 6	Total Annual Catch (t)	TC5 CPUE (t/hr)	Effective Effort (hr)
1968	0.560	40923	0.378	108262
1969	0.480	22252	0.347	64126
1970	0.291	11300	0.267	42322
1971	0.491	10862	0.219	49598
1972	0.327	5733	0.169	33928
1973	0.659	5331	0.229	23279
1974	0.109	4290	0.319	13448
1975	0.178	5420	0.265	20453
1982	(0.267)	18000	0.572	31469

Table 14. Equations used to generate population abundance at age for 1980-1982. A and B are the intercept and the slope respectively of an x-y regression model.

Dependent Variable	Independent Variable	A	B	r^2
Cohort Analysis age 1 numbers (log trans.)	Recruitment Index (log trans.)	10.5969	0.9017	0.93
Cohort Analysis age 2 numbers (log trans.)	Recruitment Index (log trans.)	10.2988	0.8858	0.93
Cohort Analysis age 3+ numbers at time t+1 (log trans.)	Survey Age 2+ number/tow at time t (log trans.)	8.78396	0.8911	0.88
Cohort Analysis age 4 to 6 F	Effective effort	0.023	7.755×10^{-6}	0.88

Table 15. Determination of partial recruitment used in projections.

Age	PR 1963-1969	PR 1970-1975
1	0.167	0.120
2	0.512	0.778
3	1	1
4	1	1
5	1	1
6	1	1
7	1	1
8	1	1
9+	1	1

Table 16. 1980-1982 predicted population at age based on autumn survey results.

Age	Year		
	1980	1981	1982
1	9099	41499	2831
2	69923	6933	30782
3	167	51312	9187
4	4114	1824	16374
5	17344	740	919
6	1168	6852	1838
7	1279	1923	2324
8	223	1874	1
9+	56	593	56

Table 17. 1982 population numbers-at-age as determined by 1980-1982 survey data. (--- no projection)

Age	Survey Year			Mean
	1980	1981	1982	
1	---	---	2831	2831
2	---	32944	30782	31863
3	4763	4643	9187	6198
4	28371	32452	16374	25732
5	63	1154	919	712
6	1563	468	1838	1290
7	6591	4334	2324	4416
8	444	1216	1	554
9+	486	1185	56	576

Table 18. Georges Bank age two year class strength estimates ($\times 10^{-6}$) as determined by 1978-1983 stock assessments.

	YEAR CLASS														
Assessment	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Clark & Palmer, 1978	7	1	1	3	1	12	28	10	7	169	10	2	-	-	-
Clark & Overholtz, 1979	8	1	1	4	1	8	11	8	2	165	11	1	71	-	-
Clark & Essig, 1980	-	-	-	-	-	-	-	-	-	170	?	?	138	3	-
Clark et al., 1981	-	-	-	-	-	-	-	-	-	170	17	6	140	13	61
Clark et al., 1982a; 1982b	9	1	1	4	1	7	9	6	1	77	19	1	10-20	2	10-20
O'Boyle, 1983	10	1	1	4	1	7	16	6	3	86	11	2	70	7	32

Table 19. Georges Bank population (t) size estimates ($\times 10^{6}$) as determined by 1978-1983 stock assessments.

Assessment	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Clark & Palmer, 1978	69	33	18	13	6	15	38	38	35	-	-	-	-	-	-
Clark & Overholtz, 1979	73	37	21	15	9	14	19	21	16	175	95	-	-	-	-
Clark & Essig, 1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clark et al., 1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clark et al., 1982a; 1982b	60	30	16	11	8	6	11	12	10	45	45	-	-	-	46
O'Boyle, 1983	68	33	18	14	8	10	23	20	28	97	93	49	94	72	63

Table 20. Input parameters to field projections given in Table 19.

Age	Numbers	Wt.(kg)	PR
1	2831	0.60	0.12
2	31863	1.00	0.778
3	6198	1.28	1
4	25732	2.02	1
5	712	2.51	1
6	1290	3.14	1
7	4416	3.78	1
8	554	3.79	1
9+	574	4.87	1

Table 21. Yield and fishable biomass projections to 1984 assuming 18000 t caught in 1982 and $F_{0.1}$ yield thereafter.

Year	Mid-Year Population Biomass (kt)	Beginning of Year Fishable Biomass (kt)	Catch Biomass (kt)
1983	90.4	102.1	21.3
1984	87.9	96.1	20.1

Table 22. Catch and stock size projections (000's) for Georges Bank haddock for 1983-1985 under differing mortality and recruitment options, assuming a catch of 16,000 tons in 1982 and F equal to $F_{0.1}$[1] and F_{max}[1] in subsequent years. (from Clark 1982a)

1982			1983			1984			1985
Stock[2] Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)
62.8 R_2=10	.31	16	52.2	$F_{0.1}$	11.5	44.4	$F_{0.1}$	9.7	36.4
				F_{max}	21.3	33.7	F_{max}	13.6	21.4
66.5 R_2=15	.29	16	56.6	$F_{0.1}$	12.6	49.1	$F_{0.1}$	10.7	40.1
				F_{max}	23.3	37.2	F_{max}	15.0	23.5
70.1 R_2=20	.27	16	60.9	$F_{0.1}$	13.6	53.8	$F_{0.1}$	11.7	43.8
				F_{max}	25.3	40.7	F_{max}	16.4	25.6

[1] $F_{0.1}$=0.26; F_{max} = 0.55

[2] As predicted from linear regressions between VPA stock size and year-class size estimates in numbers and research vessel survey catch per tow (R_2 estimates refer to recruitment from the 1980 year class in millions of fish at age 2).

[3] At full recruitment.

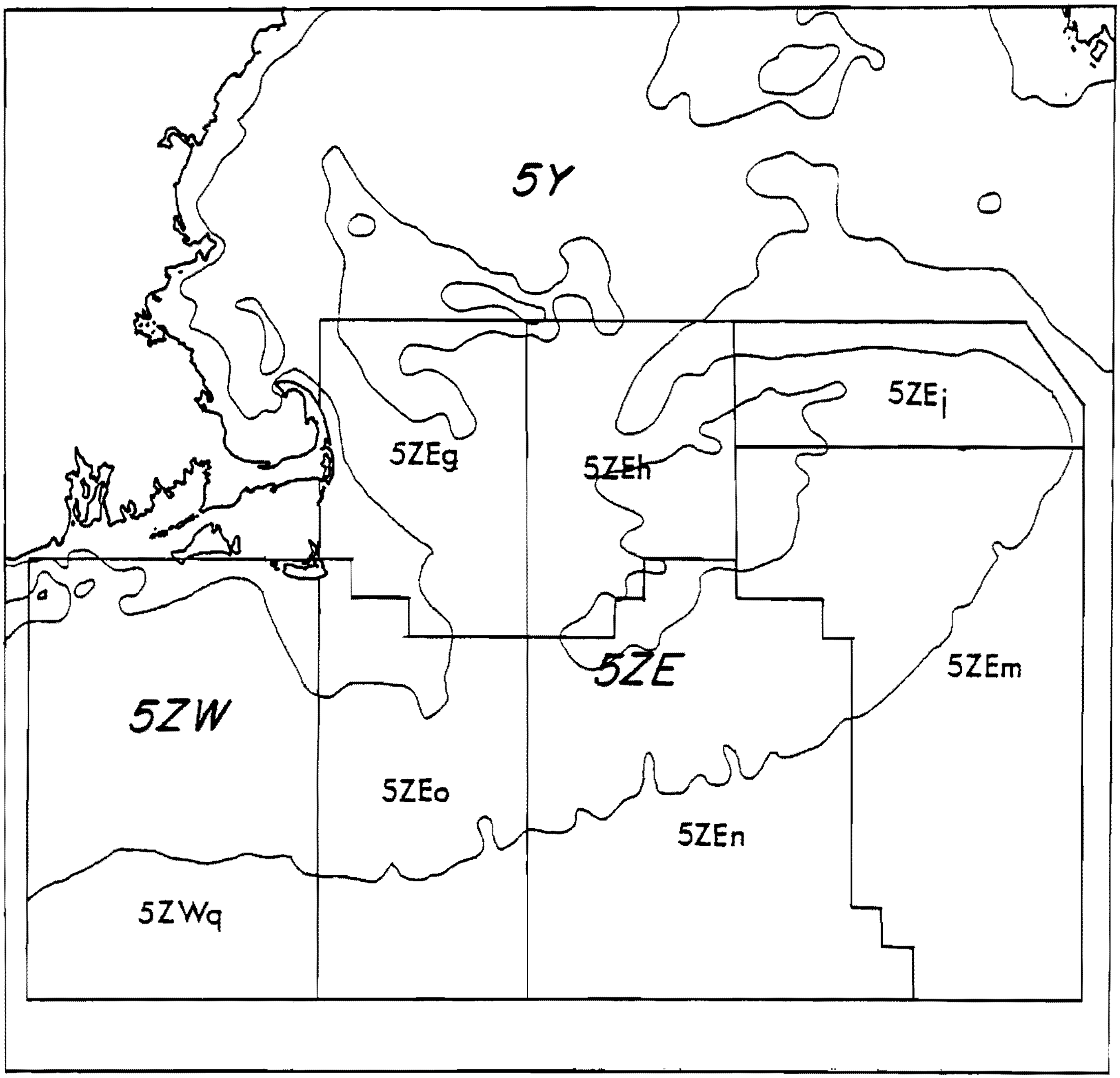

Figure 1. Statistical unit areas within NAFO Division 5Z.

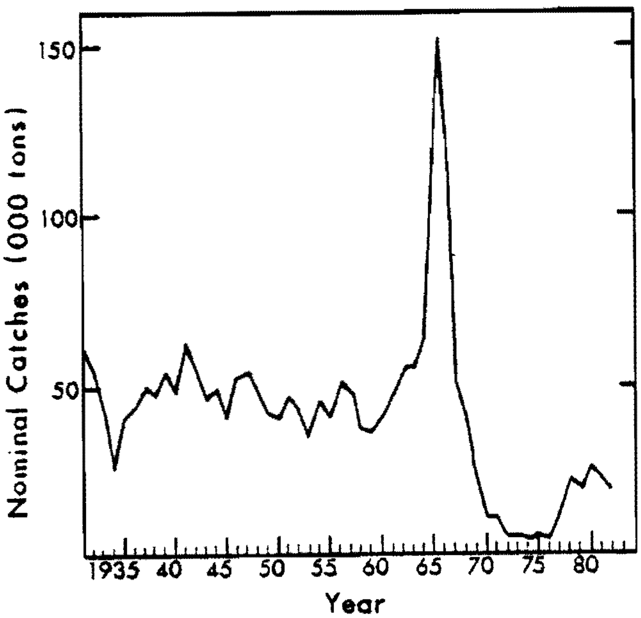

Figure 2. Trends in nominal catches of haddock from Georges Bank 1931-82.

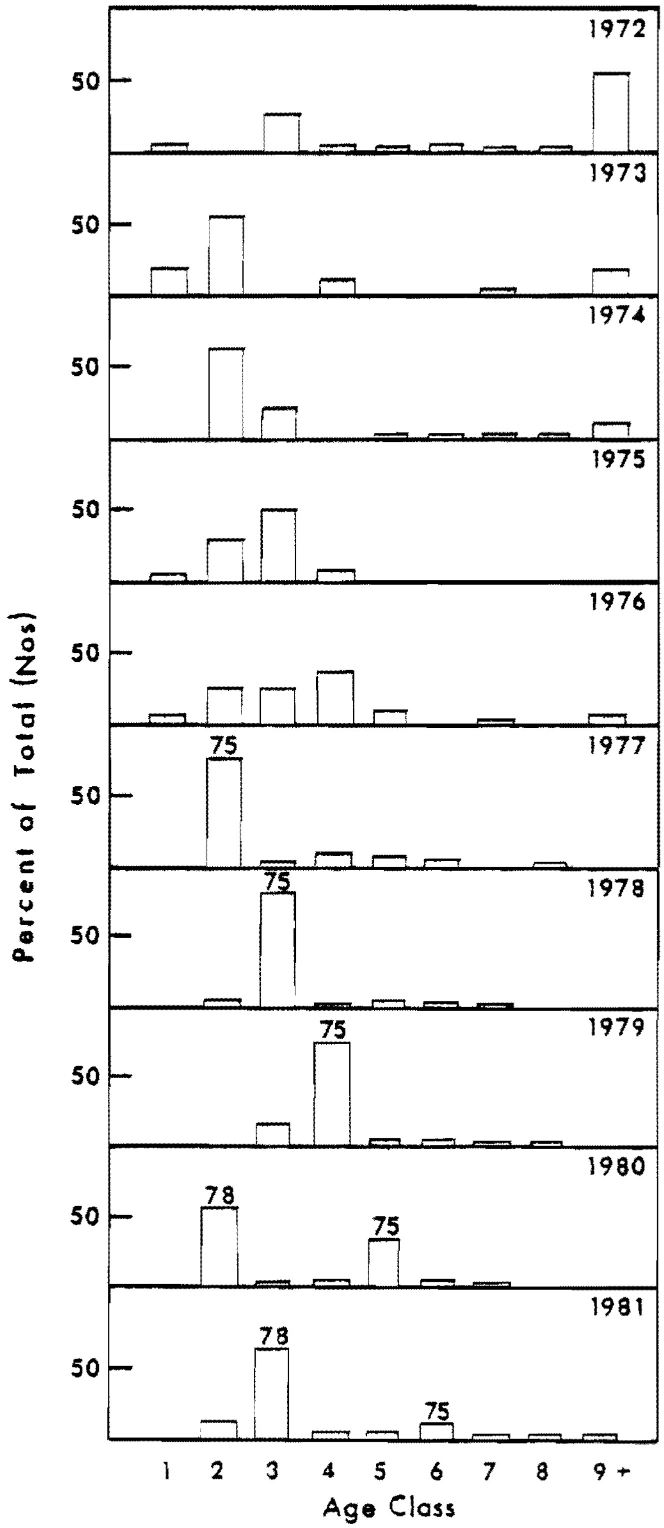

Figure 3. Age composition of commercial landings (percent by number) for Georges Bank haddock for 1972-81 (from Clark et. al., 1982a).

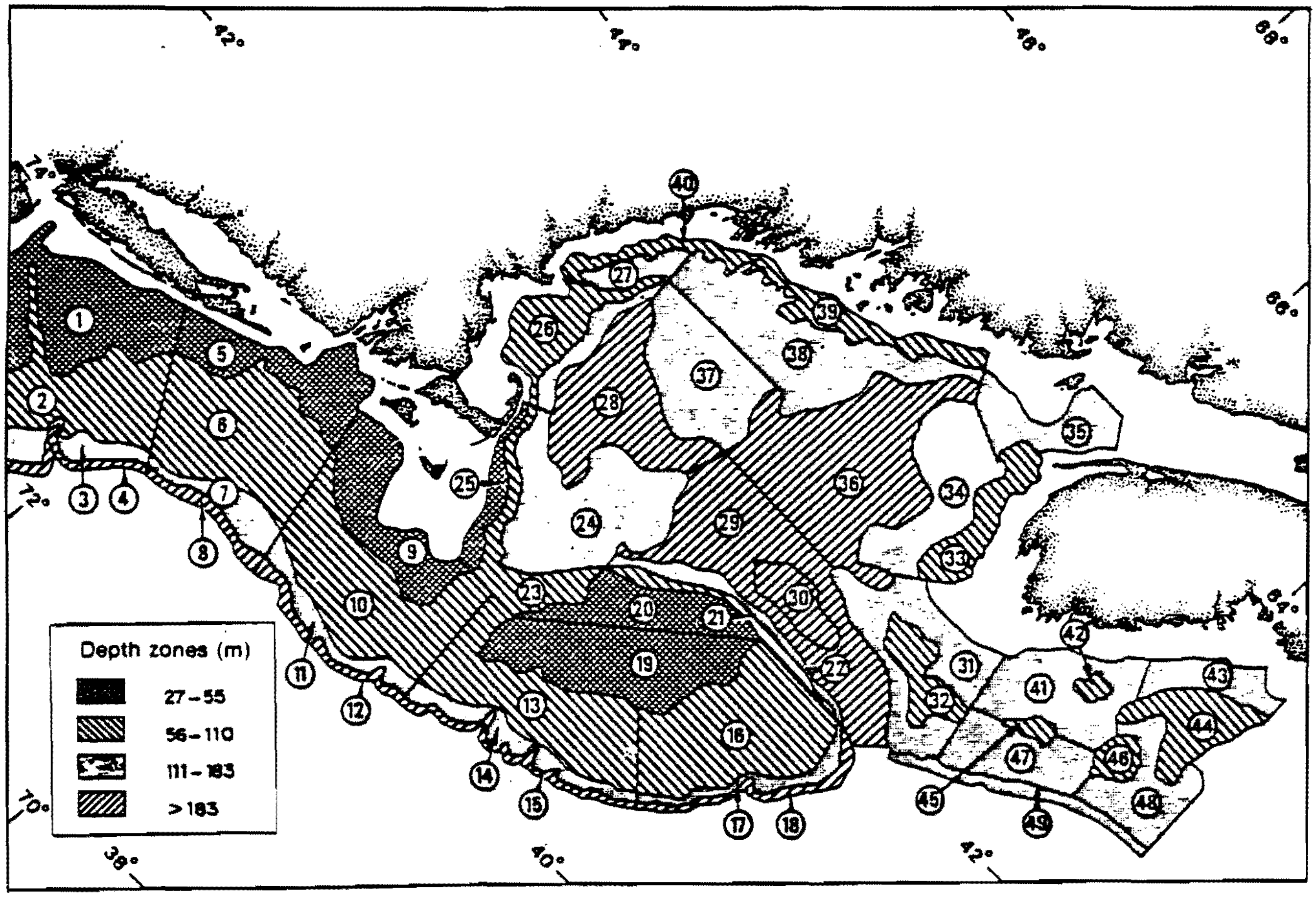

Figure 4. Stratification scheme used for USA spring and autumn bottom-trawl surveys of Georges Bank and Gulf of Maine areas.

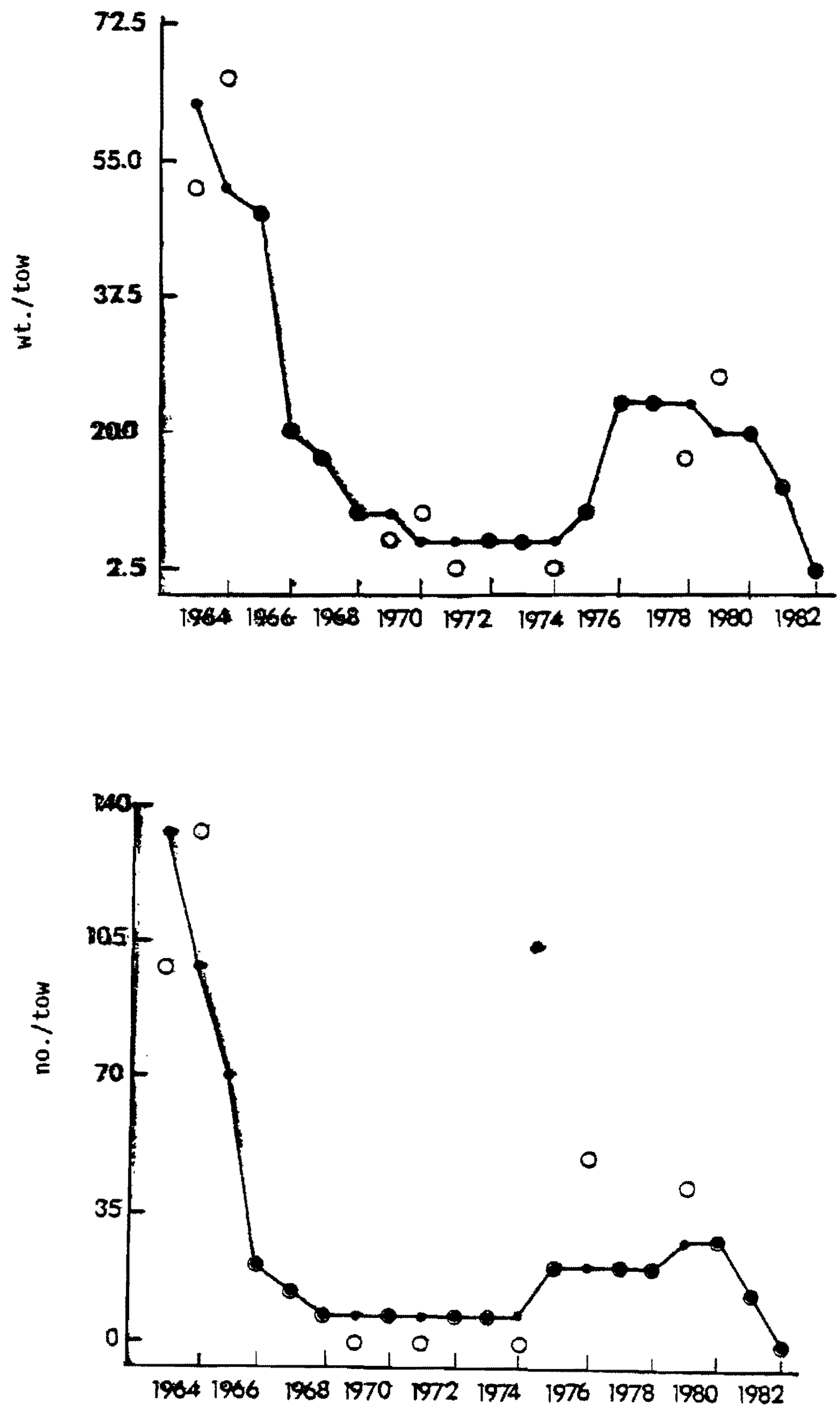

Figure 5. Trends in total stratified mean catch (no. and wt.) per tow of U.S. autumn surveys during 1963-82.

O - original
● - smoothed (3 year median) data

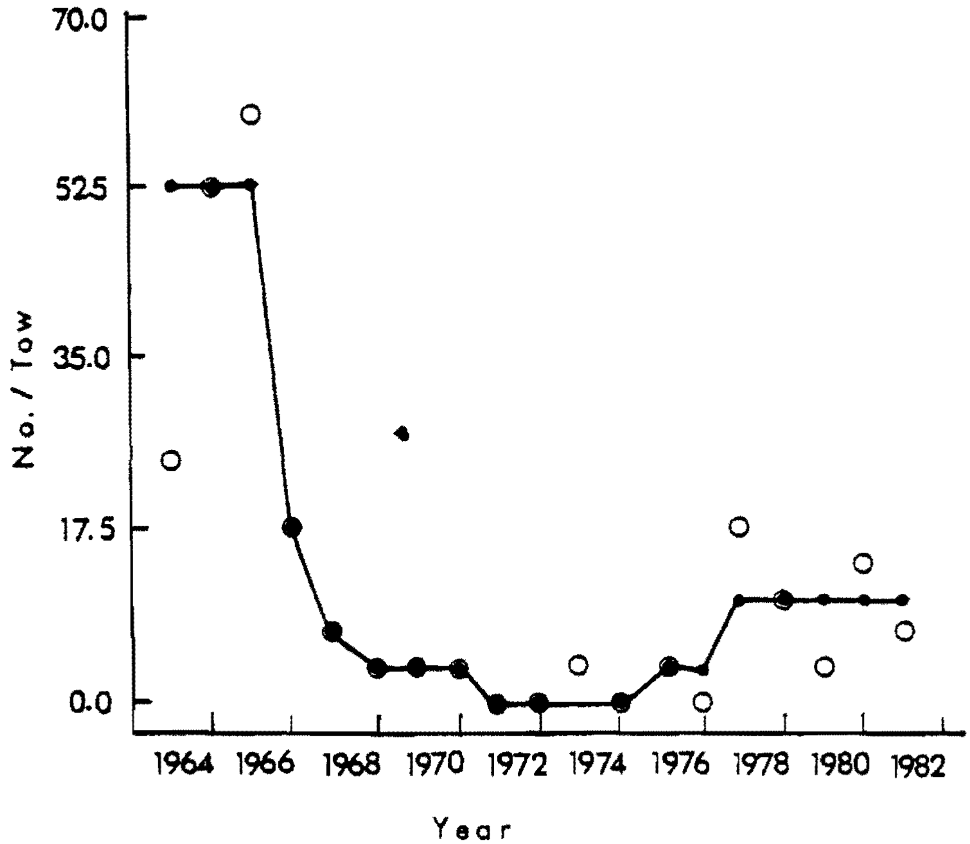

Figure 6. Trend in 2+ stratified mean catch (no.) per tow of U.S. autumn survey during 1963-81.

O - original
● - smoothed (by 3 year median) data.

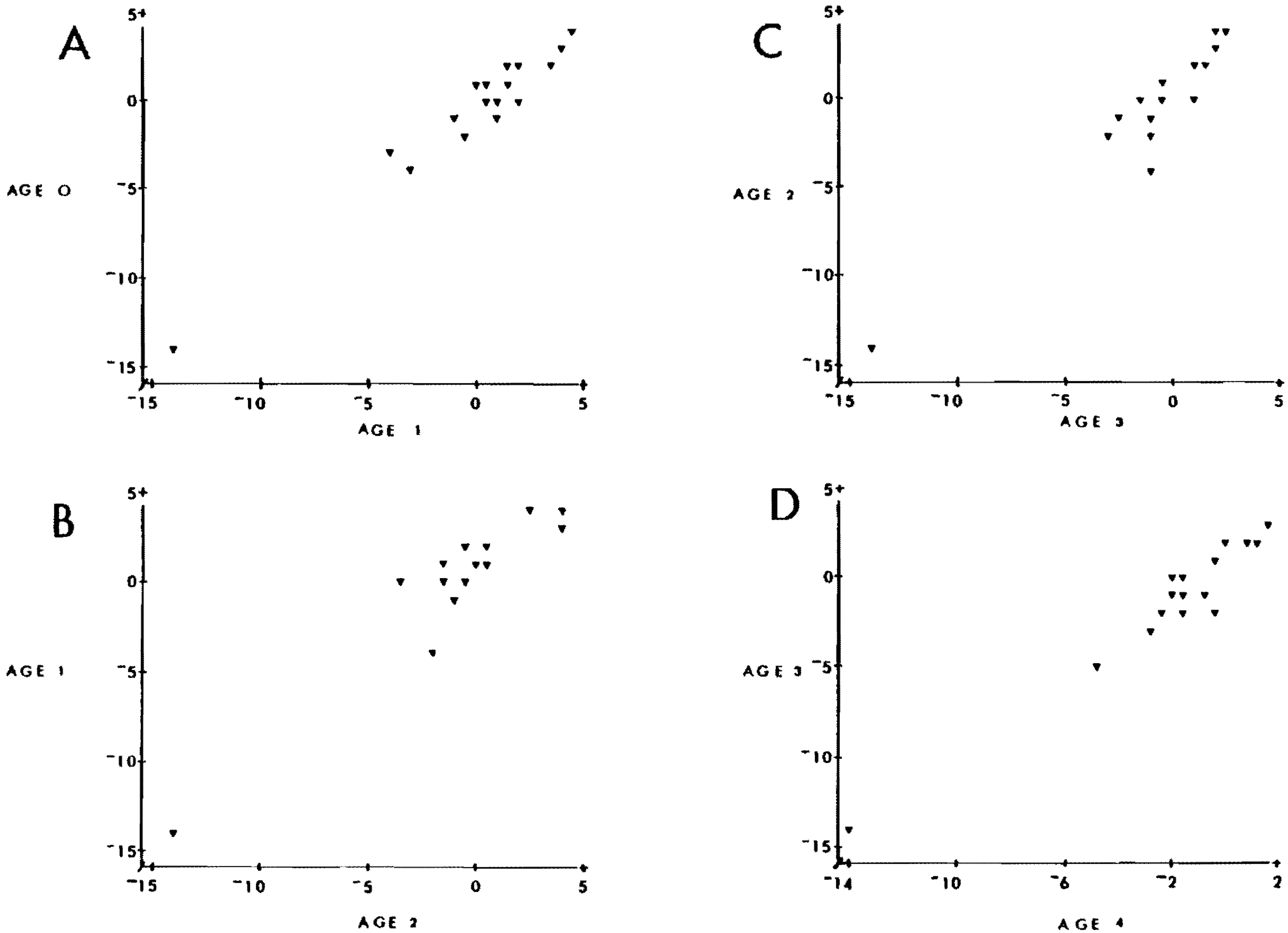

Figure 7. Relationships between U.S. autumn survey stratified mean catch (no.) per tow on a cohort by cohort basis for ages 0 to 4.

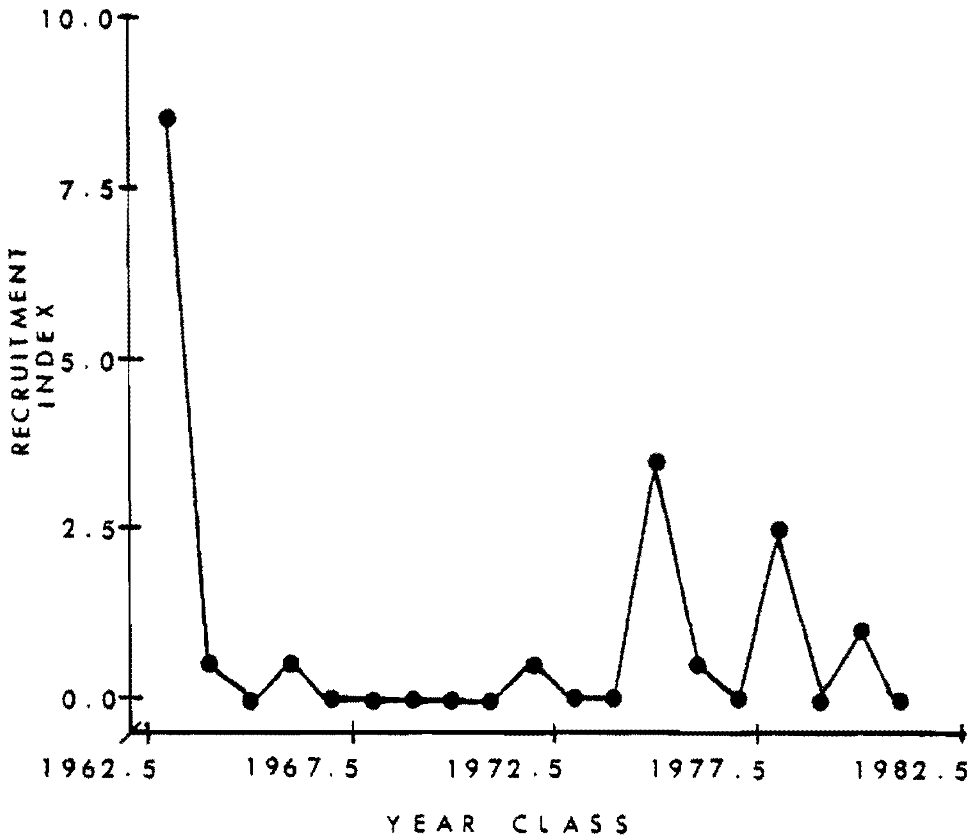

Figure 8. Trend in calculated recruitment (age 0 + 1) index for the 1963-80 year classes.

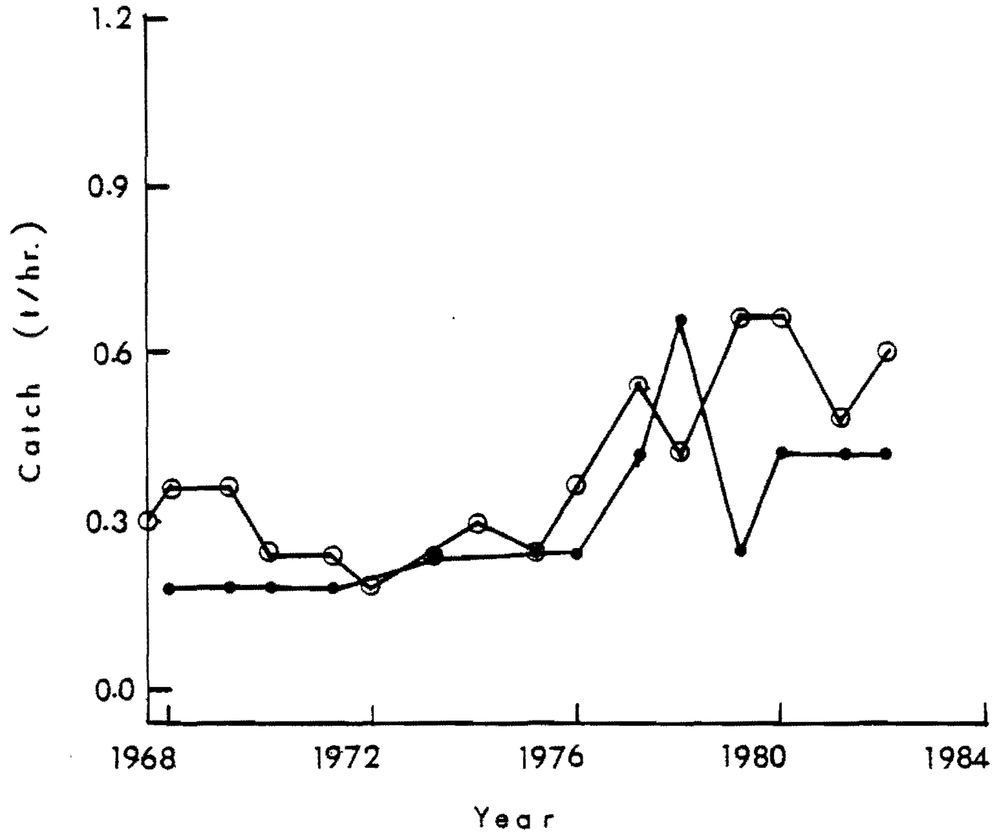

Figure 9. Trends in Canadian side (T.C. 4) and stern (T.C. 5) otter trawl catch (t) per hour during the 1968 - 82 period.

● - tonnage class 4, side trawler
o - tonnage class 5, stern trawler

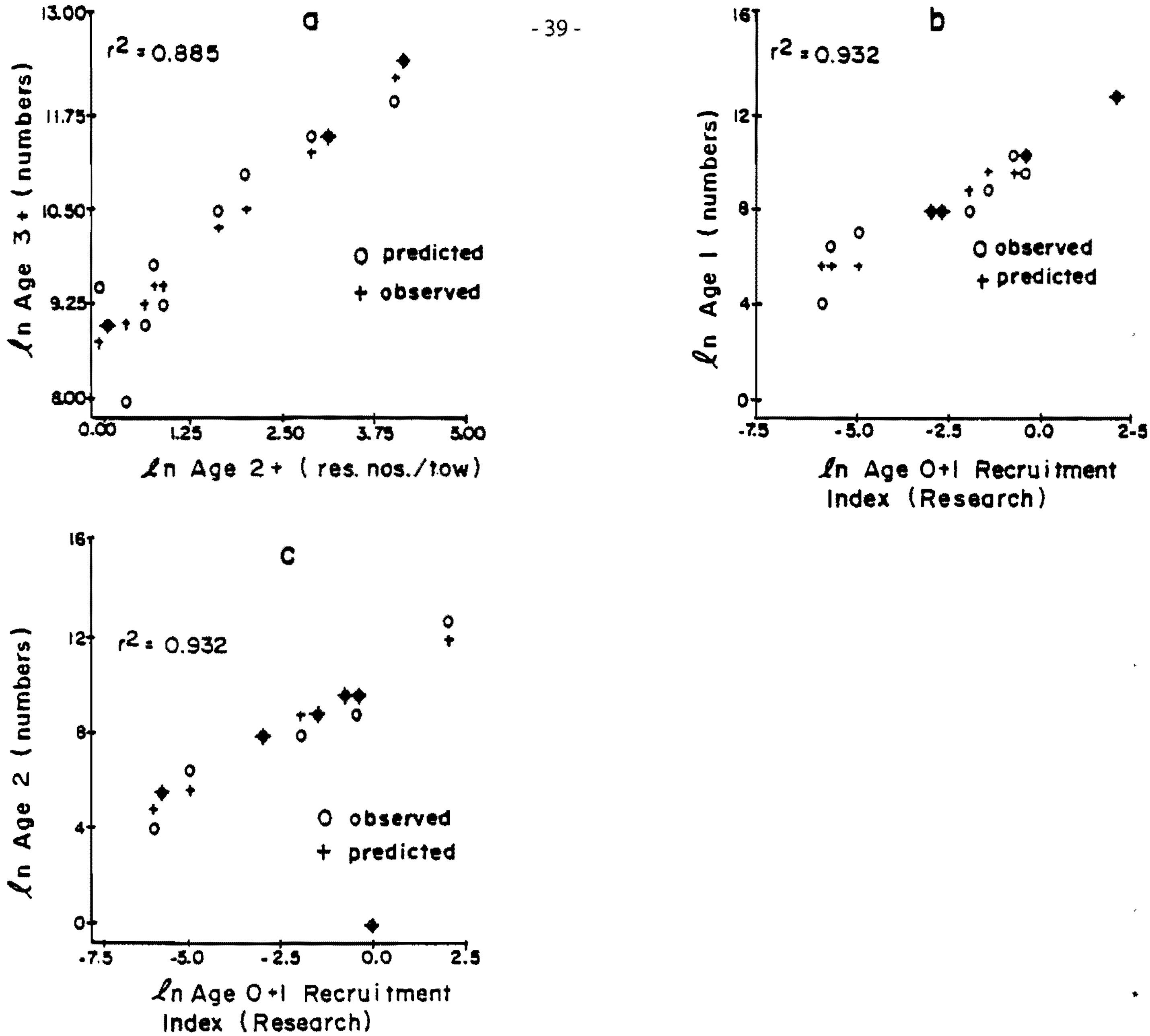

Figure 10. Plots of relationship used to tune cohort analysis.
a) ℓn age 3+ population numbers in year t+1 from cohort analysis versus ℓn age 2+ survey numbers per tow in year t.
b) ℓn age 1 population numbers from cohort analysis versus ℓn survey 0+1 recruitment index.
c) ℓn age 2 population numbers from cohort analysis versus ℓn survey 0+1 recruitment index.

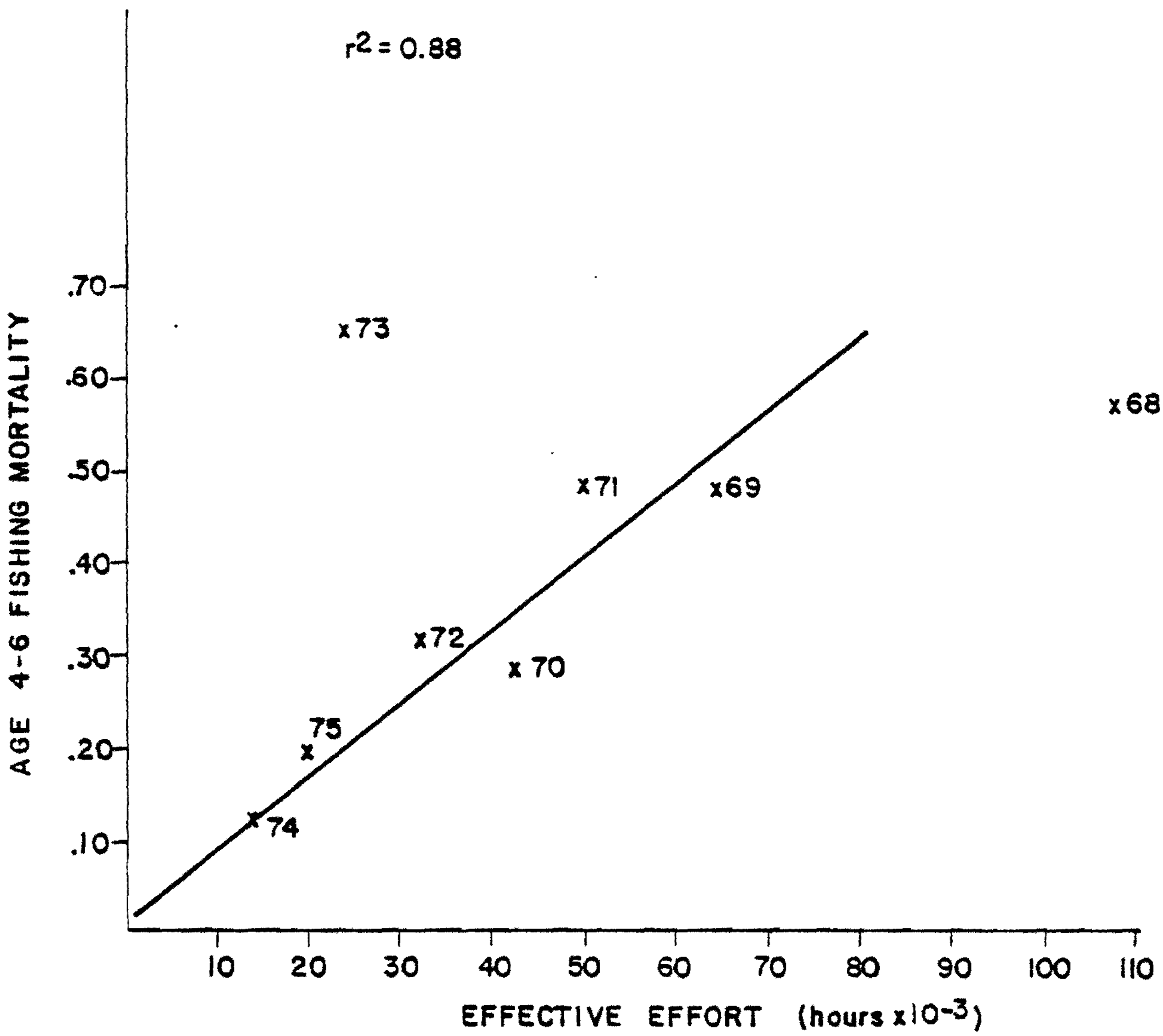

Figure 11. Relationship between cohort analysis age 4 to 6 fishing mortality and the estimated effective effort. The 1968 and 1973 points were not used in the derivation of the equation given in table 14.