Department of Fisheries and Oceans
Canadian Stock Assessment Secretariat
Research Document 97/107

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 97/107

Ne pas citer sans
autorisation des auteurs[1]

Assessment of 4TVW Haddock in 1996

by

K.T. Frank, R.K. Mohn and J. E. Simon

Marine Fish Division
Maritimes Region, Science Branch
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

The 4TVW haddock fishery was essentially closed in 1994 with reported total landings of just over 100t. Strict by-catch restrictions were in place for those fisheries (such as flatfish) operating in the area in 1995 and 1996 resulting in total landings of 135 and 133t respectively. The year-round nursery ground closure (mainly Emerald and Western banks) imposed in 1987 remains in effect to present. Given the severely restricted nature of the fishery in the recent past, it is difficult to compare the distribution of landings by gear type with those of previous years.

Resumption of routine ageing for this stock has resulted in the application of the standard age-based population analysis (SPA) of the stock. Abundance estimates indicate the population is near to historic low levels. The 3+ biomass in 1996 is about 23,000t and the 5+ biomass is about 13,000t; the 3+ and 5+ biomass reflects the range of current spawning stock biomass. Recruitment estimates for the 1989 to 1993 yearclasses are below the long-term average of 28 million fish and this has contributed to the current low spawning stock biomass. The 1988 yearclass was the last large pulse of recruitment seen in this stock and with its gradual disappearance the stock is expected to continue to decline.

Substantial long-term declines in size at age are evident in haddock age 3 and older and size at age is at a minimum in the 1990s for ages 4 to 11 years old. The potential for fish to grow large in this haddock stock is currently quite low and at present very few fish in the stock are larger than 45 cm. Total mortality estimates derived from the July survey have been relatively stable since 1992 with an average of about 0.4. Total mortality should approximate natural mortality in a closed fishery suggesting the assumed level of natural mortality of 0.2 for this stock may be too low.

The short-term prospects for this stock are not encouraging although some improvement in recruitment has been seen in the most recent years in the summer survey series to near-average levels (1993 and 1994 yearclasses). These yearclass could contribute to stock rebuilding. However, the current growth, condition and reproductive potential of the stock appears to be quite low and the population may not respond as expected to a regime of little or no commercial exploitation.

Résumé

La pêche de l'aiglefin de 4TVW était essentiellement fermée en 1994, les débarquements signalés ayant tout juste dépassé 100 t. Des restrictions sévères ont été imposées aux pêches (comme celle des poissons plats) pratiquées dans cette zone en 1995 et 1996 et les débarquements totaux n'ont atteint que, respectivement, 135 et 133 t. La fermeture totale de la pêche dans l'aire de croissance (surtout les bancs Emerald et Western) imposée en 1987 est toujours en vigueur. Les restrictions sévères imposées à la pêche au cours des dernières années rendent difficiles la comparaison avec les années antérieures, les répartitions des débarquements par types d'engins.

La reprise de la détermination de routine des âges pour ce stock a permis de procéder à l'analyse de population standard fondée sur les âges (ASP). Les estimations d'abondance font état d'un niveau s'approchant des plus faibles niveaux jamais enregistrés. La biomasse des 3+ s'élevait à 23 000 t environ et celle des 5+ à 13 000 t environ en 1996; la biomasse des 3+ et des 5+ reflète la gamme de la biomasse actuelle des géniteurs. Le recrutement estimé des classes de 1989 à 1993 est inférieur à la moyenne à long terme, de 28 millions de poissons, et cela explique la faible biomasse actuelle des géniteurs. La classe de 1988 constitue la plus importante poussée de recrutement notée pour ce stock et sa disparition progressive devrait donner lieu à la poursuite du déclin du stock.

Des baisses appréciables à long terme de la taille selon l'âge sont évidentes chez les aiglefins d'âge 3+ et ce paramètre est à son minimum au cours des années 1990 pour les âges 4 à 11 ans. La probabilité que des poissons atteignent une taille importante au sein de ce stock d'aiglefin est assez faible et, actuellement, très peu de poissons présentent une longueur supérieure à 45 cm. La mortalité totale moyenne estimée obtenue du relevé de juillet est relativement stable, à 0,4 environ, depuis 1992. Cette mortalité devrait être équivalente à la mortalité naturelle lorsque la pêche est fermée, ce qui porte à croire que la mortalité naturelle supposée de 0,2 pour ce stock pourrait être trop faible.

La perspective à court terme n'est pas favorable bien que le recrutement se soit légèrement amélioré au cours des dernières années comme le démontrent les séries des relevés d'été qui indiquent des valeurs se rapprochant de la normale (classes de 1993 et de 1994). Ces classes annuelles pourraient permettre au stock de se rétablir. Par ailleurs, la croissance, l'état et le potentiel reproductif actuels du stock ne semblent pas prometteurs et la population pourrait ne pas réagir comme prévu à un régime de pêche commerciale peu importante ou nulle.

Introduction

Progress in assessing the stock status of 4VW haddock has been limited in the recent past by the absence of routine ageing for this stock (Zwanenburg et al. 1995). A significant bias in the ageing of haddock occurred in the 1980s resulting in under-ageing of fish at ages 4 and older. Completion of an age validation study and the establishment and implementation of verified and consistent ageing criteria has led to a resolution of the problem. Here we present an age structured assessment of 4VW haddock. The last age-based evaluation of this stock was presented by Zwanenburg (1992).

Previous age-based assessments of 4VW haddock were also plagued by the so-called "retrospective" problem. The inability to estimate fishing mortality in the current year was first noticed in the late 1980s (Zwanenburg 1990). At that time it was thought that the half year formulations of the adaptive framework may have been responsible for the anomalous retrospective estimates of fishing mortality. Alternative formulations were examined resulting in retrospective estimates of fishing mortality far in excess of what had been estimated in that year (Zwanenburg 1990). No satisfactory explanation for the retrospective pattern was evident and the results of the analyses were considered unreliable.

Despite the problems alluded to above there has been little doubt about the recent status of the 4VW haddock stock. The fishery for haddock in 4VW was virtually closed in September of 1993 and since that time strict by-catch restrictions have been placed on fisheries operating in the area. This resulted in total landings of less than 140 t in 1994 and 1995 compared to the 1980-1989 average landings of 11,400 t.

The Fishery

Description

The long-term (1960-1990) reported annual landings of haddock in NAFO Div. 4TVW have averaged about 14,000 t. During this period landings peaked twice, once during the 1960's when average landings were in excess of 26,000 t (peak of about 55,000 t in 1965) and again in the early 1980s at 20,000 t (**Table 1**). Throughout the modern history of the fishery (1954-present) greater than 50% of the catches have come from 4W by large otter trawlers with the exception being 1985 to 1988 when otter trawler catches predominated from 4Vs (**Table 2**). In general, landings from 4T and 4Vn have been relatively low compared to other areas since the mid-1960s with the possible exception of the mid- to late-1980s when landings increased in these areas (**Figure 1**). Since 1987 the fishery has been regulated through a combination of by-catch restrictions and trip limits. The fishery has been virtually closed since 1994 with landings from 1994-1996 averaging about 110 t. The 1996 conservation harvesting plans for the pollock, white hake, cusk, Atlantic halibut, and flatfish fisheries operating in 4VW have strict by-catch limits (**Table 3**).

A year-round nursery ground closure (mainly Emerald and Western Banks) established in 1987 remains in effect (**Figure 2**). Fixed gear vessels were permitted to fish inside the closed area from 1987-1992 and landings rapidly rose to a peak in 1992 of about 3400 t (**Table 4**). In 1993 the area was closed to all fishing and fixed gear landings in 4W fell to less than 700 t.

Given the severely restricted nature of the fishery in the recent past, it is difficult to compare the distribution of landings by gear type with those of previous years.

Age composition of the catch

Our goal has been to re-age the commercial samples back to 1985. For the present analysis we have new commercial ages from 1990 to 1996 only. Commercial groundfish samples were stratified for the estimation of landings at age as outlined in previous documents by Zwanenburg and Comeau (1991) and Zwanenburg (1992) for 1990 and 1991 (**Tables 5 and 6**) . In general, our objective was to create quarterly age length keys by division however inadequacies in sampling intensity did not allow for this breakdown.

For trawlers, landings at age by domestic gears were calculated on a quarterly or semi-annual basis by division. In 1992 semi-annual age length keys were created by division for the first half of the year. In the second half year a single age length key was generated for the two divisions (**Table 7**). In 1993 semi-annual age length keys were created with no division breakdown (**Table 8**). Given that sampling intensity was extremely low in the past few years (due to low catches) a single age length key was used for all landings in 1994-1996 (**Tables 9,10, and 11**).

For longline/miscellaneous landings in 1992, 1993 and 1995 a single annual age length key was applied (**Tables 7,9, and 11**). In 1994 and 1996 all longline/miscellaneous landings were applied to the trawlers age length keys in those years (**Tables 9 and 11**). A fixed gear sentinel survey is a source of haddock otoliths by longline for 1995 to 1997 that will be incorporated into future assessments of this stock.

Landings at age from the foreign small mesh gear fishery were estimated by applying summer research vessel survey age length keys to the length frequency estimates derived from samples of haddock by-catch in the small mesh gear fishery.

For the period 1985-1989 there is presently no commercial ageing and we therefore applied RV age length keys to the reconstructed commercial catch at length to generate the catch at age. Zwanenburg et al. (1995) used commercial sampling data to reconstruct the catch at length in the same manner that would be used to construct the catch at age for 1970 - 1994. These data are contained in Table 8 of Zwanenburg et. al (1995) and we use them for period specified above.

No re-ageing has been initiated on samples before 1985 and thus we use the catch at age back to 1970 contained in Zwanenburg et al. (1995).

Ageing/re-ageing

Approximately 7000 otoliths from the 1985-1996 research vessel surveys and 5000 commercial otoliths from 1990-1996 have been re-aged by the new BIO agers in the past year. Age-bias plots show no bias between the primary and secondary agers, and precision (CV) has reached levels of less than 5% which is considered very good for this stock. **Figures 3 and 4** show the age-bias plots for the research vessels surveys and commercial otoliths respectively. There was no bias when tested against the otolith reference collection (which is assumed to be of known age, given its ageing by international experts and bomb radiocarbon validation of similarly interpreted haddock otoliths) in Fall 1996 (**Figure 5**), when the re-ageing of historical otoliths commenced. However, bias was evident when the primary and secondary agers were tested against the reference collection again in Fall 1997 at the end of the re-ageing period (**Figure 6**). The magnitude of the bias was generally less than 1/2 year for the primary ager, but increased gradually to about 1 year at age 9 for the secondary ager. Given that about 80% of the otoliths were aged by the primary ager, it is unlikely that the accuracy of the RV or commercial catch at age has been noticeably compromised.

Commercial catch at age

The commercial catch at age for Div. 4TVW haddock is given in **Table 12**. The catch at age for 1970 to 1984 was taken from Zwanenburg (1989). The catch at age for 1985 to 1996 was based on the new ageing criteria. These data are displayed as the cumulative proportion of catch in terms of age for the 10th, 25th, 50th (median), 75th and 90th percentiles. The median age has shown a progressive increase since the mid-1970's up to 1990 (**Figure 7**). A reduction in the median age has occurred since 1990 although in the most recent years (1993-1996) the fishery has been either closed or severely restricted.

Research Vessel Surveys

There are two research vessel groundfish trawl surveys utilizing stratified random sampling designs for this stock: the July series which started in 1970 and a March series which began in 1979 (excluding 1985). The research vessel conducting the surveys has changed over time and species-specific catch conversion factors for the vessels involved are contained in Fanning (1985). All data presented herein have been adjusted accordingly. The stratification scheme used in the March survey was revised in 1986 to improve the statistical efficiency of the estimates. The stratification scheme used in the July survey is shown in **Figure 8**.

Age-aggregated indices

Numbers and weight per tow from both survey series have tracked declines in abundance since the late 1980s (**Figures 9 and 10**). Both the number and weight per tow for the spring survey have been below average since 1990. In the summer survey, both number and weight per tow have been below average since 1991 with the exception of 1996 when the number per tow was above average. Minimum trawlable biomass estimates by division reveal that throughout the history of the summer survey haddock have been most abundant in 4W (**Figure 11**). Only during the mid-1980s was there any appreciable biomass of haddock in 4Vs and 4Vn (approximately 25% of the total biomass). After 1988 the occurrence of haddock in 4Vs and 4Vn dropped to very low levels and has remained low since that time (**Figure 11**).

Certain strata within Div. 4VW show consistently high mean numbers per tow, particularly those (strata 454- 458 and 463-465) associated with the offshore banks in Div. 4W (**Table 13**). These strata contain Emerald, Western, Sable Island and Middle banks. When grouped by six year time blocks (**Figure 12**) it is clear that across all time blocks high concentrations of haddock have been seen in strata 463-465 (Emerald/Western bank) and in four out of five time blocks haddock concentrations were evident in strata 454-456, 458 (i.e. the Sable Island bank area and Middle bank). The geographic distribution of the stock was most expansive during 1982-87 with haddock concentrations evident on Banquereau bank and the Gully (**Figure 12**).

Condition factors

Predicted weight at the pre-recruited and recruited lengths of 30 and 45 cm respectively were determined for Div. 4VW haddock collected during the summer RV survey (**Table 14**). Predicted weight of pre-recruits was highly variable from year to year and since 1994 it has been below average. There was no apparent time-dependent trend in condition of the pre-recruits from 1970 to present ($r = -0.35$, $n = 28$, $p > 0.05$).

Predicted weight of recruited haddock has been below average since 1983 with the exception of 1987 when the value was slightly above average (**Figure 13**). In the most recent survey (1997) the condition was higher than in the previous four years but remained below the long-term average. In contrast to the pre-recruits, the recruited sizes showed a significant trend in condition, declining over the period 1970 to 1997 ($r = -0.69$, $n = 28$, $p < 0.01$). Predicted weights of recruited haddock from the spring RV surveys showed a similar temporal decline although these fish generally weighed less (25-50 g) relative to fish from the summer RV.

It should be noted that the predicted weights of pre-recruited and recruited haddock are very similar from year to year between Division 4V and 4W.

Catch at length

Figure 14 shows the cumulative proportion of the catch in terms of length for the 10th, 25th, 50th (median), 75th and 90th percentiles from 1970-1997. The median size has generally ranged from 30 - 40 cm but in recent years has declined to below 30 cm (**Figure 14**). The occasional drop in the lower percentiles for some years reflects the entry of large yearclasses into the population, notably in 1981 and 1989 when the large 1980 and 1988 yearclasses were becoming available to the survey. In the 1990s the distance between the 10th and 90th percentiles is reduced relative to earlier years which reflects a shrinkage in the size structure of the population. The 90th percentile has fallen since the mid-1970s suggesting a reduction in the quantity of larger fish in the survey (**Figure 14**). The data associated with this analysis is contained in **Table 15**.

Age-specific indices

The stratified mean catch rates at age for Div. 4VW haddock from the summer survey are shown in **Table 16**. These data represent the end product of the intensive re-ageing/aging effort of samples from the 1985-1996 surveys. The remainder of the time series of catch rate at age (1970-1984) was based on historical ages. The coefficients of variation associated with the catch rate at age generally range between 20-40% for ages 2-8 (**Table 17**) with the exception of 1988. In this year the largest catch of haddock in the entire time series was made in relatively shallow water north of Sable Island in stratum 456.

It is evident from **Table 16** that the age structure of the stock has not collapsed despite the low levels of age 3+ haddock. As was done previously for the commercial catch at age and the summer survey catch at length, **Figure 15** shows the cumulation proportion of catch in terms of age for the summer survey. The median age has been quite variable reflecting the entry of new yearclasses into the population whereas the 90th percentile has shown a gradual increase since the mid-1980s.

Recent recruitment, based on the sum of the catch rates at age 1 and 2 for each cohort, is near average and slightly below average for the 1993 and 1994 yearclasses respectively (**Figure 16**). The yearclasses preceding these most recent years (1989-1992) were well-below average which, in part, explains the below average catch rates of older haddock (3+) observed since 1992 (**Figure 16**).

Cohort tracking

A concern of any survey is its ability to track the progression of a yearclass. A further concern for 4VW haddock is the continuity of the survey catch at age based on the new and the old ages. Two approaches were taken to evaluate this situation: graphical and statistical. The graphical approach was based on visual inspection of a contour plot of the number per tow by age and year from the summer survey (**Figure 17**). One of the features of this plot is the appearance and progression of three large yearclasses in the mid-1970s, early 1980s and late 1980s having similar slopes. The progression of the large 1980 yearclass (which spans the old and new ageing) suggests a seamless joining of the two data series. A contour plot of the data contained in the previous age-based evaluation of this stock (Zwanenburg 1992) which utilized incorrect ageing criteria shows quite clearly the failure to track the progression of the strong yearclasses in the 1980s (**Figure 18**).

The statistical approach used to evaluate cohort tracking was to examine the relationship between yearclass estimates at successive ages in the survey. A cross section of plots are shown in **Figure**

19 showing the relationship between ages 1 and 2, ages 2 and 3, ages 3 and 4, and so on. A correlation table (**Table 18**) contains the full matrix of correlations (r^2 in this case) for all ages. The general conclusion is that the survey does well at tracking yearclasses - a fundamental assumption of cohort analysis.

Total mortality

Total mortality estimates (Z's) derived from the summer survey show high, year-to-year variability (**Figure 20**). This makes it difficult to draw firm conclusions about trends in the data. However, total mortality estimates have been relatively stable since 1992 with an average of about 0.4. Total mortality should approximate natural mortality in a closed fishery. If this estimate is correct, then the assumed level of natural mortality of 0.2 for this stock maybe too low. Further research is required to determine the validity of the current estimate.

Growth: Mean length at age

The data thus far presented suggest a decline in the growth rate of 4VW haddock given the relative stability in the age structure of the stock and the corresponding reduction in the size structure. Mean length at age from the summer survey showed no apparent trends in size of age 0-2 haddock since 1970 (**Table 19**, **Figure 21**). However, substantial long-term declines in length at age become increasingly apparent at age 4 and older (**Figure 21**). For ages 6 and older a substantial drop in the length at age occurred between 1984 and 1985 and this coincides with both a shift in age readers and methodology associated with otolith preparation prior to reading. To determine if differences in ageing accuracy contributed to the apparent declines in growth rate, a matched pair comparison of sectioned vs. cracked 4VW haddock otoliths will be carried out. If bias between the two preparation methods is absent, then one of the pre-1983 cracked otolith samples will be re-aged and compared with the original reading to determine if the historical ages are accurate. If for the moment we confine our analysis of length at age variation to the post-1984 period there are statistically significant temporal declines in all ages group (age 3-11) with the exception of age 2 (range of r across ages: -0.62 to -0.92, n=12).

If we consider the pre-1985 data alone there was evidence for statistically significant temporal declines in length at age for ages 4-6, with age 6 being close to statistical significance (**Figure 21**). In addition, McCracken (1961) reported reductions in mean length at age of about 10 cm for ages 5-8 during the period 1948-1959.

Mean length at age data for cod and haddock in overlapping and adjacent stocks was compared to Div. 4VW haddock in an attempt to evaluate the spatial scale of changes in growth (i.e. is the reduction in size at age isolated to haddock in Div. 4VW or are size changes evident over a broader scale and across species?). **Figure 22** presents mean length at age data for ages 5-8 for cod in Div. 4Vs and 4W and Div. 4X haddock (broken into two parts: Scotian Shelf and Bay of Fundy). Reductions in length at age were evident between 1980 and 1990 for 4X (Scotian Shelf) haddock but not for the Bay of Fundy. Cod from Div. 4W exhibited a temporal decline in size similar to that of 4VW haddock, particularly for ages 5 and 6, whereas the cod in 4Vs exhibited a somewhat more variable decline in size at ages 5-7. Div. 4TVn cod mean length at age data is presented in **Figure 23**. These data show a temporal decline in size at age similar to that of Div. 4VW haddock over the entire time series. Taken together, the evidence for a decline in size at age (and possibly growth rate) of haddock and cod across the Scotian Shelf and southern Gulf of St. Lawrence is compelling.

Maturity

Maturity data for female cod was derived from the spring RV survey. Fish were assigned to the category mature or immature based on the 8 point criteria used by the Marine Fish Division, Maritimes Region. The first stage of this scheme is classed as immature and all other stages are classed as mature showing some evidence of maturing to spawn or of having spawned. Estimates of proportion mature at length were produced for each year (**Figure 24**). Because there is only sporadic haddock ageing data associated with this survey series, direct determination of age at maturity was not possible. A time series of L_{50} mature developed from the spring RV survey shows that the length at 50% maturity has declined by about 20% since 1990 (**Figure 25**). Prior to 1990, lengths at 50% maturity were generally greater than 42 cm (corresponds to a haddock 5 to 6 years old based on length at age data from the summer RV) with the exception of 1984 when the value dipped below this level. The recent estimates of lengths at 50% maturity are less than 36 cm (corresponds to a haddock 3 years old based on length at age data from the summer RV) which is below the widely assumed length of 50% maturity of 43 cm.

Preliminary estimates of length-specific fecundity are available from an on-going study of fecundity of 4VW haddock collected during the 1997 spring RV survey. Out of a total of 200 fish about 50 have thus far been processed. The relationship between fecundity and length shows considerable scatter and when compared to the published relationship between fecundity and length derived for 4X haddock from 1983 to 1985 (Waiwood and Buzeta 1989) most of the values fall below the predicted line (**Figure 26**). If the 4X relationship is a valid reference point then it suggests that the size-specific fecundity of 4VW is considerably lower. This situation could be related to below-average condition that is characteristic of recruited size haddock in recent years (**Figure 13**).

Sentinel Survey

Fixed gear sentinel surveys were carried out in the fall of 1995 and 1996 in Div. 4VW. Standardized longline sets of 1500 hooks (#12 circle hooks) were distributed throughout 4VW using the summer stratification scheme with the exception that 4Vn was not sampled. Also, three inshore strata were added to the survey shoreward of the 50 fathom isobath (strata 467, 468 and 469).

The survey caught 6335 and 7472 kg of haddock in 1995 and 1996 respectively. The number of successful sets was 221 in 1995 and 252 in 1996. The stratified mean catch rates were nearly identical between years (26kg in 1995 vs 22 kg in 1996) and most of the catch originated from those strata associated with the closed area (**Table 20**). The catch per set distributions depicted as expanding symbols are shown in **Figure 27**. The distribution patterns were very similar for both years with haddock catches concentrated on Emerald, Western and Sable Island banks. Some concentrations were evident in the Gully and along the edge of Banquereau. There were almost no catches inshore and over most of 4V. In both years, sentinel catch rates were high at the western boundary of the survey grid, suggesting that the survey may not have fully resolved that aggregation of haddock in this region. In comparison to the recent DFO July RV surveys the sentinel survey results are very similar with the possible exception of the concentrations of haddock seen on Middle bank during the July RV (**Figure 28**). This difference was not a result of concentrations of small fish in the Middle bank region.

Length frequencies from the 1995 and 1996 sentinel surveys were very similar and are shown in **Figure 29**. The median lengths from the two surveys were nearly identical at 43-44 cm. About 5% of the fish caught were smaller than 37 cm and only 10% of the fish caught were greater than 48 cm. These patterns reflect the selection characteristics of the gear and the availability of fish in the survey area. For comparison, the length composition of haddock from the recent July RV surveys is shown in **Figure 30**. Obviously the RV survey catches smaller haddock than the sentinel survey but in either case few fish larger than 47 cm were present.

Industry Consultations

Recently, industry has been questioning the efficacy of the closed area in Div. 4W suggesting that larger fish are moving away from the area to Div. 4X. This prompted a request by the Fishermen and Scientists Research Society for a review of the historical haddock tagging data from the Scotian Shelf. The presentation of this information was given to the FSRS during a March 1997 workshop in Dartmouth. These data did not suggest a directed movement of adult haddock from 4W to 4X. However, this conclusion may not be pertinent to the current situation given that most of the historical tagging from 4W was conducted before 1970.

The recently completed 1997 sentinel survey appears to have yielded much fewer haddock than the 1996 and 1995 sentinel surveys. Participants in the survey suggested that catches were about 1/3 of the previous years and disappointment was expressed in not being able to find fish given that the fishery has been closed since 1994. Seals have been implicated as the cause and the suggestion that haddock are moving to 4X also remains a possibility in the minds of the industry. What remains of the 4VW haddock resource is concentrated in 4W and some fishermen have given up on Banquereau. When asked about the possibility of a significant illegal fishery that could account for the lack of recovery the industry response was that this was highly unlikely.

The information on size at age and cohort tracking presented earlier suggests that haddock remain within the stock area and grow older but not larger.

Biological observations made during the sentinel surveys indicated the predominance of small fish with the few larger fish encountered being in relatively poor condition. It has also been observed that many of the small haddock appear to be mature.

Ocean Climate Conditions

Bottom water temperatures on the eastern Scotian Shelf remained cold in 1996, continuing a trend that has persisted since the mid-1980s. The only notable exception lay in the vicinity of Emerald Basin where warm slope water continued to keep near-bottom temperatures higher than average (Drinkwater et al. 1997). For 1997, bottom temperatures recorded during the July RV survey in Div. 4VW were simlar to those in 1996.

Stock Assessment

Estimation of parameters

The traditional age-based population analysis was performed for this stock using ACON software to fit the model which is described as:

Parameters:

Terminal F estimates -- $F_{i,\,1996}$, i = ages 2 to 9
Calibration coefficients -- q_i, i = ages 2 to 8 for the July RV survey

Structure imposed:

Error in catch assumed negligible
Partial recruitment fixed for ages 1 and 10 in year 1996
No intercept was fitted
M = 0.2 for all ages

Input:

$C_{i,t}$ i = 1 to 11; t = 1970 to 1996 Catch at age
$J_{i,t}$, i = 2 to 8; t = 1970 to 1996 July RV index

Objective function:

Minimize: $\Sigma\Sigma\{\ln J_{i,t} - \ln q_i N_{i,t}\}^2$

where $N_{i,t}$ is population numbers at age i and year t

Summary:

Number of observations: 189 from July RV
Number of parameters: 15, F's estimated by NLLS, q's algebraically

Results

The diagnostic statistics from ADAPT are given in **Table 21**. The coefficient of variation on the terminal F's range from 32 to 78% with the youngest ages having the highest CV's. This is not an unexpected pattern given that this is a closed fishery and catches have been very low in recent years. The bias estimates for the terminal F's are high for the youngest ages (2-4) and relatively low for ages 5 to 9. Because the estimates of the terminal F's are so low (range: 0.0024-0.0064) no bias correction was deemed necessary. The coefficient of variation on the calibration coefficients were also low and had small (< 3%) biases. The estimates of stock status were not corrected for these small biases.

The SPA results indicated that the population is near to historic low levels (**Tables 22 and 23**). The biomass in 1996 of 3 year old haddock and older (3+) is about 23,000t and the 5+ biomass is about 13,000t (**Figure 31**); the 3+ and 5+ biomass reflects the range of current spawning stock biomass. The estimate of recruitment for the 1993 yearclass is below the long-term average of 28 million fish. Unfortunately, recruitment has been below average since 1985 with the exception of the 1988 yearclass (estimated at age 1 in 1989). These persistent low levels of recruitment seen in this stock has contributed to the current low spawning stock biomass.

High exploitation levels seen in the early to mid- 1970s reflect the fact that the fishery was unregulated and in 1974 catch quotas were first imposed on this fishery. Fishing mortality rates (average of ages 5 to 11) have been low since 1987 (**Table 24**) coinciding with the establishment of the year round nursery ground closure and the by-catch nature of the fishery since that time. F increased up to 1992 reflecting the expansion of the fixed gear fishery inside the 4W closed area. With the removal of all fishing activity from the closed area in 1993 and a closure of the fishery in 1994, exploitation has fallen to the lowest observed since 1970. Also, trends in total mortality from the summer survey alone (**Figure 20**) and fishing mortality derived from the SPA are generally consistent, although the increase in the early 1990s from the survey estimate is more pronounced.

Previous assessments of Div. 4TVW haddock (Zwanenburg 1989, Zwanenburg et al. 1995) have exhibited significant retrospective patterns. This is the situation where fishing mortality in the current year is significantly underestimated and population abundance is overestimated, relative to estimates utilizing subsequent years of data. A retrospective analysis was carried out by sequentially dropping off a year of data and re-running the SPA. The results of this analysis indicated that biomass is not overestimated in the current year (**Figure 32**) and that fishing mortality in the current year is not significantly underestimated (**Figure 32**). However, there were patterns in the retrospective analysis throughout the 1980s indicative of years when the model did not fit the data very well. These year-effects are evident in the residual plot (**Figure 33**) and associated table (**Table 25**).

The relationship between parent stock and subsequent recruitment, based on the SPA results from 1970 to 1995, reveals several important features (**Figure 34**). During the 1970s when spawning stock biomass was very low, gradual rebuilding of the stock occurred because of the production of above-average yearclasses in the late 1970s. Both recruitment and spawning stock biomass levels increased up to the early 1980s. This pattern began to change in the mid-1980s when below average yearclasses were associated with high spawning stock biomass levels. Low recruitment has contributed to reduced spawning stock biomass levels, but as yet there has been no evidence of rebuilding as had been seen during the mid- to late 1970s.

The population analysis (SPA) presented here, using the new catch at age and survey catch at age data based on the new ageing criteria, has resulted in a considerable improvement in the fit of the model to the data over that of previous analyses. However, the historical representation of the resource generated by the current analysis deviates substantially from previous such analyses. For example, while trends in historical exploitation are similar, their magnitude is substantially different with exploitation levels resulting from the previous analyses being much higher during the 1980s and early 1990s (**Figure 35**). During this same time period the population numbers are also different, with the current analysis generating estimates of historical population numbers that are double those seen in past analyses. The causes of these difference are not fully known, however as indicated repeatedly throughout this document the input data to the present analysis has changed for the period 1985 to present. The catch at age in the present analysis has a greatly expanded age range in the population compared to the previous ageing criteria used to generate the catch at age. Further re-ageing of historical material (ie. commercial otoliths from 1985-1989) is also required .

We also conducted an SPA run with the post-1985 input data alone (**Figure 36**). The 3+ biomass and fishing mortality pattern from this abbreviated data series were visually indistinguishable from the SPA based on the entire data series (1970-96).

For these reasons the historical view of the haddock resource generated by the current population analysis should be considered an interim step until further work is completed to address the discrepancies alluded to above.

Precautionary Approach

There has been increasing interest recently in applying the precautionary approach to Canadian stocks. In order to gain familiarity with this method, preliminary runs were made using data obtained from the Div. 4X and 4TVW haddock stock. The first purpose of these trials was to develop the appropriate software. The second, and more important objective, was to begin to manipulate and hence develop an understanding for the new and evolving ideas of the precautionary approach. Two symposia were held in 1997 attempting to develop a framework to carry out precautionary analysis: the ICES Study Group on the Precautionary Approach to

Fisheries Management (Copenhagen, Feb. 1997) and NAFO Scientific Council (June, 1997). We expand their work by including more of the non-equilibrium implications and develop a broader definition of risk analysis than is usually done.

Traditional risk analysis incorporates the quantifiable uncertainty in the SPA and its effect on stock projections (**Figure 37**). The upper plot in **Figure 37** shows the probability that the spawning stock will fall in the next 3 years as function of removals. Because of the conservative assumption about incoming recruitment (9.5 million which is the GM from 1985 - 93), the spawning stock is expected to decrease irrespective of the removals. The lower plot shows the cumulative probabilities that the target F will be exceeded for 1997 to 1999.

Precautionary analysis is based upon the integration of traditional yield per recruit analysis, which has been used to define such targets as $F_{0.1}$, and stock-recruitment models. The basic approach is a family of curves which are interrelated based on the work of Sissenwine and Shepherd (1987). These sets of curves are a convenient way to display the importance of the underlying biology of a stock as well as fishery management concepts. The Sissenwine and Shepherd (1987) plots are shown in **Figure 38** for 4VW haddock. The three subplots on the left are all functions of fishing mortality. The two subplots a) and b) are the traditional yield and (spawning stock) biomass per recruit relationships. In this case, we used the Thompson-Bell method to estimate the yield and biomass per recruit. The center plot of the right-hand set (e) of three subplots is a Ricker stock-recruit function. The data to which it has been fit is included in this subplot. The stock-recruit curve and the points are mapped onto the subplot above (top-right) by dividing the biomass at each point by its recruitment; this is done so that the y-axis of the two uppermost plots will be the same which allows a link to be made between the left-hand figures and those on the right. Once this link is made the yield per recruit results can be transformed onto yields because at each level of F there is an accompanying recruitment. The equilibrium yields for each F (or SSB) are then plotted on the lowermost set of subplots, c) and f). The historical yields are plotted in f) for comparison with the equilibrium yields.

The sensitivity of the various values to underlying data are explored in **Figures 39-41**. In **Figure 39** the partial recruitment used in the base run is from the VPA (**Tables 22 and 24**) and it is shifted so that one years age younger fish are caught and the oldest age are fully recruited. The yield per recruit curve is shifted downward while the biomass per recruit, a), is higher. The most dramatic effect is in subplot c) where the yield now crashes at an F of 1.2 as opposed to base run Fcrash which is greater than 2.5. The yield as a function of biomass, f), is only slightly affected. In Figure 40 the maturity ogive is shifted one year older, i.e., instead of 3 year olds being mature the age is now 4. The biomass per recruit is reduced a) but yield per recruit, b) is unaffected. Fcrash is sensitive to the age of maturity. MSY and BMSY, the location of the peak of the yield curve in f) are both slightly reduced when the age of maturity is shifted one year older.

The linkage among the subplots is dependent upon the function which fits, or models, the relationship between stock and recruitment data. To make them more intuitive, we have reparameterized the Ricker relationship in terms of the maximum recruitment and the biomass which corresponds to that recruitment and call the new parameters RMax and BMax. The usual a and b of the Ricker curves are then:

a = exp(1) * RMax / BMax

b = 1 / BMax

Figure 41 shows the sensitivity to a change in RMax from the base value of 35 to 22 million. Both yield curves, c) and f), are seen to be quite sensitive to RMax. Because the stock-recruit relationship is quite noisy (**Figure 38a**) the fit of these data was investigated using conditioned bootstrapping. Briefly, the residuals from the base run are re-sampled and added to the fit data to make replicate data sets. The data are limited to 24 pairs and there are only 2 parameters in the model making a large number of replicates easily performed; 5000 were used for this analysis. The resultant Rmax and Bmax's are shown in **Figure 42** as contours. The darkest region is the area which contains the most frequent 25% of parameter pairs.

By re-sampling the distribution of the Ricker parameters, estimates of the uncertainty in various precautionary parameters may be found. For example, **Figure 43** shows the cumulative distributions of MSY and BMSY that may be attributed to the lack of fit of the stock and recruit data to the Ricker curve. For example, while the best estimate of MSY is about 15 KT, there is about a 10% chance that MSY is less than 10 KT. The distribution of BMSY is shown in the lower plot of Figure 43 and has a similar distribution. Similarly, cumulatives for Fcrash, the carrying capacity or other reference or limit points could be calculated.

Figure 44 focuses on applying the precautionary approach to the 4VW stock; it is comprised of enlarged subplots e) and f) from the base run. Ellipses have been added to the stock and recruit data to show the approximate uncertainty in their estimation from the SPA. The axes of each ellipse are the standard deviation in each dimension, assuming them to be independent. In reality the axes would be correlated and the ellipses tilted, but we have not included this figure. In some sense this plot may be thought of as a comparison between the measurement error (the size of the ellipses) and process error (the distance from the center of each ellipse to the stock-recruit curve). As expected, the most recent ellipse is the largest and they decrease as one goes back in time. The uncertainties portrayed as ellipses are the uncertainties which are used to produce the risk analysis plot (**Figure 37**).

Figure 45 explores a potential precautionary plot with limit and precautionary values from 4VW haddock. Blim is arbitrarily set from the stock and recruitment data as a lower limit of SSB in that there are no observations of recruitment at this level since the mid-70s. BMSY is used as Bpa, the precautionary level of biomass below which a more conservative fishing mortality (and yield) are imposed. Flim is set at F0.1 (= 0.26) and Fpa is set at half of F0.1. Although only an illustration, such a plot could be used for defining criteria for re-opening the fishery and setting catch levels while the stock is rebuilding.

The analysis in preparation of a precautionary approach allows direct inclusion of the reproductive dynamics of the stock. We have assumed in these examples that the stock recruitment relationship is stationary - does not change over time. However, the data for 4VW haddock would suggest that since the mid-80's the stock was not as productive as before. An extension of these analyses which incorporates changes in productivity should be undertaken.

Traditional risk analysis has only incorporated the errors which could be quantified from the SPA. When these are compared to the difficulty in determining a stock-recruit relationship which is needed in the precautionary analysis presented above, they are seen to be only one, relatively small, aspect of uncertainty and hence risk. More work should be directed at combining all quantifiable sources of uncertainty.

Outlook

The short-term prospects for this stock are not encouraging. The adult population biomass is presently low and recruitment has been below average since the mid-1980s with the exception of the 1988 yearclass. Some improvement in recruitment has been seen in the most recent years in the summer survey series to levels only slightly below average (1993 and 1994 yearclasses). These yearclasses could contribute to stock rebuilding. However, the current growth, condition and reproductive potential of the stock appears to be quite low and the population may not respond as expected to a regime of little or no commercial exploitation. It is expected that the stock will decline given recent low recruitment levels and the disappearance of the last large yearclass produced in 1988. A reversal of recent changes in the ecosystem of the eastern Scotian Shelf that have occurred, such as the significant cooling of the bottom waters (Drinkwater et al. 1997), increases in capelin (Frank et al. 1996) and shrimp (Roddick 1995) stocks, and the collapse of cod in the area (Fanning et al. 1995), may be necessary for improvement in the status of the Div. 4TVW haddock stock.

Acknowledgements

Enormous credit is due to the efforts of Jim Simon (one of the authors of this document) and Diane Beanlands who performed an incredible feat of ageing/re-ageing of over 14,000 otoliths in less than a year. The shear volume of material examined and the consistently high accuracy and precision of their work represents an outstanding achievement. Steve Campana also deserves special thanks for two reasons: overseeing the development and implementation of the Div. 4TVW haddock ageing protocol and as chairman of the cod, haddock and flatfish (CHF) working group. We also thank the CHF working group members for their critical feedback on this assessment. In addition, we thank A. Sinclair for providing the length at age data for Div. 4TVn cod and P. Fanning for compiling and plotting the data on length at age contained in Figure 22 and for conducting an extremely thorough internal review of this document.

References

Anon (1997a) Report of the Study Group on the precautionary approach to fisheries management. ICES CM 1997/Assess:7

Anon (1997b) Report of the Ad hoc Working Group on the NAFO Scientific Council on the precautionary approach. F. Serchuk, D. Rivard, J. Casey and R. Mayo, eds. NAFO SCS Doc. 97/12.

Drinkwater, K.F., R. Pettipas and L. Petrie. 1997. Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1996. DFO Can. Stock Assess. Sec. Res. Doc. 97/62. 27 p.

Fanning, L.P. 1985. Intercalibration of research survey results obtained by different vessels. CAFSAC Res. Doc. 85/3. 43 p.

Fanning, L.P., R.K. Mohn and W.J. MacEachern. 1995. Assessment of 4VsW cod in 1994 with consideration of ecological indicators of stock status. DFO Atl. Fish. Res. Doc. 95/73. 29 p.

Frank, K.T., J.E. Carscadden and J.E. Simon. 1996. Recent excursions of capelin (*Mallotus villosus*) to the Scotian Shelf and Flemish Cap during anomalous hydrographic conditions. Can. J. Fish. Aquat. Sci. 53: 1473-1486.

McCracken, F.D. 1961. Haddock growth changes 1948-59 on Nova Scotia banks. Fish. Res. Board Can. Annu. Rep. (Biol. Stn., St. Andrews, N.B.) 1960-61: 96-98.

Roddick, D. 1995. Status of the Scotian Shelf shrimp (*Pandalus borealis*) fishery 1994. DFO Atl. Fish. Res. Doc. 95/22. 24 p.

Sissenwine, M.P. and J.G. Shepherd. 1987. An alternative perspective on recruitment overfishing and biological reference points. Can. J. Fish. Aquat. Sci. 44:913-918.

Waiwood, K.G. and M.-I. Buzeta. 1989. Reproductive biology of southwest Scotian Shelf haddock (*Melanogrammus aeglefinus*). Can. J. Fish. Aquat. Sci. 46 (Suppl. 1): 153-170.

Zwanenburg, K. 1989. Assessment of 4TVW haddock with catch projections to 1990. CAFSAC Res. Doc. 89/64. 36 p.

Zwanenburg, K. 1990. Haddock on the eastern Scotian Shelf 1990. CAFSAC Res. Doc. 90/92. 37 p.

Zwanenburg, K. and P. Comeau. 1991. Haddock on the eastern Scotian Shelf 1991. CAFSAC Res. Doc. 91/47. 43 p.

Zwanenburg, K. 1992. An assessment of eastern Scotian Shelf haddock for 1992. CAFSAC Res. Doc. 92/39. 42 p.

Zwanenburg, K., G.A.P. Black and G. Young. 1995. Haddock in Division 4TVW in 1994. DFO Atl. Fish. Res. Doc. 95/112. 69 p.

Table 1. Nominal catches (t) of eastern Scotian Shelf haddock (4TVW) by NAFO Division and country.

	4T					4Vn					4Vs					4W						
Year	Can.	USA	USSR	Spain	Other	Can.	USA	USSR	Spain	Other	Can.	USA	USSR	Spain	Other	Can.	USA	USSR	Spain	Other	Total	TAC
1954	5918	1044			40	5549	405		1058	24						12323	1956		17		28334	
1955	3101	31				3339	450		1183	13						12777	1217				22111	
1956	2861					4899	147		1350	12						18273	1661		354		29557	
1957	1740	1				5869	120		747	9						19960	1533		132		30111	
1958	2599			151		3166	71		1343	6						17572	427		1593		26928	
1959	2996	1		64		1594	159		69		3456	111		2870		21156	4804		640		37920	
1960	2041					1317	6		97		1187	18		3926	1	20093	127		1024		29837	
1961	1297			273	2	1055	1		47	1	846			1526	7	22277	23	151	1441	16	28963	
1962	1132			10		1097	1		5	2	1235			1076		15566	51	2567	3224		25966	
1963	1019			46		1213	1	6	64		1061	1		2828	195	11002	60	3295	4915	866	26572	
1964	461			1		958			59	52	677	11		2057	2	9810	42	4391	2884	1889	23294	
1965	432			3	3	402			53	84	1201			1806	47	7007	8	42876	1500	96	55518	
1966	149			1		311		516	30		1494			940	9	8259	19	9985	1885	51	23649	
1967	112			9		203		95	26	31	898			839	9	7180	5	459	1046		10912	
1968	144				4	127			70	6	1128		59	1702	23	8392		195	1458	10	13318	
1969	167				3	245				112	726			631	66	8270		235	864	1	11320	
1970	160					395	2		75	1	620		34	830	16	4754	574	636	1332		9429	
1971	151					466			215	1	1133		11	1114		7940	497	464	1477		13469	
1972	60					362	3		136	19	421		3	599	37	2096	70	103	737	102	4748	
1973	21				2	286			76	164	233			431	9	2830	173	76	95	18	4414	
1974	17				14	161			3	1	147		30	174	196	907	6	102	521	78	2357	0
1975	35				2	67			15	4	107	1		48	3	1393	20	52	63	59	1868	0
1976	12					40				1	52	1	9		1	1198	31	15			1360	2000
1977	8					189				8	144				1	2845	1	14		38	3248	2000
1978	18					119				3	441		3		38	4949	82	139		109	5901	2000
1979	59					194				11	650				2	2339		104		73	3433	2000
1980	81					188				42	1841					12448		209		31	14840	15000
1981	177					119				25	1796					17684		187		21	20009	23000
1982	47					183				23	2373					12498		53		49	15226	23000
1983	30					206				17	1542					7302		149		166	9412	15000
1984	120					299				11	3195		2		1	3992		168		233	8021	15000
1985	498					598				59	7291				2	2862		275		79	11664	15000
1986	531					904				17	8798				4	6277		312		78	16921	17000
1987	438					484				13	1587					994		207		154	3877	0
1988	369					507					2057					1176		332		99	4540	0
1989	79					421				2	3099					3580		1754		177	9112	6700
1990	30					108					2427					4077		265		97	7004	6000
1991	18					50					972				1	4001		292		59	5393	0
1992	9					27					776					5261		42		116	6231	0
1993	4					11					435					824		27		50	1351	0
1994	0					9					35					47		0		12	103	0
1995	0					1					57					51		0		26	135	0
*1996	0					1					33					60		0		39	133	0
*1997	0					0					10					9		0		22	41	0

Between 1954 and 1958 catches for 4Vn and 4Vs were combined as 4V.
* Provisional data

Table 2. Canadian nominal catches(t) of eastern Scotian Shelf haddock (Div. 4TVW) by gear.

YEAR	Otter trawlers	Danish/Scottish Seine	Longline/ Handline	Miscellaneous	Total
1960	22643	33	1398	564	24638
1961	23537	80	875	983	25475
1962	17402	108	960	560	19030
1963	12836	189	803	467	14295
1964	11065	87	72	682	11906
1965	8417	76	355	194	9042
1966	9759	68	234	152	10213
1967	7958	82	167	186	8393
1968	9059	126	334	272	9791
1969	8677	178	316	237	9408
1970	5155	124	511	139	5929
1971	8870	109	617	94	9690
1972	2202	105	532	100	2939
1973	2456	41	675	198	3370
1974	559	28	497	148	1232
1975	621	15	887	79	1602
1976	393	12	803	94	1302
1977	2229	31	765	161	3186
1978	4190	69	1087	181	5527
1979	1776	93	1251	122	3242
1980	13146	267	922	223	14558
1981	17751	497	1333	195	19776
1982	12422	935	1604	140	15101
1983	7079	545	1287	169	9080
1984	6120	522	926	38	7606
1985	9547	830	847	25	11249
1986	14155	1149	1125	81	16510
1987	2064	602	776	61	3503
1988	2383	493	1135	98	4109
1989	4318	477	2337	46	7179
1990	2971	463	3162	47	6643
1991	1712	104	3185	42	5042
1992	2272	246	3535	22	6074
1993	374	53	843	5	1275
1994	45	4	42	1	92
1995	45	3	60	2	111
1996	29	4	58	3	94
1997	8	0	8	2	19

Table 3

Details of conservation harvesting plans (CHP) for 1996 in Div. 4VW fisheries.

Sector	Limits	Gear
fixed gear < 65' directing for pollock, white hake, cusk or Atlantic halibut	10% haddock by-catch limit (areas will be closed for this fleet sector if by-catch limits are reached or exceeded	#12 circle hook minimum or other equivalent hook sizes for all species and areas
fixed gear 45-65' directing for pollock, white hake, cusk or Atlantic halibut	10% haddock by-catch limit (areas will be closed for this fleet sector if by-catch limits are reached or exceeded	#12 circle hook minimum or other equivalent hook sizes for all species and areas
fixed gear > 65'	10% daily by-catch provision of haddock	#12 circle hook minimum or other equivalent hook sizes for all species and areas
mobile gear < 65'	5% daily by-catch of haddock, with a 2% overall cap when directing for redfish and flatfish; 10% daily by-catch of haddock when directing for pollock to a maximum of 5% overall cap	130 mm square mesh when directing for all groundfish except flatfish (155 mm square mesh for draggers and 145 mm diamond mesh for seiners)
mobile gear 65-100'	10% weekly by-catch of cod and haddock combined, with a 5% overall cap on cod and haddock combined in the pollock fishery; 5% weekly by-catch for haddock, with 2% overall cap on haddock in flatfish fisheries	minimum 130 mm square mesh or 155 mm diamond mesh in the pollock fishery; minimum 155 mm square mesh in the flatfish fishery
mobile gear > 100'	10% weekly by-catch of cod and haddock combined, with a 5% overall cap on cod and haddock combined in the pollock fishery; 5% weekly by-catch, with a 2% overall cap on haddock	minimum 130 mm square mesh or 155 mm diamond mesh in the pollock fishery; minimum 155 mm square mesh in the flatfish fishery
domestic silver hake fishery	maximum by-catch per trip is set at 0.5% for haddock	silver hake box using minimum codend and lengthening piece mesh size of 60 mm diamon or 55 mm square

Table 4. Canadian landings of haddock in Div.4T, 4Vn, 4Vs and 4W by quarter and gear from 1989 to 1997.

Otter trawl	4T					4Vn					4Vs					4W				
	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total
1989	0	9	2	0	11	25	178	46	1	250	578	1253	538	209	2579	146	581	476	276	1479
1990	1	2	0	1	5	17	32	12	6	67	830	639	370	184	2022	245	284	282	66	877
1991		3	0	0	3	8	8	4	2	21	184	257	104	129	674	145	302	288	280	1014
1992		1	0	0	1	8	2	1	1	12	204	195	60	97	555	1112	317	155	120	1704
1993		0			0	1	2	0	0	3	81	126	32	5	244	13	12	89	13	127
1994							0	4	1	5	6	6	7	3	22	9	0	7	2	18
1995							0	1	1	1	7	4	4	10	26	3	2	13	0	18
1996							0	0		0	7	4	5	1	17	4	2	4	2	12
1997							0			0	2	1	2		5	2	1	0		3

Danish/Scottish Seine	4T					4Vn					4Vs					4W				
	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total
1989		41	20	1	62	0	96	17	1	114	5	76	34	2	118	9	72	79	24	184
1990		19	3	0	22		15	5	0	20		64	62	0	126	15	70	187	23	295
1991		10	2	0	12		5	2	0	7	1	27	2	1	31	3	36	11	5	54
1992		5	1	0	6	0	1	0		2	0	80	3	2	84	1	37	82	35	154
1993		1	0		1		0	0		0	0	25	10	7	42		1	10	0	10
1994		1	0		1		1	0		1		1	2		3		0			0
1995		0	0		0		0	0		0		1	2	0	3			0		0
1996		0	0		0		0	0	0	0		0	3		4					0
1997					0		0			0		0			0					0

Longline/Handline	4T					4Vn					4Vs					4W				
	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total
1989		0	1	2	3	0	14	34	10	57	11	102	193	95	401	274	411	639	553	1877
1990		0	1	0	2	0	6	15	1	22	132	87	54	6	279	706	385	1274	495	2860
1991		0	1	2	2		2	14	3	19	3	121	133	10	267	436	550	1273	638	2896
1992			0	2	2		0	10	3	13	1	67	64	5	137	615	593	1328	846	3382
1993			0	3	3		2	5	1	8	8	57	84	0	150	19	112	510	42	683
1994						1	3	0		3	1	3	5	1	10	0	5	20	3	28
1995			0	0	0		0	0	0	0	2	5	19	2	28	0	3	19	10	32
1996			0	0	0		0	0	0	0	0	3	10	0	13	0	5	36	4	45
1997							0	0		0	1	2	0	0	3	1	3	1	0	5

Other*	4T					4Vn					4Vs					4W				
*Gillnets/dredge	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total	Qtr1	Qtr2	Qtr3	Qtr4	Total
1989		3	1	0	4			1		1		1	0	0	1	0	6	25	10	41
1990		1	1	0	2			0		0			0		0	0	3	25	17	45
1991		1	1		1			3		3					0	1	12	23	2	38
1992		0	0	0	0					0					0	0	0	11	10	21
1993		0	0		0					0					0	0	0	4		4
1994		0			0					0					0		1	0	0	1
1995		0			0			0		0		0	0		1		1	0	0	1
1996					0					0		0			0		2	0		3
1997					0					0		2			2		1			1

Table 5. Summary of commercial sampling for Div. 4TVW haddock in 1990.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	18	15	4	9
	# Measured	3626	3151	1073	1678
	# Aged	351	312	95	197
	Catch	848	771	452	191
4W	# Sampled	6	2	3	6
	# Measured	1245	400	602	1114
	# Aged	167	13	54	49
	Catch	259	354	470	89

Gear	Longline/handline *	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	1
	# Measured	-	-	-	153
	# Aged	-	-	-	30
	Catch	132	93	70	8
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	706	385	1274	495

Gear	Miscellaneous *	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	1	1	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	3	25	17

* Apply Longline/handline and Miscellaneous to appropriate trawl gear age/length key.

Table 6. Summary of commercial sampling for Div. 4TVW haddock in 1991.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	4	5	1	4
	# Measured	967	1073	242	621
	# Aged	93	109	28	80
	Catch	193	309	115	132
4W	# Sampled	4	4	-	3
	# Measured	834	859	-	497
	# Aged	87	78	-	32
	Catch	147	338	299	284

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	3	4	-
	# Measured	-	717	831	-
	# Aged	-	60	87	-
	Catch	3	122	147	15
4W	# Sampled	-	9	-	8
	# Measured	-	1462	-	1736
	# Aged	-	40	-	37
	Catch	436	550	1273	638

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	1	4	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	1	12	23	2

* Apply Miscellaneous to longline/handline gear age/length keys

Table 7. Summary of commercial sampling for Div. 4TVW haddock in 1992.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	7	5	3	3
	# Measured	1441	1057	487	544
	# Aged	142	49	-	30
	Catch	211	284	64	100
4W	# Sampled	6	11	3	1
	# Measured	1128	1835	404	126
	# Aged	104	108	25	20
	Catch	1112	354	237	154

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	1	1
	# Measured	-	-	168	178
	# Aged	-	-	23	25
	Catch	1	67	75	10
4W	# Sampled	5	2	8	8
	# Measured	948	405	1622	1430
	# Aged	19	-	-	19
	Catch	615	593	1328	846

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	0	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	11	10

* Apply Miscellaneous to longline/handline gear age/length key

Table 8. Summary of commercial sampling for Div. 4TVW haddock in 1993.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	1	10	3	2
	# Measured	200	1880	551	264
	# Aged	33	156	60	40
	Catch	83	153	42	12
4W	# Sampled	-	4	1	-
	# Measured	-	576	151	-
	# Aged	-	61	16	-
	Catch	13	13	98	13

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	3	1	-
	# Measured	-	567	217	-
	# Aged	-	32	25	-
	Catch	8	59	89	4
4W	# Sampled	-	-	16	-
	# Measured	-	-	2877	-
	# Aged	-	-	168	-
	Catch	19	112	510	42

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	0	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	4	0

* Apply Miscellaneous to longline/handline gear age/length key

Table 9. Summary of commercial sampling for Div. 4TVW haddock in 1994.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	1	1	-
	# Measured	-	95	94	-
	# Aged	-	23	9	-
	Catch	6	8	14	4
4W	# Sampled	1	-	-	-
	# Measured	144	-	-	-
	# Aged	25	-	-	-
	Catch	9	0	7	2

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	2	6	5	1
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	5	20	3

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	0	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	1	0	0

* Apply Longline/handline & Miscellaneous to trawl gear age/length key

Table 10. Summary of commercial sampling for Div. 4TVW haddock in 1995.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	1	-	1	2
	# Measured	214	-	62	387
	# Aged	20	-	18	27
	Catch	7	5	7	11
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	3	2	13	0

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	2	5	19	2
4W	# Sampled	-	-	3	3
	# Measured	-	-	395	193
	# Aged	-	-	271	83
	Catch	0	3	19	10

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	0	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	1	0	0

* Apply Miscellaneous to longline/handline gear age/length key

Table 11. Summary of commercial sampling for Div. 4TVW haddock in 1996.
The boxes represent the aggregations used in the development of the age length keys.

Gear	OTB/SNU	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	1	-
	# Measured	-	-	212	-
	# Aged	-	-	39	-
	Catch	7	5	8	1
4W	# Sampled	-	-	2	-
	# Measured	-	-	451	-
	# Aged	-	-	63	-
	Catch	4	2	4	2

Gear	Longline/handline	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	3	10	0
4W	# Sampled	-	1	1	-
	# Measured	-	19	206	-
	# Aged	-		43	-
	Catch	0	5	36	4

Gear	Miscellaneous	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
4TV	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	0	0	0
4W	# Sampled	-	-	-	-
	# Measured	-	-	-	-
	# Aged	-	-	-	-
	Catch	0	2	0	0

* Apply Longline/handline & Miscellaneous to trawl gear age/length key

Table 12. Commercial catch at age (thousands of fish) for Div. 4TVW haddock.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	306	268	306	487	59	279	431	213	714	1
2	129	667	288	1178	233	61	676	283	433	268
3	679	888	671	646	975	470	157	965	811	423
4	1743	2189	751	1467	254	805	249	335	2412	1120
5	1400	2740	924	811	464	282	323	513	436	675
6	1365	1208	668	723	298	185	189	283	715	159
7	1163	944	345	342	114	63	132	117	203	149
8	389	1177	191	159	47	30	36	80	61	16
9	88	277	159	60	8	8	8	19	23	5
10	38	39	9	99	17	4	10	15	8	6
11	19	21	18	2	16	1	3	6	2	2

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	332	870	530	497	10	888	16	83	112	1553
2	376	318	433	470	360	26	132	78	69	823
3	2372	262	1520	1084	1514	512	952	92	48	225
4	4334	5072	764	3207	4158	2947	3049	63	166	306
5	3238	5081	5629	2040	2225	4494	5676	420	239	427
6	1702	3010	1957	1677	821	1737	5352	826	952	489
7	249	1178	1220	530	410	381	1947	1113	1194	1391
8	129	139	214	235	90	830	496	406	859	1472
9	39	105	48	29	30	345	397	73	214	1323
10	9	30	28	18	5	149	130	167	76	525
11	7	10	5	19	2	96	107	91	149	273

age	1990	1991	1992	1993	1994	1995	1996
1	20	1	14	14	12	23	147
2	137	73	14	22	11	41	50
3	147	549	127	10	3	22	64
4	183	984	1721	94	2	8	40
5	147	379	1389	428	17	10	7
6	148	178	576	254	25	21	3
7	408	223	413	89	13	32	7
8	1624	306	202	46	0	11	9
9	2008	934	252	77	0	2	4
10	480	789	589	88	1	1	1
11	212	377	636	285	11	12	3

Table 13. Div. 4TVW haddock mean numbers per tow by stratum (all ages) in the 1970-1997 summer RV survey.

stratum	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
440	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
441	0.86	0.70	0.70	0.41	1.31	4.10	0.00	0.00	1.75	1.75
442	2.72	0.00	0.00	0.00	0.00	0.00	1.31	1.65	0.00	0.00
443	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
444	0.00	0.00	7.45	0.28	0.00	0.28	0.00	0.57	0.00	0.00
445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
446	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
447	4.62	0.00	2.18	1.07	1.31	2.63	13.26	12.02	0.00	0.00
448	27.68	0.66	0.00	53.00	0.00	0.00	0.50	2.92	0.00	0.00
449	0.00	7.58	8.75	1.57	0.00	0.00	0.50	0.00	0.00	0.00
450	0.00	11.30	40.51	1.97	8.65	3.75	6.36	7.00	0.39	0.39
451	0.00	0.00	0.00	0.00	0.00	2.42	0.00	0.00	0.00	0.00
452	0.00	1.37	0.00	0.91	4.50	2.92	0.87	0.00	0.00	0.00
453	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.00	0.00	0.00
454	6.04	0.00	10.27	2.67	0.32	0.67	8.87	6.59	19.83	19.83
455	11.82	5.00	2.22	0.00	5.16	6.52	5.50	78.05	112.02	112.02
456	4.20	98.07	3.96	7.97	0.00	3.89	27.55	19.58	38.50	38.50
457	0.00	7.70	0.00	2.31	0.70	0.00	0.55	6.75	190.31	190.31
458	9.71	4.81	5.44	2.45	0.35	0.00	0.00	3.76	75.41	75.41
459	14.61	5.78	1.22	1.25	0.00	0.31	12.46	55.81	7.77	7.77
460	11.16	0.00	17.75	24.09	2.10	24.00	2.33	4.67	47.85	47.85
461	0.80	0.00	0.00	0.00	0.00	0.55	0.00	0.00	4.78	4.78
462	31.93	15.46	5.51	0.37	0.29	53.92	14.06	33.29	23.24	23.24
463	56.83	51.92	36.75	30.36	4.38	196.64	72.39	542.09	32.16	32.16
464	26.31	49.07	9.67	27.10	96.76	25.06	11.15	183.47	178.85	178.85
465	26.33	20.07	15.17	11.63	34.66	36.63	50.45	41.18	230.94	230.94
466	3.50	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.87	0.87

stratum	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
440	0.00	0.00	0.00	0.32	0.00	0.26	0.00	0.41	0.34	0.26
441	2.02	4.20	11.41	2.29	16.47	25.77	36.62	7.24	7.39	5.35
442	0.74	3.18	0.34	1.23	0.00	3.21	0.00	0.67	0.77	0.57
443	1.46	0.00	1.03	3.55	2.33	0.00	0.97	0.18	0.26	0.51
444	0.62	4.34	4.21	1.18	1.67	12.61	5.85	4.78	1.29	0.17
445	0.00	0.00	0.00	0.00	0.24	2.78	0.34	0.49	0.00	0.26
446	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	1.30
447	2.02	0.38	151.02	110.23	54.80	66.04	25.24	61.72	24.67	1.30
448	13.26	2.19	25.08	0.00	50.40	10.54	56.82	26.25	0.00	1.85
449	5.83	3.65	65.14	32.80	18.53	92.85	9.78	2.30	17.73	0.51
450	4.79	8.27	495.23	140.67	301.83	6.73	18.28	6.20	75.72	26.12
451	0.50	0.70	32.64	67.08	5.47	67.31	6.40	12.10	2.06	22.42
452	16.23	0.00	8.60	1.49	17.50	4.63	31.56	2.06	55.75	1.03
453	0.00	0.00	0.65	0.00	0.00	0.34	0.00	0.00	0.00	0.00
454	13.08	24.32	356.87	145.34	278.63	78.60	11.67	24.71	45.81	38.32
455	113.99	324.03	79.93	494.89	272.21	229.42	269.19	108.43	94.91	65.39
456	61.87	182.40	108.45	208.92	362.40	96.49	82.43	196.56	985.85	397.90
457	26.12	0.00	15.07	217.27	15.44	5.47	45.13	0.27	18.05	3.55
458	76.09	1.68	8.01	438.64	116.18	56.71	166.68	10.44	77.87	42.13
459	6.57	70.20	41.06	38.84	15.96	21.02	37.82	3.44	24.90	16.64
460	29.93	63.80	28.91	13.12	24.31	3.40	7.68	15.02	18.61	21.81
461	0.00	2.33	0.46	3.89	15.44	0.51	1.70	0.00	0.00	0.00
462	48.93	67.94	78.57	42.69	80.55	42.53	24.12	10.60	2.72	6.92
463	184.30	426.27	219.36	170.28	54.04	120.07	175.19	116.32	89.66	390.29
464	514.31	156.20	219.85	77.33	202.14	116.81	158.38	41.48	109.28	81.23
465	50.41	121.55	112.19	103.19	42.85	65.34	59.12	92.79	63.91	164.31
466	0.00	0.00	1.03	0.00	0.00	10.05	4.67	2.19	1.54	0.55

stratum	1990	1991	1992	1993	1994	1995	1996	1997
440	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00
441	2.98	1.03	1.17	0.35	1.34	1.81	0.20	0.20
442	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00
443	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
444	0.14	0.13	0.00	0.00	0.00	0.00	0.00	0.00
445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
446	6.48	0.69	5.15	0.00	0.00	0.00	2.37	0.33
447	1.15	0.88	2.36	0.53	0.42	8.19	1.01	2.90
448	0.32	0.17	0.16	1.84	0.42	0.00	0.00	0.00
449	7.08	22.13	0.00	25.36	0.00	0.48	0.00	0.97
450	67.67	1.37	2.92	24.67	15.95	171.92	6.09	15.22
451	87.18	53.53	11.72	8.38	52.62	6.32	64.05	20.66
452	22.36	6.02	13.98	2.03	23.80	24.02	21.28	0.49
453	0.34	11.48	21.87	19.50	44.33	40.77	1.99	20.90
454	11.09	4.63	52.01	277.25	8.60	18.97	3.67	6.45
455	108.78	567.73	231.74	131.08	169.67	56.39	261.54	178.06
456	414.55	238.85	35.83	141.47	127.11	66.87	305.00	59.75
457	2.43	100.37	0.49	1.47	0.97	0.00	0.00	0.00
458	27.49	5.74	14.46	12.62	149.65	43.66	53.84	33.65
459	55.79	0.45	11.99	1.26	0.00	0.00	6.50	25.04
460	3.40	0.34	0.39	31.18	4.99	2.68	4.60	0.00
461	0.00	0.46	0.00	0.00	0.00	1.01	0.00	0.00
462	30.92	30.44	5.10	9.81	1.94	6.01	24.79	45.77
463	104.65	38.69	51.13	23.72	67.01	201.45	122.99	276.47
464	162.21	182.04	88.80	97.82	100.92	184.12	83.53	85.51
465	47.12	37.87	55.84	26.77	41.94	60.59	72.20	55.67
466	0.00	0.00	1.46	18.49	0.00	0.67	4.23	0.00

Table 14. Parameter estimates from regressions of weight on length for haddock($w=aL^b$).

year	a	b	n	predicted weight (g) at 30 cm	predicted weight (g) at 45 cm
1970	0.006522	3.129	784	273.21	971.63
1971	0.009704	3.009	533	269.83	913.88
1972	0.009324	3.035	460	283.54	970.61
1973	0.007201	3.093	292	266.83	935.19
1974	0.007232	3.088	333	263.19	920.44
1975	0.008879	3.038	515	272.93	935.48
1976	0.006029	3.140	556	261.81	935.10
1977	0.009184	3.039	658	283.40	971.84
1978	0.005903	3.148	1128	263.49	944.19
1979	0.006334	3.129	682	264.98	942.24
1980	0.003659	3.271	828	248.58	936.53
1981	0.008287	3.065	905	279.56	968.91
1982	0.011938	2.960	1046	280.85	932.43
1983	0.008627	3.038	1142	264.78	907.38
1984	0.008173	3.049	1190	260.75	897.70
1985	0.010463	2.976	1082	260.22	869.69
1986	0.005391	3.156	1006	247.28	888.98
1987	0.007862	3.068	861	267.14	926.65
1988	0.006273	3.125	756	259.49	921.48
1989	0.006405	3.116	844	256.17	906.02
1990	0.008427	3.046	1280	266.26	915.62
1991	0.010368	2.992	825	272.03	914.95
1992	0.010473	2.989	823	272.76	916.60
1993	0.017013	2.843	797	269.23	852.58
1994	0.008948	3.022	962	260.40	886.73
1995	0.009532	3.006	750	262.66	888.63
1996	0.008854	3.025	908	259.99	886.29
1997	0.007497	3.074	792	259.92	903.78

Table 15. Div. 4TVW haddock catch rate at length from summer RV survey from 1970-97.

4TVW July RV Catch Rates at Length															
	Year														
Length (cm)	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.50	0	0	0.0108	0	0	0	0.006	0	0	0.0516	0.0432	0.0132	0.075	0.015	0
6.50	0.03	0.0372	0.0264	0	0	0.024	0.3192	0.06	0	0.516	0.8856	4.4976	0.319	0.1	0.018
8.50	0.0744	0.0252	0.0108	0	0.1416	0.0228	0.2508	0.1296	0	0.8664	0.42	14.3148	0.28	0.031	0.258
10.50	0	0	0	0	0.0864	0.0264	0.0444	0.0672	0	0.0528	0.1248	3.3396	0.1	0	0
12.50	0	0	0	0	0	0	0	0	0	0	0.012	0.1884	0.03	0.016	0
14.50	0	0	0	0	0	0	0	0.024	0.036	0	0.0216	0.312	1.361	0.286	0.005
16.50	0.0264	0.018	0.036	0	0	0.0348	0.096	0.024	0.5256	0	0.036	2.31	7.78	4.163	0
18.50	0.2292	0.15	0.2172	0.0132	0.0276	0.096	0.1404	0.0852	2.9172	0.024	0.5928	5.238	5.809	9.825	0.04
20.50	0.792	0.3204	0.5376	0.0792	0.024	0.2196	1.2636	0.8328	4.0608	0.0348	1.476	4.7808	2.548	8.22	0.258
22.50	1.2288	0.6696	0.4932	0.2076	0.1392	0.3816	1.014	2.2416	1.7112	0.0228	1.1064	2.0916	0.745	3.071	0.339
24.50	0.3408	0.4776	0.1368	0.1848	0.1008	1.9296	0.39	2.2164	0.9084	0.1788	0.3936	1.0956	1.547	2.256	0.951
26.50	0.15	0.3396	0.198	0.1548	0.0804	2.3844	0.4452	1.1016	0.4872	0.5112	0.03	0.5868	3.612	2.65	1.839
28.50	0.042	0.3204	0.1512	0.2592	0.0384	0.5028	0.3516	1.116	0.3192	1.6212	0.0648	1.7688	4.593	4.014	3.119
30.50	0.366	0.9528	0.372	0.2448	0.1308	0.1224	0.2556	2.0184	1.5552	2.3904	0.018	2.724	3.806	4.201	5.183
32.50	0.3936	1.1928	0.36	0.5592	0.4584	0.0252	0.546	3.1224	3.4404	2.9352	0.1044	2.5908	2.329	5.154	4.54
34.50	0.1932	0.8316	0.264	0.3732	0.9096	0.0432	0.7008	2.9544	4.2552	2.538	0.7716	1.656	0.962	5.174	4.238
36.50	0.4212	0.39	0.2376	0.2232	0.7524	0.0888	0.69	2.0832	3.456	1.4832	1.8828	0.5604	1.919	7.836	7.143
38.50	0.4704	0.2148	0.222	0.2052	0.6456	0.1056	0.2964	1.3608	3.2088	2.0712	4.3992	0.3144	3.427	9.099	9.916
40.50	0.7044	0.372	0.2868	0.1656	0.504	0.4476	0.0816	1.6692	4.7424	3.3876	5.214	0.6972	3.8	5.085	10.563
42.50	0.6756	0.6288	0.2004	0.0636	0.6888	0.4848	0.1848	2.4528	3.7956	3.6348	4.4376	1.8192	2.891	3.309	6.792
44.50	0.7872	0.5484	0.1524	0.1728	0.642	0.9324	0.1164	2.1756	2.9484	3.4656	5.5668	2.3952	3.269	2.615	3.945
46.50	0.5328	0.4164	0.2508	0.15	0.4788	0.5496	0.2568	1.4028	2.274	3.0252	4.8	2.4732	2.37	2.152	2.184
48.50	0.4524	0.378	0.1344	0.0468	0.2304	0.4476	0.4008	0.534	2.0508	2.2212	4.698	2.4288	2.196	1.809	1.686
50.50	0.5868	0.378	0.3384	0.1632	0.1428	0.438	0.3696	0.6984	1.2696	1.5228	3.6984	1.77	2.039	1.348	1.039
52.50	0.498	0.252	0.144	0.1692	0.2412	0.2544	0.3132	0.7128	0.5184	0.828	1.7424	1.0428	1.65	1.177	1.066
54.50	0.2112	0.1596	0.1332	0.1524	0.2724	0.4644	0.3204	0.492	0.1632	0.6252	1.3368	0.5952	1.173	0.836	0.545
56.50	0.3324	0.1776	0.0864	0.0324	0.2136	0.2508	0.2076	0.4368	0.1656	0.1728	0.432	0.5424	0.645	0.323	0.464
58.50	0.2448	0.0864	0.0552	0.15	0.1704	0.2964	0.0708	0.312	0.1152	0.0924	0.3468	0.288	0.476	0.258	0.302
60.50	0.1068	0.0564	0.0672	0.048	0.0648	0.2496	0.0252	0.3228	0.1116	0.1548	0.2376	0.2448	0.185	0.091	0.238
62.50	0.1692	0.048	0.0912	0.0936	0.0684	0.132	0.1008	0.1128	0.1068	0.096	0.186	0.09	0.287	0.121	0.126
64.50	0.2436	0.0204	0.036	0	0.0888	0.1272	0.0792	0.084	0.0744	0.0516	0.1056	0.1332	0.175	0.083	0.102
66.50	0.1956	0.1032	0	0.0588	0.0096	0.0792	0.0444	0.0168	0	0.0612	0.0492	0.0324	0.076	0.099	0.066
68.50	0.0312	0.0084	0.0468	0	0.0216	0.03	0.0216	0.0624	0.0312	0.036	0.0528	0.0324	0	0.042	0.066
70.50	0.0444	0.0252	0	0	0.0048	0.0468	0	0	0.03	0.0192	0	0	0.018	0.002	0
72.50	0.0432	0	0	0.0228	0.0156	0.036	0.06	0.0324	0.0108	0	0	0	0	0.024	0.014
74.50	0.0084	0	0	0.0348	0	0	0.0036	0	0	0	0	0	0.022	0	0.006
76.50	0.0084	0	0	0	0	0	0	0	0	0	0	0	0	0	0.026
78.50	0.0084	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0
80.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003
82.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	10.6428	9.5988	5.2968	4.0284	7.3932	11.274	9.4668	30.9852	45.2892	34.692	45.2868	62.9676	62.514	85.485	67.08

Table 15. cont.

4TVW July RV Catch Rates at Length													
	Year												
Length (cm)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0.50	0	0	0	0	0	0	0	0	0	0	0	0	0
2.50	0	0	0.026	0	0	0	0	0	0	0	0	0	0
4.50	0	0	0	0	0	0	0	0	0.012	0	0.01	0	0.02
6.50	0	0.086	0.017	0.063	0	0	0.022	0	0.282	0.31	0.04	0.19	0.06
8.50	0.011	0.051	0.061	0.692	0.057	0	0	0	1.13	0.69	0.2	2.25	0.22
10.50	0	0	0.004	0.28	0.043	0	0	0	1.006	0.35	0.03	1.76	0.07
12.50	0	0	0	0.008	0	0	0	0	0.063	0.01	0	0	0
14.50	0	0	0	0	0	0.018	0	0	0	0	0	0.02	0
16.50	0.023	0	0.174	0	0.741	0.014	0	0.02	0.007	0	0.08	0.11	0.07
18.50	0.155	0.061	0.487	0.075	5.296	0.049	0.017	0.008	0.053	0.06	0.19	1.49	0.23
20.50	1.286	0.179	0.941	1.043	5.627	0.249	0.061	0.323	0.34	0.75	1.12	3.47	1.55
22.50	2.346	0.45	0.871	2.081	1.632	0.387	0.091	0.299	1.06	2.48	1.86	3.49	3.25
24.50	0.677	0.483	0.31	1.306	0.574	0.424	0.035	0.137	0.925	3.24	0.77	1.57	1.91
26.50	0.226	0.178	0.131	0.27	0.217	1.652	0.068	0.049	0.422	1.01	0.41	0.62	2.93
28.50	0.307	0.187	0.211	0.356	0.512	5.874	0.564	0.16	0.217	1.7	1.53	1.11	4.11
30.50	0.834	0.912	0.5	2.704	1.735	7.123	1.969	0.435	0.705	1.94	2.65	3.06	2.29
32.50	1.803	1.567	0.874	8.208	3.2	2.976	7.544	1.248	0.618	0.94	2.26	3.79	1.52
34.50	3.366	2.026	0.888	6.178	1.718	2.035	11.525	4.519	0.981	0.75	1.87	3.84	1.86
36.50	4.235	4.271	1.542	2.738	0.943	3.184	10.256	6.059	2.949	1.32	1.39	3.38	2.46
38.50	4.598	7.598	2.535	3.639	1.053	3.369	8.137	4.78	5.136	2.95	2.03	2.44	1.96
40.50	6.282	9.06	4.557	4.268	1.567	2.489	6.279	3.746	4.535	3.94	2.82	2.56	1.79
42.50	6.288	7.812	5.432	5.336	2.945	2.12	5.037	2.364	3.28	2.79	2.59	2.39	1.93
44.50	4.122	5.611	4.808	6.121	3.965	2.99	3.945	1.478	1.763	1.52	1.54	1.86	1.54
46.50	2.748	3.655	2.913	4.7	3.694	2.72	3.408	1.111	1.045	0.65	0.68	1.15	0.9
48.50	1.595	2.239	1.83	3.012	2.706	1.974	2.487	0.775	0.448	0.37	0.24	0.48	0.47
50.50	1.335	1.559	0.769	1.451	1.504	1.438	0.865	0.528	0.432	0.16	0.08	0.2	0.3
52.50	0.83	0.76	0.515	0.726	0.827	0.597	0.467	0.306	0.167	0.07	0.06	0.08	0.14
54.50	0.425	0.652	0.188	0.318	0.441	0.298	0.095	0.099	0.07	0.03	0.1	0.07	0.04
56.50	0.373	0.498	0.167	0.193	0.275	0.254	0.072	0.107	0.03	0.02	0.11	0.02	0
58.50	0.242	0.305	0.07	0.115	0.07	0.065	0.034	0.011	0.023	0	0.07	0.01	0.01
60.50	0.093	0.155	0.032	0.13	0.102	0.093	0.007	0.015	0.008	0.01	0.09	0.01	0.01
62.50	0.073	0.066	0.002	0.056	0.043	0.016	0	0.015	0	0	0.04	0.01	0.01
64.50	0.031	0.038	0.013	0.067	0.019	0.005	0.009	0	0.002	0	0.03	0.01	0.01
66.50	0.093	0.02	0.01	0.016	0.008	0.007	0	0.007	0	0	0.01	0	0
68.50	0.028	0.007	0.002	0	0.008	0	0.016	0.007	0	0	0	0	0.01
70.50	0.024	0.007	0	0	0	0	0	0	0	0	0	0	0
72.50	0.004	0	0	0	0	0.005	0	0	0	0.01	0	0	0
74.50	0	0	0	0	0	0	0	0	0	0	0	0.01	0
76.50	0	0	0	0	0	0	0	0	0	0	0	0	0
78.50	0	0	0	0	0	0	0	0	0	0	0	0	0
80.50	0.002	0	0.008	0	0	0	0	0	0	0	0	0	0
82.50	0	0	0	0	0	0	0	0	0	0	0	0	0
84.50	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	44.455	50.493	30.888	56.15	41.522	42.425	63.01	28.606	27.709	28.07	24.91	41.42	31.64

Table. 16. Div. 4TVW haddock stratified mean numbers per tow from the summer RV survey from 1970-1996.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	0.11	0.06	0.00	0.00	0.23	0.07	0.30	0.19	0.00
1	2.74	1.74	1.31	0.53	0.37	4.82	2.78	6.07	9.91
2	1.00	3.50	0.95	1.74	2.14	0.95	3.13	11.23	11.04
3	1.79	1.20	1.26	0.54	2.84	1.97	0.48	9.06	14.77
4	2.12	1.57	0.59	0.47	0.59	1.78	0.95	1.36	8.39
5	1.00	0.65	0.50	0.17	0.54	0.48	0.94	1.96	0.50
6	0.62	0.37	0.34	0.34	0.26	0.85	0.20	0.73	0.49
7	0.62	0.16	0.16	0.08	0.20	0.22	0.23	0.22	0.12
8	0.41	0.25	0.11	0.10	0.10	0.10	0.05	0.11	0.01
9	0.14	0.01	0.04	0.02	0.05	0.05	0.01	0.00	0.00
10	0.04	0.00	0.01	0.05	0.04	0.06	0.01	0.05	0.01
11	0.04	0.00	0.00	0.00	0.04	0.00	0.01	0.01	0.01
12	0.02	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unknown	0.00	0.00	0.05	0.00	0.01	0.00	0.32	0.10	0.02
total	10.64	9.53	5.29	4.03	7.42	11.35	9.49	31.10	45.31

age	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	1.49	1.44	22.36	0.80	0.14	0.28	0.01	0.14	0.08
1	0.10	3.52	15.71	18.37	21.29	0.30	4.61	1.20	3.02
2	9.42	0.28	9.32	15.21	14.68	10.79	1.39	3.25	1.23
3	9.78	14.95	0.98	12.83	30.15	17.30	8.89	4.16	2.53
4	10.27	13.92	7.32	2.54	11.72	29.30	10.94	12.77	1.59
5	2.87	8.53	4.73	7.67	3.00	5.19	11.99	13.49	7.42
6	0.37	2.08	2.02	2.98	2.77	2.39	3.37	10.09	7.38
7	0.31	0.34	0.31	0.95	0.95	1.31	0.68	3.22	5.76
8	0.07	0.12	0.10	0.21	0.27	0.24	1.49	0.81	1.34
9	0.00	0.02	0.12	0.03	0.08	0.09	0.65	0.80	0.10
10	0.04	0.00	0.02	0.02	0.03	0.02	0.29	0.32	0.26
11	0.01	0.00	0.00	0.00	0.00	0.01	0.12	0.10	0.05
12	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.11	0.09
13	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.01
14	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00
15	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unknown	0.00	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.03
total	34.76	45.24	62.99	61.61	85.16	67.25	44.47	50.49	30.89

age	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	1.04	0.10	0.02	0.02	0.00	2.43	1.36	0.27	4.19
1	4.73	13.65	0.97	0.13	0.78	2.61	7.02	3.72	9.81
2	12.88	7.64	15.00	1.88	1.10	1.53	4.49	5.39	6.14
3	6.13	1.93	9.99	21.61	3.53	1.12	1.19	4.50	8.88
4	4.52	1.39	3.54	19.87	11.86	3.56	0.89	0.52	4.78
5	3.38	1.81	0.76	7.11	6.88	9.71	2.25	0.79	0.74
6	9.57	1.73	0.92	1.52	0.83	3.43	6.93	4.13	0.34
7	6.87	4.69	1.11	2.37	0.70	0.94	2.81	4.27	1.34
8	5.35	3.71	2.02	2.01	0.22	0.23	0.24	0.80	3.09
9	0.89	3.40	2.68	2.19	0.24	0.37	0.19	0.16	1.62
10	0.35	1.03	2.44	2.29	0.70	0.15	0.09	0.05	0.26
11	0.17	0.18	1.80	0.64	0.79	0.48	0.19	0.08	0.05
12	0.18	0.23	0.20	0.16	0.58	0.27	0.19	0.13	0.02
13	0.04	0.02	0.02	0.00	0.25	0.23	0.12	0.06	0.02
14	0.01	0.01	0.13	0.00	0.00	0.01	0.08	0.04	0.09
15	0.04	0.00	0.00	0.00	0.01	0.03	0.00	0.01	0.05
16	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
unknown	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00
total	56.15	41.52	41.61	61.80	28.48	27.13	28.04	24.92	41.42

Table 17. Coefficient of variation of the mean catch rates at age for Div. 4TVW haddock from the summer RV survey from 1970-96.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	0.65	0.72	0.00	0.00	0.91	0.51	0.67	0.46	0.00	0.39
1	0.47	0.36	0.33	0.28	0.51	0.56	0.42	0.33	0.28	0.73
2	0.33	0.38	0.42	0.50	0.47	0.55	0.37	0.38	0.49	0.31
3	0.29	0.33	0.35	0.34	0.48	0.39	0.41	0.36	0.46	0.41
4	0.27	0.30	0.24	0.34	0.48	0.41	0.48	0.33	0.40	0.34
5	0.32	0.26	0.23	0.38	0.39	0.31	0.40	0.27	0.28	0.28
6	0.34	0.28	0.26	0.49	0.43	0.35	0.33	0.25	0.23	0.27
7	0.35	0.28	0.29	0.50	0.40	0.33	0.31	0.31	0.38	0.31
8	0.39	0.38	0.43	0.48	0.44	0.33	0.34	0.35	0.35	0.44
9	0.37	0.00	0.48	1.00	0.43	0.36	0.52	0.00	0.00	0.00
10	0.56	0.00	0.60	0.73	0.39	0.33	0.45	0.67	1.00	0.71
11	0.54	0.00	0.00	0.00	0.35	0.00	0.52	0.76	0.71	0.67
12	0.54	0.00	0.00	0.00	0.00	0.86	1.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
14	1.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.63	0.51	0.24	0.65	0.45	1.00	0.63	0.56	0.27	0.38
1	0.22	0.24	0.33	0.31	0.45	0.56	0.36	0.38	0.34	0.30
2	0.32	0.45	0.23	0.28	0.26	0.34	0.23	0.32	0.91	0.47
3	0.31	0.30	0.29	0.49	0.20	0.25	0.21	0.20	0.81	0.30
4	0.40	0.24	0.33	0.33	0.20	0.15	0.22	0.20	0.56	0.20
5	0.38	0.24	0.27	0.20	0.16	0.15	0.19	0.21	0.39	0.18
6	0.27	0.22	0.23	0.21	0.14	0.18	0.16	0.21	0.34	0.17
7	0.26	0.23	0.22	0.23	0.21	0.19	0.15	0.22	0.22	0.16
8	0.27	0.24	0.28	0.20	0.31	0.21	0.16	0.21	0.28	0.14
9	0.39	0.28	0.71	0.35	0.40	0.22	0.19	0.20	0.19	0.15
10	0.00	0.44	0.40	0.30	0.65	0.24	0.25	0.19	0.21	0.14
11	0.00	0.00	0.00	0.00	1.00	0.27	0.29	0.20	0.25	0.18
12	0.00	0.00	0.00	0.75	0.00	0.00	0.25	0.22	0.26	0.17
13	0.00	0.00	0.00	0.00	1.00	0.50	0.86	1.00	0.24	0.35
14	0.00	0.00	0.00	0.91	0.00	0.00	0.65	0.00	0.41	0.46
15	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.22	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

age	1990	1991	1992	1993	1994	1995	1996
0	1.00	0.50	0.36	0.15	0.31	0.27	0.25
1	0.27	0.25	0.30	0.33	0.45	0.25	0.27
2	0.40	0.33	0.32	0.25	0.34	0.30	0.26
3	0.29	0.40	0.30	0.25	0.21	0.29	0.24
4	0.23	0.43	0.25	0.25	0.19	0.26	0.23
5	0.18	0.40	0.22	0.24	0.20	0.22	0.24
6	0.20	0.45	0.22	0.23	0.20	0.19	0.25
7	0.18	0.44	0.18	0.22	0.23	0.18	0.23
8	0.18	0.42	0.19	0.24	0.29	0.17	0.24
9	0.18	0.41	0.19	0.22	0.26	0.18	0.23
10	0.19	0.33	0.20	0.22	0.28	0.17	0.23
11	0.18	0.39	0.20	0.21	0.25	0.21	0.25
12	0.21	0.00	0.21	0.21	0.27	0.25	0.25
13	0.40	0.00	0.62	0.20	0.28	0.40	0.65
14	0.19	0.00	0.34	0.35	0.26	0.45	0.22
15	1.00	0.00	0.00	0.22	0.00	0.23	0.22
16	0.35	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.39	0.00	0.00	0.00

Table 18. Correlation table showing magnitude of correlation among yearclass estimates at successive ages from the summer RV survey for Div. 4TVW haddock.

age	1	2	3	4	5	6	7	8	9
1	1.00	0.58	0.51	0.45	0.62	0.80	0.74	0.57	0.75
2	-	1.00	0.68	0.60	0.86	0.52	0.56	0.45	0.55
3	-	-	1.00	0.75	0.73	0.62	0.58	0.69	0.65
4	-	-	-	1.00	0.62	0.62	0.54	0.50	0.71
5	-	-	-	-	1.00	0.65	0.72	0.66	0.69
6	-	-	-	-	-	1.00	0.81	0.79	0.89
7	-	-	-	-	-	-	1.00	0.78	0.90
8	-	-	-	-	-	-	-	1.00	0.82
9	-	-	-	-	-	-	-	-	1.00

Table 19. Div. 4TVW haddock mean length at age from the summer RV survey from 1970-1996.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1970	7.92	21.95	31.94	39.73	45.20	50.80	54.58	58.14	62.79	65.08	67.10	70.10	69.30		78.50			
1971	7.30	22.59	31.73	40.05	45.43	50.55	54.05	56.99	62.85	60.50								
1972		21.07	29.39	36.49	45.11	49.30	56.00	59.61	57.13	58.81	68.50							
1973		23.18	32.18	40.44	47.84	51.37	57.42	58.07	63.71	72.50	72.14							
1974	9.25	23.48	34.59	41.64	47.14	53.50	58.43	57.91	60.52	59.06	67.16	66.06						
1975	8.57	25.13	28.23	43.23	48.31	54.71	58.98	60.72	63.34	62.20	67.41		72.50					
1976	8.80	21.36	32.20	38.40	47.88	52.44	56.14	61.20	63.23	64.50	54.50	64.50	72.50					
1977	9.18	23.31	32.79	41.87	47.19	53.89	56.06	60.81	64.45		68.50	78.50		78.50				
1978		20.32	32.96	39.95	46.77	52.51	57.64	62.78	56.50		72.50	68.50						
1979	7.74	21.21	31.60	39.33	45.69	50.73	56.49	60.24	64.40		69.54	66.50			66.50			
1980	7.48	21.04	28.28	39.61	45.80	49.74	55.10	60.46	64.92	60.50								
1981	8.43	19.71	30.95	37.03	44.77	49.15	54.27	59.25	60.91	63.18	66.20							
1982	7.57	17.80	28.78	39.56	44.05	48.24	53.81	57.35	62.58	72.01	64.50					74.50		
1983	6.60	18.99	25.83	35.82	42.00	48.15	51.47	55.24	59.14	64.59	60.63		66.50		72.50			
1984	8.37	20.91	29.02	35.27	40.40	46.23	51.32	56.17	61.65	64.04	66.50	74.50						
1985	8.50	22.18	31.30	35.43	40.53	42.86	47.01	50.16	51.61	52.97	68.86	58.74		66.18				
1986	7.25	23.14	32.27	38.63	39.21	42.19	44.40	47.23	50.99	53.41	56.79	57.41	55.43	62.50	66.50			
1987	8.18	21.57	31.83	37.06	39.16	41.44	43.61	45.53	47.59	53.56	53.78	56.06	49.70					
1988	8.95	22.74	32.75	35.26	39.22	41.86	42.99	46.30	45.04	49.71	47.84	58.06	57.74	57.46	58.50	50.50		
1989	9.37	19.95	31.84	37.55	42.70	43.35	44.65	45.41	47.78	47.46	50.39	53.46	52.19	58.15	60.50			
1990	14.50	22.66	29.76	35.90	39.16	43.79	43.62	47.10	46.73	47.63	47.30	46.94	54.00	60.98	48.34	72.50	58.50	
1991	6.50	21.48	32.04	34.79	38.06	40.16	42.41	45.67	45.07	46.49	47.37	49.17	49.57					
1992		21.95	33.29	35.23	37.13	40.47	43.30	43.21	47.39	48.44	47.30	47.83	48.87	49.49	60.50	54.50		
1993	9.18	23.34	31.74	36.42	39.35	39.61	41.74	43.90	42.38	46.05	47.24	46.55	49.32	46.23	52.50	51.02		54.50
1994	8.61	23.71	29.35	33.56	38.06	40.02	40.31	42.53	46.98	45.61	48.46	45.93	48.30	48.32	50.26			
1995	8.39	22.02	29.62	34.07	36.74	39.24	41.60	42.74	45.86	45.04	45.11	45.40	49.21	54.35	56.60	48.50		
1996	9.25	21.67	29.69	35.14	36.83	40.07	42.21	43.81	43.98	44.91	43.93	50.28	49.33	59.26	50.37	48.13		

Table 20. Catch rate(kg.per tow) of haddock by stratum from the fixed gear sentinel survey in Div. 4VsW in the fall of 1995 and 1996. Stratified means are also shown with and without the inclusion of three inshore strata (467-469).

Stratum	1995	1996
444	0.00	0.00
446	3.75	1.28
447	1.46	2.07
448	0.11	0.00
449	13.20	32.05
450	7.00	11.61
451	55.40	90.43
452	0.00	21.56
453	0.20	1.00
454	13.17	18.57
455	50.50	56.59
456	67.43	45.00
457	0.25	4.03
458	0.00	13.62
459	1.55	4.76
460	3.83	4.86
461	0.00	0.00
462	14.17	9.39
463	160.80	108.63
464	230.73	194.37
465	81.30	46.90
466	0.00	2.85
467	0.00	0.00
468	0.00	0.00
469	4.35	7.34
Stratified Mean(444-469)	26.14	22.18
Stratified Mean(444-466)	27.64	23.38

Table 21. Diagnostics from ADAPT.

Mean Square of the Residuals = 0.601498				
Parameter	Estimate	Standard Error	CV	Bias (%)
F2	0.00242	0.001897	0.78	-27.05
F3	0.00409	0.002252	0.55	-11.78
F4	0.00541	0.002435	0.45	-7.08
F5	0.00639	0.002490	0.39	-4.52
F6	0.00353	0.001256	0.36	-4.70
F7	0.00399	0.001281	0.32	-3.20
F8	0.00110	0.000354	0.32	-5.26
F9	0.00157	0.000557	0.36	-6.29
q2	0.00029	0.000048	0.17	-1.30
q3	0.00044	0.000071	0.16	-1.41
q4	0.00051	0.000082	0.16	-1.57
q5	0.00051	0.000082	0.16	-1.80
q6	0.00051	0.000082	0.16	-2.10
q7	0.00047	0.000075	0.16	-2.39
q8	0.00037	0.000059	0.16	-2.63

Table 22. Population numbers (thousands of fish) at age from SPA.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	8179	4529	8174	8604	4746	26356	32902	48875	62869	32345
2	5499	6420	3466	6416	6604	3832	21326	26548	39822	50826
3	7178	4385	4653	2577	4187	5196	3082	16849	21480	32212
4	7663	5263	2787	3202	1525	2546	3829	2381	12921	16852
5	4134	4697	2328	1602	1294	1019	1356	2909	1647	8397
6	3269	2117	1366	1070	578	640	579	818	1918	954
7	3418	1441	641	514	222	203	356	303	413	923
8	824	1746	326	212	112	78	110	172	142	155
9	203	323	365	94	30	49	37	57	69	61
10	78	87	14	155	23	17	33	23	30	35
11	47	29	36	3	37	3	11	18	5	17

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	49423	84977	77446	67119	39859	18051	8430	5286	21861	44044
2	26481	40164	68786	62928	54502	32624	13976	6888	4253	17797
3	41371	21341	32595	55926	51096	44297	26687	11323	5569	3419
4	25990	31725	17235	25311	44807	40464	35804	20988	9187	4516
5	12784	17357	21385	13420	17821	32923	30462	26555	17127	7372
6	6264	7537	9614	12415	9141	12578	22888	19805	21361	13806
7	637	3588	3447	6100	8647	6741	8726	13897	15467	16628
8	621	296	1872	1718	4515	6709	5175	5383	10371	11583
9	112	392	117	1339	1194	3615	4742	3788	4040	7714
10	46	57	226	52	1070	951	2648	3523	3035	3114
11	24	29	19	159	26	872	643	2050	2733	2416

age	1990	1991	1992	1993	1994	1995	1996
1	7005	2622	2766	14979	25865	0	0
2	34655	5717	2146	2252	12251	0	0
3	13826	28249	4615	1744	1824	10021	0
4	2596	11187	22632	3663	1419	1491	8184
5	3420	1960	8269	16972	2914	1160	1213
6	5649	2667	1262	5513	13508	2371	941
7	10861	4491	2023	512	4284	11037	1922
8	12355	8523	3475	1282	338	3496	9007
9	8152	8646	6701	2662	1008	277	2852
10	5118	4857	6234	5258	2110	825	225
11	2074	3756	3263	4571	4226	1727	675

Table 23. Population biomass (t) at age from SPA.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	477	264	617	451	310	2401	3658	2167	5041	1243
2	1314	1163	606	1150	1464	641	4867	4855	8596	7887
3	3950	2028	1885	1090	2052	3023	1107	8513	10545	15073
4	6578	4140	2210	2440	1289	2334	3713	1902	11789	13496
5	5552	5308	2555	1880	1724	1367	1796	4020	2161	10151
6	5678	3178	2136	1707	984	1170	1031	1384	3567	1637
7	6894	2621	1218	1013	443	445	815	646	934	2029
8	2527	4060	629	531	243	181	276	460	308	432
9	748	799	852	269	72	117	103	132	164	119
10	329	225	38	459	82	45	68	73	61	95
11	137	79	78	8	129	8	32	53	15	45
3+	32393	22438	11600	9396	7018	8690	8940	17184	29544	43076
5+	21865	16270	7506	5867	3677	3333	4121	6768	7210	14508

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	2927	3333	3326	2403	1394	849	521	336	1123	2860
2	3586	6217	9516	6313	6796	5223	2540	1287	774	3239
3	18140	7050	14422	18770	13682	14041	10752	4519	2068	1434
4	20355	24332	11768	17322	24259	21097	17741	12103	5088	2598
5	14486	19484	22352	13247	15087	22944	20700	17084	11423	5128
6	9883	11268	13628	15518	11165	12357	18314	15466	16186	11135
7	1384	7255	6250	9978	13415	8550	8837	12565	14233	14340
8	1676	727	4417	3426	8985	10158	6510	5743	9766	12140
9	300	1143	354	3472	2794	6575	6678	5465	4749	7664
10	94	158	615	151	3031	2144	4281	5506	4027	3962
11	67	63	50	386	81	2076	1238	3762	4942	3175
3+	66385	71481	73856	82270	92499	99941	95051	82212	72481	61575
5+	27890	40098	47666	46178	54558	64804	66558	65591	65326	57544

age	1990	1991	1992	1993	1994	1995	1996
1	267	173	143	935	2509	0	0
2	4734	1116	414	414	2196	0	0
3	5164	9372	1777	727	620	3069	5631
4	1443	5602	10583	1871	708	626	3531
5	2755	1224	4983	9393	1769	650	666
6	4631	2144	920	3694	8300	1580	616
7	10480	4011	1596	413	3036	7680	1468
8	12084	8387	3518	980	303	2895	7147
9	8880	8797	6872	2629	822	263	2564
10	5460	5230	6454	5564	2121	751	193
11	2402	4230	3531	4564	4063	1738	711
3+	53299	48997	40234	29835	21742	19251	22527
5+	46692	34023	27874	27237	20414	15557	13365

Table 24. Fishing mortality at age from SPA

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.04	0.07	0.04	0.06	0.01	0.01	0.01	0.00	0.01	0.00
2	0.03	0.12	0.10	0.23	0.04	0.02	0.04	0.01	0.01	0.01
3	0.11	0.25	0.17	0.32	0.30	0.11	0.06	0.07	0.04	0.01
4	0.29	0.62	0.35	0.71	0.20	0.43	0.07	0.17	0.23	0.08
5	0.47	1.03	0.58	0.82	0.50	0.37	0.31	0.22	0.35	0.09
6	0.62	1.00	0.78	1.37	0.84	0.39	0.45	0.48	0.53	0.20
7	0.47	1.29	0.90	1.33	0.84	0.42	0.53	0.56	0.78	0.20
8	0.74	1.37	1.04	1.76	0.63	0.55	0.45	0.72	0.64	0.12
9	0.65	2.97	0.66	1.22	0.35	0.20	0.27	0.46	0.46	0.09
10	0.78	0.68	1.33	1.23	1.77	0.30	0.41	1.26	0.36	0.21
11	0.58	1.49	0.79	1.34	0.64	0.43	0.37	0.46	0.53	0.14
5+	0.62	1.40	0.87	1.30	0.80	0.38	0.40	0.59	0.52	0.15

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.01	0.01	0.01	0.01	0.00	0.06	0.00	0.02	0.01	0.04
2	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.05
3	0.07	0.01	0.05	0.02	0.03	0.01	0.04	0.01	0.01	0.08
4	0.2	0.19	0.05	0.15	0.11	0.08	0.10	0.00	0.02	0.08
5	0.33	0.39	0.34	0.18	0.15	0.16	0.23	0.02	0.02	0.07
6	0.36	0.58	0.25	0.16	0.10	0.17	0.30	0.05	0.05	0.04
7	0.57	0.45	0.50	0.10	0.05	0.06	0.28	0.09	0.09	0.10
8	0.26	0.73	0.14	0.16	0.02	0.15	0.11	0.09	0.10	0.15
9	0.48	0.35	0.61	0.02	0.03	0.11	0.10	0.02	0.06	0.21
10	0.25	0.88	0.15	0.48	0.01	0.19	0.06	0.05	0.03	0.21
11	0.39	0.47	0.34	0.14	0.09	0.13	0.20	0.05	0.06	0.13
5+	0.38	0.55	0.33	0.18	0.06	0.14	0.18	0.05	0.06	0.13

age	1990	1991	1992	1993	1994	1995	1996
1	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2	0.00	0.01	0.01	0.01	0.00	0.00	0.00
3	0.01	0.02	0.03	0.01	0.00	0.00	0.00
4	0.08	0.10	0.09	0.03	0.00	0.01	0.01
5	0.05	0.24	0.21	0.03	0.01	0.01	0.01
6	0.03	0.08	0.70	0.05	0.00	0.01	0.00
7	0.04	0.06	0.26	0.21	0.00	0.00	0.00
8	0.16	0.04	0.07	0.04	0.00	0.00	0.00
9	0.32	0.13	0.04	0.03	0.00	0.01	0.00
10	0.11	0.20	0.11	0.02	0.00	0.00	0.00
11	0.12	0.12	0.24	0.07	0.00	0.01	0.00
5+	0.12	0.12	0.23	0.06	0.00	0.01	0.00

Table 25. Age by age residuals from ADAPT.

Residuals										
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
2	-0.35	0.80	0.10	0.16	0.23	-0.05	-0.56	0.48	0.06	-0.35
3	-0.39	-0.21	-0.27	-0.44	0.72	0.03	-0.89	0.35	0.59	-0.25
4	-0.32	-0.06	-0.55	-0.71	-0.04	0.69	-0.56	0.33	0.50	0.34
5	-0.36	-0.58	-0.41	-0.97	0.21	0.25	0.60	0.52	-0.20	-0.23
6	-0.52	-0.38	-0.15	0.44	0.48	1.29	-0.02	0.95	-0.27	-0.04
7	-0.55	-0.57	0.02	-0.20	1.27	1.20	0.75	0.89	0.10	-0.10
8	0.84	-0.04	0.63	1.38	1.36	1.67	0.59	1.08	-1.17	0.39
avg 2-8	-0.24	-0.15	-0.09	-0.05	0.61	0.73	-0.01	0.66	-0.06	-0.03
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
age										
2	-3.20	-0.12	-0.17	-0.11	-0.28	-1.82	-0.12	-0.38	2.46	0.52
3	-0.04	-2.14	0.03	0.33	-0.13	-0.66	-0.90	-0.56	1.04	0.41
4	0.29	-0.56	-1.09	0.11	0.43	-0.47	-0.18	-1.79	0.10	-0.34
5	0.58	-0.28	-0.03	-0.60	-0.36	-0.12	0.11	-0.47	-0.82	-0.58
6	-0.11	-0.19	-0.24	-0.62	-0.50	-0.44	0.14	-0.18	0.01	-1.27
7	0.58	-1.30	-0.12	-0.92	-0.97	-1.38	0.05	0.05	0.12	-0.33
8	-0.38	0.45	-1.00	-0.65	-1.81	-0.31	-0.68	-0.23	0.50	0.06
avg 2-8	-0.33	-0.59	-0.37	-0.35	-0.52	-0.74	-0.23	-0.51	0.49	-0.22
	1990	1991	1992	1993	1994	1995	1996			
age										
2	0.50	0.23	0.67	0.96	0.33	-0.03	0.03			
3	0.62	0.68	0.69	0.50	0.51	0.14	0.27			
4	1.15	1.43	0.20	0.78	0.33	-0.26	0.26			
5	-0.69	2.22	0.73	0.25	0.54	0.41	0.30			
6	-1.01	0.27	0.78	0.34	0.12	1.35	-0.23			
7	-1.37	0.27	-0.03	1.61	0.46	-0.07	0.52			
8	-0.61	-0.31	-1.61	-0.59	0.77	-0.36	0.04			
avg 2-8	-0.20	0.68	0.20	0.55	0.44	0.17	0.17			

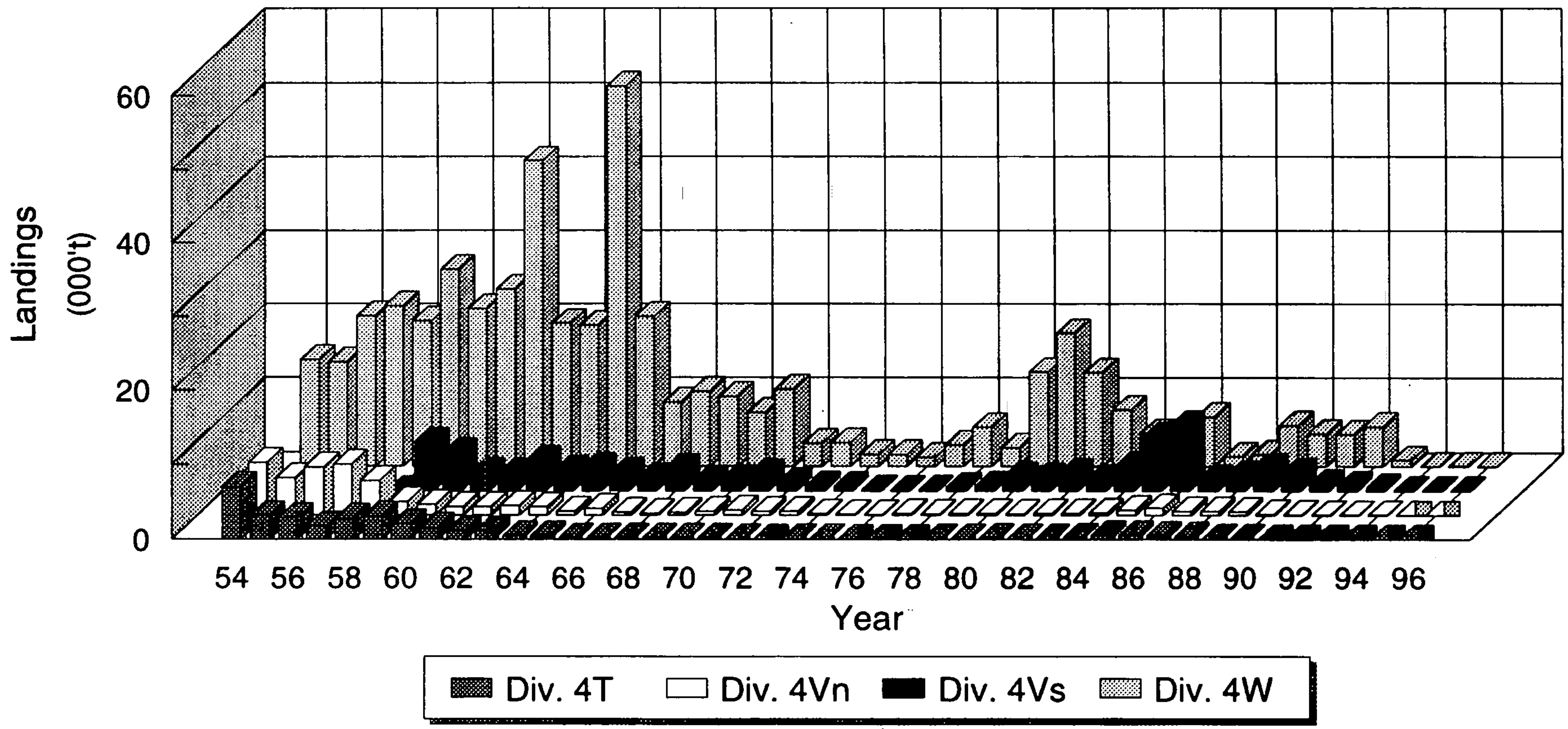


Figure 1. Nominal catches of Div. 4TVW haddock (from NAFO Stat. Bull.).

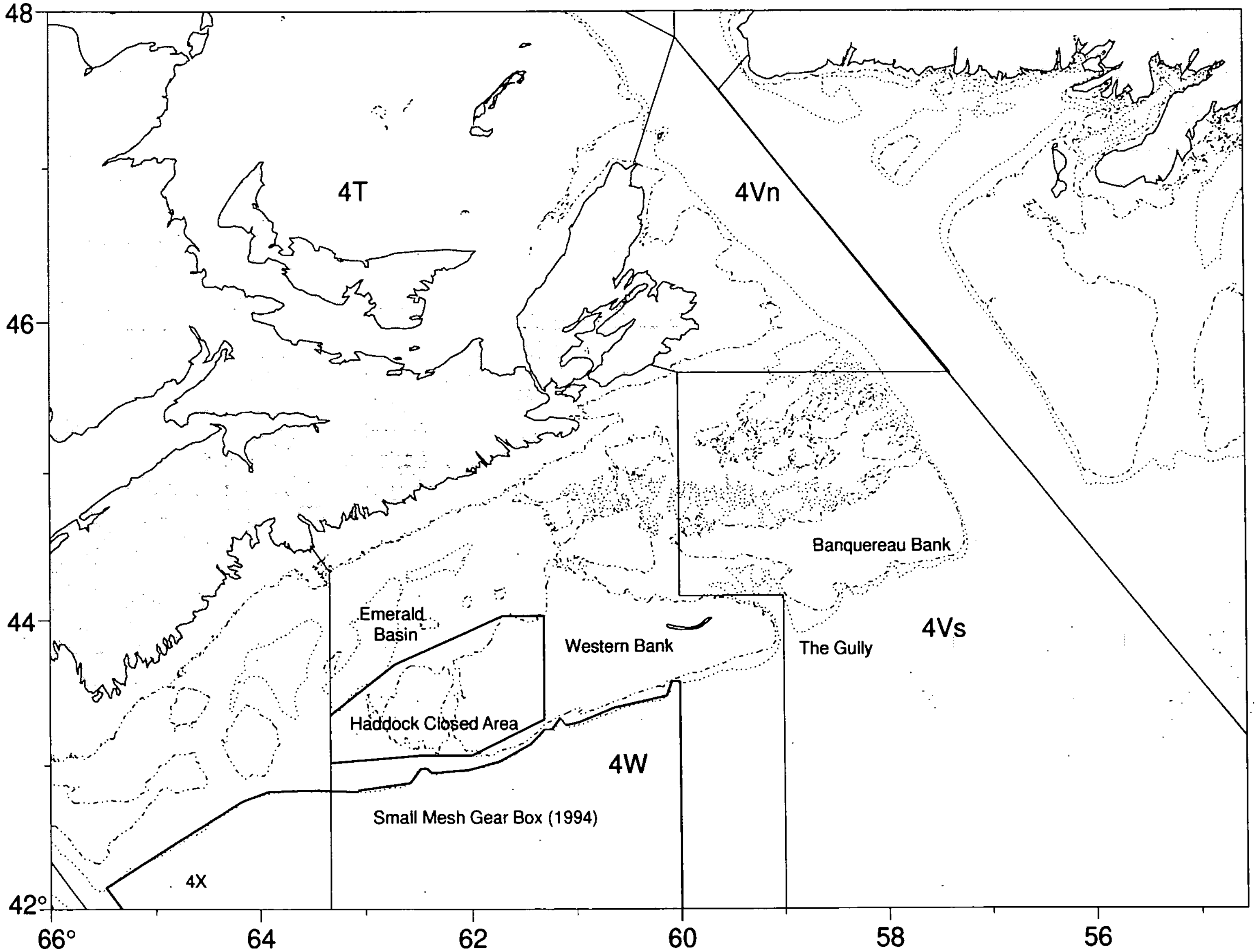


Figure 2. Geographic display of the Div. 4TVW haddock management unit.Note location of closed area and small mesh gear box.

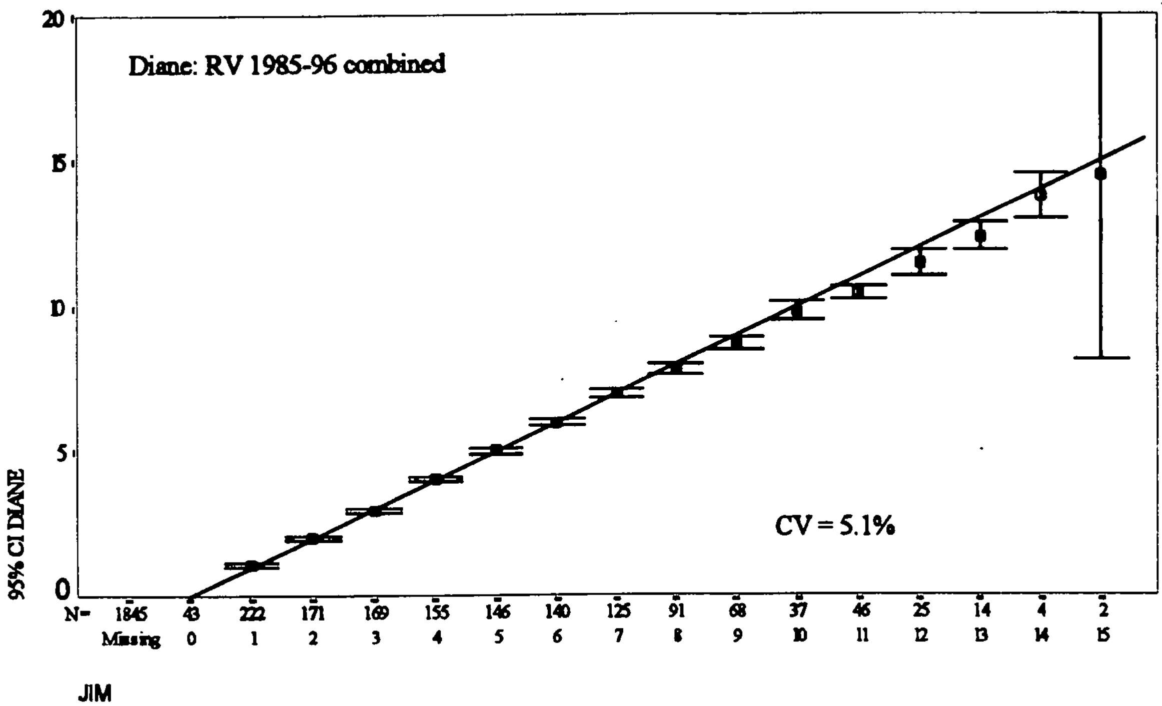


Figure 3. Div. 4TVW haddock ageing comparisons between 2nd (Diane) and 1st (Jim) readers for the summer RV survey otoliths.

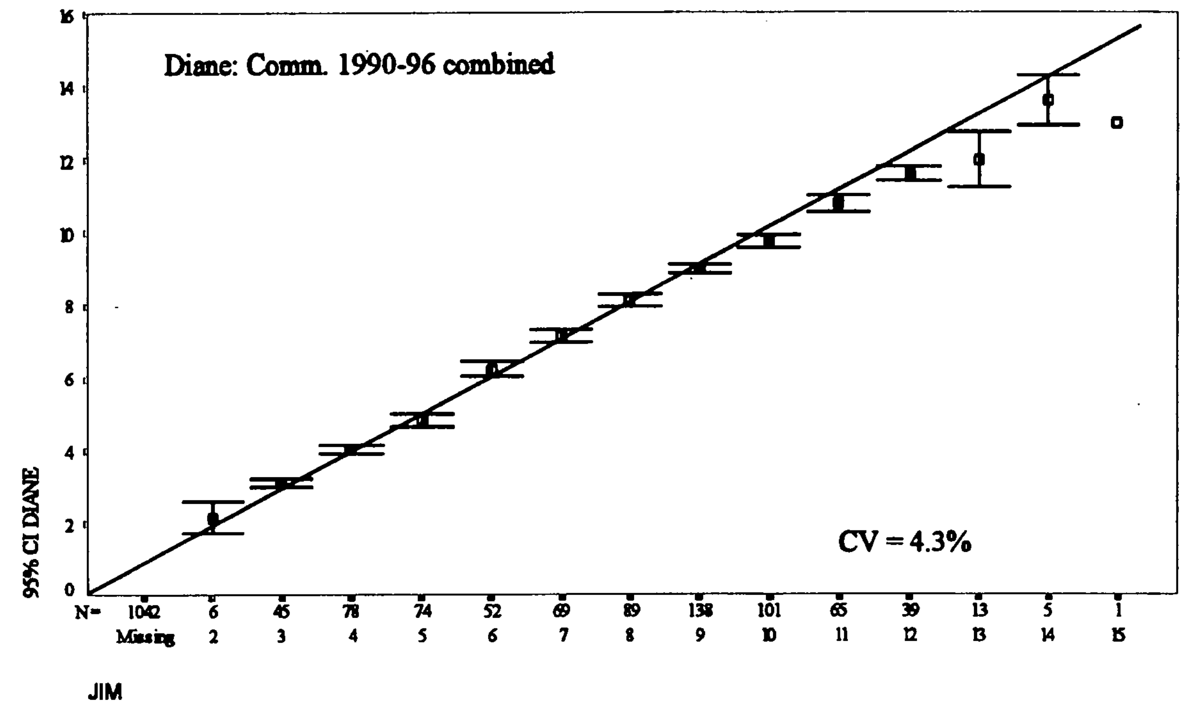
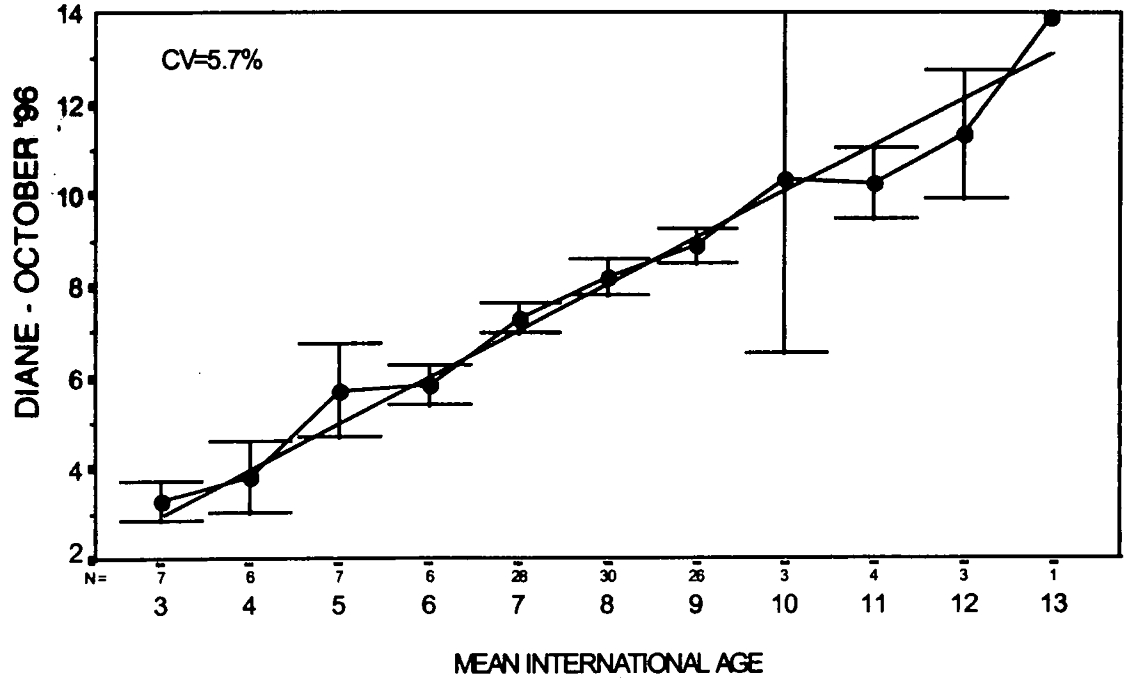


Figure 4. Div. 4TVW haddock ageing comparisons between 2nd (Diane) and 1st (Jim) readers for the summer RV survey otoliths.



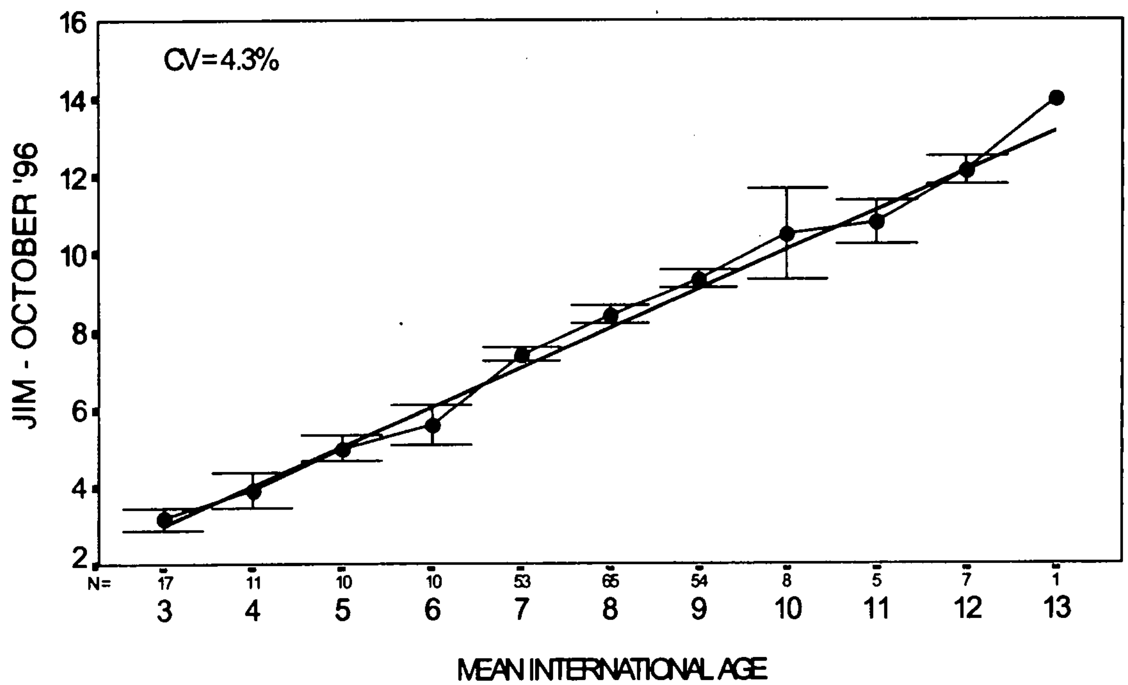
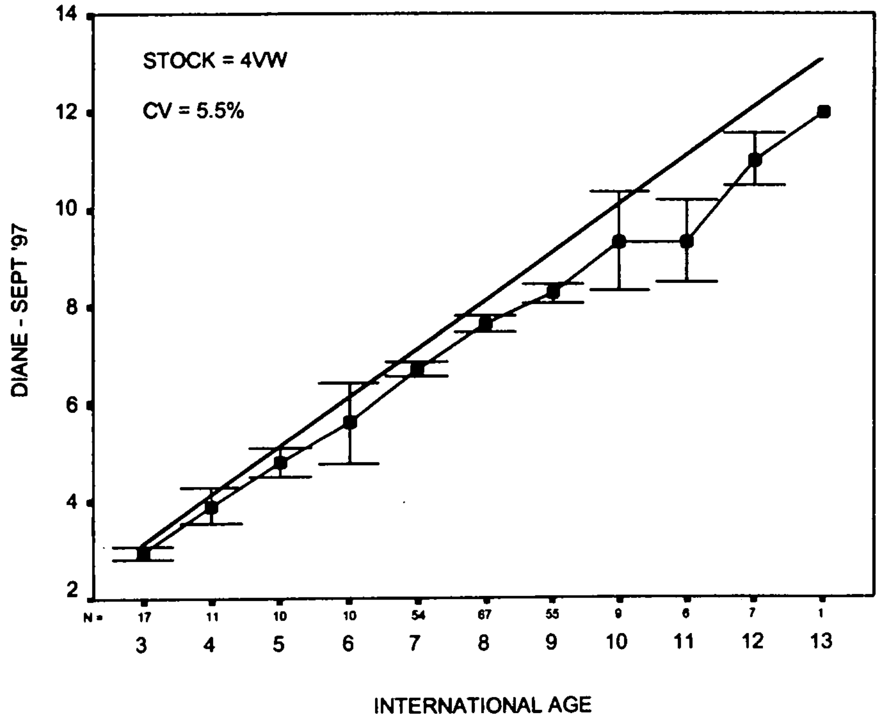


Figure 5. Comparison between ages assigned by the 1st and 2nd readers for the Div. 4TVW haddock reference otoliths. Note: this test was conducted in October of 1996.



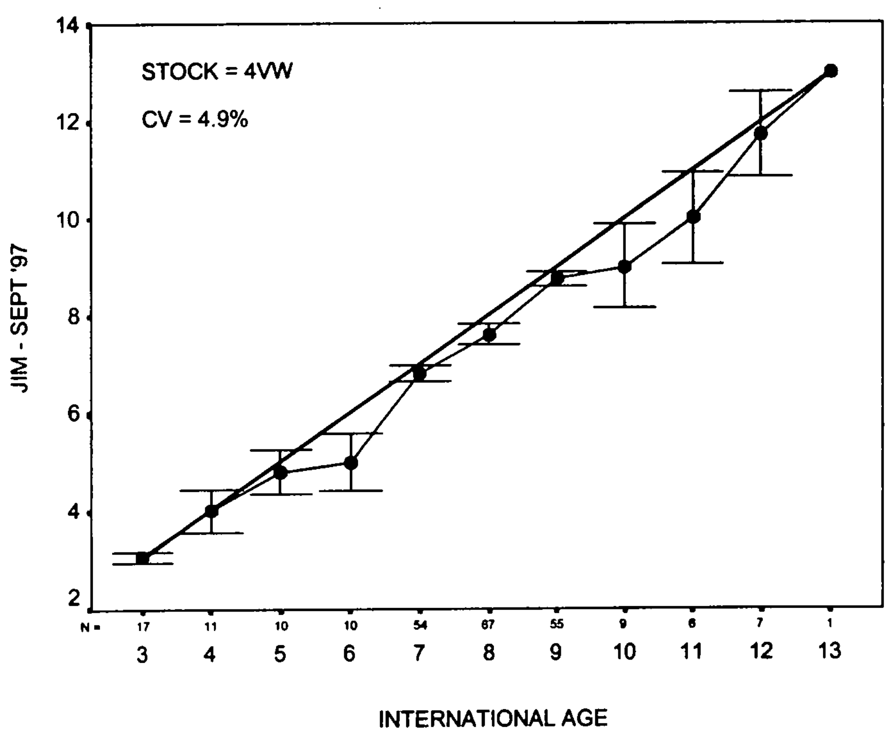


Figure 6. Comparison between ages assigned by the 1st and 2nd readers for the Div. 4TVW haddock reference otoliths. Note: this test was conducted in September of 1997.

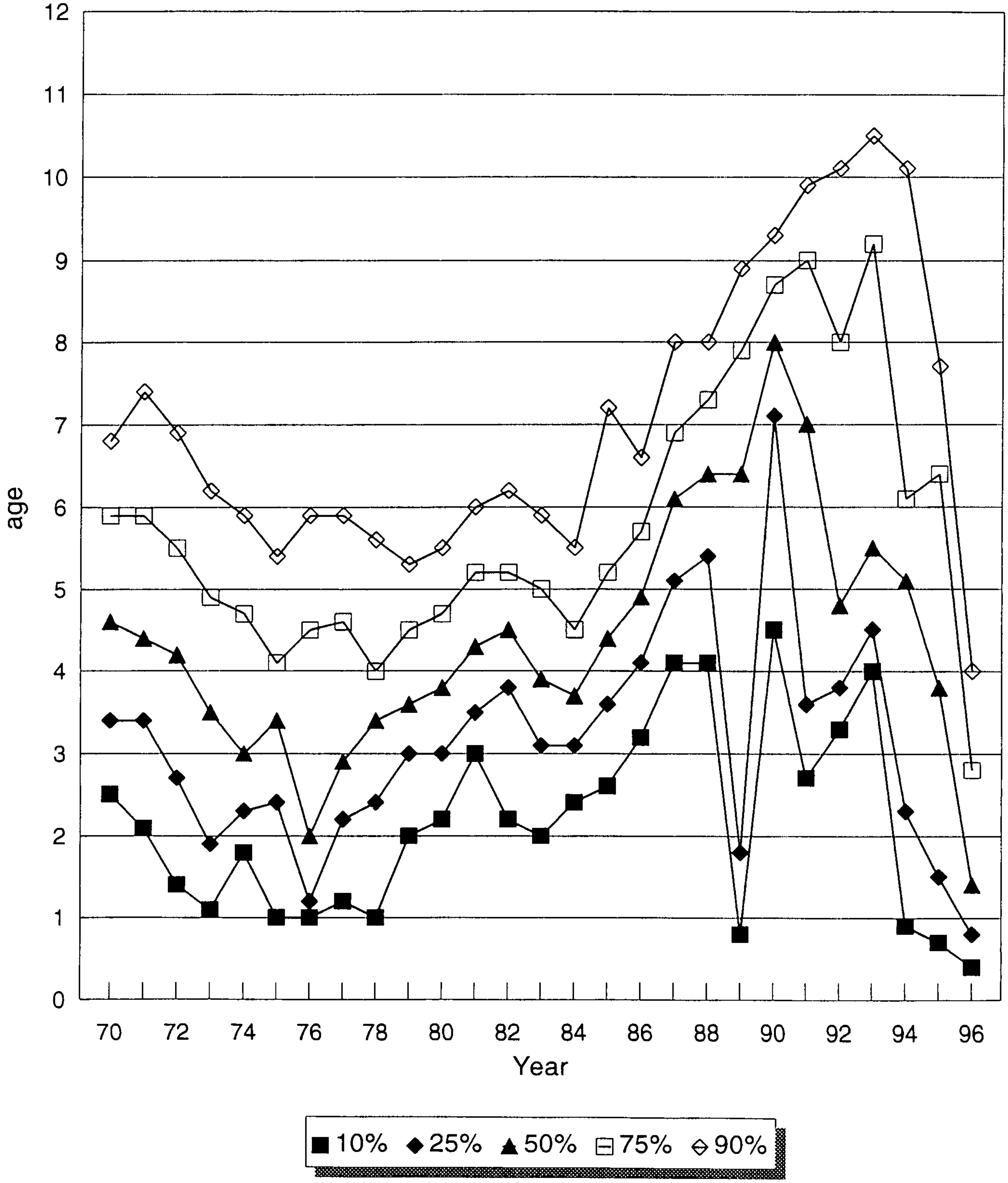


Figure 7. Cumulative proportion of catch in terms of age from haddock landings in Div. 4VW.

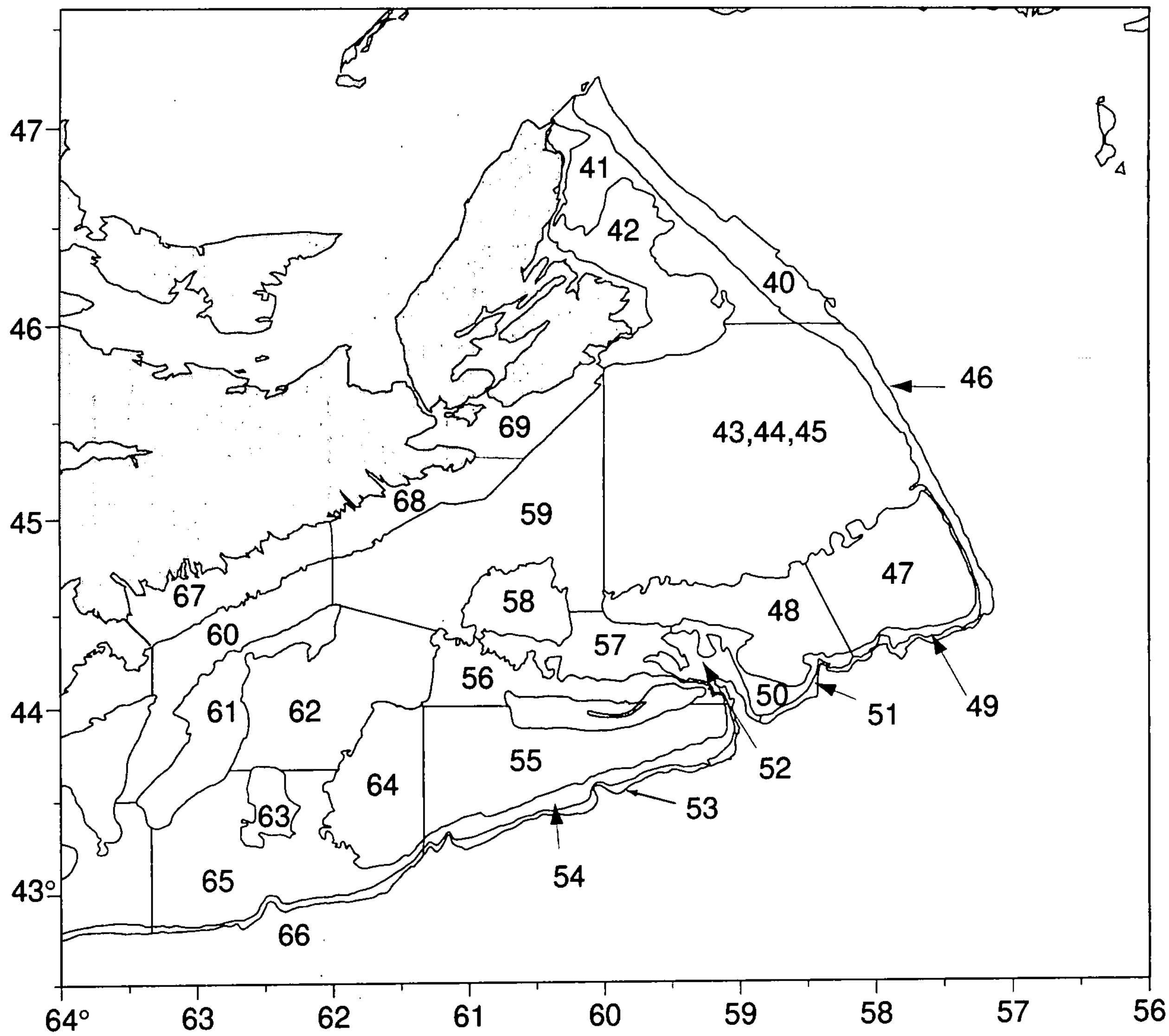


Figure 8. Stratification scheme for the summer RV survey. Note addition of three inshore strata (67-69) used in the fixed gear Sentinel Survey.

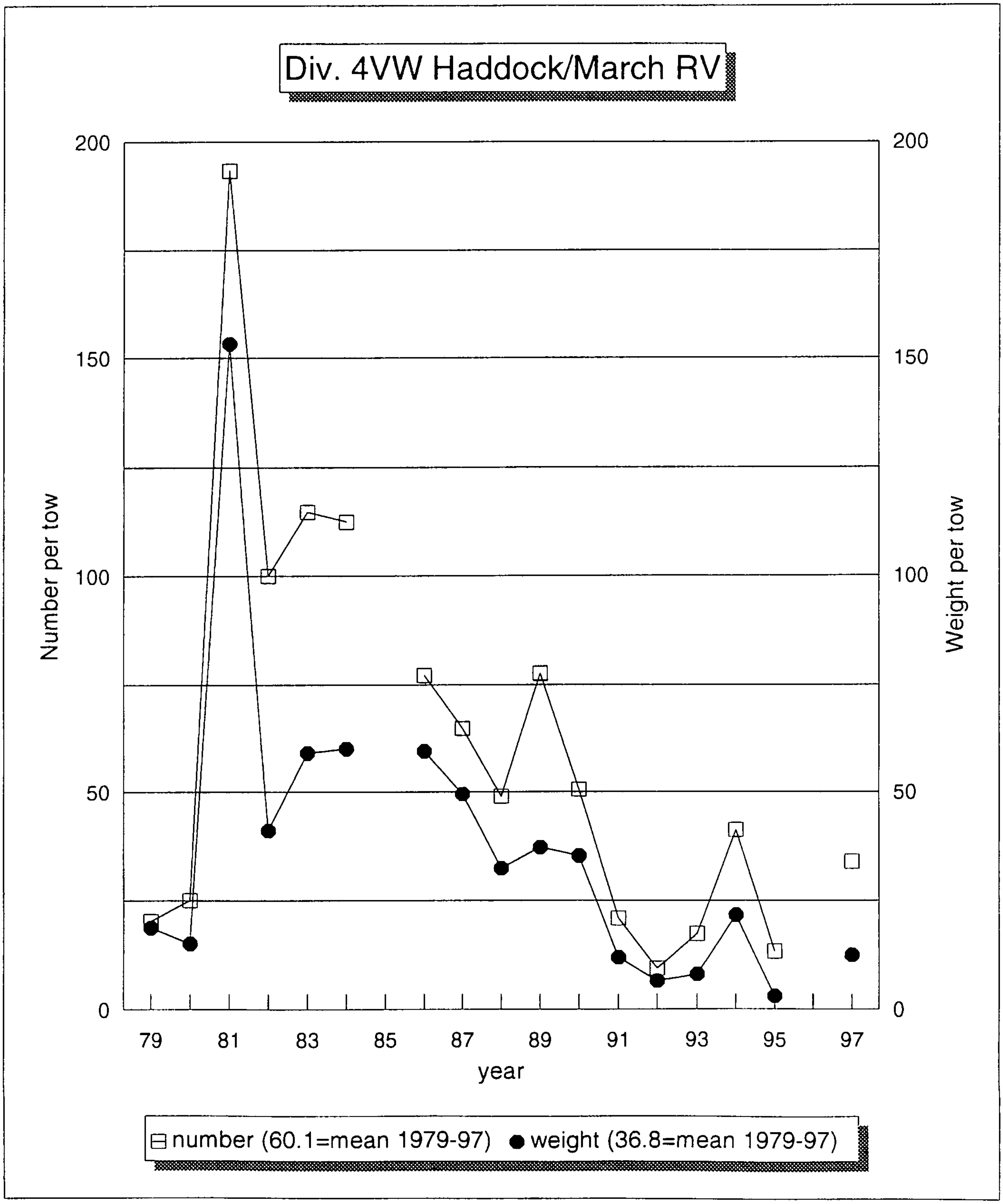


Figure 9. Spring RV survey mean number and weight (kg) per tow for haddock collected in Div. 4VW. Note: average numbers and weights for the entire series are given.

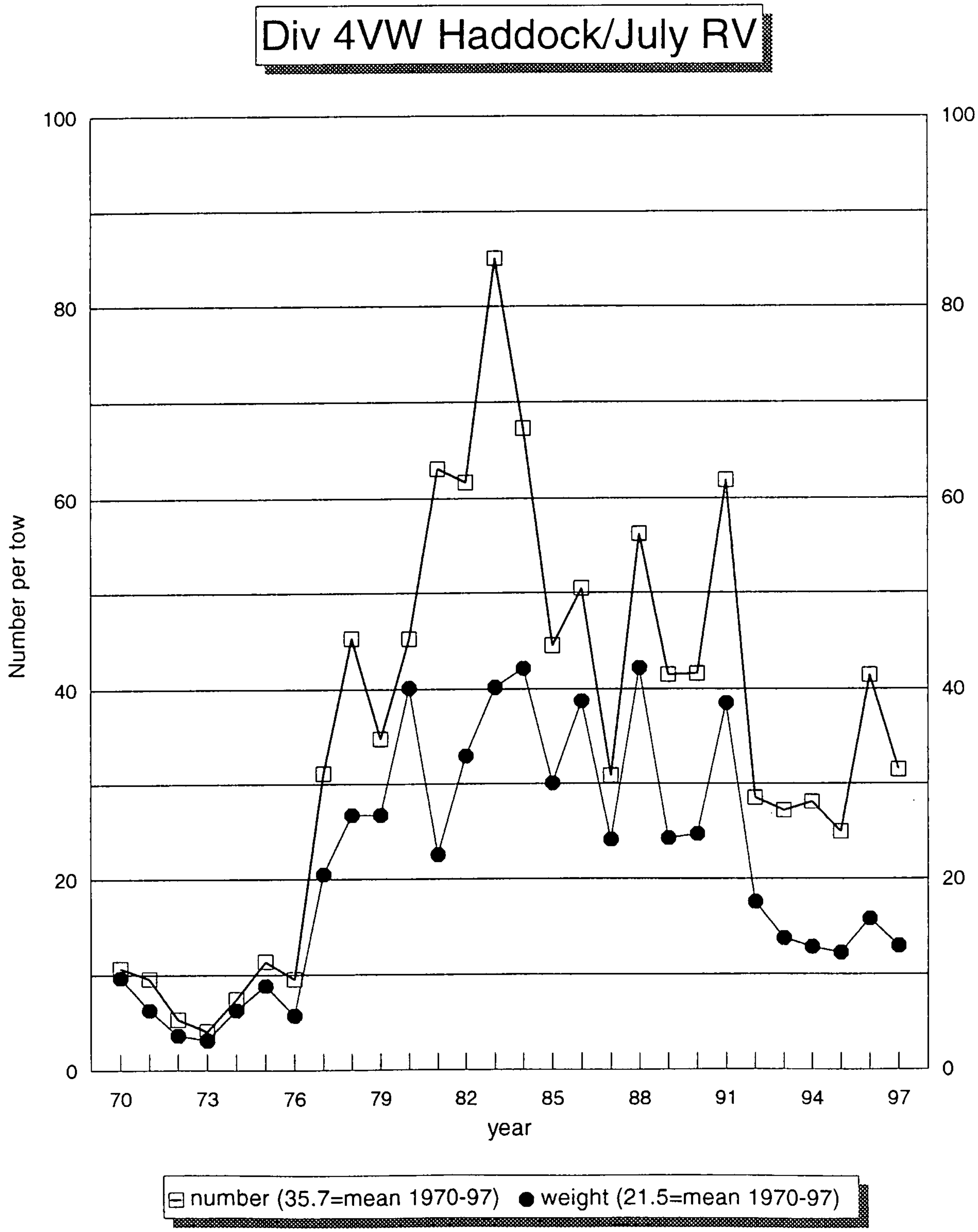


Figure 10. Summer RV survey mean number and weight (kg) per tow for haddock collected in Div. 4VW. Note: average numbers and weights for the entire data series are given.

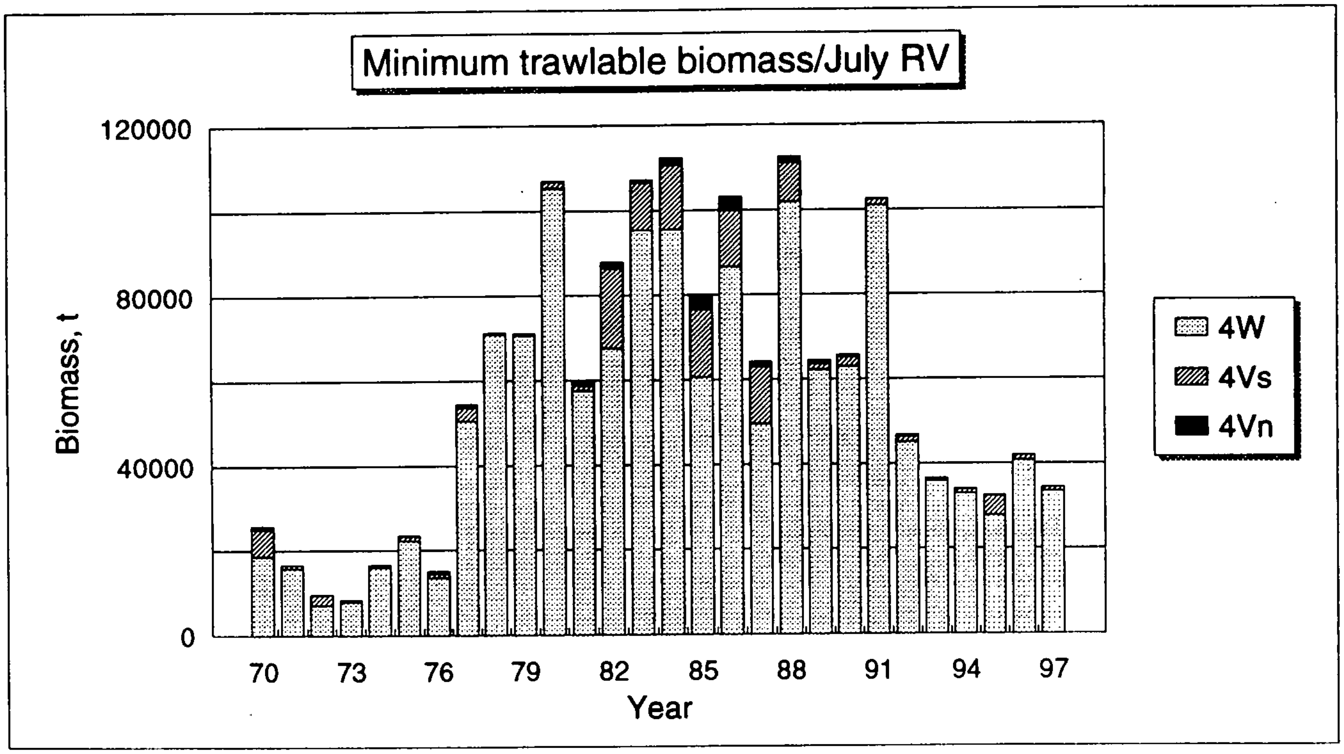


Figure 11. Minimum trawlable biomass of haddock in Div. 4W, 4Vs, and 4Vn from the summer RV survey from 1970 to 1997.

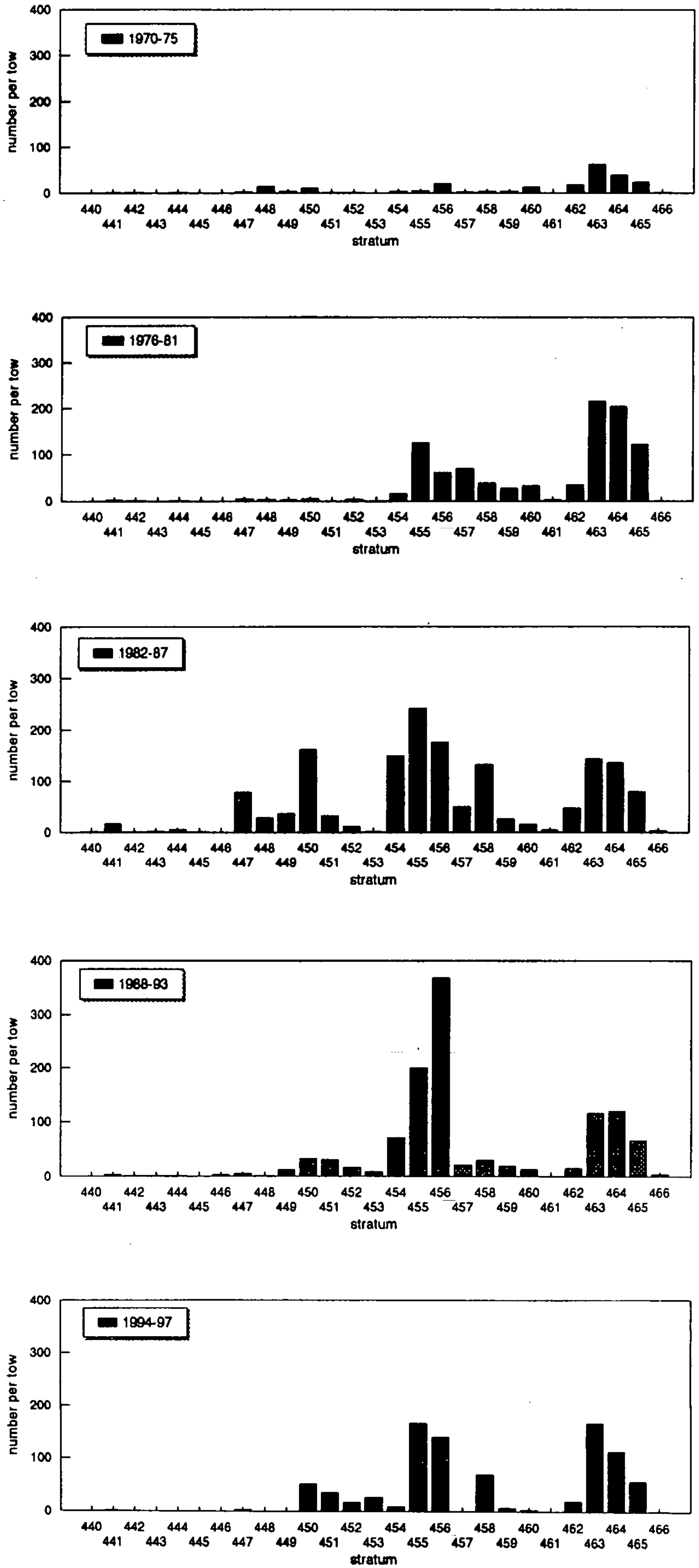


Figure 12. Mean number per tow by stratum averaged for 5 time periods from the summer RV survey.

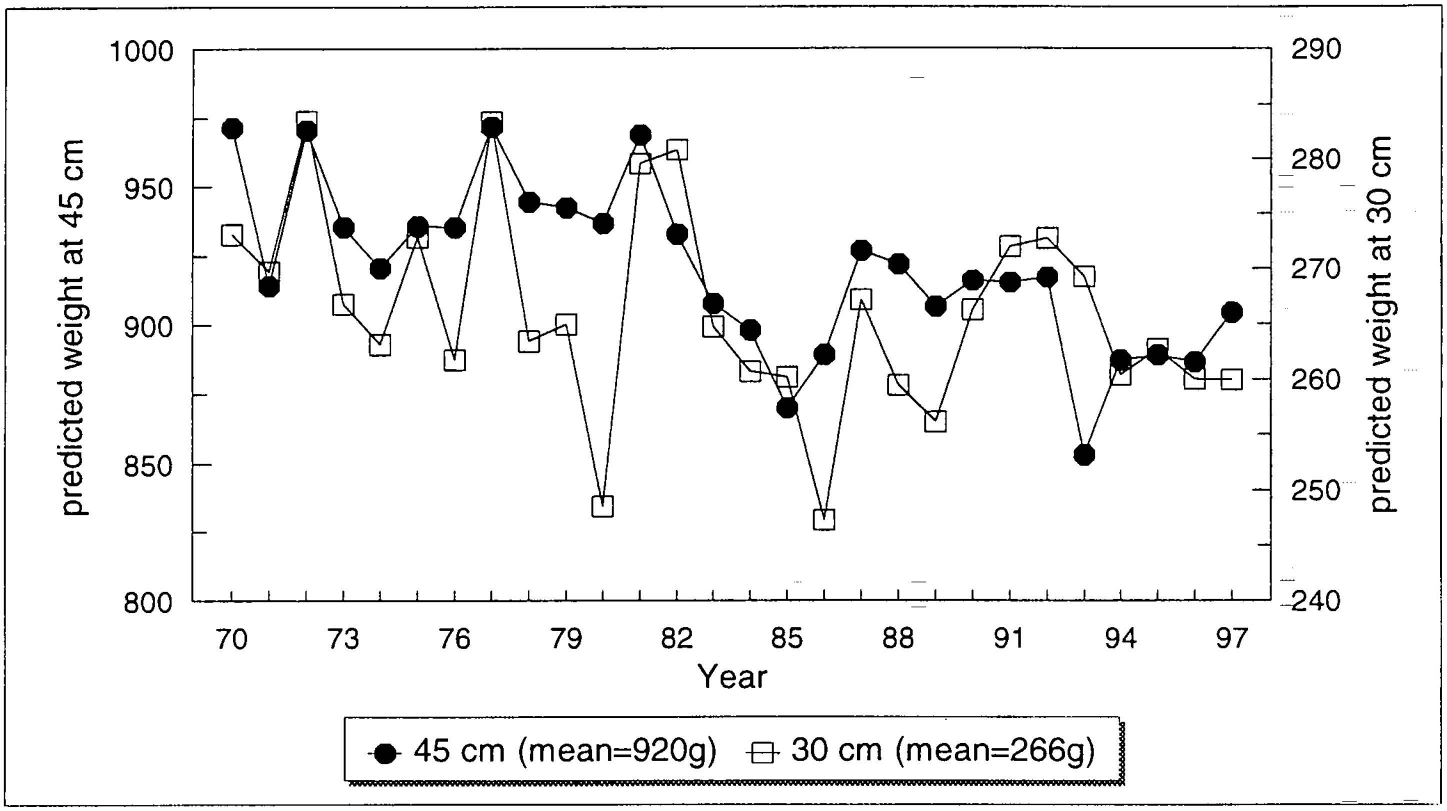


Figure 13. Predicted weight of 30 and 45 cm haddock from the summer RV survey from 1970-1997 for Div. 4VW.

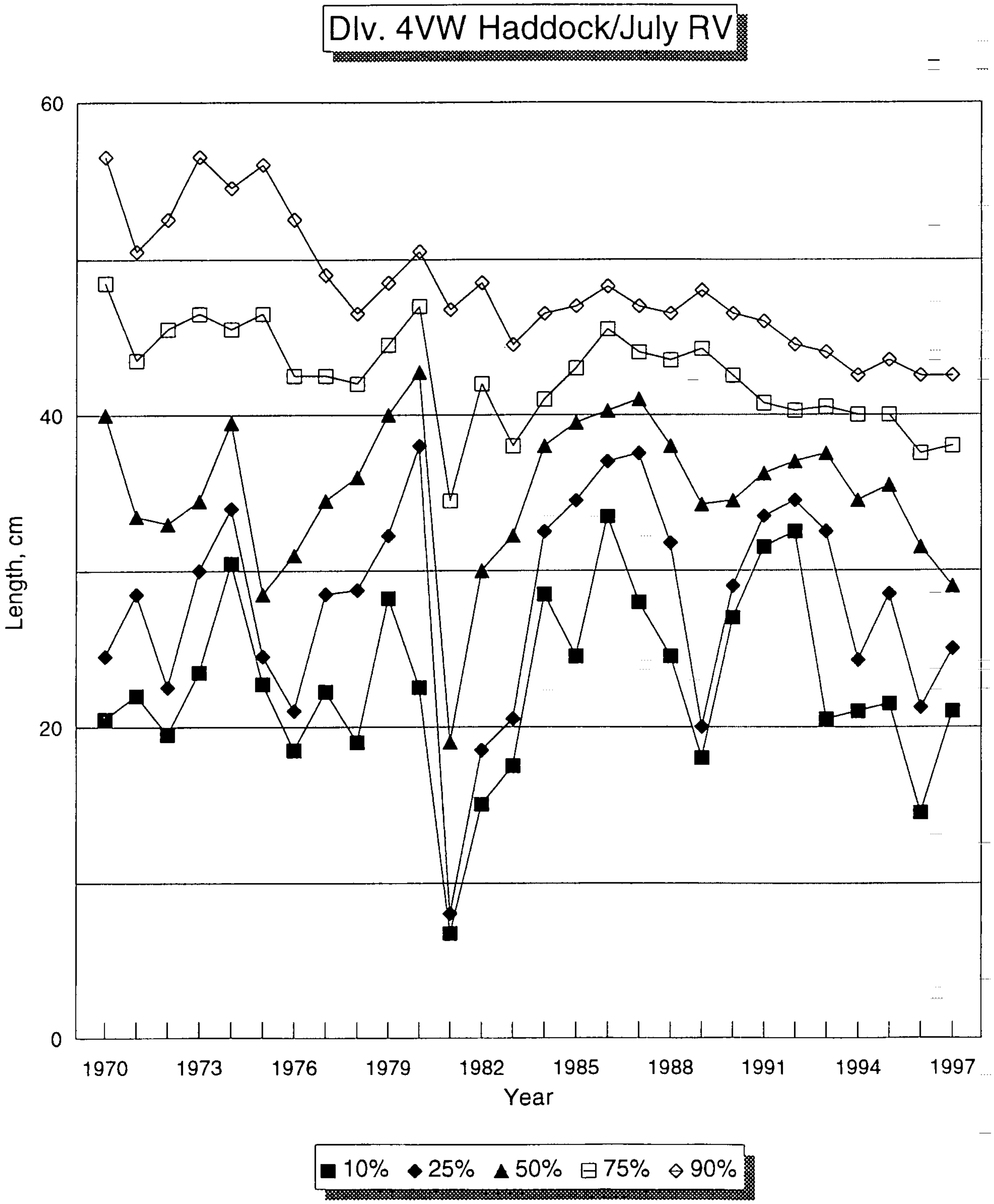


Figure 14. Cumulative proportion of catch in terms of length from the summer RV survey. The 10th, 25th, 50th (median), 75th and 90th percentiles are shown.

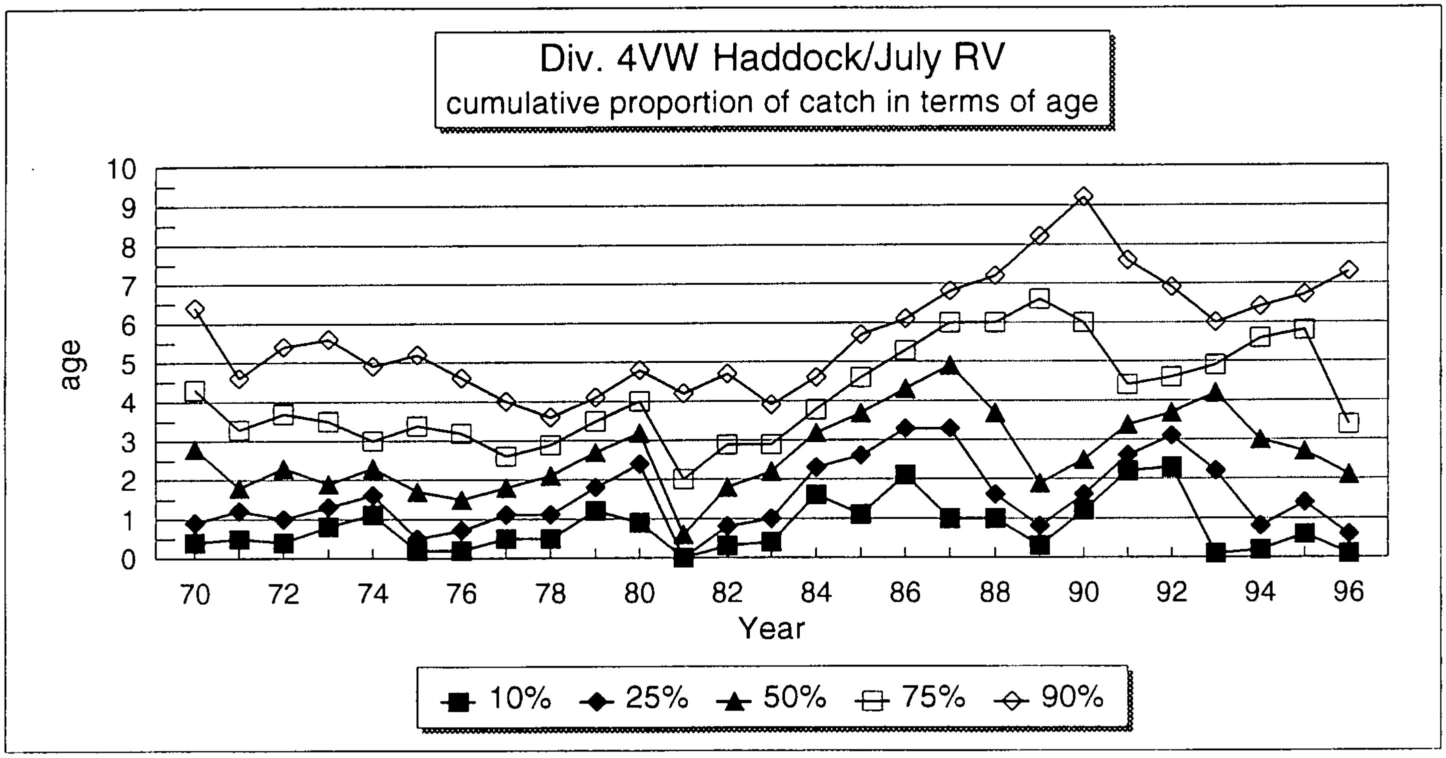
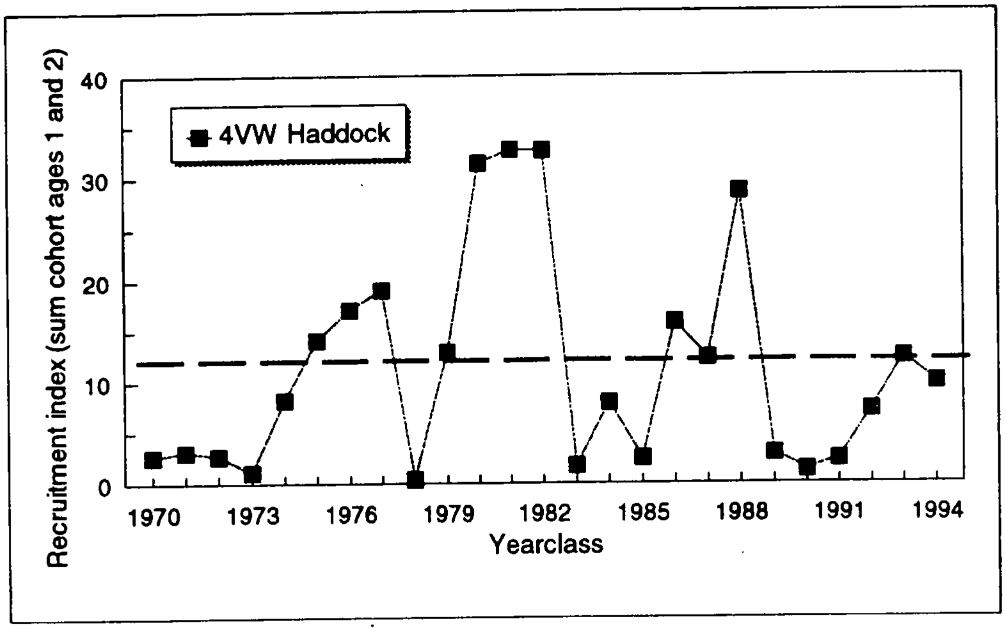


Figure 15. Cumulative proportion of catch in terms of age from the summer RV survey. The 10th, 25th, 50th (median), 75th and 90th percentiles are shown.



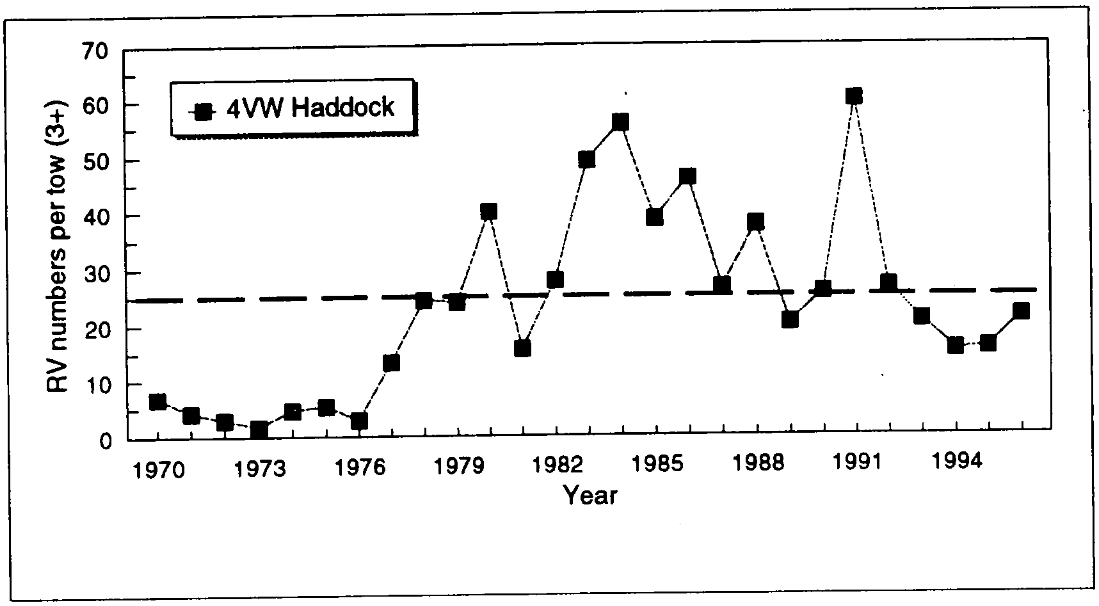


Figure 16. Recruitment index and 3+ numbers per tow for haddock from summer RV survey.

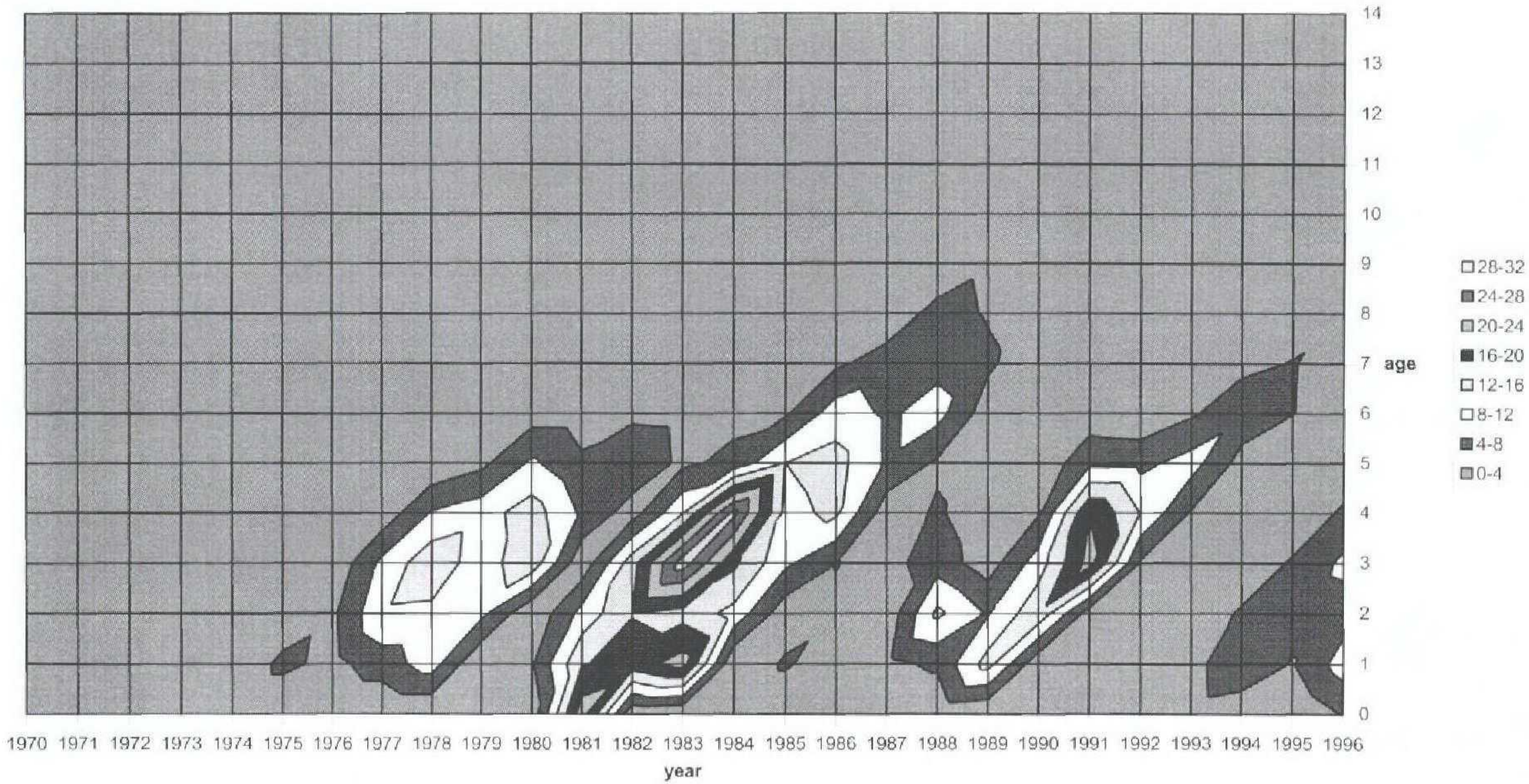


Figure 17. Contour plot of the mean numbers per tow at age from the summer RV survey from 1970 to 1996. Data taken from Table 16.

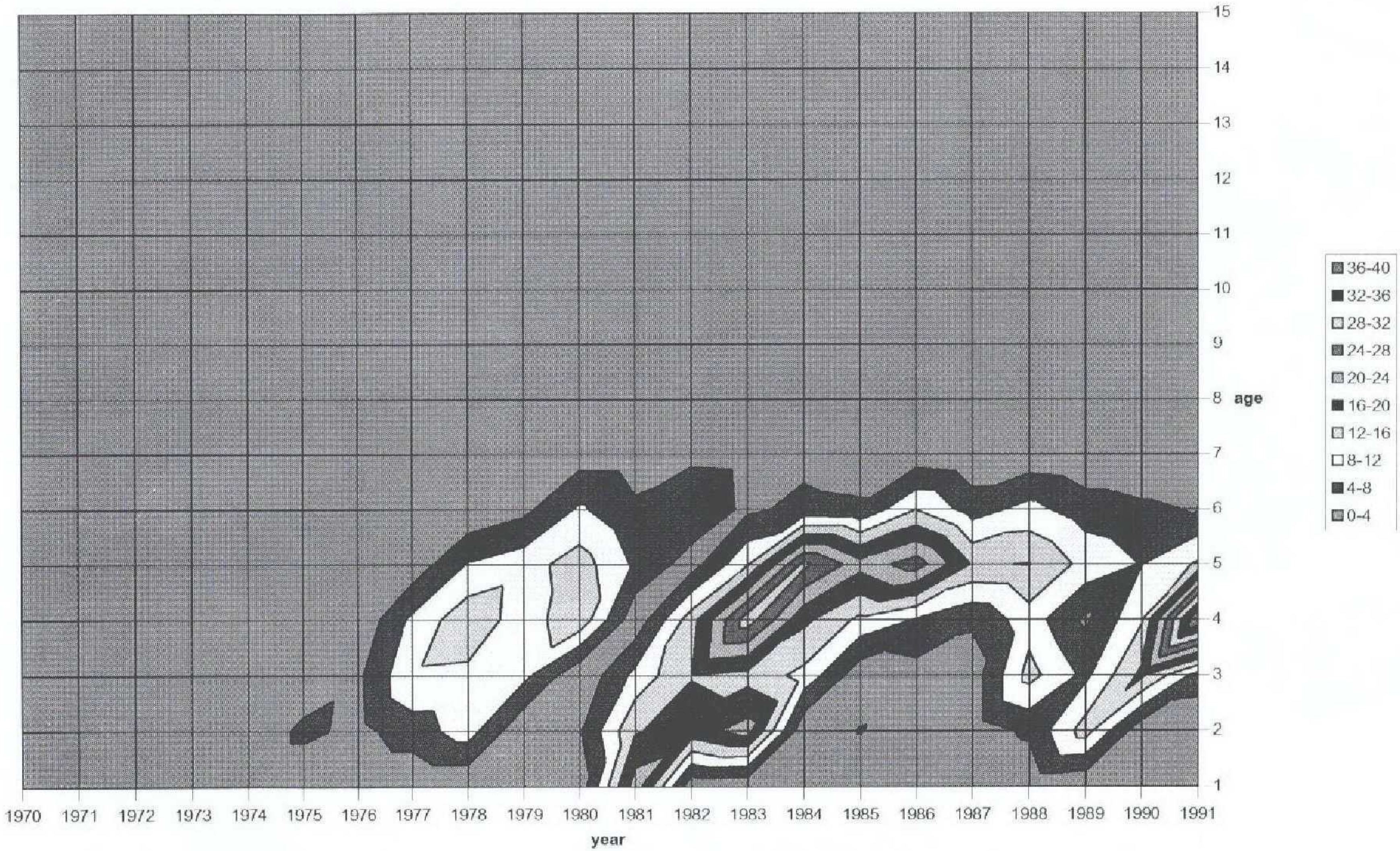


Figure 18. Contour plot of the mean numbers per tow at age from the summer RV survey from 1970 to 1996. Data taken from Zwanenburg (1992) and was based on old ageing criteria.

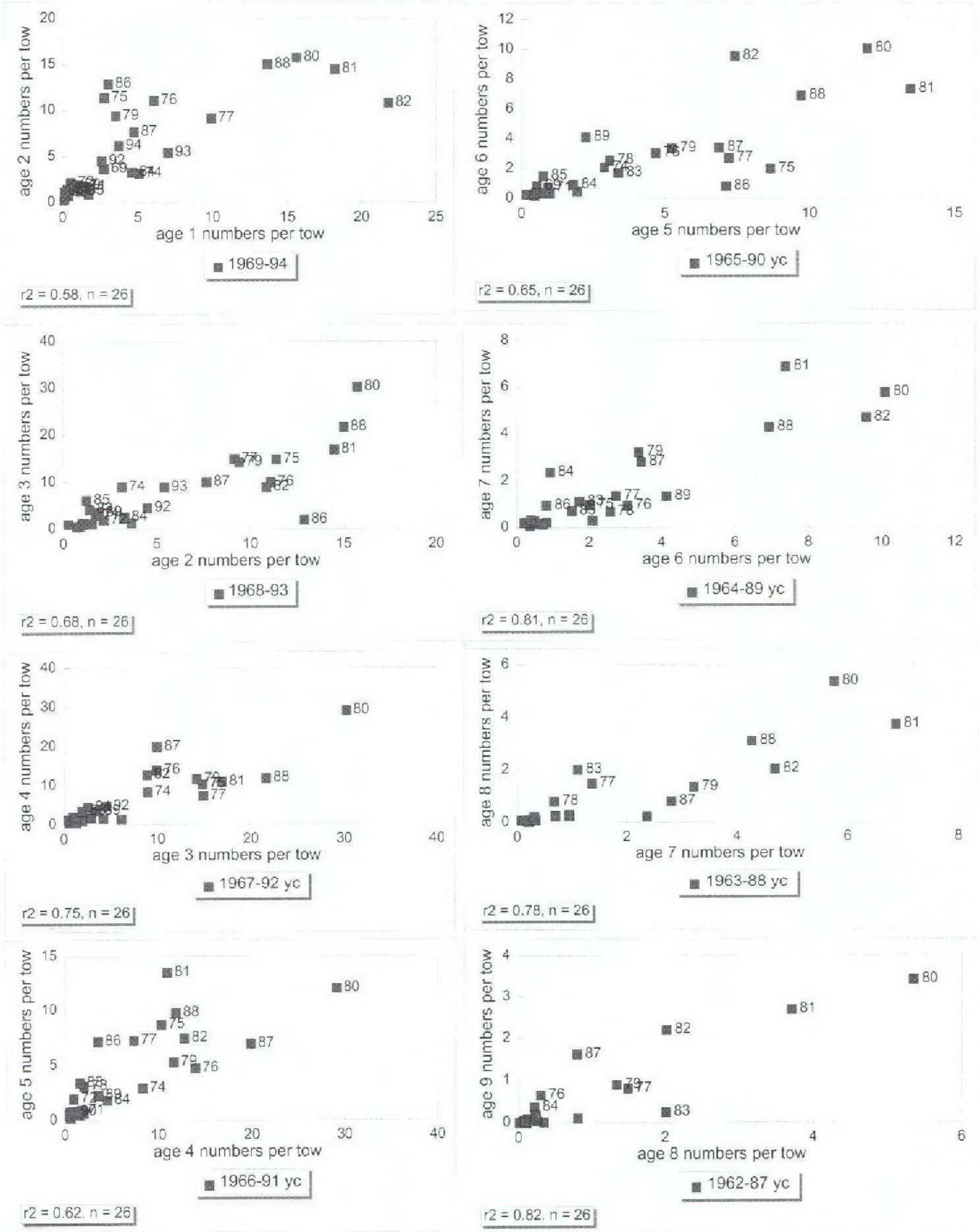


Figure 19. Relationship between yearclass estimates at successive ages in the summer RV survey for ages 1and 2, ages 2 and 3, ages 3 and 4, and so on. time period, sample sizes and r-squared values are given.

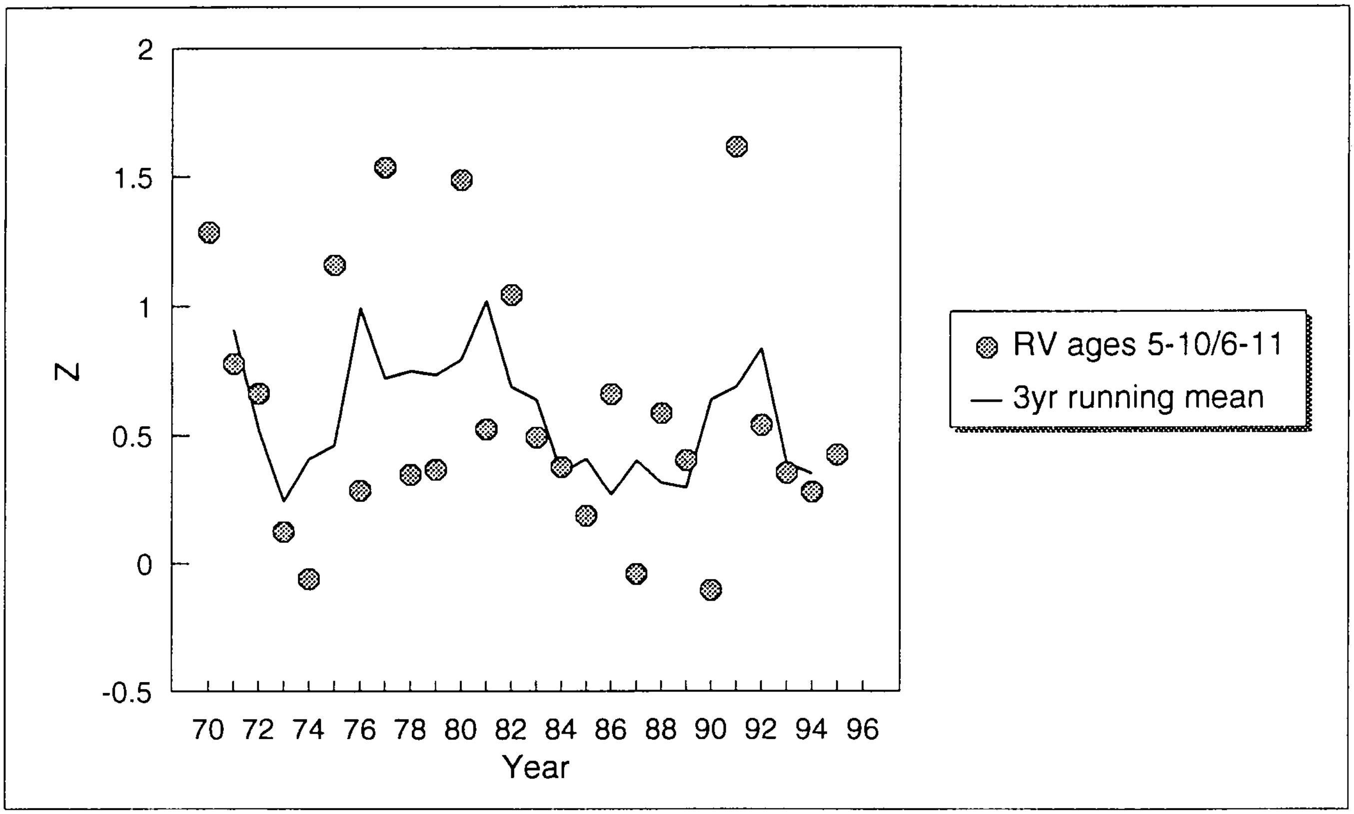


Figure 20. Total mortality rate of haddock from the summer RV survey estimated as the logarithm of the ratio of ages 5-10 in year t to ages 6-11 in year t+1.

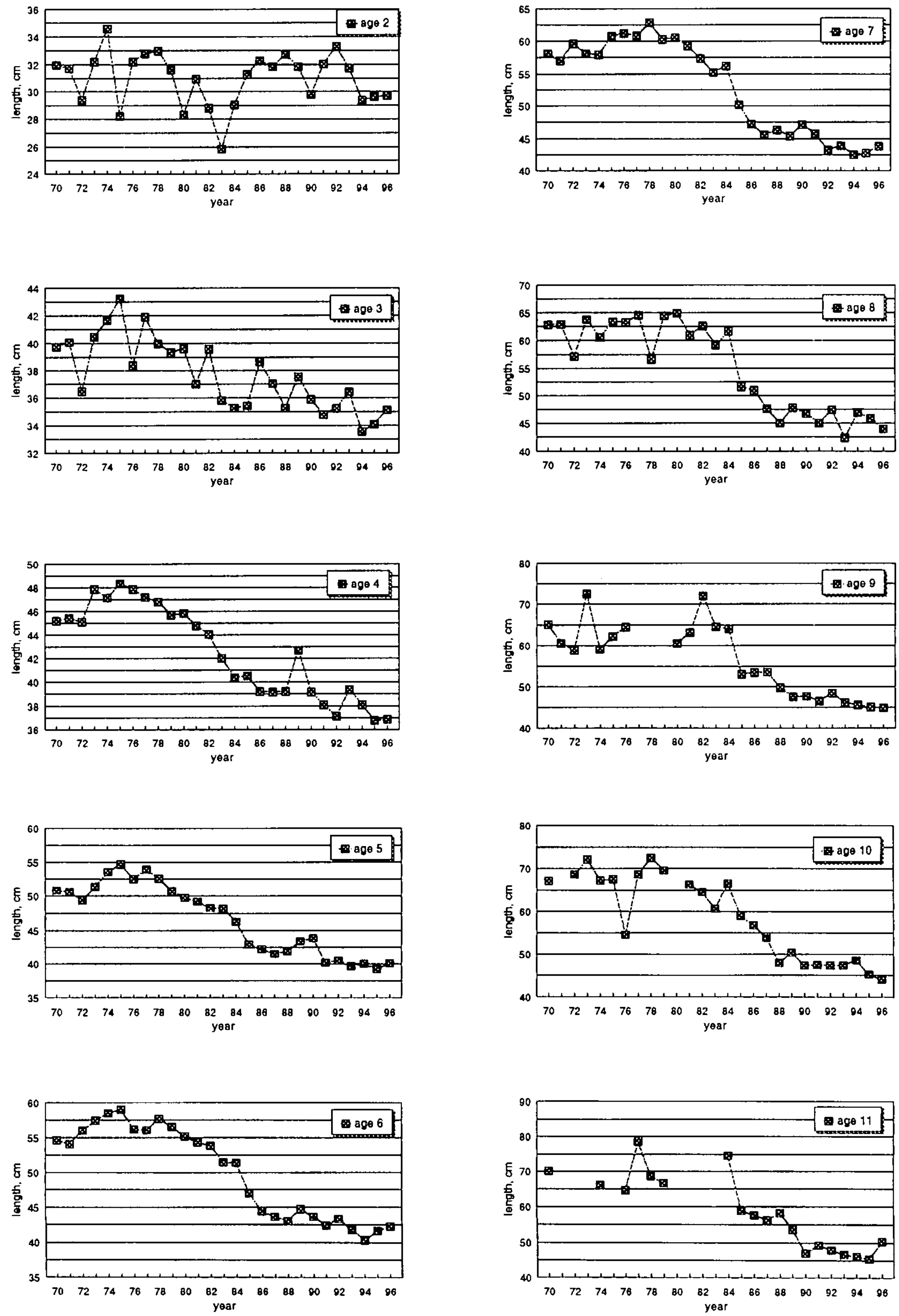


Figure 21. Div. 4VW haddock mean length at age from the summer RV survey.

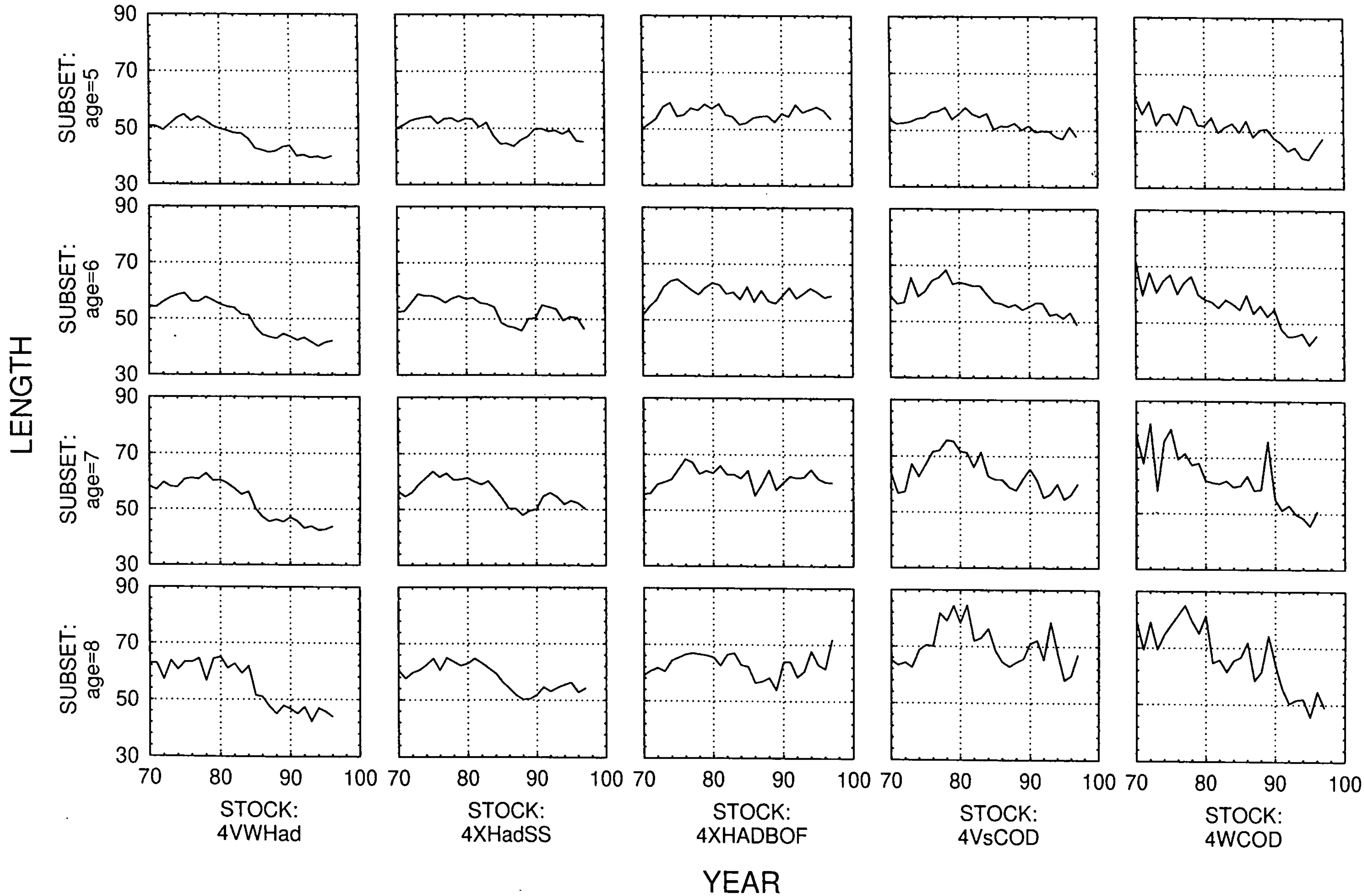


Figure 22. Mean length at age in five groundfish substocks.

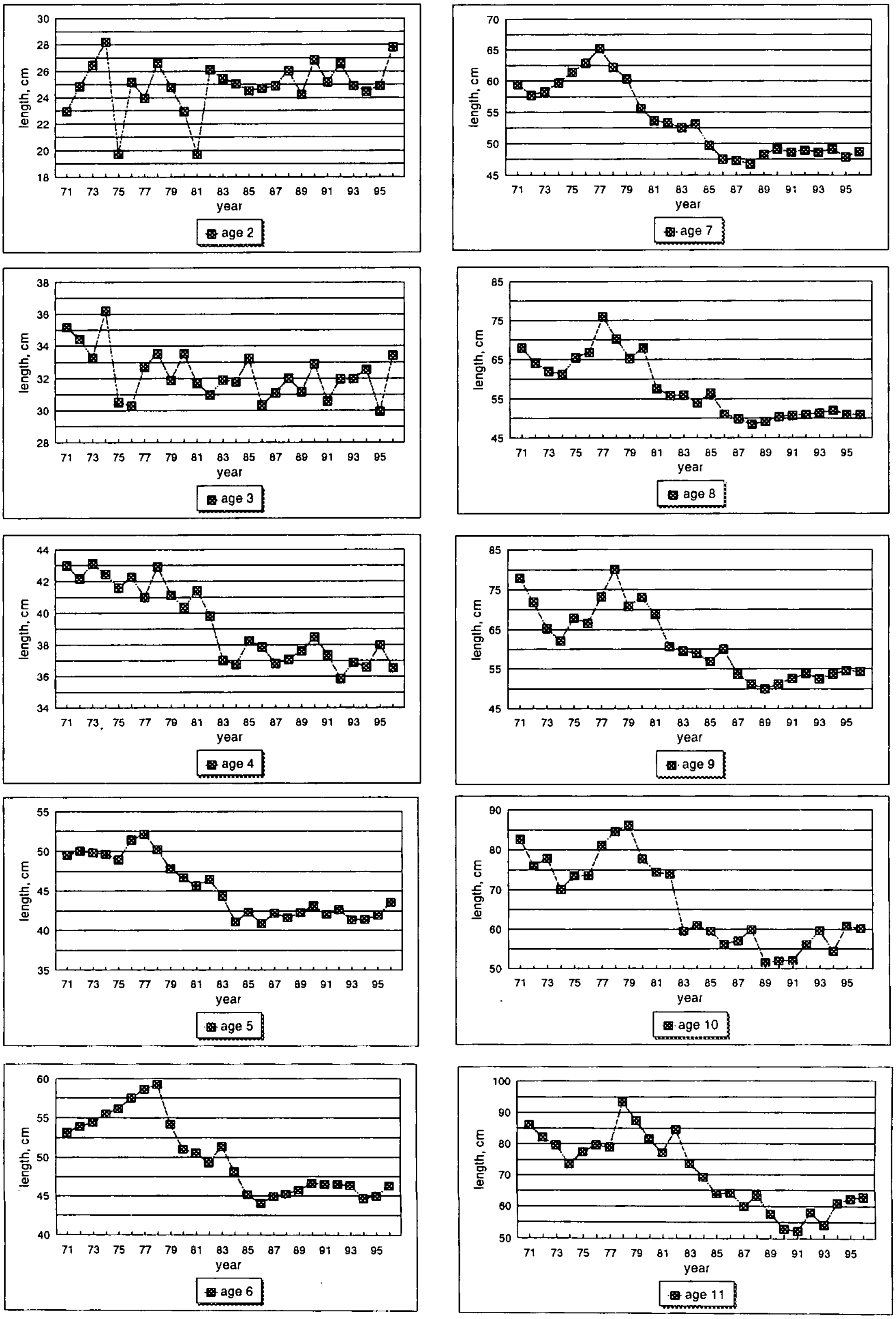


Figure 23. Div. 4TVn cod mean length at age (data provided by A. Sinclair).

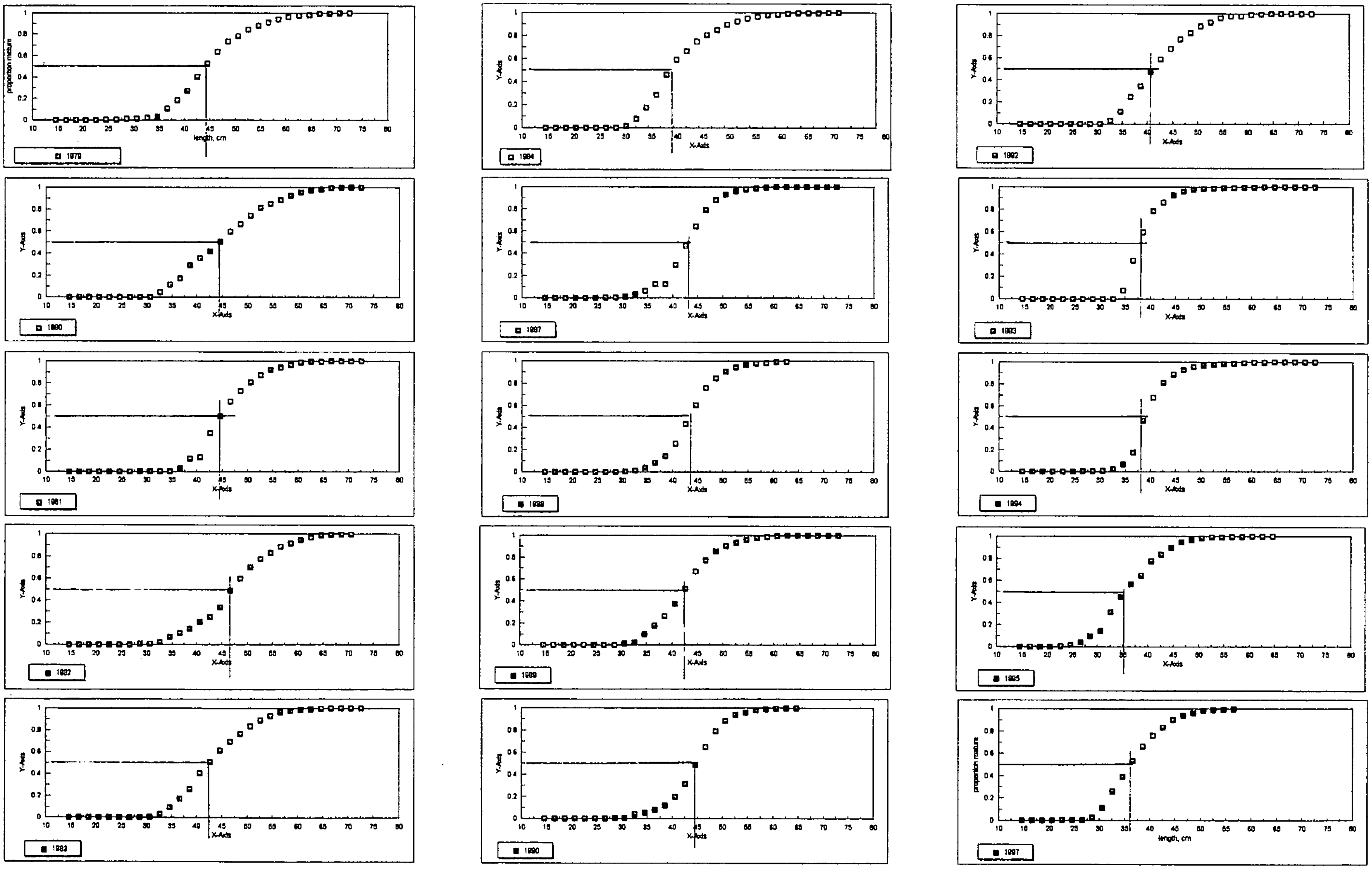


Figure 24. Female maturity from the spring RV survey.

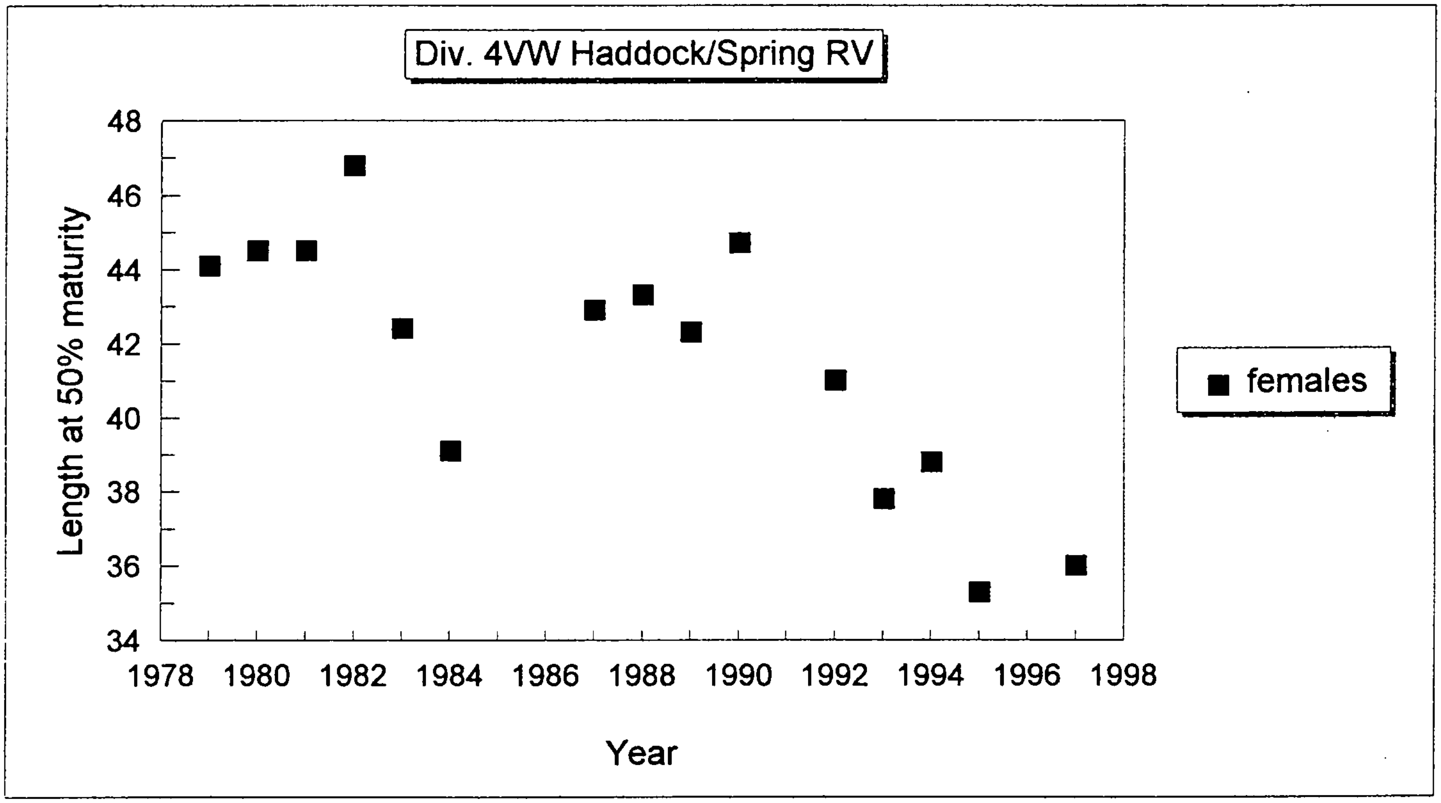


Figure 25. Length at 50% maturity for female haddock from the spring RV survey from 1979-1997.

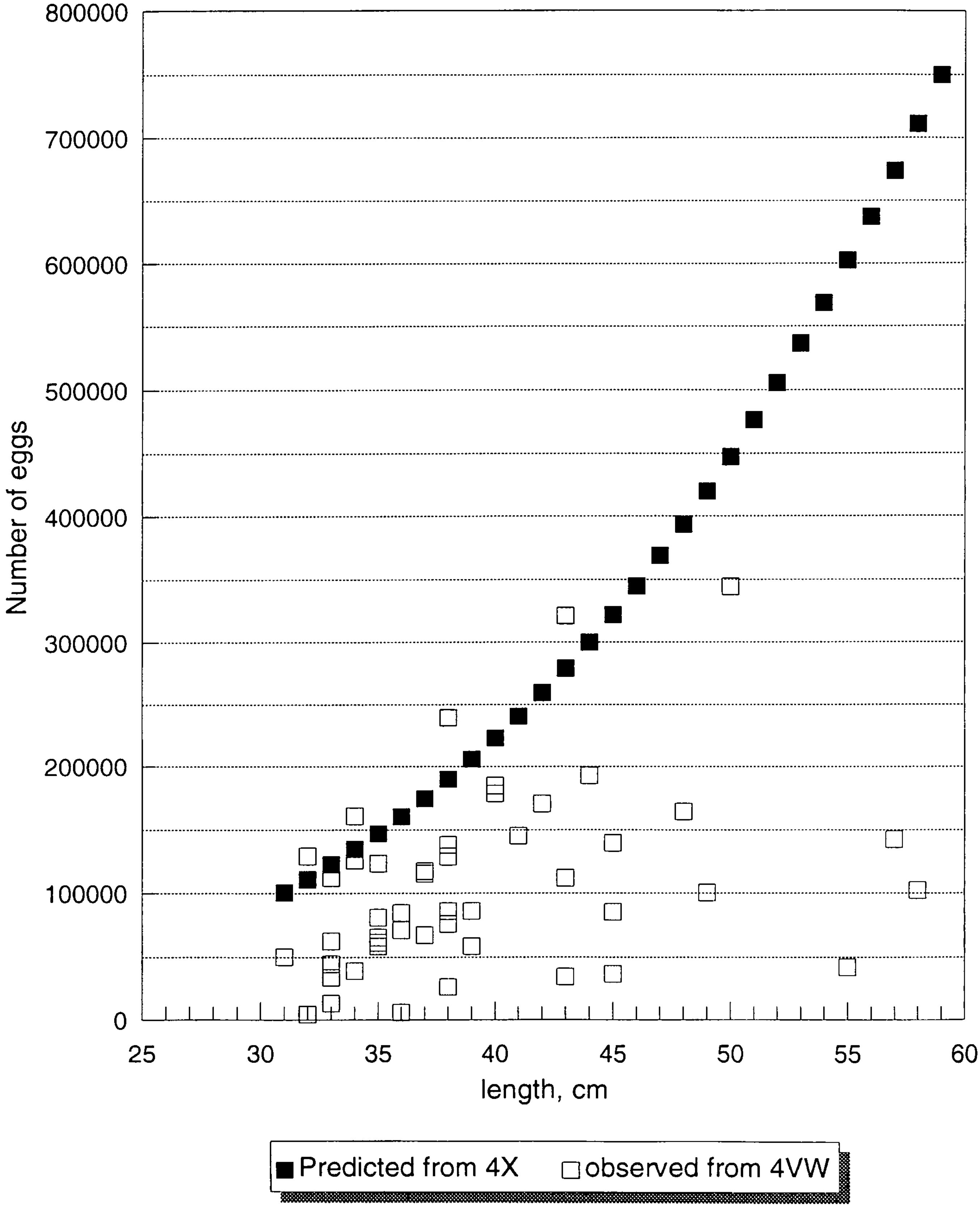
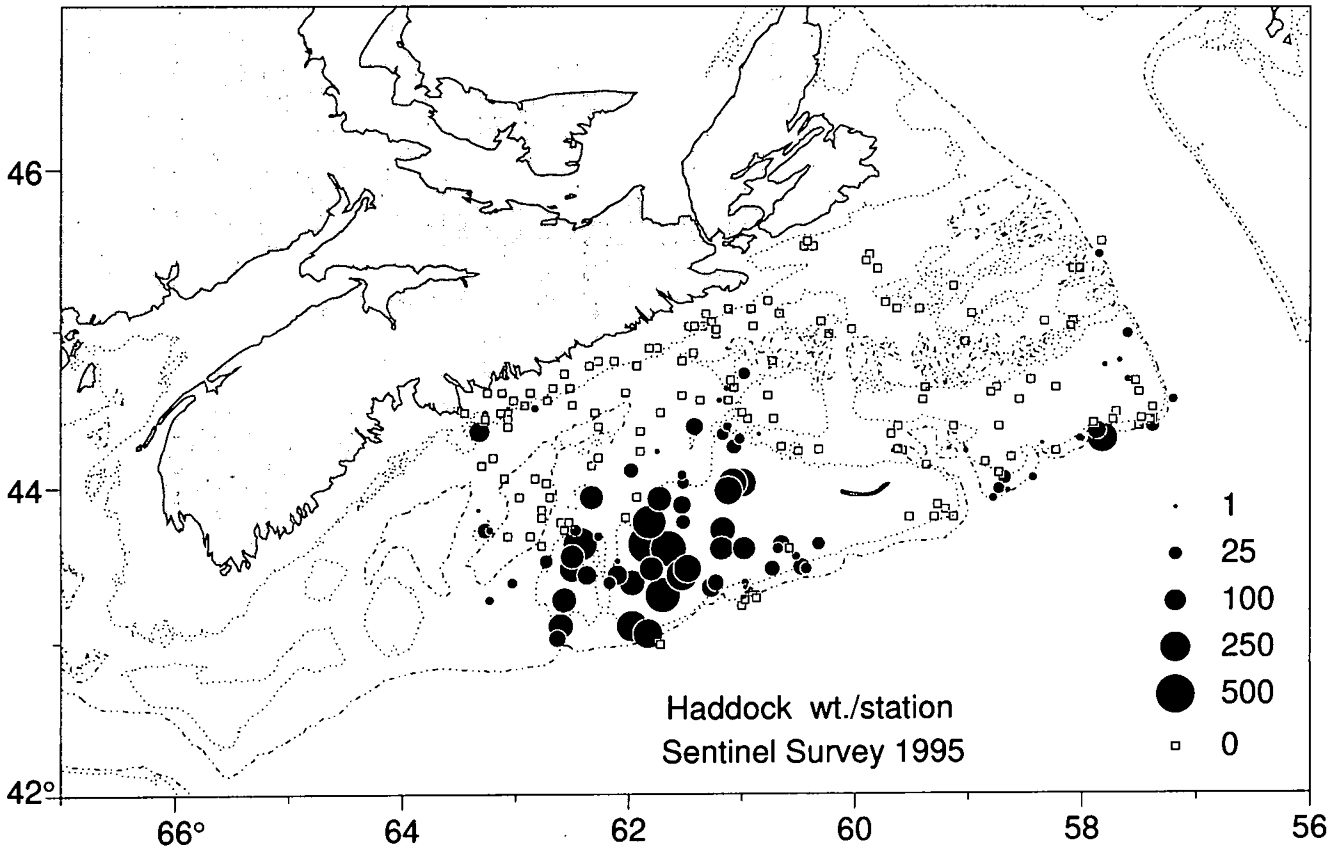


Figure 26. Size-specific fecundity of female haddock from Div. 4VW during spring 1997 (open squares) compared to that predicted from a study conducted in 1983-1985 for female haddock from Div. 4X (black squares). Data is preliminary and about 150 females remain to be processed from the 1997 collection.



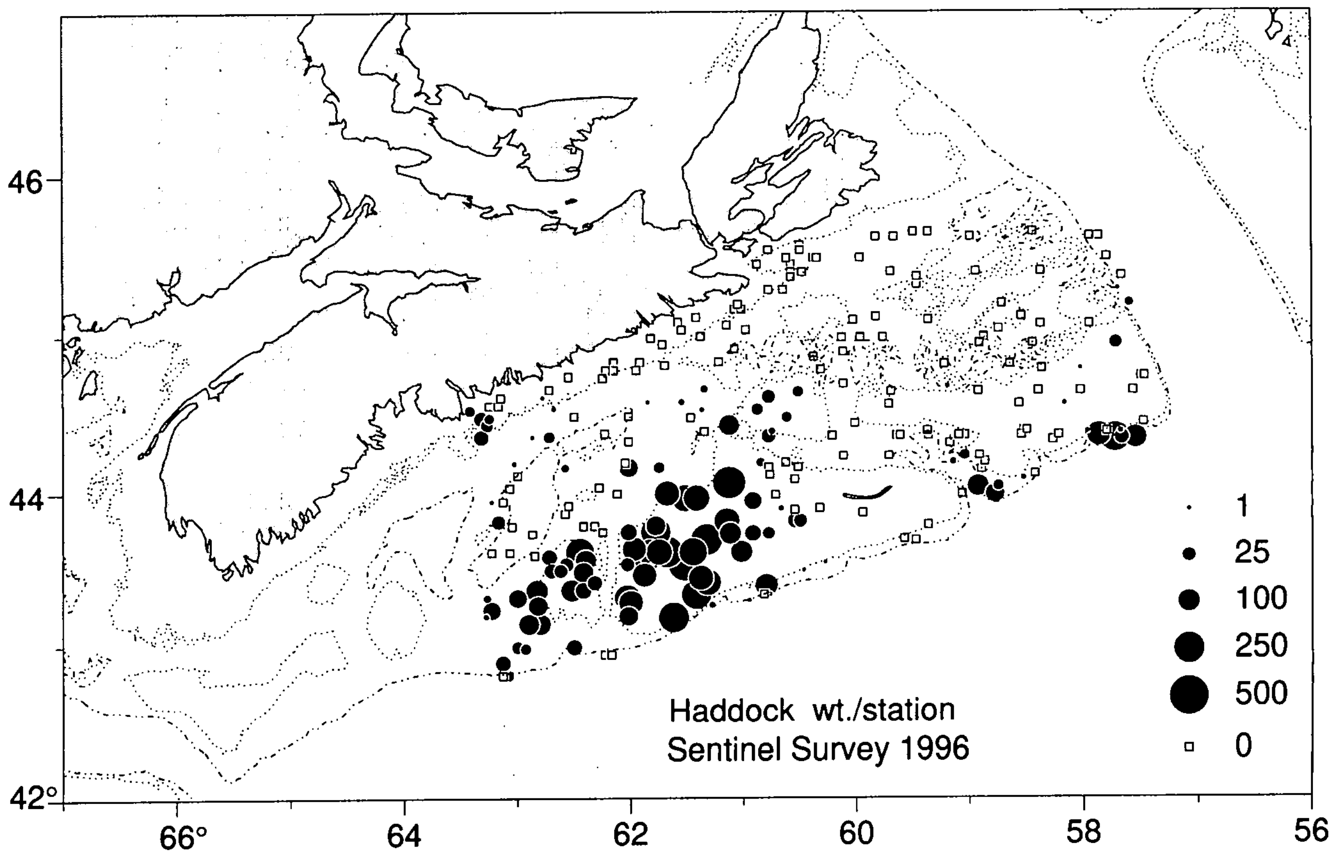


Figure 27. Expanding symbol plots of the fall 1995 and 1996 fixed gear sentinel survey catch rates of haddock in Div. 4VW.

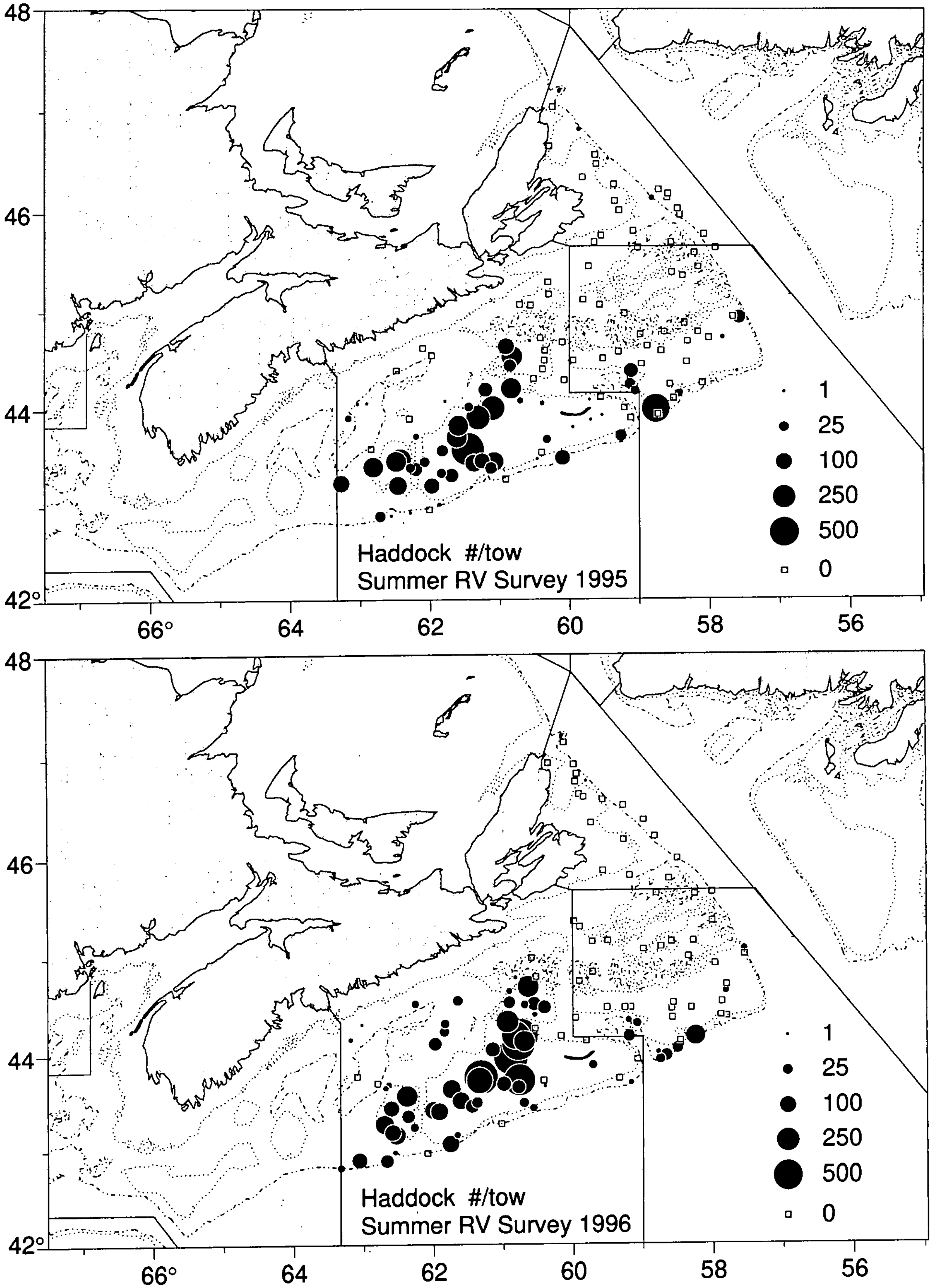
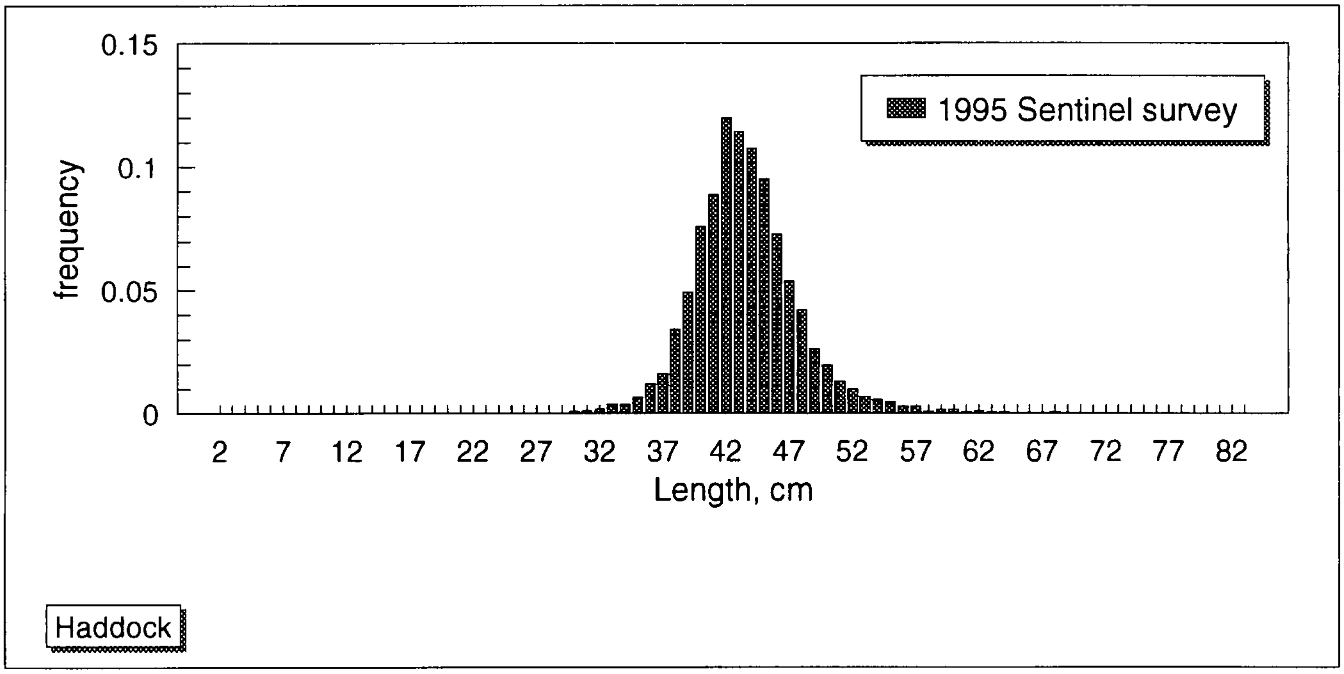


Figure 28. Expanding symbol plots of the 1995 and 1996 summer RV survey catch rates (number per tow) of haddock in Div. 4VW.

.6



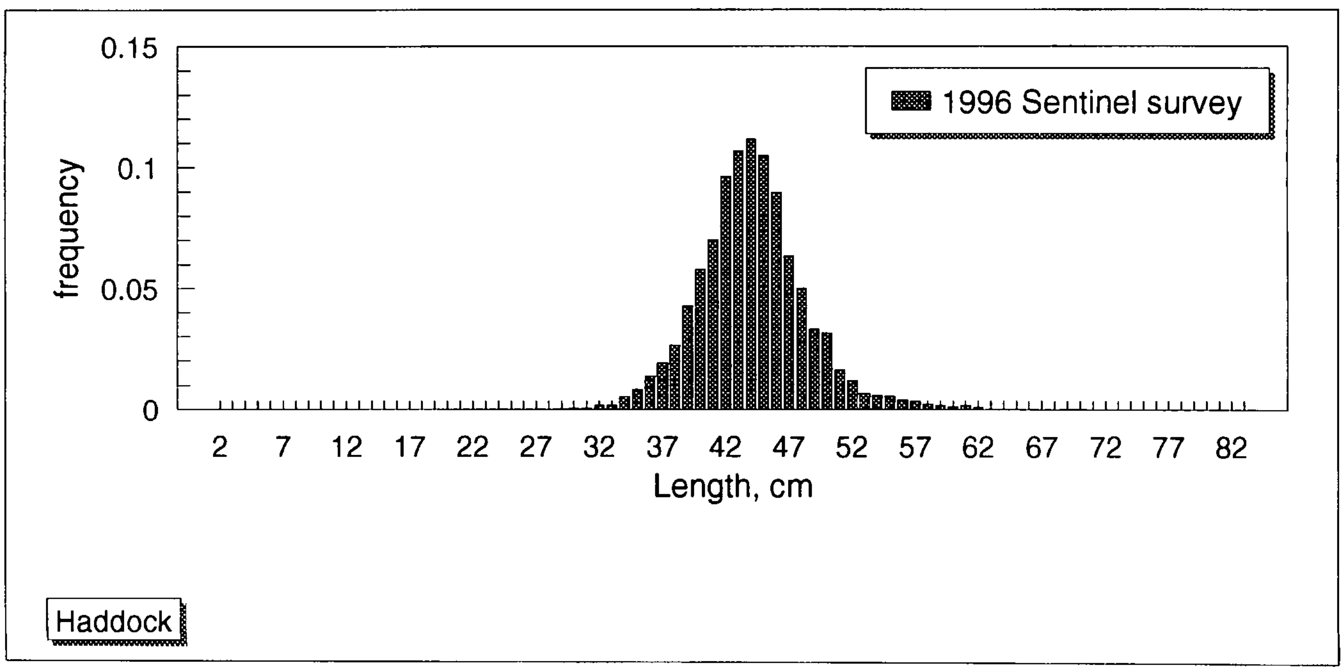
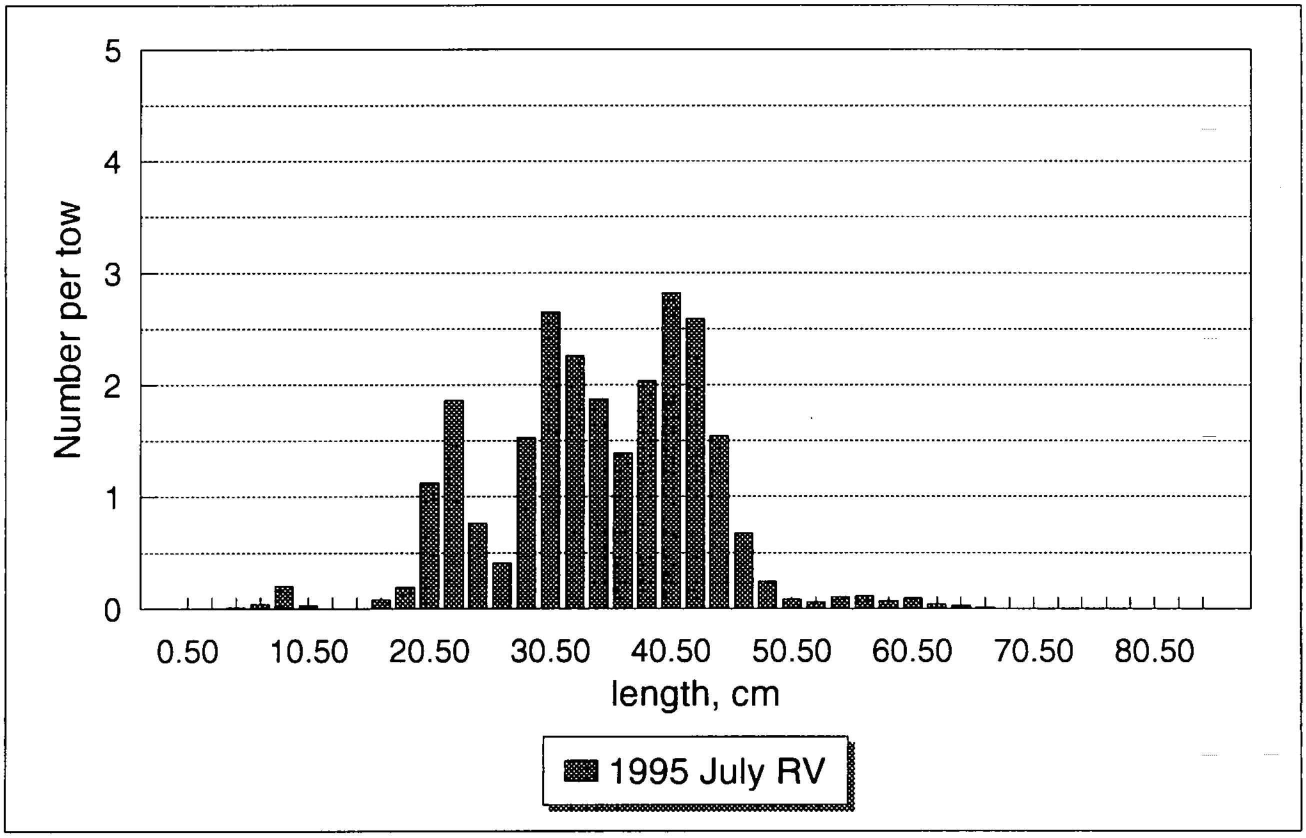


Figure 29. Length frequency distribution of haddock from the 1995 and 1996 fixed gear sentinel survey.



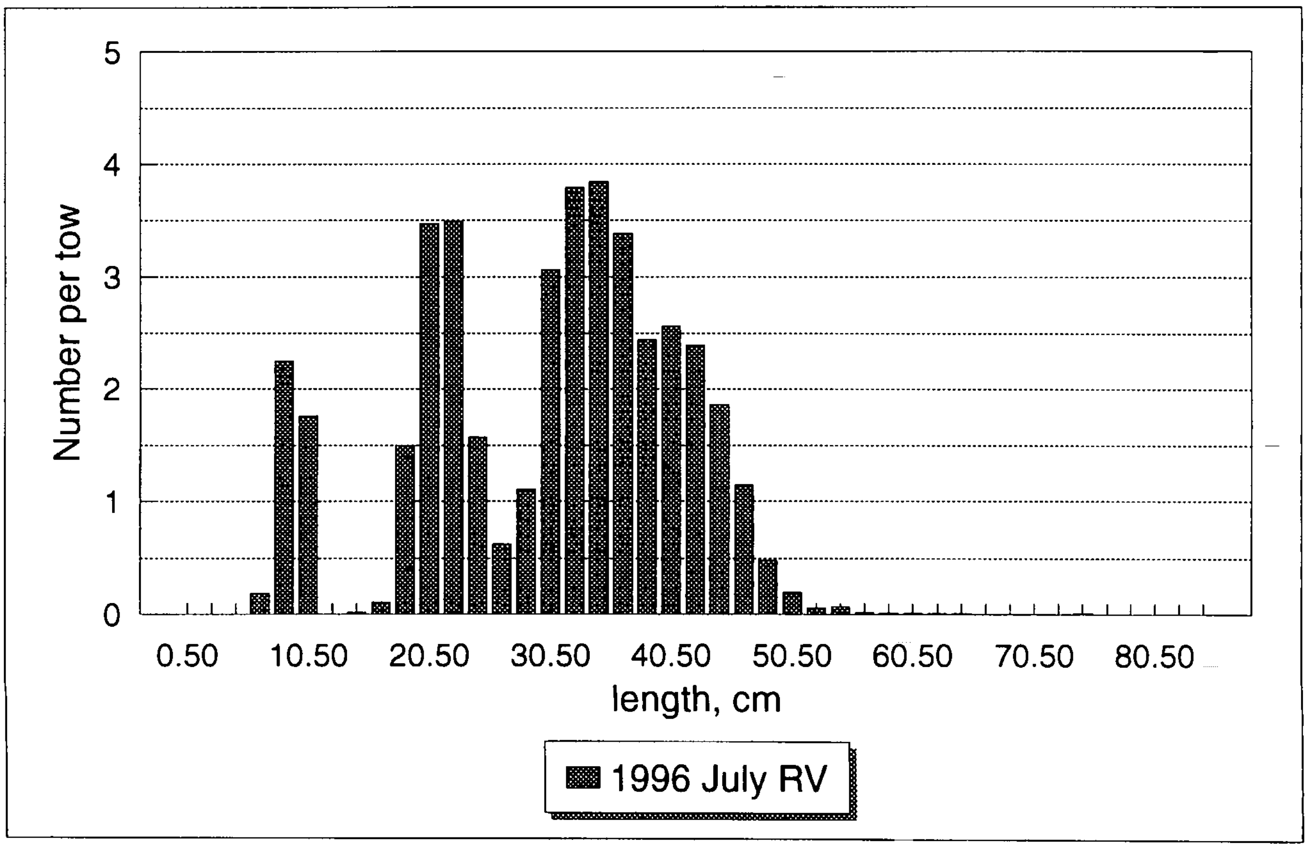
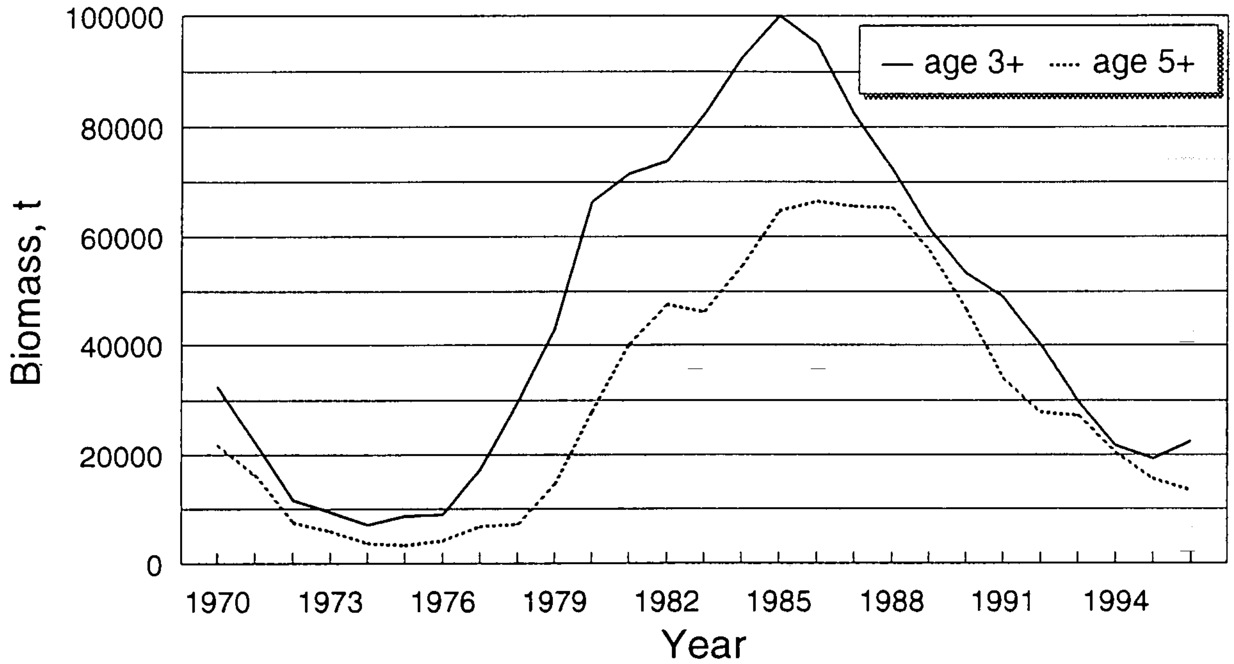


Figure 30. Length frequency distribution of haddock from the 1995 and 1996 summer RV survey in Div. 4VW.



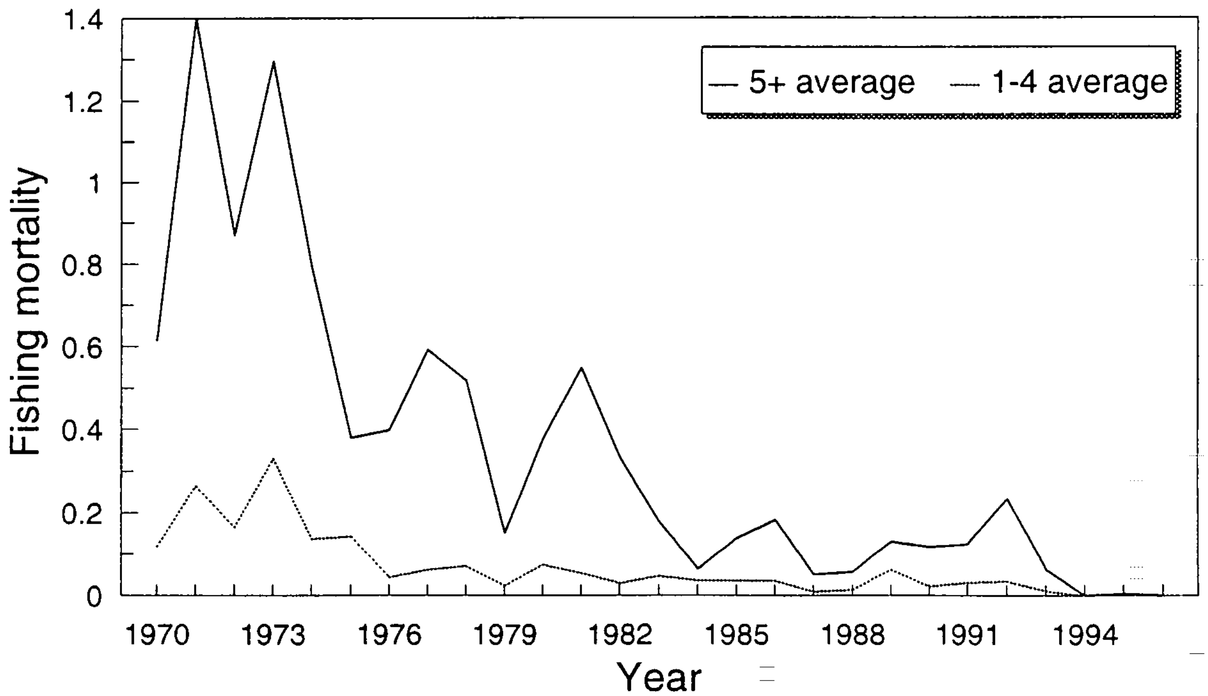


Figure 31. Biomass estimates for Div. 4TVW haddock from SPA and estimates of average fishing mortality.

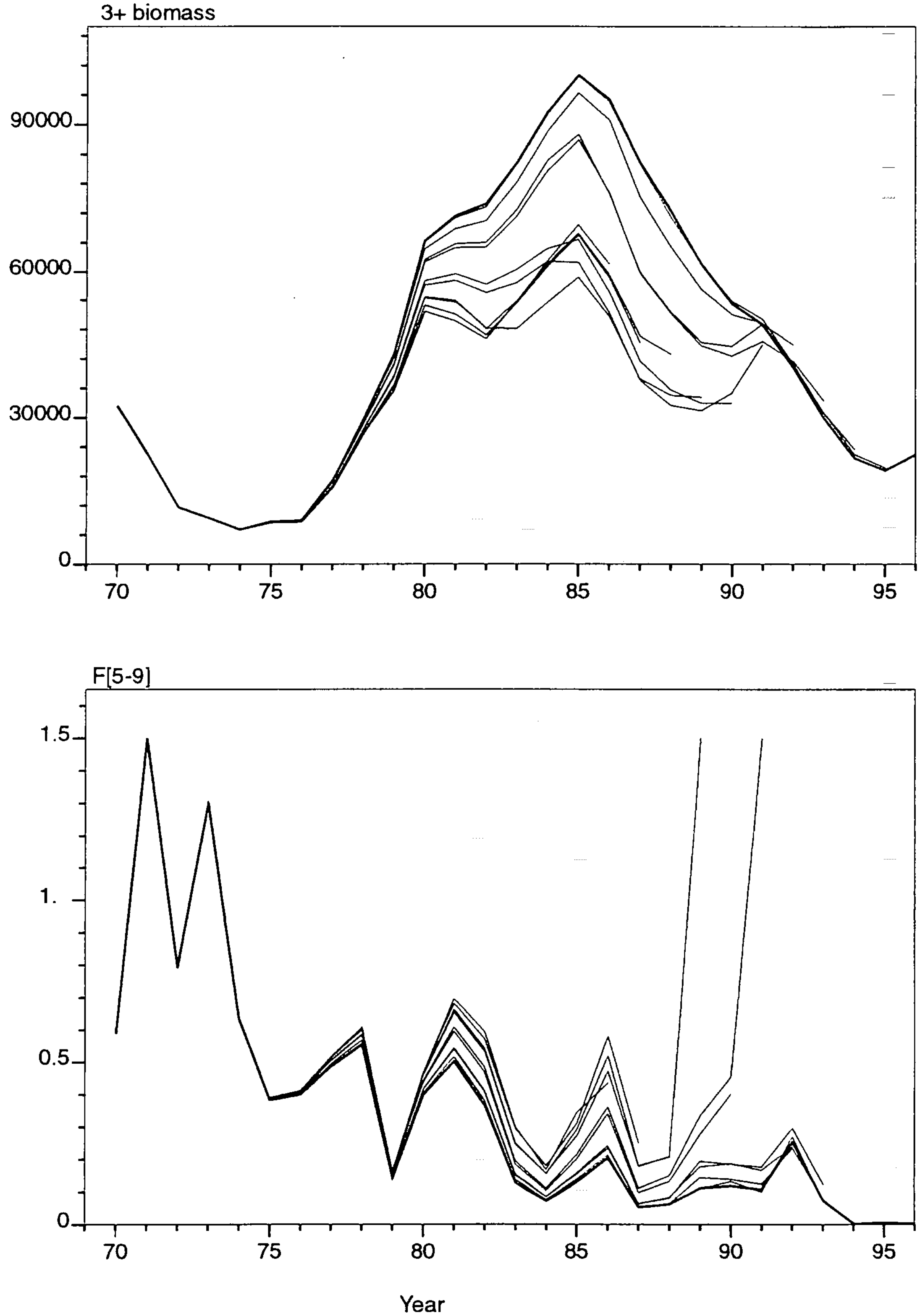
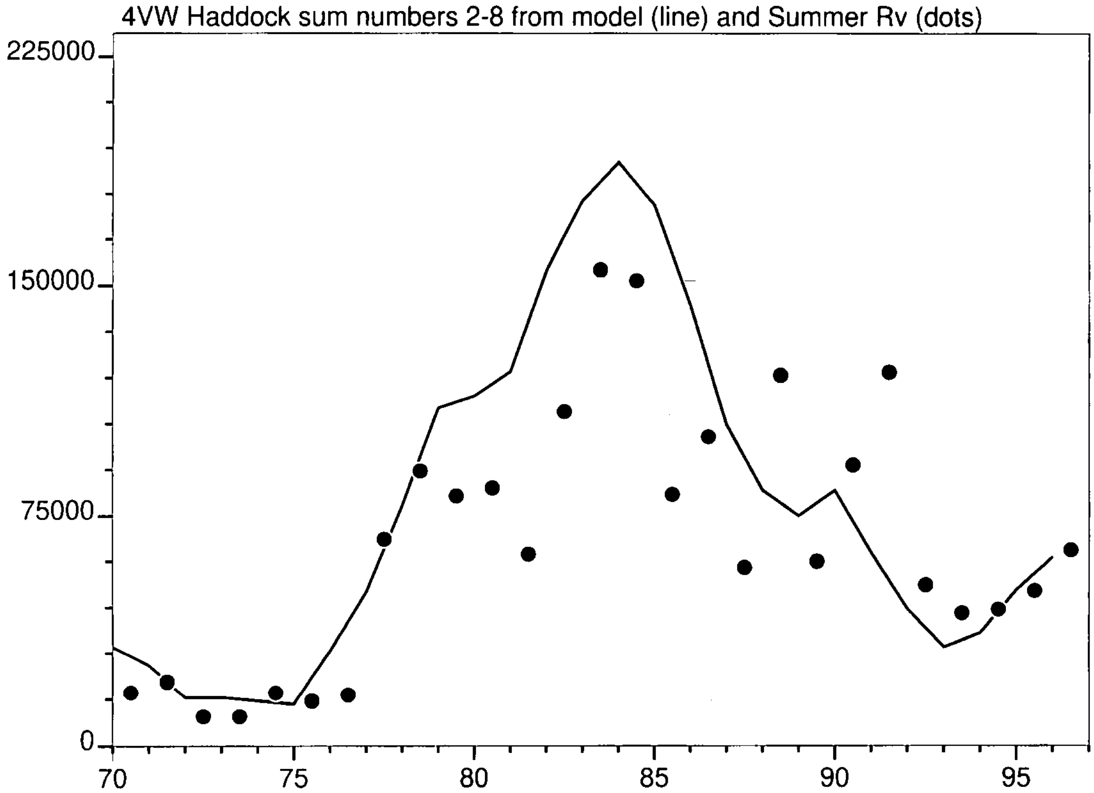


Figure 32. Retrospective plots of biomass (3+) and average F (5-9) for Div. 4TVW haddock.



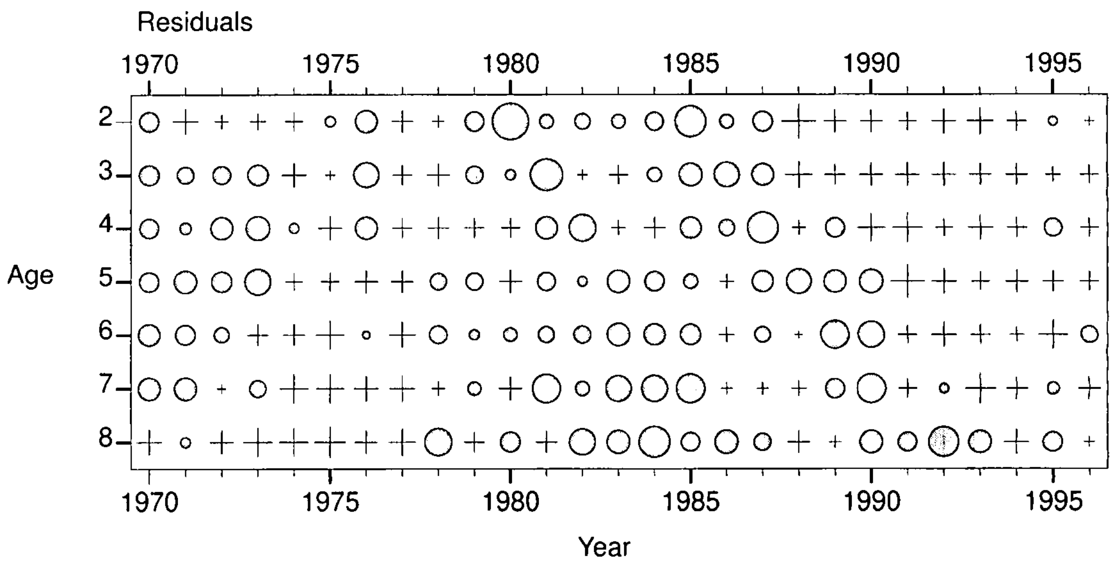


Figure 33. Div. 4VW haddock goodness of fit diagnostics.

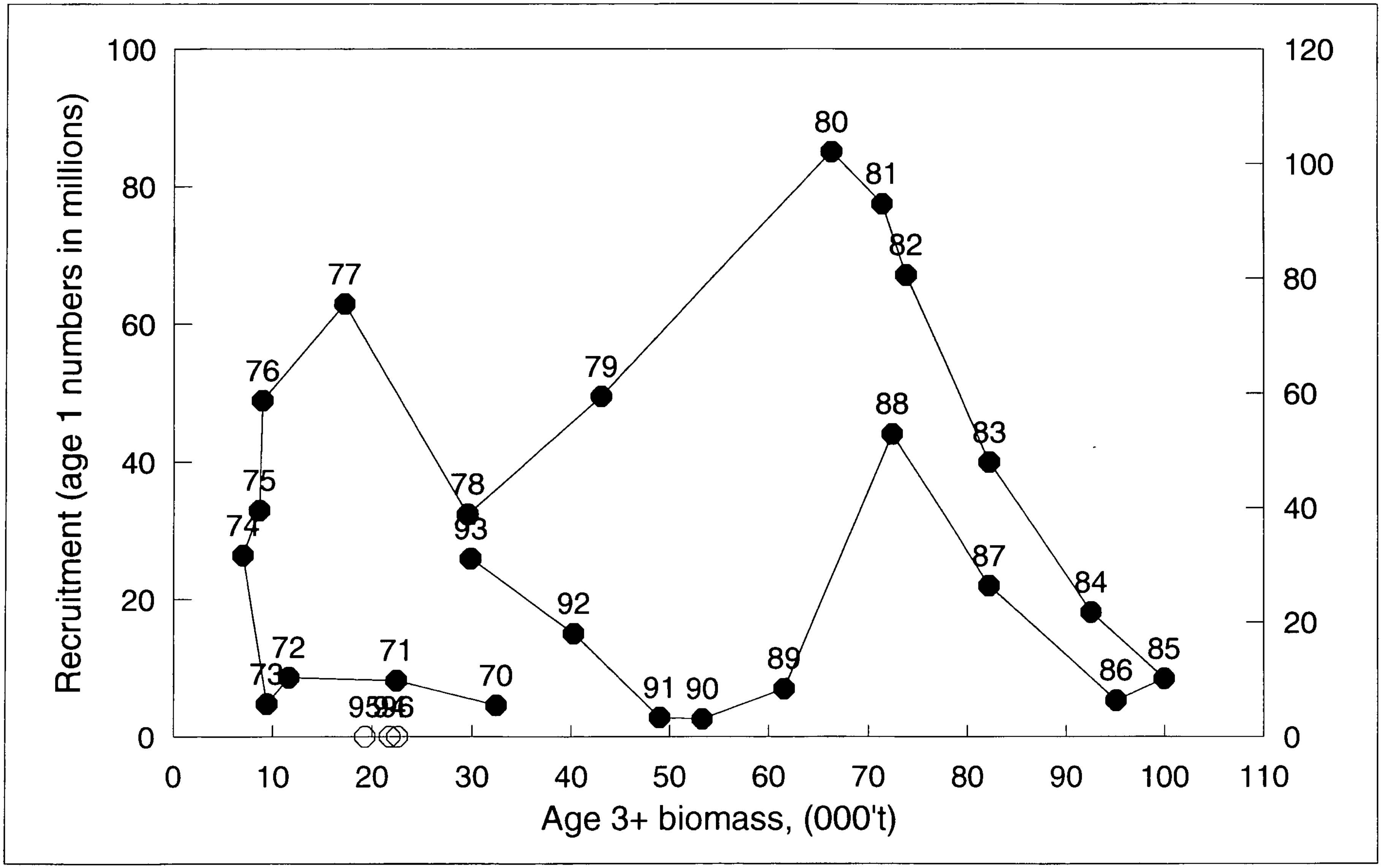


Figure 34. Relationship between recruitment and spawning stock biomass for Div. 4TVW haddock.
Lines connecting data points show time changes in stock and recruitment.
Estimates for most recent yearclasses (1994-1996) are not available.

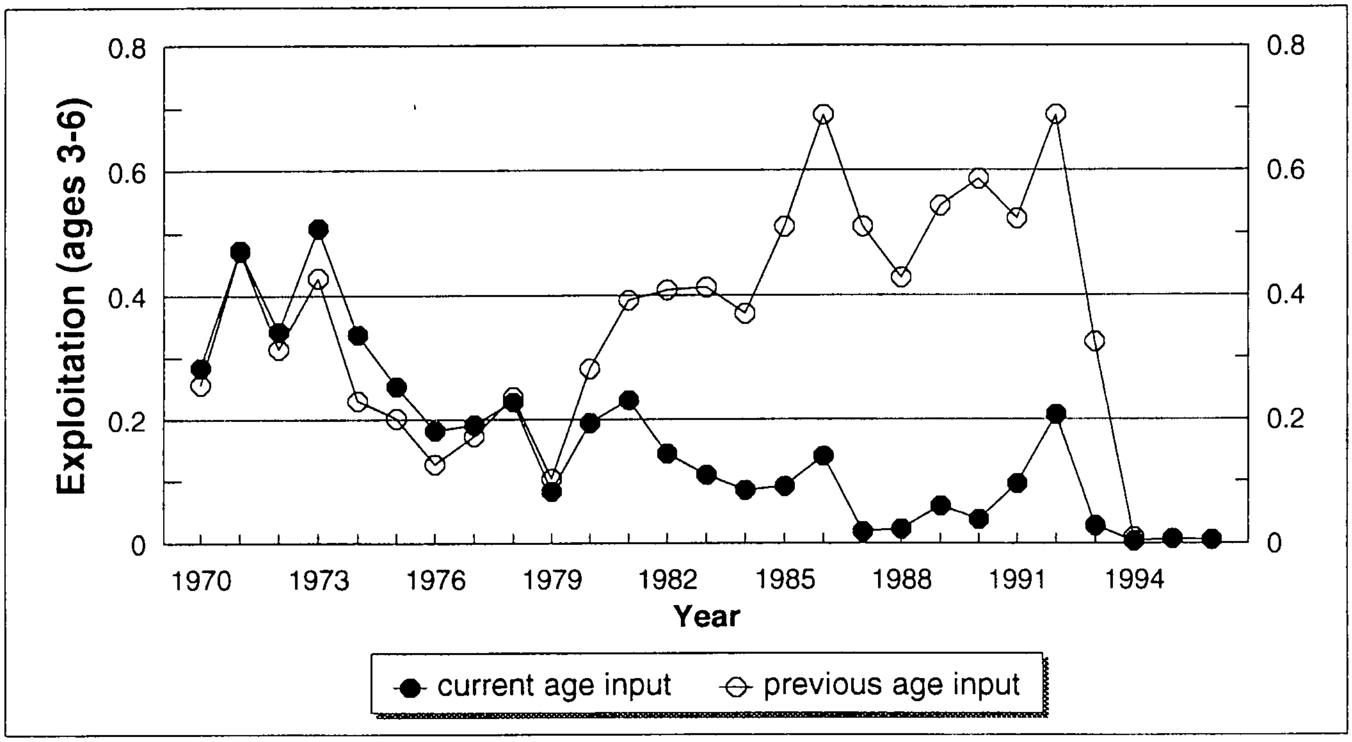


Figure 35. Estimates of exploitation rates of haddock derived from SPA using the current ageing data as input compared to the previous data. The latter estimates were contained in Zwanenburg et al. (1995). The same age data were used in both analyses for the period 1970-1984.

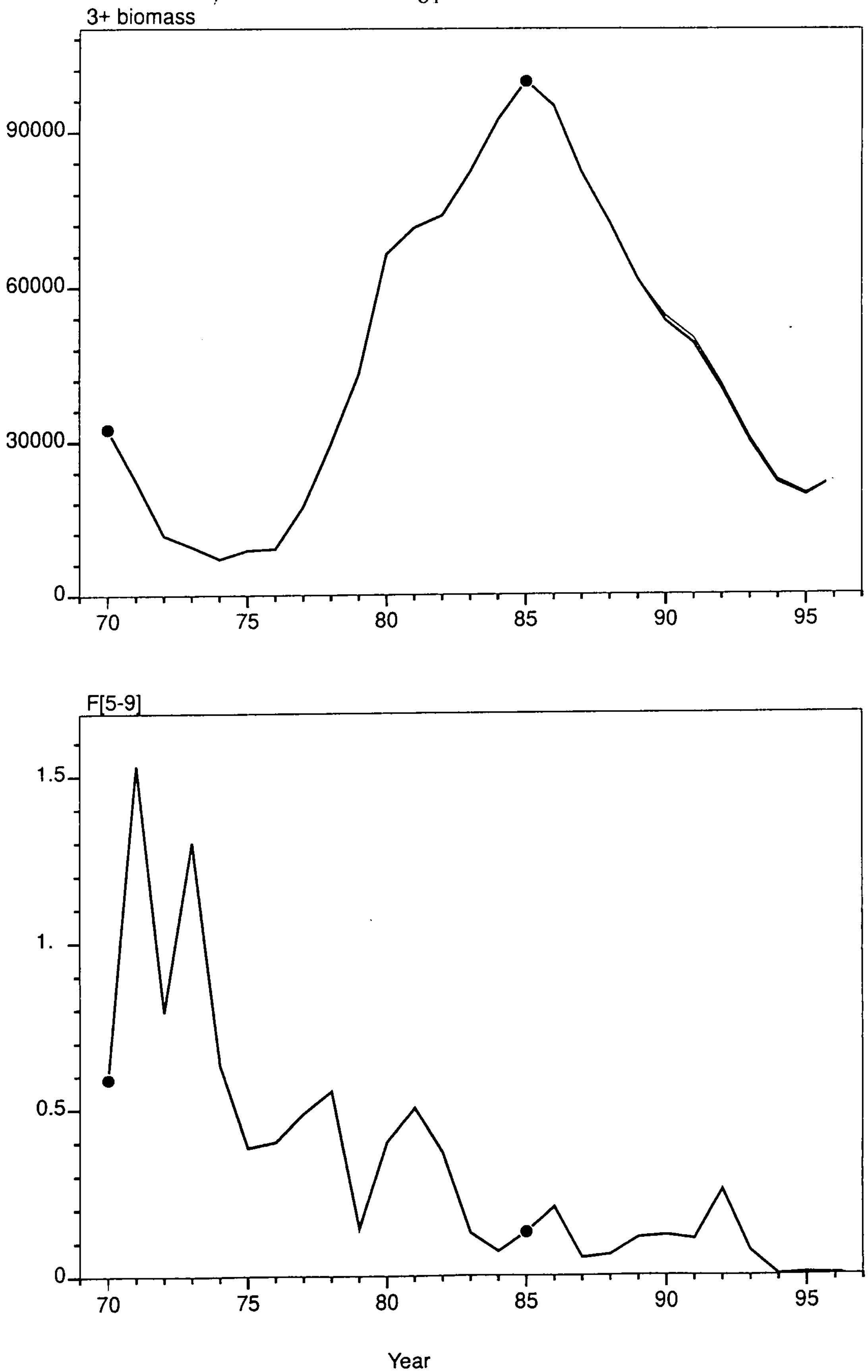


Figure 36. Biomass and F estimates using the entire data period and post-1985 data. Dots show starting points for the two SPA runs.

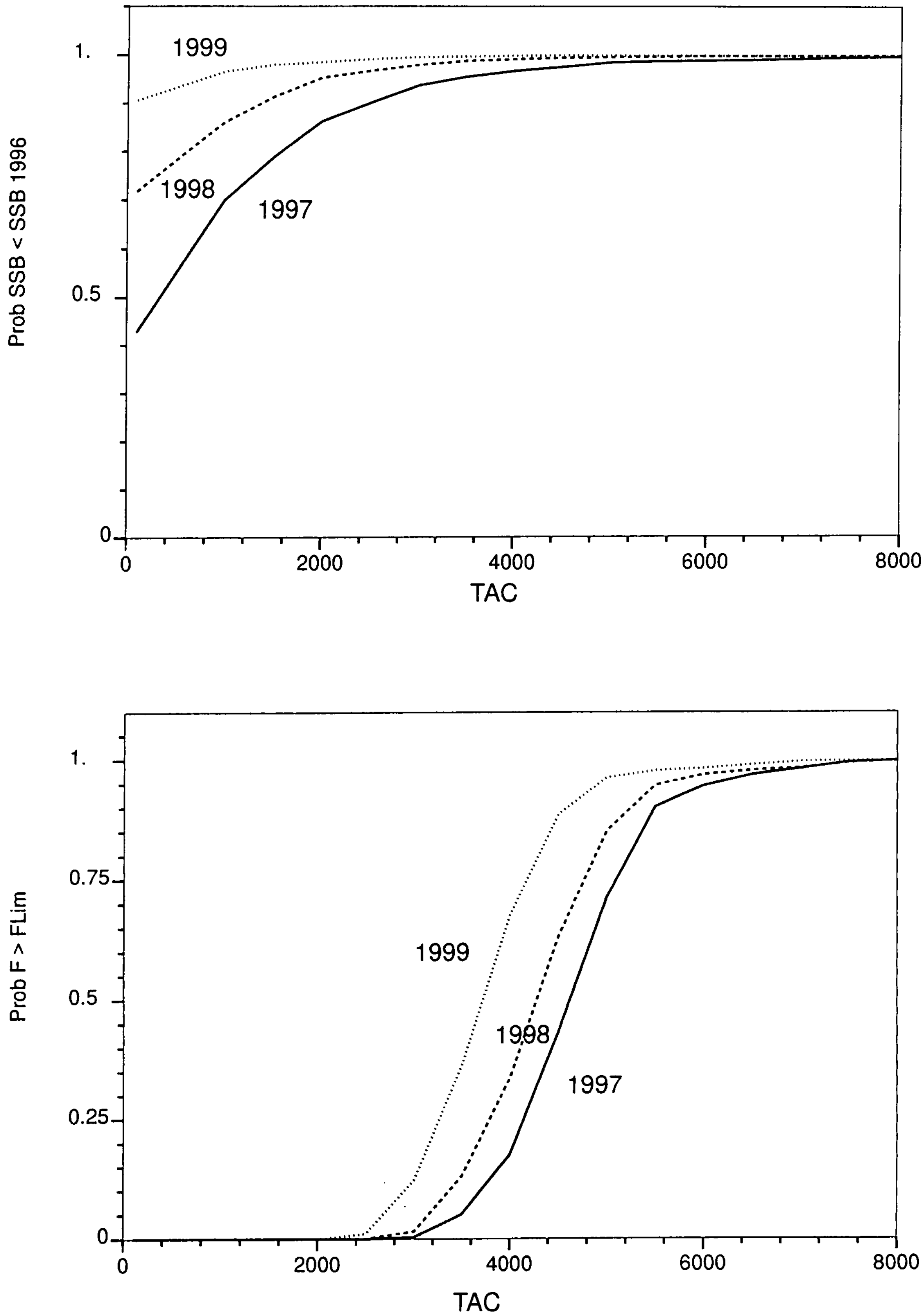


Figure 37. Risk analysis of 4VW haddock. Starting stock is bootstrapped and recruitment is 9.5 million with CV of 0.5.

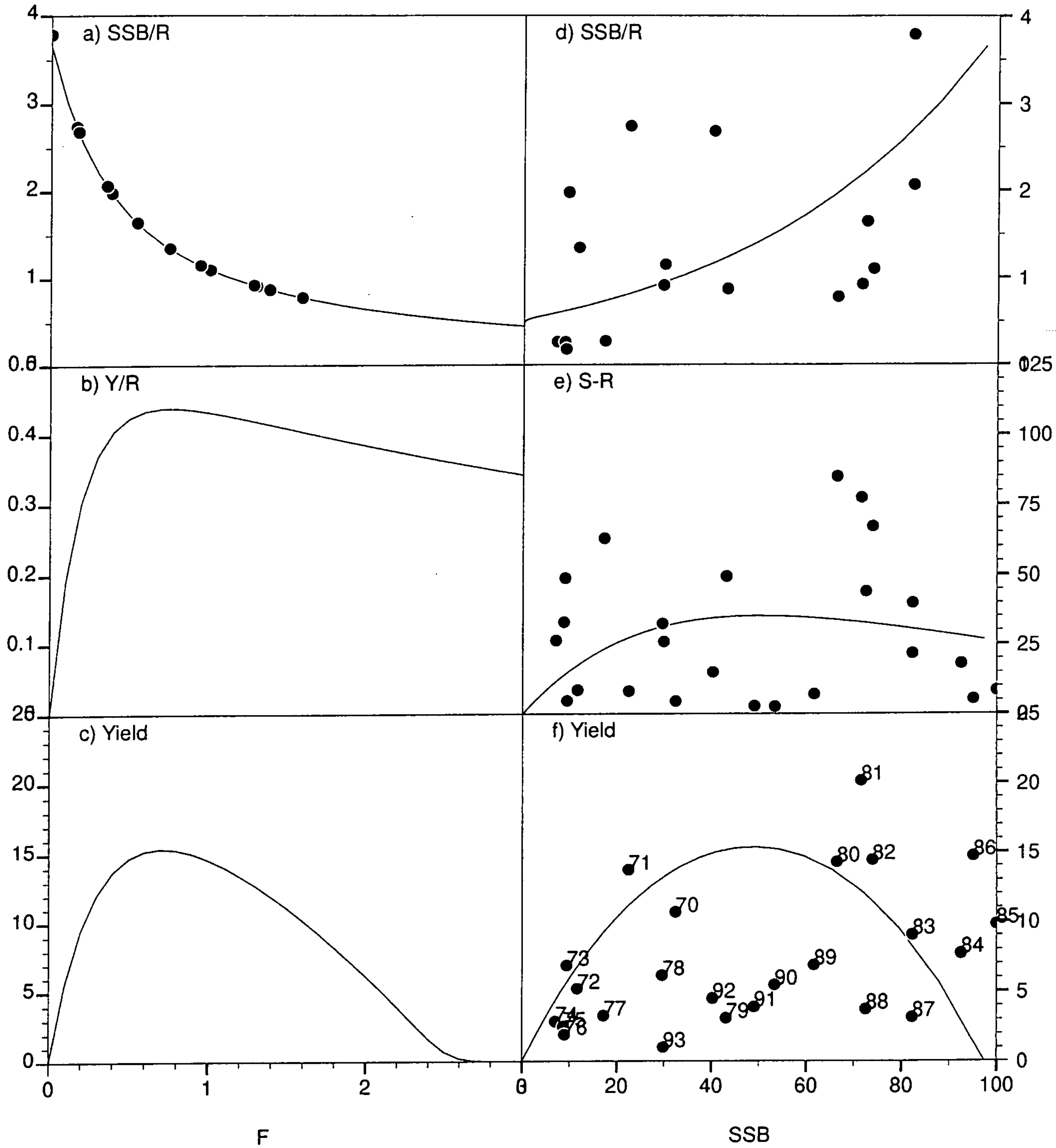


Figure 38. Precautionary plots for 4VW haddock - base run.

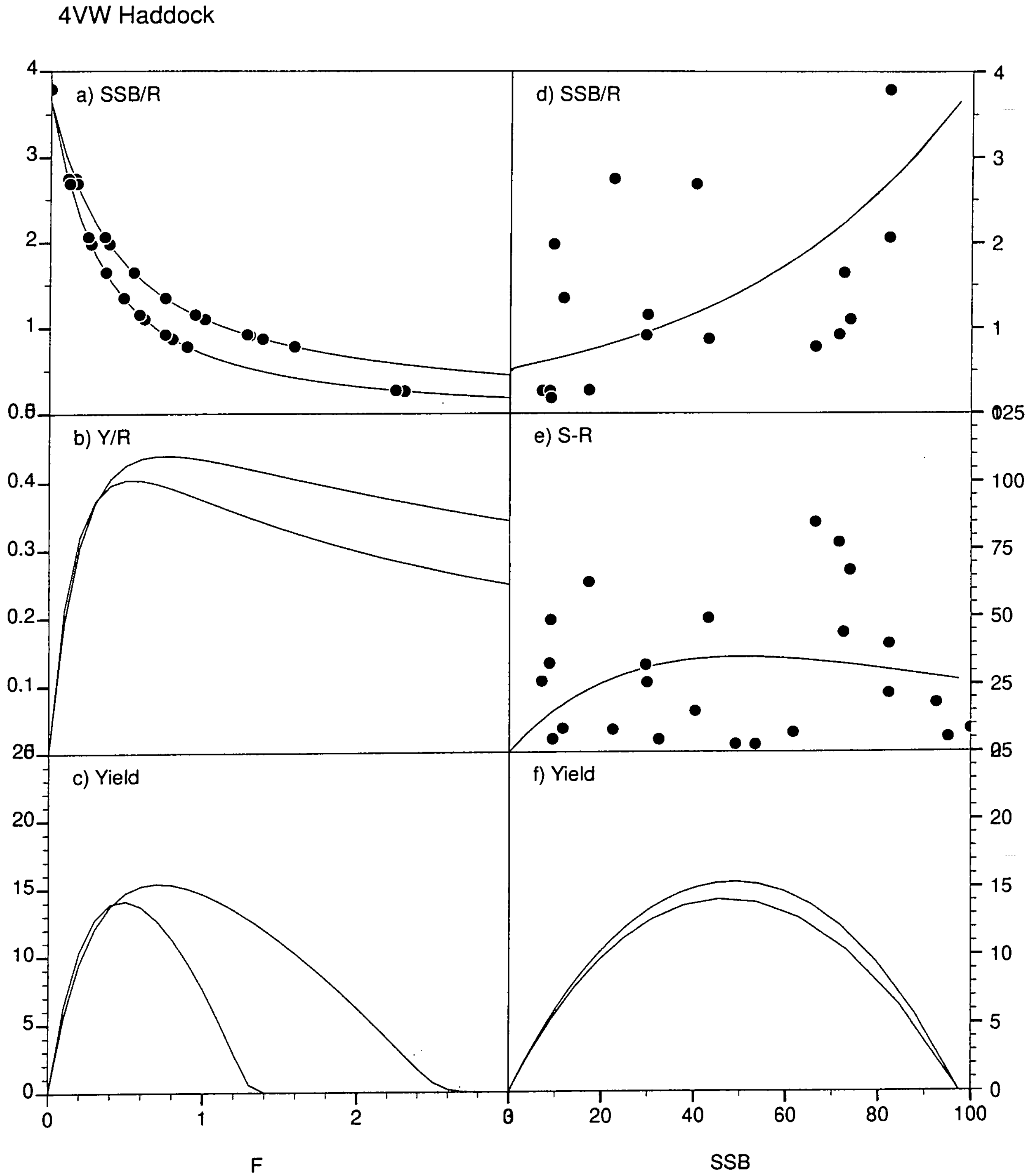


Figure 39. Sensitivity of precautionary plots to a change in partial recruitment.
Partial Recruitment = 0.04 0.07 0.17 0.4 0.63 0.81 0.89 0.93 0.9 1.

4VW Haddock

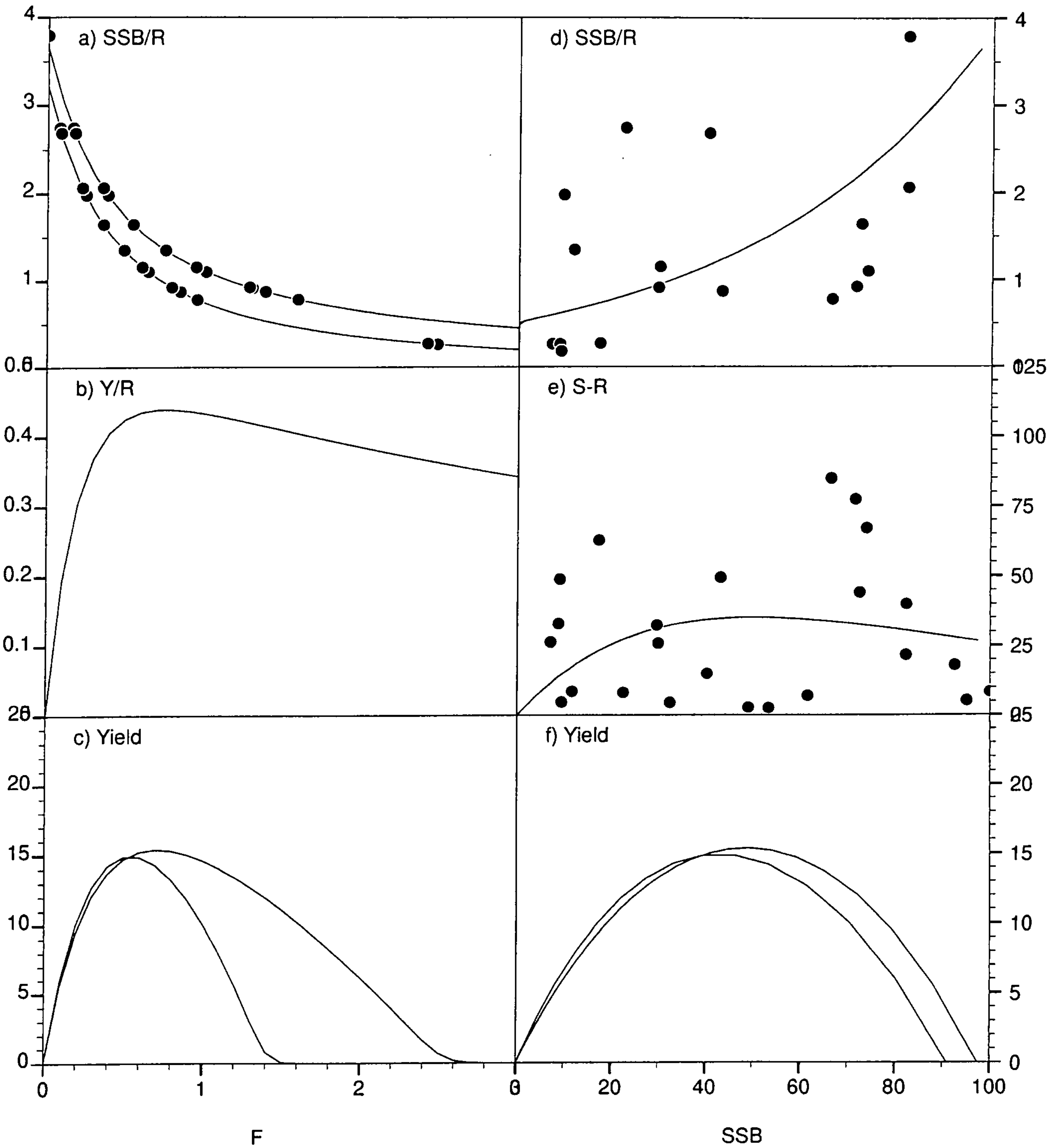


Figure 40. Sensitivity of precautionary plots to a change in maturity ogive.

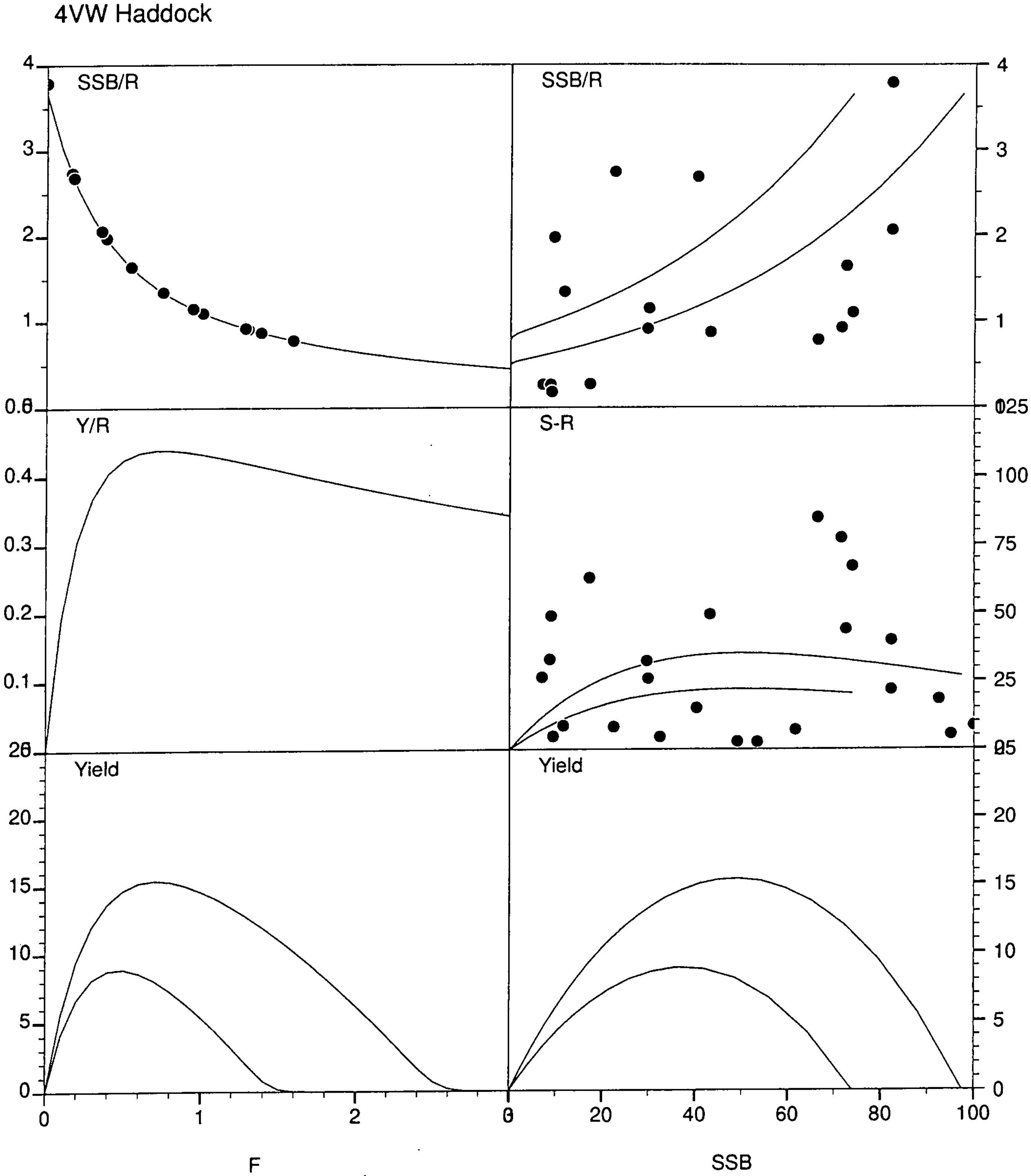


Figure 41. Sensitivity of precautionary plots to a change in Ricker RMax.

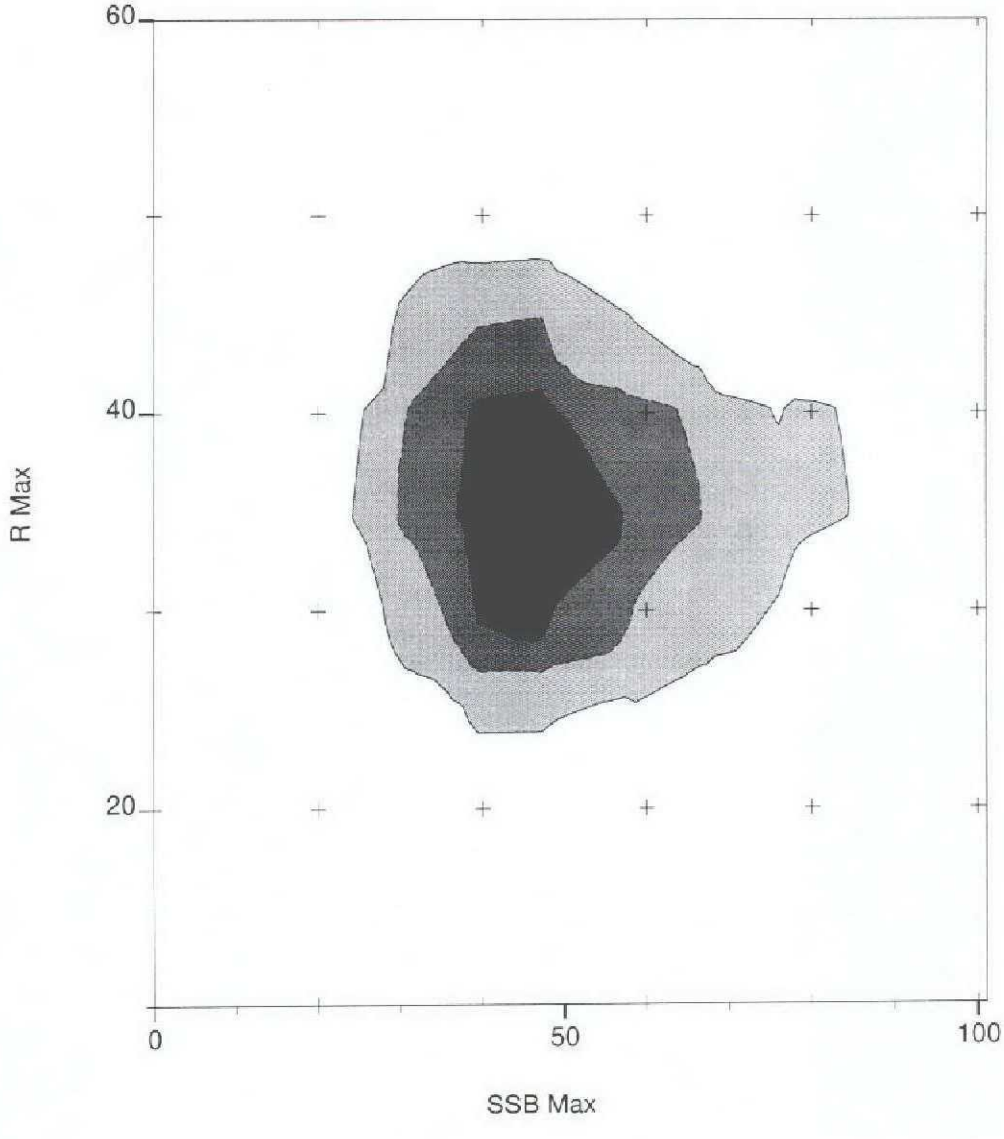
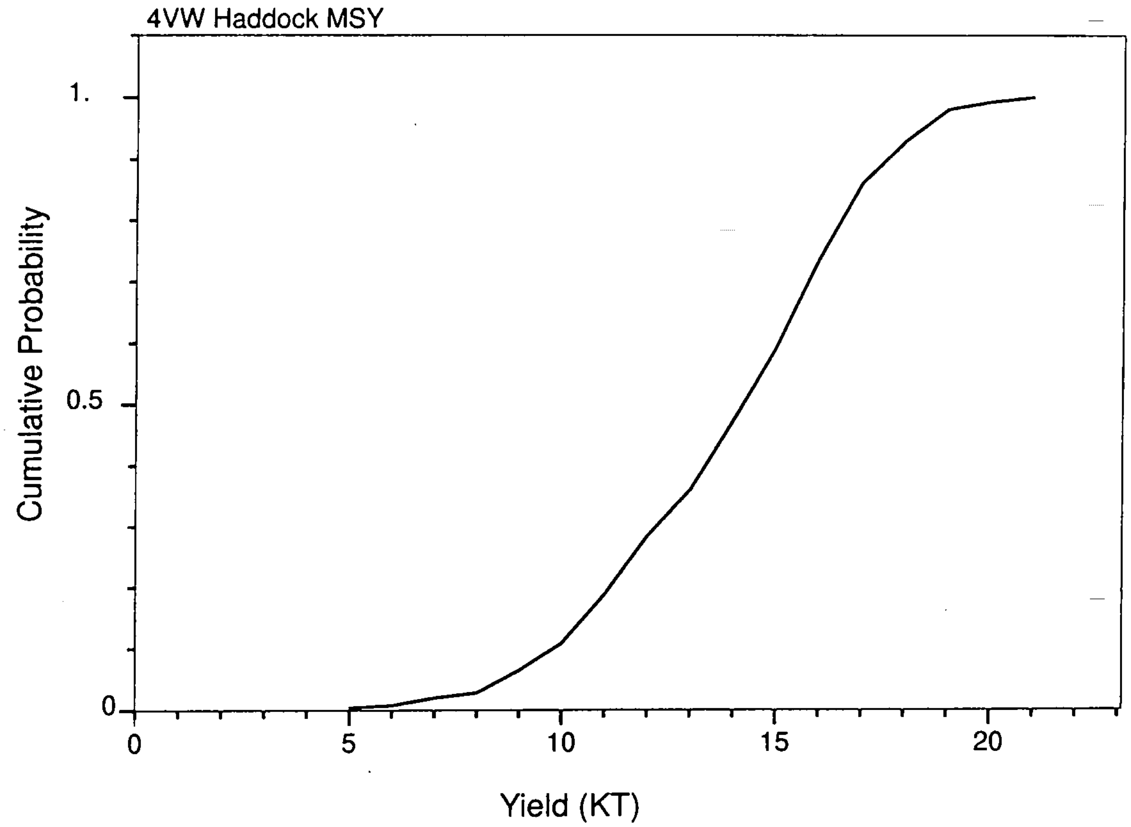


Figure 42. Probability contours of bootstrap Ricker coefficients for 4VW haddock
The darkest region encloses 25% of the replicate estimates,
the next region has 50% and the lightest encloses 75%.



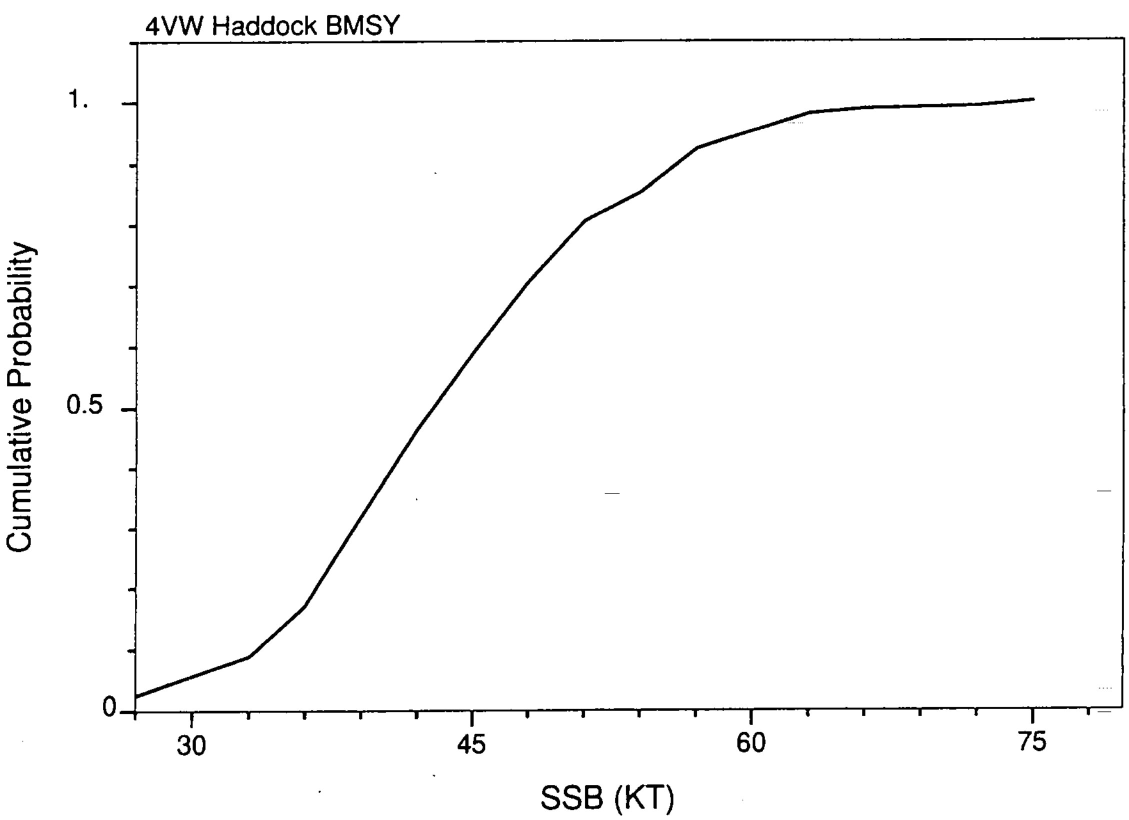


Figure 43. Cumulative distributions of MSY and BMSY from precautionary analysis due to uncertainty in stock-recruit fit to Ricker model.

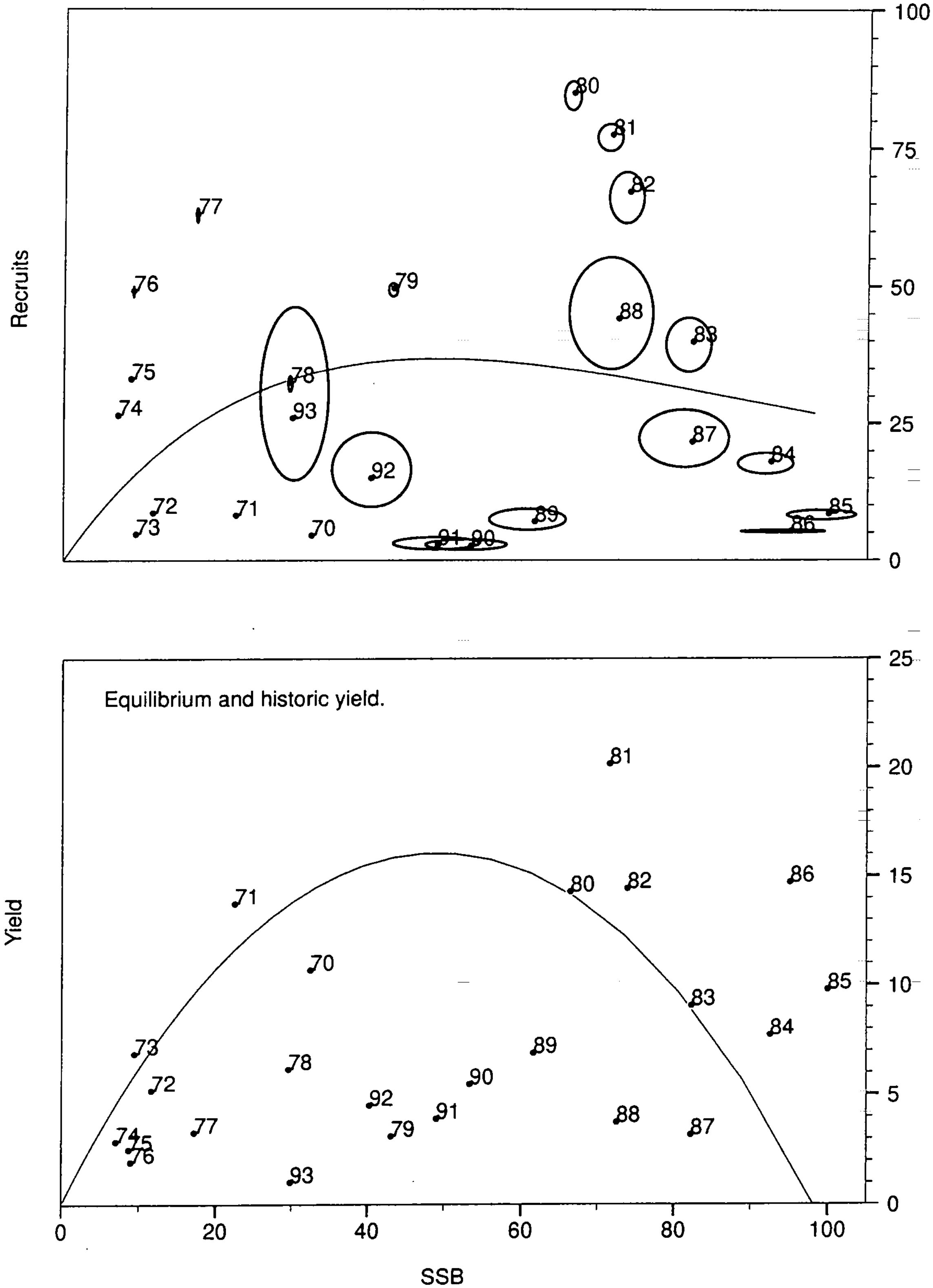


Figure 44. Stock recruit with SPA uncertainty expressed as ellipses.

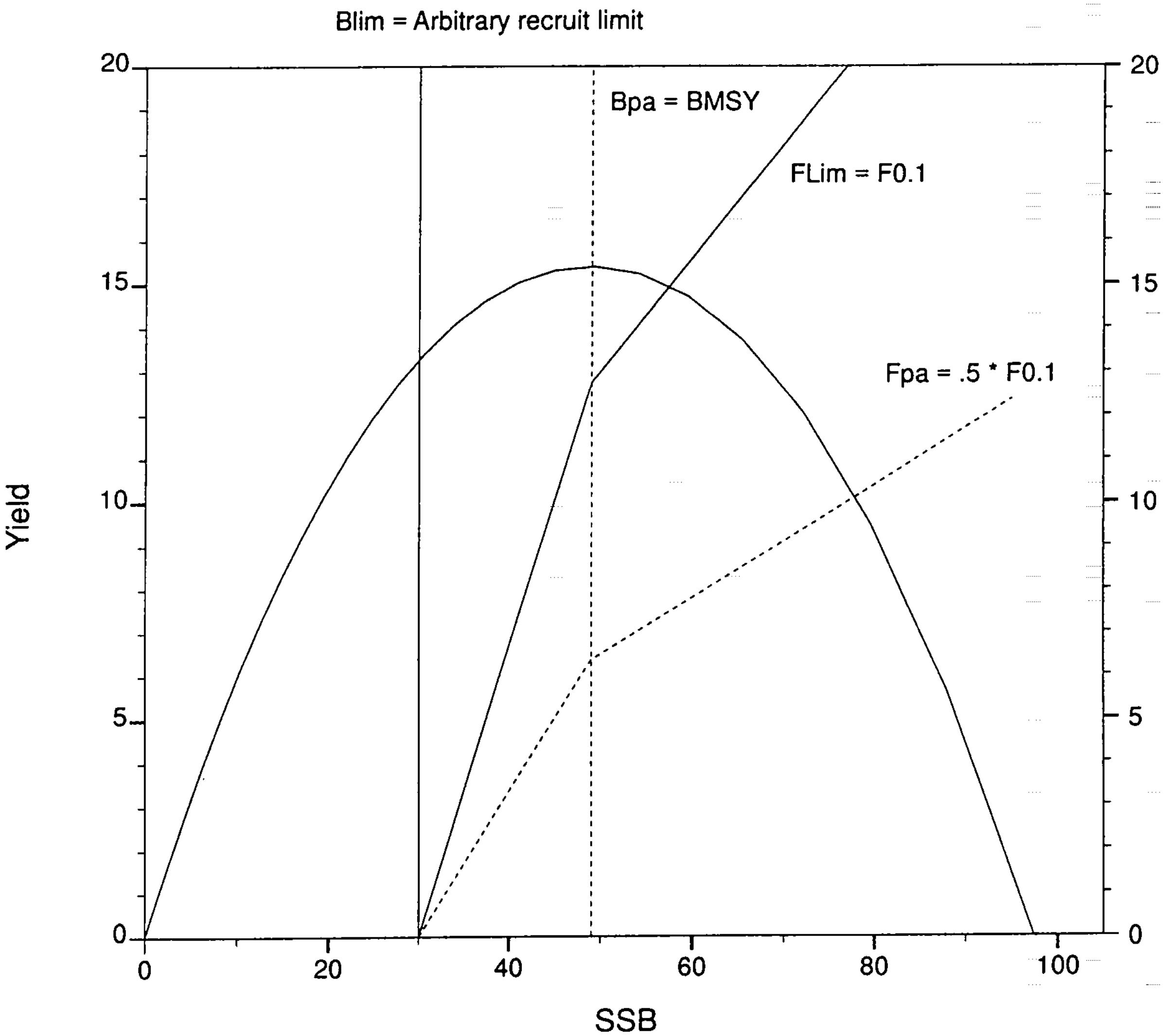


Figure 45 . Precautionary yield plot for 4VW haddock.