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Assessment of 4X Haddock in 1995

by

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ABSTRACT

Reported landings of 4X haddock in 1995 were 5,416t, while the TAC was 6,000t. This shortfall occurred primarily in the fixed gear sector, as a result of extremely restrictive fishing plans and in many cases because cod allocations were taken first. As a result of a number of new control measures, it is believed that the 1995 landings data are more accurate than in past years. The size composition of landings in 1995 was comparable to the long term mean but mean size decreased with respect to 1994. Haddock were more widely distributed in the 1995 research vessel survey and overall abundance increased again from the historic low in 1993, with small haddock encountered throughout the survey area. Results of a survey conducted by the ITQ fleet in co-operation with DFO Science Branch were comparable with the research vessel survey results and provided valuable information on the inshore area not covered by the research vessel survey. New haddock ageing criteria have been defined and routine ageing resumed. Revised ageing data for research vessel survey samples for 1987-95 were used to generate catch-at-age numbers for the research vessel survey, and in the absence of revised ageing data for commercial samples, multi-year age/length keys from the research vessel survey were used to generate a commercial catch-at-age for 1987-95 as an interim measure. These were used in a traditional Sequential Population Analysis. The analysis indicated that: fishing mortality has decreased from high levels in 1991-92 but is still above $F_{0.1}$; spawning stock biomass increased slightly from a historic low of 14,000t in 1994; and with the exception of the 1987 and 1988 year-classes, recruitment has been below average from 1983-91. The 1992 year-class is estimated to be average in strength and the 1993 year-class is estimated to be well above average in strength, although both spawning stock biomass and fish condition were at historic lows. Projections from the analysis indicate that the projected $F_{0.1}$ yield in 1997 would be about 6,700t. Spawning stock biomass would increase to 54,000t by the end of 1997. The abundance of small fish will be high in 1997 and the use of strict small fish protocols and area and season closures should be continued.

RÉSUMÉ

D'un TAC fixé à 6 000 t pour 1995, les prises signalées d'aiglefin de 4X ont atteint 5 416 t. C'est le secteur des engins fixes qui a essuyé la plus grande partie de l'insuffisance du rendement de la pêche à cause des plans de pêche extrêmement restreignants et, dans de nombreux cas, de la priorité donnée à la récolte des allocations de morue. Suite à la mise en oeuvre de nouvelles mesures de contrôle, on croit que les données sur les débarquements de 1995 sont plus précises que par les années passées. La distribution des longueurs des prises en 1995 se compare à la moyenne à long terme, bien que la longueur moyenne ait diminué par rapport à 1994. L'aiglefin était plus répandu lors du relevé par navire de recherche de 1995 et son abondance générale avait augmenté, une fois encore, par rapport au faible niveau historique relevé en 1993, de petits aiglefins ayant été capturés dans toute la zone du relevé. Les résultats d'un relevé effectué par la flottille des QTI en coopération avec la Direction des sciences du MPO se comparaient aux résultats du relevé par navire de recherche et ont fourni de l'information précieuse sur la zone côtière que ce dernier n'avait pas couvert. De nouveaux critères de détermination de l'âge de l'aiglefin ont été définis et la détermination systématique de l'âge a recommencé. Des données révisées sur l'âge obtenues d'échantillons prélevés par navire de recherche de 1987 à 1995 ont été utilisées pour obtenir des données sur les prises selon l'âge pour le relevé par navire de recherche et, en l'absence de données révisées sur l'âge pour les prises commerciales, des clés âge-longueur pluriannuelles établies d'après les données recueillies par navire de recherche ont été utilisées pour obtenir des données sur les prises commerciales selon l'âge de 1987 à 1995, à titre de mesure intérimaire. Ces dernières ont servi à une analyse séquentielle de population classique, qui a révélé que la mortalité par pêche avait baissé par rapport aux pics observés en 1991-1992 bien qu'elle était encore supérieure à $F_{0,1}$, que la biomasse de géniteurs avait augmenté légèrement par rapport au creux historique de 14 000 t noté en 1994 et que, sauf pour les classes d'âge de 1987 et 1988, le recrutement était inférieur à la moyenne de 1983 à 1991. L'abondance de la classe d'âge de 1992 est considérée comme étant supérieure à la moyenne et la classe d'âge de 1993, largement au-dessus de la moyenne, bien que la biomasse de géniteurs et la condition de l'aiglefin se situaient aux plus faibles niveaux observés. Les projections faites d'après l'analyse indiquent que le rendement à $F_{0,1}$ devrait atteindre environ 6 700 t et que la biomasse de géniteurs augmenterait pour atteindre 54 000 t d'ici la fin de 1997. Comme l'abondance de petits poissons sera élevée en 1997, on devrait continuer à appliquer des protocoles rigoureux sur les prises de petits aiglefins et des mesures de fermeture de saison et de région.

Introduction

This document contains an evaluation of the NAFO Division 4X haddock stock (Figure 1) for the 1995 fishing year. As in the past, haddock caught in unit area 4Xs were not included in this analysis because they are believed to be part of the 5Y stock (Halliday 1974).

In a previous assessment of this stock (Frank et al. 1990), it was concluded that problems with the catch-at-age and/or the ADAPT formulation needed to be resolved before the results of Sequential Population Analysis (SPA) could be used as the basis for harvest level advice. In 1992, it was determined that a bias was present in haddock ageing data in recent years.

In 1994 and 1995, length-based SPA techniques were used in an attempt to determine stock status without ageing data for recent years (Hurley et al. 1994, 1995). It was concluded that there were a number of problems with these analyses, the most basic being the uncertainty concerning the growth models that were used.

Criteria for ageing haddock otoliths for this stock have now been redefined and revised ageing data are available for research vessel samples from 1987-95 and for some commercial samples for 1993 and 1995. In this analysis, we used the age and length composition data from the research vessel survey to calculate catch-at-age for the survey and used the age composition data from the research vessel survey together with the length composition data from commercial sampling to calculate commercial catch-at-age, for the years 1987-95. The ageing data from the 1993 and 1995 commercial samples were used to evaluate the effect of using age composition data for the research vessel survey to estimate age composition of the commercial catch.

Description of the Fishery

Nominal Catches

The long-term (1930-93) reported annual landings of haddock in NAFO Division 4X average about 20,000t. Landings exceeded 30,000t during the mid- to late 1960s and again during the early 1980s (Figure 2). Landings declined subsequently and have been below the long-term average since 1984. Landings reached 6,672t in 1989 when it was recommended that the fishery be maintained at the lowest possible level and the mobile gear fishery was closed in mid-season. Landings increased from 1989 to 10,351t in 1992 under a Management Plan that called for a by-catch fishery only. A TAC of 6,000t was implemented in 1993 and landings that year were 6,832t. Landings in 1994 were 4,273t, the lowest level observed in recent history. This level was a result of a decrease in the quota to 4,500t and stringent fishing plans. The TAC in 1995 was increased to 6,000t and reported landings were 5,416t (Table 1). This shortfall occurred primarily in the fixed gear sectors and can be attributed to extremely restrictive fishing plans in 1995. In many cases, the shortfall in haddock occurred because cod allocations were taken first (Table 2). For many of the fixed gear sectors, there were closures in place for more days than they were open (Table 3).

Inshore mobile gear (<65ft) landings have remained low since 1989 and were 2,878t in 1995 (Table 4). Fixed gear (longline and handline) landings increased from 2,699t in 1989 to 6,468t in 1992 but have decreased since and were 2,363t in 1995. Gillnet landings in 1995 were 65t and offshore mobile gear landings were 99t.

The reduction in quota and the much more restrictive management plans of 1994 had resulted in substantial changes in temporal and spatial patterns in the fishery. Mobile gear landings from 4Xmnop had decreased in 1994 (Table 5) as the fleet continued to avoid haddock in 4X and directed for other species (flatfish, redfish, monkfish, shrimp, silver hake). The proportion of mobile gear landings from 4Xqr had increased as some of the fleet shifted away from the banks and into deeper water. With the increase in quota in 1995, mobile gear landings increased in 4Xmnop in the first and fourth quarters of the year as vessels directed for haddock to take advantage of good market prices early in the year and to use up remaining quota late in the year.

The fixed gear allocation was divided among a number of smaller groups. Fixed gear landings in the first quarter of 1995 remained low and dropped in the second quarter, relative to previous years, due to very restrictive fishing plans. The traditional winter longline fishery was only open for 23 days in January. When the longline fishery was re-opened in April, catches of small cod and haddock were reported from LaHave, Roseway, and Baccaro Banks. These banks were closed to the longline fleet on 30 June 1995. Subsequent test fisheries indicated continued catches of small cod and haddock and these areas remained closed throughout the remainder of the year. The handline fishery opened May 1, but was subject to numerous closures (Table 3). The longline and gillnet fleets (<45') were also subject to numerous closures.

The foreign catch of 4X haddock in 1995 was 9t (Table 1). The coordinates of the Small Mesh Gear Box was re-defined in 1994, resulting in a shift to the east and deeper than before. This change and the introduction of grates in the foreign silver hake fishery appears to have resulted in an overall reduction in groundfish by-catch in this fishery.

<u>Allocations and Management Actions</u>

Quota allocations and management actions for 4X haddock in recent years have been quite complicated, particularly in the mid- to late 1980s, and were summarized in earlier assessments (Hurley et al., 1991, 1992). Annand and Hansen (1994, 1995, 1996) summarized allocations and management actions in 1993, 1994, and 1995 respectively.

The Conservation and Harvesting Plan for the ITQ fleet in 1995 was similar to that in 1994 and 1993 in terms of small fish protocols, mandatory landings, and dockside monitoring (DMP). Aside from these control measures, the only restrictions imposed through the year were closures of Browns Bank from February 1 - June 15 and Minas Basin from May 1 - May 31.

Generalists who had been able to hail accurately (within 10% of actual weighout) 90% of the time in 1994 were subject to only 50% random weighout in 1995. This resulted in roughly half the vessels on 50% random weighouts and the remainder with 100% DMP. The number of vessels in this sector has been reduced to 33 vessels, all but 3 of which are located in Digby County. The fleet operated under self-imposed trip limits.

The Conservation and Harvesting Plan for the fixed gear sector was much more complex in 1995 than in previous years. The fishery opened on January 9, 1995 under an interim plan to allow a number of longliners that traditionally fished cod and haddock in the winter offshore fishery to operate. This plan allowed 300t of haddock to be caught in January. This interim plan was in effect until January 31. The fleet sector divided into a number of quota/season/trip limit/gear groups (Tables 2 and 3), described in detail by Annand and Hansen (1996). Dockside monitoring was not required for this fleet although submission of fishing logs and "hailing in" were required. It was the responsibility of the fisher to accurately determine the weight of the catch immediately after off-loading. LaHave Bank and an area including part of Roseway and Baccaro Banks were closed to the fixed gear sector for most of the summer and fall due to catches of small fish. The entire fixed gear sector was closed in mid-October when the fixed gear cod allocation and most of the haddock allocation had been taken.

Additional Information About the Fishery

Consultations with the mobile gear sector indicate a general feeling that haddock abundance has been increasing over the past 4-5 years but that it has not reached the level of the early to mid-1980s. Vessels continue to avoid areas where traditionally haddock abundance has been high. As a result, vessels are fishing in deep waters and continue to direct for non-traditional species. Vessels avoid small fish by using larger mesh, with most choosing 140mm square mesh and many choosing larger mesh. Reports of haddock in the deep water of 4Xqr were not as widespread as in 1994.

Consultations with the fixed gear sector also indicated that there was a feeling that haddock were becoming more abundant in recent years. There was a feeling also that abundance was increasing in the eastern portions of 4X. Fishermen indicated that there were large numbers of small haddock particularly in shallow water on the banks.

During industry consultations, it was indicated that discarding of undersized haddock occurred in the fixed gear sector, particularly while the fleet was fishing under the interim fishing plan in January. At-sea sampling conducted during DFO Surveillance boardings led to the closure of Roseway, LaHave, and Baccaro Banks in late June. As a result of these closures and the use of large mesh in the mobile gear fleet, the problem of discarding small fish was minimized. Anecdotal information suggests that, although some haddock catches were unreported, the reported landings in 1995 were more accurate than in past years.

Data

Size Composition of the Catch

Commercial sampling data were used to construct a catch-at-length for 1995 in the same manner that would be used to construct the catch-at-age. The 1995 catch-at-length was constructed using the gear and quarter stratification shown in Table 6. The catch-at-length for the foreign catch was calculated using samples from the Scotia-Fundy Observer Program. The construction of the catch-at-length for the period 1970-94 was described by Hurley et al. (1994, 1995). The overall catch-at-length (1970-95) is shown in Table 7 and Figure 3.

The overall size composition of landings in 1995 was quite comparable to the long term mean (1995 mean length of 50.2 vs. long term of 50.5cm). The 1994 overall mean length was 52.8cm (Figure 4).

Since 1990, there has been an increase in the mean length in the mobile gear catch from 48.3 to 54.7cm in 1995 (Figure 5). During the same period, there was a decrease from 54.1 to 49.4cm in 1993 in the mean length in the fixed gear catch. The mean length in the fixed gear catch in 1994 increased to 50.5cm and remained the same in 1995.

The size composition of the by-catch of 4X haddock in the foreign silver hake fishery in 1995 from Observer samples showed modes at 26 and 32cm, corresponding to the 1994 and 1993 year-classes respectively. The introduction of grates in this fishery and the change in the Small Mesh Gear Box does not allow comparisons with earlier years.

Commercial Catch Rates

Commercial catch rates have not been considered a reliable index of haddock abundance in 4X due to the high and variable levels of misreporting, particularly in the mid-1980s, and the extent of management changes in the recent period.

Research Vessel Surveys

A summer groundfish research vessel survey of the Scotian Shelf has been conducted in July since 1970. The stratification scheme used in the survey has not changed and is shown in Figure 6. Mean number per tow by stratum is shown in Table 8. Research vessel catch rates at length were calculated for the survey series 1970-95 (Table 9). The vessel conversion factor of 1.2 was used for the *A.T. Cameron* surveys, as usual.

Mean number per tow of 4X haddock in the research vessel survey increased from an all-time low of 12 fish per tow in 1993 to 38 per tow in 1994 and to 92 per tow in 1995, more than twice the long term mean of 45 fish per tow and the second highest value in the survey series (Figure 7a); however mean weight per tow increased from 16 kg in 1994 to only 35 kg in 1995, relative to the long term mean of 36 kg per tow. The increase in 1995 was not due to one or a few large sets, instead, relatively large catches of small haddock were made over much of the survey area.

This substantial increase in mean numbers per tow, relative to mean weight per tow, was due to record high catches of small haddock (Figure 7b vs. 7e).

The catch of haddock at modal lengths of 18 and 30cm respectively (representing haddock aged 1 and 2 years old) was much larger than average (Figure 8). These modes are consistent with the modes of 8 and 24cm in the 1994 survey, when these haddock were 0 and 1 years old (Figure 8). The 1995 survey indicates that the abundance of market size haddock (>43cm) has also increased (Figure 7c).

Overall the length frequency distributions from the 1992-95 summer research vessel survey indicate that the 1993 and 1994 year-classes are much stronger than average and that the 1992 year-class may be average in strength.

The research vessel survey strata on and around Browns Bank (477, 480, 481) contribute approximately 50% on average to the survey abundance estimate while stratum 490 in the mouth of the Bay of Fundy contributes an additional 15%. Survey strata were grouped into strata on and around Browns Bank (477, 480 and 481), strata west of Browns Bank and in the Bay of Fundy (482-495), and strata east of Browns Bank (470-476 and 478).

Haddock were more widely distributed in 4X in the 1995 summer survey than in recent years (Figure 9). Haddock were encountered in the eastern portion of the survey area and in the upper Bay of Fundy, where few had been seen in the survey in recent years (Figure 9). Abundance increased throughout the survey area, but the increase in the eastern and central portions of the survey area consisted primarily of small haddock (Table 10). The increase in the Bay of Fundy, however, consisted of both small and market sized haddock.

Joint Industry/DFO Survey

The ITQ Committee in cooperation with DFO Science Branch conducted a trawl survey of the 4X area during 26 June to 7 July 1995, the same time that the DFO research vessel *Alfred Needler* was conducting the annual summer groundfish survey. The ITQ survey was designed to cover the entire 4X area, including the inshore area that the *Alfred Needler* is unable to survey, with five vessels from the ITQ fleet. However, due to uncertainties over the level of available resources, the ITQ survey was conducted by three draggers (<65 ft.) which completed 139 of the proposed 210 sets. The industry vessels used a standardized gear with the same size liner as the research vessel survey. Sampling of the catch was conducted by observers (assisted by the vessel crew) and length frequency samples were taken for cod, haddock, pollock, and winter flounder. Further details are summarized in O'Boyle et al. (1995).

Catches in numbers and weights from the three vessels were standardized for tow distance and wingspread. Wingspread of the trawls used were measured using SCANMAR sensors. In areas covered by both surveys, patterns of haddock distribution looked similar (Figure 10). The ITQ survey coverage of the inshore area unsurveyed by the research vessel showed that the high haddock catch rates were continuous through the area between Lurcher Shoal and Browns Bank.

Haddock length compositions from the two surveys on a stratum by stratum basis were generally comparable (Figure 11), although catch rates were variable (Table 11). Pooled length frequencies for strata 481, 485 and 490, adjacent to the inshore area not covered by the research vessel survey, were very comparable for the two surveys (Figure 12). However, ITQ survey catches in the inshore area of haddock in the 30-45 cm range were higher than in the adjacent strata (Figure 12).

The first attempt at an industry survey of this area appears to provide a useful measure of haddock distribution, abundance and size composition and surveys of this nature may serve to compliment the current research vessel survey by providing data for areas and seasons not currently surveyed by the research vessel. Caution should be used however in direct comparison of the catch rates between the two surveys. Although they show similar patterns, the ITQ vessels had higher catch rates than the *Alfred Needler* during the 1995 survey period. It will take several more years for the ITQ survey to provide catch rate information that could be used as an index of stock abundance.

Fish Condition

Condition is the relative weight of a fish for its length i.e. its plumpness. An index of condition, the predicted weight of a haddock at a given length, was calculated from the annual length/weight relationship from the summer research vessel surveys. Only haddock from the Scotian Shelf strata (470-481) were evaluated, as Marshall (1995) had shown that this index calculated for haddock from the Bay of Fundy varied without trend. Indices were calculated for lengths of 35 and 50cm. While these indices from the Scotian Shelf strata were variable, they indicated that condition has decreased since the late 1980s to low levels in 1995 (Figure 13). The index for a 50cm haddock was at its lowest level in the survey series. Low condition is one indicator of poor health; however the cause and significance of low condition in this case is uncertain.

Haddock Ageing Data

Age reading of 4X haddock otoliths was suspended in 1992 when it was determined, during transfer of ageing responsibility for 4X haddock from the St. Andrews Biological Station to the Bedford Institute of Oceanography (BIO), that the ageing protocol had resulted in a bias in haddock ages since the early to mid-1980s. This was further elucidated during a haddock ageing workshop held at BIO in 1993. New ageing criteria were developed resulting from the workshop which suggested the age interpretations since 1985 were skewed towards much younger ages. However, in the absence of comparative age determinations using otoliths of known age, the accuracy of those ages could neither be confirmed or denied. Campana (1995) outlined a two-phased project used to address this. As a long term approach to the problem, a radiochemical age validation study was initiated; as a shorter term solution, a reference collection consisting of 200 otolith pairs was assembled and circulated to five laboratories (national and international) experienced in ageing haddock or related species. These five laboratories were quite consistent in their interpretation of the reference collection otoliths. The BIO agers trained against the reference collection until a satisfactory level of precision was attained (CV<5%), with no bias.

In fall 1995, routine age determination of 4X haddock resumed, with appropriate monitoring in place for both precision and bias.

This re-ageing was conducted by two age readers. Each acted as secondary reader for the other, reading 10% of the otoliths read by the other. A comparison of 437 otoliths read by both readers showed no bias and high precision, with an overall coefficient of variation of 3.0% (Figure 14).

A comparison of the revised ageing data with the original data showed large differences, with the revised ages resulting in a much higher proportion of older fish and an increase of more than 50% in maximum age observed. A year by year comparison for 1988 to 1992 showed high and relatively constant levels of bias for ages 4 and older (Figure 15).

A comparison of mean length-at-age from the research vessel survey calculated using the revised ageing data and the original ageing data showed a considerable decrease in size-at-age in both the Scotian Shelf and the Bay of Fundy stock components; however the slower growth rate in the Scotian Shelf observed previously was still apparent (Figure 16, Table 12 and 13).

As it was not possible to re-age the entire post-1984 otolith collection prior to this assessment in the time available, priority was placed on the otoliths from the most recent years of the research vessel surveys. At the time of this assessment, otoliths from the research vessel surveys from 1987-95 had been re-aged. These were used to generate survey numbers-at-age as usual, using separate age/length keys for the Scotian Shelf strata (470-481) and the Bay of Fundy strata (472-495). Otoliths from the 1985 and 1986 surveys had not been re-aged so the original ageing data were used; however the effect of this was thought to be minimal given that the bias in the original ageing data was progressive and would likely have been minimal in those years. The resultant research vessel survey mean numbers-at-age were used in the SPA (Table 14).

As an interim measure, the age/length keys from the research vessel surveys were also used to generate the commercial catch-at-age from the commercial catch-at-length for 1987-95; however it was noted that mean length-at-age in the research vessel survey can be variable, sometimes substantially, at ages greater than 5 (Figure 17, Table 12 and 13). Examination of the commercial catch-at-length showed that substantial amounts of catch are taken at these ages, particularly on the Scotian Shelf (Figure 18). Examination of the research vessel survey age/length keys showed that sample size was variable and low at times and older ages were not well represented in the keys. Therefore the annual keys were combined to give one well sampled key for each stock component which represented the entire 1987-1995 period. These multi-year keys were normalized and then weighted by catch numbers in a given year to make an age/length key for each year and stock component of commercial catch for 1987-95. The use of these more stable pooled keys assumes no trend in growth rate across these years. As with the research vessel data, the original ageing data for 1985-86 were used. The resultant catch-at-age was used as an input for traditional age disaggregated SPA (Table 14).

Estimation of Parameters and Assessment Results

A traditional age-based SPA was conducted using the ADAPT framework (Gavaris 1988). The model used is as follows:

Parameters:

Terminal F estimates $F_{i,1995}$, i = 2-6
Calibration coefficients K_i, i = 2-7 for July RV survey

Structure Imposed:

Error in catch assumed negligible
Partial selection fixed for ages 1 and 8-10 in 1995
F on oldest age (10) set as average F of ages 2-6 adjusted by the relative selectivity of age 10 in 1995
No intercept was fitted
M = 0.2 for all ages

Input:

$C_{i,t}$ i = 1-10; t = 1970 to 1995 - catch-at-age for entire year
$J_{i,t}$ i = 2-7; t = 1970 to 1995 - July RV survey index

Objective function: Minimize

$\Sigma\Sigma$ (ln $J_{i,t}$ - $K_{1,i}$ $N_{i,t}$)^2

Summary:

Number of observations = 156 for July RV (6 ages by 26 years)
Number of parameters = 11, Fs estimated by NLLS, Ks algebraically

age	1	2	3	4	5	6	7	8	9	10
selectivity	.0001	.033	.118	.453	.884	.972	1.00	1.00	1.00	1.00

The minimization technique used was a nonlinear least squares (NLLS) gradient technique (the Marquardt algorithm). The NLLS technique is a compiled version of ADAPT written in ACON.

The results are given in Table 15 and Figure 19. The terminal fishing mortalities have CVs which range from 32 to 56%. Bias in the fishing mortality estimates range from -5 to -15%. The survey calibration coefficients have CVs of 11% and bias of less than 1%. The residuals show some strong year effects, with positive residuals at all ages in some years and negative residuals at all ages in other years. The estimates of population numbers and fishing mortality were consistent with those of the last age-based SPA (O'Boyle et al. 1989) until 1980 but they diverged thereafter. Although the fishing mortality levels were still high during this period, the present SPA resulted in levels that were much lower than those of O'Boyle et al. (1989). The reason for the divergence is unknown; however that assessment was using the original ageing data. This could be complicated by high misreporting which was present during the mid- to late 1980s. Incorporation of underreporting estimates of 25-100% derived for 4X cod (Campana and

Hamel 1991) for the 1984-90 period resulted in a 10% increase in population numbers and a corresponding decrease in fishing mortality in the terminal year but did not produce an improvement in model fit. As there is little evidence on which determine if underreporting of haddock was of the same level as cod over this period, the results of that run were not used. This analysis shows a retrospective pattern particularly in the early 1980s, in which estimates of biomass in the terminal year are consistently higher and fishing mortalities are consistently lower than when estimated with additional data available in subsequent years (Figure 20).

This analysis indicates that fishing mortality has been above $F_{0.1}$ since the early 1970s. Fishing mortality has decreased from high levels in 1991-92 but was still above $F_{0.1}$. Population numbers have decreased from a peak in the late 1970s to a low in 1994 and increased slightly in 1995. Similarly, spawning stock biomass calculated using the maturity ogive of Waiwood and Buzeta (1989) has been decreasing since 1980 and reached a low of 14,000t in 1994 (Figure 21). It is estimated that spawning stock biomass increased to 18,000t in 1995 as the 1992 year-class began to mature. With the exception of the 1987 and 1988 year-classes, recruitment was below average from 1983-91 (Figure 22a). The 1992 year-class is estimated to be of average strength and it is indicated that the 1993 year-class is well above average in strength. In the absence of an SPA in the last few years, a recruitment index based on ages 1 and 2 in the research vessel survey has been used to estimate recruitment. This index showed a similar recruitment trend (Figure 23). A plot of age 1 recruitment against spawning stock biomass estimated by the SPA suggests no stock recruitment relationship and that the highest recruitment has occurred at the lowest observed spawning stock biomass (Figure 22b). Furthermore, it is noted that this high recruitment has occurred at very low levels of fish condition.

Outlook

It was felt that, given the strength of the 1993 year-class indicated by the 1994 and 1995 research vessel surveys and the 1995 ITQ survey, using the long term geometric mean recruitment for projections would be overly conservative. However, with only a single year in the calibration, the model estimate of 80 million age 1 recruits for the 1993 year-class was felt to be too optimistic. A significant "retrospective" effect exists between the early observations of a strong year-class and subsequent estimates, either from SPA or from research vessel surveys. Figure 24 shows the contemporaneous estimates of age 2 from retrospective SPAs on the x-axis plotted against the converged estimates on the y-axis. A Gompertz function was fit through the points. Using the Gompertz fit, the 1993 year-class which was estimated to be about 65 million as 2 year olds would be expected to be on the order of 30 million after the retrospectivity is removed. This value would be 37 million as 1 year olds if natural mortality is 0.2. Similarly in Figure 25, the relationship between 2 year olds and 3 year olds in the q-corrected research vessel survey numbers displays a similar pattern in which the strong 1976, 1980 and 1981 year-classes are much weaker as 3 year olds. In this case, the 1993 year-class would be expected to be on the order of 47 million after correcting for $m = 0.2$ back to age 1. On balance, a conservative value of 40 million age 1 recruits was used in the projection.

Year	F	Yield (t)	Population Biomass (t)	Spawning Biomass (t)
1996	0.407	6500	46225	27210
1997	0.250	6653	61188	39766
1998	0.250	9793	76341	53690

This analysis indicates that landings of 4X haddock of 6,500t in 1996 would result in a fishing mortality of 0.407. The projected $F_{0.1}$ (0.25) yield in 1997 would be about 6,700t. Spawning stock biomass would increase to 54,000t by the end of 1997 (Figure 25). This projection is very dependent upon the estimated strength of the 1993 and 1994 year-classes. The July 1996 research vessel survey will reduce the uncertainty of the strength of these year-classes.

The abundance of small fish will be high in 1997, particularly on the banks. The 1993 and 1994 year-classes will have a mean length of about 40 and 44cm respectively in this area. The use of strict small fish protocols and area and season closures should be continued to allow these recruiting year-classes to realize their growth and reproductive potential. Continuing conservation efforts such as low exploitation are also needed to rebuild the population biomass and to expand the age structure in the population.

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Table 1. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) by country. The numbers in brackets represent the number of commercial samples collected in that year.

Year	Canada (MQ)	Canada (NFLD)	USA	USSR	Spain	Other	Total	TAC
1970	15560 (26)	-	1638	2	370	12	17582	18000
1971	16067 (29)	-	654	97	347	1	17166	18000
1972	12391 (36)	-	409	10	470	1	13281	9000
1973	12535 (30)	-	265	14	134	6	12954	9000
1974	12243 (25)	-	660	35	97	-	13035	-
1975	15985 (56)	-	2111	39	7	2	18144	15000
1976	16293 (45)	-	972	-	95	5	17365	15000
1977	19555 (79)	-	1648	2	-	12	21217	15000
1978	25299 (62)	114	1135	2	-	27	26577	21500
1979	24275 (49)	268	70	3	-	15	24631	26000
1980	28209 (56)	71	257	38	-	37	28612	28000
1981	30148 (82)	117	466	-	-	15	30746	27850
1982	23201 (92)	28	854	-	-	4	24087	32000
1983	24428 (119)	44	494	17	-	7	24990	32000
1984	19402 (97)	23	206	-	-	-	19631	32000
1985	14902 (86)	-	25	-	-	1	14928	15000
1986	14986 (78)	-	38	10	-	-	15034	15000
1987	13538 (82)	-	17	-	-	-	13555	15000
1988	10921 (79)	-	2	53	-	-	10976	12400
1989	6666 (43)	-	1	5	-	-	6672	4600
1990	7297 (71)	-	32	17[2]	-	3[2]	7342	4600
1991	9636 (81)	13	-	38[2]	-	3[2]	9690	-
1992	10329 (89)	5[1]	-	-	-	17[2]	10351	-
1993	6811 (86)	-	-	-	-	21[2]	6832	6000
1994	4272 (68)	-	-	-	-	1	4273	4500
1995	5407 (78)					9	5416	6000

Long-term Averages: 1930 - 60 = 16854 t
1961 - 83 = 25217 t
1930 - 83 = 20127 t

1 = NAFO Circular Letters
2 = I.O.P. data

Table 2. 1995 quota and landings for 4X cod and haddock, shading indicates allocations which were completed or exceeded.

Vessel	Group	Cod Quota	Cod Catch	Cod % Caught	Haddock Quota	Haddock Catch	Haddock % Caught
Fixed <45	ENS Gillnet	45	44	98	12	0	0
	ENS Longline	290	288	99	184	186	101
	4X Gillnet	764	961	126	95	64	67
	4X Handline	1408	1473	105	248	152	61
	4X Longline	1869	2086	112	1333	1533	115
Fixed 45-65		330	363	110	300	302	101
Fixed <65	SWNB Longline	17	17	100			
	Other	598	335	56	428	278	65
Mobile <65	ITQ	2800	2798	100	2935	2809	96
	Generalists	114	112	98	125	124	99
Fixed 65-100		23	12	52	32	5	16
Mobile 65-100		180	131	73	32	31	97
All >100		562	260	46	276	189	68
Total		**9000**	**8880**	**99**	**6000**	**5673**	**95**

Table 3. Fixed gear (<65') closures in 4X5Y for 1995

Group A-10 Longline <45'

Closed Times	Number of Days	Open Times	Number of Days
Jan. 1 - Jan. 8	8	Jan.9 - Jan. 31	23
Feb. 1 - May 14	103	May 15 - June 24	41
June 25 - July 16	22	July 17 - July 28	12
July 29 - Aug. 14	17	Aug. 15 - Aug. 23	9
Aug. 24 - Sept. 14	22	Sept. 15 - Sept. 20	6
Sept. 21 - Dec. 31	102		
Total to Aug. 31	**274**		**91**

Group A-9 Handline <45'

Closed Times	Number of Days	Open Times	Number of Days
Jan. 1 - Apr. 30	120	May 1 - June 16	47
June 17 - June 30	14	July 1 - July 7	7
July 8 - July 10	3	July 11 - July 19 (closed weekends)	7
July 20 - Sept. 10	53	Sept. 11 - Sept. 27 (closed weekends)	12
Oct. 4 - Dec. 31	89	Sept. 28 - Oct. 3	6
Weekend Closures	7		
Total to Aug. 31	**286**		**79**

Group A-8 Gill Net <45'

Closed Times	Number of Days	Open Times	Number of Days
Jan. 1 - Apr. 5	95	Apr. 6 - Apr. 24	19
Apr. 25 - May 31	37	June 1 - July 20	50
July 21 - Aug. 31	42	Sept. 1 - Sept. 27	27
Sept. 28 - Dec. 31	95		
Total to Aug. 31	**269**		**96**

Group A-11 Longline <45'

Closed Times	Number of Days	Open Times	Number of Days
Jan. 1 - Jan. 8	8	Jan. 9 - Jan. 31	23
Feb. 1 - Apr. 4	63	Apr. 5 - May 31	57
June 1 - June 30	30	July 1 - Aug. 25	56
Aug. 26 - Sept. 30	36	Oct. 1 - Oct. 14	14
Oct. 15 - Dec. 31	78		
Total to Aug. 31	**215**		**150**

Table 4. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding Unit Area 4Xs) landed in the Maritimes split by tonnage class and gear type. The numbers in brackets represent the mean weight landed per age/size sample collected.

Year	Tonnage Class						Total
	TC 1-3			TC 4+			
	MB (OT)	FG (LL)[1]	Misc.[2]	MG (OT)	FG	Misc.	
1970	4894 (1224)	3281	767	6501 (296)	114	3	15560
1971	4289 (858)	3475 (1158)	499	7711 (367)	94	0	16068
1972	2742 (686)	4396 (440)	439	4750 (216)	63	0	12390
1973	1822 (304)	6090 (677)	324	4228 (282)	70	0	12534
1974	3949 (494)	6364 (530)	251	1622 (324)	55	0	12241
1975	6085 (320)	5193 (577)	271	4408 (157)	26	0	15983
1976	4347 (1087)	5305 (884)	445 (223)	6144 (186)	46	6	16293
1977	6178 (1030)	4328 (481)	550	8343 (130)	117	35	19551
1978	9413	6814 (568)	1084 (542)	7888 (164)	97	0	25296
1979	10171 (5086)	5127 (394)	600 (600)	8317 (252)	57	0	24272
1980	13043 (1186)	6911 (384)	1127 (376)	7045 (294)	82	0	28208
1981	14765 (328)	7846 (302)	993 (331)	6475 (809)	70	0	30149
1982	11670 (243)	7581 (345)	945 (79)	2972 (297)	32	0	23200
1983	12563 (224)	8533 (225)	754 (75)	2535 (195)	15	0	24400
1984	11828 (208)	6769 (226)	193 (193)	609 (76)	0	0	19399
1985	9834 (173)	4360 (182)	142	565 (113)	1	0	14902
1986	9201 (192)	5336 (184)	240	209 (209)	0	0	14986
1987	7952 (169)	4854 (270)	231 (21)	501 (84)	0	0	13538
1988	7074 (131)	3353 (152)	118 (118)	376 (188)	0	0	10921
1989	3656 (130)	2699 (245)	222	89 (22)	0	0	6666
1990	3183 (76)	3731 (133)	280 (280)	102	0	1	7297
1991	4061 (94)	5117 (151)	275 (275)	183 (61)	0	0	9636
1992	3365 (72)	6468 (175)	249 (125)	245 (82)	0	2	10329
1993	2507 (58)	4083 (136)	97 (14)	124 (31)	0	0	6811
1994	1956 (50)	2175 (84)	46	95 (48)	0	0	4272
1995	2878 (61)	2363 (79)	65	99 (99)	0	2	5407

1 = Includes handline.
2 = Gillnets (set, drift), traps, unspecified.

Table 5. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit Areas 4Xs) by gear type, tonnage class, area and quarter, 1984-94.

		OTB				LL[1]		Misc.[2]		
		mnop		qr		mnop	qr	mnop	qr	
		1-3	4+	1-3	4+	1-3	1-3	1-3	1-3	Total
1995	1	798	74	258	1	301	0	0	0	
	2	109	2	357	7	369	125	3	4	
	3	70	4	446	0	1054	38	43	13	
	4	456	9	383	1	447	29	0	1	5402
1994	1	239	19	231	2	331	0	0	0	
	2	194	7	362	1	535	61	5	3	
	3	87	2	399	0	923	90	23	7	
	4	144	48	300	16	233	2	8	0	4272
1993	1	598	49	62	2	1009	13	0	0	
	2	388	49	503	4	671	220	18	5	
	3	155	3	436	11	1822	209	54	6	
	4	130	5	236	0	138	2	12	1	6811
1992	1	1006	92	76	0	1698	17	43	0	
	2	410	116	563	0	707	105	22	3	
	3	197	8	534	7	2240	256	66	51	
	4	264	8	315	14	1368	77	55	11	10329
1991	1	792	37	71	4	1800	20	10	0	
	2	305	64	766	3	451	46	27	5	
	3	200	20	627	4	1702	140	168	17	
	4	865	34	435	17	929	29	48	0	9636
1990	1	1341	42	93	1	1267	8	20	0	
	2	229	16	723	0	256	11	9	56	
	3	125	16	427	1	1447	29	115	53	
	4	128	25	117	1	707	6	27	1	7297
1989	1	2121	34	143	0	916	9	36	0	
	2	501	8	587	3	216	59	55	1	
	3	46	2	253	0	1023	36	65	1	
	4	2	42	3	0	440	0	64	0	6666
1988	1	2203	77	81	0	1368	19	25	0	
	2	1476	222	763	16	176	29	22	5	
	3	1126	17	688	4	1075	29	45	2	
	4	612	40	125	0	650	7	19	0	10921
1987	1	3026	219	108	0	2161	26	31	0	
	2	1965	163	667	5	366	58	40	1	
	3	442	42	1271	3	1201	42	85	0	
	4	89	69	384	0	995	5	74	0	13538
1986	1	2568	147	157	0	1964	5	0	0	
	2	830	20	1317	0	329	32	0	0	
	3	794	14	2284	1	1719	62	0	0	
	4	642	27	609	0	1451	13	0	0	14985
1985	1	2702	522	138	0	1926	11	12	0	
	2	2391	21	1226	0	345	46	105	29	
	3	230	17	2212	13	822	59	455	52	
	4	89	17	738	0	815	3	41	4	15041
1984	1	2280	336	188	0	2931	8	10	0	
	2	3249	334	762	0	697	34	161	17	
	3	782	85	3503	12	1350	110	462	74	
	4	164	59	815	5	1155	12	77	3	19675

1 = Includes handline.
2 = Gillnets (set, drift), traps, unspecified.

Table 6. Summary of commercial sampling for the 4X haddock fishery in 1994. Tonnes landed is followed by the number of fish measured in parentheses. The boxes represent the aggregation used in length key formation.

OTTER TRAWLS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	798 (3275)	74 (207)	258 (1523)	1
2	109 (642)	2	357 (1619)	7
3	70	4	446 (1253)	0
4	456 (1982)	9	383 (720)	1

LONGLINERS/HANDLINERS

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	301 (1711)	0	0	0
2	369 (1748)	0	125	0
3	1054 (2141)	0	38	0
4	447 (1835)	0	29	0

MISCELLANEOUS*

Quarter	4Xmnop		4Xqr	
	TC 1-3	TC 4+	TC 1-3	TC 4+
1	0	0	0	0
2	3	0	4	0
3	43	0	13	0
4	0	0	1	0

* - Longline samples applied to miscellaneous landings.

Table 7. Commercial 4X haddock catch-at-length (thousands), 1970-1995.

cm.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	1	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0
16.5	4	1	14	1	3	0	0	0	0	0	0	0	0	0	0	0
18.5	19	0	24	7	3	1	4	0	0	0	0	0	0	0	0	0
20.5	48	0	31	7	6	2	8	0	0	0	9	0	0	1	0	0
22.5	19	8	11	5	6	1	7	0	0	0	2	0	0	1	2	0
24.5	15	16	4	8	3	1	5	0	0	0	13	0	0	1	0	0
26.5	22	56	2	19	4	1	3	0	0	0	1	1	0	3	0	0
28.5	20	114	0	41	11	5	29	0	1	5	22	7	8	9	8	2
30.5	18	165	1	103	99	12	34	12	8	2	52	6	22	34	32	17
32.5	103	339	39	239	211	47	106	44	29	5	29	33	58	90	108	36
34.5	308	869	138	376	696	249	130	140	38	33	86	179	139	180	227	120
36.5	569	940	356	454	564	717	354	351	173	71	212	537	251	344	375	261
38.5	729	942	531	459	471	1003	389	587	415	210	318	759	420	690	552	469
40.5	743	807	578	361	803	1074	528	907	763	410	479	821	565	1092	609	687
42.5	593	652	722	312	988	1267	569	1183	1052	577	870	1035	762	1405	951	835
44.5	576	849	756	400	865	1463	741	1396	1320	1114	1098	1317	1066	1544	1244	1082
46.5	813	737	650	492	647	1520	1064	1156	1867	1586	1406	1755	1263	1415	1355	1175
48.5	1006	692	617	490	417	1395	1268	1068	2013	1816	1423	2078	1404	1402	1406	1203
50.5	1301	725	652	587	193	1103	1280	1088	2005	1816	1577	1888	1506	1495	1327	1160
52.5	1474	792	600	526	176	769	1074	1276	1792	1859	1701	1818	1451	1394	1244	1012
54.5	1247	692	619	559	248	510	946	1284	1378	1533	1745	1628	1276	1344	1135	847
56.5	1090	705	586	550	344	417	699	1177	1091	1279	1763	1522	1217	1253	927	694
58.5	696	545	573	506	490	426	553	972	988	956	1412	1203	947	972	783	478
60.5	533	494	557	353	547	387	521	602	336	717	1076	1075	837	821	577	350
62.5	360	395	414	323	446	435	369	467	637	561	855	722	681	599	381	193
64.5	209	248	286	274	367	366	310	305	464	385	504	524	452	387	247	167
66.5	123	150	184	167	258	246	235	229	340	249	317	355	302	271	165	84
68.5	45	90	97	101	188	195	181	134	164	157	212	198	202	173	97	63
70.5	8	46	55	83	133	111	76	91	81	103	106	108	123	101	87	34
72.5	8	17	25	45	43	49	48	39	44	65	59	65	78	50	32	20
74.5	17	6	4	27	28	33	42	24	22	17	24	35	41	32	14	6
76.5	5	6	2	35	40	12	1	8	17	9	7	10	12	12	11	2
78.5	3	2	1	40	4	1	8	3	8	8	5	11	10	3	1	0
80.5	7	0	0	7	1	0	1	1	3	2	1	1	3	1	0	1
82.5	0	0	0	0	0	0	0	0	0	1	4	1	2	0	0	0
84.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86.5	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12733	12101	9135	7960	9301	13818	11583	14545	17049	15546	17388	19692	15098	17119	13897	10998

Table 7. (Continued)

cm.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0.5	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0
18.5	0	0	2	2	0	0	0	0	0	0
20.5	0	0	4	6	0	0	0	3	0	1
22.5	0	0	3	4	0	0	0	8	0	3
24.5	0	0	1	2	0	0	0	8	0	3
26.5	0	0	0	4	1	0	0	3	1	2
28.5	1	0	0	10	1	1	0	2	0	3
30.5	5	0	2	17	7	2	1	3	1	4
32.5	40	8	6	27	41	3	4	7	3	5
34.5	149	40	15	23	122	7	8	13	1	13
36.5	301	117	31	31	131	31	21	30	5	34
38.5	423	274	74	53	149	91	39	58	29	85
40.5	584	530	144	78	195	164	128	152	53	160
42.5	880	768	244	110	218	256	307	255	91	221
44.5	1305	1016	410	232	267	400	497	365	138	315
46.5	1525	1204	598	376	338	525	804	409	209	357
48.5	1519	1368	785	558	387	609	839	563	296	392
50.5	1334	1352	926	623	446	635	904	550	332	402
52.5	1071	1139	922	517	420	642	878	566	364	386
54.5	866	908	863	480	434	647	759	484	348	318
56.5	843	612	681	421	354	553	525	351	273	251
58.5	366	366	470	302	301	411	384	268	199	182
60.5	302	233	361	203	267	336	280	202	159	122
62.5	158	135	195	142	223	250	186	121	106	67
64.5	90	73	125	77	169	175	122	79	62	47
66.5	63	60	71	39	102	102	67	41	42	24
68.5	34	21	35	15	57	62	36	21	18	13
70.5	21	13	19	16	25	37	17	14	7	9
72.5	7	3	11	4	13	14	11	7	5	3
74.5	9	5	9	3	3	7	7	9	2	2
76.5	4	0	2	1	0	2	3	2	1	1
78.5	0	0	0	0	1	2	1	1	0	0
80.5	0	0	2	0	1	0	0	0	0	0
82.5	1	0	0	0	0	1	0	0	0	0
84.5	0	0	0	0	0	0	0	0	0	0
86.5	0	0	0	0	0	0	0	0	0	0
88.5	0	0	0	0	0	0	0	0	0	0
90.5	0	0	0	0	0	0	0	0	0	0
	11901	10245	7011	4376	4673	5965	6828	4595	2744	3426

Table 8. 4X haddock mean numbers per standard tow by stratum in the 1970-1995 summer RV surveys.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
470	3.94	0.59	5.68	5.14	0.41	4.20	0.70	273.94	5.75	38.30	3.28	6.11	0.00
471	0.00	0.00	2.47	0.00	0.00	0.55	0.00	0.43	0.46	0.55	2.92	2.87	4.89
472	13.72	37.80	15.86	12.56	28.86	49.18	35.26	14.92	10.55	32.56	248.92	192.04	141.20
473	90.04	9.97	82.21	51.91	53.90	11.51	113.46	169.74	26.39	81.26	31.42	10.62	135.88
474	55.73	25.61	28.96	39.59	75.43	88.73	76.85	26.00	103.58	303.43	27.18	119.46	135.37
475	78.13	53.88	21.97	57.62	105.67	27.12	137.04	36.58	81.29	77.82	71.20	45.53	47.98
476	0.00	80.50	12.38	0.00	41.53	39.53	1.31	554.52	53.78	0.00	23.10	14.84	5.50
477	45.40	34.13	24.52	31.92	132.64	25.24	66.94	31.07	45.54	44.47	35.92	53.20	94.15
478	1.75	1.75	0.70	0.59	2.52	3.20	10.50	4.68	6.16	2.52	1.75	0.67	2.94
480	100.66	240.46	98.51	191.44	262.16	179.52	64.13	628.14	192.55	88.73	224.39	180.80	73.74
481	63.26	30.89	31.69	147.02	271.90	49.72	56.51	7.87	72.49	84.59	169.64	35.11	170.30
482	2.33	3.31	0.00	0.00	5.83	3.06	4.69	9.79	8.40	20.54	14.75	9.92	23.33
483	2.53	0.00	4.08	0.00	1.85	2.10	30.34	9.96	1.75	11.05	23.57	32.22	70.04
484	0.00	0.53	0.00	0.37	0.35	0.38	6.12	0.41	0.59	14.87	2.33	1.68	6.04
485	52.16	11.77	3.11	31.92	9.29	12.00	14.77	34.49	13.88	10.87	65.92	15.01	24.85
490	30.43	56.88	0.53	70.78	323.40	48.12	109.15	189.19	63.54	384.72	311.34	1481.72	485.53
491	4.15	0.00	11.39	3.91	21.08	3.01	2.58	21.30	11.52	5.21	15.37	15.48	30.48
495	16.80	13.56	9.32	4.01	20.18	1.73	4.87	33.92	48.00	31.46	6.76	8.69	37.55

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
470	35.79	12.58	0.97	41.18	6.61	6.46	4.79	1.54	0.00	0.97	0.49	0.00	2.11
471	3.89	0.46	0.00	0.51	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
472	39.75	49.03	73.40	73.09	28.21	34.73	37.78	17.47	19.11	7.89	7.32	15.00	42.50
473	34.31	60.70	189.10	174.07	80.29	12.01	12.32	41.51	92.36	5.83	0.46	46.50	210.78
474	57.81		134.50	52.61	3.15	1.54	1.80	31.11	6.32	6.69	8.26	7.80	8.15
475	53.94	254.51	100.85	159.04	14.13	13.90	22.10	54.47	22.48	16.04	8.75	128.50	164.81
476	62.34	8.75	369.87	22.39	25.03	9.10	9.21	5.30	8.51	11.67	2.83	14.75	51.60
477	86.47	150.81	92.13	120.41	43.99	59.48	42.02	24.37	38.58	39.23	12.84	56.80	248.00
478	16.77	16.73	20.42	9.48	25.39	11.32	0.00	13.82	0.00	3.25	3.40	13.50	5.30
480	93.29	172.05	117.45	97.60	52.54	84.96	175.59	251.54	360.13	200.97	71.76	144.03	274.90
481	41.82	70.77	18.68	168.47	31.93	25.72	29.26	18.03	37.65	25.32	41.43	44.13	145.65
482	8.58	20.90	1.46	2.06	31.63	22.73	18.19	39.56	20.86	1.50	7.29	19.67	18.65
483	5.66	33.42	14.58	13.00	11.48	20.59	1.54	36.84	41.78	4.03	3.83	0.00	3.54
484	1.28	4.12	2.94	0.69	0.00	1.37	0.97	0.97	0.00	0.00	0.70	0.75	3.03
485	11.29	26.44	80.44	35.57	2.97	9.68	1.86	13.13	87.06	20.51	8.40	2.00	78.02
490	234.97	773.65	160.56	31.56	44.66	128.41	129.52	174.02	79.27	104.55	18.53	414.20	541.72
491	32.01	29.26	16.34	2.75	1.03	0.26	0.00	0.67	1.30	3.56	4.80	22.33	64.00
495	14.84	3.09	5.22	0.00	0.00	0.98	0.00	18.05	0.00	0.00	0.00	5.50	55.28

Table 9. 4X haddock mean numbers-at-length per standard tow from the 1970-1995 summer RV surveys.

cm.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00
6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11	0.01	0.13	0.15	0.12	0.06	0.00
8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.22	0.01	0.41	0.12	0.22	0.24	0.00
10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.00	0.06	0.00	0.01	0.01	0.00
12.5	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00	0.00	0.06	0.09	0.04	0.00	0.01
14.5	0.06	0.01	0.11	0.03	0.07	0.00	0.00	0.00	0.37	0.03	1.36	2.16	1.72	0.42	0.13	0.18
16.5	0.17	0.02	0.56	0.16	0.19	0.21	0.19	0.22	1.26	0.17	2.94	7.56	4.63	2.18	1.11	1.12
18.5	0.94	0.00	1.44	1.37	1.47	1.03	1.24	0.97	2.06	0.67	4.56	6.87	4.34	2.59	1.50	2.76
20.5	2.48	0.05	2.11	2.68	5.55	2.06	2.20	1.59	1.76	0.86	7.15	8.61	5.05	0.84	1.38	2.17
22.5	1.42	0.09	0.80	2.30	3.89	1.75	1.07	1.98	0.65	0.28	4.41	7.60	4.54	1.21	2.24	2.06
24.5	0.71	0.43	0.34	1.04	0.95	1.15	0.83	1.45	0.13	0.57	1.72	5.24	5.13	1.06	4.31	1.31
26.5	0.03	2.21	0.11	2.26	0.93	0.57	0.58	0.98	0.06	1.40	0.47	2.28	4.35	0.81	3.20	1.25
28.5	0.34	3.55	0.01	4.99	3.28	0.60	1.07	2.01	0.51	2.53	0.62	3.02	3.67	1.02	3.32	3.35
30.5	0.51	3.17	0.02	7.21	8.48	0.81	1.27	2.85	0.99	2.76	1.22	4.63	3.54	1.52	4.99	2.97
32.5	1.14	1.56	0.10	3.30	7.97	0.92	1.44	5.94	1.14	2.70	1.80	4.43	3.63	2.68	6.92	4.16
34.5	1.67	0.54	0.34	2.19	5.18	0.72	1.10	7.67	1.34	3.23	2.11	5.32	2.89	3.19	6.25	5.14
36.5	0.80	0.53	0.70	0.48	5.58	1.00	1.39	8.03	1.25	1.88	3.21	4.80	2.22	2.57	4.12	4.59
38.5	0.54	0.75	0.73	0.15	6.21	0.60	0.92	9.49	1.71	1.31	3.92	4.37	2.38	1.87	4.27	5.86
40.5	0.74	1.06	0.79	0.18	7.42	1.64	0.45	9.95	2.65	1.54	3.21	2.29	2.54	1.68	4.08	6.34
42.5	0.78	1.28	0.56	0.14	5.47	2.24	0.90	10.13	3.63	1.76	3.08	2.18	1.95	1.96	4.08	6.49
44.5	0.71	1.40	0.31	0.39	2.84	1.37	1.07	10.56	1.93	2.64	3.00	2.27	1.97	1.67	3.79	6.49
46.5	1.19	1.15	0.38	0.32	1.82	1.54	1.65	6.72	1.45	2.93	2.57	2.62	1.81	1.72	2.67	5.06
48.5	1.48	1.51	0.40	0.87	0.69	2.12	1.74	6.13	1.42	3.04	2.36	2.96	2.26	1.36	2.48	2.54
50.5	1.84	1.28	0.57	0.93	0.85	1.69	2.39	4.95	1.75	2.64	3.87	1.92	2.84	2.11	1.86	2.59
52.5	1.63	2.19	0.80	1.06	0.70	0.99	2.28	2.92	1.54	1.95	3.80	1.42	1.91	1.42	1.53	1.48
54.5	1.69	1.79	0.75	0.77	1.19	0.78	1.22	4.66	1.45	1.99	4.07	1.58	2.07	1.48	1.27	1.14
56.5	1.45	2.13	0.64	0.55	0.79	0.54	1.19	3.61	1.40	1.83	3.59	1.41	1.68	1.04	1.26	1.08
58.5	0.77	1.55	0.73	0.80	1.05	0.35	0.69	2.98	1.62	1.81	2.72	1.40	1.41	0.97	1.13	0.79
60.5	0.70	1.12	0.61	0.58	0.60	0.51	0.52	1.54	0.83	1.66	1.94	0.80	0.92	0.76	0.71	0.81
62.5	0.60	0.81	0.60	0.58	0.61	0.36	0.43	1.34	0.55	1.03	1.58	1.34	0.75	0.51	0.48	0.48
64.5	0.57	0.33	0.34	0.30	0.59	0.87	0.19	0.72	0.26	0.95	1.23	0.52	0.67	0.39	0.26	0.43
66.5	0.34	0.17	0.18	0.23	0.39	0.06	0.20	0.87	0.13	0.74	0.67	0.44	0.51	0.31	0.36	0.32
68.5	0.25	0.17	0.07	0.08	0.22	0.38	0.17	0.35	0.09	0.31	0.53	0.22	0.12	0.15	0.15	0.05
70.5	0.10	0.05	0.05	0.03	0.02	0.12	0.13	0.18	0.07	0.21	0.31	0.20	0.10	0.06	0.10	0.14
72.5	0.03	0.11	0.05	0.00	0.04	0.11	0.03	0.11	0.02	0.22	0.05	0.10	0.04	0.00	0.10	0.11
74.5	0.00	0.02	0.00	0.00	0.04	0.00	0.01	0.06	0.05	0.02	0.02	0.15	0.02	0.04	0.00	0.00
76.5	0.00	0.02	0.01	0.01	0.02	0.00	0.03	0.02	0.04	0.06	0.00	0.11	0.00	0.01	0.00	0.00
78.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.02	0.03	0.00	0.03	0.01	0.00	0.00
80.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
84.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sum	25.73	31.04	15.19	35.99	75.14	27.08	28.66	111.07	34.18	46.18	74.15	91.48	72.04	40.07	70.34	73.27

Table 9. (Continued)

cm.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
6.5	0.12	0.00	0.07	0.00	0.00	0.00	0.03	0.01	0.43	0.11
8.5	0.00	0.00	0.01	0.00	0.19	0.00	0.01	0.01	1.63	0.03
10.5	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00
12.5	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.21
14.5	0.04	0.01	0.04	0.02	0.00	0.00	0.13	0.00	0.00	3.45
16.5	0.80	0.20	1.23	0.51	0.00	0.21	0.65	0.01	0.06	11.15
18.5	1.66	0.20	2.20	1.45	0.00	1.32	1.11	0.39	0.70	17.15
20.5	0.60	0.45	1.23	2.22	0.04	1.27	0.55	1.41	2.80	9.69
22.5	0.46	0.17	0.57	1.33	0.04	0.88	0.38	1.77	5.95	4.08
24.5	1.18	0.18	0.77	0.55	0.13	0.47	0.27	0.92	6.98	1.50
26.5	1.86	0.28	0.78	0.68	0.47	0.11	0.32	0.22	3.94	1.26
28.5	2.02	0.44	0.57	1.53	1.52	0.11	0.69	0.20	1.18	3.49
30.5	2.68	0.38	0.54	1.95	2.34	0.14	0.58	0.26	1.00	5.21
32.5	2.94	0.55	0.55	2.18	1.91	0.16	0.54	0.27	1.45	4.90
34.5	3.66	0.81	0.44	1.39	1.94	0.42	0.24	0.19	1.56	4.70
36.5	4.21	1.41	0.47	1.19	2.39	1.35	0.46	0.25	1.32	4.01
38.5	4.06	1.61	0.77	1.00	2.56	2.57	0.37	0.27	0.95	2.92
40.5	3.62	1.76	1.02	0.99	2.76	3.07	0.83	0.51	0.79	2.99
42.5	3.92	1.42	1.54	0.68	1.98	2.90	1.44	0.46	0.54	2.50
44.5	3.85	1.80	2.05	0.70	1.51	2.94	2.08	0.52	0.71	2.19
46.5	3.27	1.63	1.49	0.89	1.21	4.44	1.94	0.63	0.79	2.77
48.5	2.91	1.37	1.28	1.20	0.98	3.59	1.51	0.48	0.80	1.77
50.5	2.56	1.34	1.36	0.80	1.46	2.99	1.36	0.77	0.92	1.53
52.5	1.37	1.29	0.87	0.86	1.06	2.56	1.52	0.44	0.72	1.45
54.5	1.58	1.00	0.94	0.59	1.14	2.72	1.24	0.38	0.50	1.00
56.5	0.75	0.72	0.56	0.44	0.94	1.75	1.34	0.59	0.34	0.95
58.5	0.79	0.48	0.37	0.38	0.67	1.20	0.67	0.35	0.17	0.54
60.5	0.38	0.21	0.40	0.18	0.45	0.79	0.49	0.23	0.27	0.26
62.5	0.11	0.13	0.21	0.17	0.66	0.57	0.50	0.12	0.11	0.26
64.5	0.12	0.06	0.18	0.04	0.42	0.24	0.36	0.11	0.18	0.11
66.5	0.23	0.06	0.15	0.03	0.38	0.24	0.13	0.10	0.16	0.14
68.5	0.07	0.02	0.13	0.02	0.11	0.16	0.16	0.03	0.09	0.09
70.5	0.05	0.00	0.06	0.01	0.09	0.10	0.02	0.00	0.08	0.08
72.5	0.06	0.00	0.03	0.00	0.03	0.07	0.01	0.00	0.08	0.00
74.5	0.04	0.00	0.05	0.00	0.02	0.00	0.00	0.00	0.00	0.00
76.5	0.00	0.00	0.02	0.00	0.04	0.01	0.00	0.00	0.00	0.00
78.5	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
80.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
92.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sum	51.93	20.03	22.95	23.98	29.46	39.35	21.93	11.93	38.02	92.49

Table 10. Stratified mean numbers of haddock by length grouping for selected strata groupings from July research vessel surveys.

Year	Size range	Strata Groupings: 470–476,478	477,480,481	482–495	Total
1991	Less than 43 cm	1.57	12.23	1.16	14.97
	Greater than 43 cm	2.39	9.20	12.77	24.36
	All sizes	3.96	21.43	13.93	39.33
1992	Less than 43 cm	1.29	6.53	0.81	8.63
	Greater than 43 cm	0.79	7.24	5.33	13.35
	All sizes	2.07	13.77	6.14	21.98
1993	Less than 43 cm	0.56	6.10	0.51	7.17
	Greater than 43 cm	0.49	2.41	1.86	4.75
	All sizes	1.05	8.50	2.36	11.91
1994	Less than 43 cm	3.56	13.06	15.45	32.07
	Greater than 43 cm	1.10	2.68	2.14	5.92
	All sizes	4.66	15.74	17.59	37.99
1995	Less than 43 cm	12.36	42.40	25.20	79.96
	Greater than 43 cm	1.32	3.53	8.30	13.15
	All sizes	13.68	45.93	33.50	93.11

Table 11. Mean number of haddock per tow by stratum from the RV Survey and ITQ Survey, June 26 - July 7, 1995.

Stratum	RV Survey			ITQ Survey		
	Sets	Mean	St. Dev	Sets	Mean	St. Dev.
470	2	2.11	1.24	4	0.54	0.94
471	2	0.50	0.71			
472	4	42.50	40.47	3	132.75	33.18
473	2	210.78	260.89	2	11.90	6.49
474	2	8.15	1.71	1	28.14	
475	2	164.81	119.88	2	674.95	540.76
476	4	51.60	50.68	15	139.03	271.89
477	5	248.00	314.99	6	442.16	254.78
478	3	5.30	9.19			
480	8	274.90	176.65	9	550.45	413.94
481	7	145.65	116.68	19	291.52	340.89
482	3	18.65	17.46			
483	2	3.54	5.01			
484	3	3.03	3.09			
485	3	78.02	24.07	16	55.47	80.05
490	5	541.72	486.02	8	294.08	299.94
491	3	64.00	33.92	5	42.56	75.73
492	2	5.01	2.64	8	44.46	43.48
493	3	0.94	1.62	2	10.57	10.57
494	2	21.19	29.97	5	5.22	5.96
495	2	55.28	11.70	7	49.79	53.03
Inshore				27	436.66	492.47

Table 12. Stratified mean length at age for the Scotian Shelf component of the 4X haddock stock using the original and revised ageing data.

Revised Ageing

	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	NA	6.50	10.50	NA	NA	NA	NA	9.08	8.50
1	19.27	18.50	20.27	21.53	20.49	18.93	22.11	22.32	18.24
2	29.62	31.88	30.77	30.60	34.47	30.12	31.61	32.90	30.29
3	36.66	38.88	40.27	39.78	40.31	39.41	39.62	39.28	39.23
4	40.86	42.05	41.90	44.67	46.58	45.13	45.87	45.45	45.85
5	43.63	45.84	47.10	49.67	49.90	48.93	49.29	48.09	49.36
6	46.96	45.98	50.18	50.44	54.95	54.37	53.61	49.54	50.86
7	50.31	47.99	49.61	50.12	54.72	56.02	54.55	51.86	53.18
8	51.70	50.19	50.47	51.92	54.55	53.15	54.38	55.45	56.27
9	54.19	51.26	51.61	54.35	52.31	52.46	51.03	53.29	60.34
10	56.22	51.21	54.69	49.48	49.91	62.35	58.03	54.50	NA
11	58.50	59.12	55.48	58.03	63.26	58.50	53.61	58.50	NA
12	NA	62.50	50.90	54.04	58.37	62.50	56.50	51.48	54.50
13	NA	NA	NA	NA	NA	68.50	56.37	52.01	NA
14	NA	NA	66.50	66.50	68.50	NA	74.50	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	NA	NA	NA	NA	64.50	NA	NA	NA	NA

Original Ageing

	1987	1988	1989	1990	1991	1992
0	NA	6.50	10.50	NA	NA	NA
1	19.00	18.47	20.16	21.98	20.46	18.58
2	26.52	31.20	30.49	30.47	30.53	29.56
3	34.55	38.13	40.20	39.69	39.84	39.26
4	42.09	43.68	46.59	47.20	46.40	44.91
5	48.86	48.25	50.79	52.02	52.51	50.59
6	54.66	53.34	55.75	57.33	57.53	54.70
7	58.26	58.90	NA	61.84	66.58	53.55
8	NA	62.50	NA	NA	NA	60.74
9	NA	NA	NA	NA	NA	61.28
10	NA	NA	NA	NA	NA	68.50
11	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA
17	NA	NA	NA	NA	NA	NA

Table 13. Stratified mean length at age for the Bay of Fundy component of the 4X haddock stock using the original and revised ageing data.

Revised Ageing

	1987	1988	1989	1990	1991	1992	1993	1994	1995
0	NA	NA	NA	8.50	NA	NA	NA	8.10	6.69
1	25.24	24.93	21.85	NA	23.93	22.36	21.71	25.02	20.02
2	37.93	37.07	35.53	36.95	43.87	35.05	38.24	36.17	34.91
3	46.25	47.12	41.18	46.19	46.98	34.50	45.62	46.17	45.11
4	51.47	50.97	49.67	53.60	53.71	52.76	51.85	53.29	51.37
5	54.59	54.77	52.55	55.55	54.52	58.66	55.94	NA	57.90
6	60.50	56.85	55.95	58.62	61.49	57.75	59.41	61.31	59.97
7	59.49	64.41	57.45	59.93	62.25	61.70	61.93	64.71	61.45
8	57.06	58.23	53.91	63.87	63.99	58.50	60.50	67.71	62.78
9	64.04	67.37	62.50	65.02	65.38	67.56	NA	NA	70.50
10	NA	62.13	62.50	63.75	58.11	59.40	NA	NA	NA
11	66.50	NA	61.89	65.54	70.50	72.50	66.35	NA	NA
12	NA	NA	NA	62.50	70.50	NA	NA	NA	NA
13	NA	NA	NA	67.98	70.50	NA	NA	70.50	NA
14	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	NA	NA	NA	NA	NA	NA	NA	NA	NA

Original Ageing

	1987	1988	1989	1990	1991	1992
0	NA	NA	NA	8.50	NA	NA
1	22.50	24.93	21.85	NA	23.50	22.36
2	26.21	34.00	35.00	36.06	31.83	33.93
3	40.75	42.37	40.00	44.83	45.50	37.07
4	51.39	50.68	49.19	52.37	52.41	52.35
5	53.38	54.98	55.49	58.82	57.29	57.94
6	58.33	60.18	60.07	63.07	62.21	61.37
7	66.50	69.19	68.50	69.50	69.64	64.51
8	60.50	74.50	NA	NA	NA	59.40
9	NA	69.17	NA	NA	NA	68.48
10	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA
17	NA	NA	NA	NA	NA	NA

Table 14. SPA input data

A. Catch Numbers-at-Age

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0	0	41	150	1	37	18	2	0	0	16	1	0
2	1055	788	22	3077	694	2175	1296	1285	75	81	161	1182	491
3	724	1617	3434	113	4653	4568	1644	3126	3354	1158	2445	2215	3639
4	1502	788	1841	2247	309	5164	4261	2019	7014	6709	3008	6219	2474
5	379	1422	509	1067	1779	485	3682	3193	2094	3881	5413	4199	4628
6	524	404	645	527	509	1103	434	2881	2832	1070	3499	3195	1703
7	4536	69	90	600	189	247	807	360	1040	1244	527	1163	1457
8	1863	3316	57	322	269	172	154	389	137	263	623	357	340
9	133	1020	1166	259	186	62	71	107	107	57	169	323	183
10	96	163	512	614	269	32	95	72	26	68	34	97	94
Total	10812	9587	8317	8976	8858	14045	12462	13434	16679	14531	15895	18951	15009

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0	2	0	0	0	8	9	0	0	0	8	0	17
2	64	708	198	290	149	79	128	271	11	32	39	37	59
3	3294	1108	1956	1170	729	149	231	840	635	52	434	231	488
4	5476	4680	2261	4378	2226	936	425	541	2013	2392	471	654	842
5	3733	3439	4516	3923	2962	1800	1325	560	953	3016	2009	170	762
6	2232	2396	1463	1476	2433	2292	661	1097	768	564	1282	993	460
7	940	948	464	246	1364	1035	1191	590	694	315	194	522	774
8	395	340	132	116	261	420	196	466	414	263	83	38	116
9	187	110	53	40	44	176	157	125	235	136	31	10	31
10	119	77	16	28	71	103	50	178	230	44	34	18	16
Total	16440	13808	11059	11667	10240	6998	4372	4668	5953	6815	4583	2674	3566

B. RV Mean Numbers-at-Age per Tow

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	5.90	0.12	5.82	6.78	11.53	6.97	6.42	6.40	6.33	1.75	21.95	41.01	13.05
2	4.72	11.12	0.26	19.35	23.08	3.74	6.12	33.57	5.04	13.43	6.86	28.8	28.74
3	1.41	4.72	3.31	0.63	31.8	4.88	3.87	38.8	10.3	10.04	15.33	7.05	12.81
4	2.60	2.08	1.39	3.06	0.95	7.95	4.23	11.33	3.11	10.68	8.04	8.65	4.68
5	1.11	2.91	0.88	1.47	4.09	0.43	7.56	11.51	1.30	4.99	12.73	3.19	6.68
6	2.64	1.38	0.92	0.46	0.89	1.95	0.57	6.65	2.53	1.98	4.38	3.40	2.55
7	5.78	2.11	0.60	0.61	0.49	0.53	0.68	0.79	1.07	3.06	1.66	1.11	2.51
8	0.81	5.18	0.88	0.46	0.58	0.42	0.13	1.03	0.03	1.16	1.35	0.24	0.33
9	0.34	0.76	1.24	0.28	0.34	0.18	0.02	0.14	0.00	0.25	0.64	0.44	0.20
10	0.28	0.09	0.04	0.38	0.25	0.11	0.04	0.13	0.00	0.03	0.24	0.28	0.06
Total	25.59	30.47	15.35	33.48	74.03	27.15	29.64	110.35	29.71	47.36	73.16	94.18	71.62

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	6.86	4.68	6.64	3.84	1.43	7.40	6.05	0.08	4.33	3.12	4.69	21.45	46.95
2	4.54	23.38	6.78	8.72	1.64	2.18	9.89	10.75	1.45	2.53	1.07	5.90	24.83
3	14.45	12.38	24.83	9.81	2.79	1.04	1.98	9.67	12.87	0.99	1.77	2.05	11.61
4	5.83	17.69	19.10	16.46	3.69	2.19	0.93	1.78	11.45	7.63	0.67	1.92	4.23
5	3.56	5.54	11.71	9.43	4.12	3.02	1.86	1.44	2.40	5.52	1.94	0.37	1.87
6	2.35	3.18	3.09	2.56	2.87	3.18	0.79	1.60	1.35	0.92	1.17	1.85	0.80
7	0.96	1.55	0.95	0.57	1.98	1.52	1.65	1.45	1.19	0.39	0.19	1.14	1.53
8	0.32	0.56	0.1	0.24	0.87	1.10	0.59	1.22	1.01	0.39	0.14	0.15	0.42
9	0.29	0.44	0.00	0.07	0.25	0.71	0.49	0.51	0.76	0.30	0.06	0.05	0.10
10	0.21	0.08	0.04	0.02	0.31	0.41	0.15	0.41	0.91	0.21	0.05	0.09	0.00
Total	39.37	69.49	73.23	51.72	19.96	22.74	24.39	28.91	37.7	21.99	11.76	34.96	92.34

Table 15. SPA Results

A. Fishing Mortality

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.10	0.04	0.00	0.09	0.02	0.13	0.04	0.03	0.00	0.00	0.01	0.05	0.02
3	0.15	0.23	0.27	0.03	0.20	0.19	0.14	0.12	0.12	0.07	0.11	0.13	0.19
4	0.25	0.25	0.44	0.28	0.11	0.35	0.28	0.25	0.41	0.36	0.25	0.43	0.22
5	0.19	0.40	0.25	0.50	0.37	0.26	0.46	0.35	0.45	0.42	0.56	0.67	0.67
6	0.21	0.31	0.31	0.44	0.47	0.42	0.40	0.80	0.60	0.43	0.86	0.79	0.64
7	0.43	0.04	0.11	0.54	0.28	0.44	0.62	0.68	0.78	0.58	0.40	0.81	1.12
8	0.47	0.66	0.04	0.67	0.50	0.44	0.55	0.71	0.60	0.45	0.66	0.51	0.59
9	0.23	0.51	0.51	0.26	1.11	0.20	0.32	0.96	0.43	0.54	0.60	0.89	0.54
10	0.37	0.50	0.52	0.54	0.48	0.55	0.53	0.63	0.64	0.52	0.73	0.84	0.70
5-7	0.28	0.25	0.22	0.49	0.37	0.37	0.49	0.61	0.61	0.48	0.61	0.76	0.81

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.03	0.01	0.03	0.03	0.02	0.01	0.02	0.00	0.00	0.01	0.00	0.00
3	0.14	0.06	0.10	0.11	0.09	0.04	0.06	0.07	0.05	0.02	0.09	0.05	0.03
4	0.50	0.30	0.17	0.33	0.33	0.16	0.14	0.19	0.25	0.28	0.26	0.18	0.24
5	0.59	0.69	0.54	0.48	0.39	0.48	0.36	0.29	0.58	0.72	0.41	0.14	0.33
6	0.81	1.01	0.72	0.34	0.63	0.60	0.32	0.56	0.81	0.84	0.80	0.36	0.70
7	0.92	1.05	0.53	0.25	0.61	0.60	0.75	0.53	0.88	0.99	0.80	0.93	0.53
8	1.14	1.11	0.38	0.24	0.45	0.38	0.21	0.76	0.93	1.06	0.78	0.35	0.53
9	0.77	1.30	0.49	0.19	0.14	0.63	0.24	0.20	1.21	0.94	0.31	0.19	0.53
10	0.83	0.85	0.63	0.52	0.60	0.53	0.36	0.46	0.69	0.76	0.63	0.30	0.53
5-7	0.78	0.92	0.60	0.36	0.54	0.56	0.48	0.46	0.76	0.85	0.67	0.48	0.52

B. Population Numbers

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	25333	6015	47023	43927	23999	48826	51652	29231	40094	29357	35625	42010	31827
2	11868	20741	4925	38462	35829	19647	39942	42273	23930	32826	24035	29153	34394
3	5688	8762	16268	4012	28706	28706	14118	31529	33447	19525	26802	19533	22799
4	7537	4002	5711	10212	3183	19292	19369	10071	22985	24349	14938	19732	13988
5	2443	4812	2563	3010	6328	2326	11122	12003	6419	12472	13865	9508	10528
6	3013	1657	2653	1638	1499	3571	1466	5775	6938	3361	6700	6454	3985
7	14324	1992	991	1588	864	766	1926	807	2121	3118	1783	2319	2393
8	5505	7624	1569	730	757	537	404	846	335	796	1427	983	846
9	702	2821	3241	1233	306	377	284	191	341	151	413	605	482
10	342	454	1387	1599	775	83	252	168	60	182	72	186	203
1-10	76755	58881	86331	106412	102246	124132	140535	132894	136670	126136	125661	130482	121445

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	35459	18333	14385	6835	6906	20055	20996	4183	8655	8276	26904	79744	0
2	26058	29031	15008	11777	5596	5654	16413	17182	3425	7086	6776	22020	65289
3	27715	21276	23128	12109	9380	4446	4558	13322	13822	2794	5773	5513	17995
4	15374	19711	16417	17166	8855	7020	3505	3523	10147	10742	2240	4334	4304
5	9214	7632	11903	11395	10093	5236	4900	2485	2395	6486	6630	1408	2956
6	4432	4166	3137	5659	5780	5583	2658	2813	1528	1098	2581	3611	999
7	1722	1609	1243	1244	3298	2531	2497	1578	1310	556	389	954	2058
8	641	559	459	598	796	1466	1136	967	758	445	170	143	308
9	385	167	150	257	384	416	820	753	370	246	126	64	82
10	229	146	37	75	174	275	181	530	503	90	78	76	43
1-10	121228	102631	85868	67115	51262	52682	57665	47336	42913	37820	51668	117866	94035

Table 15. SPA results (cont.)

C. Residuals

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	0.10	0.37	-1.97	0.33	0.54	-0.62	-0.89	0.75	-0.59	0.07	-0.28	0.98	0.79
3	-0.56	0.26	-0.69	-1.08	0.96	-0.91	-0.47	1.02	-0.36	0.12	0.25	-0.19	0.28
4	-0.29	0.11	-0.53	-0.42	-0.51	-0.06	-0.73	0.89	-1.14	0.01	0.15	0.05	-0.34
5	-0.27	0.14	-0.51	-0.02	0.19	-1.13	0.29	0.57	-0.92	-0.26	0.65	-0.29	0.34
6	0.20	0.21	-0.67	-0.80	-0.03	-0.15	-0.49	0.82	-0.45	-0.07	0.29	0.03	0.14
7	-0.63	0.11	-0.40	-0.61	-0.37	-0.08	-0.65	0.40	-0.20	0.35	0.19	-0.23	0.73

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
2	-0.78	0.76	0.18	0.68	-0.24	0.02	0.46	0.51	0.11	-0.06	-0.87	-0.35	0.00
3	0.18	0.24	0.88	0.60	-0.41	-0.68	-0.05	0.47	0.71	-0.28	-0.39	-0.21	0.33
4	-0.05	0.69	0.87	0.78	-0.06	-0.45	-0.62	0.05	0.89	0.45	-0.42	-0.08	0.75
5	-0.19	0.49	0.71	0.50	-0.26	0.14	-0.35	0.03	0.75	0.67	-0.58	-0.84	0.15
6	0.05	0.53	0.62	-0.38	-0.12	0.00	-0.81	-0.03	0.56	0.53	-0.12	-0.25	0.39
7	-0.01	0.61	0.07	-0.61	-0.13	-0.13	0.05	0.26	0.44	0.24	-0.21	0.75	0.04

Est.	Param	SE	CV	Bias	
1	0.00100067	0.00056074	0.560359	-15.622000	f2
2	0.03037810	0.0121142	0.398781	-7.812580	f3
3	0.24202900	0.0842644	0.348158	-5.890670	f4
4	0.33258700	0.113308	0.340686	-5.922960	f5
5	0.69728500	0.226317	0.324568	-4.620040	f6
6	0.00042802	4.81E-05	0.112472	-0.483204	q2
7	0.00053243	5.87E-05	0.110336	-0.478898	q3
8	0.00060127	6.60E-05	0.109715	-0.529779	q4
9	0.00074559	8.17E-05	0.109573	-0.601652	q5
10	0.00090928	0.00010003	0.110013	-0.714950	q6
11	0.00109112	0.00011929	0.109324	-0.861586	q7

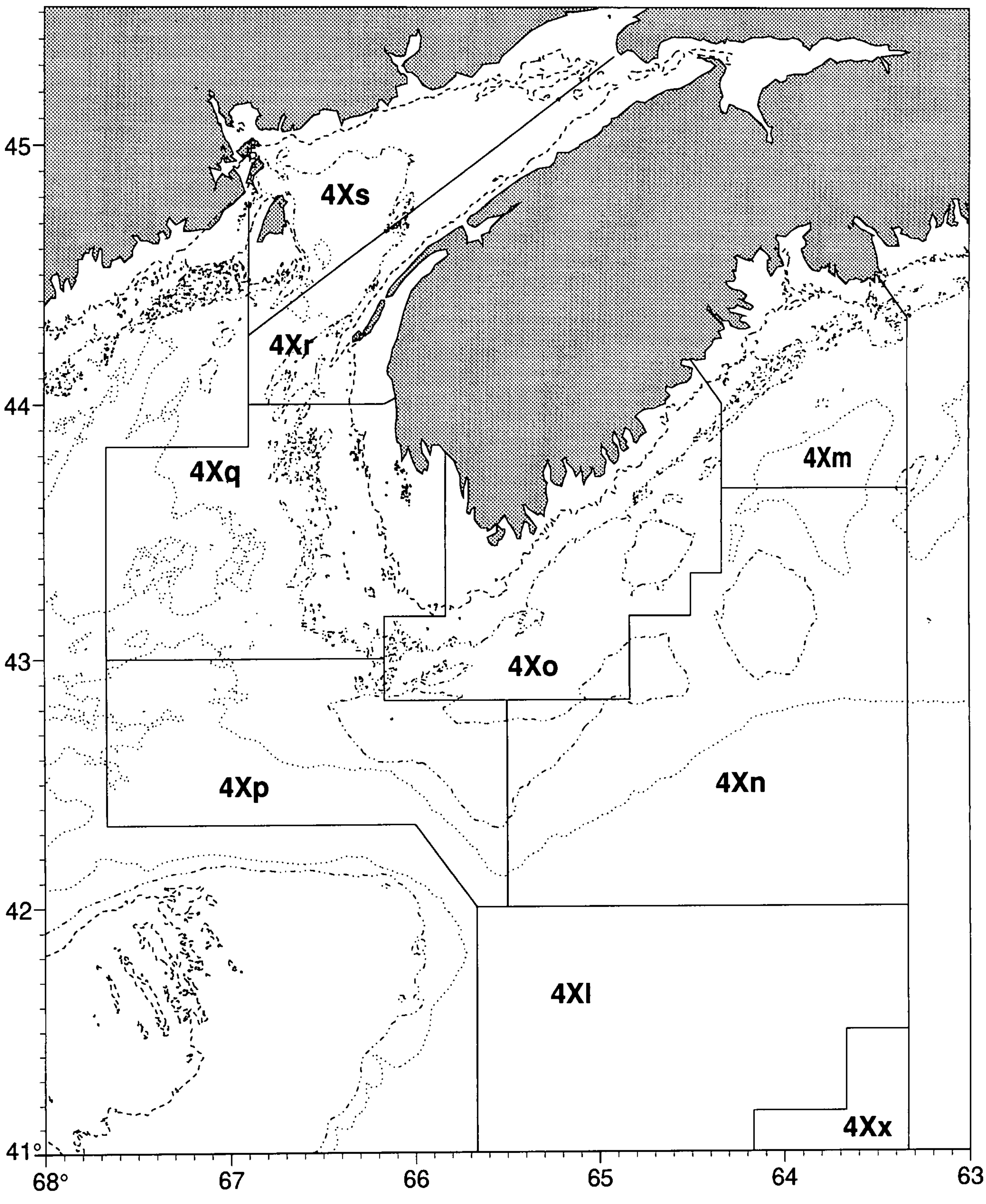


Figure 1. Unit areas in NAFO Division 4X.

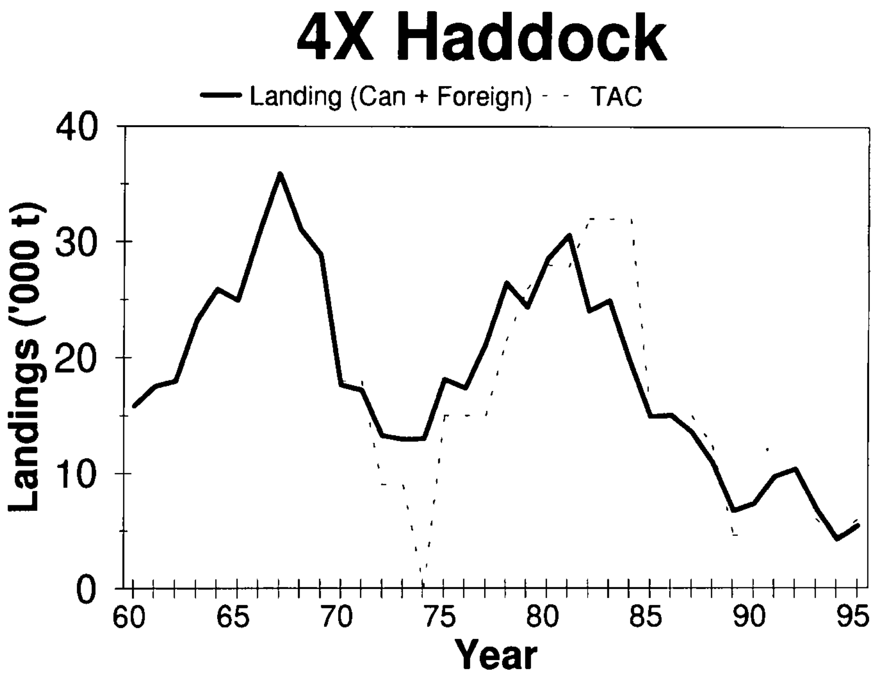


Figure 2. Long-term trends in 4X haddock landings, along with TAC.

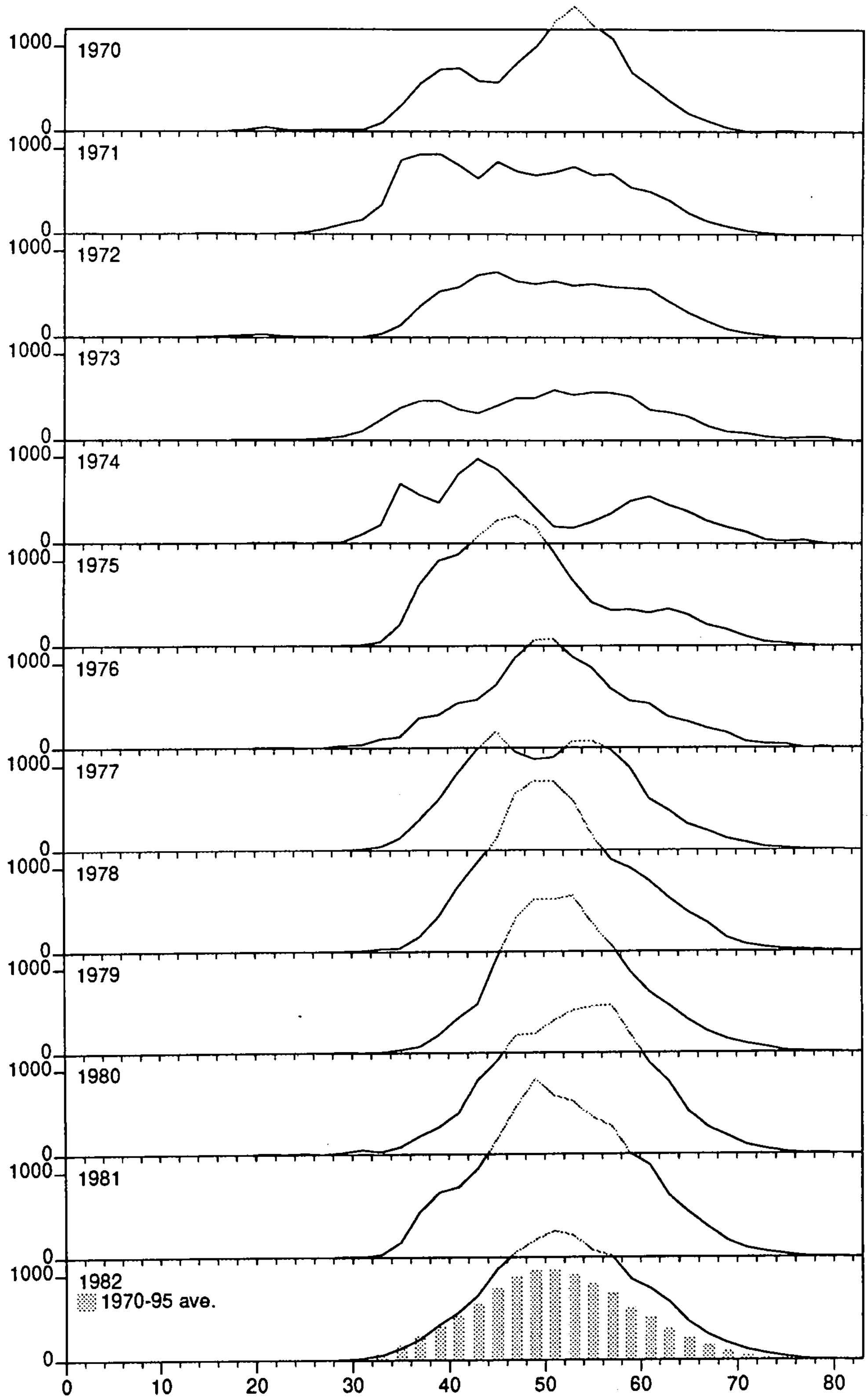


Figure 3a. Commercial catch-at-length for 4X haddock, 1970-1982 (bars represent long term mean).

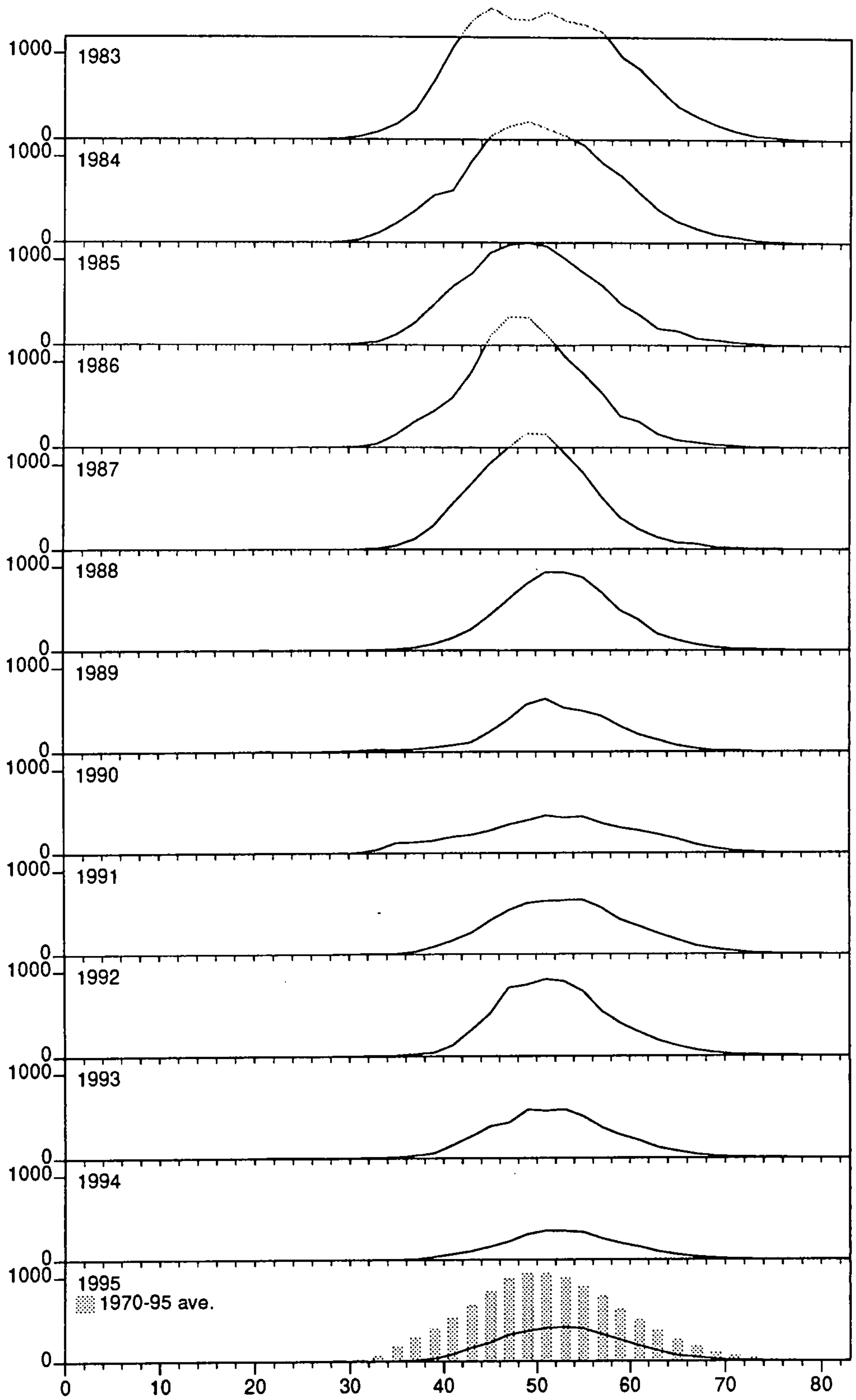
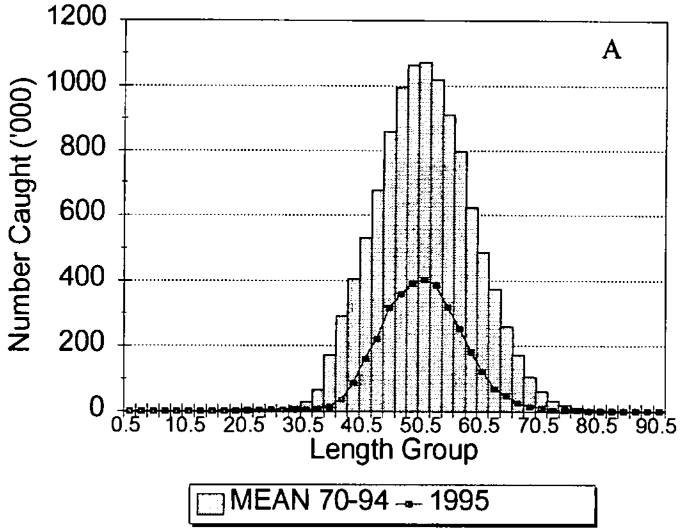


Figure 3b. Commercial catch-at-length for 4X haddock, 1983-1995 (bars represent long term mean).



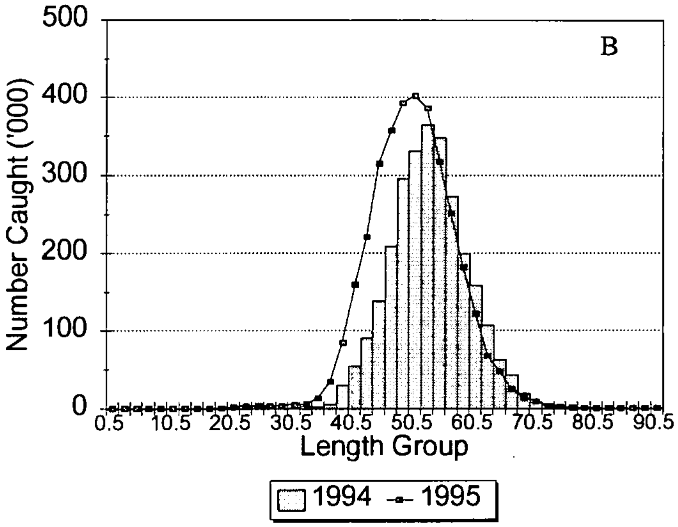


Figure 4. Commercial catch-at-length for 4X haddock, (a) 1995 catch compared to th 1970-1994 mean, (b) 1995 catch compared to the 1994 catch-at-length.

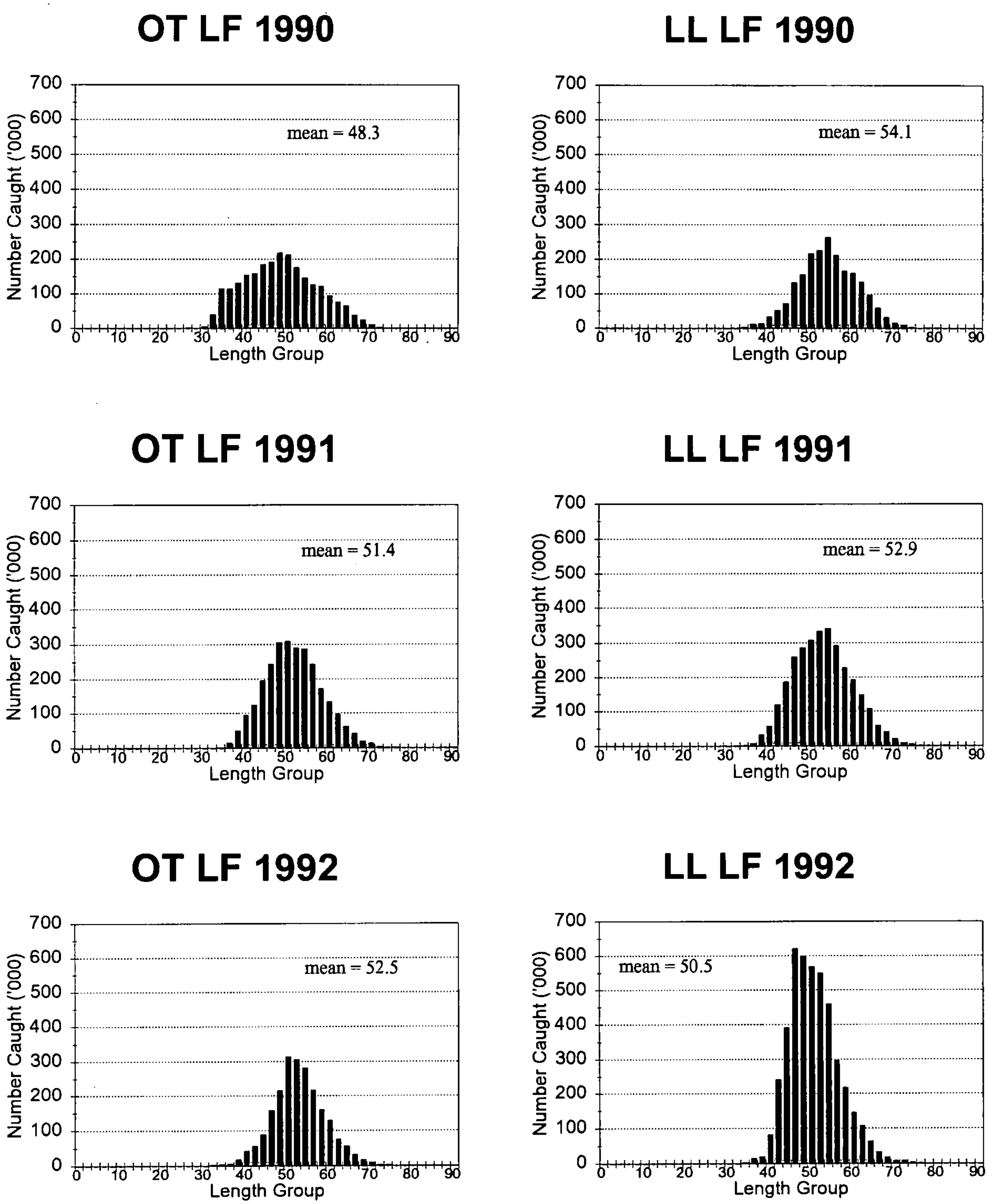


Figure 5a. Catch-at-length (cm) for 4X haddock, 1991-1992, for the otter trawl and longline gear sectors.

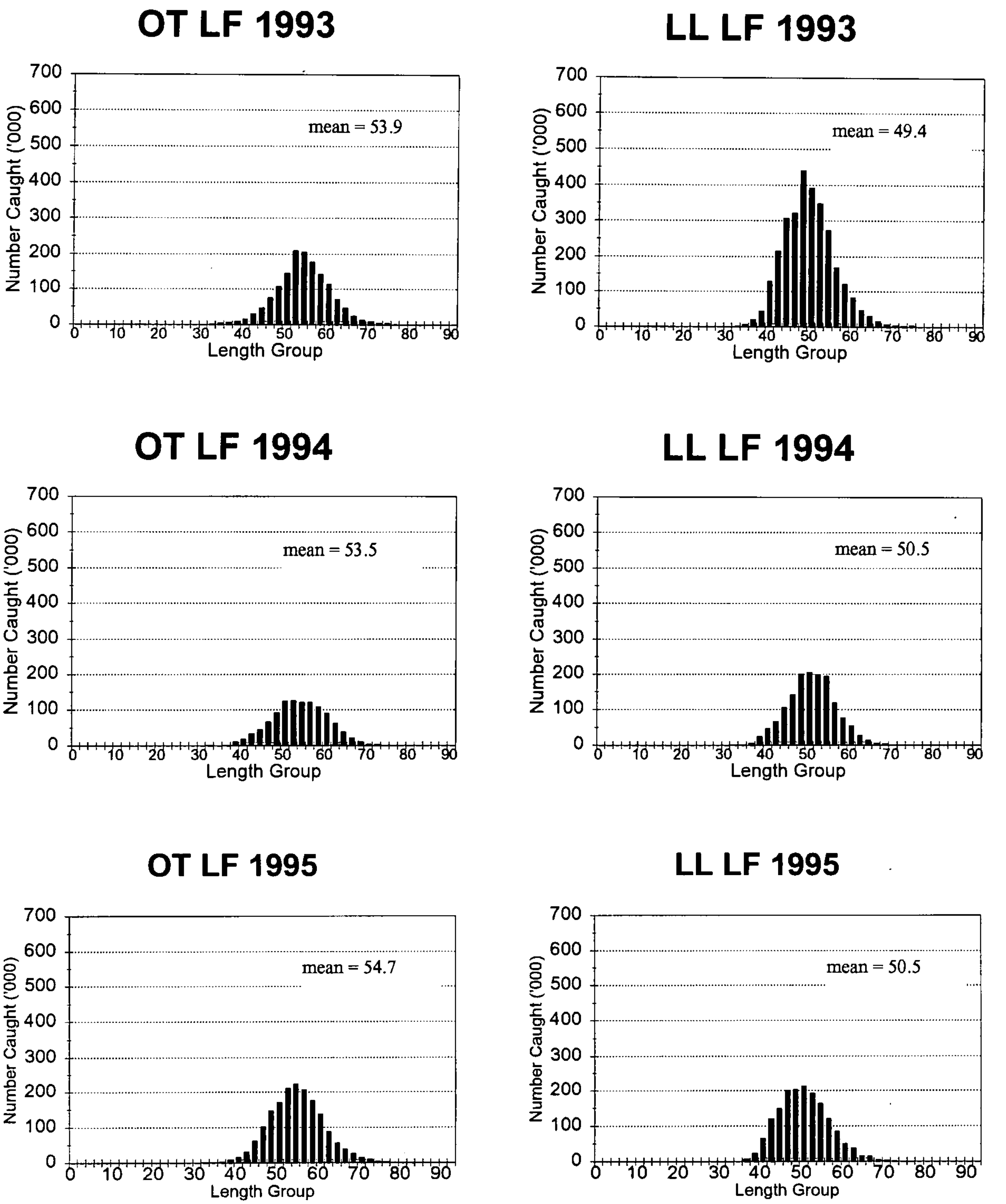


Figure 5b. Catch-at-length (cm) for 4X haddock, 1993-1995, for the otter trawl and longline gear sectors.

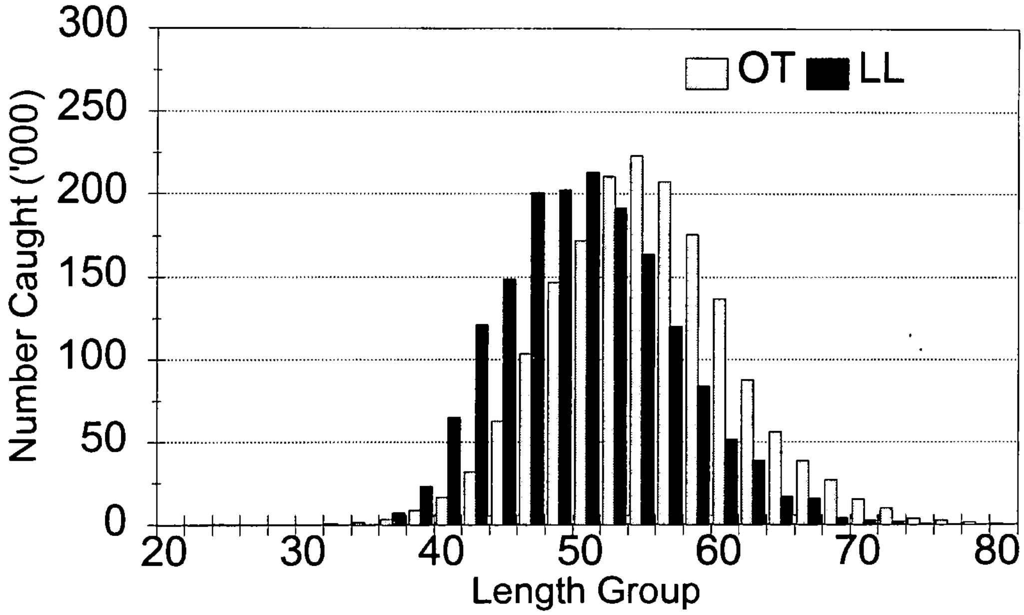


Figure 5c. 1995 4X haddock commercial catch at length plotted on the same axis.

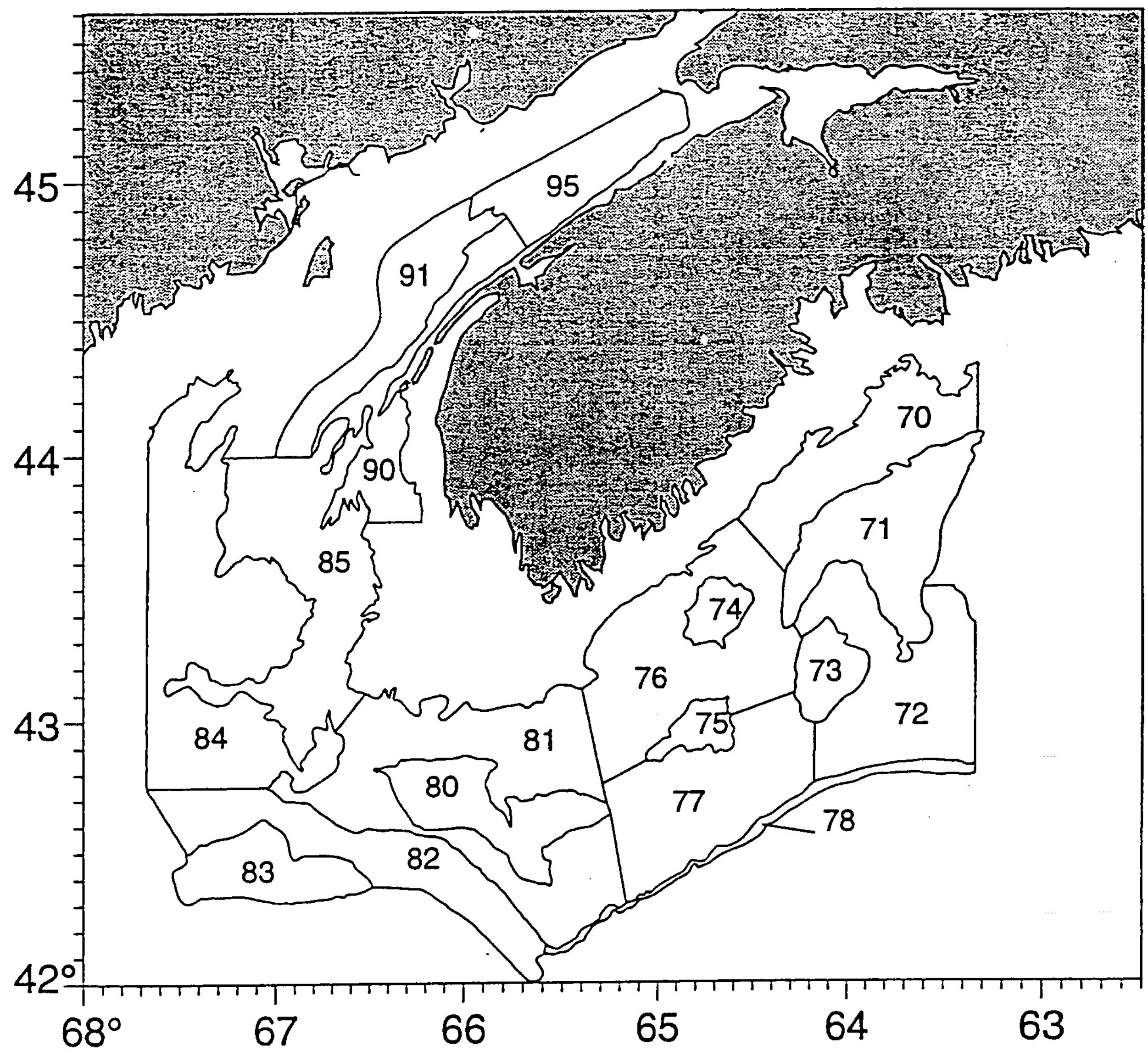


Figure 6. Research vessel survey strata in NAFO Division 4X.

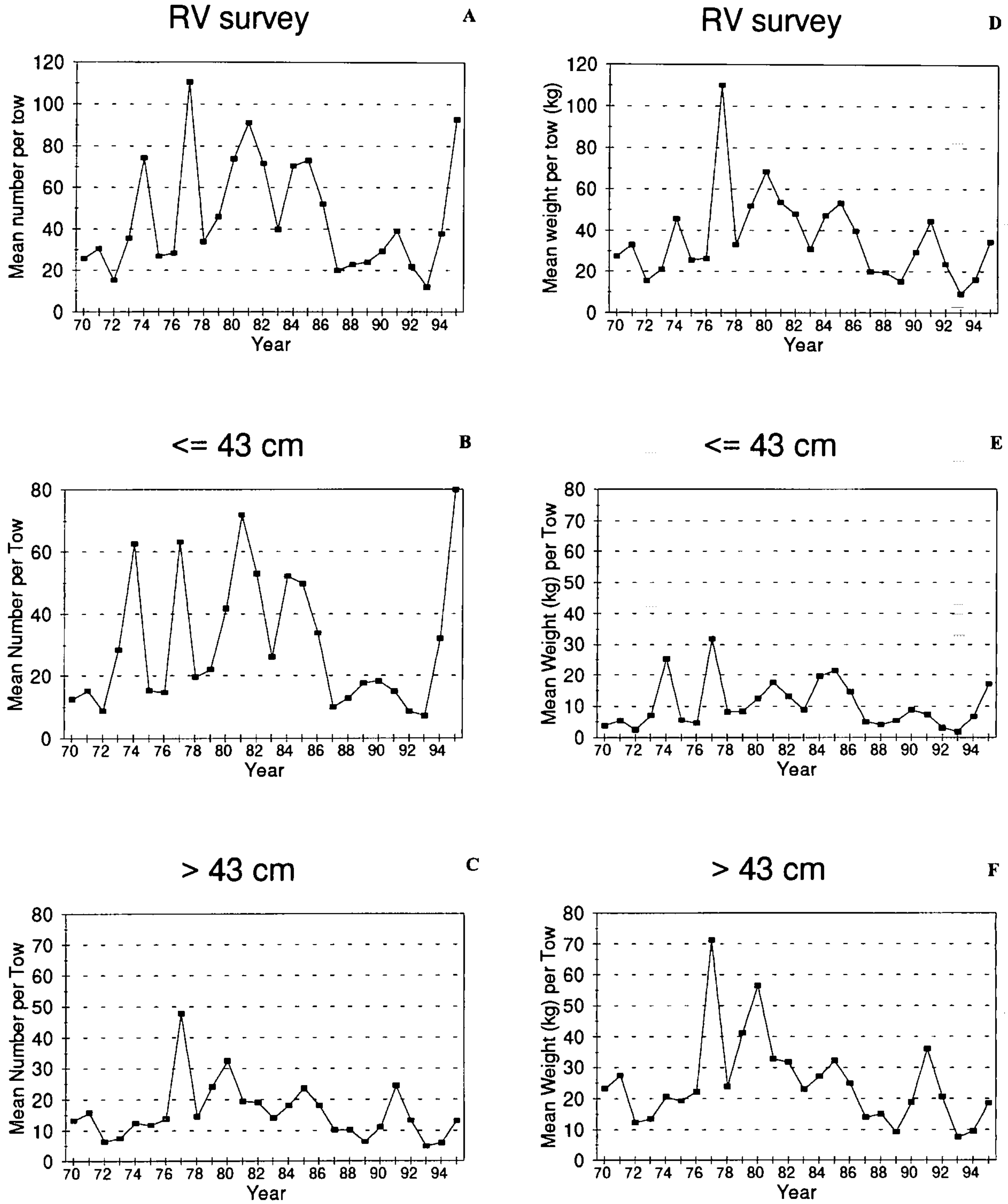


Figure 7. Summer RV survey, mean catch rate of haddock from 4X during 1970-1995 for (a) all lengths combined (nos./tow), (b) lengths <=43 (nos./tow), (c) lengths >43cm (nos./tow), (d) all lengths combined (wt/tow), (e) lengths <=43cm (wt/tow) and (f) lengths >43cm (wt/tow).

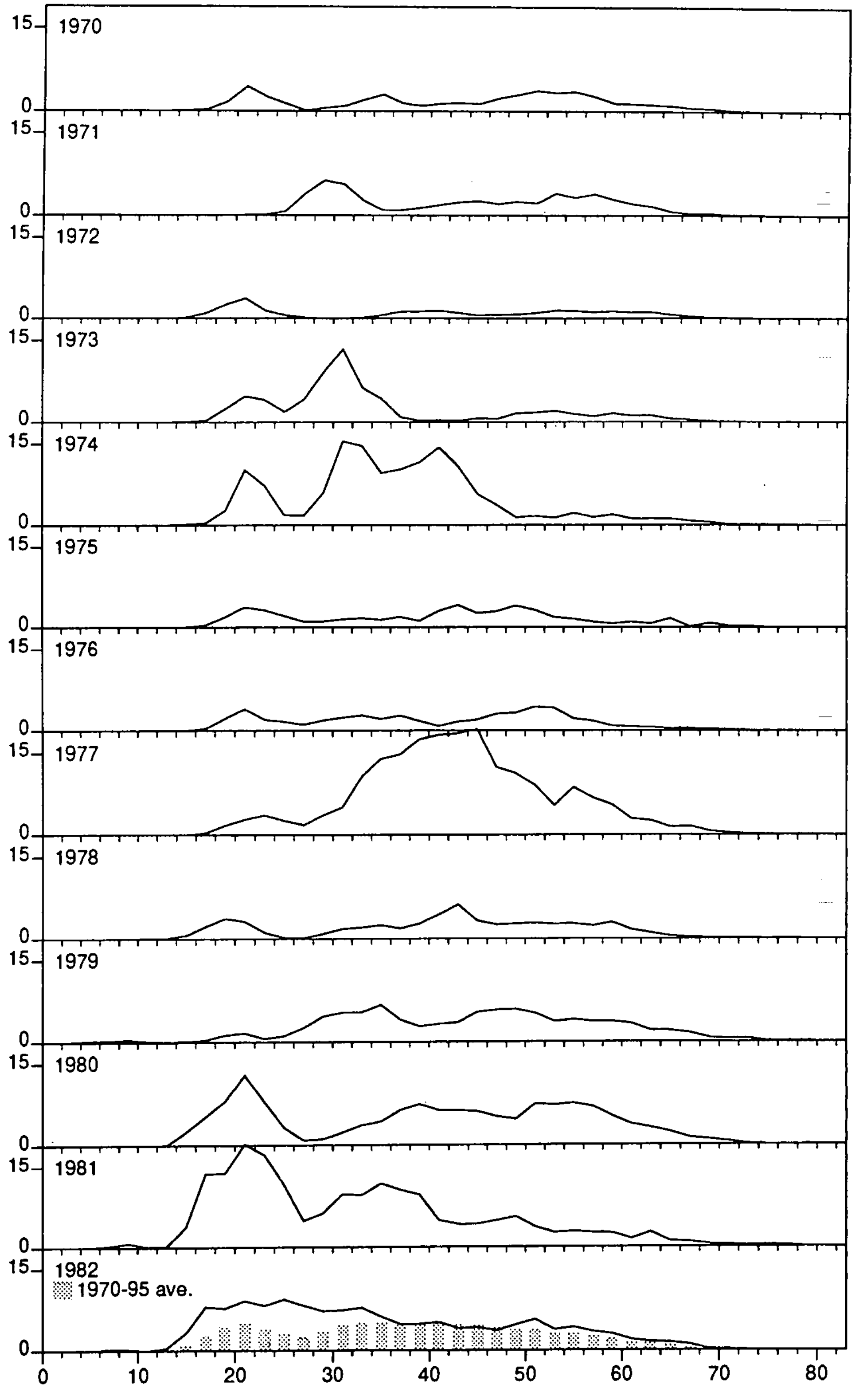


Figure 8a. Mean numbers-at-length per tow for 4X haddock from research vessel surveys, 1970-1982 (bars represent long term mean).

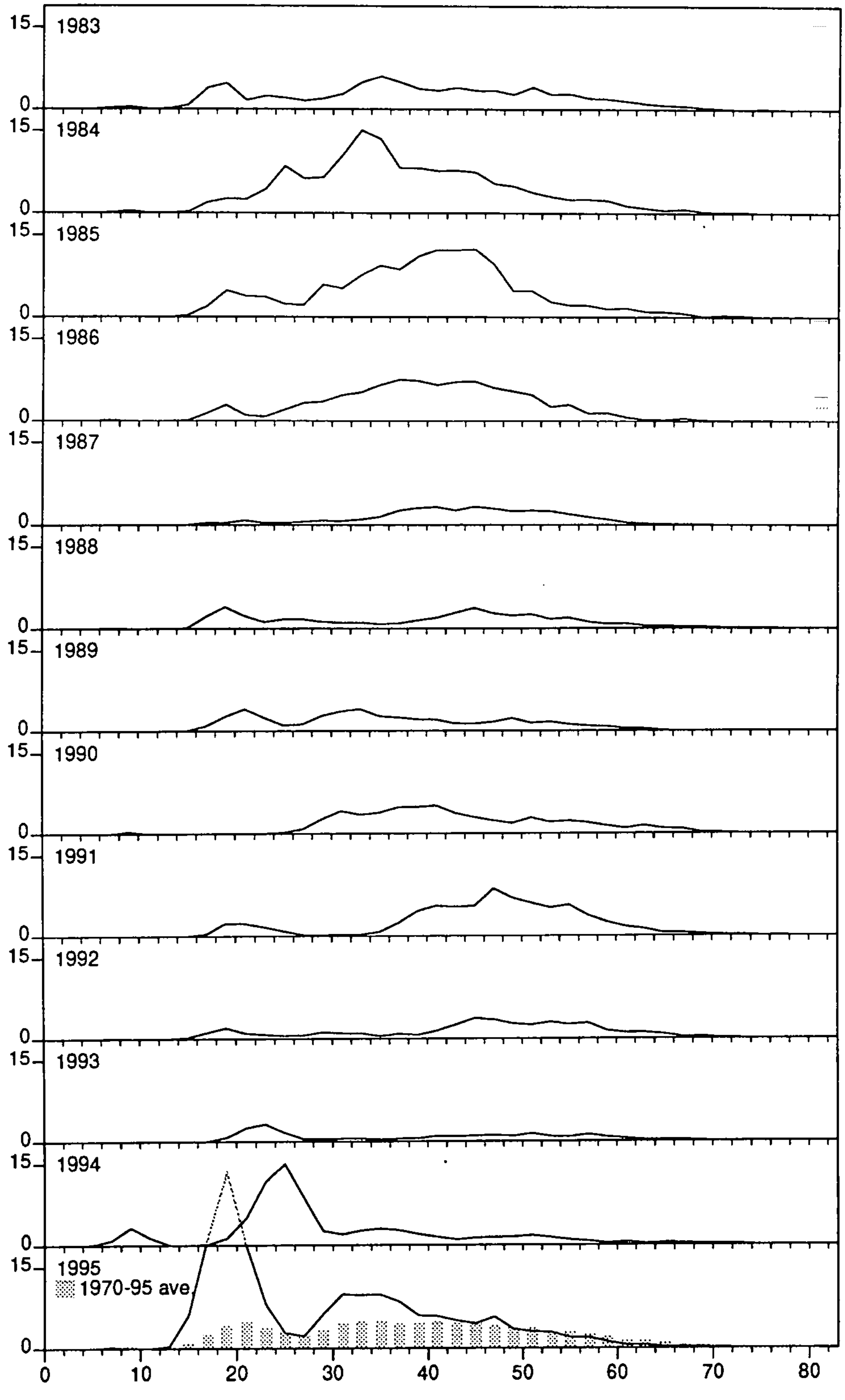


Figure 8b. Mean numbers-at-length per tow for 4X haddock from research vessel surveys, 1983-1995 (bars represent long term mean).

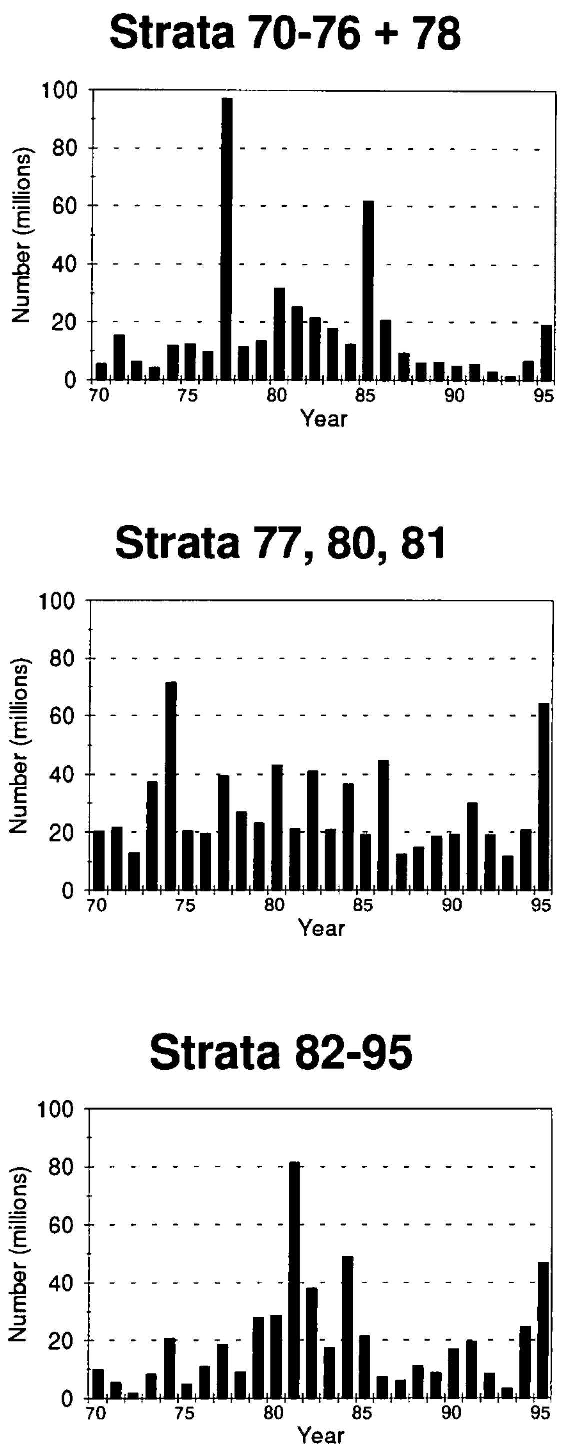


Figure 9. 4X haddock summer RV survey stratified numbers by stratum grouping

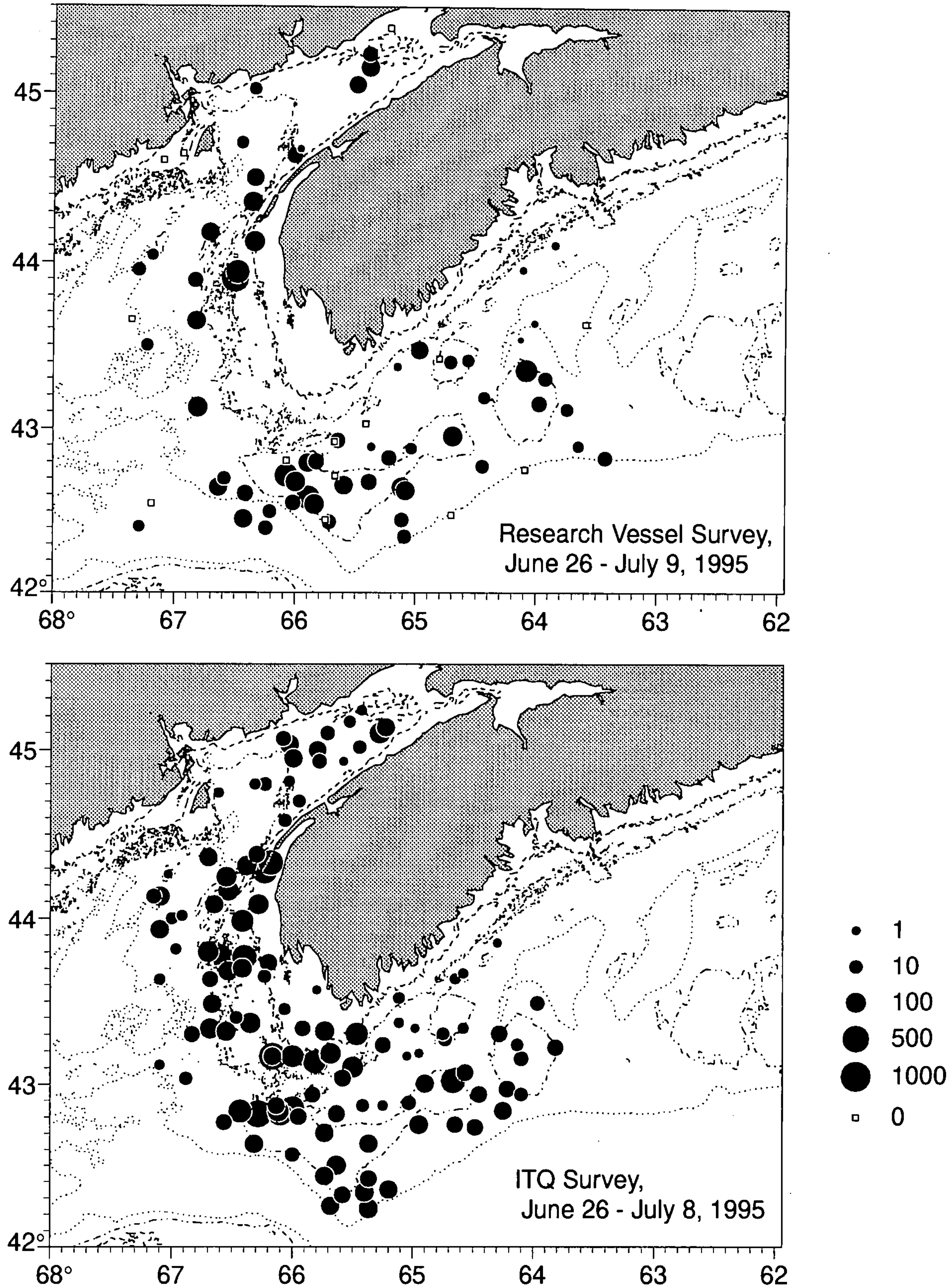


Figure 10. Haddock catches (kg. per standard tow) in 1995 Research Vessel Survey and ITQ Survey.

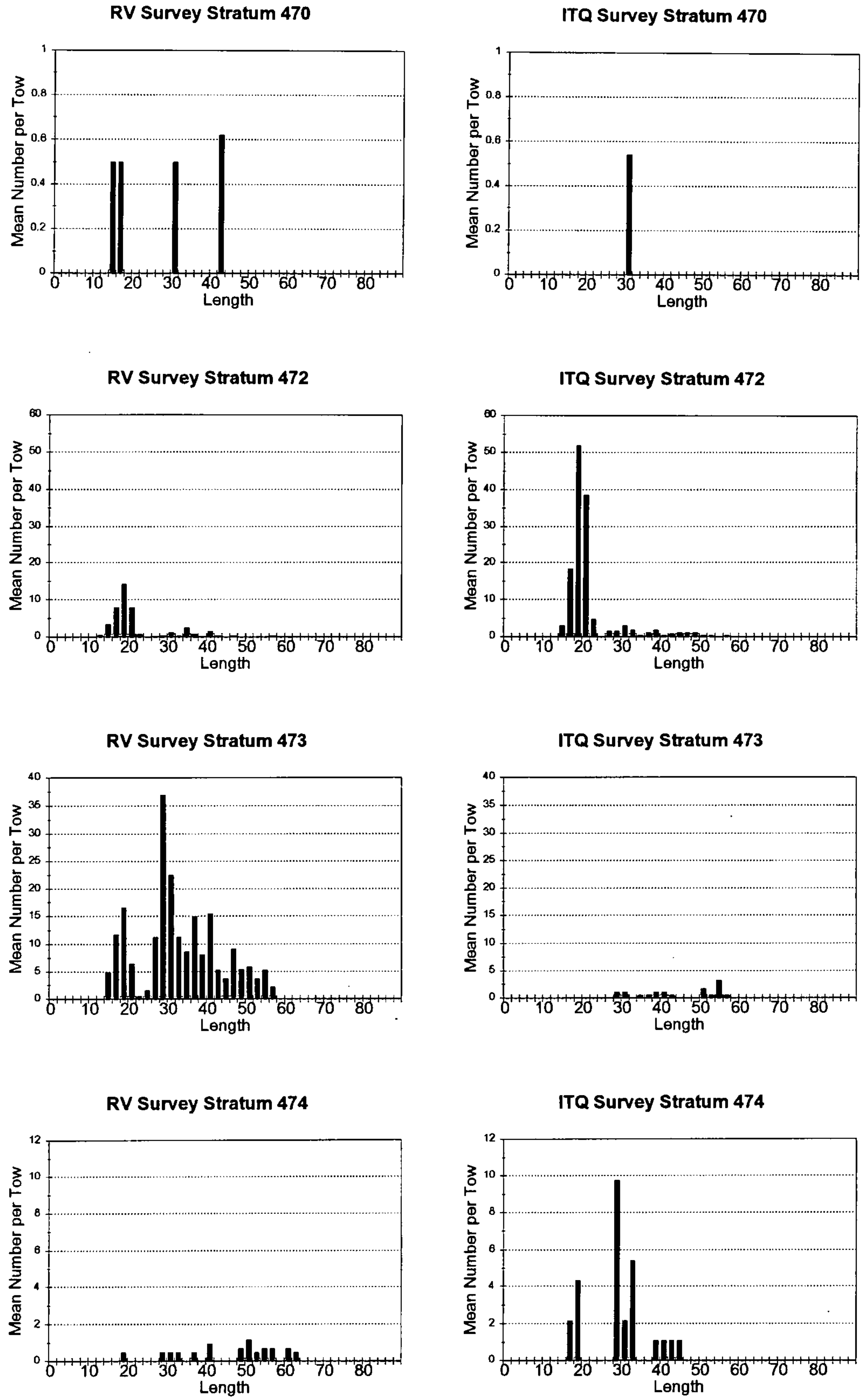
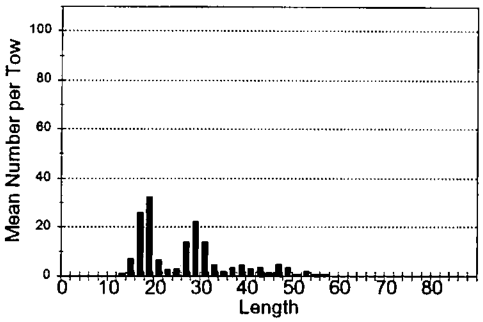
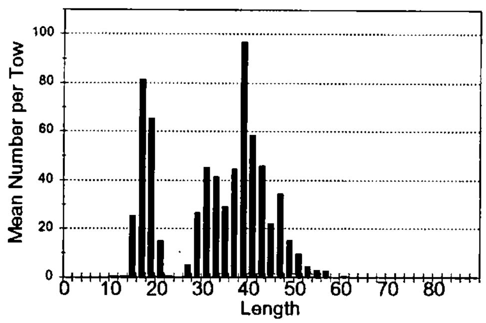


Figure 11. Length frequency distributions by stratum from the Research Vessel Survey and ITQ Survey, June 26 - July 7, 1995.

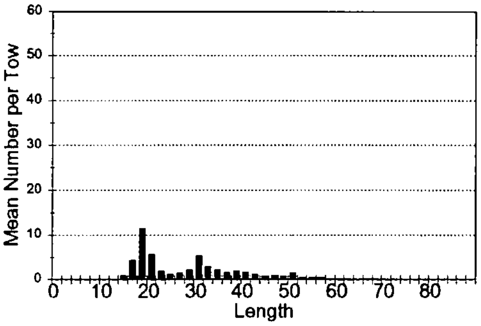
RV Survey Stratum 475



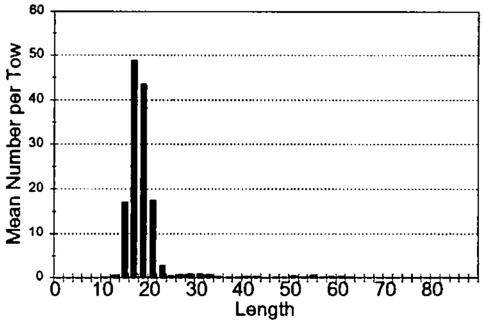
ITQ Survey Stratum 475



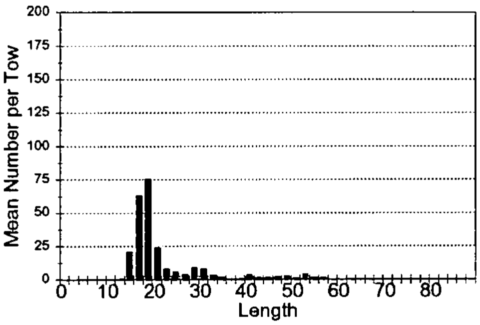
RV Survey Stratum 476



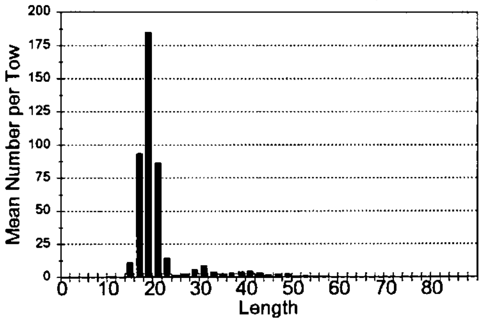
ITQ Survey Stratum 476



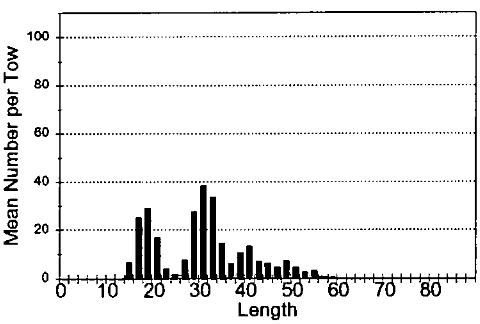
RV Survey Stratum 477



ITQ Survey Stratum 477



RV Survey Stratum 480



ITQ Survey Stratum 480

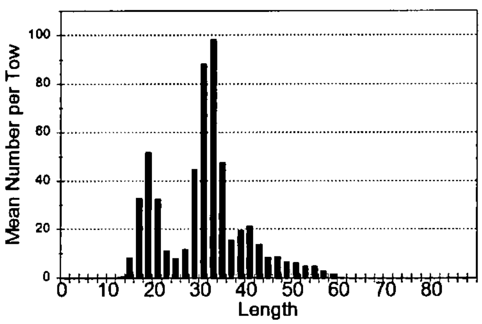


Figure 11. (cont.) Length frequency distributions by stratum from the Research Vessel Survey and ITQ Survey, June 26 - July 7, 1995.

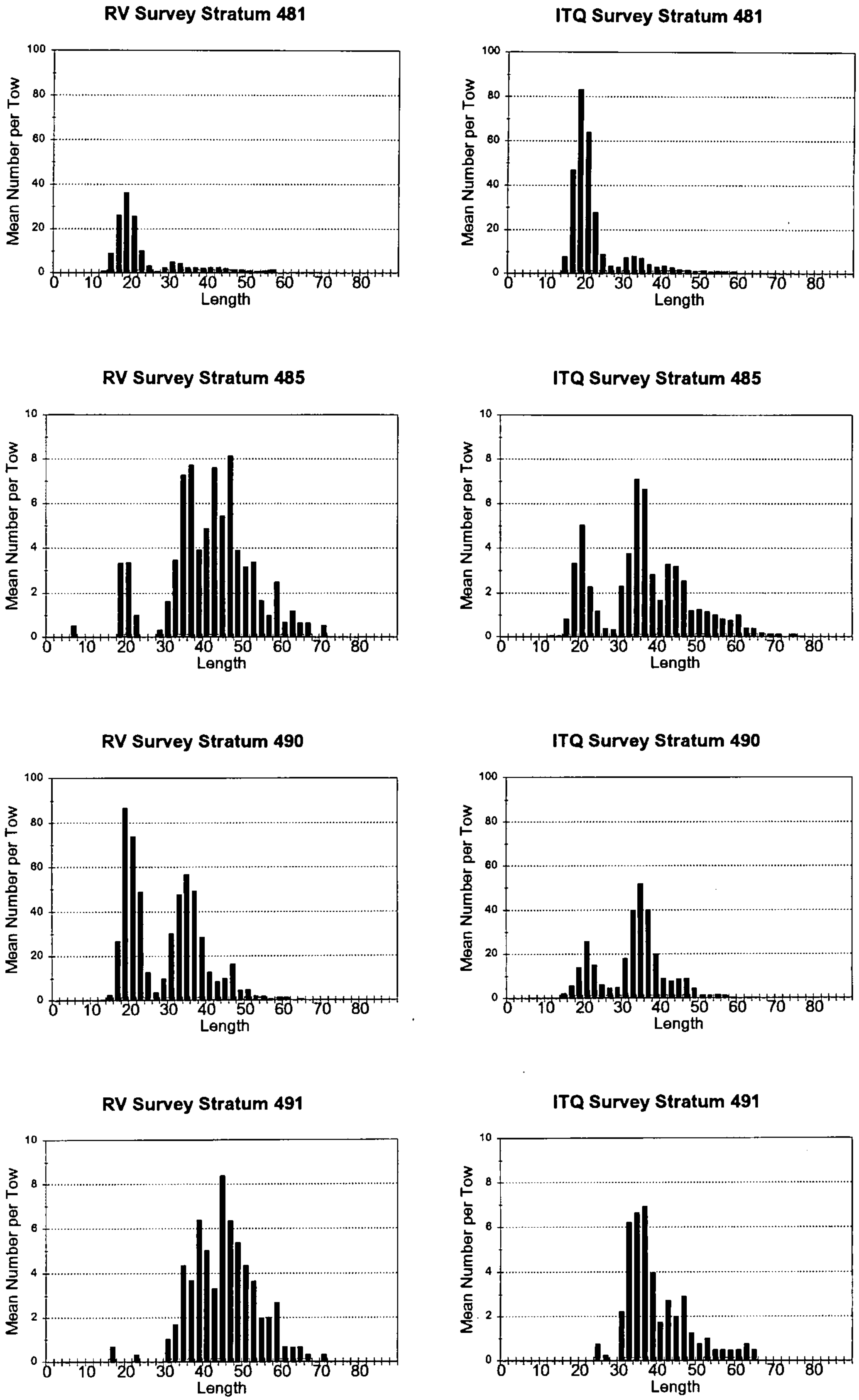


Figure 11. (cont.) Length frequency distributions by stratum from the Research Vessel Survey and ITQ Survey, June 26 - July 7, 1995.

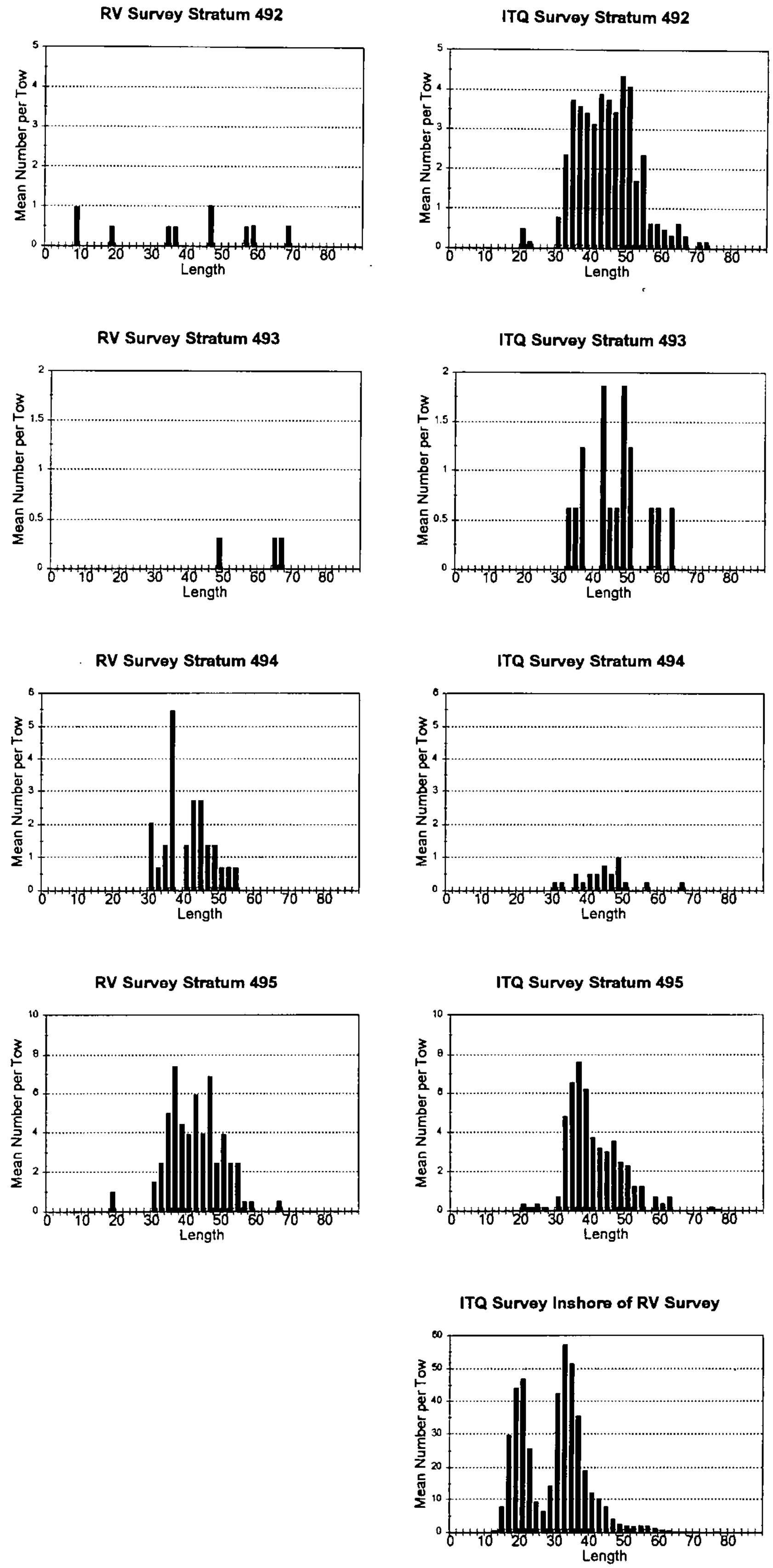


Figure 11. (cont.) Length frequency distributions by stratum from the Research Vessel Survey and ITQ Survey, June 26 - July 7, 1995.

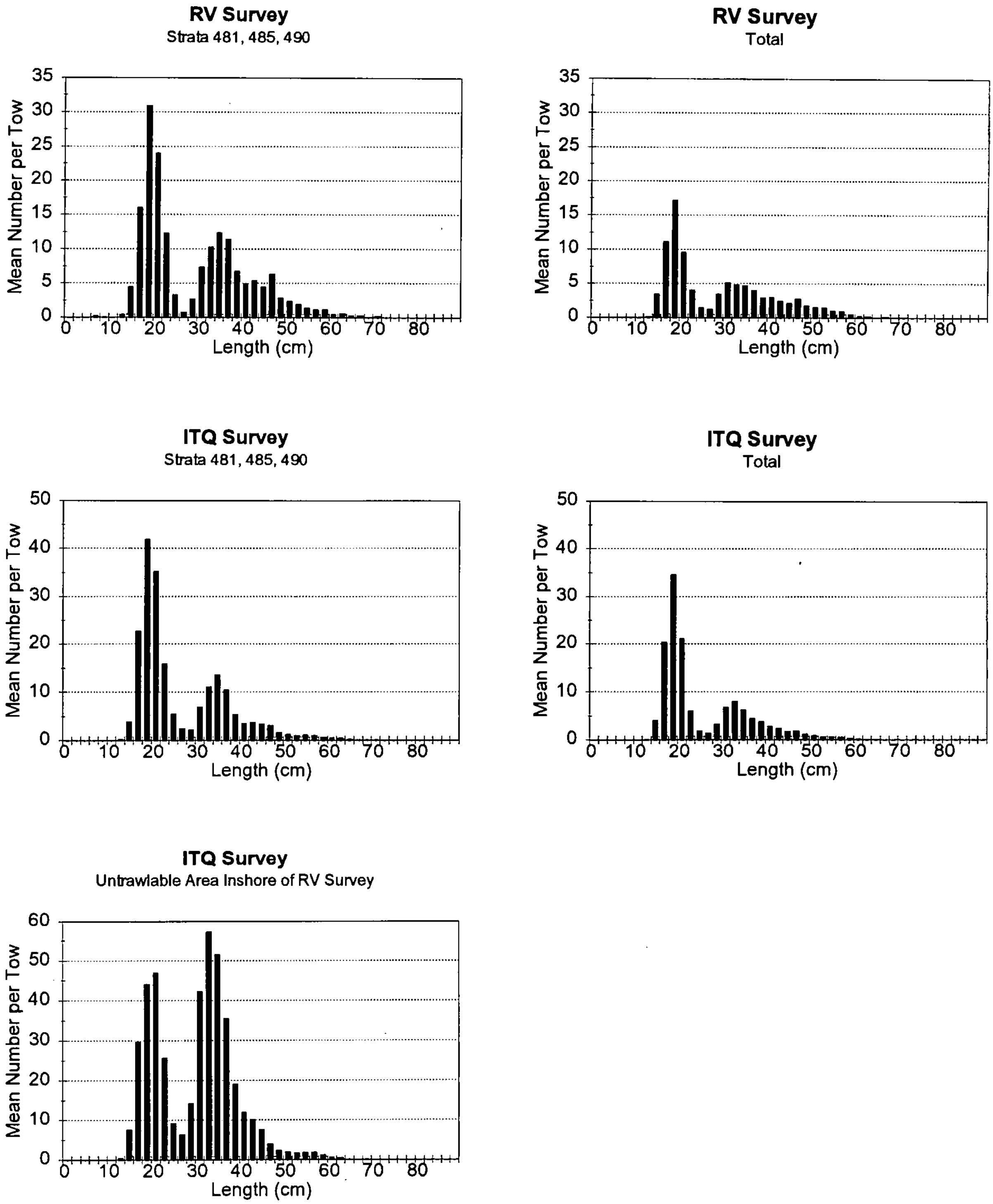


Figure 12. Length frequency distributions from the Research Vessel Survey and ITQ Survey, June 26-July 7, 1995.

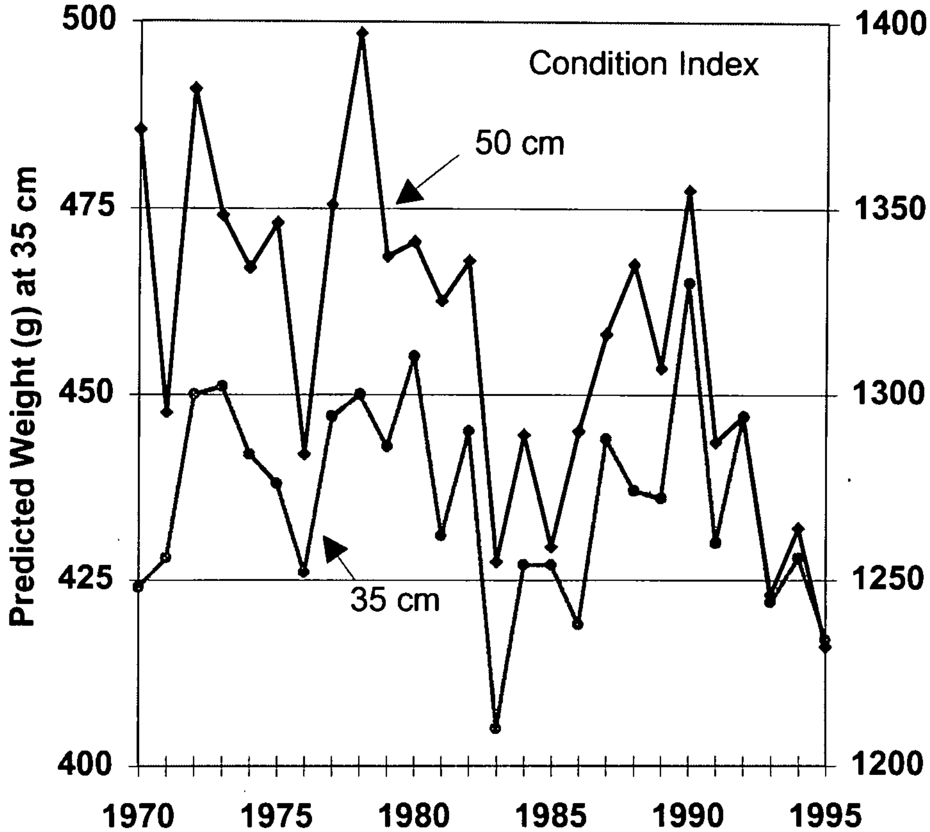


Figure 13. Trend of predicted weight (g) for a 35cm and 50cm haddock in NAFO Division 4X.

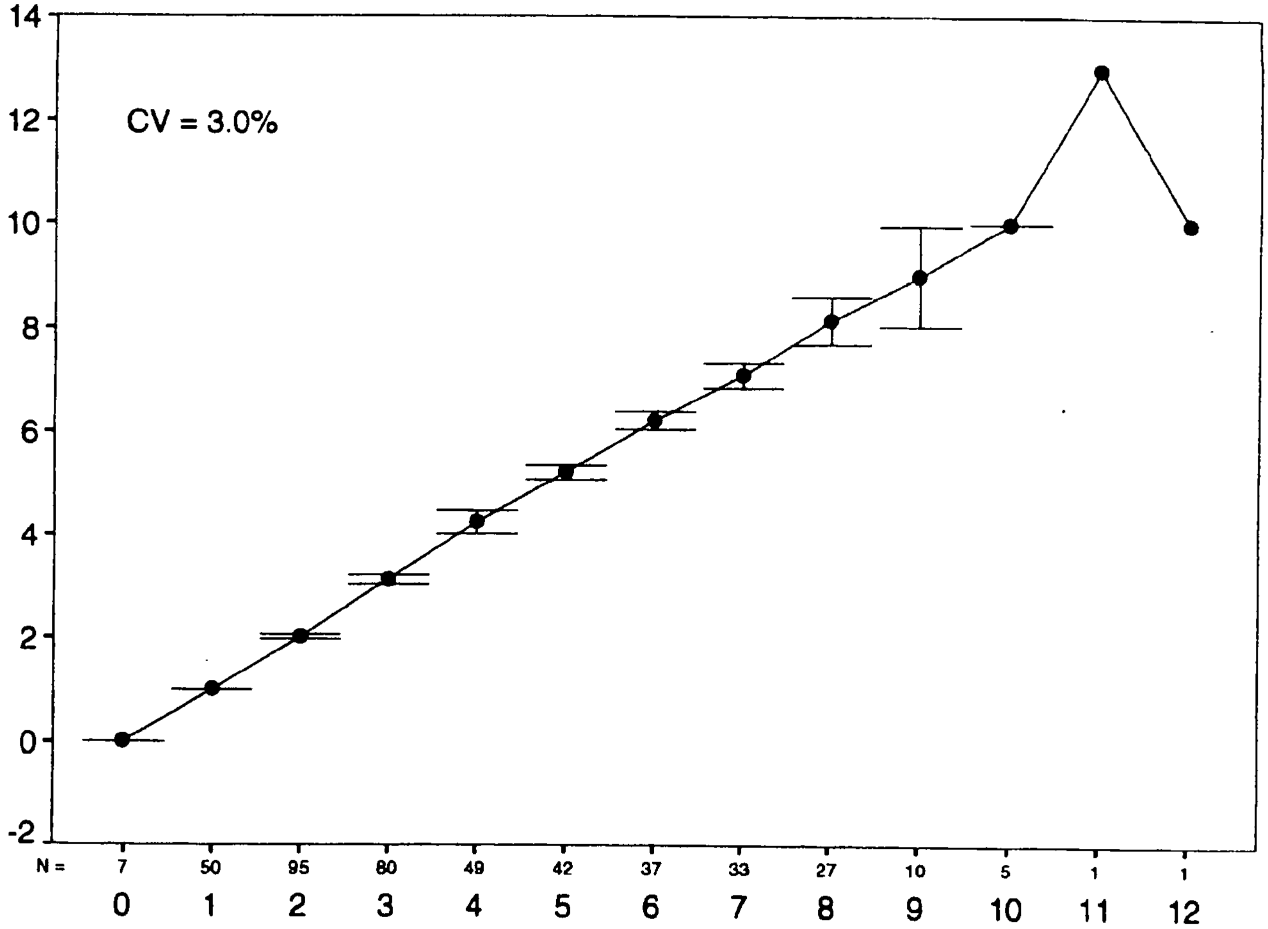


Figure 14. Age bias plot of pairwise age comparisons of revised 4X haddock ages from BIO agers. Bars represent 95% confidence interval around each category. The 1:1 line is not plotted as all but the last 2 ages lie on the line. Sample size is indicated above x-axis ages.

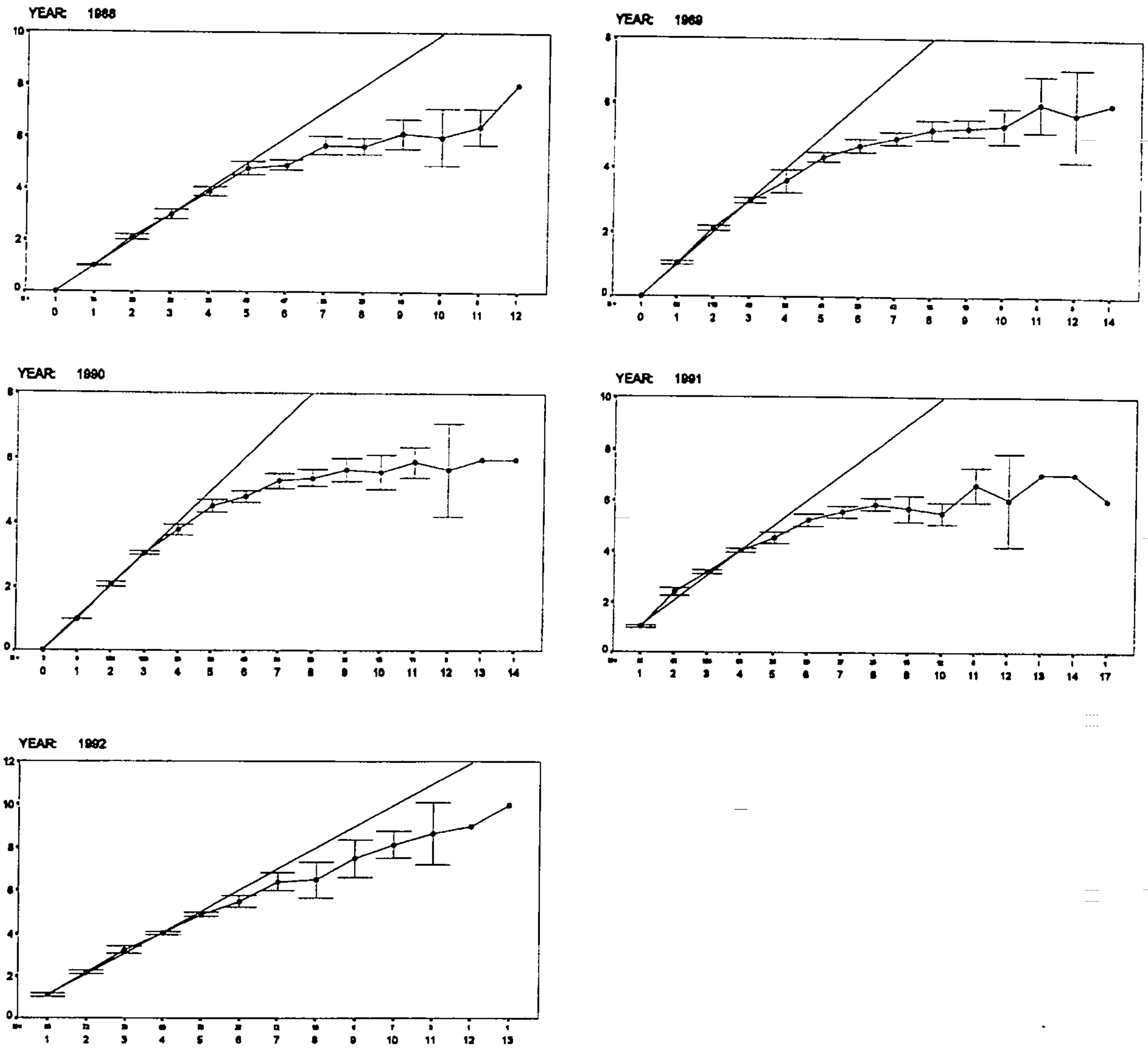


Figure 15. Age bias plotsof pairwise age comparisons of 4X haddock ages from original (y-axis) and revised (x-axis) ages for 1988-1992. Bars represent 95% confidence interval around each age category. The 1:1 line which represents 0 ageing bias is also plotted.

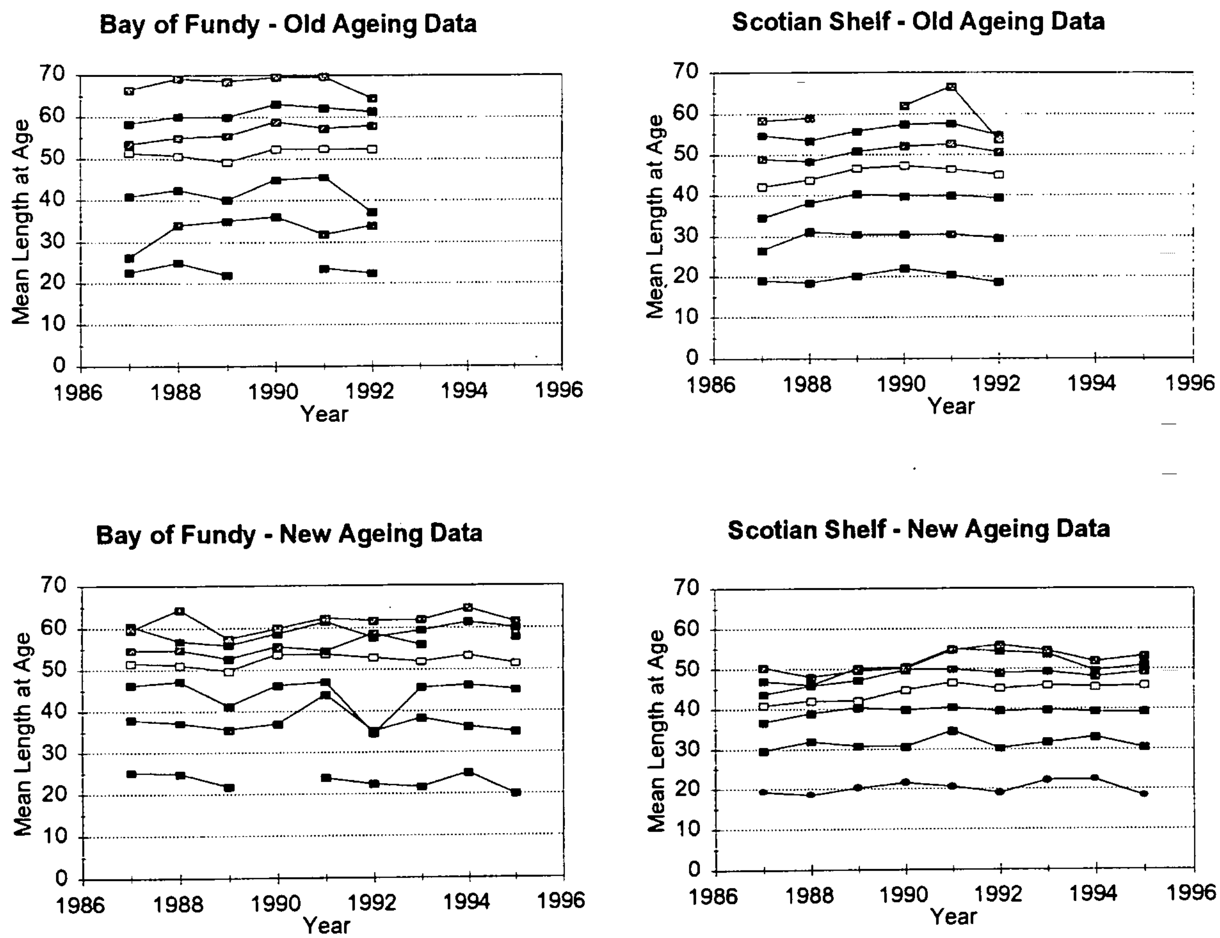


Figure 16. Stratified mean length-at-age for the Bay of Fundy and Scotian Shelf components of the 4X haddock stock useing the original and revised ageing data, ages 1-7.

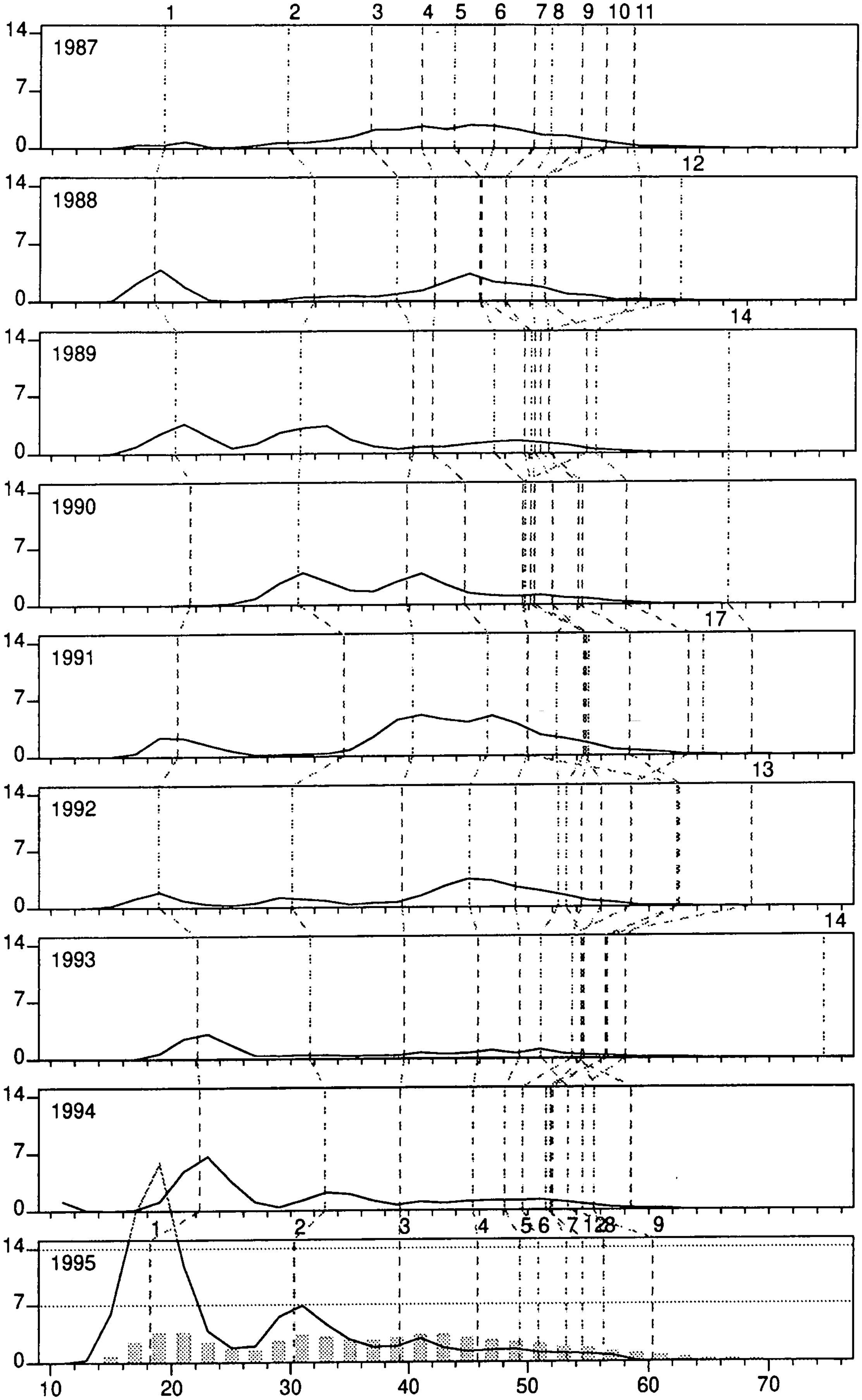


Figure 17a. Mean numbers-at-length per tow for the Scotian Shelf component of 4X haddock from research vessel surveys, 1987-1995. (shaded bars represent the long term mean; vertical dashed lines are annual values of mean length-at-age calculated from revised ageing data)

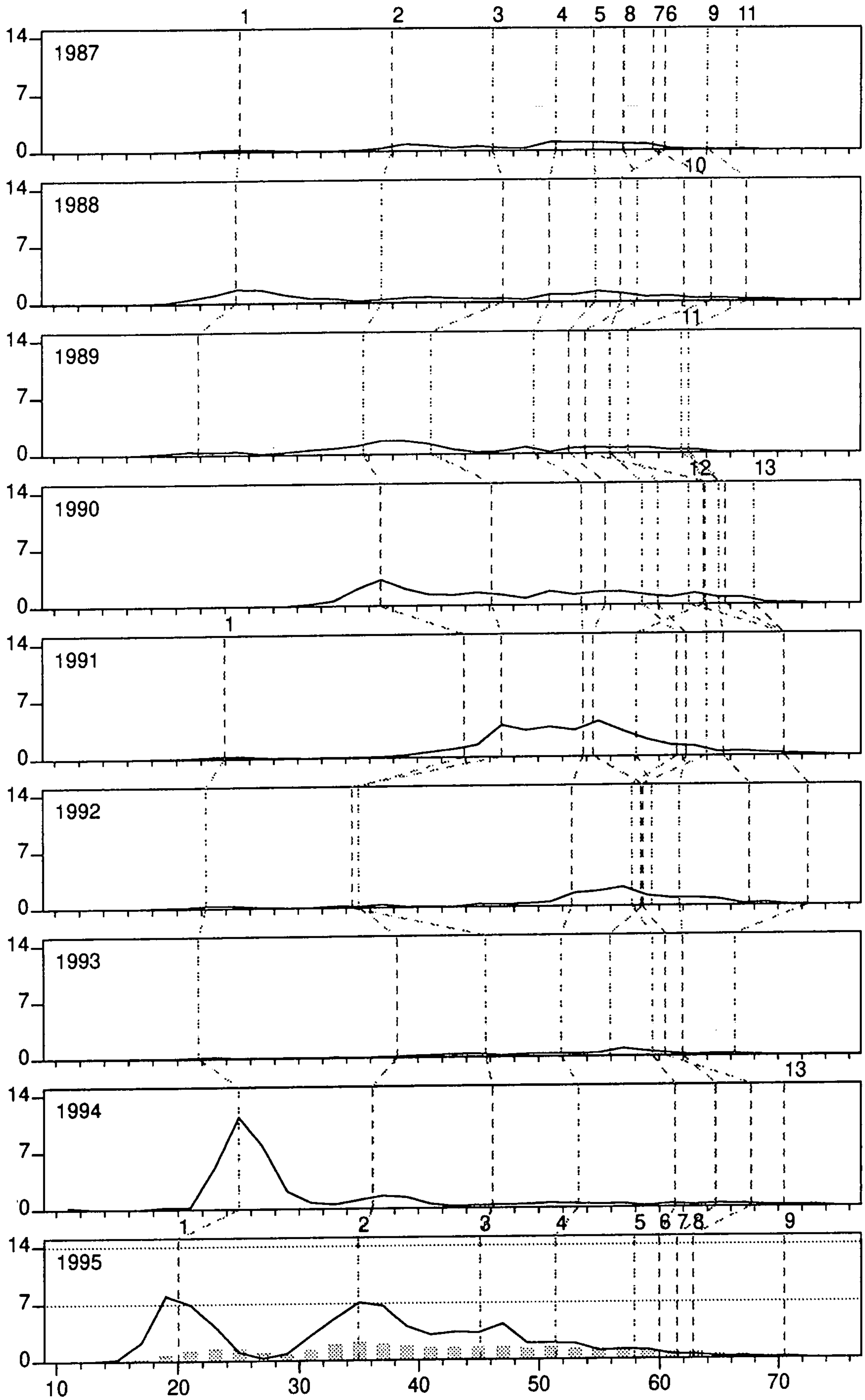


Figure 17b. Mean numbers-at-length per tow for the Bay of Fundy component of 4X haddock from research vessel surveys, 1987-1995. (shaded bars represent the long term mean; vertical dashed lines are annual values of mean length-at-age calculated from revised ageing data)

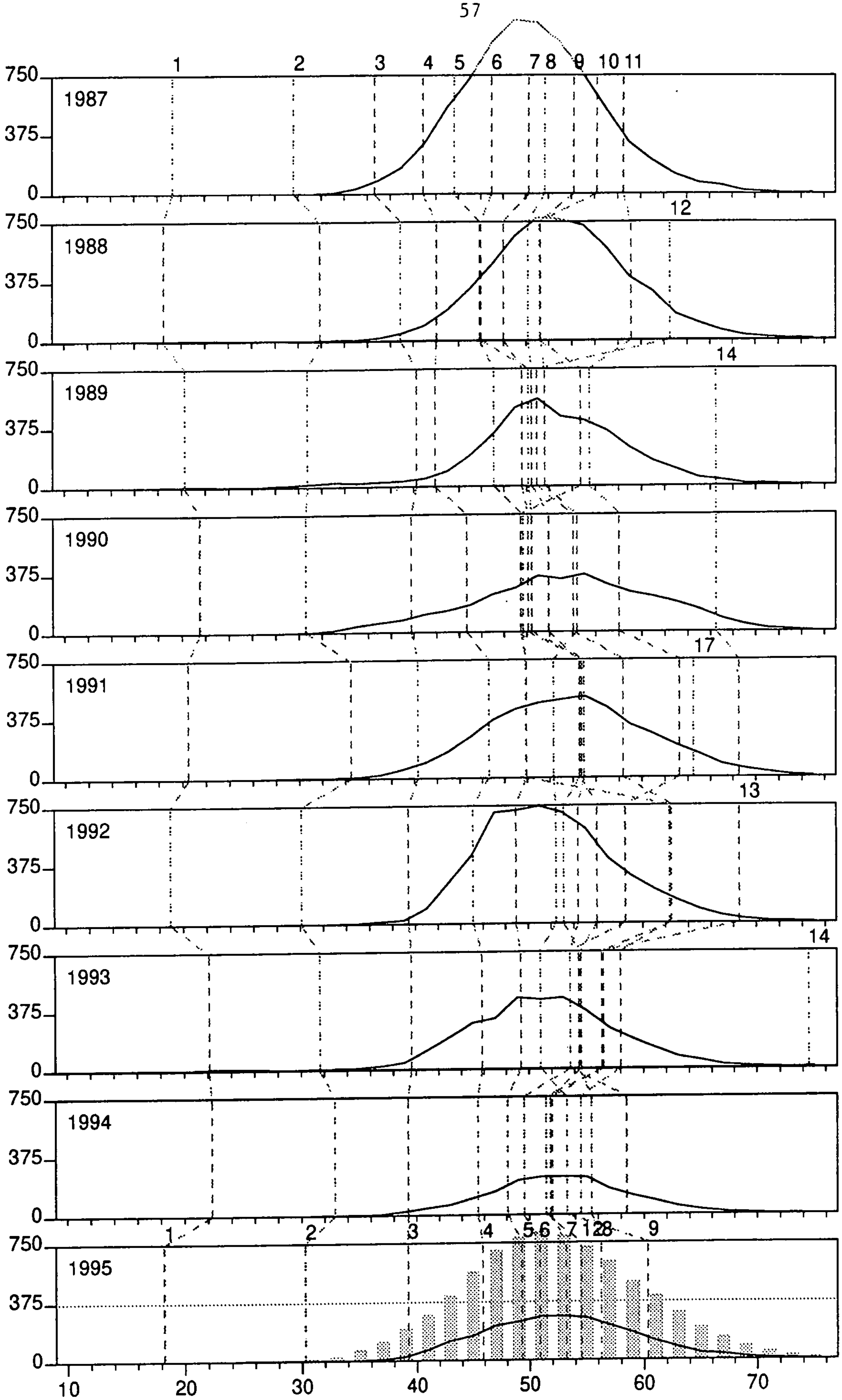


Figure 18a. Commercial catch-at-length for the Scotian Shelf component of 4X haddock, 1987-1995. (shaded bars represent the long term mean; vertical dashed lines are annual values of mean length-at-age calculated from revised ageing data)

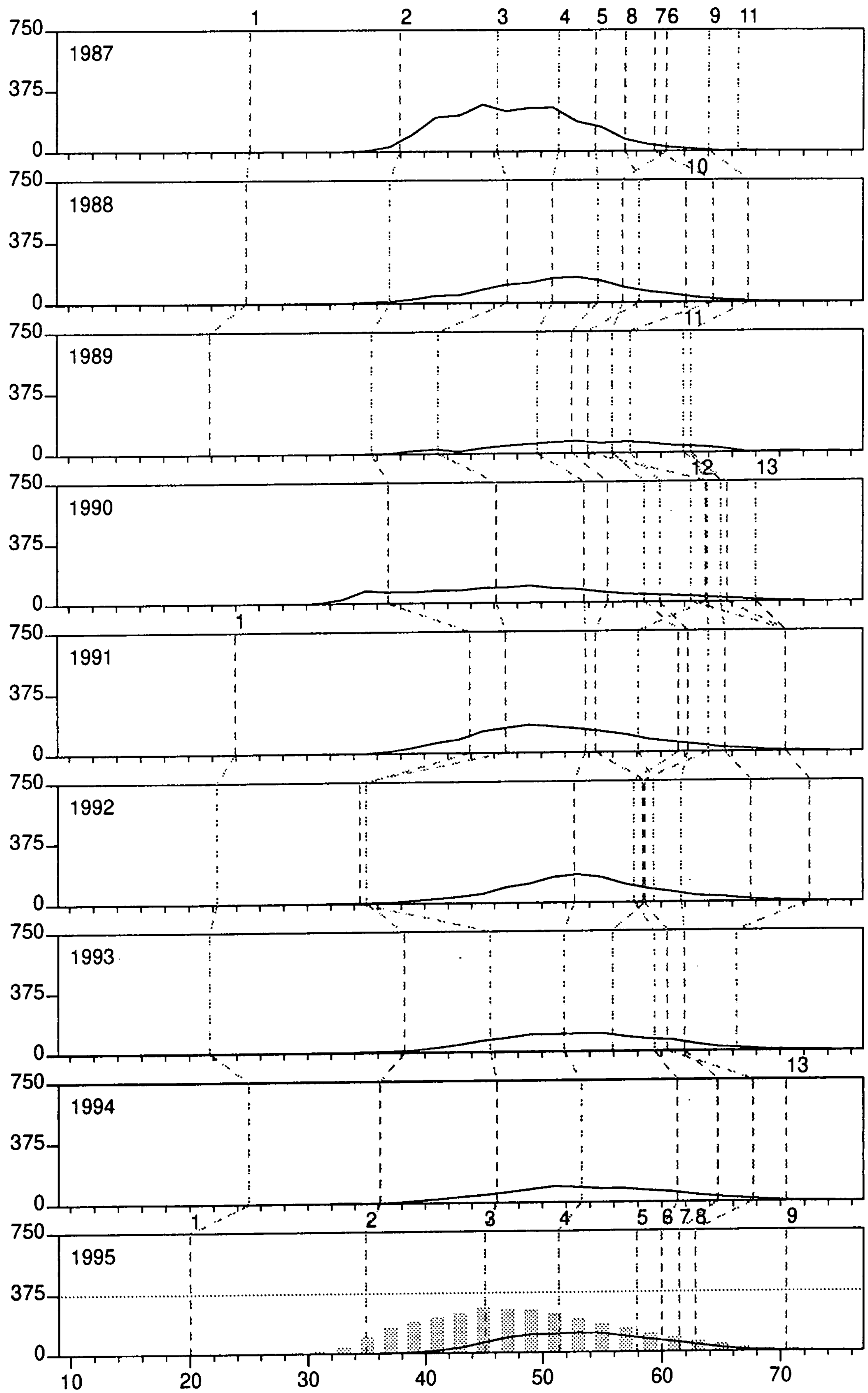


Figure 18b. Commercial catch-at-length for the Bay of Fundy component of 4X haddock, 1987-1995. (shaded bars represent the long term mean; vertical dashed lines are annual values of mean length-at-age calculated from revised ageing data)

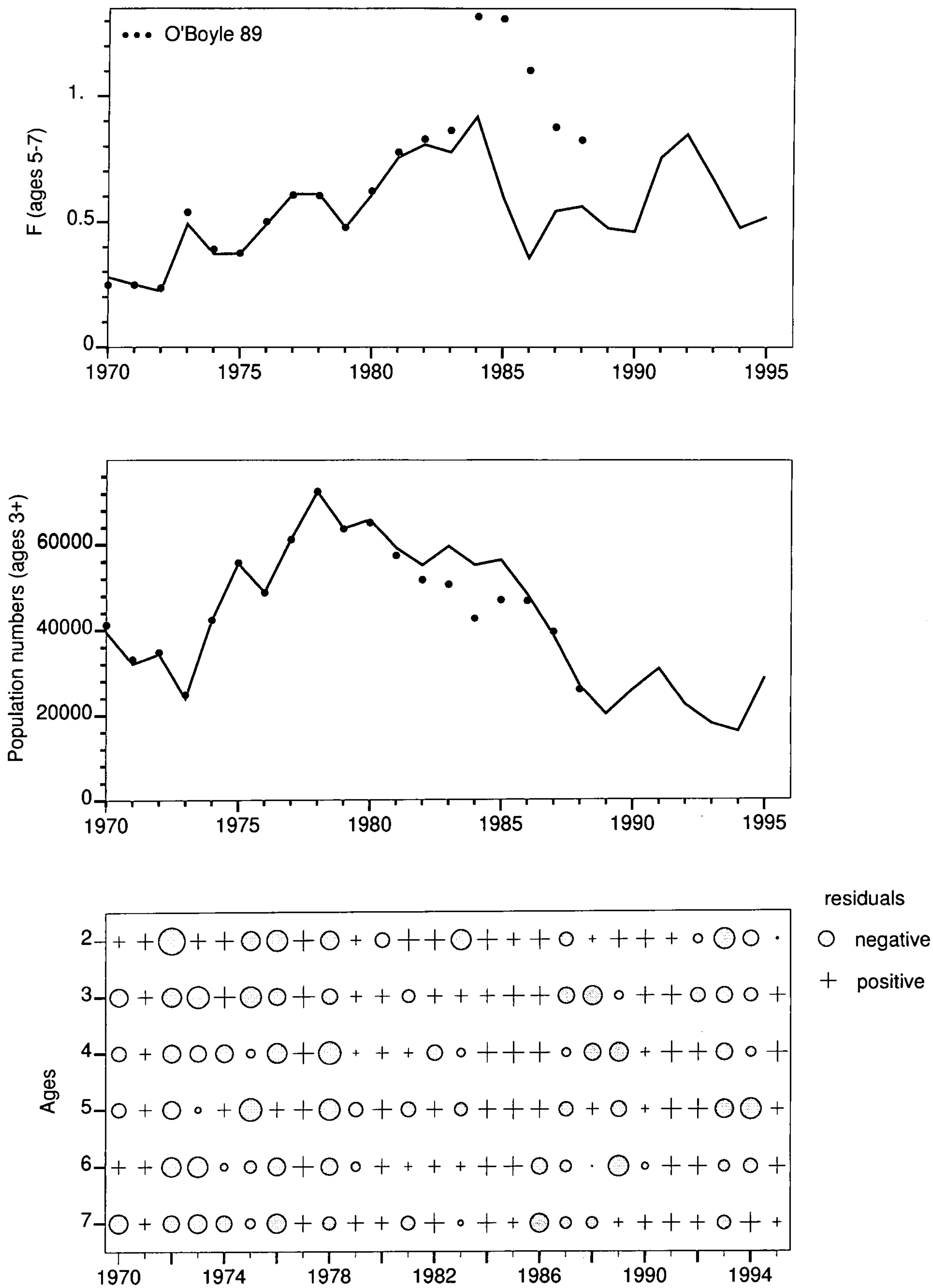


Figure 19. SPA results.

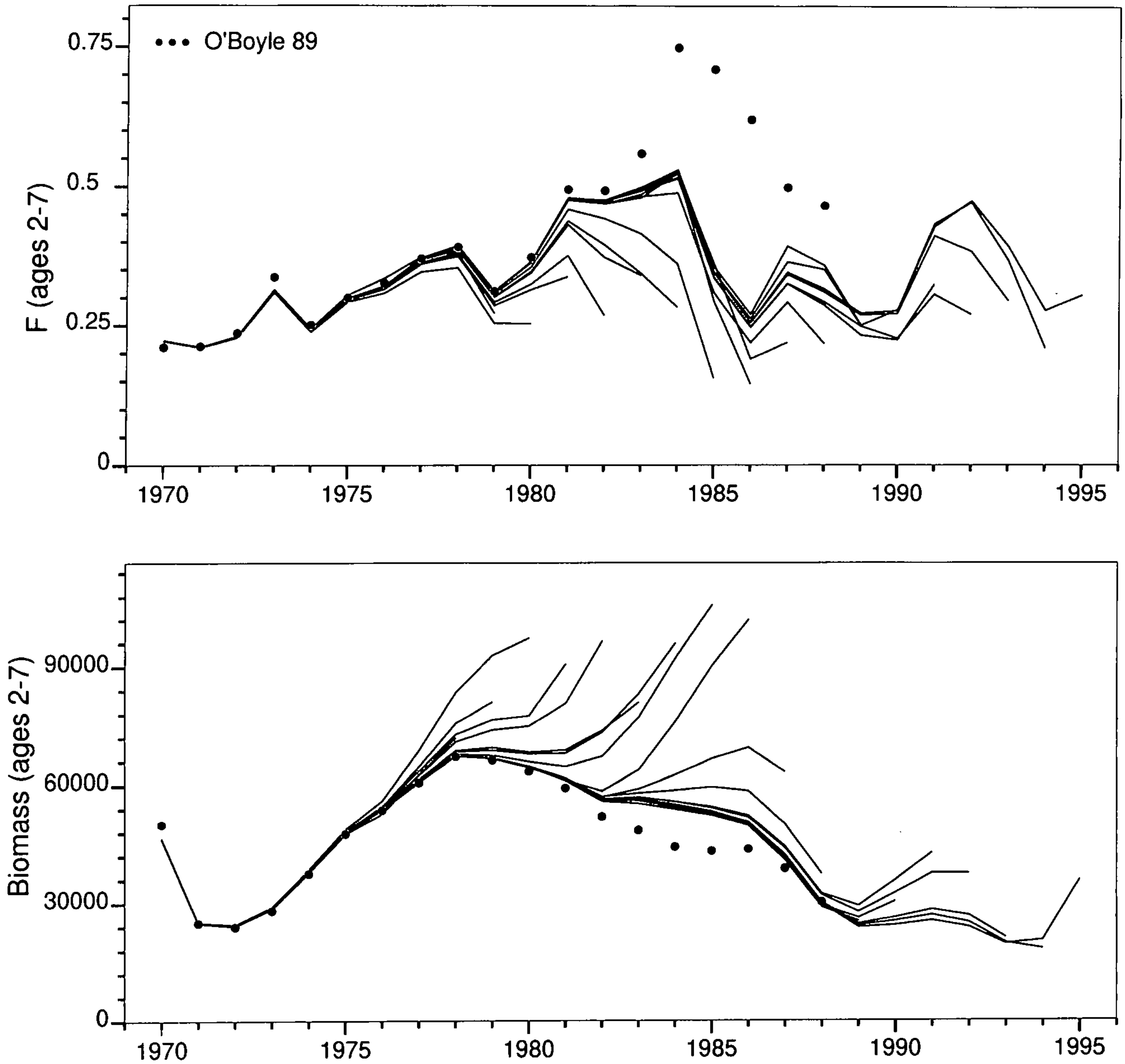


Figure 20. Retrospective Analysis of SPA results.

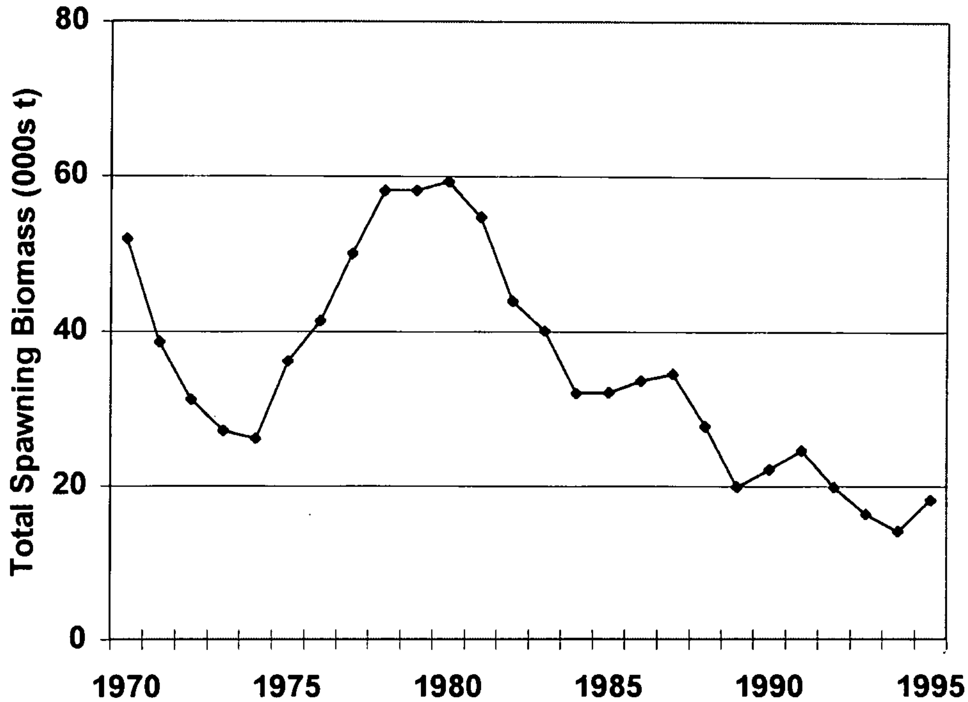


Figure 21. 4X haddock total spawning stock biomass.

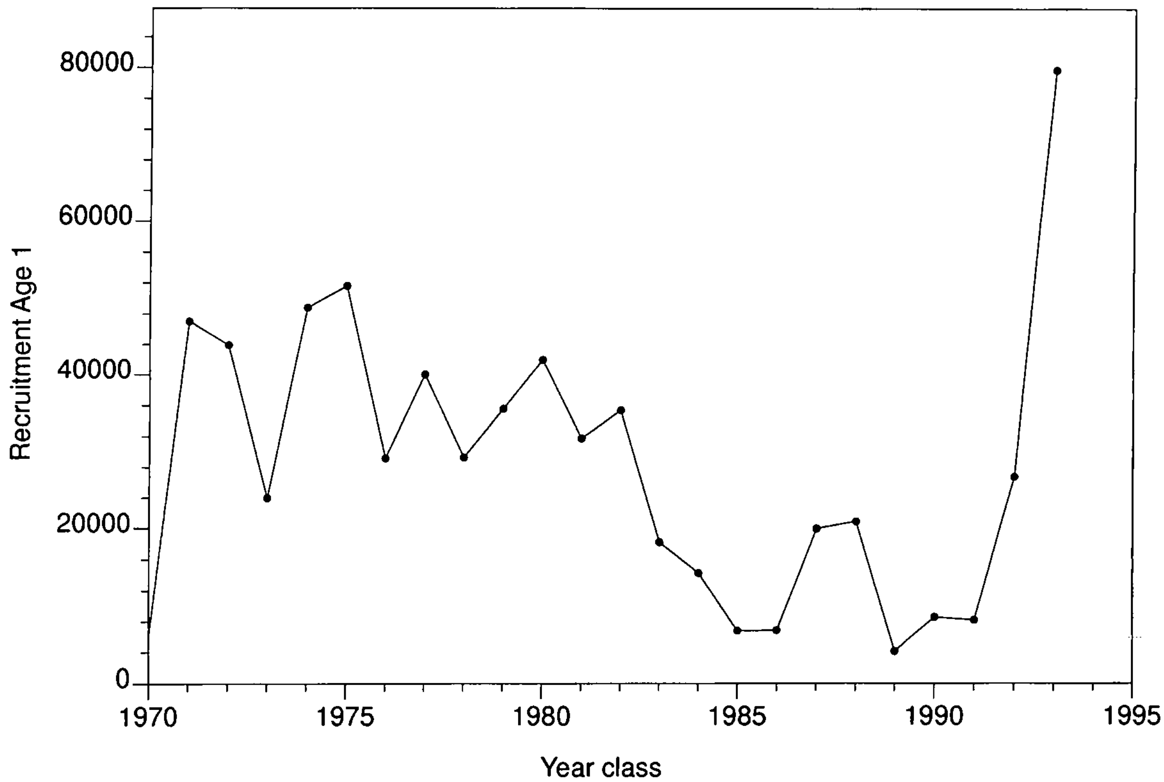


Figure 22a. Age 1 recruitment.

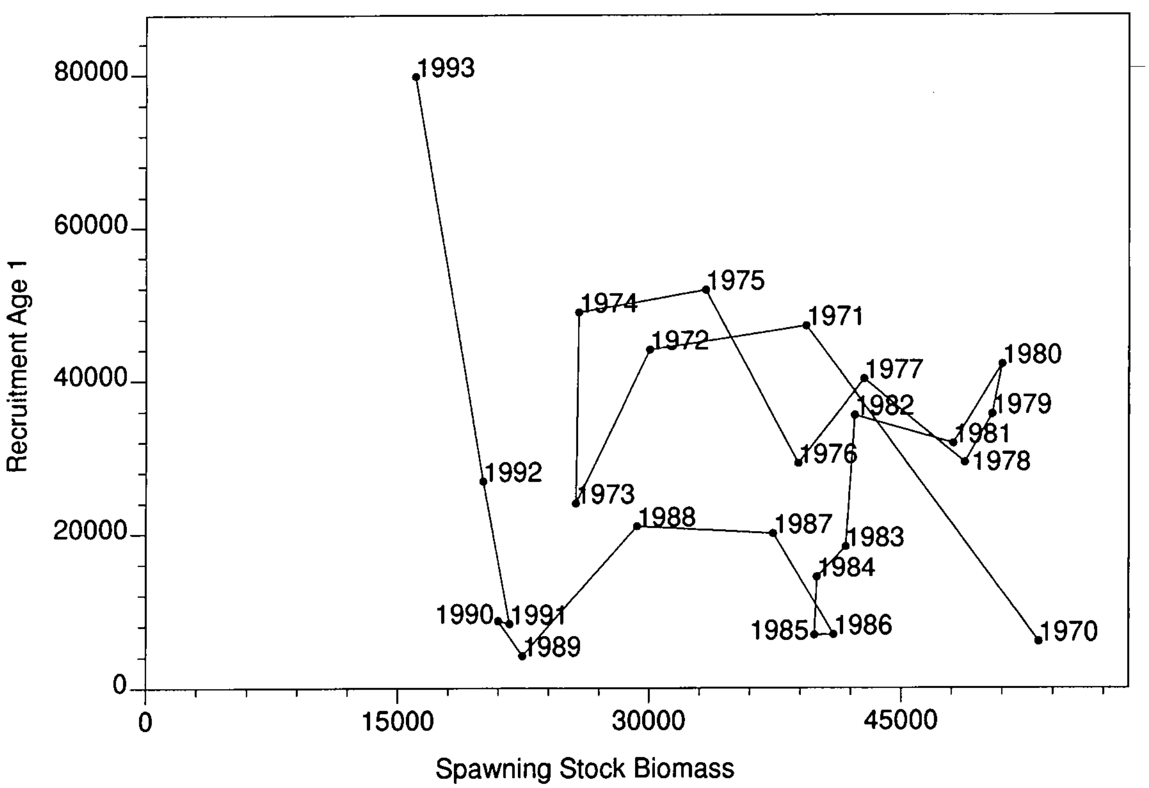
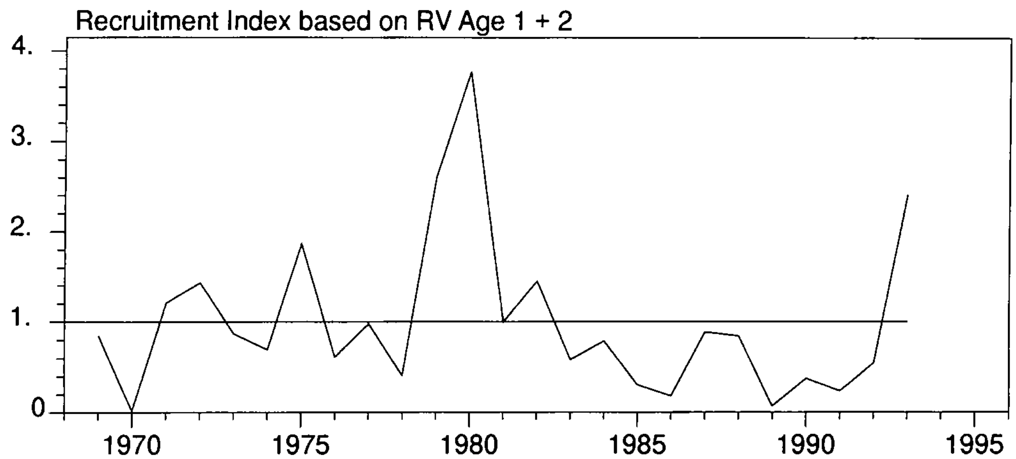


Figure 22b. Spawning stock biomass and Age 1 recruitment in the subsequent year.



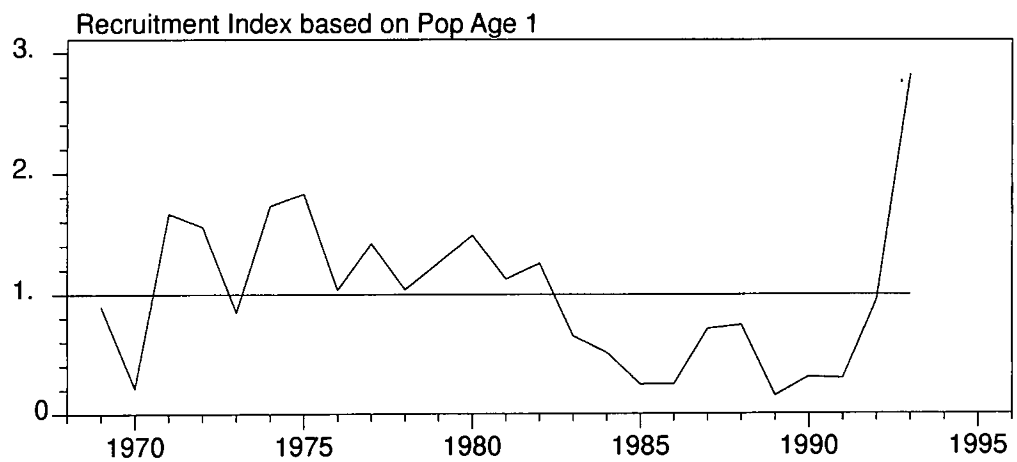


Figure 23. Recruitment indices based on research vessel survey and SPA.

Figure 24. Contemporaneous and 'converged' SPA estimates of age 2 numbers. The solid line is a Gompertz fit and the dashed line is unit slope.The numbers denote yearclasses from 1969 to 1993.

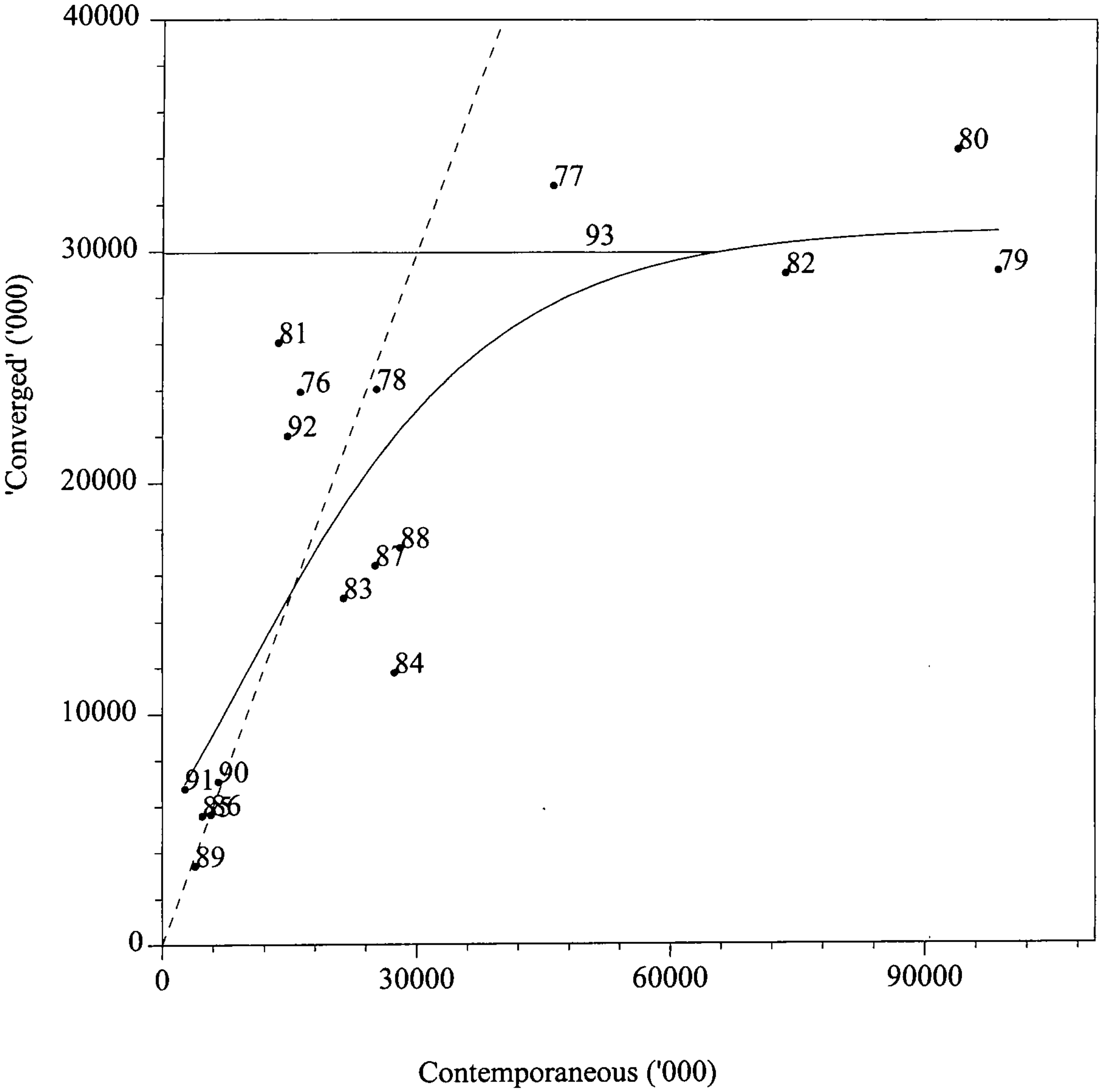
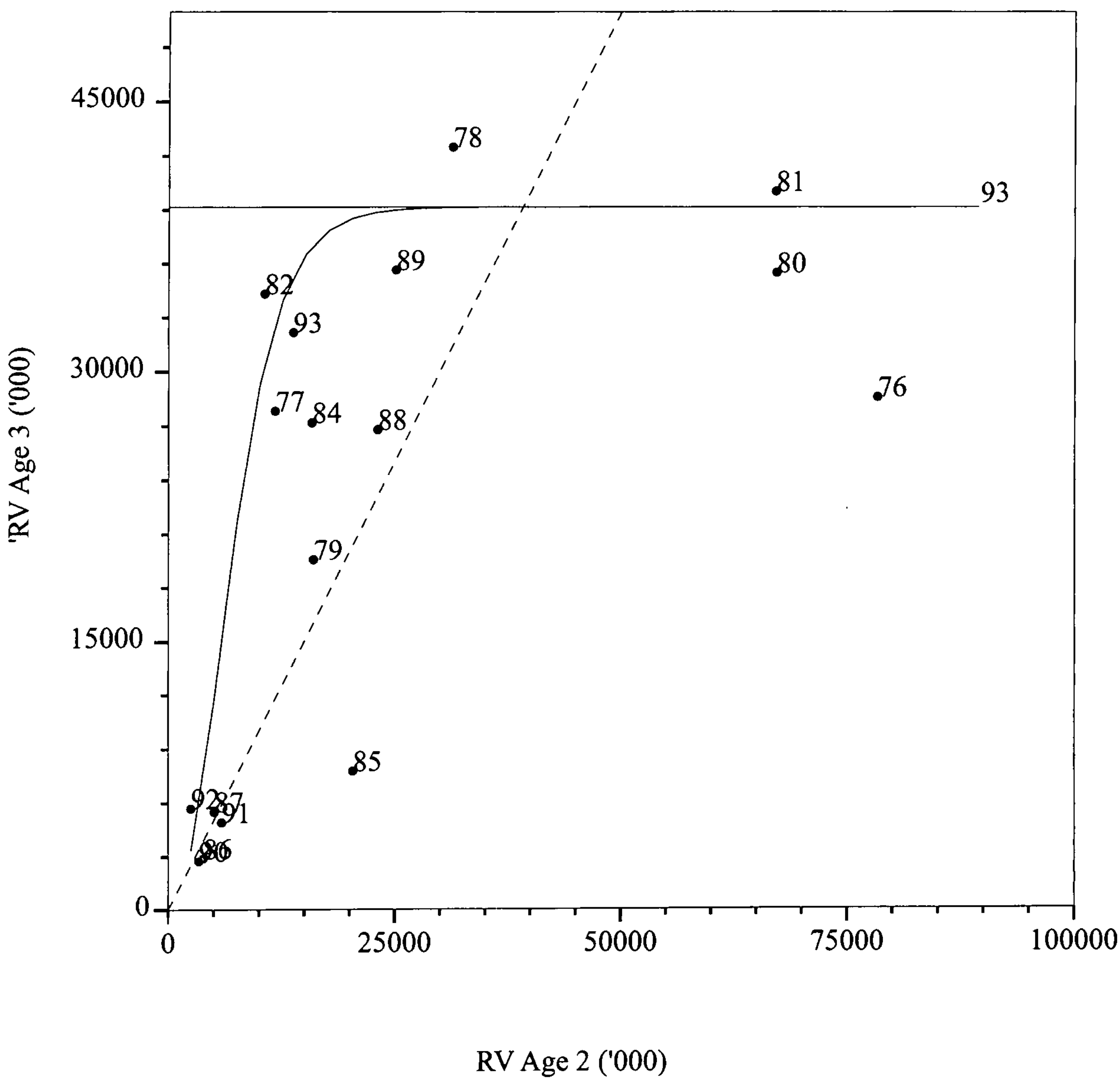


Figure 25. q scaled RV estimates of age 2 numbers versus age 3 corrected for m of 0.2. The solid line is a Gompertz fit and the dashed line is unit slope. The numbers denote yearclasses from 1977 to 1993.



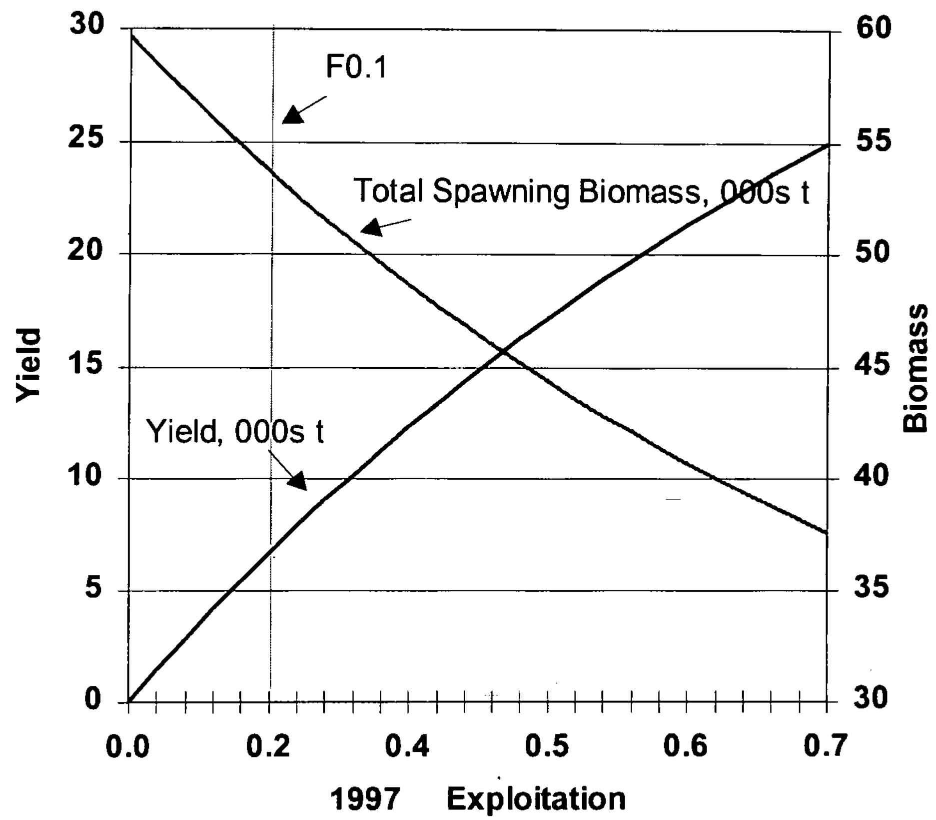


Figure 26. 4X haddock projection showing 1997 yield and total spawning biomass trajectories at exploitation levels from 0 to 70%. Vertical line is $F_{0.1}$ exploitation rate.