Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/50

Not to be cited without
permission of the authors[1]

Ministère des pêches et océans
Secrétariat canadien pour l'évaluation des stocks
Document de recherche 97/50

Ne pas citer sans
autorisation des auteurs[1]

Atlantic Halibut (*Hippoglossus hippoglossus*) on the Scotian Shelf and Southern Grand Banks: Evaluation of Resource Status

K.C.T. Zwanenburg, G. Black, P. Fanning,
R. Branton, M. Showell, and S. Wilson

Marine Fish Division
Science Branch, Maritimes Region
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia, B2Y 4A2

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

Abstract

Halibut abundance, as estimated from the results of research vessel surveys in the management unit, is presently low relative to the available time series. Present landings are also low relative to the long-term (1883 - 1996) history of this resource. Survey results for the geographic range of halibut suggest that declines in abundance have been more evident for the southern Grand Banks than for the Scotian Shelf.

Loss rates from the Scotian Shelf have increased since 1971 and are presently at their highest value. The observed increase is likely due to increased mortality since halibut abundance in the northern part of the management unit (3NOPs), where migrating fish are predicted to go, has declined since the early 1980s.

Halibut size compositions show a reduced range of sizes in the present population (1994 - 1996) relative to that for 1960; however, present estimates do not include size information for 3NOPs while the 1960s size composition included data for 3Ps.

Résumé

L'abondance du flétan, telle qu'estimée à partir des relevés par navires de recherche dans l'unité de gestion, est actuellement faible par comparaison aux valeurs de la série chronologique. Les débarquements sont, eux aussi, faibles par rapport aux volumes à long terme (1883-1996). Les relevés effectués dans l'aire de distribution de l'espèce portent à croire que le déclin a été plus prononcé dans la partie sud des Grands Bancs que sur le plateau néo-écossais.

Le déclin s'est accru depuis 1971 sur le plateau néo-écossais et sa valeur est actuellement la plus élevée jamais notée. Cela s'explique sans doute par un accroissement de la mortalité car l'abondance du flétan dans la partie nord de l'unité de gestion (3NOPs), où devraient se trouver les poissons en migration, a diminué depuis le début des années 1980.

La composition des tailles montre que la gamme des tailles de la population actuelle (1994-1996) est réduite par rapport à celle de 1960, mais il est à signaler que la composition des tailles des années 1960 reposait en partie sur des données obtenues pour 3Ps.

Introduction

Landings of Atlantic halibut have been recorded for the east coast of Canada since 1883. The long-term average landings from the entire east coast has been about 2000t annually. Present annual landings are about equivalent to those observed at the beginning of the century. Landings from the present management unit have averaged just under 2000t annually since 1960 and have declined since then with the exception of a resurgence during the mid 1980s. In spite of the precautionary TAC of 3200t imposed in 1988, the halibut fishery remained essentially unrestricted until 1993. Landings in 1996 totalled 811t close to the TAC of 850t. Inshore fleets have released halibut less than 81 cm since 1994. Offshore management plans and licence conditions also require the release of these undersized halibut. Given the relatively high (up to 75%) survival of these undersized fish releasing them could significantly reduce their mortality in the fishery. Longliners are the dominant fleet on both the Scotian Shelf and southern Grand Banks fishery accounting for over 70% of the landings.

The continuous distribution of halibut and tagging results showing long distance movements suggest that the stock area may be broader than the present management unit. Groundfish surveys in this area show a lot of inter-annual variability in halibut catch-rates; however, all the surveys from the stock area and adjacent waters show broadly similar trends. All show an increase in abundance through the 1970s to a maximum in the period 1979-1981 after which they decline. Present estimates from trawl surveys show that halibut abundance is low relative to the long-term average.

For the stock area as a whole commercial catch rates shows a decline since 1988 for all vessel classes using fixed gear. Halibut catch rates for the 3NO longline halibut fishery have declined from 1988 to 1993 and have remained low since.

No reliable ageing information is available for 3NOPs4VWX halibut to allow calculation of total mortality. Using halibut growth rates from the Gulf of St. Lawrence as a proxy we estimated total loss rate (total mortality and an unquantified degree of emigration) for the Scotian Shelf portion of the stock. This loss rate has been increasing since at least the mid 1980s and is now at the highest value since 1971.

Samples of commercial halibut catches collected during 1960 and the present (1994-1996) were also used to compare estimates of mortality for the two time periods. These analyses indicate that mortality rates are presently between 2 and 3 times higher than they were in 1960 and that the age range in the population has been much reduced. It should be noted that these estimates may change once a growth model specific to 3NOPs4VWX halibut is developed . It should also be noted that recent estimates of age compositions do not include samples from 3NOPs. Since there are indications that larger fish may tend to migrate to these more northerly waters, the total mortality values for recent years may be over estimated.

History of the Fishery

The history of reported landings for Atlantic halibut from the Atlantic Coast of Canada since 1883 are shown in Figure 1. Prior to 1929 all landings are for NAFO Sub-area 4 combined and exclude what is presently the province of Newfoundland. From 1930 to the present landings are by NAFO Sub-area as indicated. From 1961 to the present all landings were derived from NAFO statistics. Over the history (1883-1995) of this fishery landings from these areas have averaged just over 2000 metric tonnes annually. From the earliest landing data (1883) until 1910 landings averaged about 500 t annually. Between 1911 and the start of the second world war landings gradually increased to a maximum of about 2500 t in 1939. Landings declined during the war years but increased thereafter to reach a maximum of just over 5000 t in 1960. Since 1960 landings declined to the mid 1970's with some resurgence through the mid 1980's. Since the mid-1980's landings have again reached the low values last observed during the mid 1940's.

Figure 2 gives the history of landings for this fishery by NAFO Sub-area (with the exception of Sub-area 4 which is split into a Gulf and off-shore component. These data indicate that the average landings from what is now the 3NOPs4VWX stock area have averaged just under 2000 t (1991t) since 1961. Total landings for Subareas 3 and 4 have declined since 1960 with some interim resurgence during the 1980's. Since the mid 1980's landings have declined to an annual total of slightly under 1000 t. Preliminary landings figures for 1996 indicate a total of 811 t landed for the stock area.

Landings from areas adjacent to the stock area are also shown (Fig. 2). Over the recent history of the stock, landings from these areas have generally been below 500 t annually with the exception of the Gulf of St. Lawrence during the early 1960's and Sub-Areas 0,1 during the late 1970's and early 1980's. Landings from these areas show some synchrony with those of the stock area particularly the decline in landings during the period 1961 to the mid to late 1970's which is apparent in all areas.

Details of landings distributions by year, country, gear types, and area are presented in Tables 1-5.

Industry Consultations

During 1996 / 1997 the Halibut Working Group of the Scotia-Fundy Fixed Gear Groundfish Committee produced a report which criticized the 1996 Stock Status Report. The response to this critique has been appended as Appendix I. The major criticism of the 1996 SSR dealt with the inappropriate inclusion of non halibut-directed effort in the commercial CPUE series (see Annand and Beanlands 1995 for details), the failure to take into account the effects of closed areas and seasons on the CPUE series, the failure to account for the potential effects of the release of small under-sized halibut, and the inadequacy of the Departments trawl surveys in estimating halibut abundance. All of these short-comings taken in concert were concluded to have resulted in the setting of inappropriately low TAC's for this resource.

We have attempted to address as many of these criticisms as possible in this years assessment of resource status with particular emphasis on the re-coding of halibut effort to ensure that only truly halibut directed effort was used in the calculation of the CPUE series, a closer examination of the trawl survey series, particularly the examination of seasonal surveys to look for coherence in the various signals, and examination of surveys from waters adjacent to the stock area to look for synchrony of signals. In addition we have examined the historical data available for commercial landings and with the inclusion of a proxy growth model, have attempted to estimate population mortality for two time periods to determine the effects of present exploitation rates. We have also examined the results of the 1995 and 1996 4VW fixed gear sentinel survey, which we feel will become a very important index of halibut abundance in the coming years.

We have also had discussions with members of industry and fisherman members of the Fishermen and Scientists Research Society to increase the rate and protocols for sampling of commercial halibut landings.

Research Vessel Survey Results

Distribution

The global distribution of halibut along the east coast of North America is given in Figures 3a-d. These figures show the distribution and abundance of halibut catches from all standard groundfish monitoring surveys conducted by either Canada or the U.S.A during the period 1975 - 1994 (see Brown et al 1996 for details of this data set and analyses). From these we conclude that during this period halibut were distributed from the latitude of Cape Cod (Mass.) to the northern portions of the Labrador shelf. The center of distribution during this period, as judged by relatively higher catch rates, occurred between the latitudes of northern Georges Bank, and the Southern Grand Banks. Within these areas, halibut were generally encountered on the slopes of the continental shelf or on the slopes of the banks. We also conclude from these broad-scale observations that the concentrations of halibut in the northern end of the range showed a significant shift in distribution or a decline in abundance, especially during the period 1990 -1994. These changes are most evident for the SA3 portion (3NOPs) of the stock area and are not as apparent in the SA4 portion.

Within the stock area halibut show some ontogenetic changes in distribution in that older (longer) halibut occur more frequently in deeper water than do smaller (younger) ones (Figure 4a-c). These results show that although larger halibut were encountered in relatively shallow waters, small halibut were seldom encountered in deeper waters. We interpret this to reflect a general increase in depth of the habitat of halibut distribution with age.

We also observe that small (< 40 cm) halibut tend to be most abundant in the southwestern portions of the stock area while larger halibut are more abundant in the northeastern sectors (Figure 5 a,b). We interpret these observations to indicate that

halibut spawn in the southwestern portions of the stock area and that they show a general northeastward movement as they mature. If this is an accurate description of the ontogenetic movements of halibut, it implies a contranatant migration of the adults back to the southwestern spawning grounds, for which we as yet have no evidence.

The observations of increasing depth with size could be linked to the temperature preferences of halibut which appear to be indicate that they prefer waters above 2 C. Since the shoaler waters of the eastern Scotian Shelf are generally cooler than those of the southwest, halibut might be selecting water masses of the appropriate temperature.

The implications of a gradual shift to the northeast with increasing age (if this is indeed borne out by further analysis) are that evaluation of sub-areas of the stock would not be feasible. It is only be examining survey data which cover the entire stock area that we may be able to draw conclusions about overall changes in abundance or age composition.

Abundance

At present the Department does not have a research vessel survey that covers the entire stock area within any restricted time period of the year. There is a single survey which covers the entire Scotian Shelf during the summer (July) and another that covers the eastern end of the survey during the late winter (March). From 1979 through 1984 there was a late winter (March survey which covered the entire Scotian Shelf. For this same period there was also a fall (October) survey which sampled the entire Scotian Shelf. There are a number of surveys of the 3NOPs area which occur from February through June for which we have examined the data for 1975-1994. Surveys in Sub-Areas 2 and 3 occurred at various times of the years (1975 - 1994), while surveys of Subarea 5 were generally conducted in the fall of the year. We examined results of all of the research vessel survey series to determine their utility in estimating trends in halibut abundance and size / age composition of the population. We examined the results of surveys in adjacent waters to determine if observed changes in abundance or age composition (if any) could be linked to conditions or events which transcend the present stock boundaries.

The average catch per unit of effort for each year of each series (numbers of fish per standard research vessel survey tow) is low relative to that of most of the other commercially exploited groundfish species surveyed (Table 6). This is both a reflection of the overall lower numerical abundance of halibut and it's relatively solitary distribution compared to the more schooling species such as cod and haddock. The result is that only a very few halibut are caught during any given survey and the resultant variance in the annual estimates of abundance is very high. Trends in estimated abundance, expressed as number of halibut caught per standard survey tow, derived from these survey series are given in Figure 6.

Examining all the survey indices together reveals a remarkable degree of coherence between them. All of the surveys, perhaps with the exception of Subarea 5 show an

increased abundance through the 1970's to a maximum in the period 1979-1981 whereafter they decline. Within the stock area, the abundance estimated by the summer survey of the Scotian Shelf indicates increasing abundance to about 1990 followed by a decrease until 1995. The winter survey of the eastern Scotian Shelf (4VW Cod survey) gives broadly the same results. The survey results for 3NOPs decline rapidly from 1980 to 1987 and then decline slowly to 1994. It must be pointed out that the results of the 3NOPs survey were calculated as global mean catch per tow values without stratification. In future these results should be calculated as stratified estimates. The tentative conclusion to be drawn from these results is that at present the abundance of halibut within the 3NOPs4VWX area is low relative to the long-term average estimate for each of the three major surveys.

Examination the results of the summer and winter survey of the Scotian Shelf separately for each sex (Figures 7 and 8) show that although the two sexes follow roughly the same trajectories of abundance, it appears that female halibut are over-represented in the winter survey (9 of 11 years).

Results of the summer survey of the Scotian Shelf gives estimates of trawlable biomass which range from jut over 1000 t (early 1970's) to just over 5000 t (late 1970's, early 1980's). Present estimates are just under 2000 t (Figure 9).

Size / Age Composition

The size composition of the catches by the summer and winter surveys of the Scotian Shelf (Figure 10a,b) show the highly peaked and variable length frequencies indicative of the very low catch rates of halibut. The minimum size of capture for halibut by these two surveys is 16 cm while the maximum is 220 cm. Catches of the smallest and largest size classes are extremely rare with only a few occurrences for the entire time series. The long-term average length-frequencies for all the surveys (Figure 11a-d) shows that the modal length of the winter survey is slightly larger than that of the summer survey. This is consistent with the fact that the winter survey covers only the eastern portion of the Scotian Shelf and halibut tend to move northeastward as they grow.

It is difficult to identify age equivalent modes from these composite distributions given the high inter-annual variability in catches of halibut by these surveys. It may be that the modes at 16 - 19 cm represent fish that were spawned in the late winter of the year preceding the summer survey. This would mean that the fish caught at these lengths in the summer survey grew 160 mm in 4 months and that those caught at these lengths the following spring grew the same amount over 12 months. Another possibility is that there are multiple spawning periods during the year, or that the spawning period in the winter is relatively long.

Data for the individual years of the surveys are difficult to interpret with regard to changes in overall length composition of the population. Size data for the 3NOPs portion of the stock area are not presently available for analysis. These data are however essential

to a full description of the population size / age structure, and efforts are being made to have these data compiled and made available to the assessment.

Sentinel Survey

The size composition of the halibut caught during the 1995 and 1996 sentinel surveys are presented for information on Figure 12. The limited numbers of fish caught during the surveys make it difficult to draw conclusions about the size structure of the population from this source of information. The results of the surveys indicate a decline in raw (unstratified) halibut catch rate from 1995 to 1996. The catch rate in 1995 was 3.2 kg per standard set (1500 hooks) while in 1995 the catch rate was 2.6 kg per standard set. These estimates should not be over interpreted relative to the increase or decrease in abundance for halibut in the survey area. It should also be pointed out that the survey (as is the case with the individual trawl survey results) give estimates for only a portion of the present stock area and could be affected by intra-stock migration patterns or shifts in seasonal distribution patterns.

Age-model and estimation of mortality

Estimating total mortalities from catch data requires conversion of lengths to age. Since no reliable growth model exists for 3NOPs4VWX halibut we tentatively adopted that published for the Gulf of St. Lawrence (Archambault 1995). The data presented by Archambault (1995) were grouped into 3 cm bins to conform with survey data collection protocols used on the summer surveys of the Scotian Shelf. The resultant male and female "age-length keys" (Table 7 a,b) were then used to convert the summer survey population estimates at length to population estimates at age. These population estimates were then pooled by five year blocks to fill in 'voids' in the age-frequency compositions (Figure 13) and used to calculate total mortality rates by estimating the slope of the descending limb of the ln catch curve (Figure 14). These two figures show the results for males only as an illustrative example. The resulting Z values ranged from approximately 0.27 to 0.35 for the four 5-year time periods.

To estimate the trend in mortality rate from the summer survey as a whole, we calculated three year running mean population numbers at age (by sex) and calculated the slope of the descending limb of each resulting catch curve. The results of these analyses show that Z for females (Figure 15) was relatively stable at about 0.3 throughout the 1970's and then increased to a higher level through the mid 1980's. Total mortality is now at a relatively high value (0.5- 1.0). Moralities for males (Figure 16) were variable but higher in the 1970's than those estimated for females. Since the mid 1980's male mortality has fluctuated between 0.2 and 0.5. The trends for both sexes pooled indicate an overall increasing trend in mortality through the late 1980's and early 1990's to a present level of about 0.5 (Figure 17).

Commercial Fisheries Information

Commercial Catch / Effort (Stats.)

We used commercial catch and effort statistics (analytical format) to calculate a catch per unit of effort (CPUE) series for 3NOPs4VWX halibut. We used only those data from 1988 to 1996 since data prior to 1988 recorded fixed gear effort in lines fished rather than the thousands of hooks of the subsequent period. In discussions with representatives of the halibut fishing sector early in 1997, it was indicated that the effort used in calculating the fixed gear CPUE series in last year's assessment of this resource was thought to be inflated by; 1)the inclusion of all effort expended with size #14 hooks (some of which was reported to have been directed at hake), and 2) by the statistics data recording protocol of assigning "main species caught" in those landings where halibut were caught, to that species having the greatest dollar value in the landing. Given the high value of halibut relative to other species of groundfish (pound for pound), even a small amount of halibut could result in all effort being assigned to halibut when it was actually directed at another species. We reclassified all catch and effort records where halibut was caught to "main species = halibut" only in those cases where halibut was the largest single portion of the catch for that trip or sub-trip. We considered that in this manner we would assure that all effort assigned to the CPUE series would be halibut directed in the strictest sense of the word. In subsequent discussions with fishermen it was indicated that this might exclude a number of records where effort really was directed at halibut, but where white hake was the largest single portion of the catch for the trip or sub-trip. We have not yet looked into the effect of including these hake dominated halibut trips.

The CPUE series calculated based on the data described above indicates a decline in catch rates from 1988 to the present (Figure 18). The large decline from 1988 to 1989 is most evident for tonnage class 3 (150 - 500 GRT) vessels (Figure 19) whereas the declines for the other major vessel classes participating in the fishery (25 - 50 GRT, and 50 - 150 GRT) show a more gradual decline over this period. The longline CPUE is shown relative to the results of the RV surveys on Figure 20 where it appears to show some relationship to the 3NOPs (unstratified) index (although not significant $P > 0.05$) but does not appear to correlate with the other survey indices for the stock area.

The otter trawl catch rate series shown of Figure 17 is extremely variable due to the relatively small amount of landings and effort associated with the series. As a result we did not consider this to be a reliable indicator of resource abundance.

For the fixed gear CPUE series both the total effort included in the series and the total amount of landings included have increased since 1994. In 1996 the landings included in the series represent about 36% of the total landings (Figure 21).

Observer Program Data

We used two sources of data gathered by the Maritimes Region Observer Program. The first is information on halibut by-catch in the silver hake directed fishery conducted in the small mesh gear zone along the edge of the Scotian Shelf (NAFO Divisions 4VWX), and the second is information on halibut catch and effort in the halibut directed longline fishery in NAFO Divisions 3NO, and the halibut by-catch in the 3NO longline cod / hake fishery.

The halibut by-catch catch rate in the silver hake directed fishery did not correlate well with the estimates of abundance derived from the 4VW winter survey, even when the survey catch rates were estimated only for those strata where the silver hake fishery is conducted and the halibut by-catch rate is calculated only for the time period of the survey (Figure 22). The halibut by-catch catch rate for the June-July period was compared to the July survey results for 4VWX and again the two series showed no correlation. Although neither series shows a significant correlation with trawl survey estimates, the by-catch catch rate series are based on a very large number of observations and must not be dismissed as indicators of resource abundance. The March-April series shows relatively little change in catch rate until 1994 when the catch rate decreases significantly. This decline is however due the introduction of the Nordmor exclusion grate. The June-July series shows a variable catch rate through 1988 and a near monotonic decline until 1994 when the exclusion grate was introduced (Figure 23).

Halibut by-catch rates in the longline cod / hake directed fishery in 3NO did not correlate with the overall 3NO survey index r=0.05 (Figure 24), while the halibut directed catch rate showed some degree of correlation (Figure 25) with the 3NOPs (unstratified survey index). The latter two series both show a decline from 1988 to 1993. In 1994-1996, the halibut catch rate remains more or less stable. The results of the 3NOPs survey have not yet been obtained for these years.

Estimation of Mortality

We used two main sources of information from which to estimate mortality for halibut in 3NOPs4VWX. The first are a number of commercial samples collected from the halibut fishery during 1960, and the second are samples collected from the present halibut fishery by the National Sampling Program. Our objective was to compare estimates of mortality derived from the 1960's samples to those obtained from samples of the recent fishery. As was the case with the survey data we converted the length frequencies into age frequencies using the Gulf age-length model, however given the much greater size range of fish in the 1960's sample than were available in the age-length keys (based on 1994 data) we modeled age as a linear function of length. We first attempted to fit the Gulf age-length data to a Von Bertalanffy growth model and obtained a very poor fit with unrealistic estimates of L inf (= 9m, Figure 26). The linear model gave a very good fit (figure 27) and was used to convert lengths to ages.

We have some concerns about using the simplistic linear growth model especially since we were using the model to predict age from fish at lengths outside of the range of observation of the input data. However, the model indicated a growth of about 7 to 8 cm per year which at an assumed maximum age for 3NOPs4VW halibut of 30 - 35 years would result in a maximum size of 210 - 280 cm, sizes of fish which have been encountered. We also considered that even if the age model proves to be inaccurate, if we apply the same model to the data for the two time periods, the errors in the model would be of equal magnitude for the two periods and thus validate the comparison in relative terms.

The age composition of the longline caught halibut for 1960 relative to the age composition of recent catches (Figure 28) shows that the former had a much broader range of ages than the latter, presumably a reflection of the greater number of age classes in the population. The catch curves for the corresponding age-compositions (Figure 29) show correspondingly different estimates of Z for the two periods. The estimated instantaneous total mortality in the 1960 population was approximately 0.32 while Z for the most recent three years range from 0.51-0.53 an increase of about 160% over the 36 year period. Since these estimates are not based on a constant age range and since the age range for the more recent period is contracted relative to the 1960 population, these estimates are likely conservative. We recalculated the Z's using only a range of ages common to the two time period (ages 11 - 17). The resultant catch curves give estimates of Z which range from 0.28 in the 1960 population to 0.70 - 0.85 in the last three years, an increase of about 300% (Figure 30). Given the similarity of the catch curves estimated for 1994-1996 we also estimated a pooled catch curve and a pooled Z value for the three year time block (Figure 31). The results of this analysis indicates a present mortality rate of about 0.8 versus a 1960 mortality rate of about 0.6, or a 60 percent increase.

We also examined the age composition of the otter trawl landings for the two periods. From this it is evident that otter trawls caught a greater number of young halibut than did the longliners. Figure 32 gives the catch curves for the two gears in 1960 and shows clearly that halibut recruited to the otter trawl fishery 4 to 5 years before they recruited to the long-line fishery (the combined catch curve for the 1960 landings is shown in Figure 33). Present day age-composition of the otter trawl landings are available for only a restricted portion of the stock area (4X) and for only a few years 1989-1994 excluding 1990. Since 4X contains a greater number of small halibut than other portions of the stock, using these samples to characterize the age composition of recent removals could result in over-representing these small fish in the total catches. We therefore considered it prudent to base our comparisons of mortality only on samples from the longline fleets.

It is of interest to examine the age-composition of the otter trawl landings in that they do have an impact on this population by acting as what amounts to an intercept fishery for the fixed gear fleet and tend to catch fish at sizes well below the age at first maturity or the length at maximum yield. In 1960 the age-composition of the otter trawl caught fish was far broader than in recent years (Figure 34). The data for the most recent years shows that there appears to have been a significant shift towards landing larger fish by the otter trawl fleet (based on limited sampling from 4X only). Since there were significant

amounts of halibut reported as having been landed by otter trawls during the mid to late 1980's in 3NO, and during the early 1980's in 4VW, and these are likely made up of mainly immature fish, the impacts of such removals on the age structure of the population may have been severe.

Yield per Recruit Calculations

Based on a length weight relationship derived from otter trawl caught halibut (Figure 35), the Gulf age-length model to convert length to ages, and assuming knife-edged recruitment to the fishery at age 10, and M=0.2 we calculated yield per recruit for halibut. The results (Table 8 and Figure 36) show that given the present growth model F0.1 for halibut = 0.08 and Fmax = 0.24. If we assume that M=0.2 and that Z is in the range of 0.5 to 0.8 as indicated by the analyses above then present F is between 0.3 and 0.6, well above Fmax.

Conclusions and Prognosis

The foregoing analyses suggest that : 1) halibut abundance, as estimated from the results of research vessel surveys, is presently low relative to the available time series, 2) mortality rates (Z) in 1994-1996 may be 2 to 3 times higher than estimated for the 1960s and that present values of Z may be on the order of 0.5 to 0.8., 3) the size range of the population has been significantly reduced since the 1960s, and 4) existing data for commercial longline vessels (1988-1996) indicate a declining CPUE.

Evaluation of the status of 3NOPs4VWX halibut is presently hampered by the absence of a dedicated survey, the lack of an appropriate growth model, and by inadequate sampling of commercial landings.

The lack of this information necessitates making a large number of assumptions. If we assume that the trawl survey indices are an indication of overall abundance , and the degree of agreement between the various surveys indicates that they are tracking abundance, we conclude that, at present, halibut abundance is low relative to the available time series. If the Gulf age-length model applied to both the research vessel survey data and the commercial sampling data is appropriate, then we conclude that present mortality (Z) is in the range of 0.5 to 0.8 and that this is significantly higher than what was estimated for the population some 35 years ago.

Commercial catch rates have declined gradually in the directed longline fishery since 1988. The release of halibut less than 81 cm in recent years, and the introduction of other restrictive management measures may have reduced the overall catch rate to some degree, unfortunately these effects cannot be quantified. The result is that the commercial catch rate indices should be interpreted with caution.

Summary

The biological indicators for this stock suggest, low abundance relative to the last 26 years, a high total morality, a declining commercial catch rate, and a compressed size range relative to the historical population. These are indicators of a heavily exploited resource. At present there are no survey results which would allow us to estimate future recruitment to the resource.

References

Archambault, D. 1994. Le fletan Atlantique des Divisions 4RST. DFO Canadian Stock Assessment Secratariat Research Document 94/35 24p.

Annand, C. and D. Beanlands. 1996. A review of the 4VWX3NOPs halibut stock. Can. Atl. Fish. Res. Doc. 96/33, 31p.

Brown, S.K., R. Mahon, K.C.T. Zwanenburg, K.R. Buja, L.W. Claflin, R.N. O'Boyle, B. Atkinson, M. Sinclair, G. Howell, and M.E Monaco. 1996. East Coast of North America groundfish: Initial explorations of biogeography and species assemblages. Silver Spring, MD: National Oceanic and Atmospheric Administration, and Dartmouth, NS: Department of Fisheries and Oceans. 111p

Table 1. Halibut landings (t round fresh) by country for divisions 4VWX and divisions 3N0 and 3Ps.

	4VWX			3N0Ps			Total 4VWX + 3NOPs
Year	Canada	Foreign	Total	Canada	Foreign	Total	
1961	1498	78	1576	1230	468	1698	3274
1962	1660	40	1700	1194	339	1533	3233
1963	1453	80	1533	674	222	896	2429
1964	1461	90	1551	373	583	956	2507
1965	1574	35	1609	167	414	581	2190
1966	1030	146	1176	318	212	530	1706
1967	1236	12	1248	368	568	936	2184
1968	1175	42	1217	415	285	700	1917
1969	1024	57	1081	413	256	669	1750
1970	818	12	830	664	25	689	1519
1971	946	59	1005	481	100	581	1586
1972	825	25	850	402	89	491	1341
1973	765	9	774	452	42	494	1268
1974	641	13	654	345	136	481	1135
1975	638	12	650	332	87	419	1069
1976	708	6	714	269	76	345	1059
1977	705	8	713	576	27	603	1316
1978	1082	10	1092	337	8	345	1437
1979	1224	-	1224	420	3	423	1647
1980	1454	4	1458	255	40	295	1753
1981	1389	6	1395	217	27	244	1639
1982	1720	5	1725	468	54	522	2247
1983	1827	5	1832	253	193	446	2278
1984	1954	40	1994	871	182	1053	3047
1985	1940	28	1968	1591	472	2063	4031
1986	1609	23	1632	1492	221	1713	3345
1987	1161	22	1183	801	589	1390	2573
1988	1263	3	1266	765	277	1042	2308
1989	1156	2	1158	669	115	784	1942
1990	1094	6	1100	702	299	1001	2101
1991*	990	59	1049	429	690	1119	2168
1992*	931	42	973	338	62	400	1373
1993*	867	38	905	322	391	338	1618
1994*	861	1	862	162	82	244	1106
1995*	550	3	553	158	144	302	855
1996*	626	0	626	157	27	184	811

* Data from DFO Statistics Branch; provisional data for countries other than Canada.

Table 2. Halibut landings by division and year for all countires combined.

Year	4V	4W	4X	Total 4VWX	3N	3O	3Ps	Total 3N0Ps	Total
1961	415	544	617	1576	212	840	646	1698	3274
1962	294	621	785	1700	67	1180	286	1533	3233
1963	214	479	840	1533	125	561	210	896	2429
1964	332	358	861	1551	88	335	533	956	2507
1965	486	458	665	1609	66	341	174	581	2190
1966	527	318	331	1176	112	225	193	530	1706
1967	380	322	546	1248	234	372	330	936	2184
1968	250	363	604	1217	118	284	298	700	1917
1969	192	433	456	1081	91	298	280	669	1750
1970	115	349	366	830	133	246	310	689	1519
1971	231	360	414	1005	164	241	176	581	1586
1972	178	216	456	850	104	254	133	491	1341
1973	147	226	401	774	79	228	187	494	1268
1974	123	127	404	654	20	267	194	481	1135
1975	115	159	376	650	93	169	157	419	1069
1976	144	148	422	714	76	182	87	345	1059
1977	88	177	448	713	36	178	389	603	1316
1978	244	283	565	1092	43	137	165	345	1437
1979	230	358	636	1224	49	213	161	423	1647
1980	339	371	748	1458	46	104	145	295	1753
1981	250	379	766	1395	42	64	138	244	1639
1982	342	476	907	1725	63	288	171	522	2247
1983	419	546	867	1832	173	117	156	446	2278
1984	496	572	926	1994	279	463	311	1053	3047
1985	606	620	742	1968	516	1032	515	2063	4031
1986	553	579	500	1632	394	907	412	1713	3345
1987	345	354	484	1183	750	457	183	1390	2573
1988	298	360	608	1266	656	245	141	1042	2308
1989	300	415	443	1158	334	227	223	784	1942
1990	278	369	453	1100	492	325	184	1001	2101
1991*	221	456	372	1049	770	237	112	1119	2168
1992*	199	380	352	973[1]	164	175	61	400	1373
1993*	192	284	391	905[1]	113	547	53	713[1]	1618
1994*	219	282	361	862	84	92	68	244	1106
1995*	158	178	217	553	132	79	91	302	855
1996*	153	194	279	626	24	104	57	185	811

* Data from DFO Statistics Branch; provisional data for countries other than Canada.
[1] Includes catch where area not known.

Table 3a. Halibut landings for Canada (Maritimes and Quebec) for divisions 4VWX by quarter of year for 1970 - 1996.

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	59	19	23	7	108	122	119	88	18	347	44	134	121	64	363	818
1971	110	44	56	8	218	124	114	61	15	314	49	111	180	74	414	946
1972	58	31	83	6	178	26	77	78	12	193	38	135	220	61	454	825
1973	53	23	57	10	143	56	102	57	10	225	49	128	160	60	397	765
1974	43	27	40	8	118	7	47	67	6	127	21	96	184	95	396	641
1975	45	19	39	5	108	23	66	57	11	157	23	124	162	64	373	638
1976	50	45	44	3	142	8	88	47	4	147	35	113	179	92	419	708
1977	21	15	33	15	84	11	78	64	23	176	69	166	147	63	445	705
1978	35	88	55	66	244	24	139	99	14	276	54	206	224	78	562	1082
1979	47	90	62	31	230	20	253	78	7	358	65	260	206	105	636	1224
1980	83	140	74	40	337	40	209	91	31	371	85	317	196	148	746	1454
1981	75	86	72	13	246	78	197	73	31	379	127	273	242	122	764	1389
1982	44	154	113	31	342	69	199	176	31	475	117	283	335	168	903	1720
1983	48	227	104	39	418	86	277	164	18	545	129	289	340	106	864	1827
1984	103	197	140	18	458	61	199	295	17	572	119	176	442	187	924	1954
1985	143	313	123	14	593	52	252	279	23	606	90	179	374	98	741	1940
1986	107	322	96	12	537	47	252	259	14	572	62	128	248	62	500	1609
1987	71	153	88	16	328	37	176	127	9	349	49	172	211	52	484	1161
1988	84	114	71	26	295	11	155	188	6	360	80	201	263	64	608	1263
1989	99	121	52	26	298	75	133	191	16	415	83	137	174	49	443	1156
1990	116	106	37	16	275	52	108	190	16	366	73	128	192	60	453	1094
1991	65	98	46	5	214	29	118	233	27	407	70	159	93	47	369	990
1992	72	69	41	27	209	36	138	186	30	390	54	130	112	56	352	951
1993	68	79	54	2	203	23	99	153	14	289	84	123	135	41	383	875
1994	37	90	74	19	220	50	111	108	13	282	32	103	151	75	361	862
1995	78	45	28	7	158	45	76	46	8	175	31	77	75	34	217	550
1996	51	65	23	13	153	45	74	65	10	194	46	70	103	60	279	676

Table 3b. Halibut landings for Canada (Maritimes and Quebec) for divisions 3NOPs by quarter of year for 1970 - 1996.

	3N					30					3Ps					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	82	32	14	5	133	141	34	21	50	246	162	16	44	63	285	664
1971	34	69	18	7	128	58	25	51	58	192	86	52	15	8	161	481
1972	4	20	12	7	43	56	36	32	104	228	61	20	27	23	131	402
1973	1	4	40	11	56	86	73	34	32	225	87	26	36	22	171	452
1974	5	3	4	3	15	71	63	18	2	154	59	74	27	16	176	345
1975	0	34	21	16	71	36	34	18	17	105	32	88	30	6	156	332
1976	8	47	2	1	58	54	51	18	5	128	16	22	32	13	83	269
1977	4	13	0	4	21	43	36	39	55	173	59	168	30	125	382	576
1978	10	16	6	8	40	25	74	22	12	133	20	67	55	22	164	337
1979	1	23	13	12	49	20	102	41	50	213	55	69	17	17	158	420
1980	10	7	9	20	46	4	25	46	21	96	22	37	30	24	113	255
1981	0	9	13	11	33	27	16	12	9	64	50	47	20	3	120	217
1982	0	2	7	26	35	71	193	8	7	279	21	81	33	19	154	468
1983	3	17	3	2	25	55	33	17	4	109	38	39	31	11	119	253
1984	3	80	131	1	215	63	174	96	85	418	44	78	40	76	238	871
1985	25	94	93	74	286	182	394	167	134	877	120	155	94	59	428	1591
1986	0	57	199	7	263	376	255	180	32	843	149	167	59	11	386	1492
1987	21	142	160	7	330	115	177	41	5	338	46	53	27	7	133	807
1988	72	182	153	30	437	84	100	22	30	236	45	19	19	9	92	765
1989	59	136	77	11	283	69	101	35	7	212	64	75	26	9	174	669
1990	22	116	54	8	200	110	130	65	13	318	79	77	23	5	184	702
1991	2	46	17	19	84	58	132	25	18	233	55	29	24	4	112	429
1992	15	35	40	12	102	53	68	37	17	175	42	35	7	8	92	369
1993	22	24	14	1	61	63	61	34	49	207	26	11	15	2	54	322
1994	11	8	0	0	19	20	33	12	9	74	9	38	17	4	68	161
1995	3	-	1	-	4	23	20	19	9	71	46	34	8	3	91	166
1996*	3	0	2	-	5	24	26	18	27	96	21	19	17	0	57	158

* Provisional.
[1] Area not known.

Table 3c. Halibut landings for all Foreign Countries combined for divisions 4VWX by quarter of year for 1970 - 1996.

	4V						4W						4X						
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	Total
1970	3	2	2	0		7	-	2	-	-		2	0	2	0	1		3	12
1971	0	0	6	7		13	2	44	0	0		46	-	-	-	-		-	59
1972	-	-	-	-		-	1	1	0	1	20	23	2	0	0	0		2	25
1973	3	1	0	0		4	0	1	0	0		1	2	1	0	1		4	9
1974	0	0	2	3		5	-	-	-	-		-	6	2	0	0		8	13
1975	3	1	3	-		7	0	1	0	0	1	2	1	0	0	0	2	3	12
1976	2	-	-	-		2	0	0	0	0	1	1	1	0	0	0	2	3	6
1977	4	-	-	-		4	-	1	-	-		1	1	0	0	0	2	3	8
1978	-	-	-	-		-	-	-	4	3		7	1	0	0	0	2	3	10
1979	-	-	-	-		-	-	-	-	-		-	-	-	-	-		-	-
1980	2	-	-	-		2	-	-	-	-		-	0	0	0	1	1	2	4
1981	3	1	0	0		4	-	-	-	-		-	0	0	1	0	1	2	6
1982	-	-	-	-		-	-	-	1	-		1	0	0	1	0	3	4	5
1983	1	-	-	-		1	-	-	1	-		1	0	0	0	0	3	3	5
1984	32	-	2	4		38	-	-	-	-		-	0	0	0	0	2	2	40
1985	1	6	1	5		13	-	14	-	-		14	0	0	0	0	1	1	28
1986	4	4	5	3		16	0	7	0	0		7	-	-	-	-	-	-	23
1987	1	4	12	0		17	0	5	0	0		5	-	-	-	-	-	-	22
1988	0	1	1	1		3	-	-	-	-		-	-	-	-	-	-	-	3
1989	-	-	1	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
1990	-	-	3	-	-	3	-	3	-	-	-	3	-	-	-	-	-	-	6
1991	-	-	-	-	7	7	-	-	-	-	49	49	-	-	-	-	3	3	59
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42[1]
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38[1]
1994	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
1995	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	0	0	3
1996*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3d. Halibut landings for all Foreign Countries combined for divisions 3NOPs by quarter of year for 1970 - 1996.

	3N						30						3Ps						
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	NK	Total	Total
1970	-	-	-	-		-	-	-	-	-		-	17	6	2	0		25	25
1971	-	15	21	0		36	0	48	1	0		49	14	1	0	0		15	100
1972	18	7	2	34		61	0	14	0	12		26	2	0	0	0		2	89
1973	1	3	19	0		23	0	0	3	0		3	2	7	6	1		16	42
1974	0	0	5	0		5	51	17	45	0		113	11	5	0	2		18	136
1975	15	0	7	0		22	5	47	12	0		64	1	-	-	-		1	87
1976	18	-	-	-		18	54	-	-	-		54	-	1	3	-		4	76
1977	-	5	10	-		15	5	-	-	-		5	5	2	-	-		7	27
1978	-	2	-	1		3	-	4	-	-		4	1	-	-	-		1	8
1979	-	-	-	-		-	-	-	-	-		-	2	1	-	-		3	3
1980	-	-	-	-		-	-	2	-	6		8	6	7	8	11		32	40
1981	0	1	6	2		9	-	-	-	-		-	5	4	0	9		18	27
1982	2	19	5	2		28	-	7	2	-		9	6	11	-	-		17	54
1983	17	100	4	27		148	6	2	-	-		8	1	24	9	3		37	193
1984	-	19	11	34		64	-	1	6	38		45	53	15	4	1		73	182
1985	41	85	74	29	1	230	66	25	25	39		155	33	48	6	-		87	472
1986	52	43	26	7	3	131	11	28	15	10		64	9	8	6	3		26	221
1987	66	187	72	94	1	420	37	47	27	8		119	19	22	1	8		50	589
1988	91	83	16	16	13	219	0	5	0	4		9	37	8	1	3		49	277
1989	-	-	-	-	51	51	-	-	-	-	15	15	-	-	-	-	49	49	115
1990	60	84	73	75	-	292	-	1	5	1	-	7	-	-	-	-		-	299
1991	-	-	-	-	686	686	-	-	-	-	4	4	-	-	-	-		-	690
1992	-	-	-	-	62	62	-	-	-	-	-	-	-	-	-	-		-	62
1993	-	-	-	-	52	52	-	-	-	-	339	339	-	-	-	-	-	-	391
1994	7	27	17	13	-	64	1	8	3	6	-	18	-	-	-	-	-	-	82
1995	40	20	60	-	8	128	3	3	6	-	4	16	-	-	-	-	-	-	144
1996*	3	11	5	-	-	19	3	2	3	-	-	8	-	-	-	-	-	-	27

* Provisional.
[1] Area not known.

Table 4a. Halibut landings by otter trawlers <150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	-	-	-	-	-	-	1	-	-	1	5	7	1	1	14	15
1971	-	-	-	-	-	-	1	-	-	1	1	8	19	1	29	30
1972	-	-	-	-	-	-	-	-	-	-	0	2	0	0	2	2
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	0	3	1	0	4	4
1975	-	-	-	-	-	-	1	-	-	1	-	11	6	2	19	20
1976	-	-	-	-	-	-	-	-	-	-	0	2	1	1	4	4
1977	-	-	-	-	-	0	0	0	1	1	1	7	6	2	16	17
1978	-	-	-	-	-	-	-	-	-	-	1	7	6	2	16	16
1979	-	-	-	-	-	0	0	2	-	2	3	35	13	5	56	58
1980	0	1	0	0	1	0	5	0	0	5	4	43	12	8	67	73
1981	-	-	-	-	-	1	3	0	0	4	14	18	19	4	55	59
1982	-	-	-	-	-	3	5	0	0	8	7	28	16	6	57	65
1983	-	-	-	-	-	1	2	0	0	3	15	36	20	4	75	78
1984	-	-	-	-	-	0	2	0	-	2	16	20	19	1	56	58
1985	-	-	-	-	-	0	2	0	0	2	9	15	8	2	34	36
1986	1	0	0	0	1	-	-	-	-	-	10	8	4	1	23	24
1987	-	-	-	-	-	0	2	0	0	2	11	11	4	0	26	28
1988	-	-	-	-	-	0	6	0	0	6	21	34	3	2	60	66
1989	-	-	-	-	-	0	5	0	0	5	28	17	2	1	48	53
1990	4	5	1	0	10	0	0	0	0	0	25	16	16	14	71	81
1991	0	0	0	0	0	0	1	1	0	2	31	29	10	18	88	90
1992	0	0	0	0	0	0	0	0	0	0	27	27	14	15	83	83
1993	-	0	0	0	0	0	-	-	-	0	61	41	5	1	108	108
1994	0	1	1	0	2	0	0	0	0	0	17	13	8	0	38	40
1995	1	1	2	0	4	0	0	0	0	0	20	8	1	0	29	33
1996**	0	1	1	0	2	-	0	0	0	0	27	1	1	1	30	32

Table 4b. Halibut landings by otter trawlers of >150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	16	7	2	6	31	49	27	16	7	99	18	28	7	19	72	202
1971	31	15	4	0	50	87	40	8	4	139	35	31	5	8	79	268
1972	22	10	2	0	34	16	7	11	9	43	20	15	8	2	45	122
1973	8	2	0	1	11	22	10	3	3	38	36	10	1	3	50	99
1974	12	11	1	3	27	2	0	1	2	5	3	2	5	10	20	52
1975	10	16	6	1	33	3	10	-	3	16	4	9	20	17	50	99
1976	14	12	20	2	48	0	2	1	3	6	16	13	36	26	91	145
1977	7	9	13	14	43	3	5	11	13	32	35	21	2	13	71	146
1978	20	62	23	10	115	12	32	15	8	67	20	22	4	9	55	237
1979	21	26	20	30	97	4	21	16	3	44	24	22	3	41	90	231
1980	30	45	31	35	141	33	35	16	28	112	22	6	3	33	64	317
1981	23	38	19	13	93	45	42	8	8	103	25	11	0	13	49	245
1982	27	65	47	26	165	15	31	8	7	61	18	5	5	10	38	264
1983	16	30	29	30	105	19	29	13	1	62	16	3	3	1	23	190
1984	33	19	8	5	65	6	7	1	0	14	6	2	1	0	9	88
1985	61	55	15	8	139	0	1	1	0	2	3	0	0	0	3	144
1986	19	48	8	4	79	1	0	0	1	2	1	1	0	0	2	83
1987	19	15	8	1	43	-	-	-	-	-	1	0	0	0	1	44
1988	8	6	0	0	14	2	0	1	0	3	-	-	-	-	-	17
1989	4	3	4	1	12	-	-	-	-	-	-	-	-	-	-	12
1990	14	11	0	1	26	0	0	0	0	0	0	0	0	0	0	26
1991	16	15	5	1	37	0	1	40	6	47	0	1	2	1	4	88
1992	7	5	0	3	15	2	27	50	0	34	1	1	0	0	2	51
1993	6	5	-	1	12	0	5	19	0	24	0	1	1	0	2	38
1994	3	2	1	1	7	0	1	1	0	2	0	1	0	1	2	11
1995	17	2	1	3	23	3	0	0	0	3	1	0	0	1	2	28
1996*	6	1	0	1	8	1	0	0	0	1	2	1	0	0	3	12

* Data from DFO Statistics Branch.

Table 4c. Halibut landings by longline and handline boats <150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	36	8	21	1	66	64	88	70	11	233	18	88	108	43	257	556
1971	62	19	36	-	117	29	67	51	11	158	12	63	149	65	289	564
1972	21	7	65	0	93	0	53	58	3	114	18	97	198	59	372	579
1973	37	11	49	2	99	32	80	49	7	168	13	116	157	57	343	610
1974	25	7	21	0	53	2	43	57	2	104	18	83	172	83	356	513
1975	28	2	24	-	54	12	47	57	8	124	19	100	134	45	298	476
1976	28	16	24	1	69	7	77	44	1	129	19	91	140	63	313	511
1977	14	6	16	1	37	8	67	47	7	129	32	122	119	44	317	483
1978	14	10	11	0	35	10	91	71	2	174	32	155	196	58	441	650
1979	25	27	32	1	85	16	213	57	4	290	35	167	183	51	436	811
1980	34	39	28	2	103	6	159	55	3	223	57	241	172	106	576	902
1981	17	39	44	0	100	32	149	62	21	264	87	231	210	102	630	994
1982	3	72	53	4	132	49	159	166	24	398	90	242	308	150	790	1320
1983	10	180	75	6	271	62	243	148	13	466	97	242	301	97	737	1474
1984	41	171	132	12	356	48	165	292	17	522	96	153	416	176	841	1719
1985	47	254	103	5	409	51	249	277	22	599	71	155	360	91	677	1685
1986	40	271	88	6	405	42	245	251	13	551	45	111	232	54	442	1398
1987	21	134	78	4	237	37	173	126	8	344	37	146	206	52	441	1022
1988	39	107	71	26	243	8	149	185	4	346	59	167	254	62	542	1131
1989	30	114	43	9	196	75	121	189	16	401	55	120	171	48	394	991
1990	28	89	36	7	160	52	107	189	15	363	45	112	173	46	376	899
1991	26	78	40	1	145	29	115	189	21	354	38	124	79	27	268	767
1992	46	62	40	23	161	32	107	177	30	346	25	100	96	41	262	779
1993	42	72	52	0	154	18	93	133	13	257	22	79	127	39	267	690
1994	33	84	72	18	207	49	109	107	13	278	14	86	141	73	314	794
1995	41	36	25	4	106	37	76	48	7	165	9	68	73	33	183	454
1996*	9	65	22	12	108	28	74	65	9	176	18	68	100	59	245	529

Table 4d. Halibut landings by longline and handline boats of >150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	7	4	-	-	11	9	3	-	-	12	3	1	-	-	4	27
1971	17	10	16	8	51	8	4	1	-	13	1	-	-	-	1	65
1972	15	14	16	6	51	10	9	3	0	22	0	7	0	0	7	80
1973	8	10	8	7	33	1	9	2	0	12	-	-	-	-	-	45
1974	6	8	15	3	32	3	0	1	0	4	0	1	0	0	1	37
1975	7	1	9	4	21	7	6	-	-	13	-	-	-	-	-	34
1976	7	17	0	0	24	1	8	0	-	9	-	-	-	-	-	33
1977	0	0	4	0	4	0	2	-	-	2	0	2	-	-	2	8
1978	1	11	20	2	34	1	2	1	1	5	-	-	-	-	-	39
1979	1	37	10	0	48	0	6	0	0	6	1	1	0	4	6	60
1980	19	55	15	3	92	1	3	18	0	22	2	3	0	0	5	119
1981	35	9	9	0	53	0	1	1	0	2	-	-	-	-	-	55
1982	14	17	13	1	45	2	4	0	0	6	-	-	-	-	-	51
1983	22	17	0	3	42	4	1	0	3	8	-	-	-	-	-	50
1984	29	7	0	1	37	7	21	0	-	28	1	0	0	9	10	75
1985	35	4	5	1	45	1	0	0	0	1	5	0	0	3	8	54
1986	47	2	0	2	51	1	0	0	0	1	-	-	-	-	-	52
1987	31	4	2	11	48	-	-	-	-	-	-	-	-	-	-	48
1988	37	1	0	0	38	-	-	-	-	-	-	-	-	-	-	38
1989	65	4	5	16	90	-	-	-	-	-	-	-	-	-	-	90
1990	70	1	0	8	79	-	0	-	1	1	-	-	-	-	-	80
1991	23	5	1	2	31	-	0	-	0	0	-	-	-	-	-	31
1992	19	2	1	1	23	2	1	1	-	4	0	0	-	-	0	27
1993	20	2	2	1	25	0	0	-	1	1	-	0	-	0	0	26
1994	1	2	0	-	3	0	0	-	-	0	0	0	0	-	0	3
1995	20	7	-	-	27	5	-	-	-	5	0	-	-	-	0	32
1996*	34	-	-	-	34	16	-	-	-	16	-	0	-	-	-	50

* Data from DFO Statistics Branch.

Table 4e. Halibut landings for other gear, all tonnage classes combined by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	4V					4W					4X					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Canadian Total
1970	-	-	-	-	-	-	-	2	-	2	-	10	5	1	16	18
1971	-	-	-	-	-	-	2	1	-	3	-	9	7	-	16	19
1972	-	-	-	-	-	0	8	6	0	14	0	14	0	0	28	42
1973	-	-	-	-	-	1	3	3	0	7	0	2	2	0	4	11
1974	0	1	3	2	6	0	4	8	2	14	0	7	6	2	15	35
1975	-	-	-	-	-	1	2	-	-	3	-	4	2	-	6	9
1976	1	0	0	0	1	0	1	2	0	3	0	7	2	2	11	15
1977	-	-	-	-	-	0	4	6	2	12	1	14	20	4	39	51
1978	0	5	1	54	60	1	14	12	3	30	1	22	18	9	50	140
1979	-	-	-	-	-	0	13	3	0	16	2	35	7	4	48	64
1980	-	-	-	-	-	0	7	2	0	9	0	24	9	1	34	43
1981	-	-	-	-	-	0	2	2	2	6	1	13	13	3	30	36
1982	-	-	-	-	-	0	0	2	0	2	2	8	6	2	18	20
1983	-	-	-	-	-	0	2	3	1	6	1	8	16	4	29	30
1984	-	-	-	-	-	0	4	2	0	6	0	1	6	1	8	14
1985	-	-	-	-	-	0	0	1	1	2	2	9	6	2	19	21
1986	0	1	0	0	1	3	7	8	0	18	6	8	12	7	33	51
1987	-	-	-	-	-	0	1	1	1	3	0	15	1	0	16	19
1988	-	-	-	-	-	1	0	2	2	5	0	0	6	0	6	11
1989	-	-	-	-	-	0	7	2	0	9	0	0	1	0	1	10
1990	0	0	0	0	0	0	1	1	0	2	3	0	3	0	6	8
1991	0	1	0	0	1	0	1	3	0	4	1	5	2	1	9	14
1992	0	0	0	0	0	-	1	3	0	3	-	2	3	0	4	7
1993	0	1	0	-	1	-	1	1	0	2	1	1	2	1	5	8
1994	0	0	0	-	0	-	0	0	0	0	0	0	0	1	1	1
1995	1	0	1	0	2	-	0	0	0	0	0	0	1	0	1	3
1996*	3	0	0	0	3	1	-	0	0	1	0	1	-	0	1	5

* Data from DFO Statistics Branch.

Table 5a. Halibut landings by longline and handline boats <150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	3N					30					3Ps					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	70	23	-	-	93	79	34	-	-	113	5	7	5	-	17	223
1971	34	69	7	-	110	39	21	38	7	105	16	26	14	-	56	271
1972	1	0	0	0	1	42	20	6	1	69	37	13	7	1	58	128
1973	-	-	-	-	-	7	14	24	11	56	5	14	3	3	25	81
1974	-	-	-	-	-	12	15	6	1	34	10	6	3	2	21	55
1975	-	3	1	-	4	7	12	12	2	33	6	6	10	1	23	60
1976	0	14	1	1	16	13	4	3	0	20	3	2	3	0	8	44
1977	-	-	-	-	-	4	3	2	0	9	4	11	8	0	23	32
1978	-	-	-	-	-	1	3	5	0	9	0	12	4	2	18	27
1979	-	-	-	-	-	0	12	0	1	13	1	3	0	0	4	17
1980	-	-	-	-	-	3	13	0	0	16	2	10	7	3	22	38
1981	-	-	-	-	-	-	-	-	-	-	1	14	1	1	17	27
1982	-	-	-	-	-	-	-	-	-	-	2	12	14	1	29	29
1983	-	-	-	-	-	0	3	15	-	18	6	28	10	0	44	62
1984	0	79	56	0	135	1	74	56	2	133	5	53	9	0	67	335
1985	19	32	64	32	147	0	143	120	47	310	1	87	35	2	125	582
1986	0	32	170	3	205	0	55	146	0	201	41	114	50	3	208	614
1987	0	87	93	3	183	8	31	24	0	63	2	26	6	1	35	281
1988	0	80	105	1	186	6	44	13	1	64	15	5	16	0	36	286
1989	8	87	55	5	155	5	60	19	0	84	14	54	4	0	72	311
1990	3	77	23	2	105	10	52	30	1	93	4	10	7	0	21	219
1991	-	7	-	-	7	3	28	6	7	44	1	9	19	1	30	81
1992	-	7	14	-	21	1	22	27	-	50	11	13	3	1	28	99
1993	1	20	6	1	28	2	29	11	-	42	2	7	0	0	9	79
1994	-	8	-	0	8	-	22	1	-	23	-	-	-	0	0	31
1995	-	-	-	-	-	0	6	4	7	17	10	4	2	1	17	34
1996	-	-	-	-	-	6	2	13	9	30	-	0	0	0	0	30

Table 5b. Halibut landings by longline and handline boats >150 GRT by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec).

	3N					3O					3Ps					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	7	6	-	-	13	7	-	-	-	7	6	-	-	-	6	26
1971	-	-	-	-	-	14	4	2	1	21	6	21	-	-	27	48
1972	3	18	0	0	21	3	2	3	1	9	6	0	7	1	14	44
1973	0	3	30	0	33	11	40	4	8	63	18	1	2	8	29	125
1974	-	-	-	0	-	14	33	8	1	56	14	5	9	6	34	90
1975	-	27	-	-	28	28	4	2	14	48	5	2	5	2	14	90
1976	0	23	0	0	23	29	1	0	5	35	3	1	1	0	5	63
1977	0	10	0	1	11	17	6	5	13	41	1	1	3	0	5	57
1978	9	9	0	0	18	15	2	0	2	19	0	1	8	0	9	46
1979	-	14	-	-	14	15	0	0	0	15	6	0	0	0	6	35
1980	10	3	5	0	18	0	0	0	11	11	0	0	4	0	4	33
1981	0	8	0	0	8	16	2	1	4	23	2	6	4	1	13	44
1982	0	1	0	0	1	14	9	0	0	23	0	12	9	0	21	45
1983	0	14	0	2	16	10	13	2	1	26	3	6	9	0	18	60
1984	0	0	74	0	74	9	98	36	0	143	26	8	0	14	48	265
1985	2	57	27	39	125	8	59	19	19	105	36	19	7	3	65	295
1986	0	19	24	0	43	36	119	18	23	196	27	11	0	4	42	281
1987	21	50	59	3	133	57	47	15	2	121	15	18	12	4	49	303
1988	72	102	46	27	247	53	42	9	29	133	15	7	2	6	30	410
1989	51	47	21	5	124	46	23	14	5	88	40	8	20	4	72	284
1990	19	39	31	6	95	65	42	33	11	151	48	48	16	5	117	363
1991	2	37	16	19	74	33	27	19	10	89	19	10	3	3	35	198
1992	15	28	25	12	80	28	30	7	10	75	10	9	2	6	27	182
1993	20	3	8	0	31	53	22	18	1	94	13	2	12	1	28	153
1994	11	0	-	0	11	18	3	7	8	36	9	24	13	1	47	94
1995	3	0	-	-	3	22	2	12	1	37	33	17	1	-	51	91
1996	3	0	-	-	3	18	9	5	12	44	20	2	9	-	31	78

* Data from DFO Statistics Branch.

Table 5c. Halibut landings for all other gears by quarter of year for 1970 - 1996 for Canada (Maritimes and Quebec), includes unknown TC.

	3N					3O					3Ps					
Year	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	1st Quart.	2nd Quart.	3rd Quart.	4th Quart.	Total	Total
1970	5	3	14	5	27	55	-	21	50	126	151	9	39	63	262	415
1971	0	0	11	7	18	5	0	11	50	66	64	5	1	8	78	162
1972	0	2	12	7	21	11	14	23	102	150	18	7	13	21	59	230
1973	1	1	10	11	23	68	19	6	13	106	64	11	31	11	117	246
1974	5	3	4	3	15	45	15	4	0	64	35	63	15	8	121	200
1975	0	4	20	15	39	1	18	4	1	24	21	80	15	3	119	182
1976	8	10	1	0	19	12	46	15	0	73	10	19	28	13	70	162
1977	4	3	0	3	10	22	27	32	42	123	54	156	19	125	354	487
1978	1	7	6	8	22	9	69	17	10	105	20	54	43	20	137	264
1979	1	9	13	12	35	5	90	41	49	185	48	66	17	17	148	368
1980	0	4	4	20	28	1	12	46	10	69	20	27	19	21	87	184
1981	0	1	13	11	25	11	14	11	5	41	47	27	15	1	90	156
1982	0	1	7	26	34	57	184	8	7	256	19	57	10	18	104	394
1983	3	3	3	0	9	45	17	0	3	65	29	5	12	11	57	131
1984	3	1	1	1	6	53	2	4	83	142	13	17	31	62	123	271
1985	4	5	2	3	14	174	192	28	68	462	83	49	52	54	238	714
1986	0	6	5	4	15	340	81	16	9	446	81	42	9	4	136	597
1987	0	5	8	1	14	50	99	2	3	154	29	9	9	2	49	217
1988	0	0	2	2	4	25	14	0	0	39	15	7	1	3	26	69
1989	0	2	1	1	4	18	18	2	2	40	10	13	2	5	30	74
1990	0	0	0	0	0	35	36	2	1	74	27	19	1	0	46	120
1991	0	3	0	0	3	22	77	1	0	100	35	9	2	1	47	150
1992	0	0	0	0	0	24	16	3	6	49	22	13	1	1	37	86
1993	0	0	1	0	1	9	10	5	48	72	11	3	3	0	17	90
1994	0	0	0	0	0	2	7	11	0	19	0	13	3	2	18	37
1995	0	0	1	-	1	1	13	1	1	16	3	12	5	2	22	39
1996*	-	0	2	-	2	2	16	1	7	26	1	17	8	0	26	54

* Data from DFO Statistics Branch.

6

Table. Halibut catch per standard tow for all surveys conducted in the stock area and adjacent waters

Year	Summer	4VW Cod	Spring	Fall	3NOPs	SA23M	SA5	
70	0.11							
71	0.11							
72	0.09							
73	0.14							
74	0.22							
75	0.19				0.09	0.00	0.02	
76	0.34				0.15	0.01	0.03	
77	0.39				0.45	0.04	0.01	
78	0.28			0.21	0.28	0.06	0.02	
79	0.30		0.88	0.27	0.57	0.10	0.02	
80	0.41		0.32	0.39	0.65	0.07	0.02	
81	0.31		0.50	0.20	0.56	0.07	0.03	
82	0.23		0.37	0.32	0.55	0.05	0.01	
83	0.07		0.39	0.10	0.17	0.05	0.00	
84	0.20		0.21	0.10	0.22	0.03	0.01	
85	0.16				0.31	0.03	0.03	
86	0.17	0.28			0.13	0.04	0.01	
87	0.19	0.38			0.09	0.05	0.00	
88	0.23	0.59			0.22	0.04	0.00	
89	0.32	0.33			0.15	0.04	0.06	
90	0.20	0.30			0.10	0.03	0.09	
91	0.33	0.61			0.10	0.01	0.04	
92	0.24	0.33			0.10	0.01	0.01	
93	0.15	0.34			0.07	0.01	0.02	
94	0.12	0.20			0.10	0.01		
95	0.11	0.16						
96	0.12	0.25						

Table 7a. Age_length_mal_gulf_3cm

Age_length_key_gulf_males																				
Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
22	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0.16667	0.83333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0.80952	0.19048	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0.38095	0.57143	0.04762	0	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0.38095	0.52381	0.09524	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0.1	0.2	0.6	0.1	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0.28571	0.57143	0.14286	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0.16667	0.33333	0.5	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0.16667	0.16667	0.33333	0.33333	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0.2	0.6	0.2	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0.14286	0.57143	0.28571	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0.33333	0.33333	0.33333	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0.2	0.6	0.2	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0.25	0.25	0.375	0.125	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0.25	0.625	0	0.125	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0.25	0.375	0.25	0.125	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0.57143	0.14286	0.28571	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0.22222	0.22222	0.55556	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0.25	0.5	0.25	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.6	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0.66667	0	0.33333	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0.16667	0.33333	0.33333	0.16667	0	0	0	0	0
103	0	0	0	0	0	0	0	0	0	0	0	0.25	0.33333	0.41667	0	0	0	0	0	0
106	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.6	0	0	0	0	0
109	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0.33333	0.33333	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	0.42857	0.14286	0.42857	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.6	0.2	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Table 7b. fem_z_calc_3yr_rmn

Age_length_key_gulf_females																			
length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
19	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0.166667	0.666667	0.166667	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0.428571	0.428571	0.142857	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0.36	0.6	0.04	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0.111111	0.666667	0.222222	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0.571429	0.428571	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0.333333	0.416667	0.25	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0.090909	0.636364	0.272727	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0.666667	0.333333	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0.222222	0.444444	0.333333	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0.166667	0.333333	0.333333	0.166667	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0.25	0.25	0.5	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0.6	0.4	0	0	0	0	0	0	0	0	0
76	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0.8	0	0.2	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0.833333	0	0.166667	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0.5	0.25	0.25	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0	0.666667	0	0	0.333333	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0.333333	0.333333	0.333333	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0.166667	0.5	0	0.333333	0	0	0	0
103	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.6	0	0	0	0	0
106	0	0	0	0	0	0	0	0	0	0	0	0.333333	0.333333	0.333333	0	0	0	0	0
109	0	0	0	0	0	0	0	0	0	0	0	0	0.333333	0.333333	0	0.333333	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.5	0.25	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333333	0.333333	0.333333	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.166667	0.333333	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
124	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.4	0.4	0	0	0
127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.666667	0.333333	0	0
133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0.75	0	0
136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0
139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Table 8. Yield per Recruit Calculations for halibut

Input data

AGE	LENGTH	wt	recr
1	6.680729	0.000791	0
2	14.43677	0.011858	0
3	22.19281	0.053726	0
4	29.94885	0.154013	0
5	37.70489	0.34593	0
6	45.46092	0.667488	0
7	53.21696	1.160973	0
8	60.973	1.872569	0
9	68.72904	2.852068	0
10	76.48508	4.152633	1
11	84.24112	5.830612	1
12	91.99716	7.94537	1
13	99.7532	10.55916	1
14	107.5092	13.73697	1
15	115.2653	17.54648	1
16	123.0213	22.05789	1
17	130.7774	27.3439	1
18	138.5334	33.47957	1
19	146.2894	40.54233	1
20	154.0455	48.61184	1
21	161.8015	57.76996	1
22	169.5575	68.1007	1
23	177.3136	79.69018	1
24	185.0696	92.62655	1
25	192.8257	107	1

Output

F	Yield	biomass
0	0	39134.03
0.0001	3.183575	39106.93
0.0002	6.361934	39079.84
0.1	1542.635	21835.68
0.2	1776.988	14759.93
0.3	1758.78	11429.73
0.4	1703.962	9644.764
0.5	1653.667	8578.711
0.6	1613.309	7886.137
0.7	1581.661	7406.645
0.8	1556.771	7058.32
0.9	1537.022	6795.773
1	1521.207	6592.09
1.1	1508.439	6430.406
1.2	1498.066	6299.651

f0.1	fmax
0.087303	0.242791

yld0.1	yldmax
1528.63	1800.11

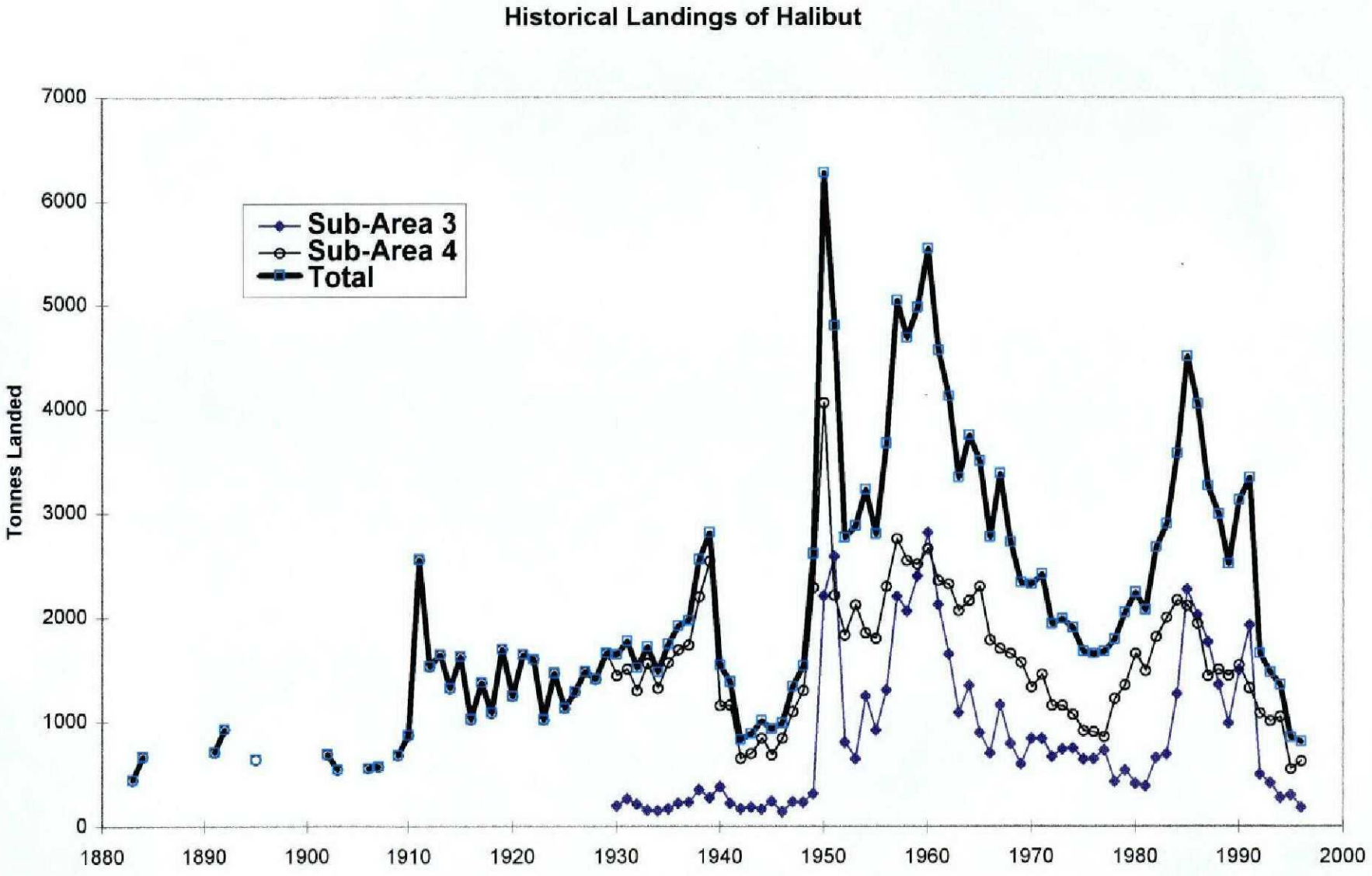


Figure 1. Historical Landings of Halibut from the East Coast of Canada (see text for details).

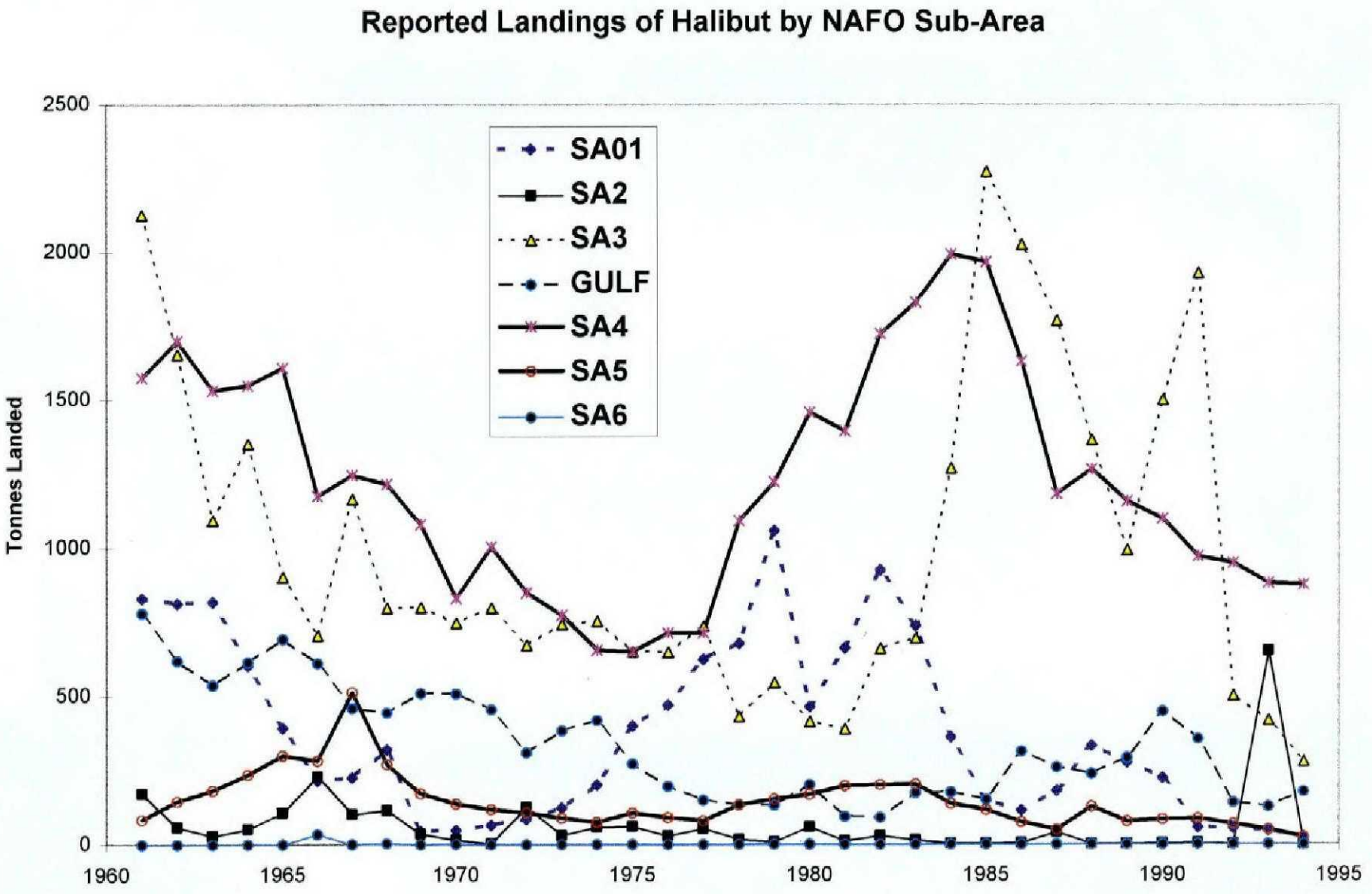


Figure 2. Landings of Halibut by NAFO Sub-area from NAFO Landings statistics. Note that the SA4 has been separated into Gulf and offshore components to conform to present management unit boundaries.

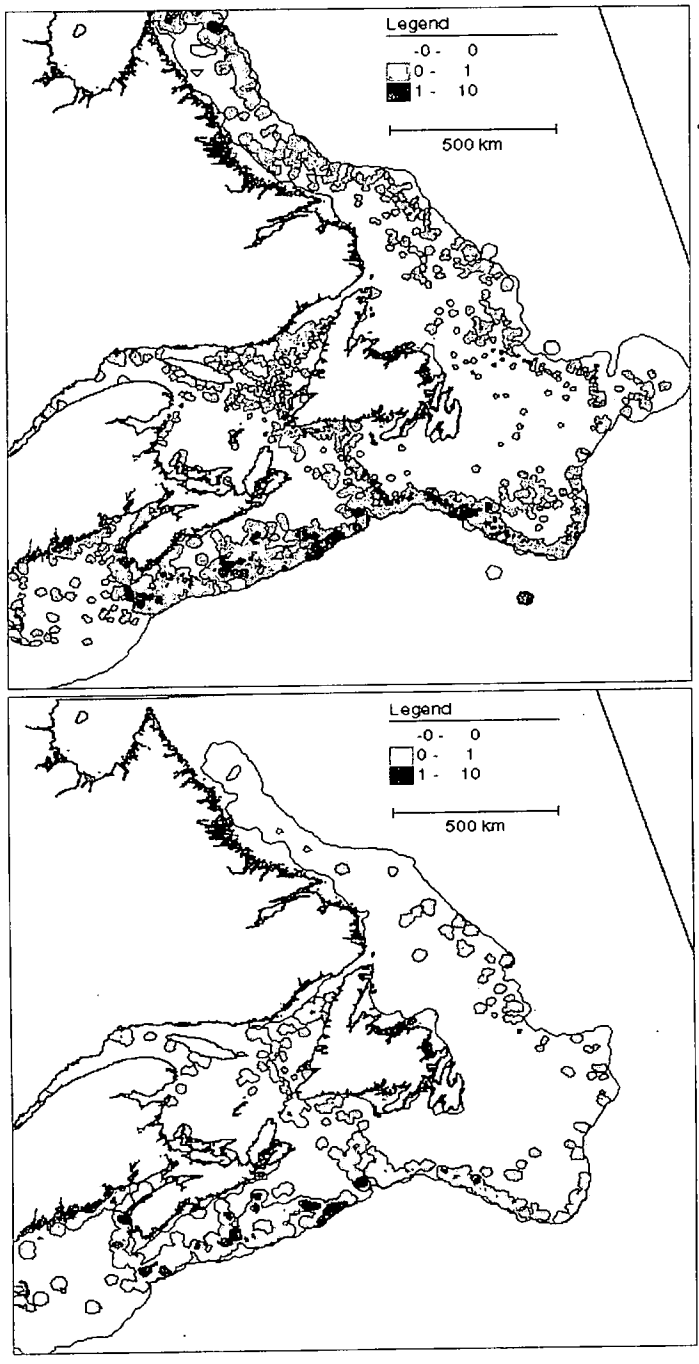


Figure 3. Distribution of Halibut along the east coast of North America derived from the ECNASAP (Brown et al., 1996) data set.

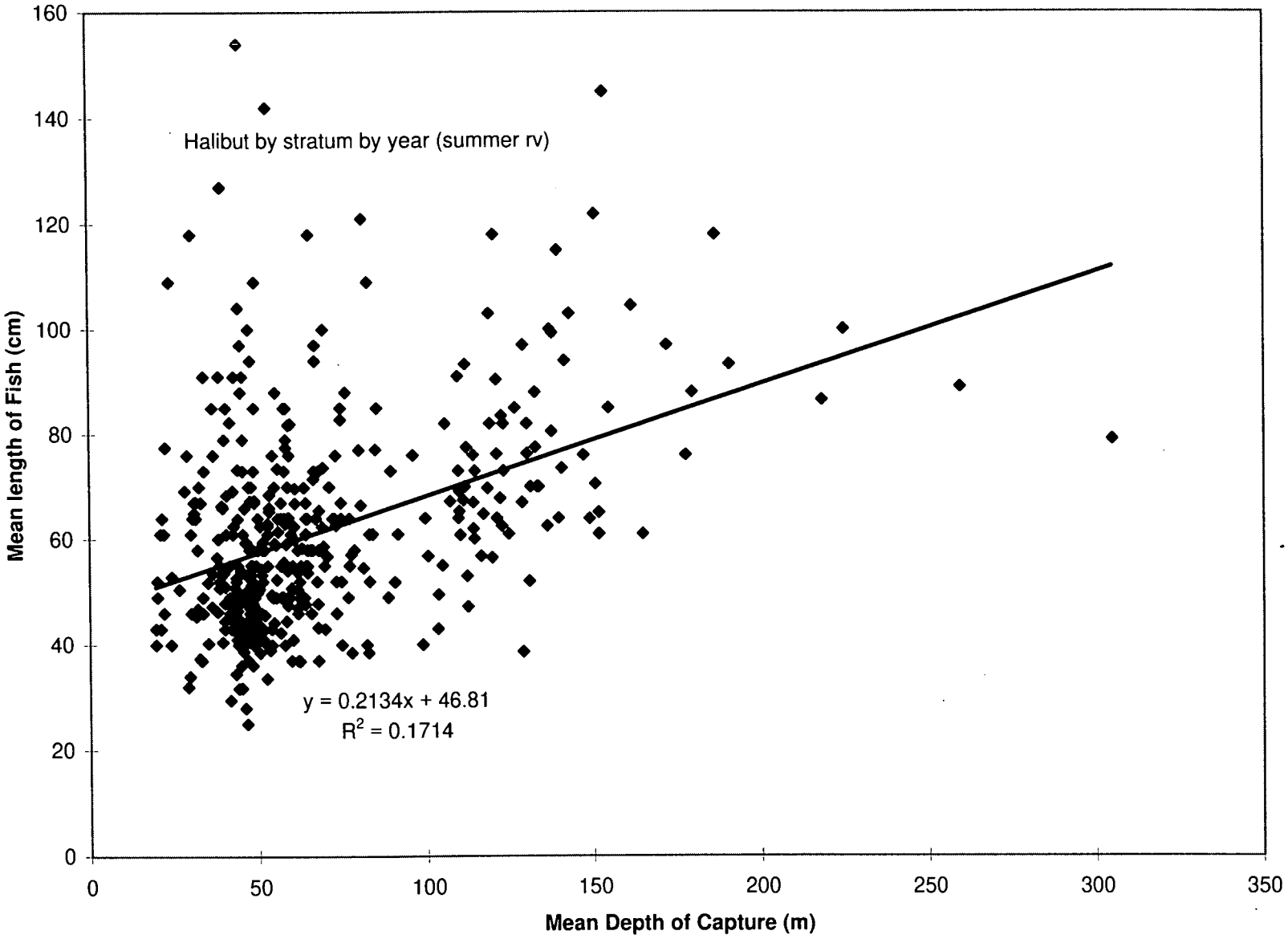


Figure 4. Mean length of halibut caught versus the mean depth of survey tows (by stratum) for the a) summer, b) winter, and c) fall surveys conducted on the Scotian Shelf.

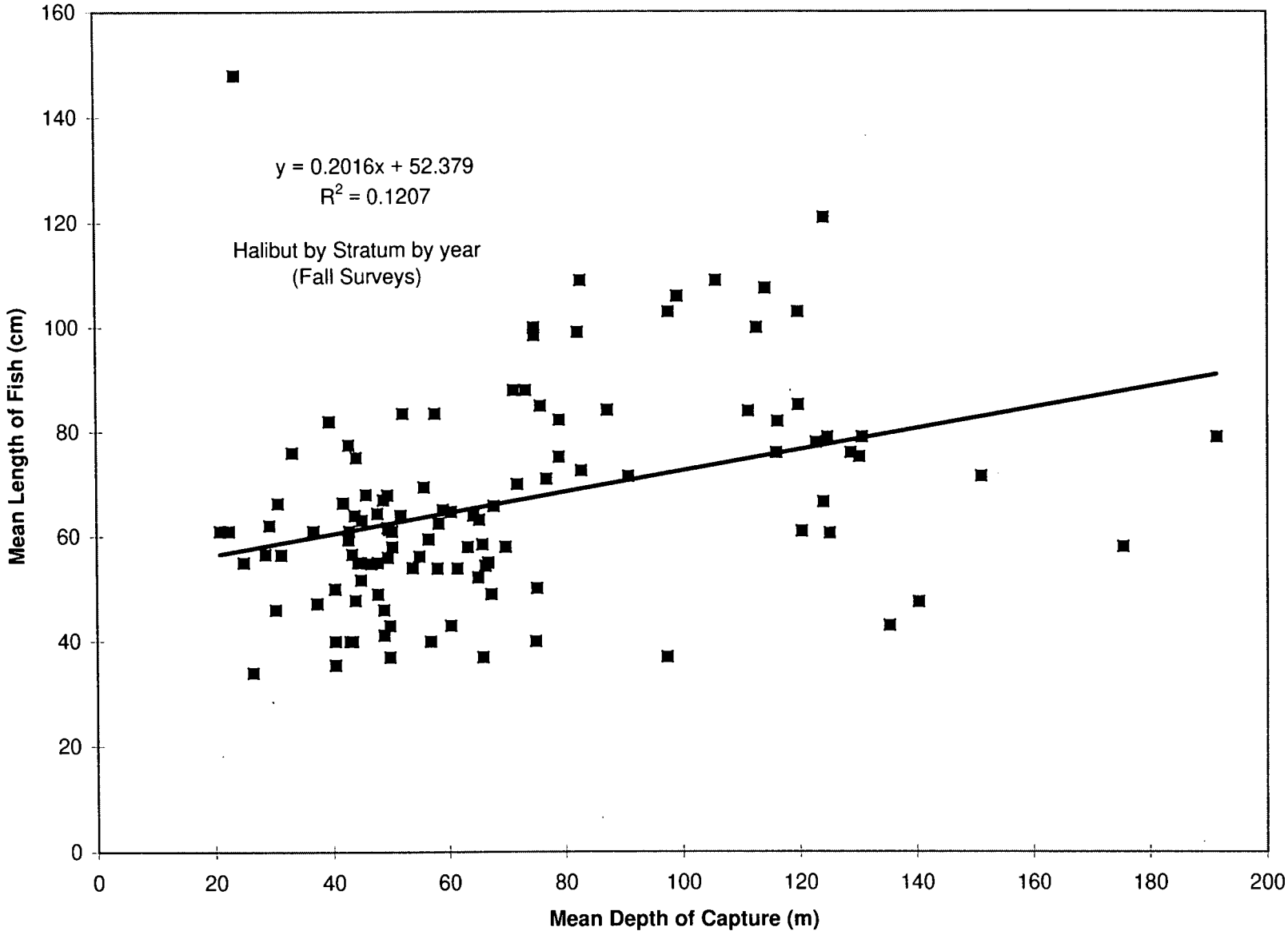


Figure 4. Continued.

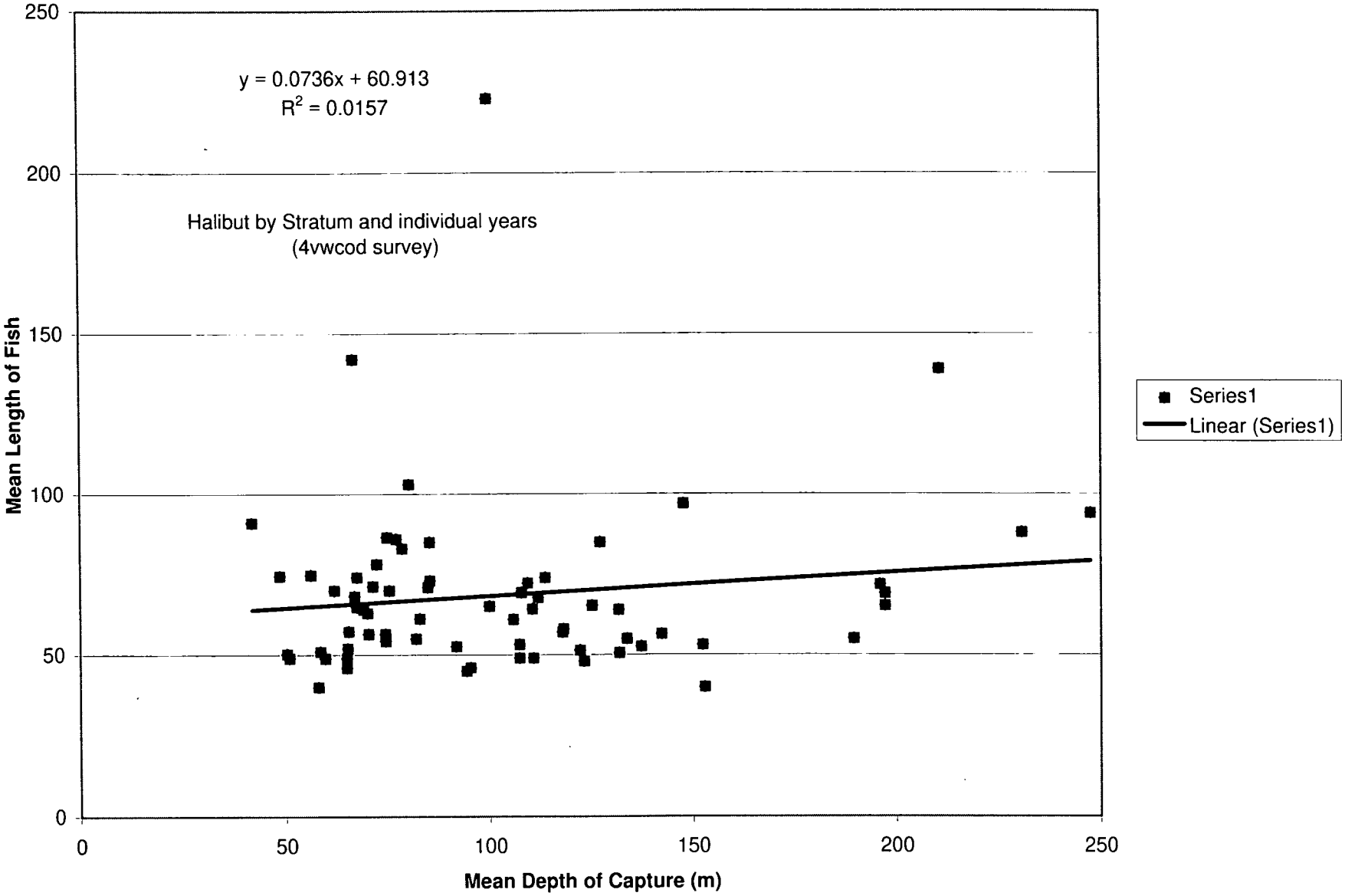


Figure 4. Continued.

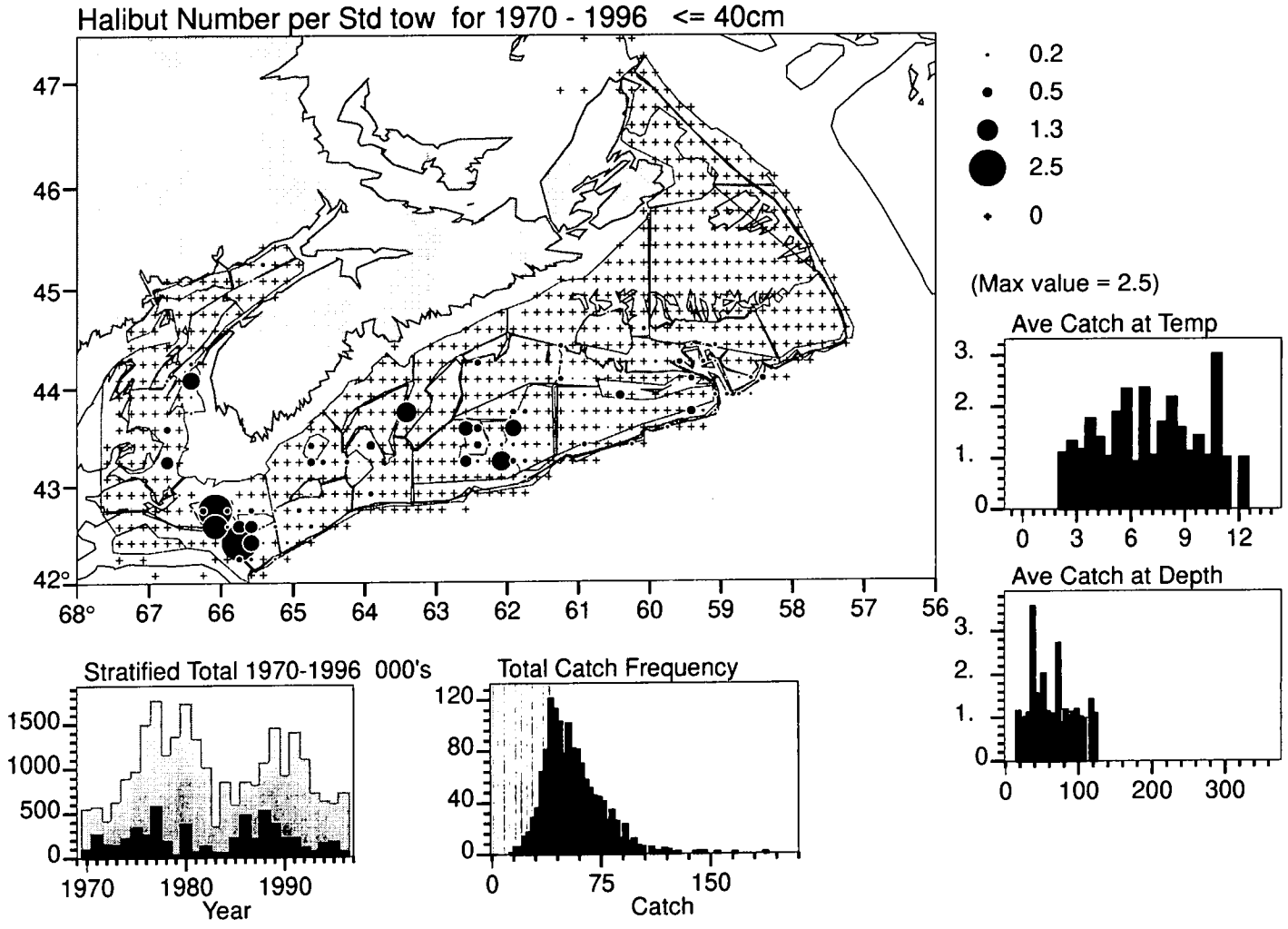


Figure 5. Distribution of small (<40 cm) and large (>40 cm) halibut on the Scotian Shelf. The data presented are the composite distribution derived from summer surveys for the years 1970 - 1996.

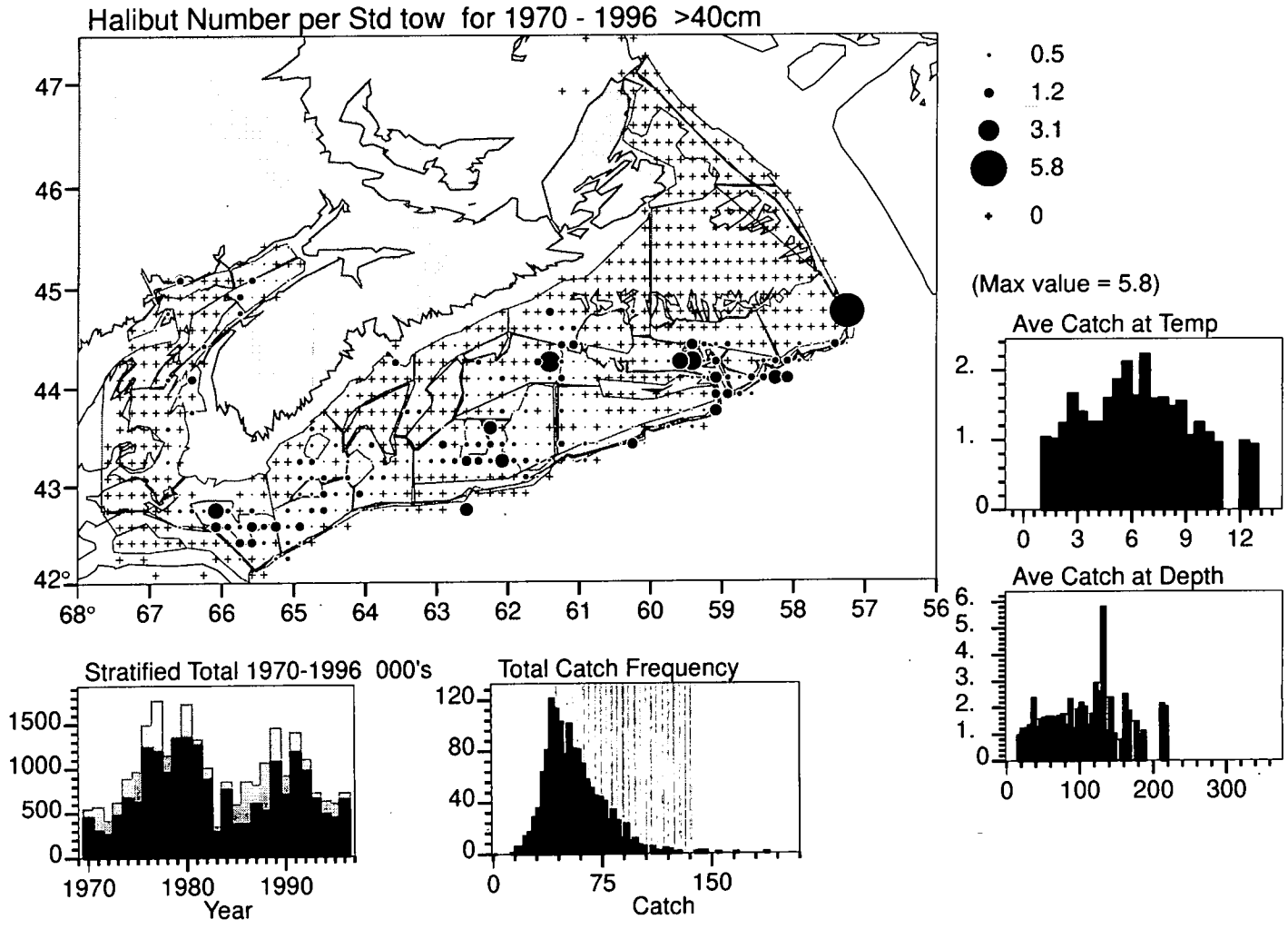


Figure 5. Continued.

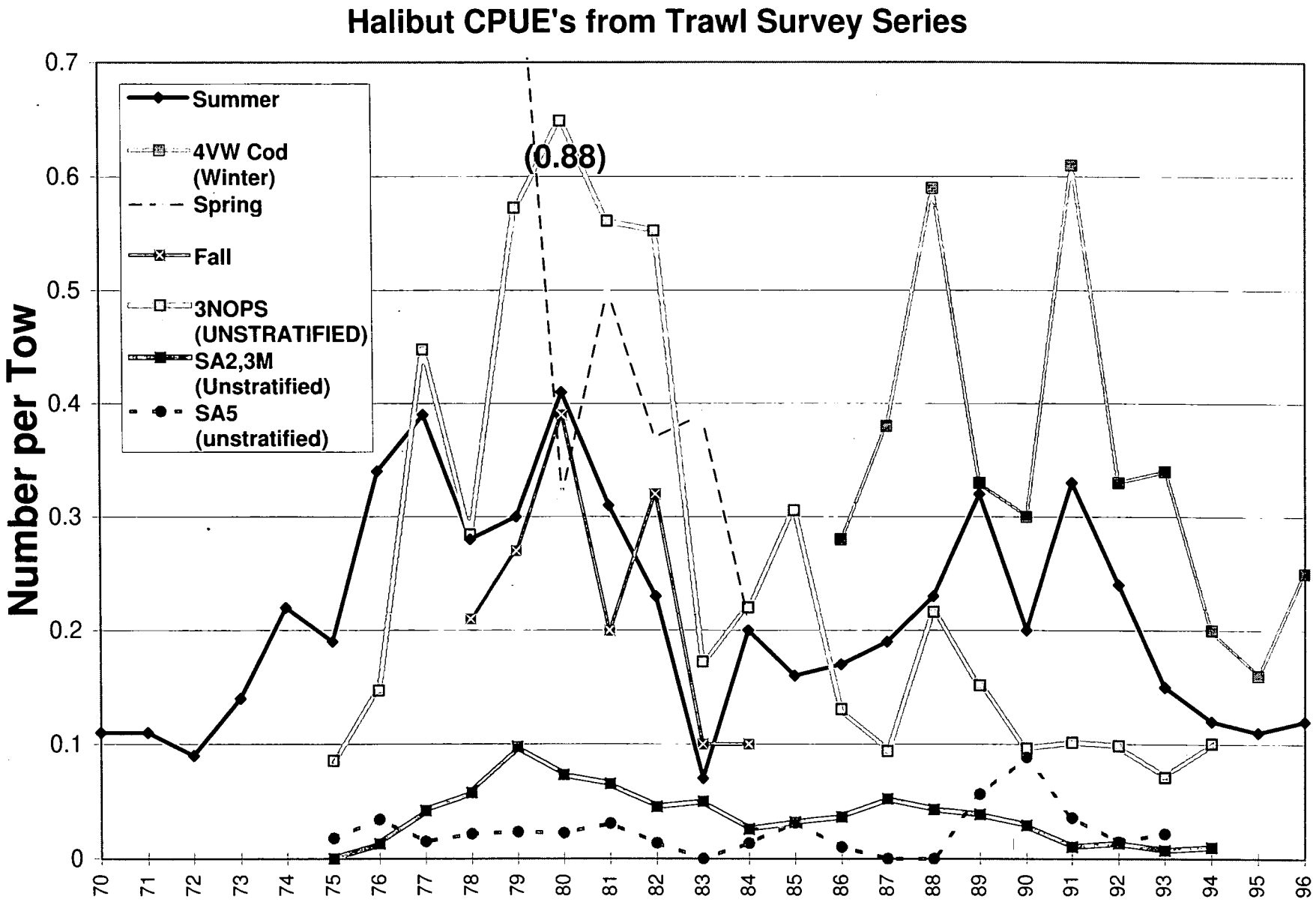


Figure 6. Estimates of halibut abundance by year from all trawl survey series conducted in the 3NOPs4VWX halibut stock area and adjacent waters.

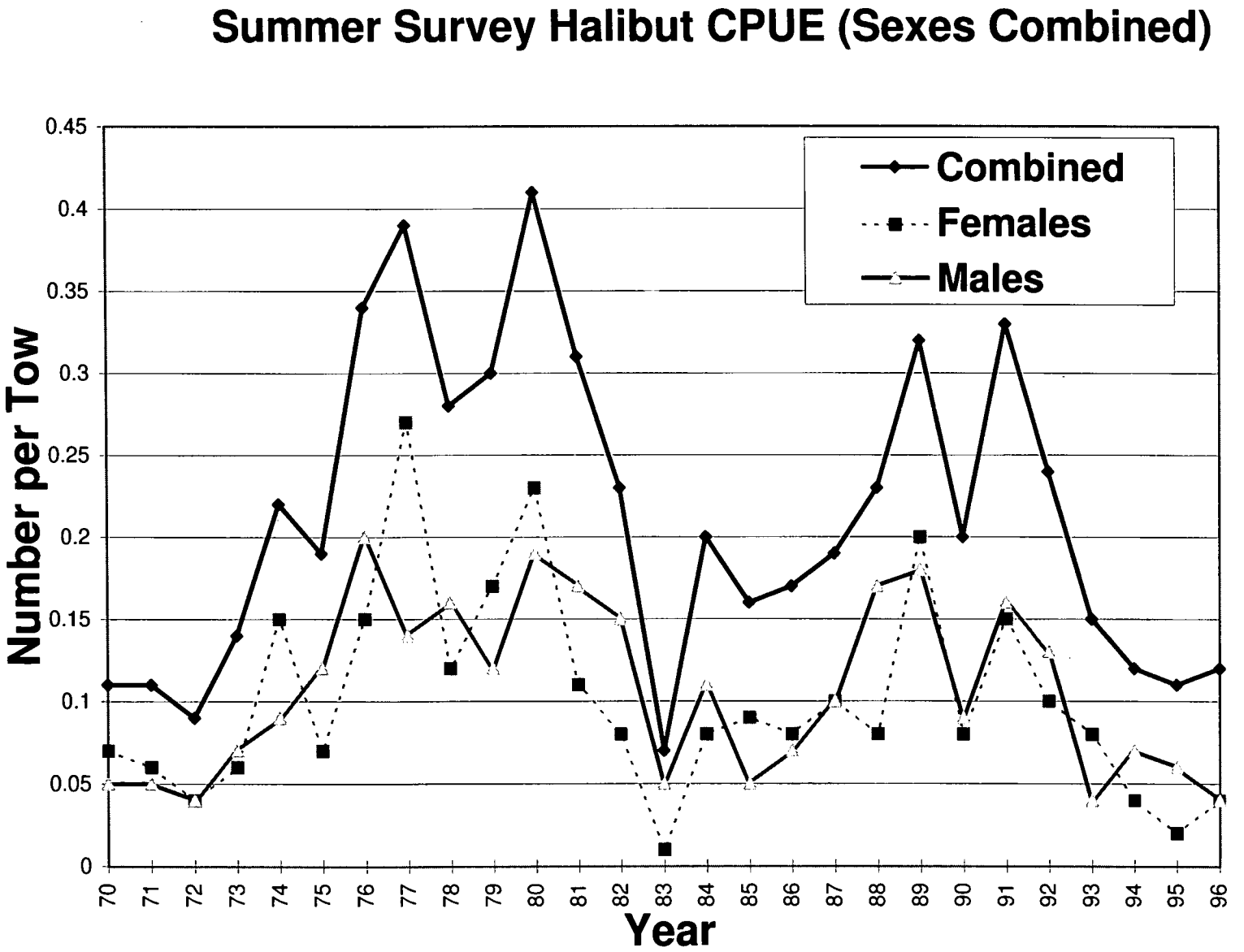


Figure 7. Estimates of halibut abundance, by sex and year, for the summer survey of the Scotian Shelf for the period 1970 - 1996.

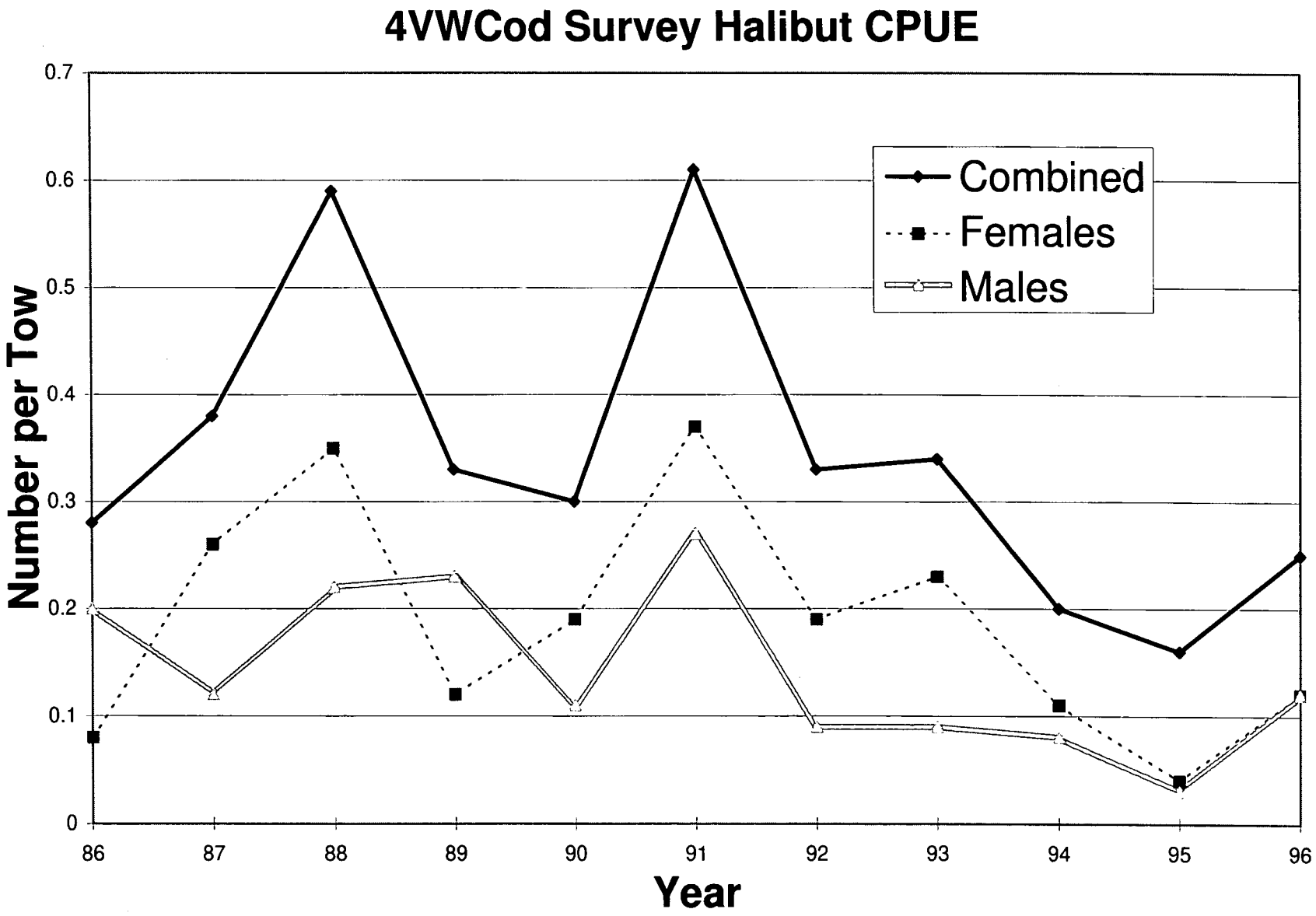


Figure 8. Estimates of halibut abundance, by sex and year, for the winter survey of the Scotian Shelf for the period 1986 - 1996.

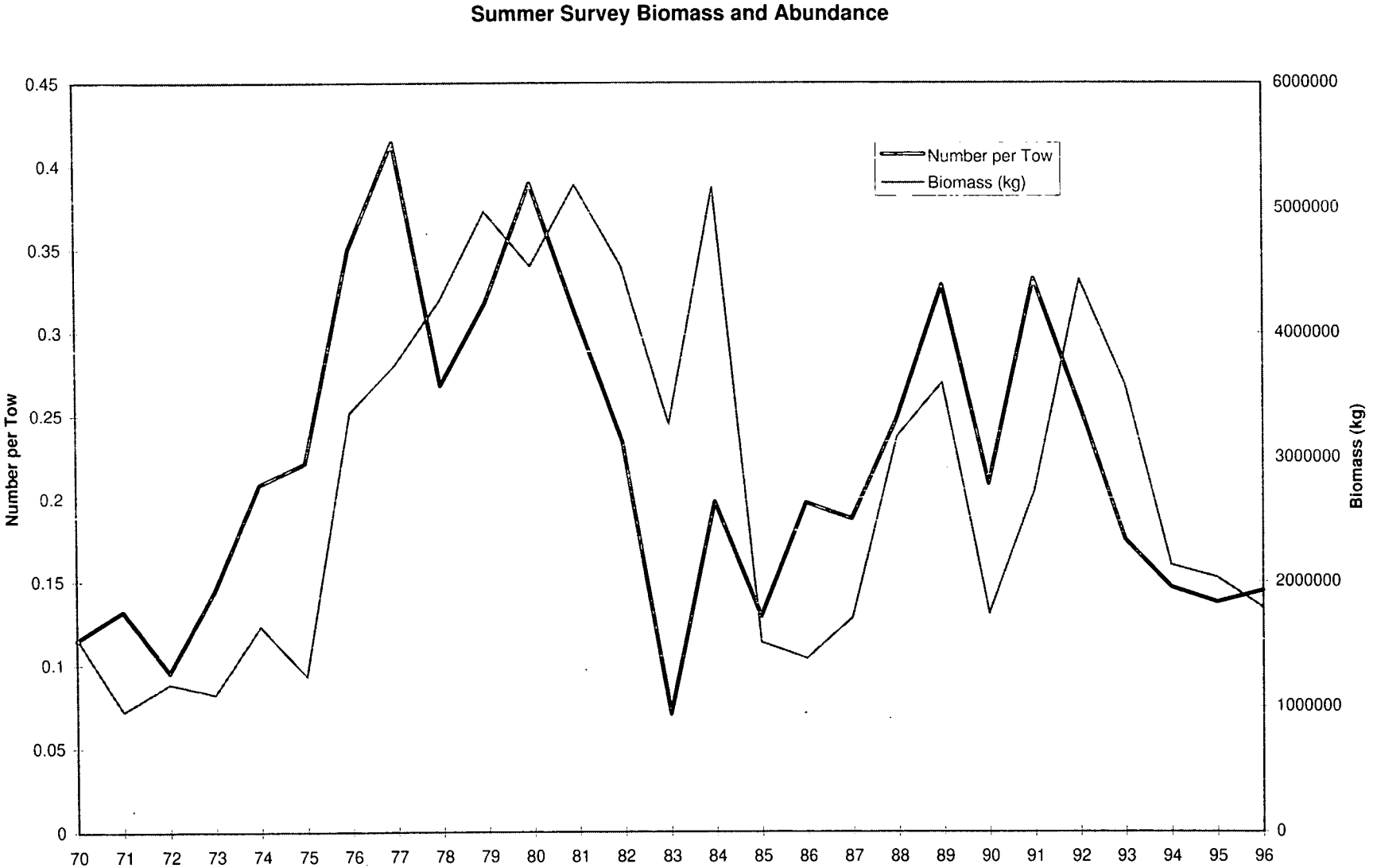


Figure 9. Estimates of trawlable biomass (q=1) of halibut for 4VWX estimated from summer survey results for the period 1970 - 1996.

(Fig. 10a)

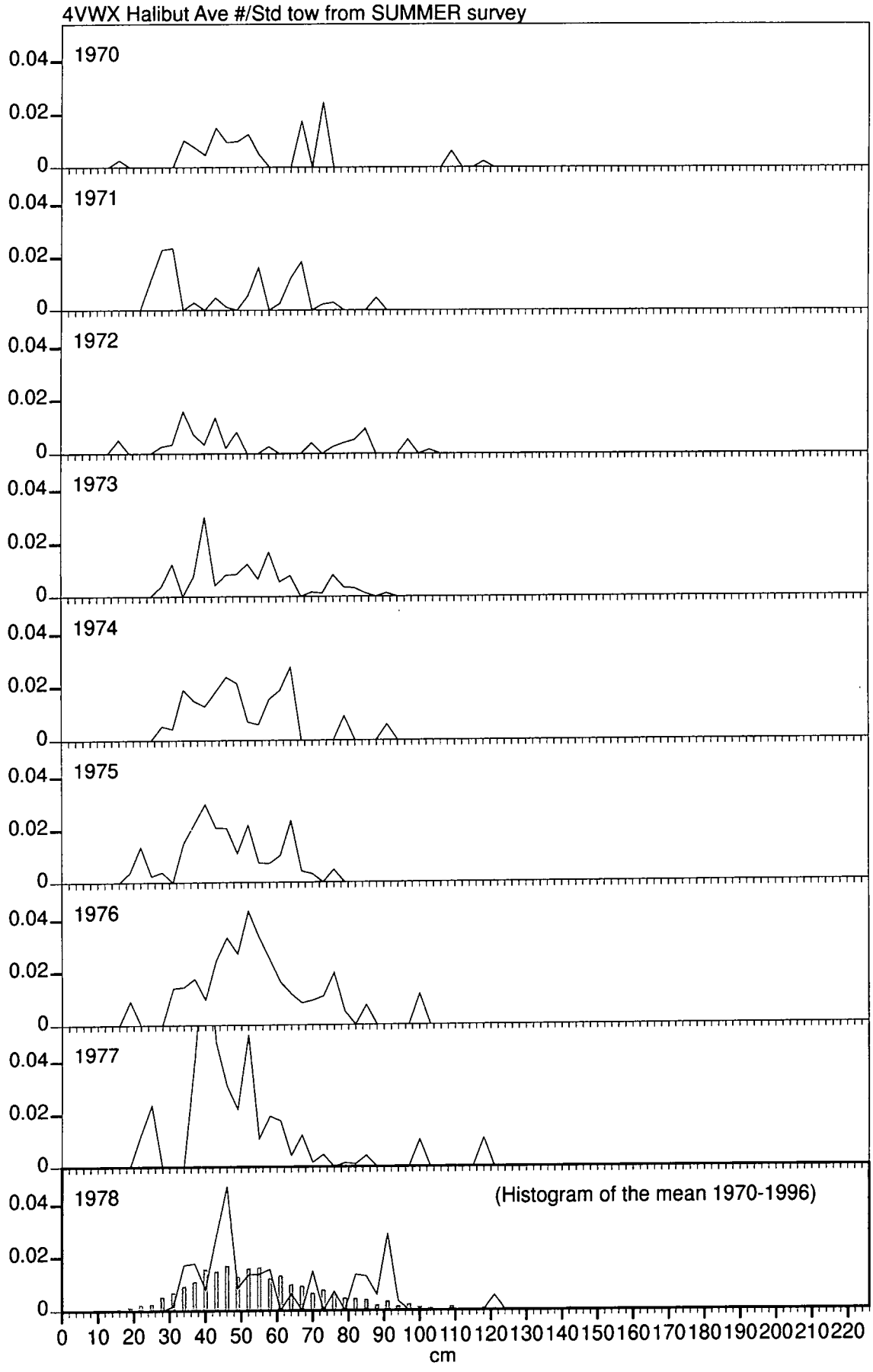
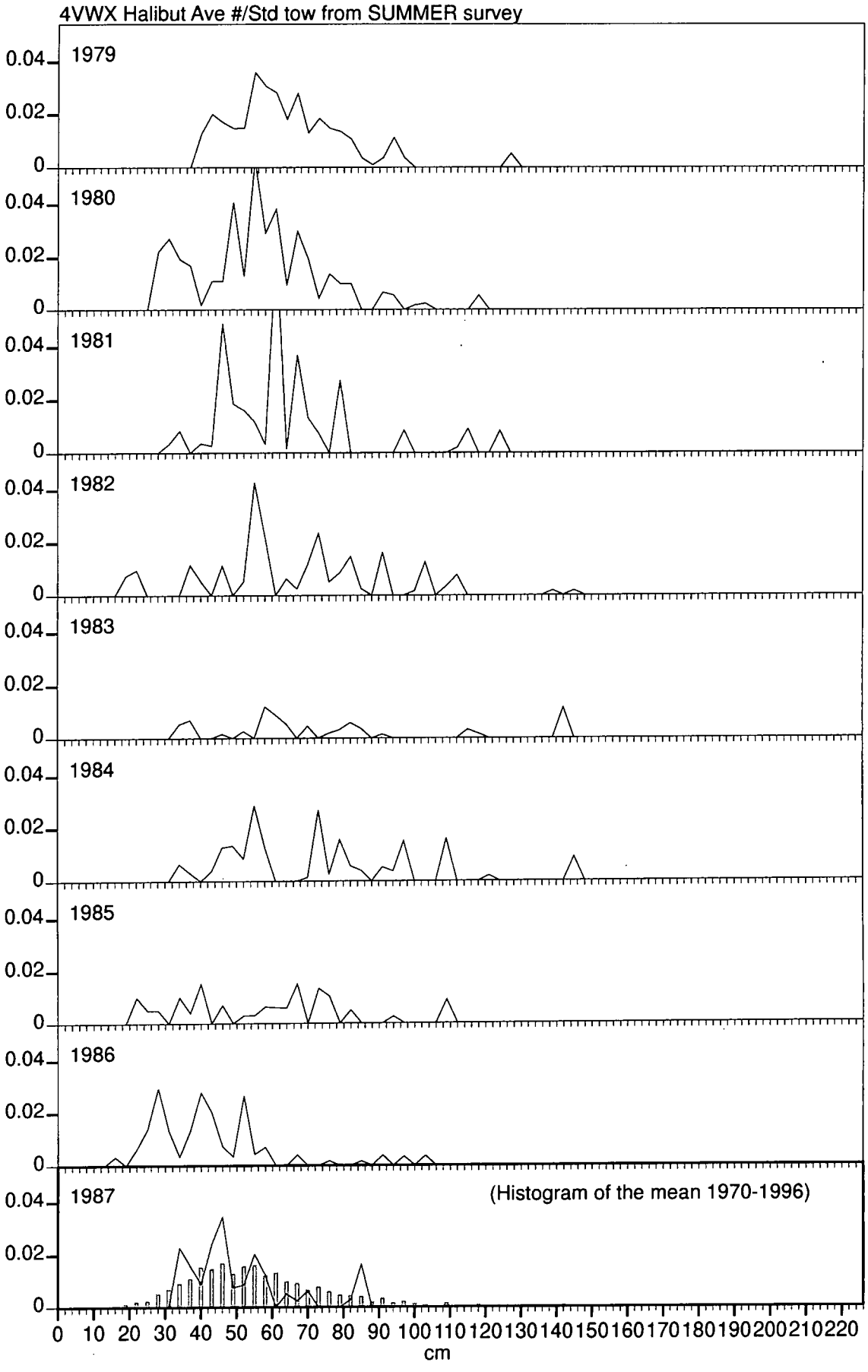
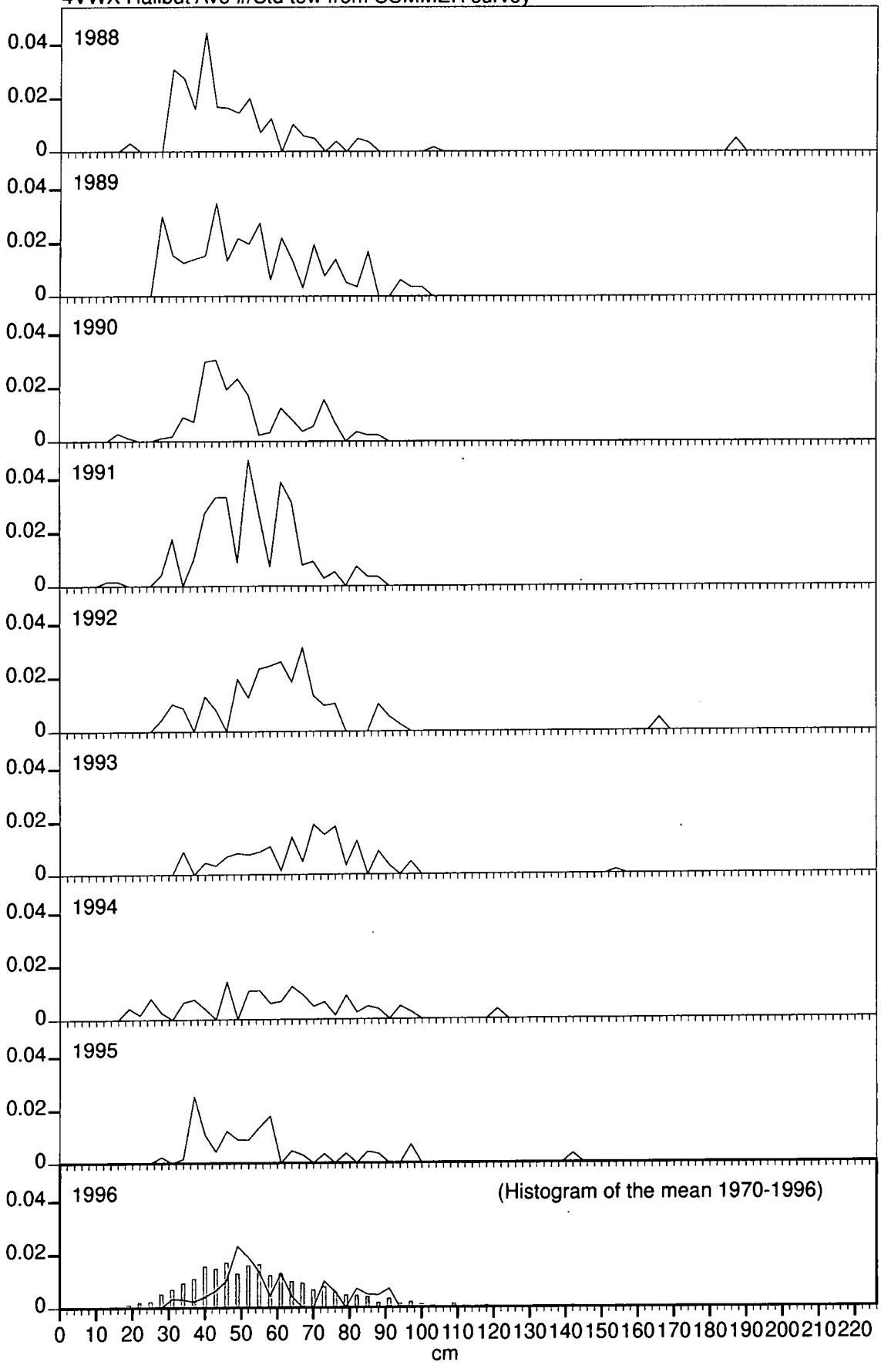


Figure 10. Length-frequency distributions of halibut catches from the a) summer and b) winter surveys of the Scotian Shelf. The histogram following each group of years indicates the long-term (series) average for the series.

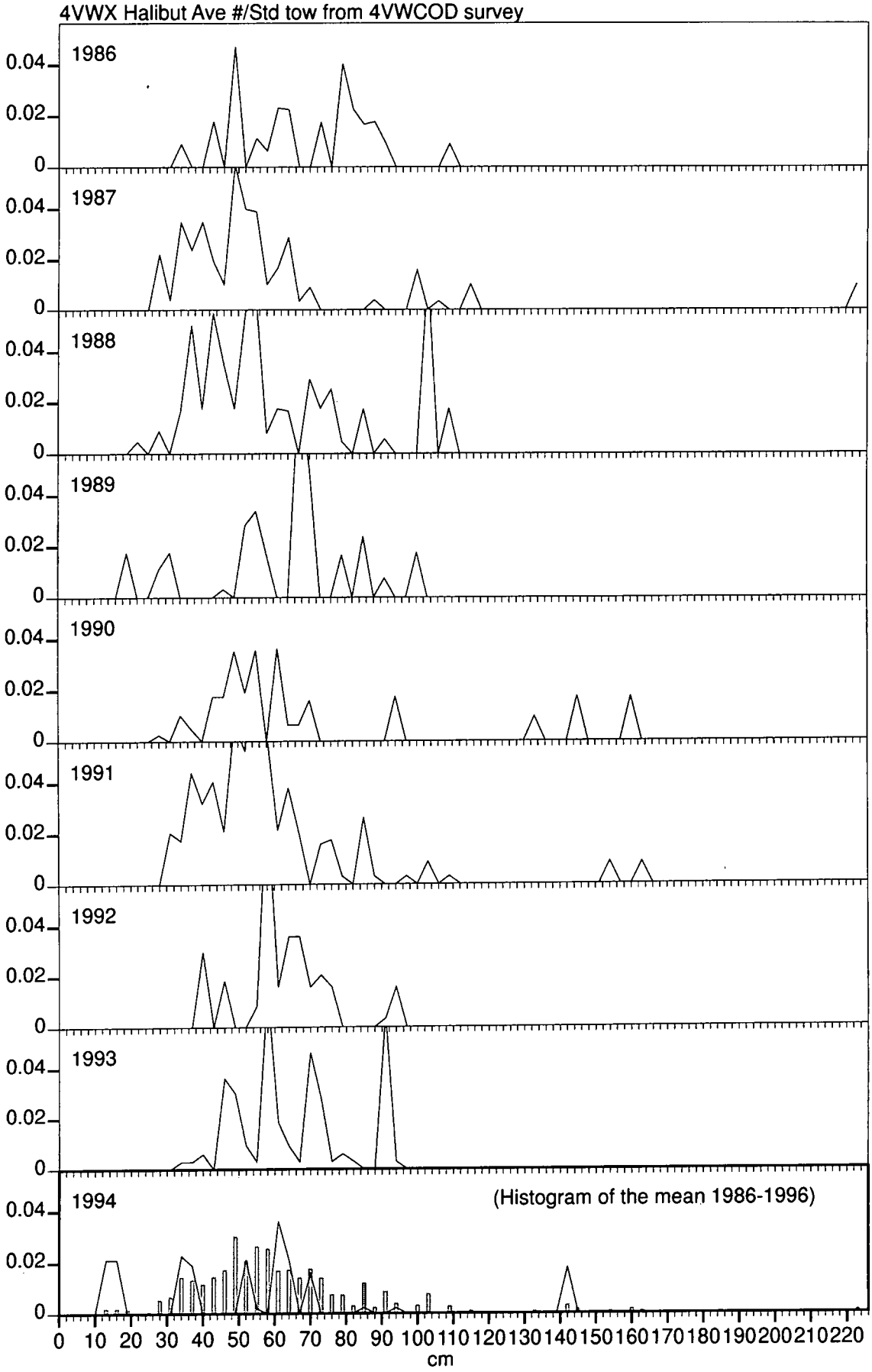
(Fig 10a. Contiuned)



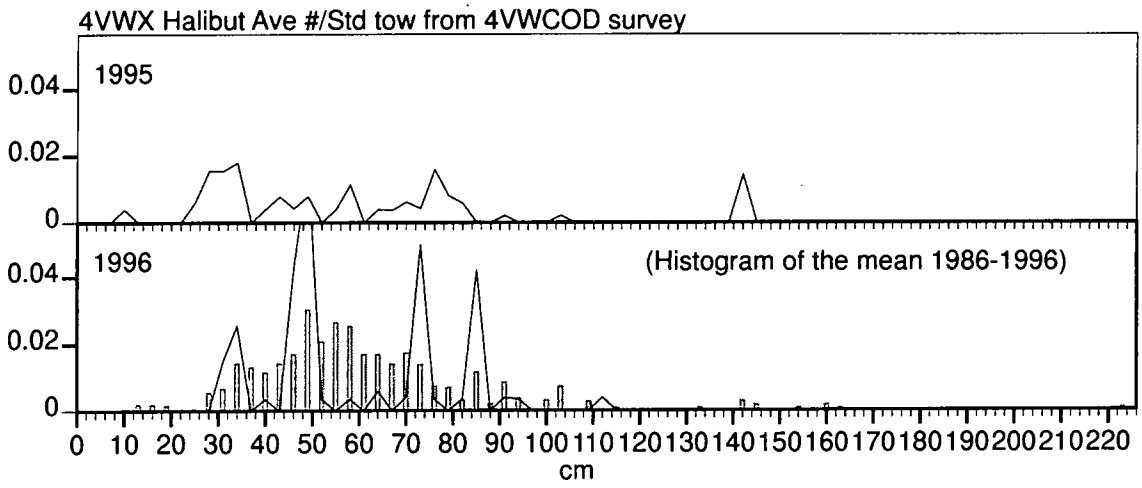
(Fig. 10a. Continued)



(Fig 10b.)


4VWX Halibut Ave #/Std tow from 4VWCOD survey
1986
1987
1988
1989
1990
1991
1992
1993
1994
(Histogram of the mean 1986-1996)
0.04
0.02
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220
cm

(Fig 10b. Continued)



(Fig 11a)

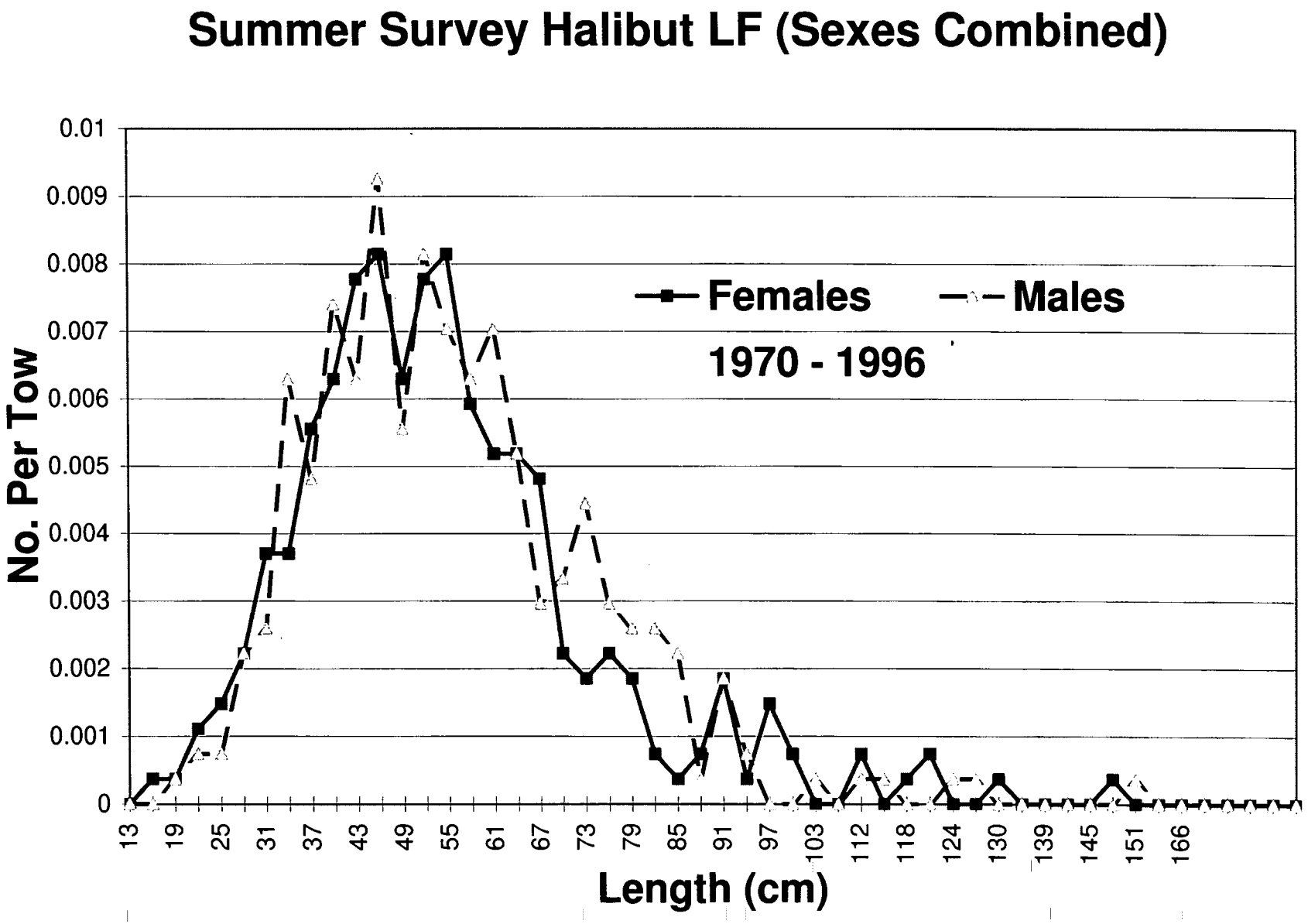
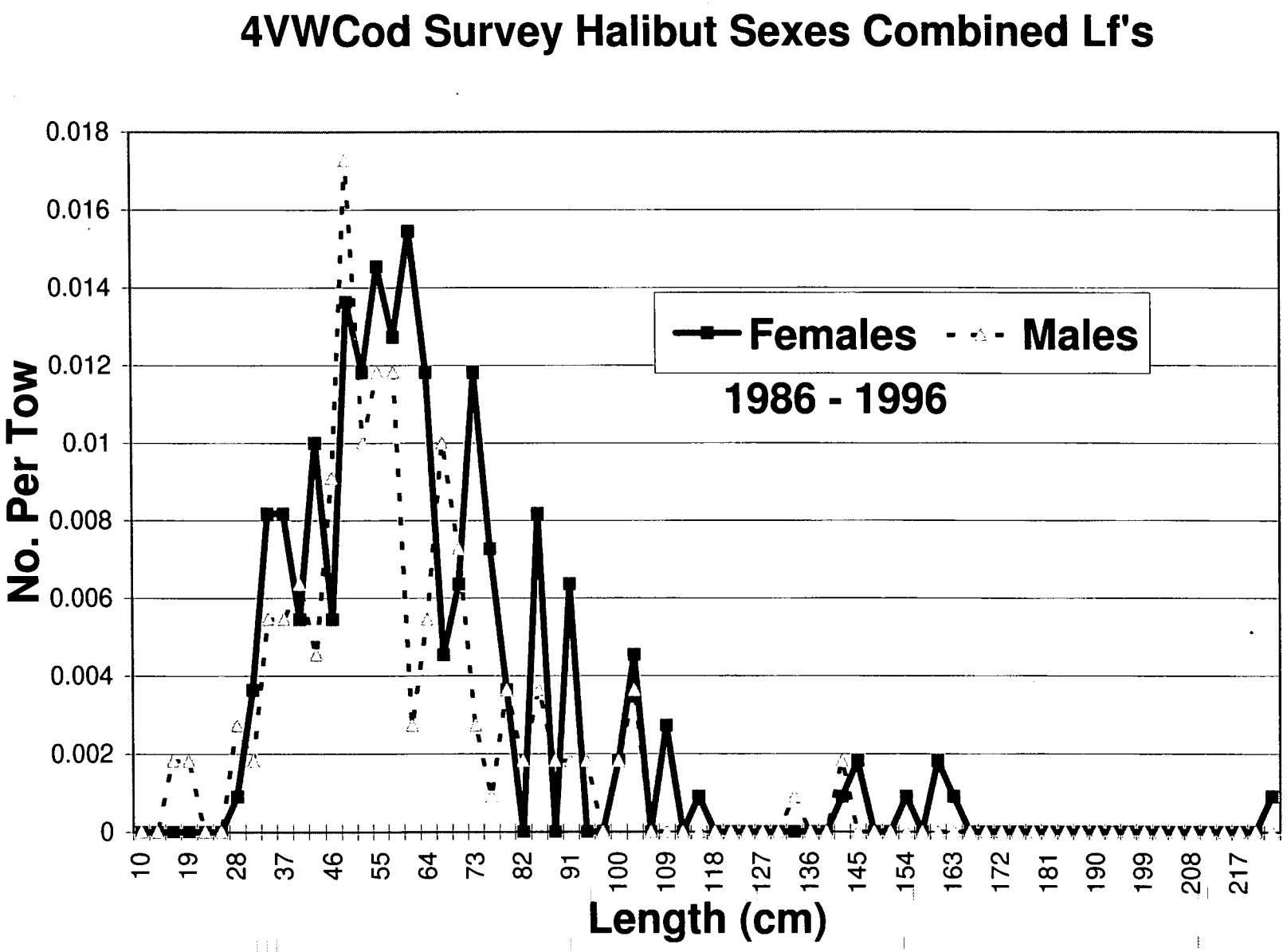
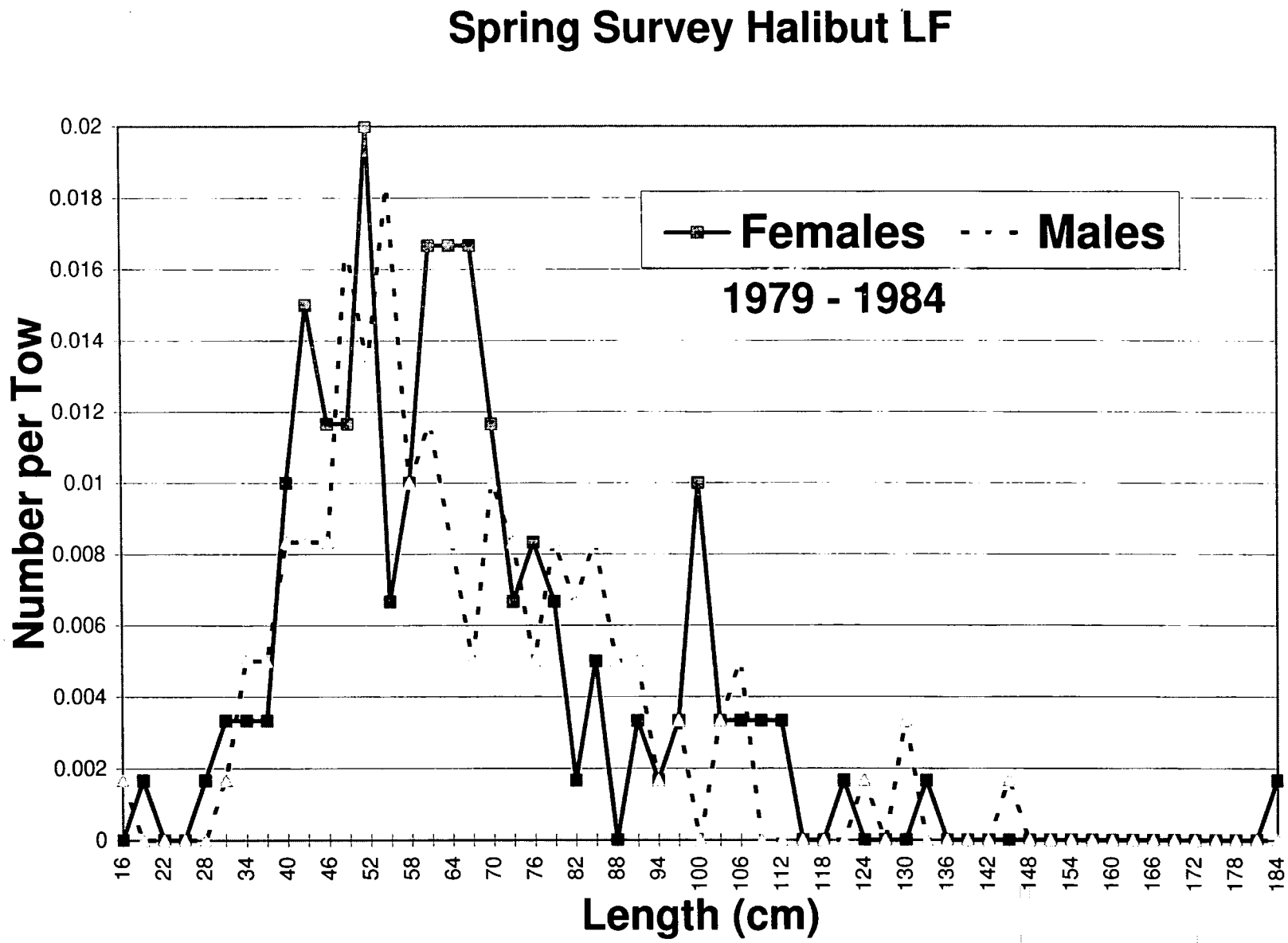


Figure 11. Composite (average) length-frequency distributions of halibut catches from the a) summer, b) winter, c) spring, and d) fall surveys of the Scotian Shelf.

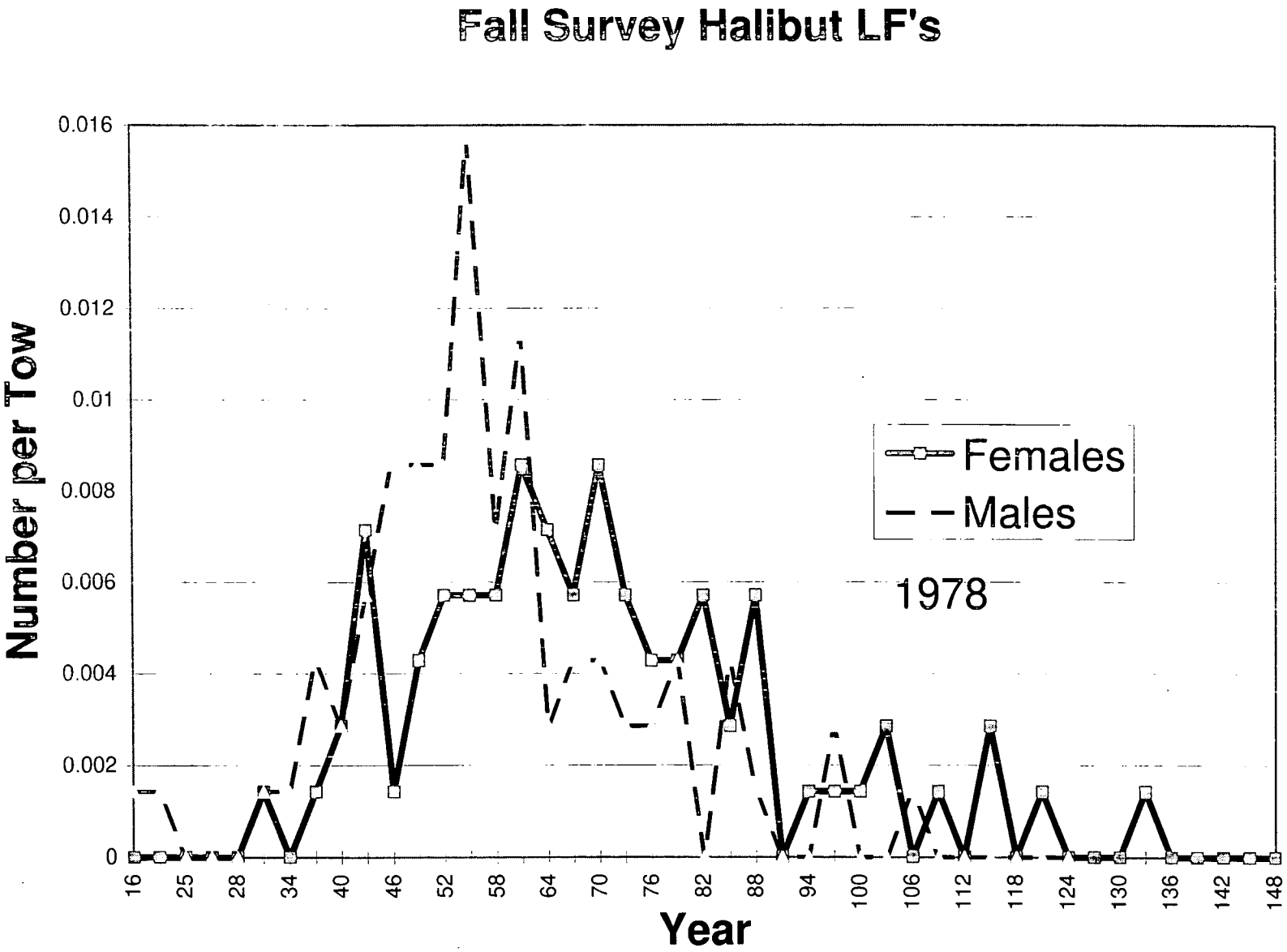
(Fig 11b)


4VWCod Survey Halibut Sexes Combined Lf's
Females
Males
1986 - 1996
No. Per Tow
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
10
19
28
37
46
55
64
73
82
91
100
109
118
127
136
145
154
163
172
181
190
199
208
217
Length (cm)

(Fig 11c)


Spring Survey Halibut LF
Females
Males
1979 - 1984
Number per Tow
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
16
22
28
34
40
46
52
58
64
70
76
82
88
94
100
106
112
118
124
130
136
142
148
154
160
166
172
178
184
Length (cm)

(Fig 11d)


Fall Survey Halibut LF's
Number per Tow
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
16
25
28
34
40
46
52
58
64
70
76
82
88
94
100
106
112
118
124
130
136
142
148
Year
Females
Males
1978

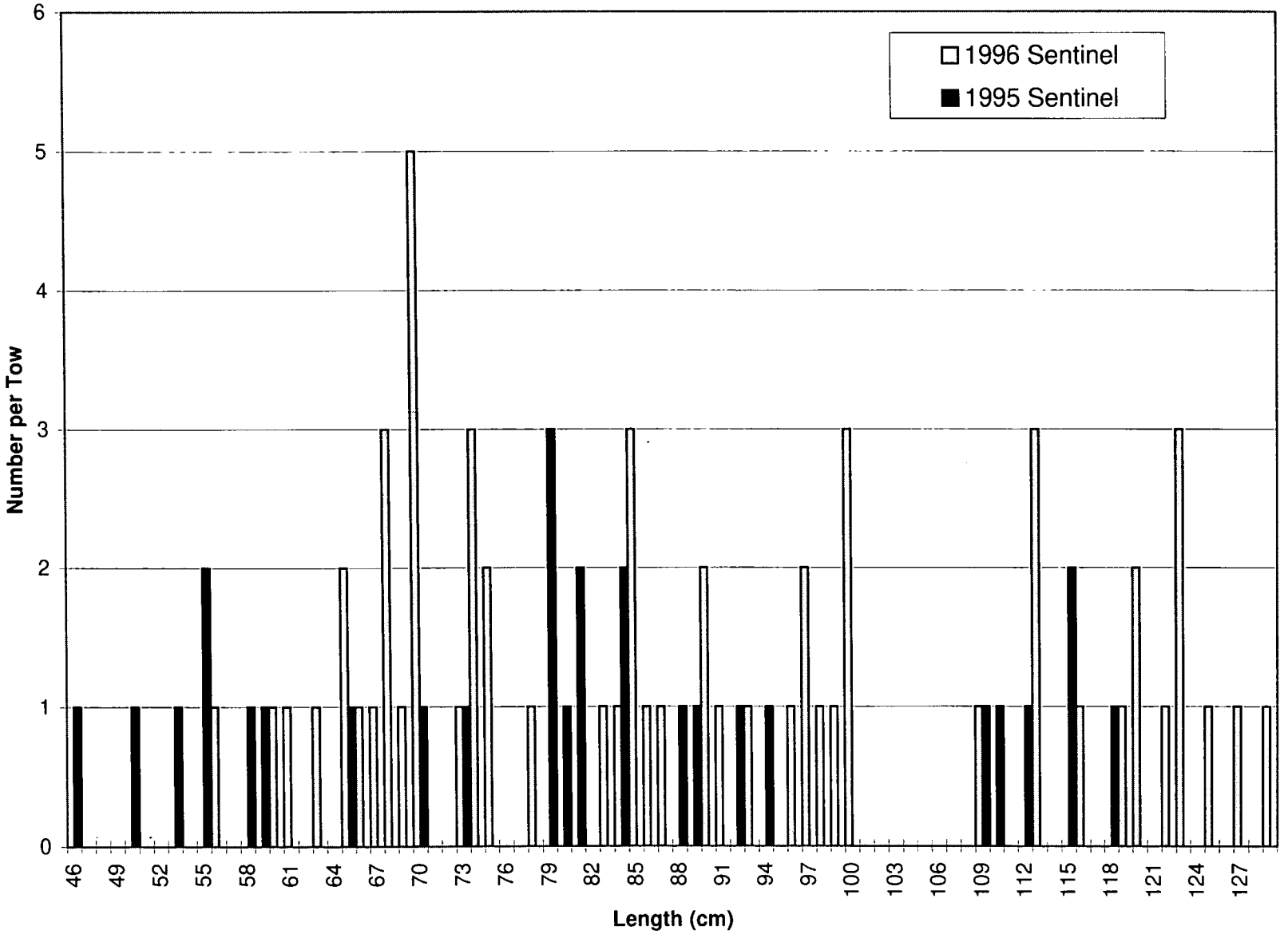


Figure 12. Length distribution of fish caught by the 1995 and 1996 fixed gear survey of 4VW. The survey employed a standard set of 1500 #12 circle hooks and was designed as stratified random, adopting the summer survey depth stratification scheme.

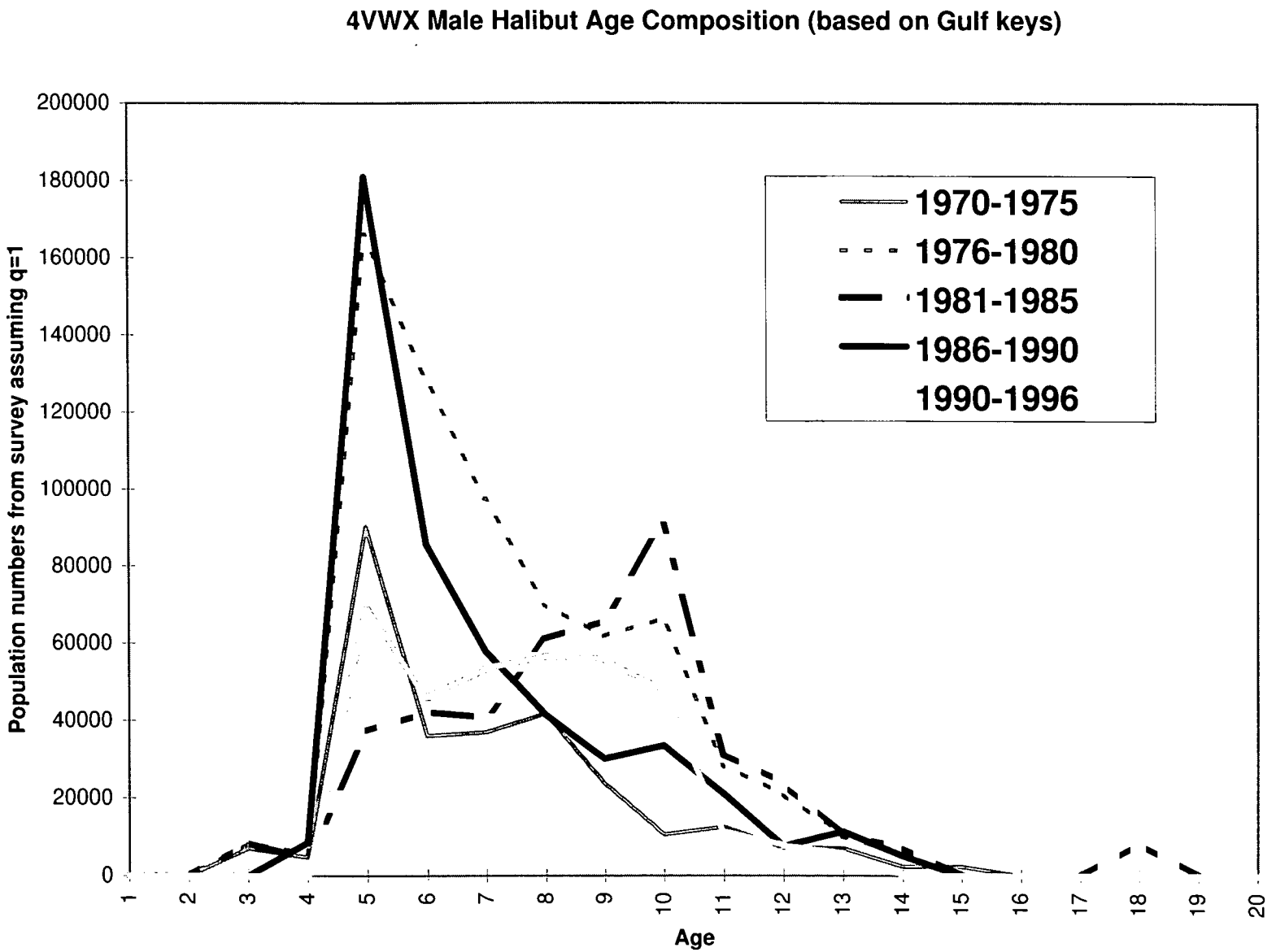


Figure 13. Age composition of summer survey halibut catches (males only) by 5 year blocks. Ages were estimated using the growth model for Gulf of St. Lawrence halibut (Archambault 1996).

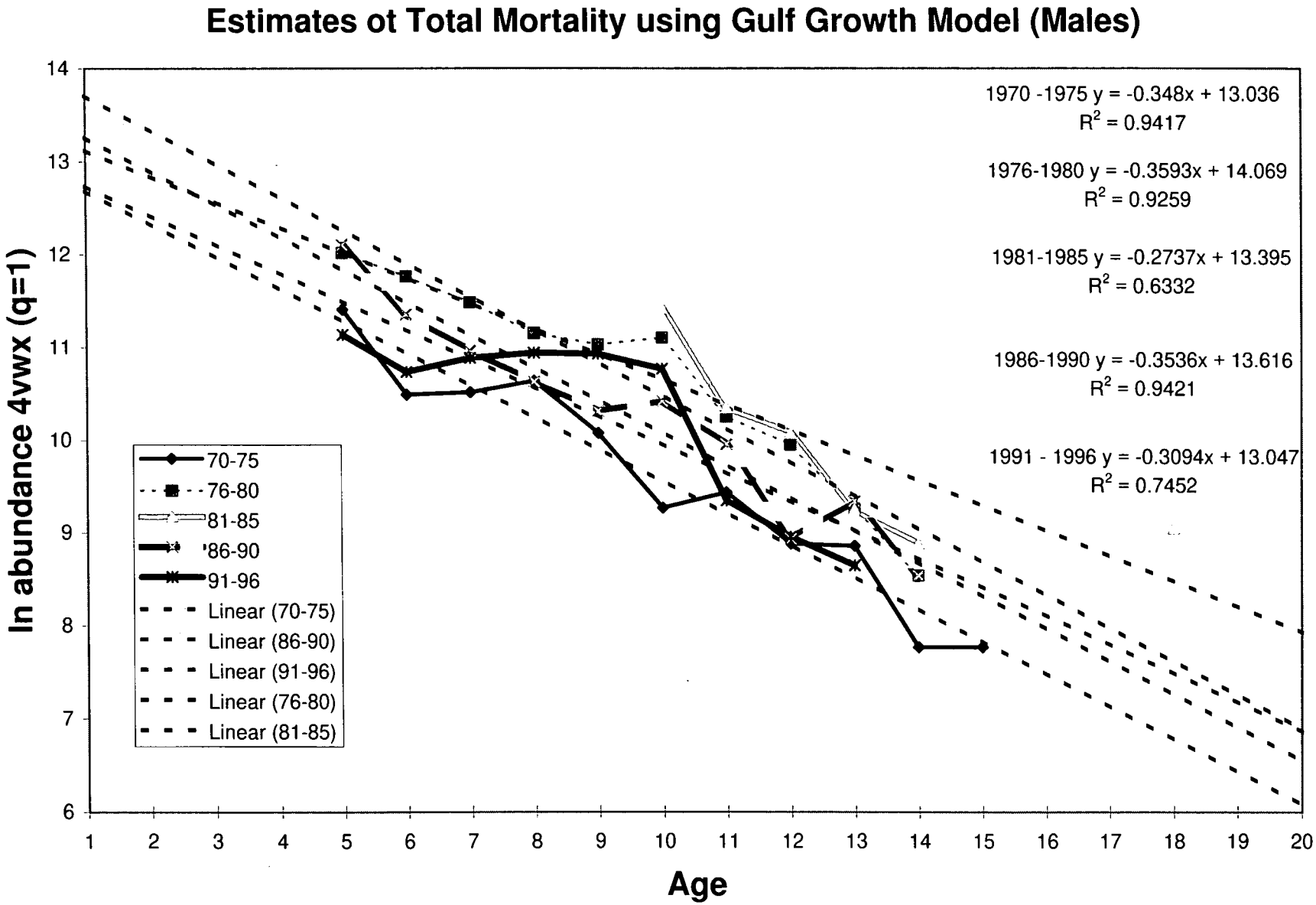


Figure 14. Catch curves for male halibut caught by the summer survey (1970-1996) by five year blocks using the growth model for Gulf of St. Lawrence halibut (Archambault 1996).

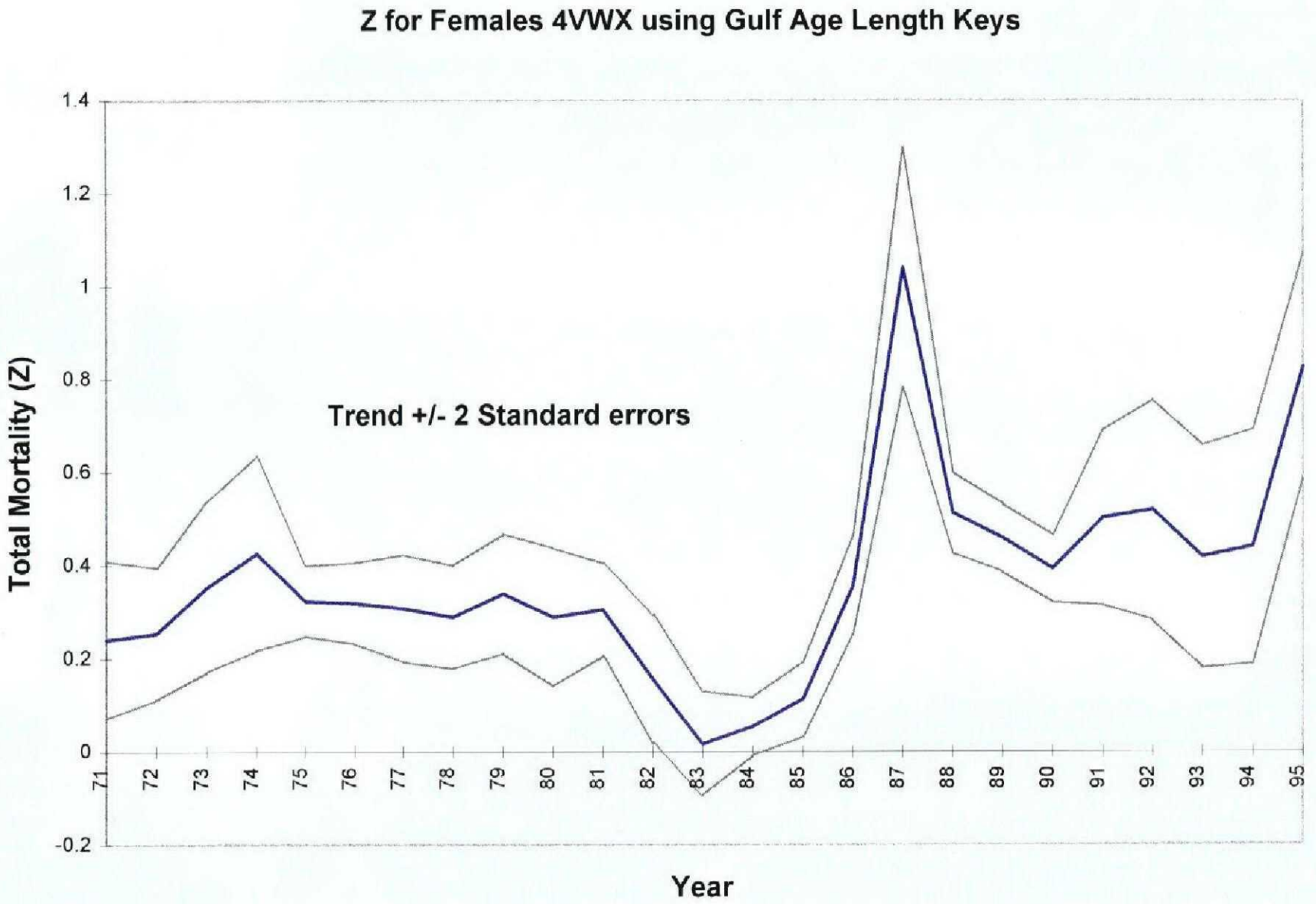


Figure 15. Total mortality rates (Z) for female halibut caught during the summer surveys of 1970 - 1996. Catch curves were based on 3 year running average population numbers at age.

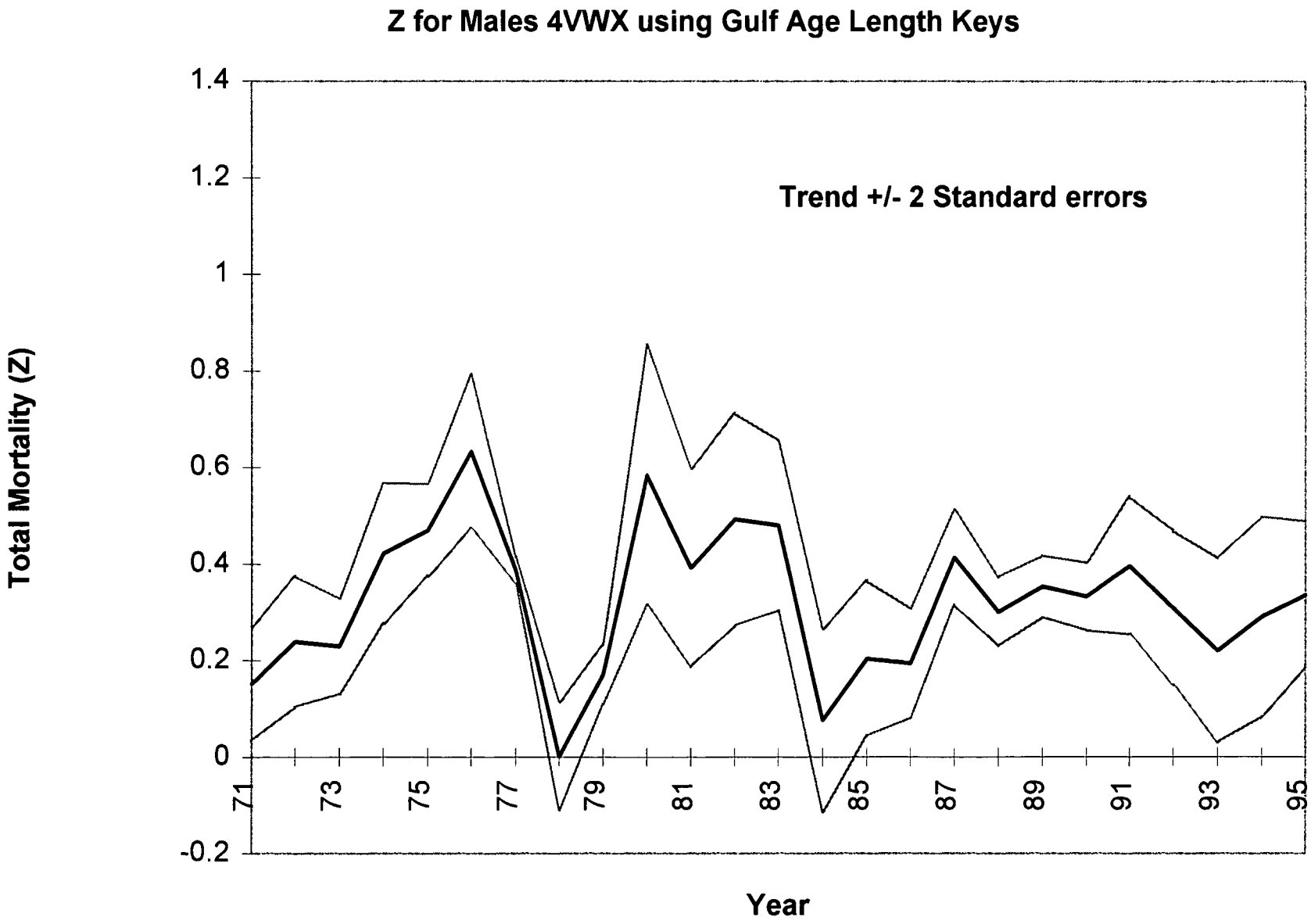


Figure 16. Total mortality rates (Z) for male halibut caught during the summer surveys of 1970 - 1996. Catch curves were based on 3 year running average population numbers at age.

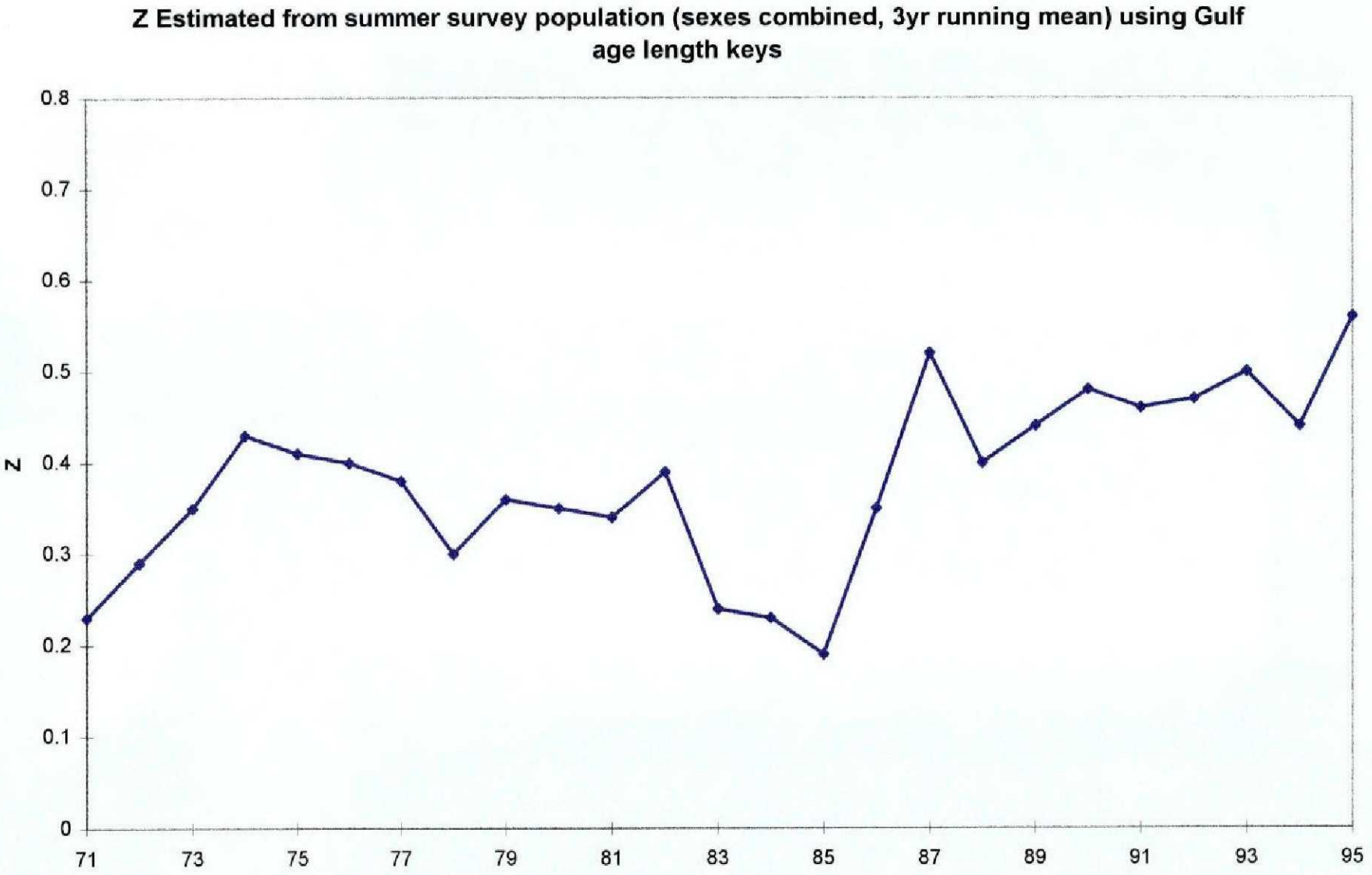


Figure 17. Total mortality rates (Z) for halibut (sexes combined) caught during the summer surveys of 1970 - 1996. Catch curves were based on 3 year running average population numbers at age.

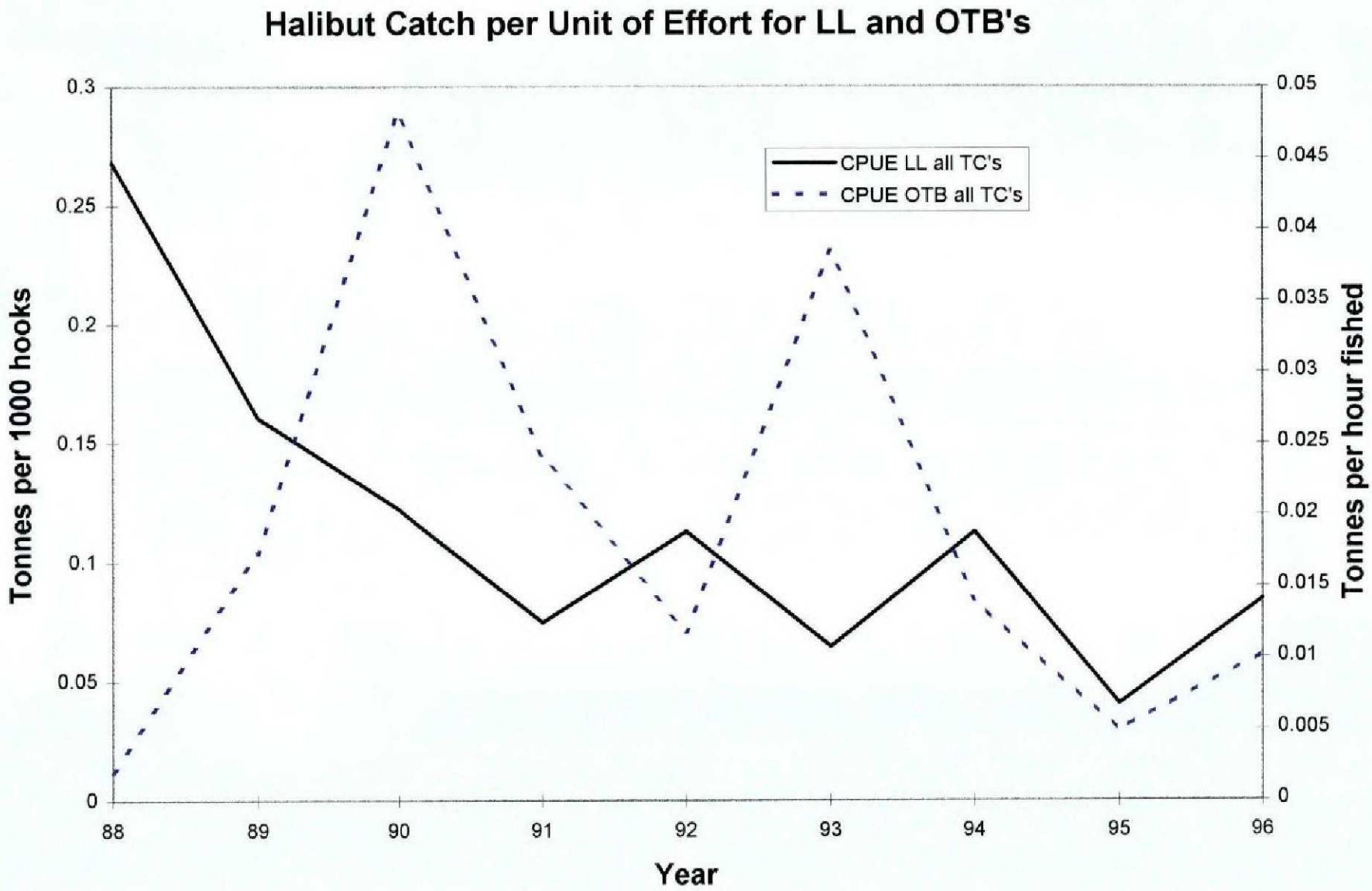


Figure 18. Halibut catch per unit of effort for fixed and mobile gear halibut directed fisheries 1988 - 1996. The catch rate series includes only those landings where halibut represented the single largest proportion (by weight) for each trip or sub-trip.

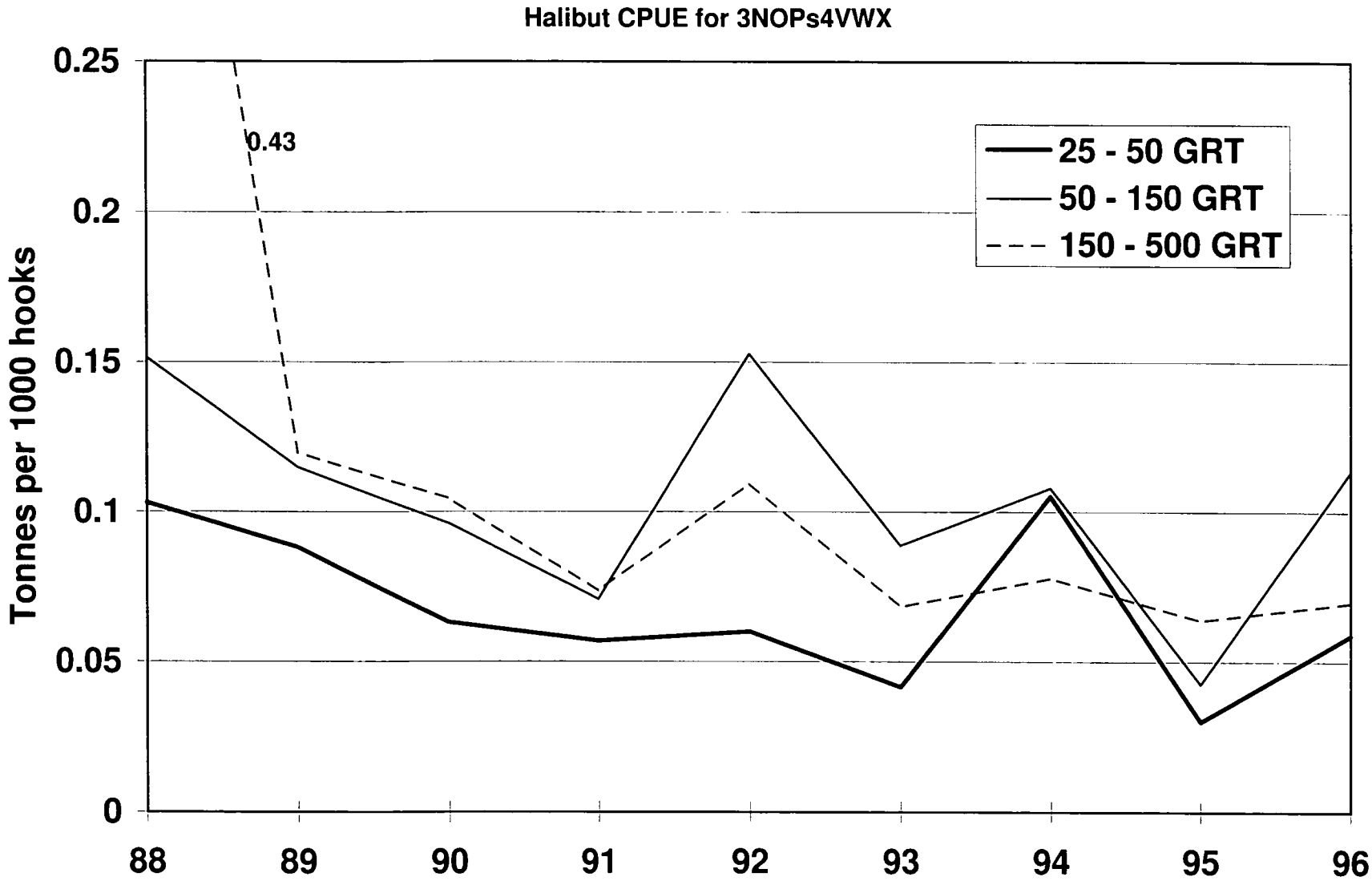


Figure 19. Halibut CPUE for fixed gear by tonnage class

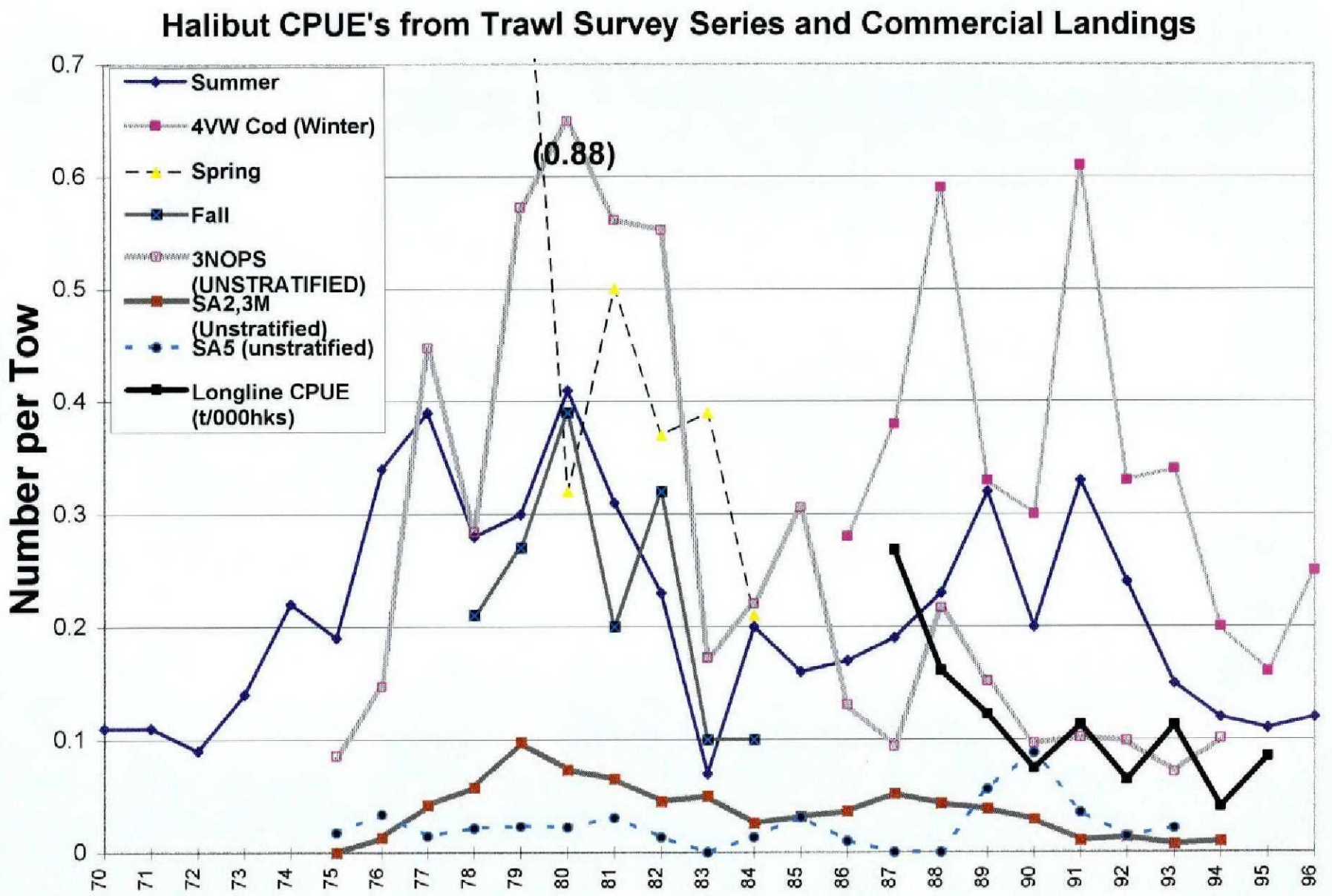


Figure 20. Halibut fixed gear CPUE 1988 - 1996 relative to all trawl survey abundance estimates for the halibut stock and adjacent areas.

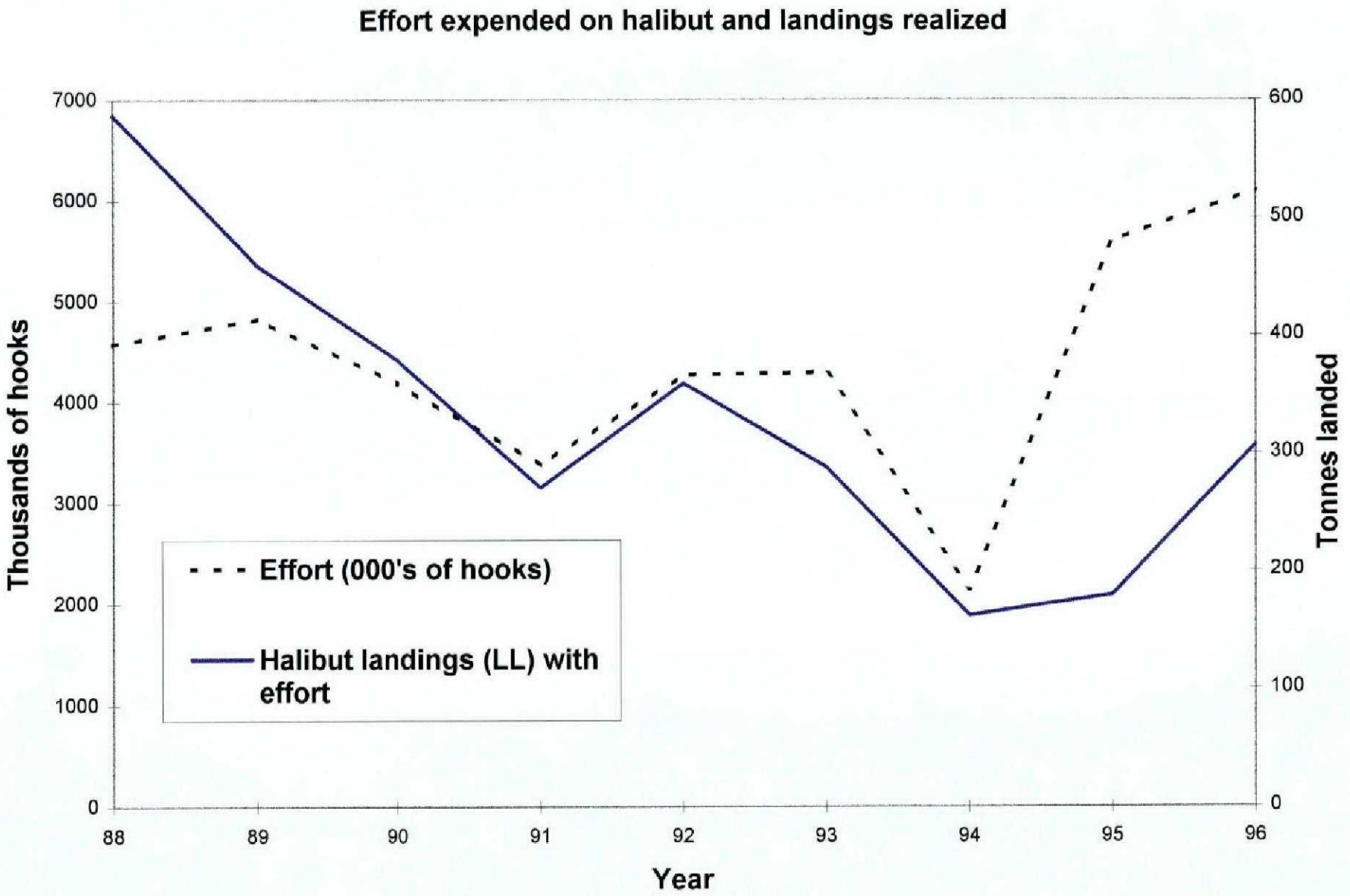


Figure 21. Trends in landings and effort included in the halibut fixed gear CPUE series (1988 -1996).

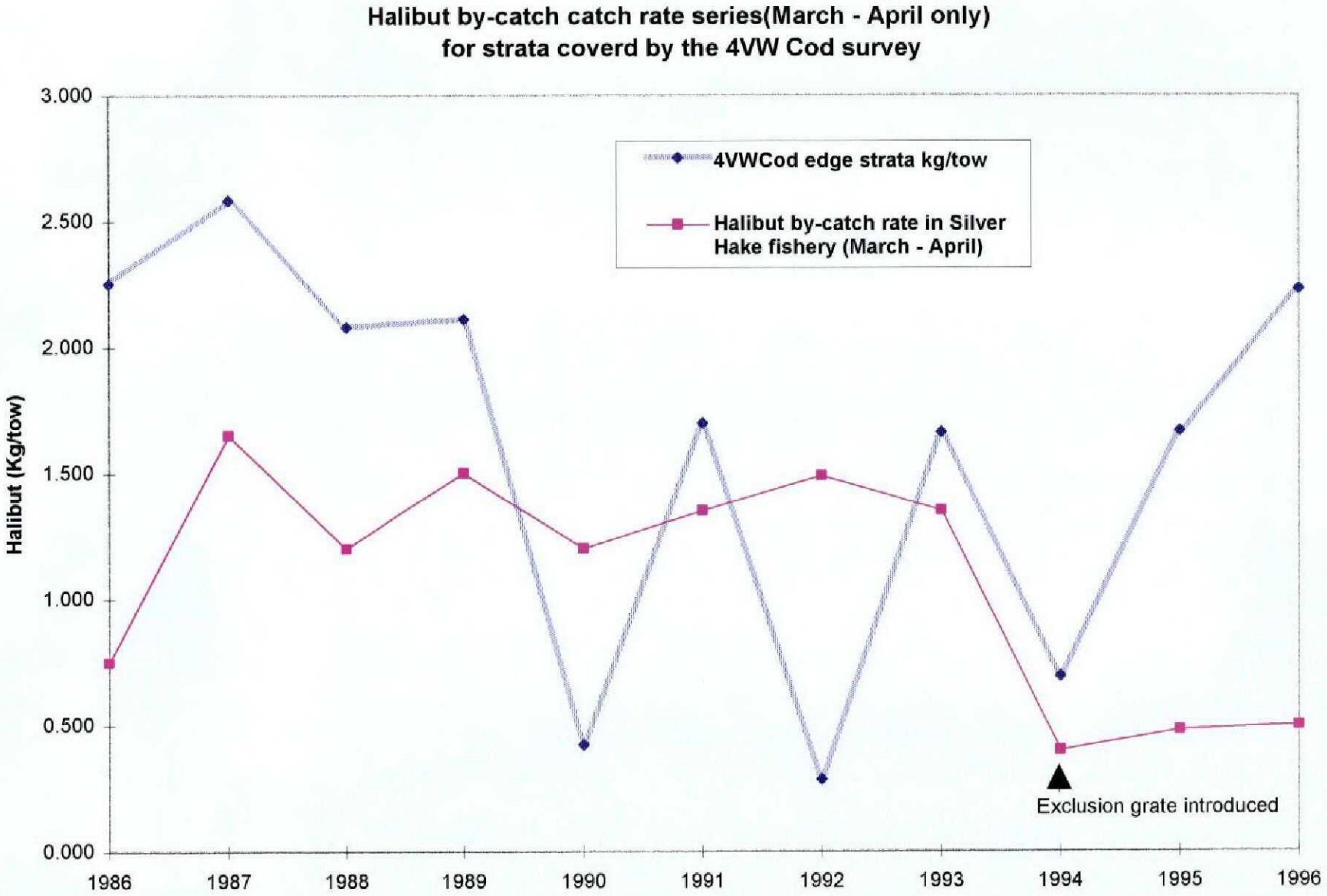


Figure 22. Halibut by-catch catch rate in the trawl fishery for silver hake conducted during March and April relative to the halibut catch rate observed by the winter survey of the eastern Scotian Shelf. The survey CPUE applies only to those strata where the silver hake fishery was prosecuted during March and April. The Nordmor exclusion grate was introduced in 1994.

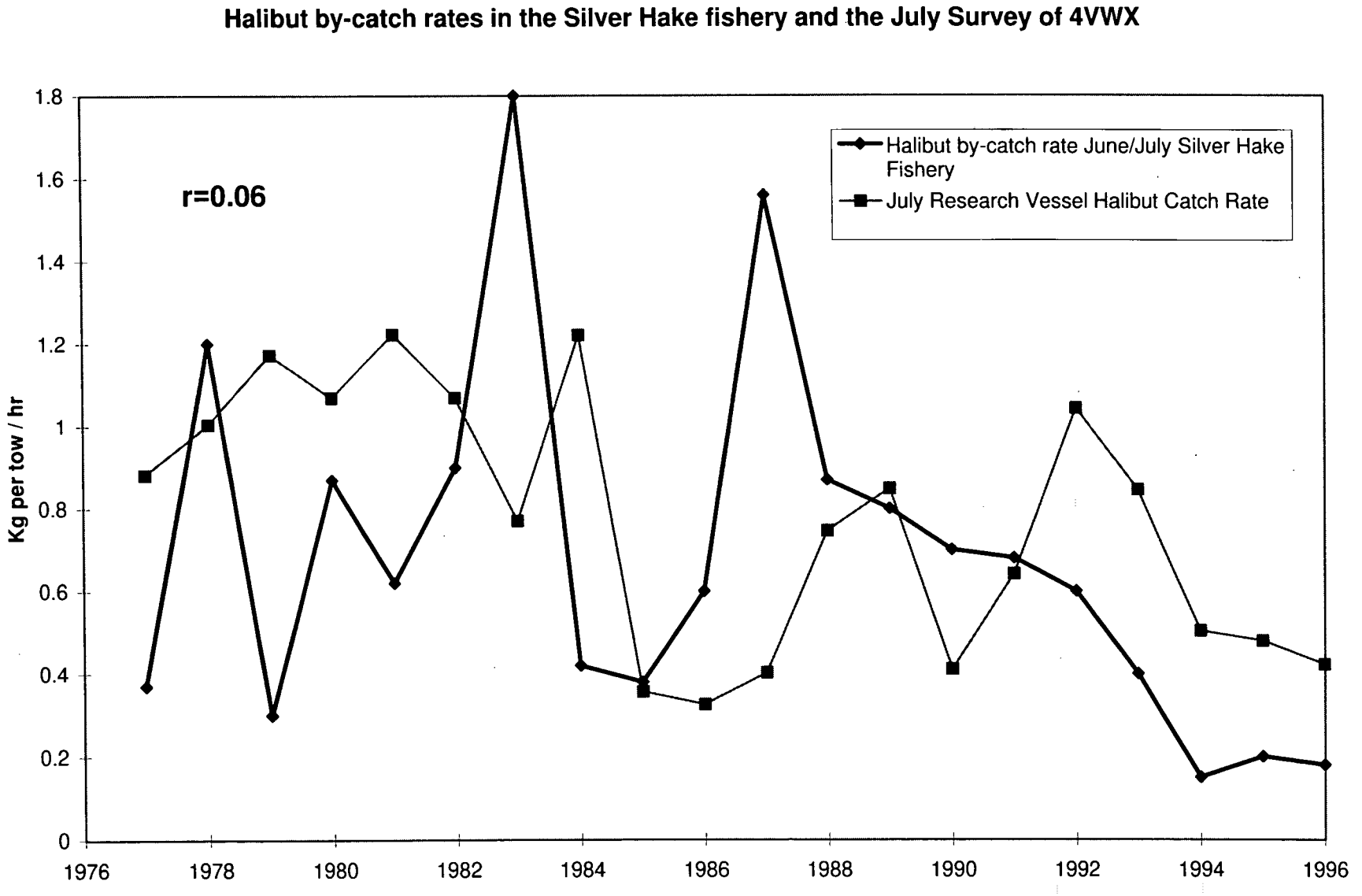


Figure 23. Halibut by-catch catch rate in the trawl fishery for silver hake conducted during June - July relative to the halibut catch rate observed by the summer survey of the eastern Scotian Shelf. The Nordmor exclusion grate was introduced in 1994.

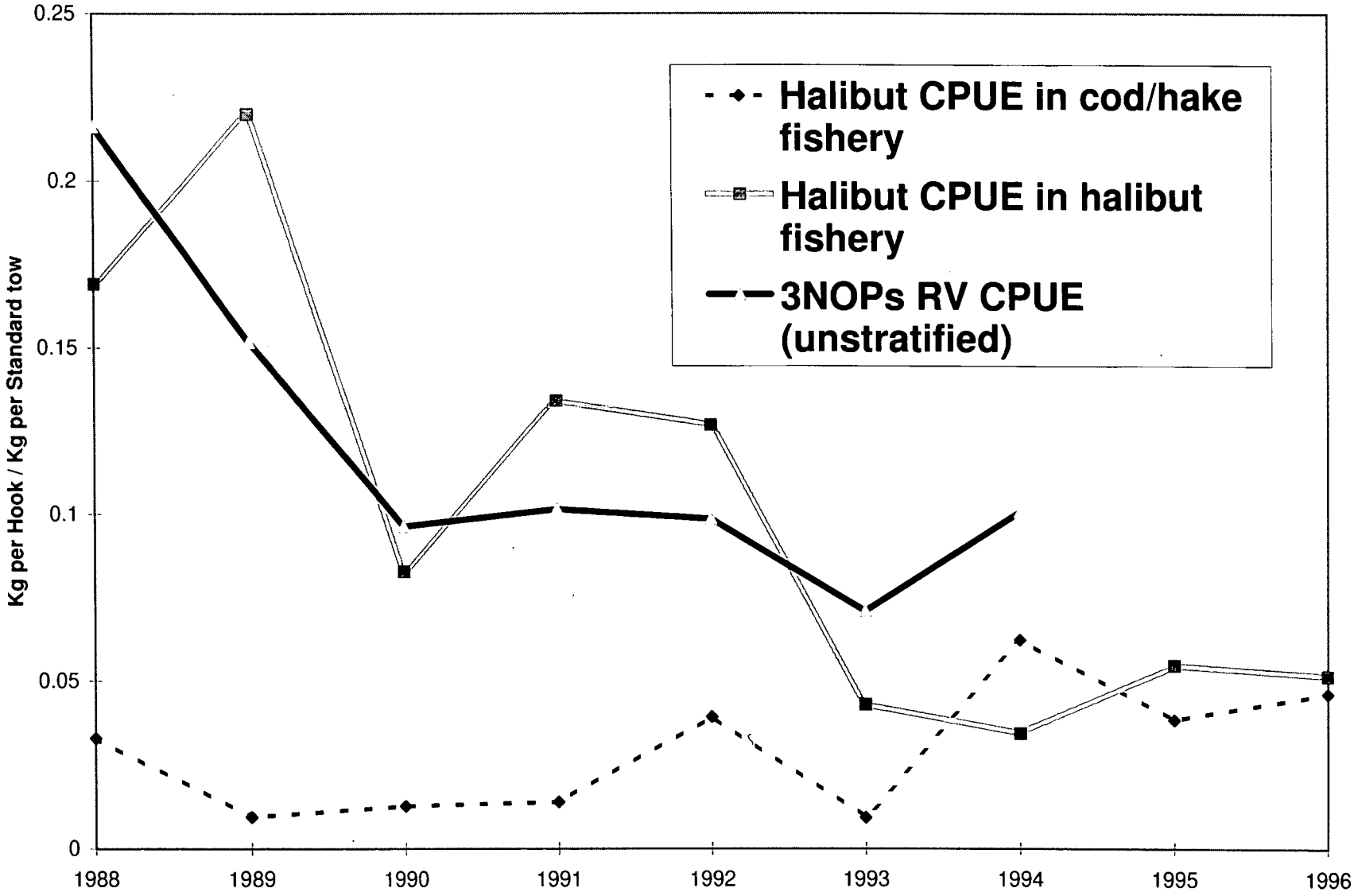


Figure 24. Halibut catch rates in the 3NO Longline fishery relative to the 3NOPs survey catch rates (unstratified).

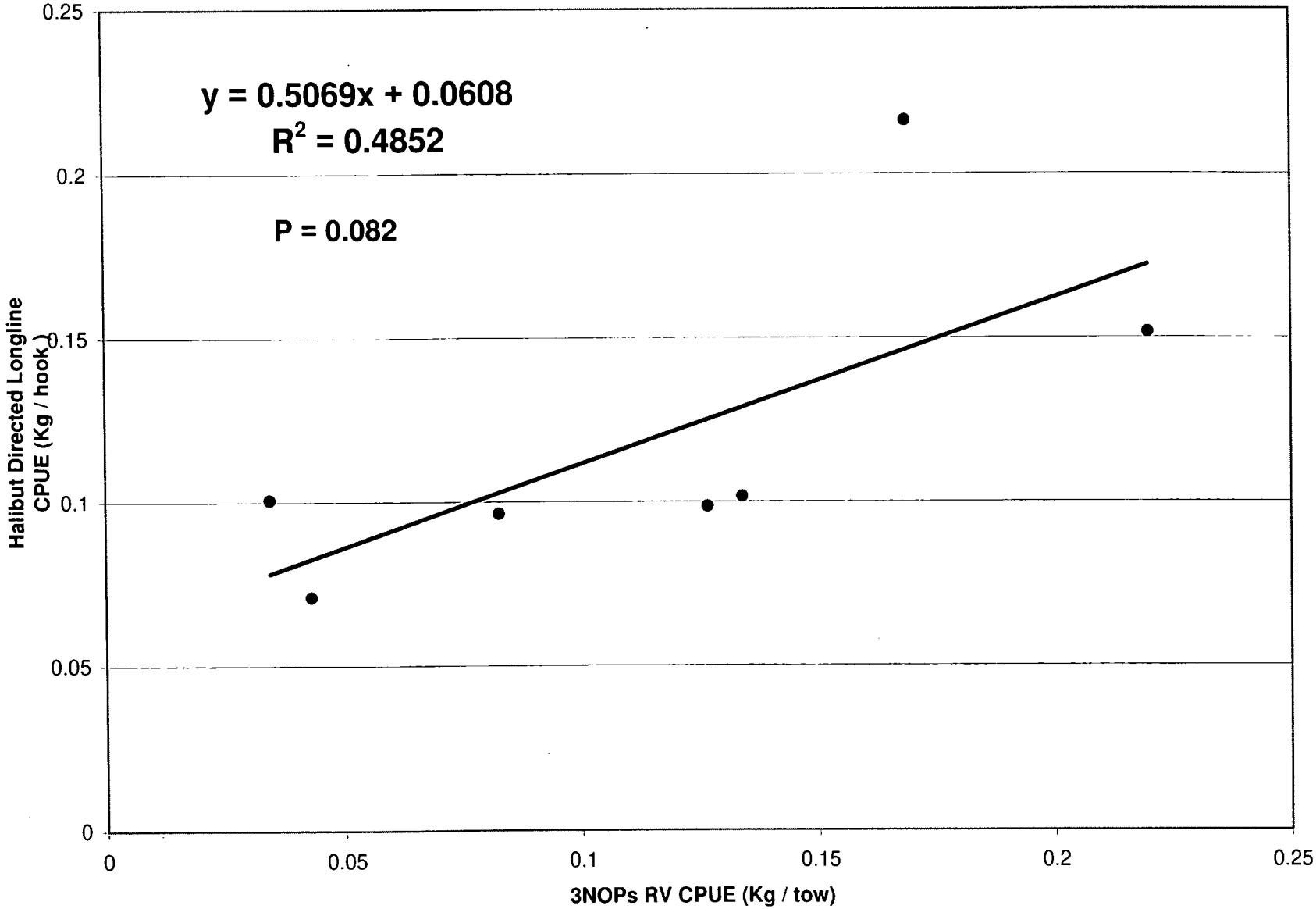


Figure 25. Correlation between the 3NO longline fishery halibut catch rate and the 3NOPs survey halibut catch rates (unstratified)

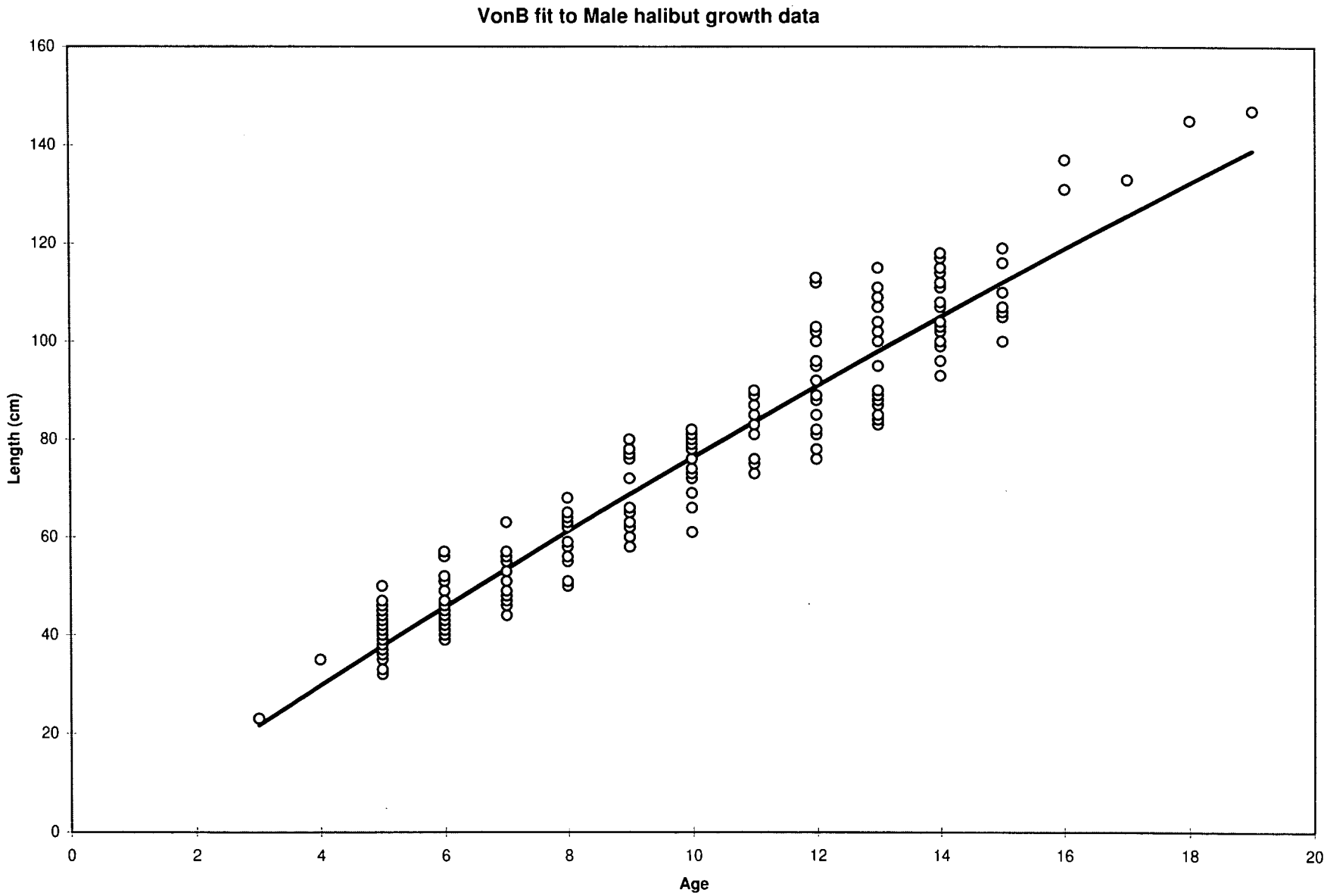


Figure 26. Fit of male halibut age and length data (Archambault 1995) to a Von Bertalanffy growth model (linf = approx. 9m)

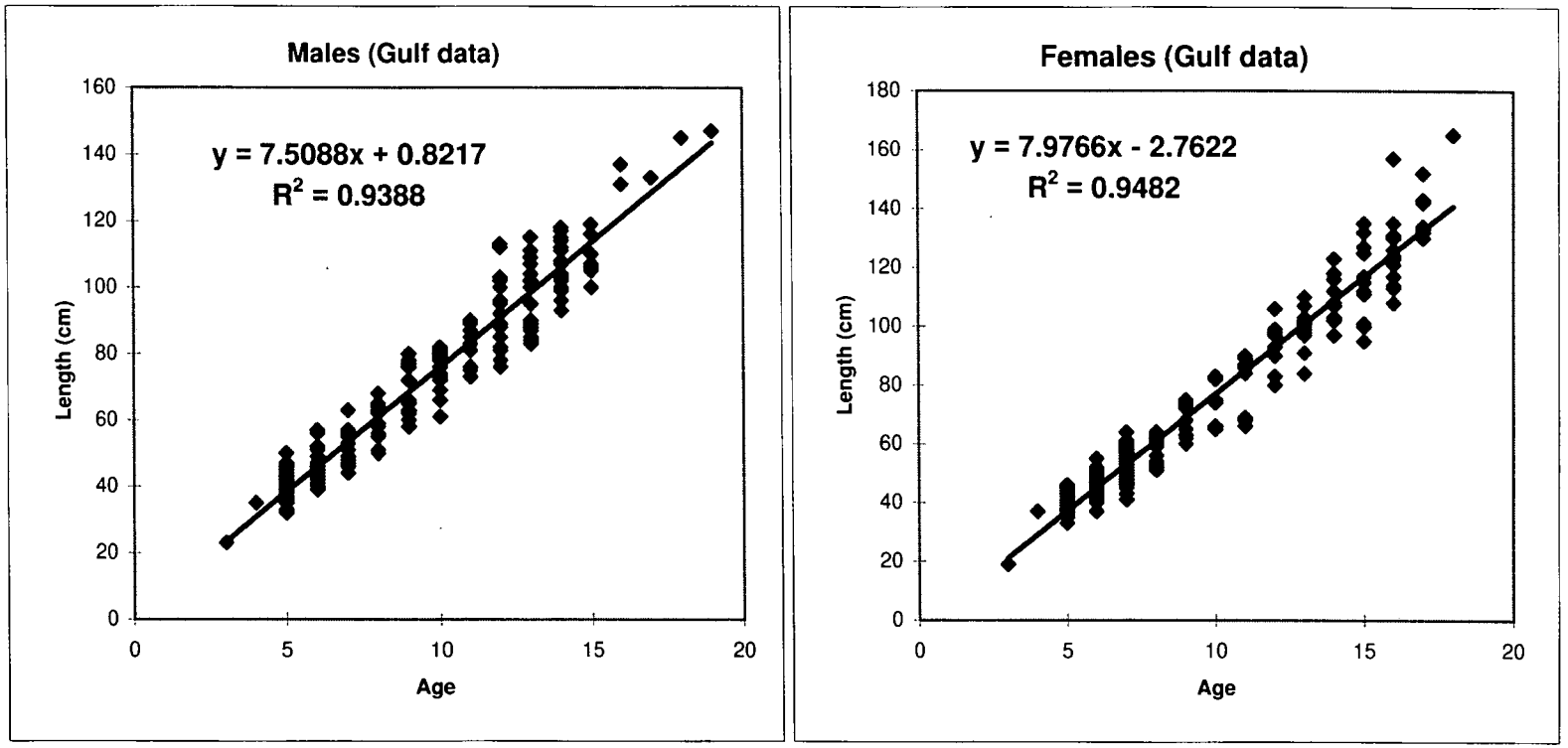


Figure 27. Fit of age halibut age and length data (Archambault 1995) to a linear model.

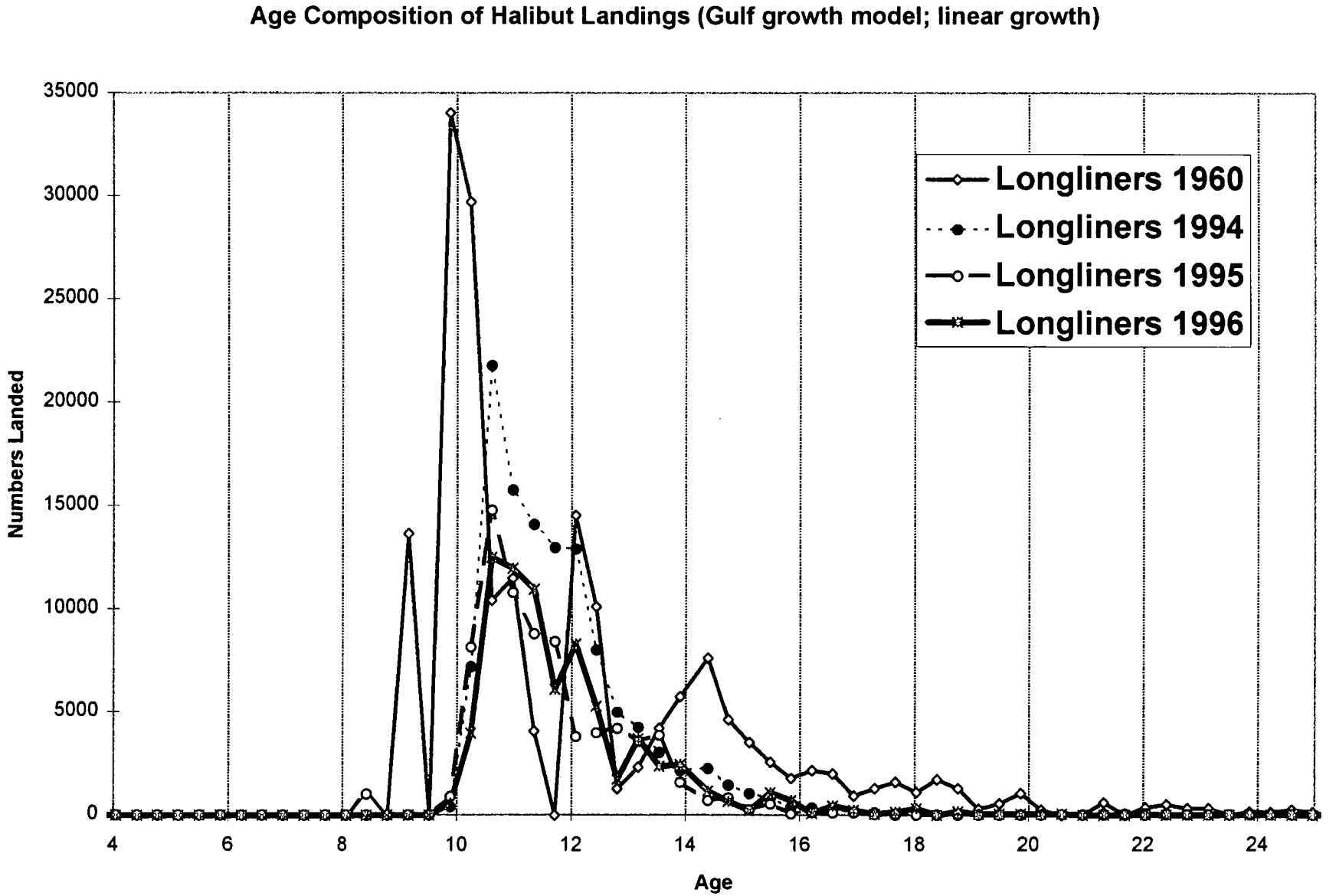


Figure 28. Age composition of Longline landings sampled in 1960 and in recent (1994-1996) years.

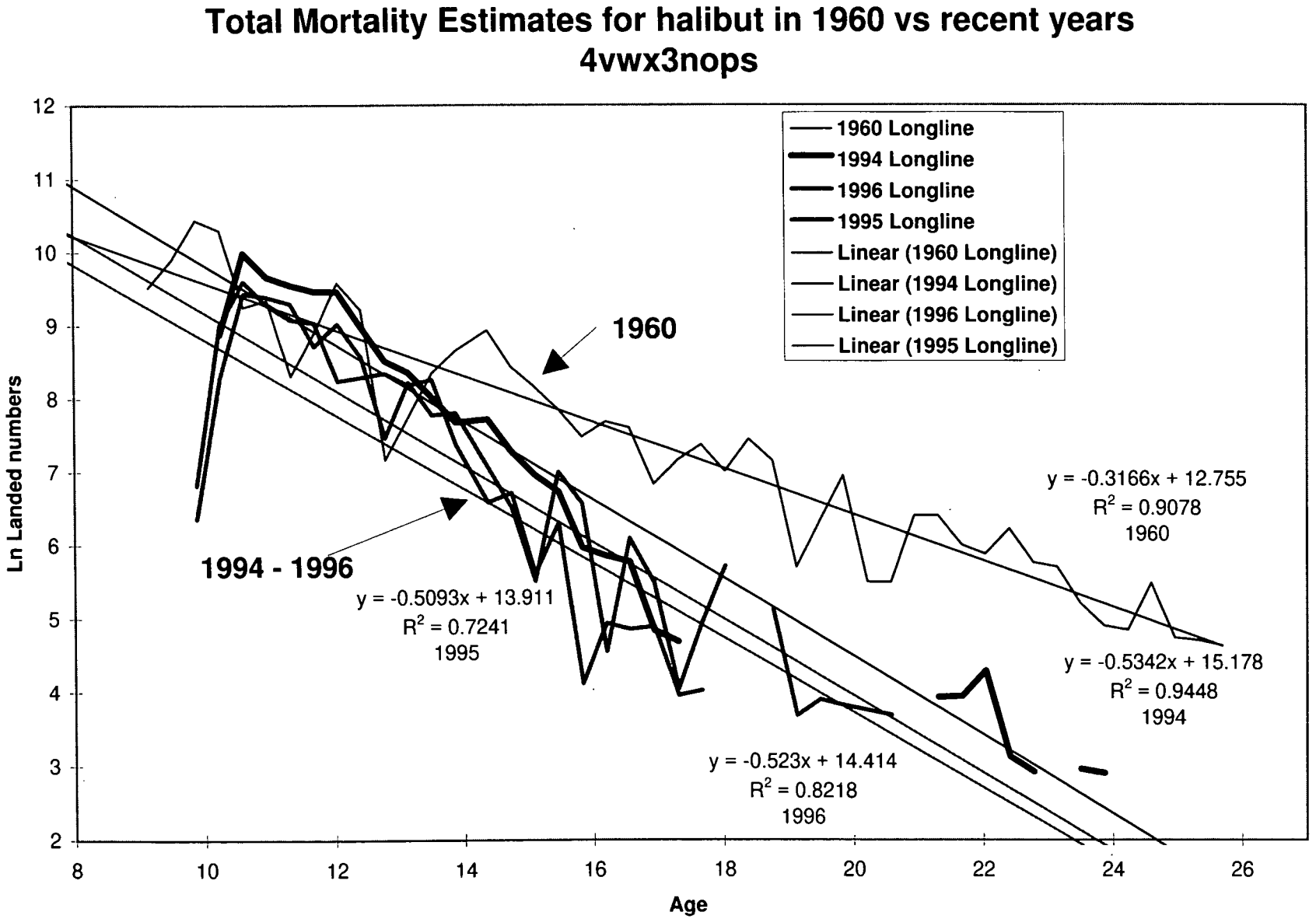


Figure 29. Estimation of total mortality (Z) from catch-curves derived from samples of longline landings in 1960, and in recent (1994 - 1996) years.

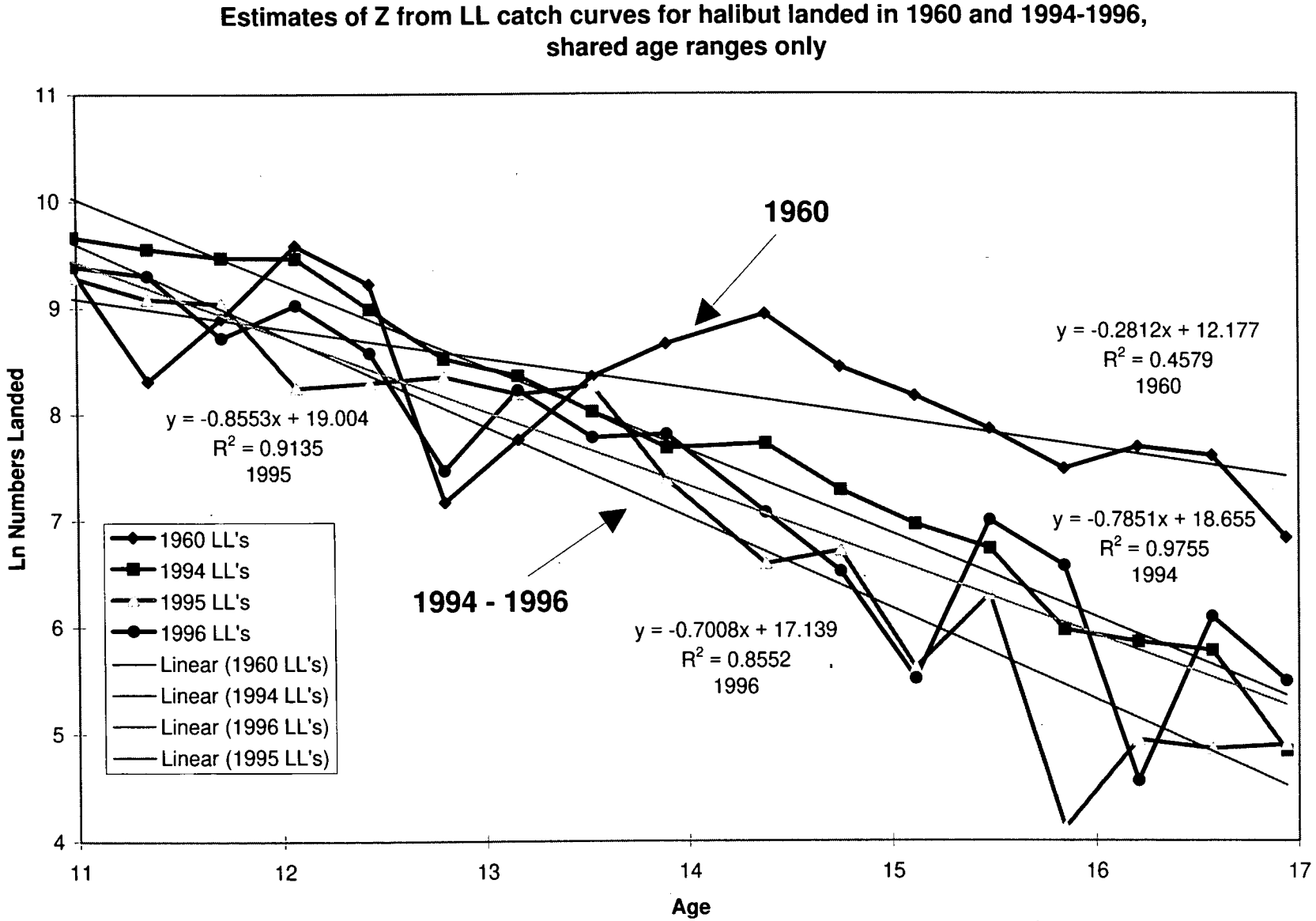


Figure 30. Estimation of total mortality (Z) from catch-curves derived from samples of longline landings in 1960, and in recent (1994 - 1996) years. The catch-curves used only those ages which were observed in both time period (11-17).

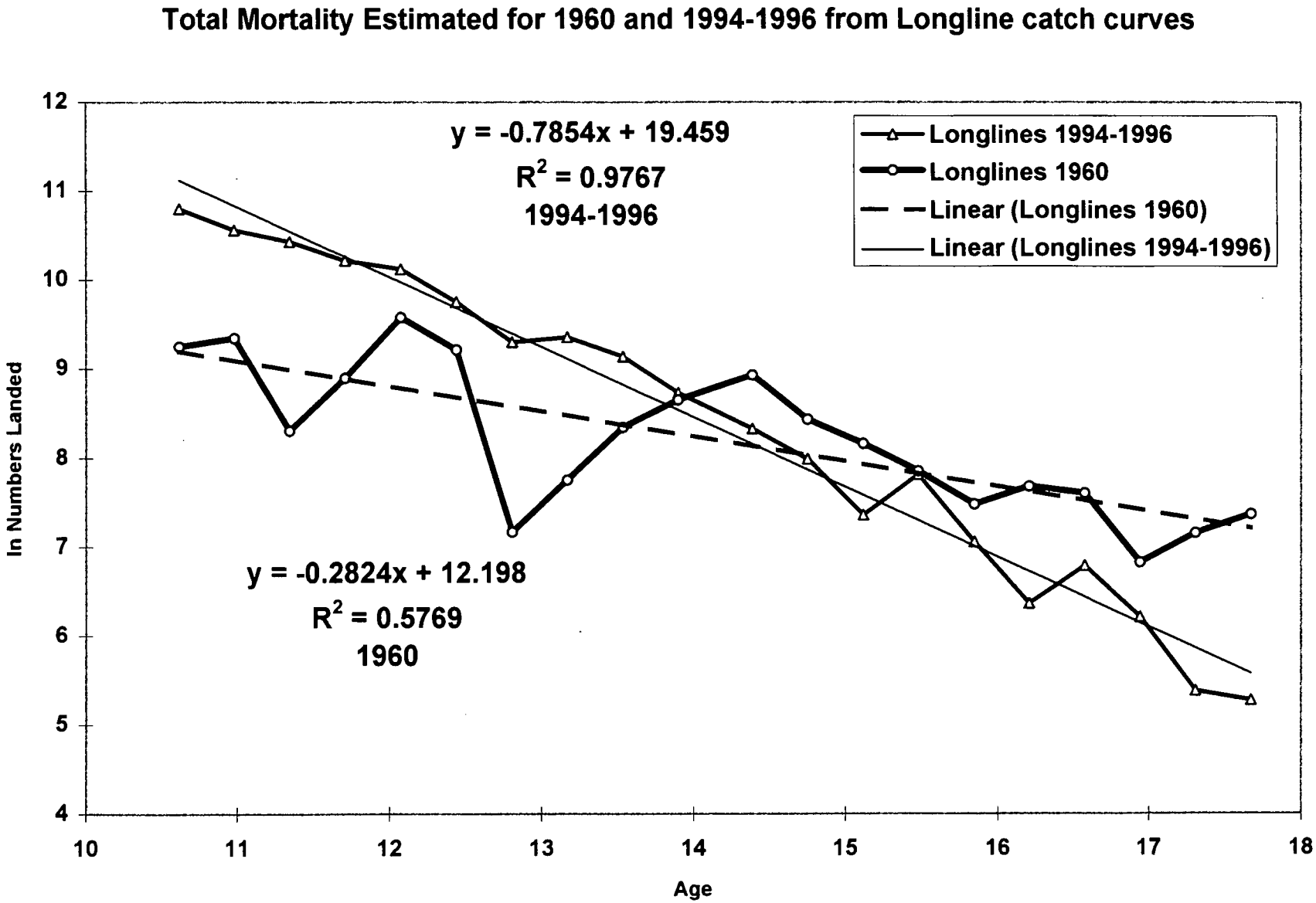


Figure 31. Estimation of total mortality (Z) from catch-curves derived from samples of longline landings in 1960, and in recent (1994 - 1996) years. The catch-curves used only those ages which were observed in both time period (11-17). Catches for 1994-1996 were combined to derive a single estimate of Z for the time period.

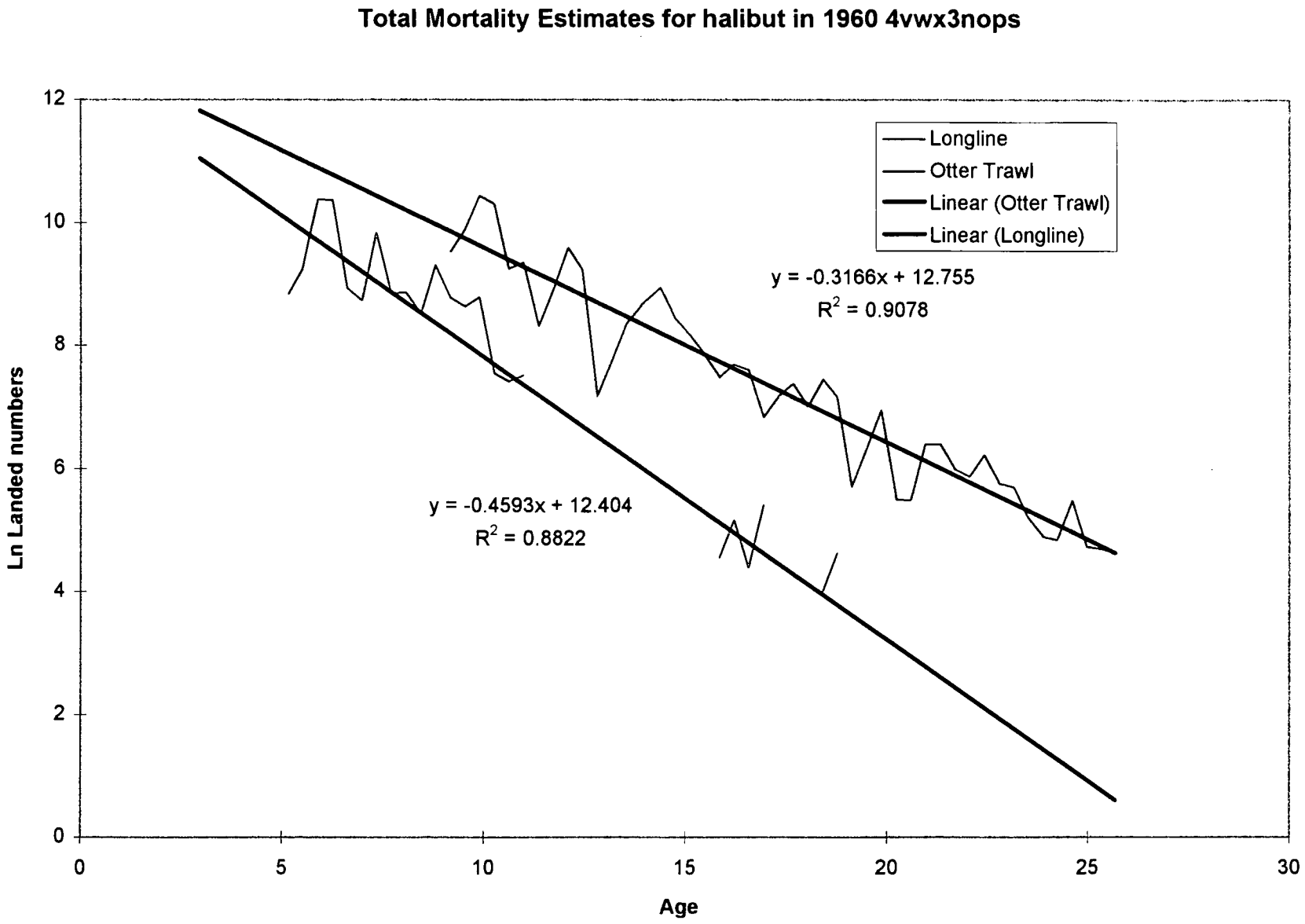


Figure 32. Catch-curves from samples of long-line and otter trawler landings taken during 1960.

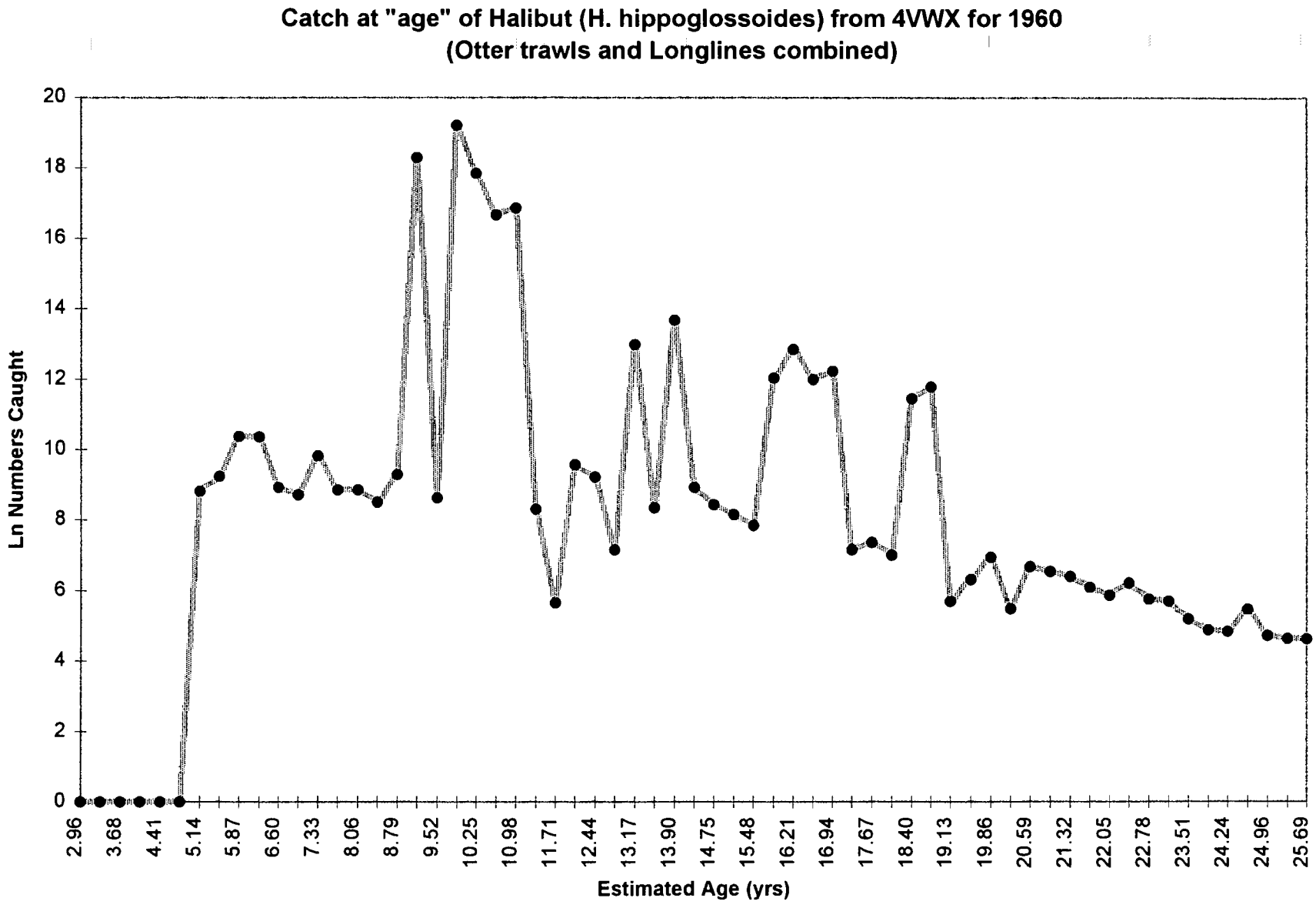


Figure 33. Catch at age for longline and trawl landings for 1960.

Halibut Age - Composition from Otter Trawl Landings
(Gulf Age Model; linear growth)

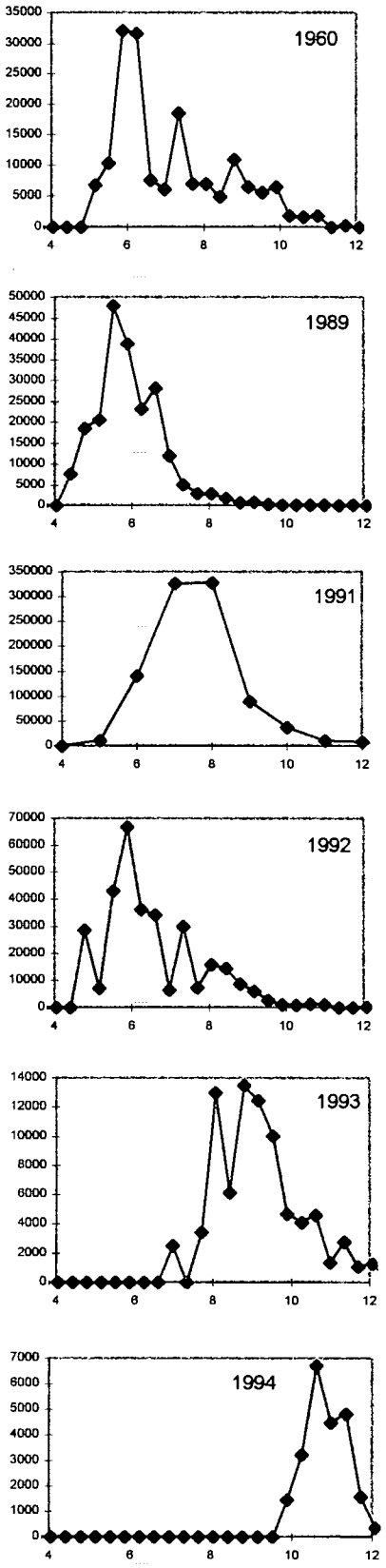


Figure 34. Age composition of otter trawl landings 1960 and recently (1994-1996). Data for the most recent years is restricted to samples of 4X caught halibut.

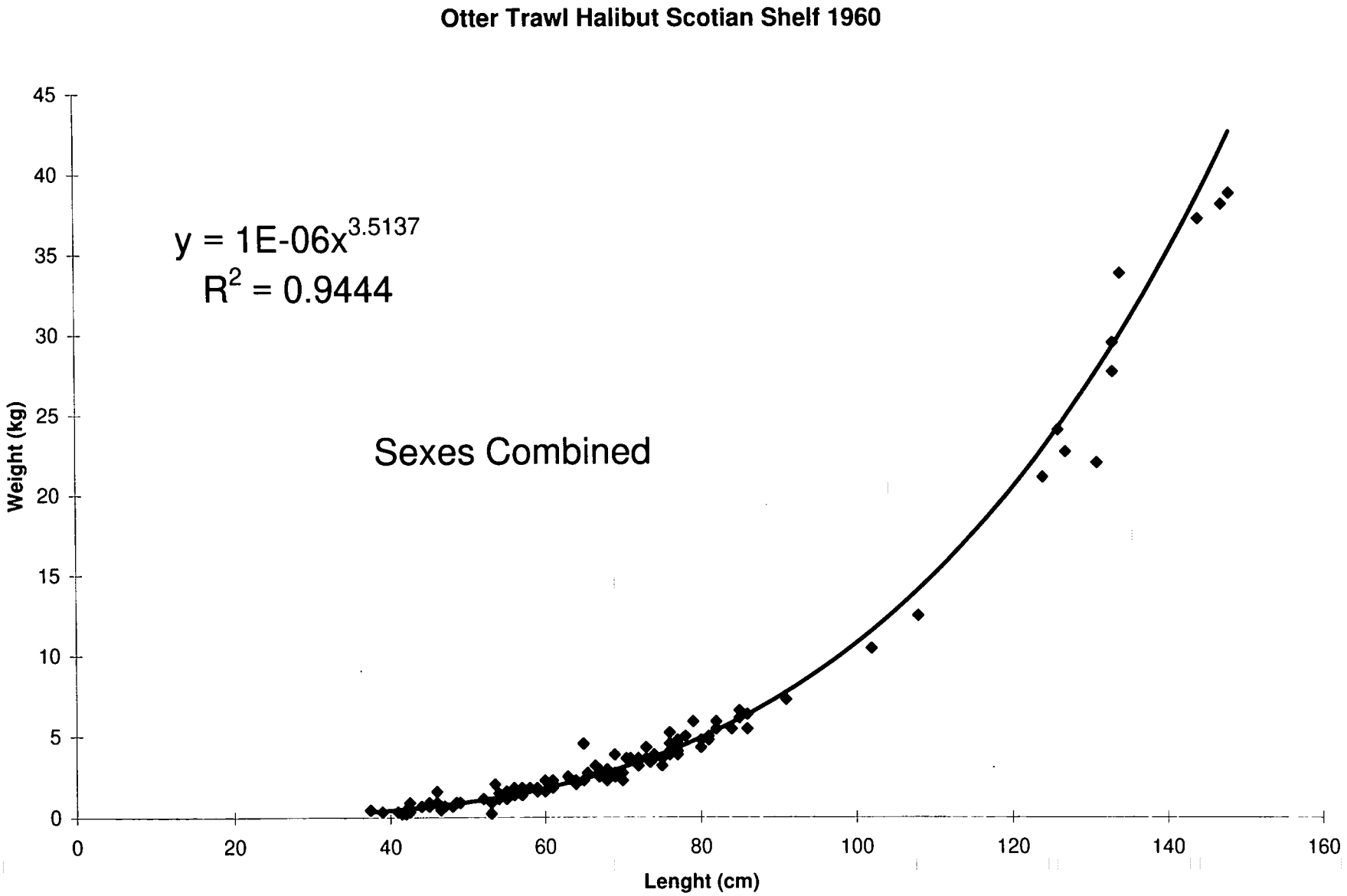


Figure 35. Length-weight relationship for 4VWX halibut.

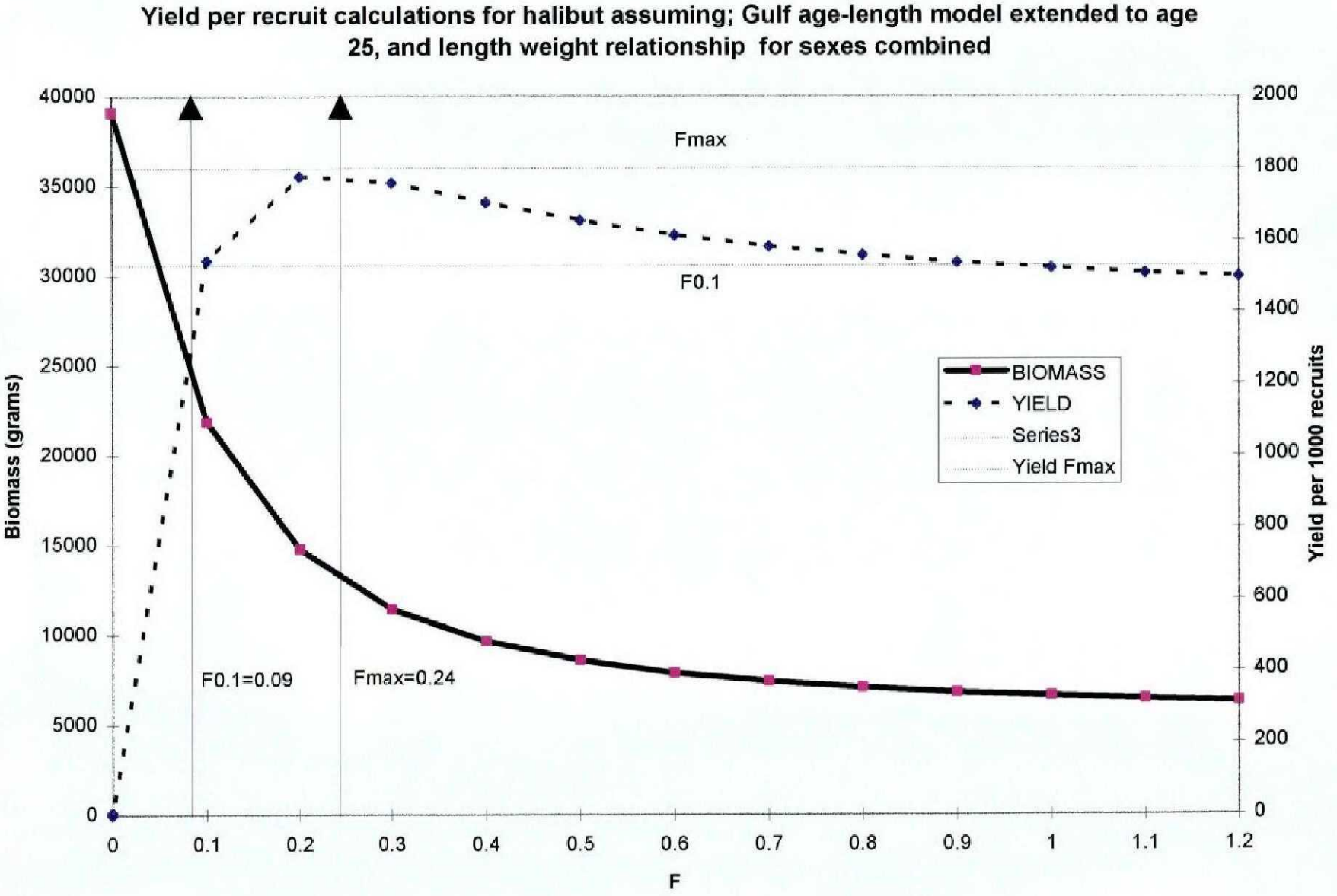


Figure 36. Results of the Thompson and Bell yield per recruit analysis for halibut assuming the linearized Gulf growth model (see text) and knife-edged recruitment at age 10.

Appendix I

To: J. Kearney
Chair, Halibut Working Group
Scotia-Fundy Fixed Gear Groundfish Committee

From: K. Zwanenburg
Senior Assessment Biologist
Marine Fish Division

Subj: **Halibut Working Group Report Nov. 18, 1996** 10 December, 1996

Further to our telephone conversation of DEC 4, 1996, I have reviewed the report produced as a result of the November 18 meeting of the Halibut Working Group as you requested. The thrust of your report appears to be two-fold. The first is a critique of the latest halibut stock status report (96/72E), and the second are a series of recommendations regarding halibut assessment research for 1997. The latter includes a recommendation for an 100t allocation of halibut to the <65 ft fixed gear sector to be used as a scientific quota over and above the present allocation for that fleet sector. I will comment on each of the sections in the report in turn.

Critique of Stock Status Report

Your first point raises concerns about the stock structure of halibut. The management unit of interest covers NAFO areas 4VWX, 3NO, and 3Ps. You contend that this is too large an area and that the abundance and biology of the species should be evaluated on a smaller geographic scale. The decision to combine this large area as a single management unit was, to my recollection, based largely on the results of mark and recapture experiments, which show that halibut are a highly mobile species. Marked individuals have been captured at great distances from the point of release. Given this degree of mobility it was probably considered unlikely that halibut within smaller areas constituted discreet populations. It would however be worthwhile to review the scientific literature relevant to this topic to determine if a review of the present management structure is warranted.

Your next three points are of great interest. Your contention is that the catch per unit of effort (CPUE) series used to evaluate halibut abundance is biased. You maintain that total effort is "grossly overestimated", especially during the period 1992 - 1995 by virtue of inclusion of all effort with size 14/0 hooks. You state that much of this effort was actually directed at other species and that halibut was only a by-catch in these fisheries. Before effort is used to calculate a CPUE series for any fishery, the effort is first classified by the main species caught during the trip for which the effort is reported. Main species is defined as that species which makes up the largest single proportion of the landed weight for any given trip, except in the case of halibut. In the case of halibut, if it's landed value is greater than the landed value of the species having the largest proportion of the trip

landed weight, then halibut becomes the main species caught. With the very high landed value of halibut, even a small amount of halibut can be worth more than a much greater weight of another species, resulting in the classification of the effort for that trip as halibut directed. Such a protocol has the potential for overestimating the amount of halibut directed effort expended during any given period. A possible solution to this problem would be to classify the effort based only on weight of catch as is the case for all other species, or to have fishermen classify their effort as halibut directed or otherwise on the log books.

You also point out that the CPUE series is further biased by virtue of not reflecting catch rates on prime halibut grounds which are presently closed to fishing. This raises an important concern about catch per unit of effort series in general, and that is the effect of spatial patterns of fish and fishery distribution on the relationship between CPUE and stock size. It has been observed that in some fisheries CPUE remains relatively stable (it does not increase or decrease) even though overall stock size declines. This is accomplished by virtue of fishermen's knowledge of fish distribution and the fact that fishermen fish for catch rates rather than catch. Since fishermen know where to find fish and since they tend to fish only in areas where fish are abundant, high catch rates are maintained until the last area of high fish density has been exploited after which CPUE crashes rapidly. In short it is not clear what the effect of having the prime areas closed to fishing would be on CPUE. This is an issue which is being investigated by a number of researchers. It would be informative if the results of some of this work were to be presented at an upcoming halibut working group meeting.

You comment that the assessment fails to take into account the release of large numbers of small (<32 inch) halibut caught during the fishery. It is difficult to see how this would affect the assessment since these fish presently do not appear as catch, they are not counted as part of the total removals and therefore do not contribute to the estimates of fishing mortality. I am not aware of a quantitative estimate of the number of these releases. If such an estimate were available it could be combined with previous work on survival of released halibut to determine the potential rate of mortality of small halibut which are caught and subsequently released. Such an estimate could improve the overall assessment by providing an estimate of the impact of a previously undocumented source of mortality.

The fact that the present TAC is easily caught by the longline sector could as easily be interpreted as over-capacity in the long-line sector rather than a higher than estimated abundance of halibut. There are published estimates which indicate that fleet capacity overall has been as much as 4 times that required to exploit groundfish resources at $F_{0.1}$.

The abundance time series for Atlantic halibut based on standard groundfish trawl surveys show a very high variance. This means that estimates of abundance can change a great deal from year to year. This variability is probably due to the small numbers of halibut caught during any given survey. This same variability makes the time series very difficult to interpret. A halibut directed survey has the potential of improving our ability to estimate and monitor abundance, but would need to be carried out on a large

geographic scale given the presently understood population structure. As with any monitoring survey it would also have to carried out over the long term (5 - 10 years plus) to become an effective independent estimate of halibut population abundance. However given the value of this resource, this should be given very careful consideration.

Additional Concerns

Maximum size limits have been established for some salmon fisheries for purposes of ensuring adequate brood stock. I am not aware of any maximum size limits established for commercial marine fisheries. Such an action would require careful study as to the potential benefits relative to the costs of enforcing the regulation. Recent work on cod suggests that larger older fish produce disproportionately larger numbers of eggs than smaller females. The eggs produced by these females also appear to be more viable. If halibut show the same response it may well be beneficial to maintain some proportion of older large females in the population.

Regarding your contention that the mobile gear sector continues to land undersized halibut, there are a number of sources of information which could be accessed to investigate this. The Observer Programs in both the Maritimes and Newfoundland Regions maintain detailed records of by-catch and disposition of by-catch for all observed trips. These records could be searched to determine the numbers of halibut caught by the mobile gear sector.

Recommendations for Halibut Scientific Assessment 1997

Your comments regarding joint DFO/Industry projects are appropriate. I feel that increased sampling of halibut landings to better characterize removals with regard to size, age, and stage of sexual maturity, would improve our overall understanding of this valuable resource.

With regard to tagging studies to determine migratory or other patterns of distribution, these need to be carefully planned. By this I mean that these kinds of experiments are most useful if they are designed and implemented with a particular objective in mind, you need to ask a specific question and then set up the experiment in a manner most likely to give you an answer to that question. In the case of 4VWX3NO3PS halibut, it is not sufficient to ask only in general terms what the migratory patterns are. These patterns are reasonably well understood by both fishermen and by fisheries scientists who have worked on halibut biology in the past. It might be more appropriate to ask what the average distance a tagged halibut moves per unit of time at large. This would give some indications of how much interchange there is between various portions of the management units, and might give some indications of potential stock sub-structure. I am not aware of any recent work on halibut stock structure through either enzyme or DNA work, but these might be useful avenues to pursue to get a potentially more detailed understanding of population structure.

A directed scientific fishery, one which collects detailed information for each set, such as is presently the case for the 4VW sentinel fishery, may provide a good CPUE index. The philosophy behind this in the 4VW sentinel fishery is that each fisherman fishes in his (or her) traditional manner, but records in detail all aspects of the operation and catch. It is considered that this will provide a "true" CPUE index, one which is not biased due to management constraints. It should however be pointed out that during the fisherman directed portion of the 4VW sentinel survey, the Emerald Western closure remained in effect. Such an index would only be effective if it became an established monitoring time series and was implemented over a period of more than 5 - 10 years. There are a number of options which could provide the requisite amount of fish required to conduct such an index. One is to use part of the existing quota (or allocation) to "fund" the survey. This would require discussions among all the fleet sector participants to determine both the amount, and how the landed value of that catch is to be allocated. A second option would be to obtain an additional allocation over and above the existing quota, as you propose in the report. The decision to allocate additional catch to a fleet sector would rest with the management hierarchy, however, the scientific advice provided to the FRCC through the latest stock status report indicates that this resource is presently in a depressed state and that effort on it should be reduced. This would appear to leave little room for an increased allocation, especially since the requested increase represents more than 10% of the 1995 TAC of 900 t.

I agree entirely with your final comment regarding the full integration of halibut fishermen into the halibut assessment process. I look forward to meeting with and working with your group to discuss and find ways of implementing some of your suggestions for new or additional research.

K. Zwanenburg

cc. R.N. O'Boyle
M. Sinclair
C. Annand
J. Hansen