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# An evaluation of the Emerald/Western Bank juvenile haddock closed area

by

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## ABSTRACT

A juvenile haddock closed area was established in Div. 4W in 1987 with the objective to protect incoming recruits and allow the stock to rebuild. The areas chosen for closure included Emerald and Western banks; these areas contain relatively large and persistent aggregations of young haddock as revealed by the July research vessel survey series. Initially, it was decided that fixed gear fisheries could fish inside the closed area because these gears were believed to catch older fish than that of mobile gear. Such was not the case and fixed gear fishing was prohibited inside the closed area in 1993. Ten years have now elapsed since the establishment of the closed area and a review of the impact of the closure has been requested by industry and managers. The current review focused on evaluation of changes in abundance and mortality rate of haddock inside the closed area and in contiguous areas subjected to fishing. Several other groundfish species have also been examined for changes in abundance inside the closed area and in relation to adjacent areas. The most significant findings were as follows: i) haddock yearclasses inhabiting the Emerald/Western banks region that were in existence during the imposition of the closed area experienced lower mortality in comparison to adjacent areas, ii) juvenile mortality was highly variable and the expected trend of declining mortality coincident with the establishment of the closed area was not discernable, iii) a declining trend in adult mortality preceded the imposition of the closed area and, on average, adult mortality was higher prior to the mid-1980s and lower thereafter, in both the closed area and adjacent reference areas, iv) the eastern boundary of the closed area divides the distribution of haddock in Div. 4W which complicates the interpretation of the impact of the closed area, and v) American plaice was more abundant inside the closed area after the imposition of the closure relative to the adjacent reference areas and this species is poorly selected by fixed gear directing for haddock and would have been protected from fishing inside the closed area for over a decade. Although no effects have been detected on juvenile haddock mortality in the closed area it does not rule out the potential beneficial impacts on the stock.



## RÉSUMÉ

La pêche des aiglefins juvéniles a été interdite dans une zone de la division 4W en 1987 afin de protéger le recrutement et de permettre le rétablissement du stock. La zone comprend les bancs Emerald et Western. Comme le montrent les relevés par navires de recherche de juillet, on y trouve des concentrations relativement importantes et constantes de jeunes aiglefins. Il avait été décidé d'autoriser la pêche par engins fixes dans la zone interdite car on jugeait que ces engins donnaient lieu à la capture de poissons plus âgés que les engins mobiles. Cela s'est avéré faux et la pêche aux engins fixes a été interdite en 1993. Il s'est écoulé dix années depuis la création de la zone et tant l'industrie que les gestionnaires ont demandé un examen des effets de la fermeture. L'examen actuel porte sur l'évolution de l'abondance et de la mortalité des aiglefins se trouvant dans la zone et dans les régions voisines faisant l'objet d'une pêche. Un examen analogue a été effectué pour plusieurs autres espèces de poisson de fond. Les principaux résultats obtenus sont : i) les classes d'âge des aiglefins de la zone des bancs Emerald et Western qui s'y trouvaient déjà au moment de l'interdiction de la pêche présentent un taux de mortalité inférieur à celui des classes des régions voisines; ii) la mortalité des juvéniles a été très variable et la tendance à la baisse de la mortalité découlant de la création de la zone qui avait été prévue n'a pu être decelée; iii) une tendance à la baisse de la mortalité des adultes a précédé la création de la zone et cette mortalité était, en moyenne, plus élevée avant les années 1980 et s'est amoindrie par la suite, tant dans la zone de pêche interdite que dans les zones témoins voisines; iv) la limite est de la zone fermée à la pêche divise l'aire de répartition de l'aiglefin dans la division 4W et cela complique l'interprétation des incidences de la fermeture et v) la plie canadienne était plus abondante dans la zone après l'interdiction de la pêche, par rapport aux zones voisines témoins, et comme cette espèce est peu vulnérable aux engins fixes utilisés pour la pêche de l'aiglefin, elle a été protégée au sein de la zone fermée pendant plus d'une décennie. Aucun effet n'a été décelé sur le taux de mortalité des aiglefins juvéniles dans la zone fermée à la pêche, mais cela n'exclut pas la possibilité d'effets utiles pour le stock.

## Introduction

*Background*

The haddock fishery in Div. 4TVW has generally been concentrated on the offshore banks of Div. 4W during late winter and early spring. It is during this time that haddock move up on the banks (mainly Emerald and Western banks) to spawn in dense aggregations. These spawning aggregations formed the target of intensive fisheries by both domestic and foreign trawlers and remained the dominant fishing grounds of the domestic fleet after extended jurisdiction.

A succession of strong yearclasses in the early 1980's resulted in a prevalence of small fish (so-called ping-pong haddock) in Div. 4W during the mid-1980's. Reports of discarding were increasing (Angel et al. 1994) and reported landings were less than the TAC's by a substantial amount (e.g. in 1983 and 1984 there was a 5,000 and 7,000 mt shortfall, respectively). These shortfalls were attributed to the presence of numerous small, unmarketable haddock subjected to appreciable but unknown quantities of discarding at sea in these years (Mahon et al. 1985). In 1984, fisheries managers attempted to prevent the capture of these abundant yearclasses by closing Div. 4W to trawlers from May to December. This management measure did divert landings away from Div. 4W to Div. 4Vs (Zwanenburg et al. 1986) but was not completely effective at reducing the discarding problem.

At a Scotia-Fundy Groundfish Advisory Committee meeting in November 1986, industry representatives unanimously recommended closing the Div. 4VW haddock nursery areas to all groundfish fishing activity for 1987. The areas identified for closure were those which showed persistent and relatively large aggregations of young haddock in the July research vessel survey series. The results indicated that Western and Emerald banks (strata 463 and 464) and the western Gully and southwest of Emerald Bank (stratum 465) were the most important nursery areas (Fanning et al. 1987). It was later decided that fixed gear fisheries could fish inside the closed area (subject to all other regulations in effect) because these gears were believed to catch older fish than that of mobile gear. In summary, a haddock nursery area was defined (**Figure** 1) and closed year-round to mobile gear fisheries in 1987 with the objective to protect incoming recruits from fishing to allow the stock to rebuild. The year-round nursery ground closure imposed in 1987 remains in effect to the present and in 1993 the area was closed to all fishing (including fixed gear).

Preliminary evaluations of the closed area on the haddock resource (Zwanenburg 1990, 1992) suggested: i) the 1987 and 1988 yearclasses were benefiting from the effects of the closed area because higher catch rates were observed inside the closed area compared to contiguous areas and ii) the closed area appears to encompass the centre of distribution of both juvenile and adult haddock. It was further suggested that if the closed area is the centre of distribution for this stock then this could make the closed area an effective management initiative.

*Requested review*

Ten years have now elapsed since the establishment of the closed area in Div. 4W and a review of the impact of the closure has been requested by industry and managers. Specifically, we have been asked to conduct a review of the Western Bank juvenile haddock closed area and examine the impacts of the closure on the Div. 4TVW haddock stock and other fish species.

*Expected effects of areas protected from fishing*

The expectations of areas protected from fishing are numerous and have been discussed in the literature dealing with marine reserves or marine protected areas. At a recent workshop on the design and monitoring of marine reserves, Pitcher (1997) listed several benefits that can accrue from areas protected from fishing. These included:

- restricted fishing mortality
- protection against stock collapse
- insurance against overfishing
- buffering ineffective control over fisheries effort
- providing a buffer against uncertainty associated with stock biomass estimates
- enhancement of spawning biomass, recruitment, and survival of older fish
- allow habitat to recover in the absence of perturbations like bottom trawling
- increase fisheries catches in contiguous areas

Unfortunately, most of these benefits have been modelled rather than directly demonstrated and the few examples that have established benefits are from tropical reef systems. Currently, there are no clear demonstrations of the benefits of areas protected from fishing in marine temperate ecosystems.

*Objectives*

The current review of the closed area will focus principally on evaluation of changes in abundance and mortality rate of haddock inside the closed area relative to contiguous areas subjected to fishing. Data are insufficient to examine other aspects of the environment such as the benthos or food supply for haddock, although information is presented on haddock condition factors and recent diet studies conducted by the Fishermen and Scientist Research Society (FSRS). Several other groundfish species have also been examined for changes in abundance inside the closed area and in relation to adjacent areas. Lack of ageing data for the other species limits the types of analyses that can be performed. Furthermore, it must be kept in mind that the closed area was established based only on the distribution of young haddock and no consideration was given to the distributions of other species.

## Methods

All of the data used for the analysis was derived from the July RV survey in Div. 4VWX. Survey data exists for March beginning in 1979 but was not used in the analysis because of the absence of age information for haddock. The research vessel conducting the surveys has changed over time and conversion factors for the vessels involved are contained in Fanning (1985). The haddock data presented herein have been adjusted accordingly (i.e. for 1970 to 1981 haddock catch rates were multiplied by 1.2). Catch rates were expressed as mean number per tow for three geographic areas: 1) the closed area - strata 463, 464 and 465 (area = 3982 $n.m^2$) which includes Emerald Bank, Western Bank, and Emerald mid-depths south, 2) reference area east - strata 454, 455, 456, and 462 (area = 5692 $n.m^2$) which includes Sable slope, Sable Island Bank (north and south), and Emerald mid-depth north, and 3) reference area west - strata 472 and 473 (area = 1514 $n.m^2$) which includes LaHave mid-depths and LaHave Bank. The reference areas represent contiguous areas of similar depth surrounding the closed area that have not been closed to fishing and they are shown in **Figure** 2. The western reference area is in Div. 4X and the other in Div. 4W. The strata making up the closed area and the eastern reference area generally contain over 80% of the total haddock biomass in Div. 4VW. Therefore, the stock dynamics are expected to be well represented by information coming from these two areas.

Estimation of total mortality was based on survivorship curves of haddock yearclasses in the three areas constructed from the mean numbers per tow at age data adjusted for the survey gear catchability, q. This so-called "q" correction results in an approximate estimate of the population numbers at age. Estimates of age-specific q were taken from the most recent assessment conducted for the Div. 4VW (ages 2 to 8; Frank et al. 1997) and 4X (ages 2 to 7; Hurley et al. 1997) haddock stocks. The estimates are as follows:

| | $q_2$ | $q_3$ | $q_4$ | $q_5$ | $q_6$ | $q_7$ | $q_8$ |
|---|---|---|---|---|---|---|---|
| 4VW | 0.00029 | 0.00044 | 0.00051 | 0.00051 | 0.00051 | 0.00047 | 0.00037 |
| 4X | 0.00043 | 0.00053 | 0.00058 | 0.00071 | 0.00081 | 0.00087 | - |

Survivorship curves were generally constructed for ages 2 to 10 so the estimated q on the oldest age group was applied to ages 9 and 10 in Div. 4VW and to ages 8-10 in Div. 4X. Survivorship curves were developed for 22 yearclasses (1968 to 1989) from each of the three areas.

## Results

*History of the closed area*

It is important to review the history of the closed area by addressing the question - how closed has the closed area been since its imposition in 1987? Recall that fixed gear fisheries were permitted to fish inside the closed area while mobile gear fishing was banned so this has to be taken into account in the closed area evaluation. Also invertebrate fisheries, particular scallop fishing, have been active inside the closed area so details of by-catch and effort distributions are of interest. Finally, estimates of the number of violations associated with illegal fishing inside the closed area were reviewed. A schematic diagram showing the history of the closed area is presented in **Figure** 3.

Longline landings of haddock from Div. 4W increased from 434 mt in 1987 to a peak of 3382 mt in 1992 (**Figure** 4) This represents an 8-fold increase in landings during this time period and it raised concerns about protection of young haddock in the closed area (Zwanenburg 1992). In 1993 all groundfish fishing ceased inside the closed area. Fixed gear landings in 1993 were only 20% of the 1992 value and have remained low since due to the moratorium on cod and haddock fishing in Div. 4VW.

Scallop fishing in Div. 4W has generally been unrestricted in terms of effort (quotas were first implemented for this area in 1994) and location. Haddock by-catch in the Div. 4W scallop fishery has generally been below 0.3 mt during 1989 to 1997 with the exception of 1989 when haddock by-catch was 2 mt (**Figure** 4). By-catch of other species such as cod, plaice, yellowtail flounder, witch flounder, winter flounder and wolffish were low as well with the only exception being monkfish where by-catch levels ranged from 17 - 241 mt (**Table** 1). Scallop fishing locations have been confined to the shallow, sandy bottom regions of Western bank with no fishing taking place on Emerald bank or the western half of Western bank. Therefore, with respect to the closed area only the easternmost areas have been subjected to scallop fishing (**Figure** 5). There has also been a noticeable decrease in scallop fishing activity since the imposition of quotas in 1994.

Surveillance of the closed area by the Conservation and Protection Branch of DFO has detected between 50-60 incidents of illegal fishing activity inside the closed area over the past 10 years. The 5-6 reports of illegal activity in the closed area per year is only an approximation and some of the reports do not pan out while others may involve vessels sitting near unmarked gear. Positional data associated with such incidents is currently not available in the existing database and a search of paper records would be required to provide the necessary detail. DFO port technicians have also noted instances of haddock landings originating from the closed area (Angel et al. 1994).

Collectively, this information indicates that the closed area has not been completely closed to fishing for a ten year period (since 1987) but has experienced a mixture of fishing activity, the degree to which has been lower than surrounding areas that were not under similar restrictions (**Figure** 6). Since 1994 the cod and haddock fishery in Div. 4VW has been under moratorium so there has been no directed haddock fishing outside of the closed area during the past four years. Strict by-catch limits exist for other fisheries directed at pollock, white hake, cusk, Atlantic halibut and flatfish in Div. 4VW (Frank et al. 1997).

*Abundance trends of haddock*

*Ages 1-3*

Haddock ages 1-3 years old represent immature or juvenile fish that are only partially recruited to the fishery. Mean number per tow of haddock ages 1-3 exhibited a variable pattern of abundance inside the closed area (**Table** 2), reflecting the infrequent appearance of large yearclasses (**Figure** 7). Post-closure abundances (1987-97 average = 37 fish per tow) of young haddock were, on average, lower than pre-closure levels (1970-86 average = 44 fish per tow) among those strata associated with the closed area. Persistent low recruitment has been characteristic of the Div. 4VW haddock stock since the mid-1980s with the only exception being the 1988 yearclass (Frank et al. 1997). Since 1994, catch rates of young haddock have increased inside the closed area.

The reference area immediately adjacent to the closed area on the eastern side contained, on average, higher levels of young haddock throughout the entire time series relative to the closed area (1970-86 average = 52 fish per tow; 1987-97 average = 59 fish per tow; also see **Table** 3). Variability was also high from year-to-year but trends in abundance of young haddock between the closed area and the eastern reference area were dissimilar (**Figure** 7).

The reference area immediately adjacent to the closed area on the western side exhibited similar levels of young haddock abundance throughout the entire time series (1970-86 average = 34 fish per tow; 1987-98 average = 25 fish per tow; also see **Table** 4). Similar to the other two areas, high interannual variability was characteristic of this time series (**Figure** 7). Trends in abundance of young haddock between the closed area and the western reference area were roughly similar ($r = 0.42$, $n = 28$, $p < 0.05$).

*Ages 4-6*

Haddock ages 4-6 years old generally represent maturing fish that are fully recruited to the fishery. It is expected that this age group and older ages inhabiting areas of reduced fishing would experience positive benefits. During the post-closure period, abundance levels averaged 27 fish per tow versus 35 fish per tow during the pre-closure period (**Figure** 7) suggesting no appreciable differences in abundance between the two time periods. Abundances increased in 1991 and 1992 following a minimum in 1990.

In comparison to the closed area, abundance levels in the eastern reference area were higher during 1987-97 (average = 44 fish per tow) and lower during 1970-86 (average = 28 fish per tow). Abundances rose sharply in 1991, following a minimum in 1990, and remained above average until 1994 (**Figure** 7). This pattern is somewhat similar to what was observed in the closed area. Trends in abundance between the closed area and the eastern reference area were correlated ($r = 0.52$, $n = 28$, $p < 0.01$).

Haddock abundance in the western reference area was higher during 1970-86 compared to 1987-97 (26 versus 9 fish per tow, respectively). Trends in abundance between the closed area and ref west were highly correlated ($r = 0.73$, $n = 28$, $p < 0.001$).

*Ages 7-9 and 10+*

The older age groups of haddock were generally more abundant after establishment of the closed area, both in the closed area and the eastern reference area (**Figure** 7). The magnitude of this difference is striking - a 10-fold increase inside the closed area and the eastern reference area. In contrast, abundances of older haddock in the western reference area were generally low throughout the entire time series. The similarity of the increase of the older age groups between the closed area and the eastern reference area could indicate that the two areas are coupled, e.g. one acting as a spillover area from the other. Support for this connection is based on the observation that high abundances in the closed area generally preceded increases in abundance in the eastern reference area (**Figure** 7). Collectively, these data suggest the closed area may be having a positive effect on survivorship.

*Geographic distribution of haddock in Div. 4VW*

The strata making up the closed area and the eastern reference area generally contain over 80% of total haddock biomass in Div. 4VW (**Figure** 8). Therefore, the stock dynamics are well represented by information coming from these two areas. It is interesting to note, however, that prior to 1983 between 40 and 60% of the haddock biomass was contained in the strata associated with the closed area and since that time the closed area strata have contributed less than 40% to the total (**Figure** 8). While this suggests a change in distribution has occurred it is, in fact, quite subtle given that the two areas are contiguous and their relationship to one another has in the past been described as an "overspill" area (Fanning et al. 1987). A better appreciation of the dynamics of the distributional patterns of haddock can be gleaned from **Figure** 9 where the age-specific catch per tow of haddock is presented as a composite of five to six years of data in five discrete time blocks.

The most consistent features of this geographical data are: i) persistent centres of high concentration associated with the closed area (Emerald/Western banks) and the eastern reference area (Sable Island bank) and ii) age-specific patterns of distribution that are similar across all ages (**Figure** 9). These conclusions are in agreement with those of previous analyses of haddock distributions in Div. 4VW (Zwanenburg 1990). Since 1987, however, two patterns stand out: i) higher concentrations of haddock are evident in eastern areas adjacent to the closed area and as suggested above, this is a rather subtle change in distribution (on the order of 10-100 km) and ii) older haddock (7+) appear more abundant. The centre of mass or centroid of each of the age-specific distributions within the five time blocks is shown in **Figure** 10. This exercise merely serves to quantify the preceding conclusions that haddock exhibit consistent centres of abundance across ages. The maximum distance between centroids at age within four out of the five time blocks was 50-60 kms or less. In 1981-86 the distances were on the order of 90 kms (i.e. the distance separating ages 1 and 9). The eastern boundary of the closed area divides the centre of distribution of haddock in Div. 4W. This situation complicates the interpretation of the impact of the closed area.

*Total mortality trends*

The data suggest increased survivorship of haddock coincident with the establishment of the closed area and two approaches have been taken to evaluate this hypothesis. The first is the estimation of total mortality from the survey data across selected age groups (juveniles and adults) and the second is the construction of catch curves by cohort from the q-corrected survey data.

*Juvenile mortality*

The pattern of juvenile mortality from the survey data in each of the three areas is highly variable and not easily interpreted (**Figure** 11). The expected result was for relatively high mortality before the closure followed by a decline. There were frequent instances of negative Z's and this occurred in spite of the data having been smoothed using a 3 year, centre-weighted moving average. Using another block of ages, e.g. ages $(2\text{-}4)_t$ vs ages $(3\text{-}5)_{t+1}$ did not improve the pattern so further analysis of these data was not pursued. It appears that the closed area had little effect on juvenile mortality. However, variability in the data may have obscured the trend and further research is warranted on this problem.

*Adult mortality*

The pattern of Z's on the older ages indicated that total mortalities were highest throughout the 1970s and early 1980s among those strata associated with both the closed area and the eastern reference area. Thereafter, in the closed area, total mortalities steadily declined prior to the imposition of the closed area reaching a minimum in 1987 (**Figure** 12). Mortality gradually increased up to 1992 reflecting the increase in fixed gear landings in the closed area and then declined coincident with the elimination of fixed gear fishing from the closed area in 1993 (Frank et al. 1997). In the eastern reference area, the pattern of adult mortality was similar to the closed area. The pattern of total mortality estimated for adult haddock in the western reference area was higher than the closed area and eastern reference area throughout the late 1980s to present. As was the case for the juvenile mortality data, the adult mortality data was smoothed using a 3 year, centre-weighted moving average.

*Total mortality estimated from catch curves*

Catch curves for 22 haddock yearclasses constructed for the closed area and each of the two reference areas provided estimates of total mortality, as inferred from the slopes of the regression lines. Ages 2 to 10 were generally included in the analysis. There were only five instances of slopes that did not differ significantly from zero and this occurred because of lack of trend in the data. **Table** 5 provides a summary of the analysis for each of the three areas. The first eleven yearclasses available for analysis (1968-78) preceeded the imposition of the closed area with the exception of the 1977 and 1978 yearclasses where ages 10 (in 1987) and ages 9 (in 1987) and 10 (in 1988) respectively could have been influenced by the closed area. The remaining eleven yearclasses (1979-89) were either partially or completely in existence during the imposition of the closed area. This provides a convenient basis for separation and comparisons are made in this manner. Fitting of the regression lines for some yearclasses was conducted after removing outlying data and these data are identified in the accompanying figures as circled points.

The first eleven yearclasses in those strata associated with the closed area exhibited relatively high mortality rates ranging from 0.44 (1968 yearclass) to 1.25 (1974 yearclass) with an average mortality of 0.83 (**Table** 6, **Figure** 13). The slopes associated with each of these yearclasses were significantly different from zero. The next eleven yearclasses (**Figure** 13) exhibited much lower mortality rates ranging from 0.16 (1981 and 1989 yearclasses) to 0.45 (1984 yearclass) with an average of 0.28 (**Table** 6). All slopes were significantly different from zero with exception of the 1989 yearclass.

Mortality rates in the eastern reference area showed a general pattern similar to that observed in the closed area although mortality rates associated with the first eleven yearclasses tended to be lower (average = 0.58, range: 0.35 - 0.78) and mortality rates associated with next eleven yearclasses tended to be higher (average = 0.42, range: 0.28 - 0.62) than those observed in the closed area (**Figure** 14 and **Table** 6). All slopes were significantly different from zero with the exception of the 1970 yearclass.

In the western reference area, average mortality rates associated with the first eleven yearclasses were similar to the average rate derived from the second eleven yearclasses (0.67 versus 0.70; **Table** 6). The data are noticeably more variable associated with construction of catch curves from this area (**Figure** 15). This is probably due to the limited sampling effort such a small geographic area receives during the annual surveys. In spite of this variability all but two yearclasses had slopes that differed significantly from zero.

In summary, the analysis suggests that yearclasses inhabiting the Emerald/Western bank region that were in existence during the imposition of the closed area experienced higher survivorship in comparison to the eastern reference area (**Figure** 16) and the western reference area (**Figure** 17). This analysis assumes that the yearclass distributions at age are relatively stationary - an assumption that appears to be true given the limited ontogenetic dispersion of Div. 4VW haddock evident from past (Fanning et al. 1987, Zwanenburg 1990) and present analyses (**Figures** 9 and 10). Generally speaking, the size of a closed area needed to protect a species will depend on individual movement rates on daily, seasonal and migratory time scales. Collectively, the results of the analyses suggests that the proportion of time haddock spend in a limited geographic area on a annual basis is substantial.

*Condition factors of haddock*

Condition factors are considered to be indicators of the physiological profile of fish and it is possible that areas protected from fishing may promote higher condition factors, possibly through increased food supplies and/or reduced stress. Condition factors were evaluated for each of the three areas and for juvenile and adult haddock.

Inside the closed area, condition factors for juvenile haddock have increased since the imposition of the closure, peaking in the early 1990s and levelling off since that time (**Figure** 18). Pre-closure condition factors of juvenile haddock were also high during the late 1970s to early 1980s. Juvenile condition factors in the eastern reference area have also increased since the imposition of the closure, however the predicted weights were generally lower. After reaching a minimum in the mid-1980s, conditions factors of juveniles increased in the eastern reference area. Presently, all three areas have similar predicted weights of juvenile haddock.

The condition of adult haddock from the closed area and eastern reference area exhibited similar trends throughout the time series (**Figure** 18; $r = 0.81$, $n = 26$, $p < 0.001$). Peaks in condition occurred in the early and mid-1980s and a trend of increasing weights is evident from 1993 to present. The trend in condition of adult haddock from the western reference area was also similar to the other two areas although predicted weights generally tended to be higher.

In summary, these data indicate that slightly higher condition factors of juvenile haddock prevailed on Emerald/Western bank during the post-closure period compared to those juveniles occurring in the vicinity of Sable Island bank (i.e. the eastern reference area). Whether or not this pattern can be ascribed to the imposition of the closed area is unknown. Recent diet studies of haddock conducted by the FSRS show marked differences in diet composition between the closed area and the eastern reference area. This could contribute to differences in condition. Haddock feed more heavily on crustaceans and fish inside the closed area while haddock in the eastern reference area feed primarily on echinoderms (such as brittle stars) and mollusks. This preliminary analysis is based on the collection of 213 and 270 haddock collected inside the closed area and eastern reference area respectively during 1995, 1996 and 1997 (Smith 1998). Obviously, further research is required to established a causal relationship between the closed area, haddock food supply, and growth patterns of haddock.

*Other species*

The possibility that other fish species have experienced increases in abundance due to the imposition of the closed area was addressed by examining abundance trends of 29 species, most of which were commercially important, from each of the three areas (**Tables** 7, 8, and 9). Low abundance levels typified many of the species suggesting that the closed area and reference areas were not the preferred habitat of these species. Visual examination of time series plots of abundance for the remaining species revealed that some species were more abundant during the post-closure period inside the closed area, notably winter flounder, American plaice, red hake, and longhorn sculpin (**Figure** 19). These species have distributional patterns on the Scotian Shelf that are either centred inside or in close proximity to the closed area (see Simon and Comeau 1994). Other species that fit this criterion included monkfish, yellowtail flounder, witch, and sea raven.

For each of the eight resident species, abundance trends have been expressed as annual anomalies from the 1970-86 mean abundance and plotted against survey year for the closed area and the two reference areas. In the closed area winter flounder, American plaice, longhorn sculpin, and to a lesser extent, red hake, exhibited a run of positive anomalies (i.e. above average catch rates) during the post-closure period (**Figure** 20). Winter flounder exhibited a similar pattern in the eastern reference area while almost no winter flounder occurred in the western reference area. In the eastern reference area, American plaice exhibited a run of negative anomalies - a pattern in direct contrast to what was seen in the closed area. For longhorn sculpin, positive abundance anomalies occurred in four consecutive years (beginning in 1989) during the post-closure period in the eastern reference area followed by below average levels of abundance. Red hake abundance anomalies were generally positive during the post-closure period in the eastern reference area but of lower magnitude compared to the closed area.

In summary, the data suggest that American plaice resident in the Emerald/Western banks region benefitted from the imposition of the closed area. This species is poorly selected or unavailable to fixed gear directing for haddock and such species would have been protected from fishing inside the closed area for over a decade.

Other analyses that have been conducted but not presented on community level responses include assessment of changes in species diversity and total biomass inside the closed area and among adjacent areas. These analyses suffer from the fact that all species are not sampled equally by the survey gear and while trawlable biomass is a useful index of temporal trends in abundance, it does not provide a basis for comparing abundance between species nor does it provide an estimate of the aggregate or total biomass. Correction factors for the relative catchability of each species are required and very little progress has been made towards this end since the pioneering work of Edwards (1968).

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Table 1. By-catch (t) of groundfish species in the scallop fishery in Div. 4W.

| YEAR | Scallops | Scallop roe | Haddock | Cod | Am. Plaice | Yellowtail | Witch | Winter fldr. | Unspec. fldr. | Wolffish | Monkfish | Unspec. | Skate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | 4471.5 | 3.6 | 2.0 | 11.1 | 19.2 | 2.5 | 13.3 | 0.7 | 3.2 | 3.4 | 241.1 | 0.9 | 0.0 |
| 1990 | 3627.6 | 0.0 | 0.2 | 3.2 | 4.8 | 0.1 | 6.4 | 2.7 | 2.2 | 2.9 | 168.8 | 0.7 | 0.0 |
| 1991 | 3260.3 | 0.0 | 0.3 | 2.0 | 0.0 | 0.0 | 5.5 | 0.9 | 9.2 | 2.0 | 80.1 | 1.1 | 0.0 |
| 1992 | 4336.3 | 0.0 | 0.2 | 4.7 | 0.0 | 0.2 | 1.4 | 0.1 | 10.8 | 1.1 | 185.5 | 0.2 | 0.0 |
| 1993 | 2033.2 | 0.0 | 0.1 | 1.3 | 0.0 | 0.0 | 0.8 | 0.1 | 2.2 | 0.2 | 43.6 | 0.1 | 0.0 |
| 1994 | 979.9 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 1.3 | 0.3 | 0.1 | 0.0 | 21.0 | 0.4 | 1.1 |
| 1995 | 1253.2 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 4.6 | 0.0 | 35.3 | 0.1 | 0.0 |
| 1996 | 1460.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.7 | 0.0 | 0.0 |
| 1997 | 1445.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 96.2 | 0.0 | 0.0 |

Table 2. Haddock mean number per tow at age from the July RV for the closed area.

closed area
trata 63,64,65

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 0.14 | 6.41 | 3.05 | 5.84 | 6.44 | 2.51 | 1.67 | 1.33 | 0.84 | 0.28 | 0.04 | 0.08 | 28.64 |
| 71 | 0.00 | 5.41 | 12.81 | 4.25 | 5.21 | 2.16 | 1.15 | 0.50 | 0.42 | 0.02 | 0.00 | 0.00 | 31.93 |
| 72 | 0.00 | 5.69 | 0.97 | 1.95 | 1.96 | 2.01 | 1.21 | 0.62 | 0.35 | 0.20 | 0.03 | 0.00 | 15.01 |
| 73 | 0.00 | 3.43 | 6.06 | 1.81 | 2.51 | 0.99 | 2.15 | 0.58 | 0.33 | 0.18 | 0.04 | 0.00 | 18.09 |
| 74 | 1.63 | 1.84 | 15.88 | 20.13 | 4.21 | 3.95 | 2.00 | 1.55 | 0.67 | 0.37 | 0.15 | 0.20 | 52.59 |
| 75 | 0.58 | 7.58 | 1.79 | 12.83 | 11.95 | 2.97 | 5.34 | 1.18 | 0.40 | 0.22 | 0.12 | 0.02 | 45.00 |
| 76 | 2.33 | 11.91 | 9.15 | 1.85 | 5.03 | 4.46 | 0.91 | 0.84 | 0.15 | 0.01 | 0.08 | 2.58 | 39.32 |
| 77 | 0.48 | 27.42 | 45.89 | 39.57 | 5.09 | 4.92 | 1.73 | 0.32 | 0.11 | 0.00 | 0.06 | 0.00 | 125.59 |
| 78 | 0.00 | 25.25 | 53.47 | 72.82 | 43.05 | 2.12 | 1.58 | 0.58 | 0.04 | 0.00 | 0.00 | 0.07 | 198.99 |
| 79 | 8.72 | 0.60 | 11.77 | 24.42 | 35.34 | 11.10 | 1.54 | 1.08 | 0.12 | 0.00 | 0.00 | 0.07 | 94.78 |
| 80 | 7.91 | 7.54 | 0.33 | 71.86 | 73.41 | 42.29 | 6.89 | 0.79 | 0.15 | 0.05 | 0.00 | 0.34 | 211.55 |
| 81 | 15.87 | 69.21 | 9.97 | 2.71 | 35.20 | 16.10 | 5.72 | 0.80 | 0.19 | 0.14 | 0.03 | 0.00 | 155.94 |
| 82 | 0.34 | 18.90 | 52.46 | 35.28 | 8.10 | 28.99 | 8.90 | 2.18 | 0.24 | 0.00 | 0.01 | 0.00 | 155.39 |
| 83 | 0.87 | 50.69 | 16.55 | 14.10 | 9.03 | 4.36 | 3.28 | 0.82 | 0.12 | 0.01 | 0.02 | 0.00 | 99.86 |
| 84 | 2.18 | 0.84 | 10.93 | 18.84 | 48.55 | 9.20 | 3.33 | 1.34 | 0.16 | 0.06 | 0.03 | 0.09 | 95.54 |
| 85 | 0.00 | 11.29 | 5.99 | 19.85 | 20.97 | 20.61 | 4.54 | 0.81 | 1.49 | 0.53 | 0.11 | 0.06 | 86.26 |
| 86 | 0.10 | 5.26 | 11.14 | 8.83 | 24.40 | 26.08 | 18.10 | 4.80 | 0.81 | 0.51 | 0.14 | 0.09 | 100.25 |
| 87 | 0.00 | 8.60 | 2.64 | 6.85 | 4.13 | 18.97 | 18.30 | 14.18 | 3.16 | 0.21 | 0.50 | 0.33 | 77.86 |
| 88 | 3.42 | 12.12 | 3.67 | 4.80 | 7.19 | 6.65 | 18.27 | 13.19 | 8.91 | 1.37 | 0.60 | 0.46 | 80.64 |
| 89 | 0.08 | 52.91 | 16.90 | 7.03 | 6.20 | 7.96 | 7.67 | 20.12 | 15.54 | 14.31 | 4.14 | 1.60 | 154.46 |
| 90 | 0.00 | 2.34 | 26.85 | 20.65 | 8.17 | 2.03 | 2.35 | 2.68 | 5.28 | 6.91 | 6.30 | 5.40 | 88.97 |
| 91 | 0.00 | 0.34 | 2.40 | 23.97 | 26.47 | 10.78 | 2.56 | 4.44 | 3.71 | 4.07 | 4.43 | 1.71 | 84.87 |
| 92 | 0.00 | 2.69 | 2.76 | 6.57 | 23.59 | 18.59 | 2.50 | 2.10 | 0.65 | 0.64 | 1.94 | 4.17 | 66.22 |
| 93 | 5.48 | 4.12 | 2.37 | 1.90 | 6.51 | 17.74 | 6.29 | 1.84 | 0.42 | 0.72 | 0.30 | 1.99 | 49.68 |
| 94 | 4.84 | 7.37 | 7.72 | 3.26 | 2.53 | 6.46 | 19.85 | 7.98 | 0.69 | 0.54 | 0.27 | 1.55 | 63.05 |
| 95 | 1.10 | 24.80 | 20.38 | 20.73 | 2.49 | 3.40 | 17.05 | 17.17 | 2.82 | 0.58 | 0.20 | 0.80 | 111.52 |
| 96 | 6.96 | 33.50 | 9.80 | 11.96 | 6.43 | 1.03 | 0.38 | 2.15 | 4.45 | 2.34 | 0.37 | 0.37 | 79.74 |
| 97 | 0.14 | 29.12 | 18.99 | 7.16 | 8.82 | 4.82 | 2.17 | 0.67 | 1.10 | 4.64 | 3.23 | 1.19 | 82.06 |

Table 3. Haddock mean number per tow at age from the July RV for the eastern reference area.

Reference area east
Weighted mean #/ tow for strata 54,55,56,62

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 0.14 | 8.57 | 1.21 | 2.97 | 2.44 | 0.74 | 0.41 | 0.44 | 0.41 | 0.09 | 0.02 | 0.07 | 17.51 |
| 71 | 0.34 | 3.71 | 9.21 | 3.05 | 3.97 | 1.54 | 0.95 | 0.43 | 0.84 | 0.03 | 0.00 | 0.00 | 24.06 |
| 72 | 0.00 | 1.19 | 0.52 | 1.13 | 0.50 | 0.27 | 0.28 | 0.20 | 0.03 | 0.02 | 0.03 | 0.26 | 4.44 |
| 73 | 0.00 | 0.18 | 0.65 | 0.35 | 0.44 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.71 |
| 74 | 0.12 | 0.00 | 0.51 | 1.08 | 0.15 | 0.14 | 0.02 | 0.02 | 0.01 | 0.00 | 0.00 | 0.02 | 2.06 |
| 75 | 0.00 | 16.72 | 3.10 | 0.96 | 0.91 | 0.36 | 0.70 | 0.19 | 0.07 | 0.05 | 0.13 | 0.00 | 23.19 |
| 76 | 0.00 | 4.13 | 3.70 | 0.70 | 1.45 | 1.74 | 0.36 | 0.48 | 0.04 | 0.02 | 0.03 | 0.02 | 12.68 |
| 77 | 0.75 | 10.02 | 16.70 | 10.13 | 2.15 | 3.56 | 1.16 | 0.26 | 0.09 | 0.00 | 0.06 | 0.45 | 45.34 |
| 78 | 0.00 | 16.67 | 13.35 | 18.63 | 8.65 | 0.44 | 0.59 | 0.17 | 0.02 | 0.00 | 0.06 | 0.00 | 58.60 |
| 79 | 1.71 | 0.08 | 31.36 | 33.32 | 29.65 | 7.23 | 0.71 | 0.49 | 0.06 | 0.00 | 0.11 | 0.00 | 104.74 |
| 80 | 1.10 | 7.41 | 0.62 | 24.52 | 20.25 | 12.84 | 4.30 | 0.79 | 0.31 | 0.04 | 0.00 | 0.00 | 72.19 |
| 81 | 105.23 | 29.65 | 13.16 | 1.87 | 13.10 | 11.07 | 3.78 | 0.49 | 0.17 | 0.18 | 0.08 | 0.00 | 178.79 |
| 82 | 2.63 | 34.69 | 24.21 | 23.34 | 3.76 | 11.88 | 5.91 | 1.74 | 0.21 | 0.10 | 0.00 | 0.00 | 108.49 |
| 83 | 0.03 | 51.57 | 40.63 | 115.11 | 29.83 | 4.73 | 4.38 | 1.45 | 0.55 | 0.10 | 0.07 | 0.02 | 248.48 |
| 84 | 0.00 | 0.89 | 38.25 | 60.15 | 93.90 | 15.15 | 5.80 | 2.30 | 0.27 | 0.07 | 0.02 | 0.00 | 216.79 |
| 85 | 0.06 | 17.03 | 3.01 | 29.04 | 30.57 | 30.86 | 7.28 | 1.39 | 2.99 | 1.39 | 0.52 | 0.29 | 124.42 |
| 86 | 0.67 | 2.48 | 8.75 | 12.23 | 37.75 | 33.74 | 21.24 | 5.16 | 0.96 | 0.74 | 0.20 | 0.16 | 124.09 |
| 87 | 0.34 | 9.67 | 4.20 | 7.46 | 4.49 | 19.56 | 17.75 | 12.53 | 2.60 | 0.14 | 0.35 | 0.36 | 79.45 |
| 88 | 3.38 | 13.81 | 68.09 | 29.89 | 17.89 | 11.36 | 29.59 | 15.71 | 13.72 | 1.44 | 0.72 | 0.31 | 205.91 |
| 89 | 0.18 | 30.77 | 27.47 | 5.22 | 2.87 | 3.73 | 3.39 | 9.29 | 6.34 | 5.85 | 1.49 | 0.44 | 97.05 |
| 90 | 0.00 | 2.00 | 56.69 | 30.91 | 9.58 | 1.67 | 2.00 | 2.16 | 3.94 | 4.94 | 4.72 | 3.97 | 122.59 |
| 91 | 0.00 | 0.45 | 8.06 | 96.62 | 85.48 | 29.56 | 6.08 | 9.43 | 7.90 | 8.52 | 8.66 | 2.62 | 263.38 |
| 92 | 0.00 | 2.33 | 4.03 | 14.53 | 46.81 | 21.90 | 2.18 | 1.87 | 0.45 | 0.47 | 1.40 | 2.98 | 98.96 |
| 93 | 7.38 | 6.54 | 6.04 | 4.52 | 14.33 | 39.03 | 13.26 | 3.48 | 0.88 | 1.31 | 0.52 | 3.25 | 100.55 |
| 94 | 3.63 | 30.07 | 17.44 | 3.82 | 2.43 | 5.40 | 16.55 | 5.52 | 0.25 | 0.27 | 0.08 | 0.64 | 86.09 |
| 95 | 0.63 | 1.19 | 6.85 | 7.24 | 0.93 | 1.59 | 8.02 | 7.78 | 1.22 | 0.27 | 0.08 | 0.35 | 36.13 |
| 96 | 12.72 | 30.34 | 26.43 | 38.77 | 20.65 | 3.09 | 1.42 | 5.09 | 12.02 | 6.08 | 0.99 | 0.63 | 158.24 |
| 97 | 1.33 | 13.87 | 32.65 | 12.77 | 13.39 | 6.26 | 2.74 | 0.72 | 1.13 | 4.66 | 3.22 | 1.24 | 93.98 |

Table 4. Haddock mean number per tow at age from the July RV for the western reference area.

ref area west
strata 72,73

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11+ | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 0.0000 | 1.2028 | 2.1201 | 2.6551 | 5.2720 | 2.0498 | 4.5984 | 7.5892 | 0.9343 | 0.3209 | 0.1905 | 0.1138 | 27.05 |
| 71 | 0.0000 | 0.1130 | 14.7492 | 6.6055 | 3.1280 | 2.7168 | 1.0428 | 1.4511 | 2.8280 | 0.2703 | 0.0251 | 0.0000 | 32.93 |
| 72 | 0.0000 | 11.2329 | 0.2351 | 1.5755 | 2.8995 | 2.5235 | 2.4224 | 1.7696 | 2.1025 | 2.6177 | 0.0621 | 0.0368 | 27.48 |
| 73 | 0.0000 | 0.9721 | 7.1397 | 0.5064 | 4.6526 | 1.9787 | 0.9309 | 1.1381 | 0.7053 | 0.4603 | 0.8570 | 0.1095 | 19.45 |
| 74 | 0.0000 | 2.6366 | 12.7613 | 8.2507 | 0.3110 | 5.7500 | 0.9646 | 0.6656 | 0.8310 | 0.4769 | 0.2568 | 0.3372 | 33.24 |
| 75 | 0.0000 | 13.0732 | 4.0588 | 5.8936 | 10.3411 | 0.7969 | 4.5699 | 1.3573 | 0.7905 | 0.2179 | 0.6610 | 0.8247 | 42.58 |
| 76 | 0.0000 | 7.4261 | 4.7678 | 6.9373 | 9.6018 | 14.5850 | 2.2681 | 2.2532 | 0.2927 | 0.0000 | 0.0000 | 0.8066 | 48.94 |
| 77 | 0.0000 | 0.0764 | 4.5923 | 6.1009 | 4.8007 | 11.9975 | 8.9523 | 2.1437 | 2.4130 | 0.2693 | 0.2075 | 0.6775 | 42.23 |
| 78 | 0.0000 | 3.8978 | 0.9931 | 3.4265 | 1.3902 | 0.5594 | 1.5832 | 0.8486 | 0.0000 | 0.0000 | 0.0000 | 0.6041 | 13.30 |
| 79 | 1.6041 | 0.0150 | 14.2021 | 7.0851 | 7.1476 | 5.9219 | 2.1124 | 2.3739 | 0.6153 | 0.0000 | 0.0000 | 0.0000 | 41.08 |
| 80 | 0.3196 | 49.6548 | 7.6888 | 42.7109 | 25.8724 | 44.5667 | 21.9434 | 8.1251 | 4.9145 | 2.8200 | 1.4332 | 0.0627 | 210.11 |
| 81 | 0.0000 | 60.5390 | 19.9859 | 10.2364 | 42.2314 | 14.1325 | 10.4808 | 2.1993 | 0.2110 | 0.2024 | 0.0292 | 0.0292 | 160.28 |
| 82 | 0.0000 | 25.2647 | 52.7701 | 26.9608 | 7.7202 | 16.3508 | 7.7783 | 2.8974 | 0.3857 | 0.1046 | 0.0150 | 0.0224 | 140.27 |
| 83 | 0.0729 | 3.0185 | 3.8231 | 12.9489 | 7.1990 | 3.7245 | 4.1024 | 1.9736 | 0.8563 | 0.5882 | 0.1982 | 0.2756 | 38.78 |
| 84 | 0.8492 | 9.4839 | 17.1404 | 6.2236 | 7.1704 | 3.3609 | 3.6918 | 2.4237 | 0.5806 | 0.1523 | 0.0000 | 0.0000 | 51.08 |
| 85 | 0.0000 | 0.6948 | 9.5907 | 27.0460 | 16.3650 | 25.9579 | 8.2407 | 2.5377 | 1.8416 | 1.1456 | 0.1472 | 0.0000 | 93.57 |
| 86 | 0.4246 | 6.7052 | 25.1427 | 10.7936 | 20.3524 | 9.8752 | 10.4683 | 3.7401 | 1.8299 | 0.8111 | 0.3238 | 0.2967 | 90.76 |
| 87 | 0.0000 | 5.6262 | 2.4798 | 5.2955 | 6.0661 | 7.1820 | 5.9788 | 3.0681 | 0.7944 | 0.2914 | 0.5130 | 0.0300 | 37.33 |
| 88 | 0.0000 | 3.2747 | 0.4015 | 1.8857 | 4.2714 | 5.0780 | 6.8372 | 3.5868 | 2.1848 | 1.6514 | 0.8962 | 0.6818 | 30.75 |
| 89 | 0.0000 | 13.0730 | 14.2986 | 2.0075 | 1.5407 | 3.1324 | 1.4219 | 3.0924 | 0.8076 | 1.0984 | 0.3272 | 0.3216 | 41.12 |
| 90 | 0.0000 | 0.4010 | 5.1078 | 10.2483 | 1.3578 | 0.5877 | 1.0952 | 0.6199 | 0.9630 | 0.3801 | 0.5001 | 0.4134 | 21.67 |
| 91 | 0.0000 | 0.1900 | 1.6497 | 11.1262 | 10.0623 | 2.4458 | 1.4805 | 1.3549 | 1.4540 | 1.1171 | 0.8354 | 0.2169 | 31.93 |
| 92 | 0.0000 | 0.0000 | 0.4182 | 1.5322 | 3.6342 | 1.5745 | 0.0998 | 0.0460 | 0.1201 | 0.0589 | 0.0239 | 0.0239 | 7.53 |
| 93 | 0.0000 | 1.4036 | 0.8313 | 1.9532 | 0.6114 | 0.9164 | 0.2531 | 0.0258 | 0.0125 | 0.0676 | 0.0000 | 0.0446 | 6.12 |
| 94 | 3.8411 | 6.2553 | 4.6913 | 1.9553 | 1.3839 | 0.3451 | 1.2372 | 0.5783 | 0.0324 | 0.0423 | 0.0395 | 0.0841 | 20.49 |
| 95 | 0.0000 | 35.9103 | 19.3695 | 9.3996 | 3.1761 | 1.5557 | 0.7978 | 1.4391 | 0.2488 | 0.0271 | 0.0000 | 0.0367 | 71.96 |
| 96 | 17.3010 | 15.7179 | 42.9521 | 29.2568 | 10.8685 | 5.0094 | 0.8526 | 0.4598 | 0.8852 | 0.0336 | 0.1914 | 0.0336 | 123.56 |
| 97 | 0.0000 | 4.6025 | 7.1187 | 19.0042 | 8.9090 | 1.9335 | 0.8173 | 0.2525 | 0.0799 | 0.2416 | 0.1528 | 0.1344 | 43.25 |

Table 5. Summary statistics for the regression analysis of the q-corrected haddock catch rates for the closed area, eastern reference area (ref east), and the western reference area (ref west).

| area | yearclass | slope | YInt | r | n | sign. level | comments |
|---|---|---|---|---|---|---|---|
| closed | 68 | -0.4438 | 10.2725 | 0.87 | 7 | $p < 0.05$ | no data for ages 9 and 10 |
| closed | 69 | -0.5689 | 11.2786 | 0.80 | 7 | $p < 0.05$ | no data for ages 9 and 10 |
| closed | 70 | -1.0921 | 13.8193 | 0.97 | 5 | $p < 0.01$ | ages 2 and 3 omitted |
| closed | 71 | -0.9667 | 13.8049 | 0.99 | 8 | $p < 0.001$ | age 2 omitted |
| closed | 72 | -0.8774 | 13.0682 | 0.96 | 9 | $p < 0.001$ | |
| closed | 73 | -0.8657 | 12.9478 | 0.98 | 6 | $p < 0.001$ | ages 2 and 3 omitted; no data for age 9 |
| closed | 74 | -1.2452 | 16.0156 | 0.96 | 8 | $p < 0.001$ | age 2 omitted |
| closed | 75 | -0.9904 | 14.9222 | 0.95 | 9 | $p < 0.001$ | |
| closed | 76 | -0.8383 | 14.1161 | 0.94 | 9 | $p < 0.001$ | |
| closed | 77 | -0.7364 | 13.9822 | 0.95 | 8 | $p < 0.001$ | age 2 omitted |
| closed | 78 | -0.4761 | 11.3890 | 0.89 | 7 | $p < 0.01$ | ages 2 and 3 omitted |
| closed | 79 | -0.2624 | 11.1562 | 0.81 | 9 | $p < 0.01$ | |
| closed | 80 | -0.1988 | 11.8306 | 0.76 | 9 | $p < 0.05$ | |
| closed | 81 | -0.1550 | 11.3391 | 0.84 | 9 | $p < 0.01$ | |
| closed | 82 | -0.2400 | 11.5669 | 0.84 | 9 | $p < 0.01$ | |
| closed | 83 | -0.3449 | 10.9535 | 0.84 | 9 | $p < 0.01$ | |
| closed | 84 | -0.4467 | 11.4176 | 0.94 | 9 | $p < 0.001$ | |
| closed | 85 | -0.3670 | 10.3833 | 0.92 | 9 | $p < 0.001$ | |
| closed | 86 | -0.3849 | 10.9013 | 0.92 | 9 | $p < 0.001$ | |
| closed | 87 | -0.3034 | 11.7112 | 0.93 | 9 | $p < 0.001$ | |
| closed | 88 | -0.2636 | 11.8807 | 0.92 | 8 | $p < 0.001$ | no data for age 10 |
| closed | 89 | -0.1598 | 9.9957 | 0.43 | 7 | n.s. | no data for ages 9 and 10 |

| area | yearclass | slope | YInt | r | n | sign. level | comments |
|---|---|---|---|---|---|---|---|
| ref east | 68 | -0.7208 | 9.7927 | 0.79 | 7 | $p < 0.05$ | age 10 omitted: no data for age 9 |
| ref east | 69 | -0.5697 | 10.0265 | 0.75 | 7 | $p < 0.05$ | age 10 omitted: no data for age 9 |
| ref east | 70 | -0.3540 | 7.9763 | 0.72 | 7 | n.s. | no data for ages 9 and 10 |
| ref east | 71 | -0.4213 | 9.1999 | 0.86 | 9 | $p < 0.01$ | |
| ref east | 72 | -0.7773 | 12.0590 | 0.85 | 7 | $p < 0.05$ | ages 2 and 3 omitted |
| ref east | 73 | -0.4187 | 9.5623 | 0.90 | 9 | $p < 0.001$ | |
| ref east | 74 | -0.8920 | 13.4549 | 0.97 | 8 | $p < 0.001$ | age 2 omitted |
| ref east | 75 | -0.6745 | 12.8906 | 0.92 | 9 | $p < 0.001$ | |
| ref east | 76 | -0.6114 | 12.6753 | 0.92 | 9 | $p < 0.001$ | |
| ref east | 77 | -0.5463 | 12.5822 | 0.98 | 9 | $p < 0.001$ | |
| ref east | 78 | -0.4214 | 11.0603 | 0.78 | 7 | $p < 0.05$ | ages 2 and 3 omitted |
| ref east | 79 | -0.3792 | 11.9613 | 0.96 | 9 | $p < 0.001$ | |
| ref east | 80 | -0.4207 | 13.4942 | 0.95 | 8 | $p < 0.001$ | age 2 omitted |
| ref east | 81 | -0.2887 | 12.3944 | 0.93 | 9 | $p < 0.001$ | |
| ref east | 82 | -0.3649 | 12.5307 | 0.91 | 9 | $p < 0.001$ | |
| ref east | 83 | -0.2845 | 10.6149 | 0.68 | 9 | $p < 0.05$ | |
| ref east | 84 | -0.5060 | 11.7254 | 0.82 | 9 | $p < 0.01$ | |
| ref east | 85 | -0.6244 | 12.2189 | 0.89 | 8 | $p < 0.01$ | age 2 omitted |
| ref east | 86 | -0.5821 | 12.4754 | 0.83 | 9 | $p < 0.01$ | |
| ref east | 87 | -0.3845 | 12.4991 | 0.84 | 9 | $p < 0.01$ | |
| ref east | 88 | -0.4136 | 13.1609 | 0.94 | 8 | $p < 0.01$ | no data for age 10 |
| ref east | 89 | -0.3369 | 11.2743 | 0.87 | 7 | $p < 0.01$ | no data for ages 9 and 10 |

| area | yearclass | slope | YInt | r | n | sign. level | comments |
|---|---|---|---|---|---|---|---|
| ref west | 68 | -0.4972 | 10.2807 | 0.93 | 8 | $p < 0.001$ | no data for age 10 |
| ref west | 69 | | | | | | no apparent trend in data |
| ref west | 70 | | | | | | no apparent trend in data |
| ref west | 71 | -0.6502 | 12.0609 | 0.82 | 9 | $p < 0.01$ | |
| ref west | 72 | -0.7559 | 12.4789 | 0.86 | 9 | $p < 0.01$ | |
| ref west | 73 | -0.5589 | 10.8025 | 0.82 | 9 | $p < 0.01$ | |
| ref west | 74 | -0.4109 | 10.5252 | 0.69 | 8 | $p < 0.05$ | no data for age 10 |
| ref west | 75 | -0.9702 | 14.6806 | 0.92 | 7 | $p < 0.01$ | ages 2 and 3 omitted |
| ref west | 76 | -0.8006 | 13.7614 | 0.96 | 7 | $p < 0.001$ | ages 2 and 3 omitted |
| ref west | 77 | -0.7608 | 13.6785 | 0.98 | 8 | $p < 0.001$ | age 2 omitted |
| ref west | 78 | -0.4640 | 11.0646 | 0.94 | 9 | $p < 0.001$ | |
| ref west | 79 | -0.5739 | 12.0387 | 0.94 | 9 | $p < 0.001$ | |
| ref west | 80 | -0.5975 | 12.5526 | 0.95 | 9 | $p < 0.001$ | |
| ref west | 81 | -0.5596 | 11.9076 | 0.91 | 8 | $p < 0.01$ | age 2 omitted |
| ref west | 82 | -0.9126 | 14.0842 | 0.93 | 8 | $p < 0.001$ | age 2 omitted |
| ref west | 83 | -0.7444 | 12.0611 | 0.93 | 8 | $p < 0.001$ | no data for age 10 |
| ref west | 84 | -0.8698 | 12.4564 | 0.98 | 9 | $p < 0.001$ | |
| ref west | 85 | -0.8562 | 10.8925 | 0.91 | 8 | $p < 0.01$ | no data for age 10 |
| ref west | 86 | -0.6720 | 9.9670 | 0.77 | 8 | $p < 0.05$ | age 2 omitted |
| ref west | 87 | -0.8170 | 12.0650 | 0.94 | 9 | $p < 0.001$ | |
| ref west | 88 | -0.5385 | 10.7782 | 0.92 | 8 | $p < 0.01$ | no data for age 10 |
| ref west | 89 | -0.5237 | 9.3394 | 0.91 | 7 | $p < 0.01$ | no data for ages 9 and 10 |

Table 6. Summary of total mortality rates of haddock yearclasses for the closed area, eastern reference area, and western reference area. Number of age groups of each yearclass protected by the closed is also shown.

| | | | | | | |
|---|---|---|---|---|---|---|
| | Cohort Z's based on July RV q-corrected mean numbers per tow at age. | | | | | |
| | Whenever possible ages 2-10 were used in the Z calculation. | | | | | |
| | | | | | | |
| | | | | | # of age groups | |
| yearclass | closed | ref east | ref west | | protected | |
| 68 | 0.4438 | 0.7208 | 0.4972 | | 0 | |
| 69 | 0.5689 | 0.5697 | | | 0 | |
| 70 | 1.0921 | 0.354 | | | 0 | |
| 71 | 0.9667 | 0.4213 | 0.6502 | | 0 | |
| 72 | 0.8774 | 0.7773 | 0.7559 | | 0 | |
| 73 | 0.8657 | 0.4187 | 0.5589 | | 0 | |
| 74 | 1.2452 | 0.892 | 0.4109 | | 0 | |
| 75 | 0.9904 | 0.6745 | 0.9702 | | 0 | |
| 76 | 0.8383 | 0.6114 | 0.8006 | | 0 | |
| 77 | 0.7364 | 0.5463 | 0.7608 | | 1 | |
| 78 | 0.4761 | 0.4214 | 0.464 | | 2 | |
| 79 | 0.2624 | 0.3792 | 0.5739 | | 3 | |
| 80 | 0.1988 | 0.4207 | 0.5975 | | 4 | |
| 81 | 0.155 | 0.2887 | 0.5596 | | 5 | |
| 82 | 0.24 | 0.3649 | 0.9126 | | 6 | |
| 83 | 0.3449 | 0.2845 | 0.7444 | | 7 | |
| 84 | 0.4467 | 0.506 | 0.8698 | | 8 | |
| 85 | 0.367 | 0.6244 | 0.8562 | | all | |
| 86 | 0.3849 | 0.5821 | 0.672 | | all | |
| 87 | 0.3034 | 0.3845 | 0.817 | | all | |
| 88 | 0.2636 | 0.4136 | 0.5385 | | all | |
| 89 | 0.1598 | 0.3369 | 0.5237 | | all | |
| | | | | | | |
| | | | | | | |
| 68-78 mean | 0.82736364 | 0.58249091 | 0.6714375 | | | |
| 79-89 mean | 0.28422727 | 0.41686364 | 0.69683636 | | | |

Table 7. Mean number per tow of 29 fish species collected during the July RV from 1970-1997 from the closed area.

Mean of strata 63.64.65(closed area)
trawlable units (337441).

| Year | cod | haddock | white hake | red hake | silver hake | cusk | pollock | redfish | halibut | plaice | witch | yellowtail | winter fl | wolffish |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 11.01 | 28.64 | 0.86 | 0.00 | 22.91 | 0.58 | 0.12 | 0.45 | 0.54 | 16.32 | 0.33 | 9.44 | 0.00 | 0.26 |
| 71 | 3.95 | 31.93 | 0.72 | 0.11 | 3.95 | 0.47 | 8.38 | 0.07 | 0.42 | 9.43 | 0.21 | 11.27 | 0.00 | 0.22 |
| 72 | 3.53 | 15.01 | 0.17 | 0.00 | 10.01 | 1.05 | 0.06 | 0.24 | 0.23 | 4.72 | 0.58 | 11.81 | 0.00 | 0.23 |
| 73 | 24.12 | 18.09 | 1.23 | 0.81 | 14.80 | 0.31 | 0.07 | 0.90 | 0.21 | 8.38 | 1.05 | 25.33 | 0.00 | 0.49 |
| 74 | 15.79 | 52.59 | 4.28 | 0.00 | 17.79 | 0.66 | 14.98 | 0.25 | 0.11 | 16.97 | 3.84 | 76.09 | 0.11 | 0.23 |
| 75 | 7.06 | 45.00 | 0.40 | 0.15 | 0.51 | 0.71 | 0.95 | 0.00 | 0.87 | 3.87 | 0.24 | 6.11 | 0.00 | 0.69 |
| 76 | 11.12 | 39.32 | 1.69 | 0.00 | 63.73 | 0.58 | 1.96 | 0.00 | 1.12 | 2.64 | 0.65 | 21.17 | 0.31 | 0.00 |
| 77 | 6.68 | 125.52 | 1.71 | 0.00 | 1.78 | 0.71 | 1.84 | 0.08 | 0.82 | 2.52 | 1.82 | 12.44 | 0.00 | 0.55 |
| 78 | 10.48 | 198.90 | 4.55 | 0.00 | 19.94 | 0.00 | 1.39 | 0.36 | 0.25 | 7.85 | 1.72 | 3.10 | 0.00 | 0.49 |
| 79 | 14.87 | 94.77 | 0.56 | 3.45 | 6.64 | 1.16 | 0.88 | 2.09 | 0.76 | 16.27 | 2.92 | 8.67 | 0.00 | 0.37 |
| 80 | 15.12 | 211.66 | 0.09 | 1.30 | 11.47 | 0.21 | 0.08 | 0.00 | 0.27 | 1.02 | 0.33 | 1.21 | 0.09 | 0.21 |
| 81 | 3.89 | 155.94 | 1.31 | 2.27 | 33.28 | 0.50 | 0.92 | 0.25 | 0.21 | 6.68 | 1.36 | 8.87 | 0.00 | 0.25 |
| 82 | 12.65 | 155.38 | 0.00 | 3.18 | 16.86 | 1.60 | 0.12 | 1.48 | 0.43 | 5.65 | 0.53 | 14.50 | 0.63 | 0.93 |
| 83 | 5.11 | 99.86 | 0.17 | 0.10 | 4.28 | 0.08 | 14.10 | 0.11 | 0.11 | 1.00 | 0.25 | 0.49 | 0.00 | 0.00 |
| 84 | 6.50 | 95.58 | 1.47 | 3.57 | 77.36 | 0.92 | 0.97 | 0.00 | 0.50 | 2.88 | 0.32 | 2.85 | 0.34 | 0.40 |
| 85 | 9.87 | 86.26 | 0.49 | 1.29 | 63.06 | 0.30 | 2.70 | 0.04 | 0.56 | 1.57 | 0.58 | 7.03 | 0.00 | 0.04 |
| 86 | 1.92 | 100.25 | 1.83 | 12.56 | 131.63 | 0.36 | 0.40 | 0.60 | 1.41 | 4.60 | 0.27 | 8.58 | 0.18 | 0.27 |
| 87 | 9.01 | 77.86 | 0.53 | 2.03 | 154.10 | 0.77 | 5.38 | 2.67 | 0.85 | 2.44 | 0.15 | 4.76 | 0.74 | 0.45 |
| 88 | 5.46 | 80.64 | 0.38 | 11.57 | 122.98 | 0.54 | 1.68 | 0.85 | 0.76 | 7.55 | 1.22 | 5.48 | 1.65 | 0.41 |
| 89 | 29.07 | 154.39 | 1.57 | 3.75 | 44.86 | 0.00 | 10.35 | 4.25 | 0.90 | 16.78 | 0.33 | 11.94 | 0.06 | 0.00 |
| 90 | 17.25 | 88.97 | 2.65 | 0.61 | 16.49 | 0.10 | 1.33 | 2.18 | 0.52 | 16.83 | 0.04 | 16.83 | 0.85 | 0.09 |
| 91 | 32.09 | 84.89 | 0.13 | 0.26 | 32.36 | 0.07 | 10.19 | 2.20 | 0.55 | 23.31 | 0.81 | 31.97 | 6.61 | 0.12 |
| 92 | 5.00 | 86.22 | 0.61 | 0.71 | 4.73 | 0.06 | 10.47 | 0.66 | 0.61 | 10.50 | 1.61 | 28.62 | 1.85 | 0.00 |
| 93 | 3.31 | 49.68 | 0.89 | 2.80 | 25.54 | 0.00 | 2.59 | 128.45 | 0.26 | 8.60 | 0.60 | 23.55 | 1.63 | 0.05 |
| 94 | 2.96 | 63.05 | 0.30 | 9.99 | 121.99 | 0.00 | 9.91 | 1.25 | 0.50 | 7.88 | 0.65 | 13.17 | 1.23 | 0.00 |
| 95 | 3.59 | 111.51 | 4.54 | 8.80 | 40.17 | 0.05 | 11.06 | 11.92 | 0.46 | 8.16 | 2.75 | 9.67 | 4.02 | 0.11 |
| 96 | 5.35 | 79.74 | 0.81 | 3.48 | 34.00 | 0.00 | 24.08 | 0.77 | 0.40 | 5.85 | 0.23 | 8.62 | 4.31 | 0.00 |
| 97 | 1.63 | 82.13 | 0.59 | 6.38 | 74.37 | 0.18 | 5.18 | 2.94 | 0.40 | 8.27 | 1.26 | 14.13 | 1.13 | 0.06 |

| Year | herring | alewife | mackerel | longfin hake | argentine | thorny skate | smooth skate | winter skate | dogfish | lghm sculpin | mailed sculp | sea raven | monkfish | marlin spike | ocean pout |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 12.79 | 0.00 | 0.00 | 0.00 | 0.08 | 3.94 | 0.21 | 0.21 | 0.00 | 9.66 | 0.58 | 0.44 | 0.28 | 0.00 | 0.36 |
| 71 | 2.05 | 0.00 | 0.04 | 0.00 | 1.28 | 3.04 | 0.12 | 0.00 | 0.00 | 0.17 | 0.64 | 0.22 | 0.31 | 0.00 | 0.00 |
| 72 | 0.74 | 0.00 | 2.91 | 0.00 | 0.00 | 6.43 | 0.20 | 0.03 | 0.00 | 0.77 | 0.62 | 0.43 | 0.21 | 0.00 | 0.13 |
| 73 | 0.00 | 0.00 | 1.14 | 0.00 | 18.79 | 4.65 | 0.15 | 3.06 | 0.00 | 21.43 | 0.00 | 0.49 | 1.63 | 0.00 | 0.32 |
| 74 | 0.00 | 0.00 | 0.23 | 0.00 | 12.94 | 7.60 | 0.22 | 0.07 | 0.00 | 9.38 | 2.01 | 0.89 | 2.12 | 0.00 | 1.00 |
| 75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.64 | 5.47 | 1.35 | 0.00 | 0.00 | 1.48 | 0.00 | 0.36 | 0.38 | 0.00 | 0.05 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.94 | 1.40 | 0.00 | 0.00 | 3.63 | 0.00 | 0.29 | 0.52 | 0.00 | 0.12 |
| 77 | 0.00 | 0.00 | 0.44 | 0.00 | 37.23 | 4.65 | 1.33 | 0.05 | 0.00 | 1.48 | 0.00 | 0.14 | 0.66 | 0.00 | 0.00 |
| 78 | 0.00 | 0.00 | 0.00 | 0.41 | 0.00 | 2.08 | 1.22 | 0.20 | 0.06 | 2.06 | 0.00 | 0.00 | 0.60 | 0.00 | 0.10 |
| 79 | 0.00 | 0.00 | 0.10 | 0.00 | 0.35 | 3.12 | 0.55 | 0.00 | 0.00 | 1.35 | 0.00 | 0.77 | 1.59 | 0.00 | 0.33 |
| 80 | 0.00 | 0.00 | 0.56 | 0.05 | 0.91 | 2.84 | 0.56 | 0.04 | 0.47 | 0.99 | 0.00 | 0.21 | 0.42 | 0.00 | 0.09 |
| 81 | 0.00 | 0.00 | 0.08 | 0.00 | 4.13 | 1.89 | 0.25 | 0.00 | 0.44 | 2.10 | 0.00 | 0.07 | 2.29 | 0.00 | 0.00 |
| 82 | 0.08 | 0.00 | 0.09 | 0.00 | 21.65 | 2.85 | 0.46 | 0.16 | 0.09 | 3.77 | 10.17 | 0.34 | 0.47 | 0.00 | 0.64 |
| 83 | 0.00 | 0.00 | 0.00 | 0.00 | 3.79 | 0.18 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.17 | 0.07 | 0.00 | 0.00 |
| 84 | 0.00 | 0.00 | 4.49 | 0.00 | 7.30 | 0.21 | 0.00 | 0.00 | 0.00 | 1.44 | 0.00 | 0.00 | 0.87 | 0.07 | 0.00 |
| 85 | 18.46 | 0.00 | 4.01 | 0.04 | 0.00 | 1.25 | 0.13 | 0.45 | 20.89 | 9.24 | 0.32 | 0.06 | 0.28 | 0.00 | 0.00 |
| 86 | 6.11 | 0.00 | 5.88 | 0.00 | 0.12 | 0.25 | 0.22 | 0.09 | 0.71 | 3.35 | 0.14 | 0.18 | 0.23 | 0.00 | 0.05 |
| 87 | 9.20 | 0.00 | 0.08 | 0.00 | 0.00 | 0.59 | 0.00 | 0.11 | 0.00 | 2.00 | 0.28 | 0.09 | 0.22 | 0.00 | 0.44 |
| 88 | 3.59 | 0.08 | 6.97 | 0.00 | 0.31 | 0.35 | 0.07 | 0.19 | 0.00 | 3.81 | 1.11 | 0.24 | 0.52 | 0.00 | 0.14 |
| 89 | 14.20 | 0.00 | 3.49 | 0.16 | 0.15 | 0.48 | 0.07 | 0.04 | 0.93 | 1.14 | 0.08 | 0.40 | 0.36 | 0.00 | 0.07 |
| 90 | 1.24 | 0.00 | 0.19 | 0.00 | 1.39 | 0.59 | 0.08 | 0.10 | 0.23 | 13.66 | 2.56 | 0.57 | 0.16 | 0.00 | 0.12 |
| 91 | 14.84 | 0.00 | 2.76 | 0.00 | 0.00 | 2.10 | 0.16 | 1.73 | 1.71 | 14.26 | 6.35 | 0.64 | 0.33 | 0.00 | 0.32 |
| 92 | 10.92 | 0.00 | 11.97 | 0.00 | 2.45 | 0.32 | 0.08 | 0.72 | 0.00 | 6.38 | 0.00 | 0.36 | 0.21 | 0.00 | 0.09 |
| 93 | 13.42 | 0.00 | 9.72 | 0.00 | 32.60 | 0.11 | 0.03 | 1.37 | 0.00 | 5.84 | 1.43 | 0.17 | 0.52 | 0.00 | 0.19 |
| 94 | 38.50 | 0.00 | 9.26 | 0.00 | 14.19 | 0.13 | 0.33 | 0.55 | 0.55 | 6.77 | 0.00 | 0.09 | 0.32 | 0.00 | 0.00 |
| 95 | 224.43 | 0.00 | 5.40 | 0.00 | 33.87 | 0.05 | 0.00 | 0.05 | 0.00 | 4.85 | 0.91 | 0.39 | 1.91 | 0.00 | 0.73 |
| 96 | 43.02 | 0.00 | 2.48 | 0.00 | 0.04 | 0.09 | 0.00 | 0.19 | 0.65 | 1.34 | 0.00 | 0.18 | 0.10 | 0.00 | 0.10 |
| 97 | 11.38 | 0.00 | 1.05 | 0.00 | 0.49 | 0.29 | 0.11 | 0.08 | 0.50 | 9.27 | 5.10 | 0.22 | 1.22 | 0.00 | 0.32 |

Table. 8. Mean number per tow of 29 fish species collected during the July RV from 1970-1997 from the eastern reference area.

Mean of stratum 54.55.56.62
trawlable units (482349).

| Year | cod | haddock | white hake | red hake | silver hake | cusk | pollock | redfish | halibut | plaice | witch | yellowtail | winter fl | wolffish |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 4.67 | 17.51 | 2.24 | 0.89 | 77.15 | 0.12 | 0.07 | 158.97 | 0.22 | 38.64 | 0.89 | 82.67 | 3.13 | 0.04 |
| 71 | 5.36 | 24.06 | 1.22 | 0.31 | 4.57 | 0.00 | 0.29 | 188.06 | 0.00 | 20.74 | 0.73 | 64.67 | 3.94 | 0.09 |
| 72 | 9.87 | 4.44 | 1.73 | 0.09 | 9.37 | 0.09 | 0.03 | 58.46 | 0.14 | 28.90 | 1.79 | 47.41 | 9.61 | 0.18 |
| 73 | 13.11 | 1.71 | 1.48 | 0.00 | 17.47 | 1.40 | 0.03 | 8.20 | 0.21 | 10.81 | 1.92 | 50.16 | 4.30 | 0.11 |
| 74 | 42.94 | 2.06 | 6.57 | 0.84 | 108.71 | 0.09 | 1.90 | 6.04 | 0.49 | 26.75 | 2.31 | 39.68 | 2.65 | 0.09 |
| 75 | 14.89 | 23.19 | 3.20 | 0.00 | 15.12 | 0.19 | 1.02 | 10.57 | 0.22 | 22.69 | 3.06 | 87.48 | 3.42 | 0.28 |
| 76 | 20.89 | 12.66 | 1.65 | 0.00 | 13.21 | 0.39 | 0.19 | 34.45 | 0.34 | 13.45 | 2.92 | 66.30 | 0.82 | 0.39 |
| 77 | 20.04 | 45.34 | 1.06 | 0.00 | 6.82 | 0.00 | 0.06 | 0.77 | 0.11 | 12.90 | 2.87 | 44.19 | 2.06 | 0.19 |
| 78 | 16.24 | 58.60 | 4.81 | 0.00 | 16.43 | 0.00 | 1.45 | 108.82 | 0.20 | 46.51 | 3.01 | 42.72 | 0.60 | 0.13 |
| 79 | 46.85 | 104.68 | 0.49 | 3.41 | 22.14 | 0.09 | 0.45 | 0.40 | 0.38 | 50.85 | 1.41 | 55.57 | 0.54 | 0.00 |
| 80 | 14.67 | 72.21 | 1.17 | 3.95 | 36.56 | 0.00 | 20.52 | 1.13 | 0.19 | 10.71 | 2.69 | 31.11 | 1.59 | 0.16 |
| 81 | 33.14 | 178.79 | 2.08 | 4.31 | 138.65 | 0.00 | 2.66 | 2.33 | 0.49 | 17.02 | 1.68 | 70.85 | 0.88 | 0.06 |
| 82 | 465.36 | 108.49 | 2.23 | 8.45 | 224.57 | 0.10 | 0.63 | 1.35 | 0.38 | 17.75 | 2.93 | 98.26 | 2.30 | 0.31 |
| 83 | 280.13 | 248.16 | 4.94 | 5.30 | 202.79 | 0.00 | 0.13 | 1.49 | 0.09 | 23.73 | 1.04 | 43.67 | 0.59 | 0.03 |
| 84 | 5.52 | 216.66 | 2.95 | 5.39 | 359.12 | 0.00 | 0.98 | 21.43 | 0.08 | 10.64 | 2.16 | 84.35 | 6.83 | 0.00 |
| 85 | 6.53 | 124.42 | 5.77 | 6.89 | 443.31 | 0.00 | 22.77 | 15.52 | 0.05 | 18.66 | 4.04 | 53.16 | 6.99 | 0.12 |
| 86 | 8.52 | 124.17 | 7.69 | 14.37 | 327.52 | 0.00 | 5.57 | 93.15 | 0.28 | 9.61 | 2.63 | 74.12 | 4.81 | 0.00 |
| 87 | 19.41 | 79.51 | 4.15 | 5.07 | 177.02 | 0.00 | 1.64 | 7.61 | 0.37 | 16.88 | 3.22 | 115.96 | 5.56 | 0.00 |
| 88 | 11.34 | 205.82 | 6.32 | 4.61 | 289.43 | 0.00 | 3.34 | 82.40 | 0.26 | 11.04 | 0.64 | 53.70 | 3.76 | 0.00 |
| 89 | 71.00 | 97.07 | 2.99 | 3.73 | 78.95 | 0.00 | 1.16 | 38.39 | 0.50 | 13.70 | 2.31 | 81.00 | 6.43 | 0.00 |
| 90 | 78.22 | 122.57 | 7.78 | 0.95 | 183.68 | 0.00 | 5.57 | 91.16 | 0.10 | 36.48 | 0.72 | 133.95 | 12.68 | 0.03 |
| 91 | 28.01 | 263.45 | 2.55 | 3.74 | 104.26 | 0.16 | 7.08 | 9.46 | 0.42 | 16.06 | 1.32 | 161.51 | 18.41 | 0.08 |
| 92 | 88.49 | 98.86 | 2.73 | 3.15 | 58.73 | 0.00 | 2.85 | 0.80 | 0.11 | 17.79 | 0.91 | 113.07 | 8.28 | 0.00 |
| 93 | 51.21 | 100.56 | 3.82 | 4.36 | 295.39 | 0.00 | 8.25 | 2.25 | 0.24 | 12.77 | 1.07 | 66.02 | 20.06 | 0.00 |
| 94 | 20.23 | 86.06 | 0.63 | 7.13 | 98.33 | 0.00 | 1.66 | 0.22 | 0.10 | 6.83 | 0.77 | 60.26 | 9.39 | 0.00 |
| 95 | 24.62 | 36.14 | 1.40 | 4.56 | 136.39 | 0.09 | 1.60 | 3.19 | 0.11 | 14.87 | 0.65 | 33.14 | 4.24 | 0.00 |
| 96 | 14.18 | 158.21 | 1.51 | 6.81 | 405.70 | 0.00 | 0.96 | 3.57 | 0.04 | 15.84 | 1.57 | 59.53 | 6.98 | 0.32 |
| 97 | 5.39 | 93.99 | 0.77 | 2.66 | 110.35 | 0.00 | 4.73 | 4.96 | 0.00 | 6.63 | 2.95 | 65.30 | 7.29 | 0.00 |

| Year | herring | alewife | mackerel | longfin hake | argentine | thorny skate | smooth skate | winter skate | dogfish | lghm sculpin | mailed sculp | sea raven | monkfish | marlin spike | ocean pout |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 5.33 | 0.00 | 17.52 | 0.00 | 0.00 | 1.78 | 0.59 | 0.77 | 0.00 | 23.11 | 0.44 | 0.75 | 0.86 | 0.00 | 0.90 |
| 71 | 7.50 | 0.00 | 2.82 | 0.00 | 0.04 | 2.23 | 0.26 | 0.90 | 0.00 | 17.64 | 0.05 | 0.77 | 0.30 | 0.00 | 0.26 |
| 72 | 4.73 | 0.00 | 0.13 | 0.00 | 0.00 | 2.77 | 0.19 | 0.32 | 0.00 | 6.96 | 0.02 | 1.25 | 0.47 | 0.00 | 0.72 |
| 73 | 0.11 | 0.00 | 0.15 | 0.00 | 0.00 | 2.90 | 0.40 | 1.71 | 0.00 | 22.15 | 0.00 | 1.24 | 0.36 | 0.00 | 0.50 |
| 74 | 0.00 | 0.00 | 0.54 | 0.88 | 1.92 | 2.70 | 0.70 | 1.06 | 0.11 | 7.69 | 0.63 | 0.97 | 1.32 | 0.07 | 0.30 |
| 75 | 2.37 | 0.00 | 0.52 | 0.05 | 0.10 | 4.02 | 0.62 | 2.59 | 0.00 | 19.30 | 0.35 | 1.54 | 0.89 | 0.00 | 1.44 |
| 76 | 0.08 | 0.00 | 0.59 | 0.00 | 0.46 | 7.43 | 0.56 | 0.16 | 0.00 | 8.78 | 0.00 | 0.47 | 0.55 | 0.00 | 0.48 |
| 77 | 0.00 | 0.00 | 0.19 | 0.00 | 0.16 | 5.16 | 0.79 | 0.94 | 0.00 | 9.05 | 0.00 | 1.22 | 0.57 | 0.00 | 0.51 |
| 78 | 0.00 | 0.00 | 1.47 | 0.81 | 0.21 | 12.59 | 1.54 | 1.33 | 0.08 | 6.62 | 0.00 | 0.91 | 0.30 | 0.00 | 1.69 |
| 79 | 0.00 | 0.00 | 2.94 | 0.00 | 14.34 | 8.87 | 2.45 | 7.67 | 0.00 | 9.26 | 0.00 | 0.25 | 0.06 | 0.00 | 0.15 |
| 80 | 0.00 | 0.00 | 0.34 | 0.00 | 0.98 | 3.49 | 0.90 | 0.73 | 0.06 | 2.30 | 0.11 | 0.59 | 1.08 | 0.00 | 0.39 |
| 81 | 0.03 | 0.00 | 0.09 | 0.00 | 0.70 | 4.11 | 0.33 | 1.98 | 0.00 | 6.38 | 0.14 | 0.48 | 1.16 | 0.00 | 0.54 |
| 82 | 1.15 | 0.00 | 0.10 | 0.00 | 30.75 | 2.98 | 0.57 | 0.77 | 1.28 | 5.58 | 1.09 | 0.49 | 1.02 | 0.00 | 0.12 |
| 83 | 1.98 | 0.00 | 0.05 | 0.00 | 13.26 | 3.54 | 0.15 | 1.33 | 0.10 | 2.29 | 0.08 | 0.30 | 0.62 | 0.00 | 0.30 |
| 84 | 2.01 | 0.00 | 17.94 | 0.29 | 7.46 | 1.63 | 0.20 | 2.22 | 0.49 | 10.79 | 0.00 | 0.86 | 1.40 | 0.00 | 0.23 |
| 85 | 6.06 | 0.00 | 22.35 | 0.00 | 1.02 | 1.54 | 0.25 | 1.92 | 37.91 | 3.23 | 0.00 | 0.79 | 0.81 | 0.00 | 0.41 |
| 86 | 0.77 | 0.89 | 10.76 | 0.00 | 13.55 | 1.20 | 0.11 | 1.87 | 0.32 | 9.93 | 0.03 | 0.79 | 0.92 | 0.00 | 0.77 |
| 87 | 33.84 | 0.00 | 7.57 | 0.00 | 0.08 | 3.21 | 0.46 | 1.30 | 0.00 | 8.26 | 0.05 | 0.33 | 0.53 | 0.00 | 0.90 |
| 88 | 1.26 | 0.00 | 30.47 | 0.00 | 0.00 | 0.43 | 0.13 | 0.99 | 0.00 | 8.77 | 0.03 | 0.33 | 1.12 | 0.00 | 0.66 |
| 89 | 12.54 | 0.00 | 3.89 | 0.00 | 0.10 | 0.83 | 0.19 | 0.42 | 0.37 | 16.62 | 0.03 | 0.47 | 0.23 | 0.00 | 0.84 |
| 90 | 3.88 | 0.00 | 3.57 | 0.00 | 0.00 | 0.96 | 0.02 | 2.26 | 0.15 | 21.53 | 0.29 | 0.99 | 0.44 | 0.00 | 1.40 |
| 91 | 36.91 | 0.00 | 3.34 | 0.00 | 0.00 | 0.42 | 0.05 | 3.06 | 0.00 | 23.65 | 0.04 | 0.97 | 0.97 | 0.00 | 0.32 |
| 92 | 21.56 | 0.00 | 6.57 | 0.00 | 0.04 | 0.60 | 0.15 | 1.70 | 0.00 | 23.23 | 0.05 | 0.81 | 0.33 | 0.00 | 0.17 |
| 93 | 4.37 | 0.09 | 0.23 | 0.09 | 0.54 | 0.13 | 0.00 | 2.30 | 0.11 | 6.84 | 0.25 | 0.87 | 0.61 | 0.00 | 0.64 |
| 94 | 217.52 | 0.00 | 3.26 | 0.09 | 6.99 | 0.09 | 0.07 | 4.32 | 0.04 | 9.42 | 0.04 | 0.62 | 0.72 | 0.00 | 0.34 |
| 95 | 24.28 | 0.00 | 11.82 | 0.00 | 0.23 | 0.26 | 0.02 | 0.64 | 0.02 | 15.30 | 0.04 | 0.42 | 0.85 | 0.00 | 0.30 |
| 96 | 6.10 | 0.00 | 11.23 | 0.00 | 0.00 | 0.13 | 0.10 | 0.53 | 0.27 | 5.14 | 4.57 | 0.33 | 0.35 | 0.00 | 1.23 |
| 97 | 64.32 | 0.00 | 10.11 | 0.00 | 0.09 | 0.35 | 0.13 | 1.13 | 0.00 | 7.32 | 0.88 | 0.66 | 0.95 | 0.00 | 0.66 |

Table 9. Mean number per tow of 29 fish species collected during the July RV from 1970-1997 from the western reference area.

Mean of stratum 72 and 73
trawlable units (128298).

| Year | cod | haddock | white hake | red hake | silver hake | cusk | pollock | redfish | halibut | plaice | witch | yellowtail | winter fl | wolffish |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 3.52 | 27.05 | 0.76 | 0.00 | 3.80 | 0.80 | 1.70 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 |
| 71 | 3.25 | 32.93 | 0.44 | 0.00 | 0.00 | 0.09 | 18.77 | 1.74 | 0.00 | 3.06 | 0.00 | 0.00 | 0.00 | 1.93 |
| 72 | 0.51 | 27.48 | 0.94 | 0.00 | 4.08 | 0.31 | 0.67 | 1.44 | 0.00 | 14.75 | 0.25 | 0.00 | 0.00 | 0.57 |
| 73 | 1.02 | 19.45 | 2.84 | 0.52 | 212.69 | 1.42 | 0.80 | 37.51 | 0.00 | 4.38 | 3.30 | 0.00 | 0.00 | 0.00 |
| 74 | 4.19 | 33.24 | 1.23 | 0.00 | 20.71 | 2.50 | 2.12 | 1.67 | 0.46 | 0.72 | 0.00 | 0.00 | 0.00 | 0.26 |
| 75 | 3.14 | 42.58 | 1.27 | 0.00 | 27.18 | 0.42 | 0.00 | 0.00 | 0.08 | 1.01 | 0.00 | 0.00 | 0.00 | 5.05 |
| 76 | 8.82 | 48.94 | 1.03 | 0.00 | 5.16 | 0.88 | 1.75 | 0.00 | 0.72 | 1.03 | 0.00 | 0.00 | 0.00 | 0.80 |
| 77 | 3.29 | 42.23 | 3.90 | 0.00 | 1.43 | 7.79 | 1.53 | 121.17 | 0.28 | 0.92 | 0.00 | 0.00 | 0.00 | 0.70 |
| 78 | 2.61 | 13.30 | 1.90 | 0.00 | 6.39 | 0.79 | 0.38 | 4.84 | 0.09 | 3.81 | 0.00 | 0.00 | 0.00 | 1.86 |
| 79 | 4.19 | 41.08 | 0.27 | 0.28 | 0.27 | 0.57 | 0.28 | 1.40 | 0.36 | 0.36 | 0.00 | 0.00 | 0.00 | 0.47 |
| 80 | 7.30 | 210.84 | 0.00 | 0.00 | 0.00 | 0.00 | 13.61 | 0.16 | 2.78 | 1.17 | 0.00 | 1.15 | 0.00 | 0.79 |
| 81 | 12.93 | 160.28 | 0.00 | 0.40 | 10.43 | 0.00 | 4.81 | 0.63 | 1.92 | 0.10 | 0.00 | 0.00 | 0.00 | 0.61 |
| 82 | 2.78 | 140.27 | 3.70 | 1.27 | 8.70 | 1.20 | 0.40 | 633.62 | 0.09 | 12.83 | 0.00 | 0.00 | 0.00 | 0.92 |
| 83 | 5.91 | 38.78 | 0.00 | 0.00 | 26.71 | 2.69 | 4.51 | 14.58 | 0.38 | 0.90 | 0.00 | 0.00 | 0.00 | 2.88 |
| 84 | 4.72 | 51.08 | 0.91 | 10.59 | 72.18 | 0.42 | 1.44 | 0.00 | 0.85 | 3.37 | 1.92 | 0.00 | 0.00 | 2.55 |
| 85 | 14.60 | 93.65 | 1.20 | 0.00 | 11.63 | 2.41 | 311.28 | 0.34 | 0.00 | 8.42 | 0.40 | 0.00 | 0.00 | 0.09 |
| 86 | 1.63 | 90.76 | 0.42 | 0.42 | 30.57 | 0.00 | 5.47 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| 87 | 1.51 | 37.32 | 0.42 | 6.79 | 97.94 | 0.41 | 3.06 | 0.00 | 0.09 | 4.88 | 0.00 | 0.00 | 0.00 | 0.18 |
| 88 | 2.97 | 30.75 | 2.02 | 5.22 | 81.05 | 0.66 | 7.02 | 4.43 | 0.21 | 9.62 | 0.24 | 0.00 | 0.00 | 0.00 |
| 89 | 0.56 | 41.12 | 0.00 | 4.42 | 34.17 | 0.21 | 14.65 | 0.09 | 0.21 | 10.56 | 0.40 | 0.21 | 0.00 | 0.09 |
| 90 | 7.40 | 21.67 | 0.80 | 1.07 | 4.81 | 0.54 | 0.81 | 2.81 | 0.00 | 1.69 | 0.00 | 0.00 | 0.00 | 0.00 |
| 91 | 1.08 | 31.93 | 1.33 | 0.00 | 6.65 | 0.38 | 1.71 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| 92 | 2.10 | 7.53 | 1.15 | 1.70 | 29.30 | 0.00 | 16.53 | 3.10 | 0.20 | 0.51 | 0.00 | 0.21 | 0.00 | 0.00 |
| 93 | 0.77 | 6.12 | 0.00 | 0.00 | 0.00 | 0.41 | 6.89 | 1.06 | 0.00 | 2.29 | 0.20 | 0.60 | 0.00 | 2.11 |
| 94 | 1.43 | 20.49 | 1.22 | 1.22 | 15.70 | 0.09 | 8.39 | 17.06 | 0.61 | 10.63 | 2.23 | 0.61 | 0.00 | 2.38 |
| 95 | 3.45 | 71.95 | 5.47 | 2.22 | 43.24 | 0.21 | 41.85 | 115.17 | 0.00 | 4.34 | 0.86 | 0.09 | 0.00 | 1.33 |
| 96 | 1.02 | 123.58 | 0.00 | 0.00 | 0.00 | 0.00 | 2.72 | 0.17 | 0.00 | 0.36 | 0.00 | 3.09 | 0.27 | 0.68 |
| 97 | 0.75 | 43.25 | 0.42 | 2.83 | 5.88 | 0.00 | 60.14 | 13.55 | 0.00 | 3.08 | 0.41 | 0.00 | 0.00 | 1.38 |

| Year | herring | alewife | mackerel | longfin hake | argentine | thorny skate | smooth skate | winter skate | dogfish | lghm sculpin | mailed sculp | sea raven | monkfish | marlin spike | ocean pout |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 0.00 | 0.00 | 0.00 | 0.00 | 5.70 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 71 | 0.36 | 0.00 | 0.00 | 0.00 | 12.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.16 | 0.00 | 0.00 | 0.00 |
| 72 | 0.00 | 0.00 | 0.00 | 0.00 | 3.91 | 0.06 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 |
| 73 | 0.45 | 0.00 | 0.00 | 0.00 | 6.19 | 1.52 | 1.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 |
| 74 | 0.00 | 0.00 | 0.00 | 0.00 | 26.37 | 0.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.00 | 1.63 |
| 75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.15 | 0.45 | 0.00 | 0.00 | 0.68 | 0.08 | 0.45 | 1.27 | 0.00 | 0.00 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 1.39 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 |
| 77 | 0.00 | 0.00 | 0.40 | 0.00 | 4.24 | 1.47 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 0.00 | 0.00 |
| 78 | 0.00 | 0.00 | 0.00 | 0.00 | 19.47 | 0.41 | 1.14 | 0.00 | 0.00 | 0.07 | 0.83 | 0.00 | 0.00 | 0.00 | 1.52 |
| 79 | 0.00 | 0.00 | 0.00 | 0.00 | 57.46 | 0.37 | 0.53 | 0.53 | 0.09 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 |
| 81 | 0.00 | 0.00 | 0.00 | 0.00 | 4.01 | 1.79 | 0.00 | 0.00 | 0.48 | 0.58 | 1.02 | 0.20 | 0.00 | 0.00 | 0.00 |
| 82 | 0.00 | 0.00 | 0.00 | 0.00 | 11.89 | 1.63 | 0.42 | 0.00 | 0.42 | 4.10 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 |
| 83 | 0.00 | 0.00 | 0.00 | 0.00 | 290.54 | 2.19 | 0.38 | 0.00 | 46.47 | 2.52 | 16.37 | 1.14 | 0.00 | 0.00 | 3.32 |
| 84 | 0.42 | 0.00 | 0.00 | 0.00 | 27.43 | 0.58 | 0.10 | 0.00 | 26.95 | 2.97 | 2.12 | 0.85 | 0.96 | 0.00 | 0.42 |
| 85 | 0.40 | 0.00 | 0.00 | 0.00 | 23.66 | 1.29 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 |
| 86 | 0.00 | 0.00 | 0.00 | 0.00 | 1.27 | 0.42 | 0.00 | 0.00 | 37.73 | 3.82 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 |
| 87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 1.27 | 0.00 | 0.00 | 16.26 | 0.21 | 0.00 | 0.30 | 0.21 | 0.00 | 0.00 |
| 88 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.68 | 0.00 | 0.00 | 0.51 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.24 |
| 89 | 0.42 | 0.00 | 1.06 | 0.00 | 1.25 | 0.00 | 0.00 | 0.00 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 |
| 90 | 0.00 | 0.00 | 0.13 | 0.00 | 5.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 91 | 0.00 | 0.00 | 1.71 | 0.00 | 8.36 | 0.19 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 |
| 92 | 0.00 | 0.00 | 0.00 | 0.00 | 2.29 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 | 0.41 |
| 93 | 2.49 | 0.00 | 2.89 | 0.00 | 72.24 | 0.00 | 0.00 | 0.09 | 0.09 | 0.20 | 3.28 | 0.09 | 0.00 | 0.00 | 0.00 |
| 94 | 107.91 | 0.00 | 1.87 | 2.64 | 13.45 | 1.91 | 0.20 | 0.00 | 0.00 | 1.69 | 1.20 | 0.49 | 1.42 | 0.00 | 0.41 |
| 95 | 21.82 | 0.00 | 0.00 | 0.00 | 296.36 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 | 0.89 | 0.09 | 0.20 | 0.00 | 0.43 |
| 96 | 12.11 | 0.00 | 0.00 | 0.00 | 0.54 | 0.00 | 0.00 | 0.00 | 0.27 | 0.25 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| 97 | 20.48 | 0.00 | 12.76 | 0.00 | 13.27 | 0.21 | 0.00 | 0.06 | 0.00 | 0.26 | 1.09 | 0.00 | 0.06 | 0.00 | 0.20 |

Figure 1. Geographic display of the Div. 4TVW haddock management unit, including the location of closed area and other place names referred to in the text.

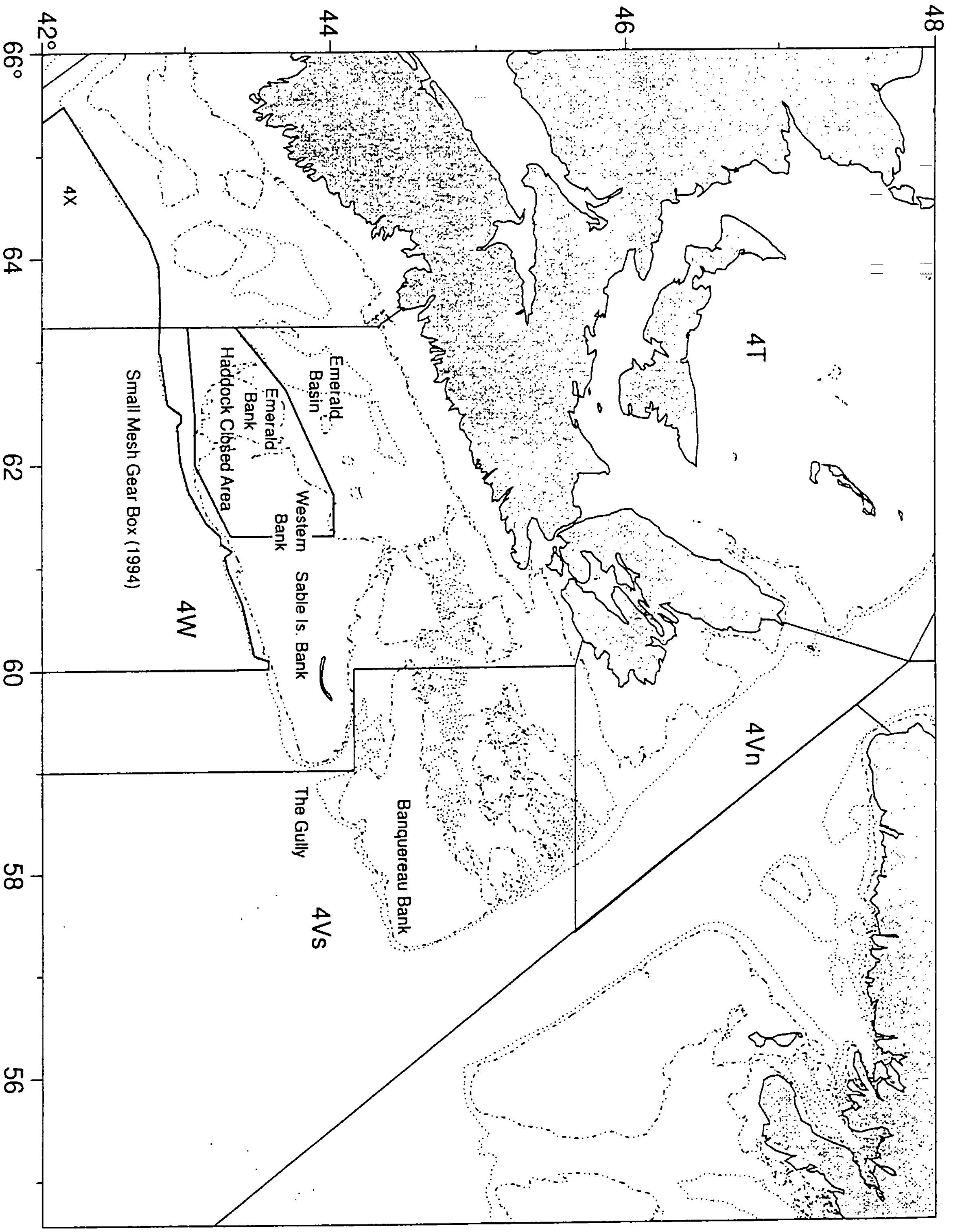


Figure 2. Summer survey strata groupings that comprise the closed area (strata 63, 64 and 65), the eastern reference area (strata 54, 55, 56 and 62) and the western reference area (strata 72 and 73).

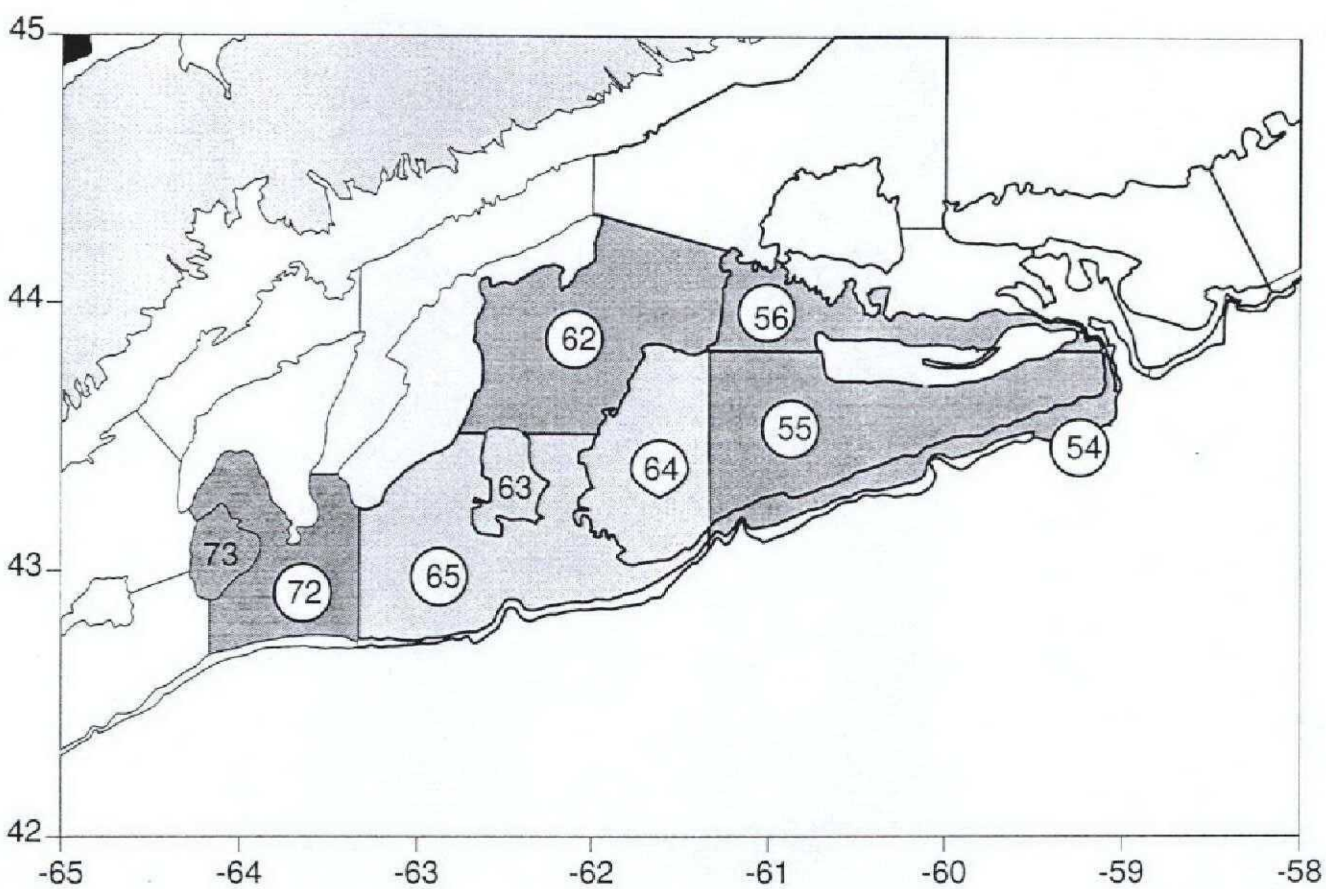


Figure 3. Schematic diagram of the history of the closed area highlighting significant events in the fishery.

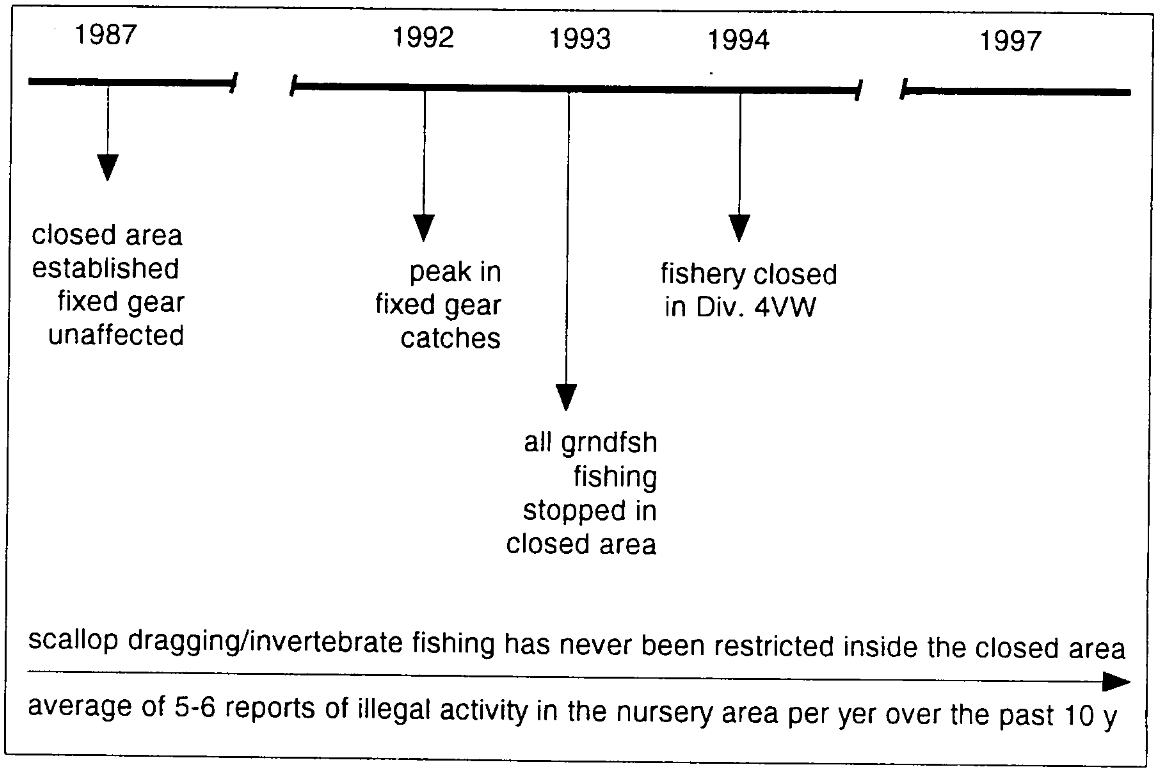
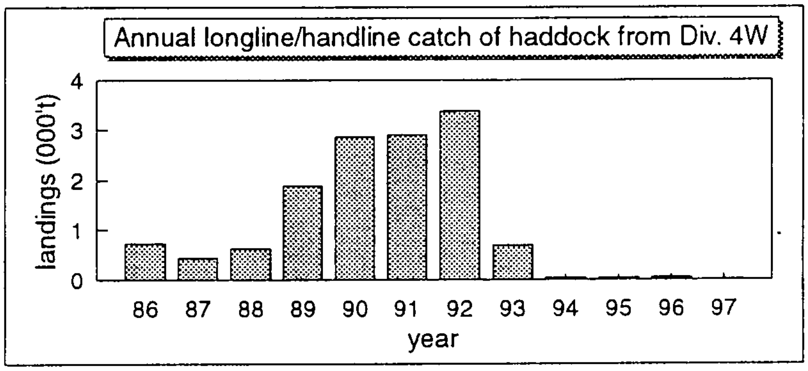


Figure 4. Top panel: Annual longline landings of haddock from Div. 4W. Bottom panel: Scallop landings from Div. 4W and associated by-catch of haddock.



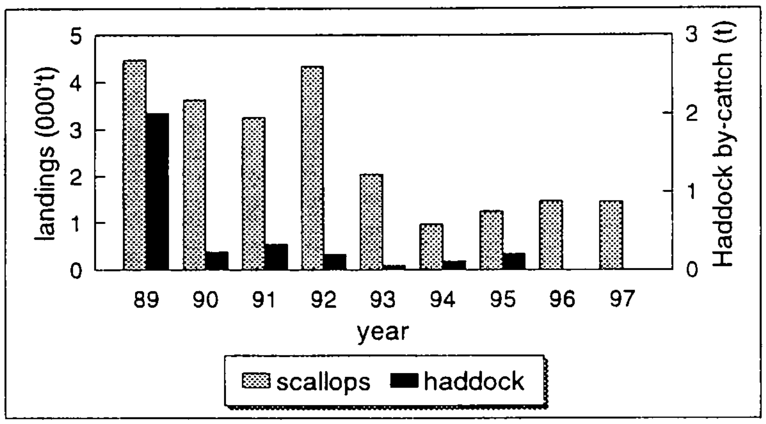



Figure 5. Locations of scallop fishing in the vicinity of the closed area on an annual basis from 1987 to 1995. Outline of the boundary of closed area is shown as a dashed line.

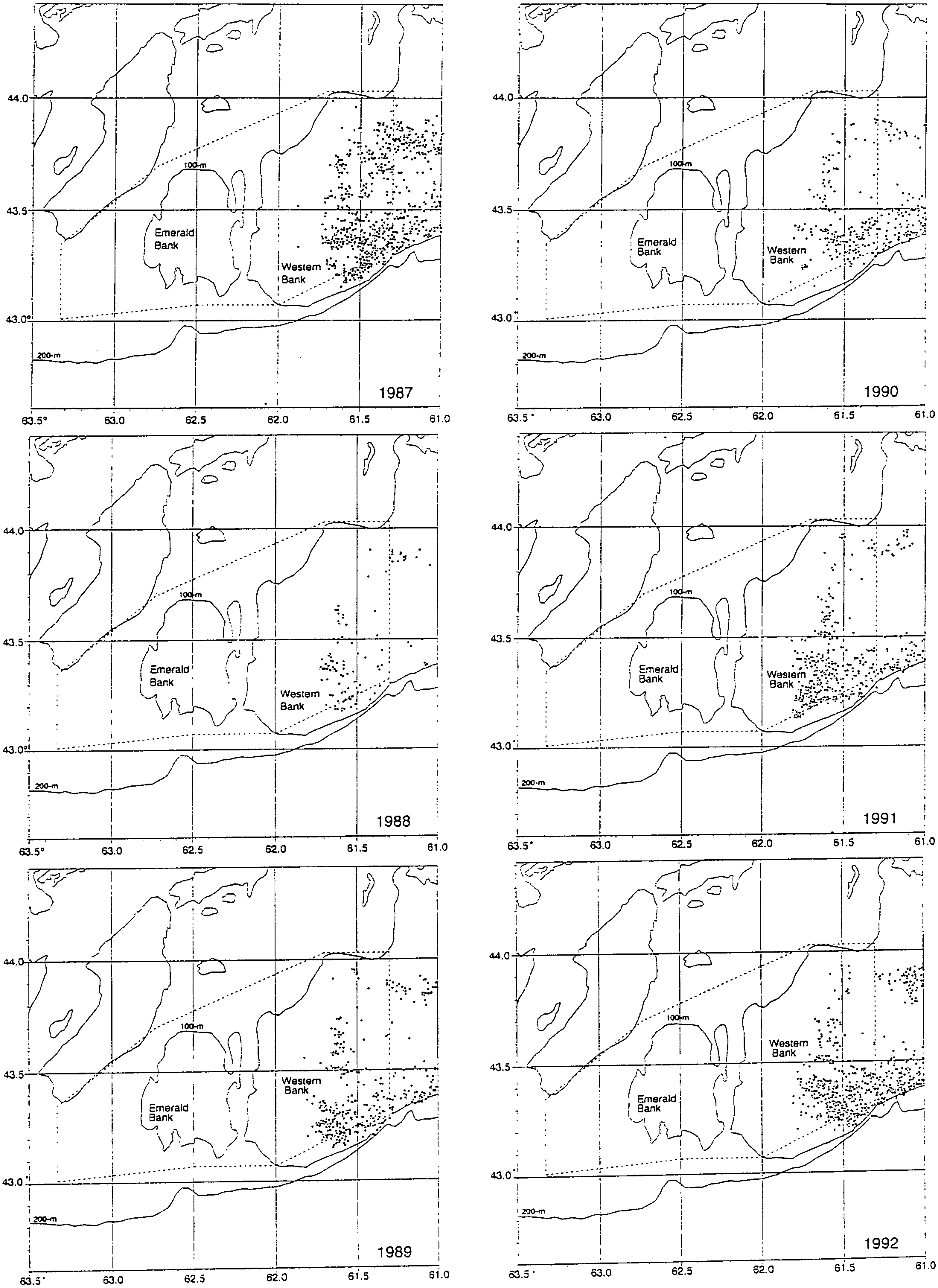


**Figure 5 cont'd**

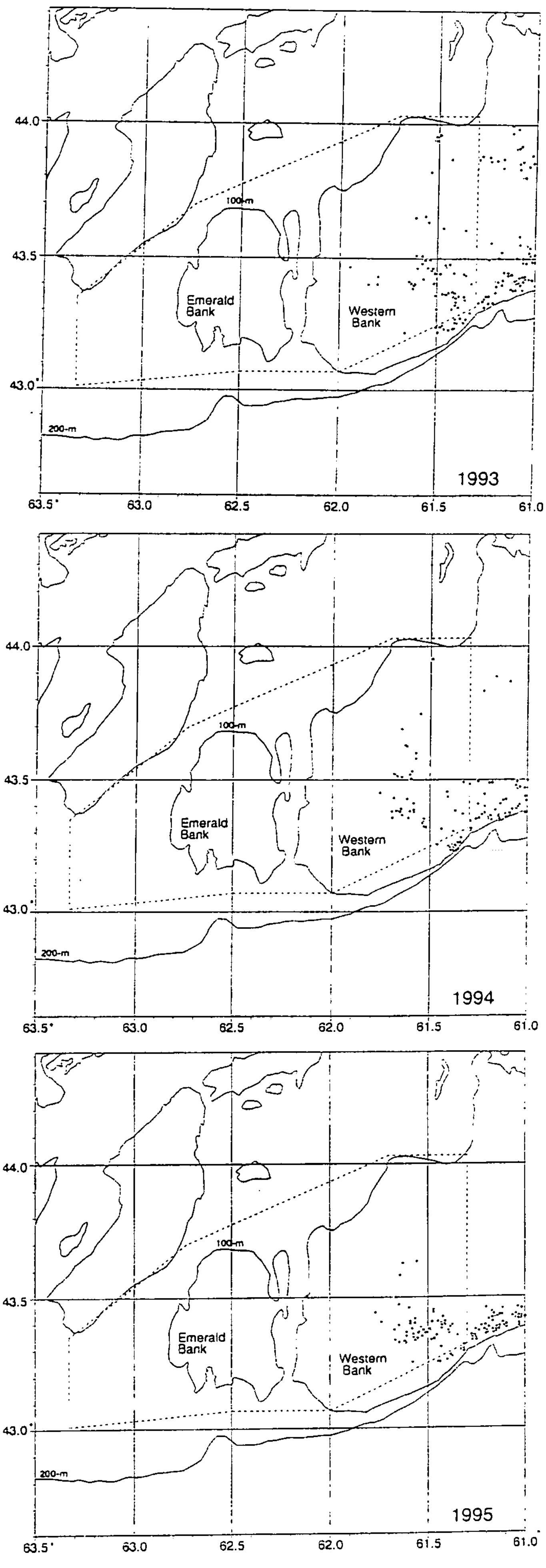
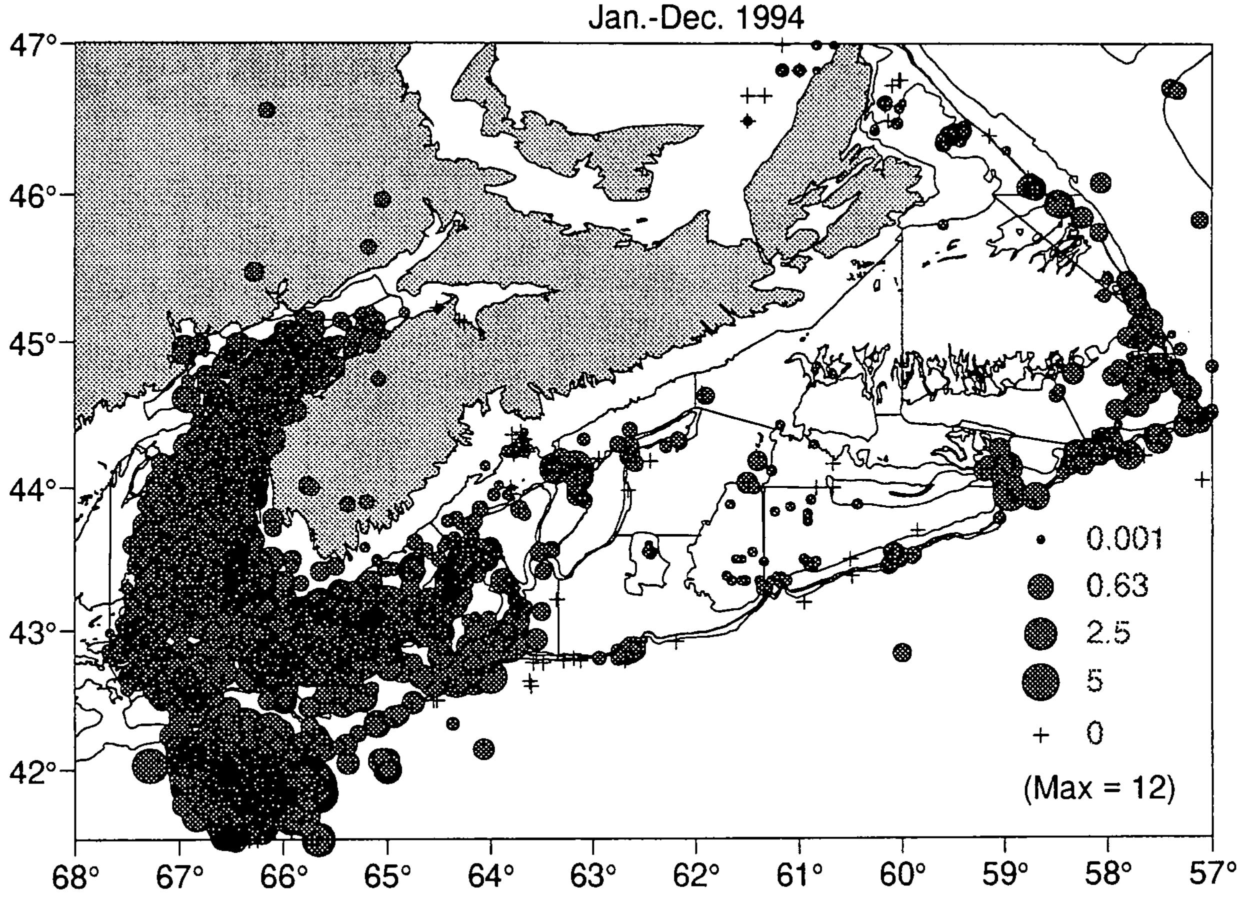


Figure 6. Location of haddock catches by all gear types in Div. 4VWX and 5Z on an annual basis from 1994 to 1997. Data for 1997 does not include the entire year. Expanding symbols are proportional to catch as shown in the key.



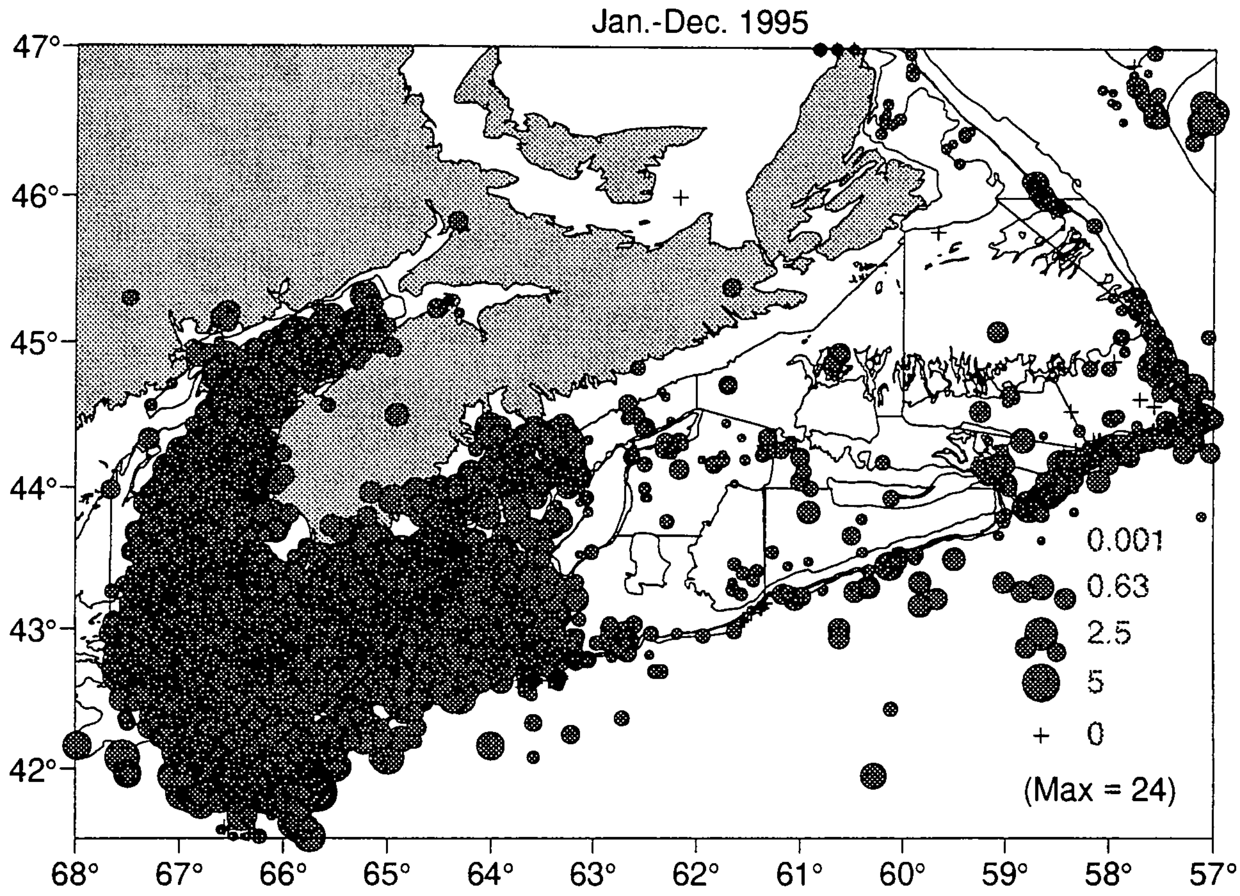
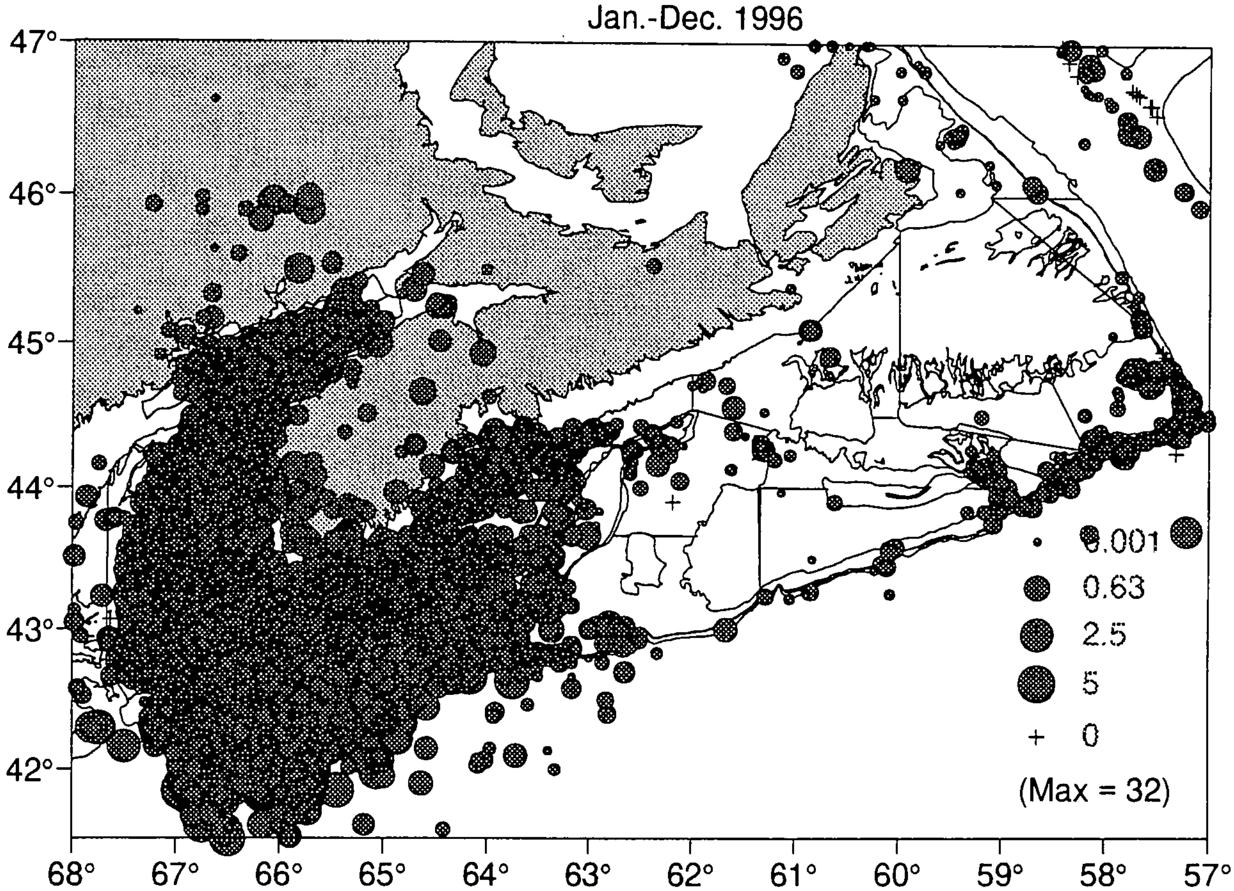
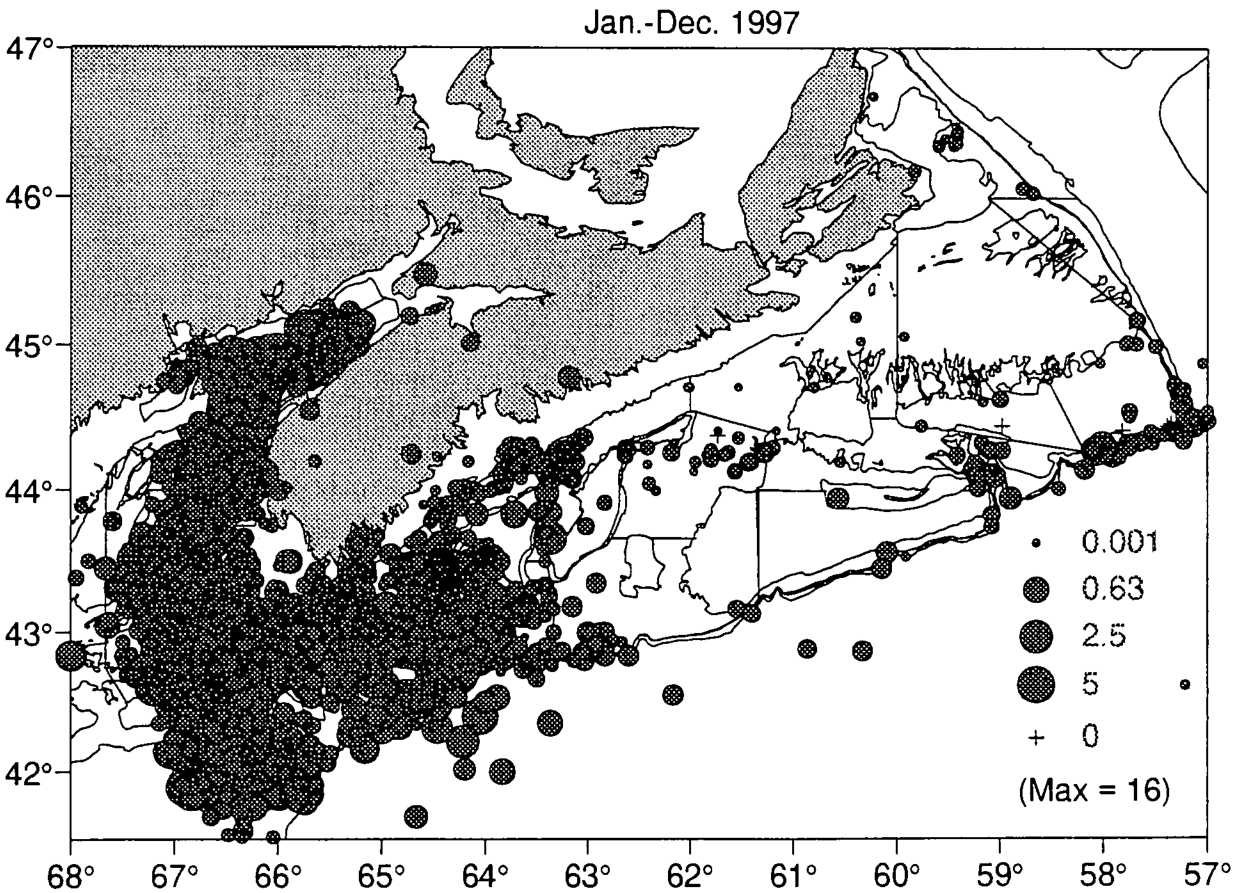



**Figure 6 cont'd**



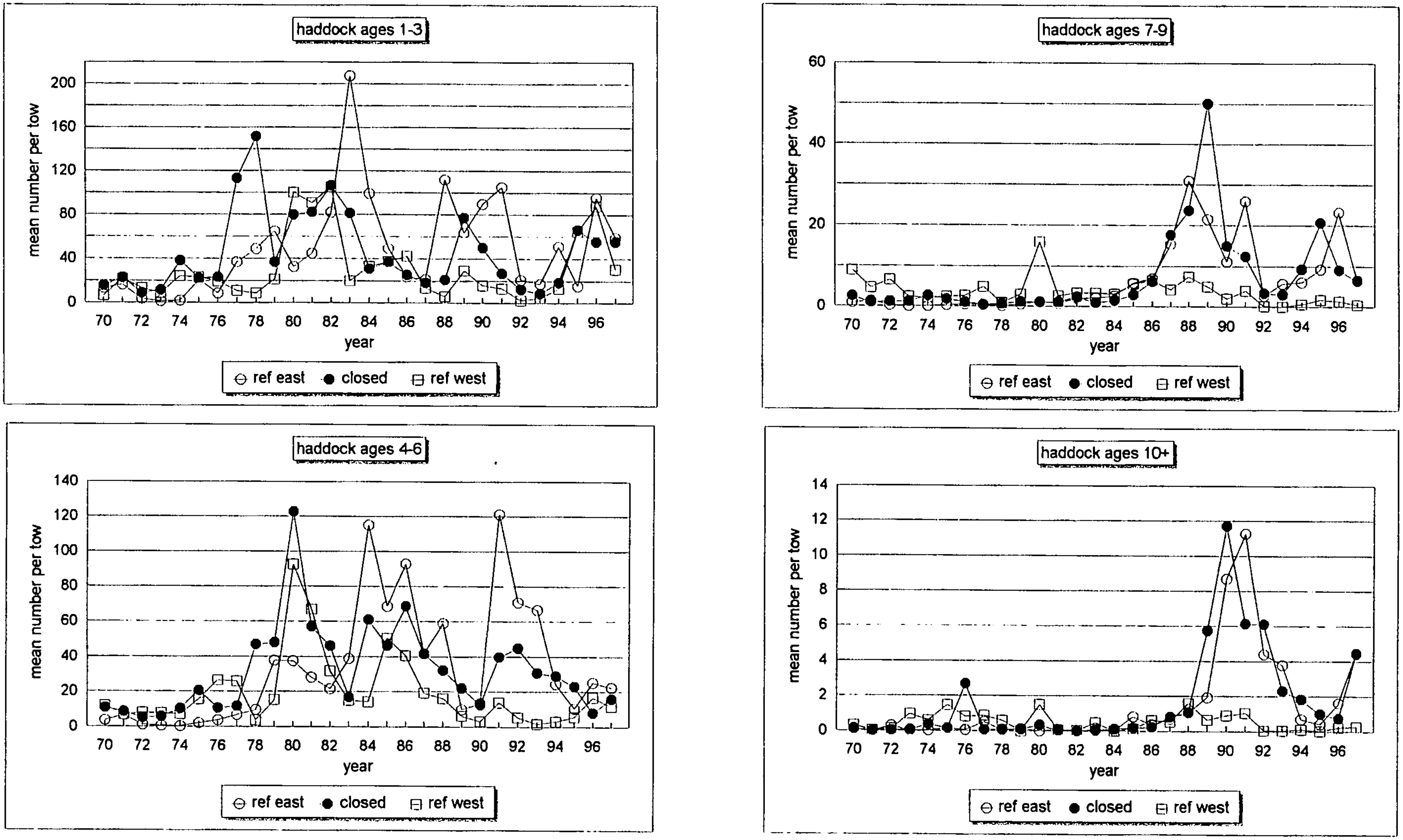



Figure 7. Mean number tow for haddock ages 1-3, 4-6, 7-9 and 10+ from the July RV for the closed area and the two reference areas.

Figure 8. Proportion of the total biomass of haddock from Div 4VW for the closed area and the eastern reference area from 1970 to 1997.

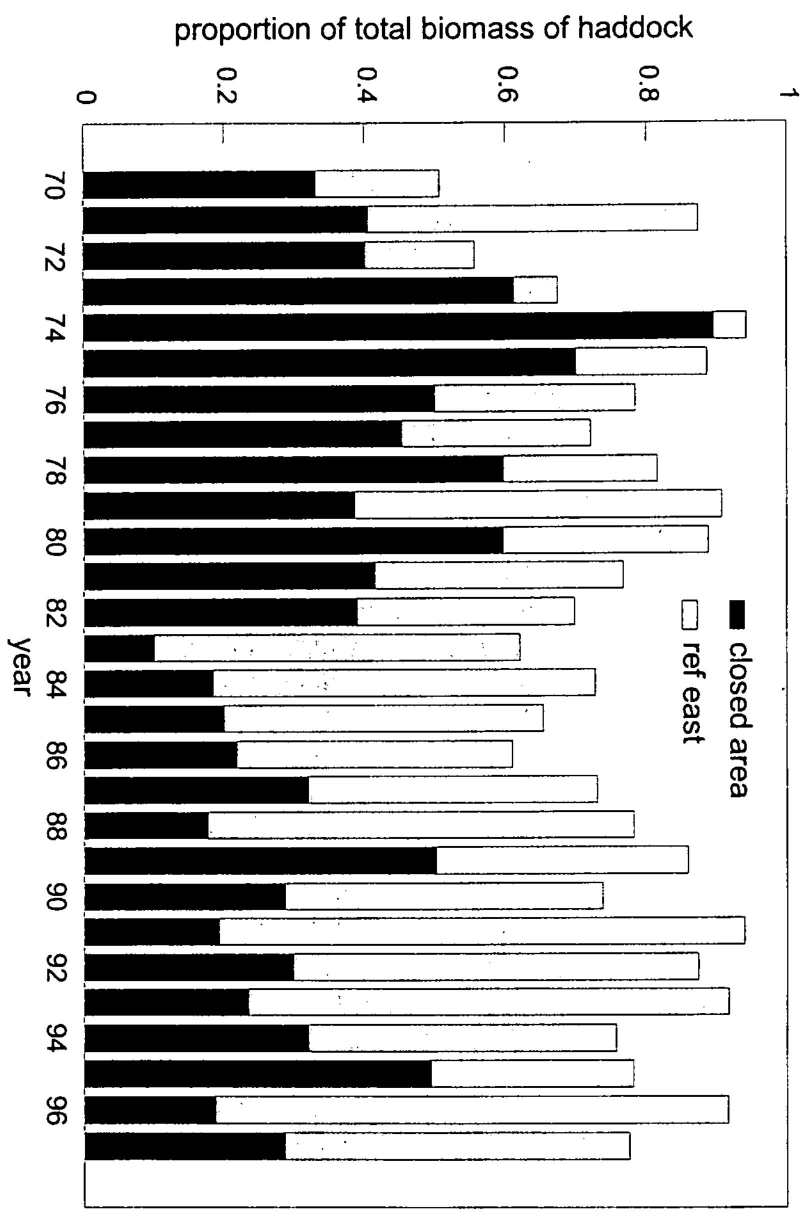


Figure 9. Expanding symbol plots of haddock catch rates (number per tow) for age groups 1 to 10 from the July RV in Div. 4VW. Each panel is a composite of 5 to 6 years of data for the periods 1975-80, 1981-86, 1987-92, and 1993-97. Outline of the boundary of the closed area is shown for all time periods in spite of it not coming into effect until 1987.

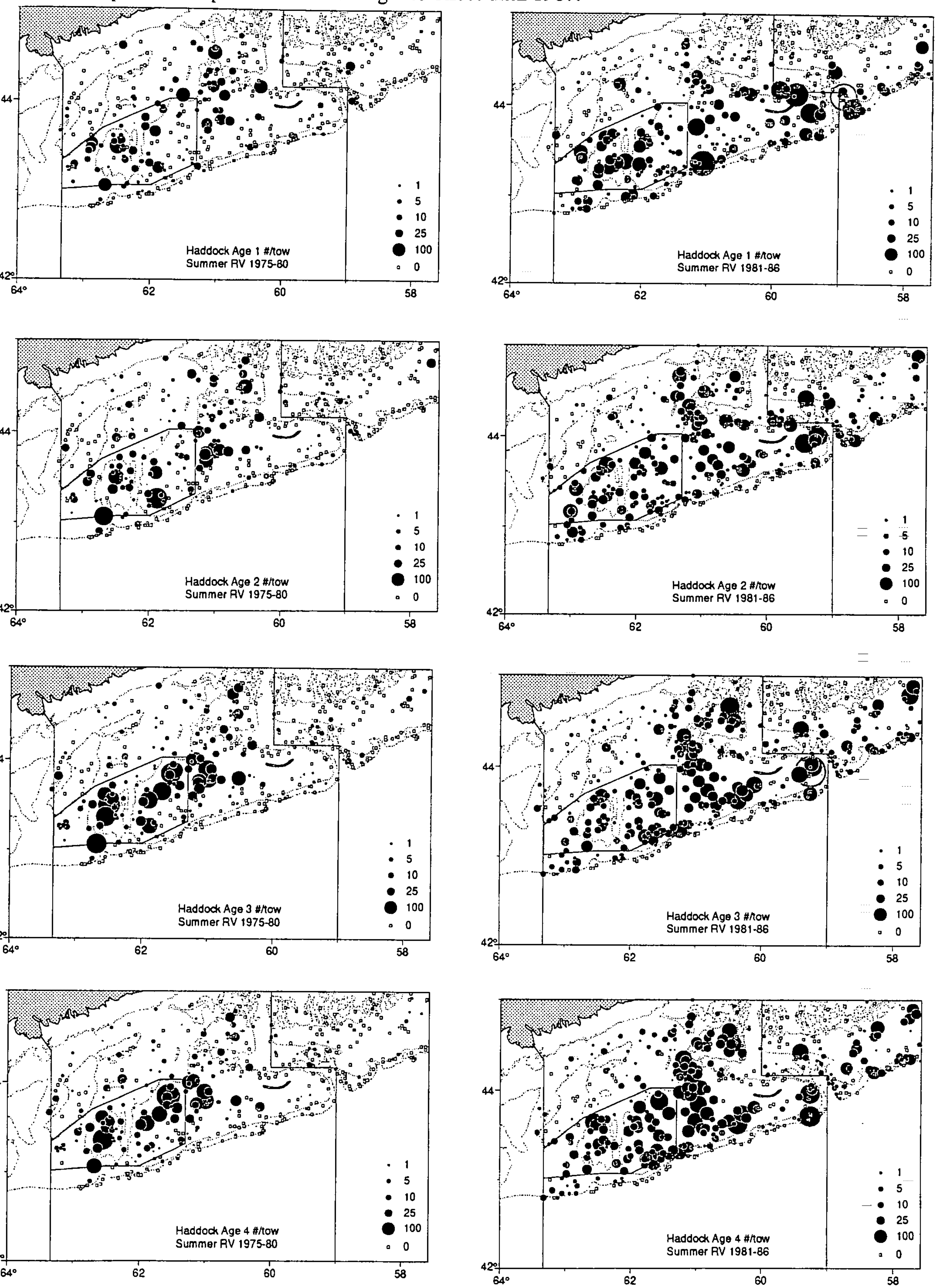


**Figure 9 cont'd**

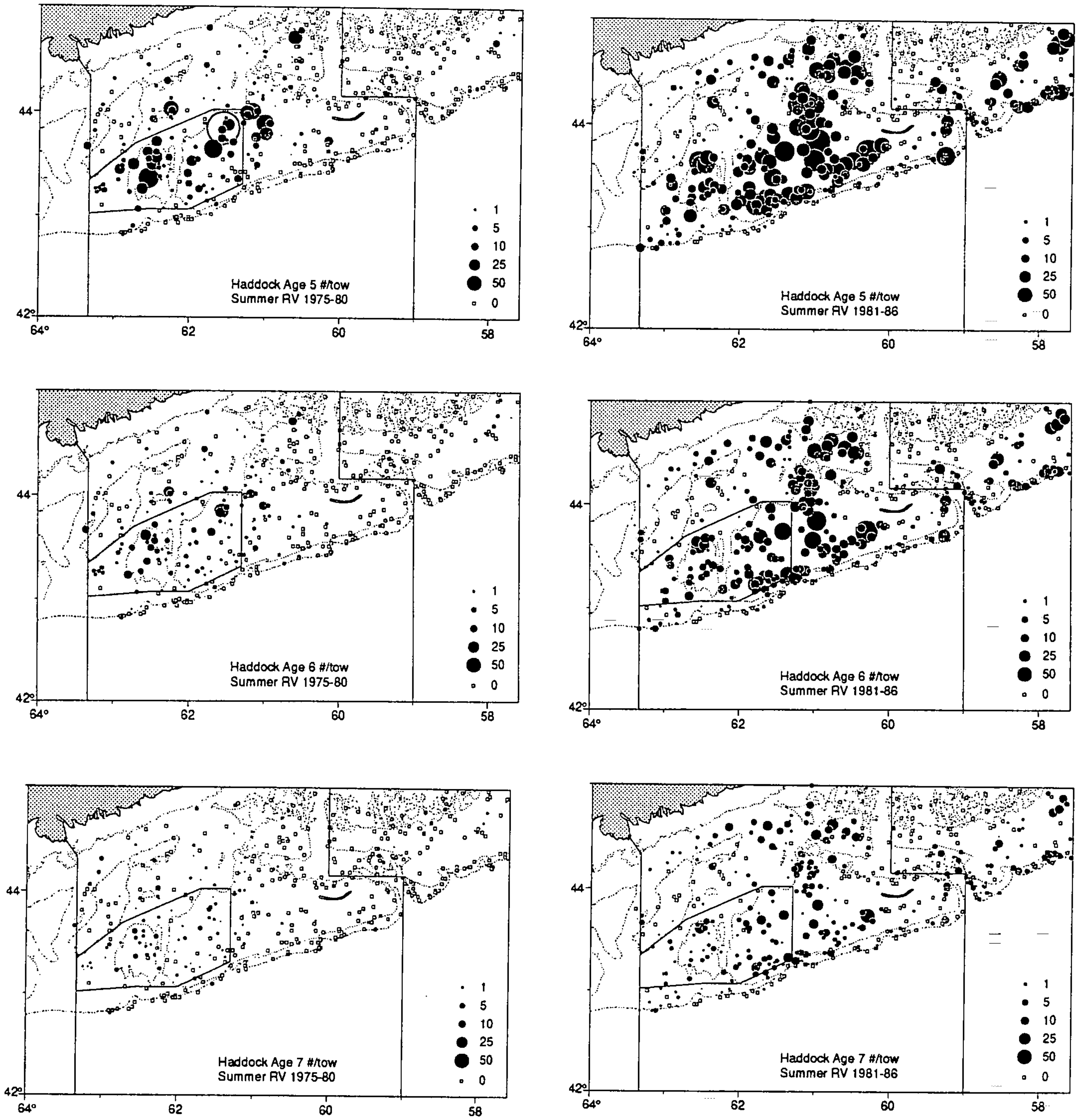


**Figure 9 cont'd**

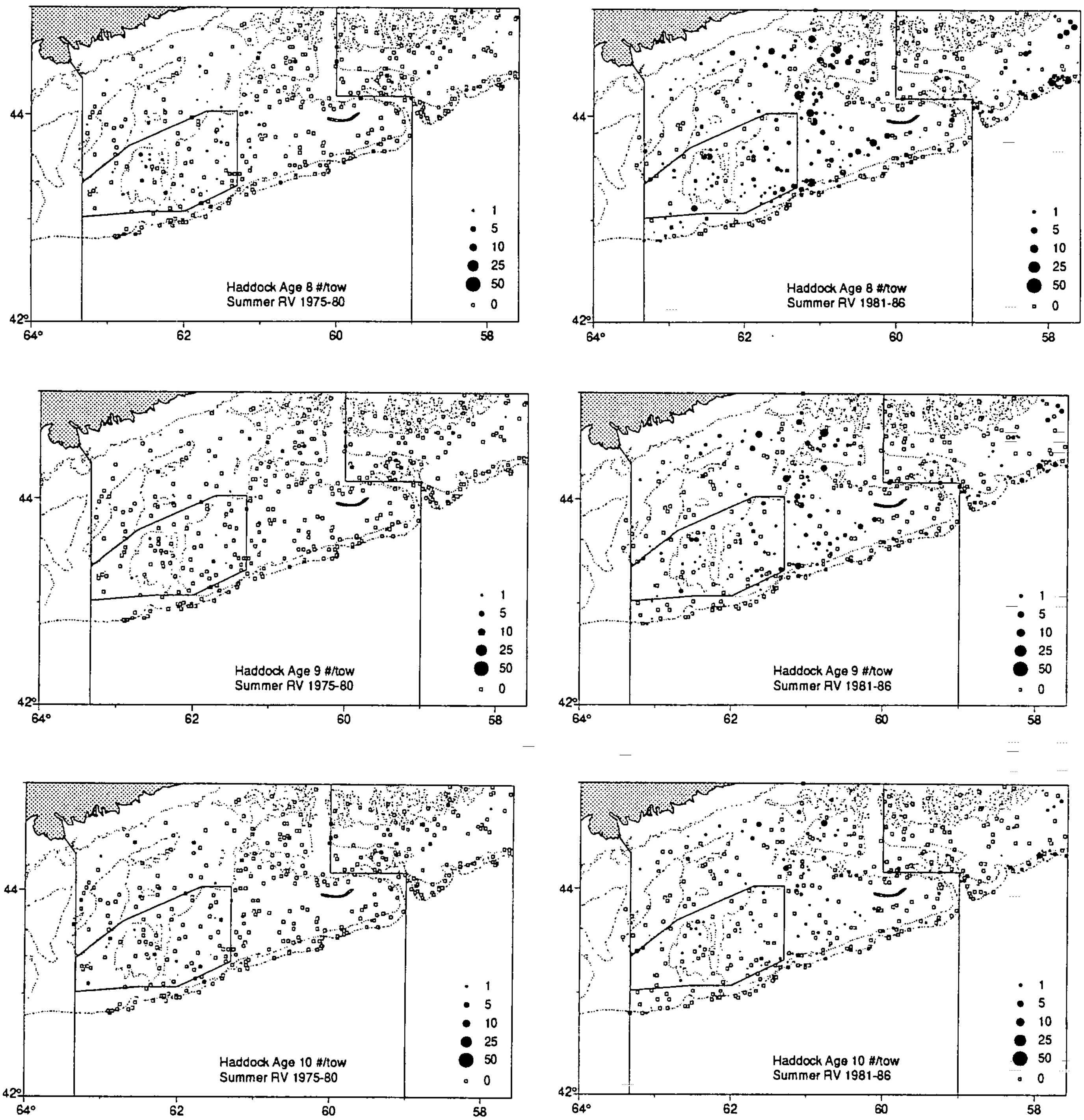


**Figure 9 cont'd**

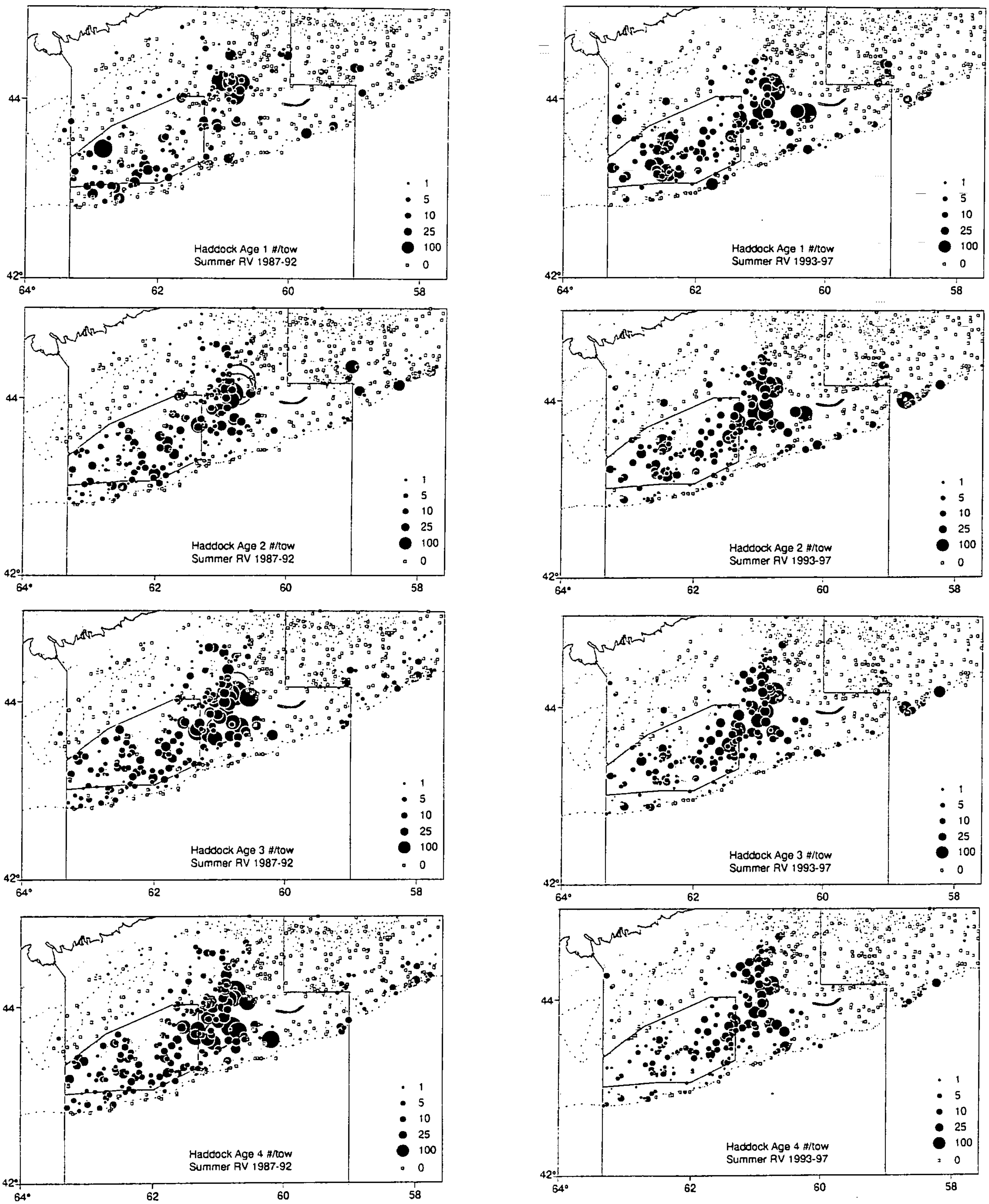


**Figure 9 cont'd**

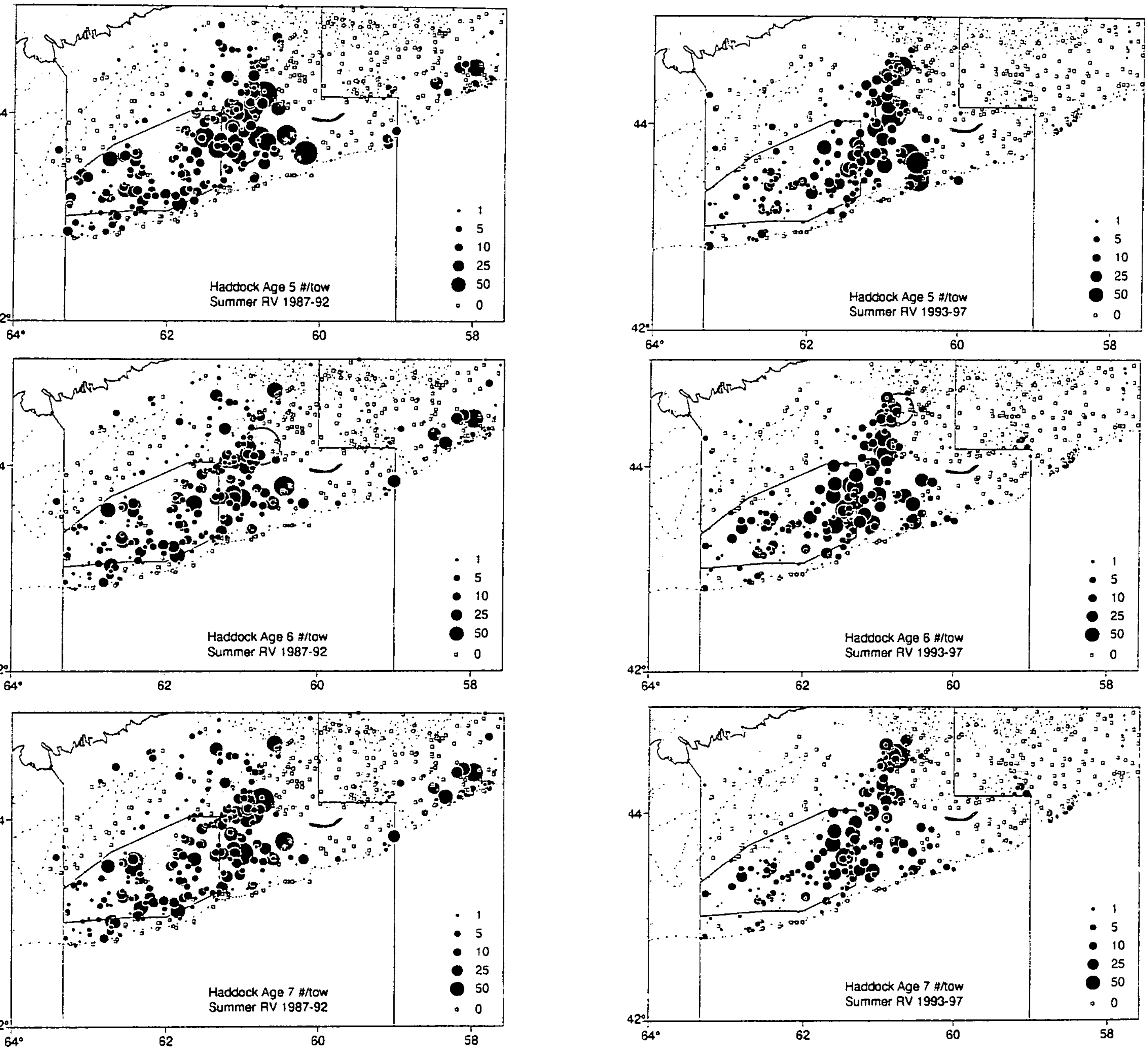


**Figure 9 cont'd**

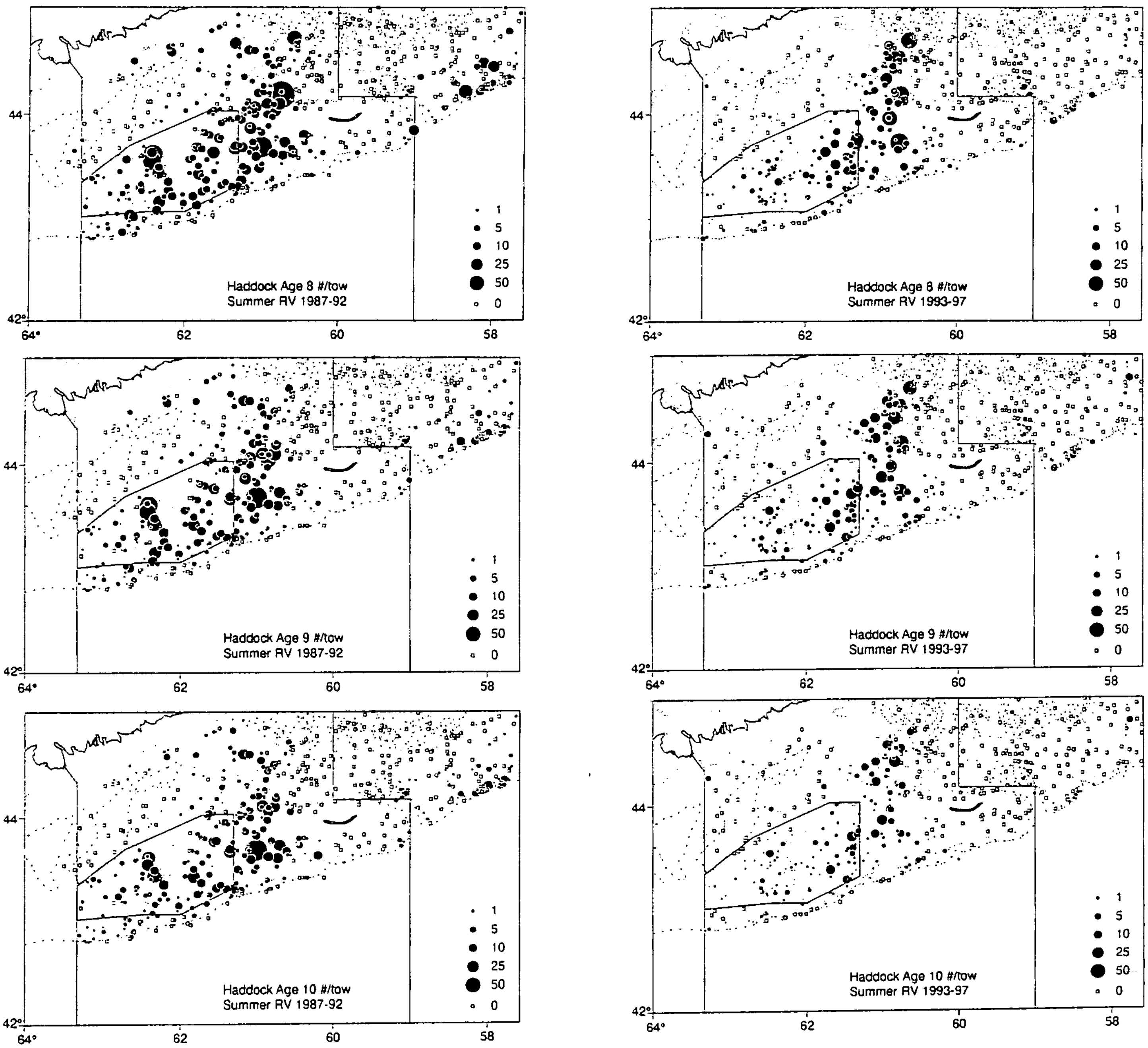


Figure 10. Centroids or centre mass of the horizontal distributions of haddock catch rates at age for ages 1 to 9 for the composite distributions shown in Figure 9.

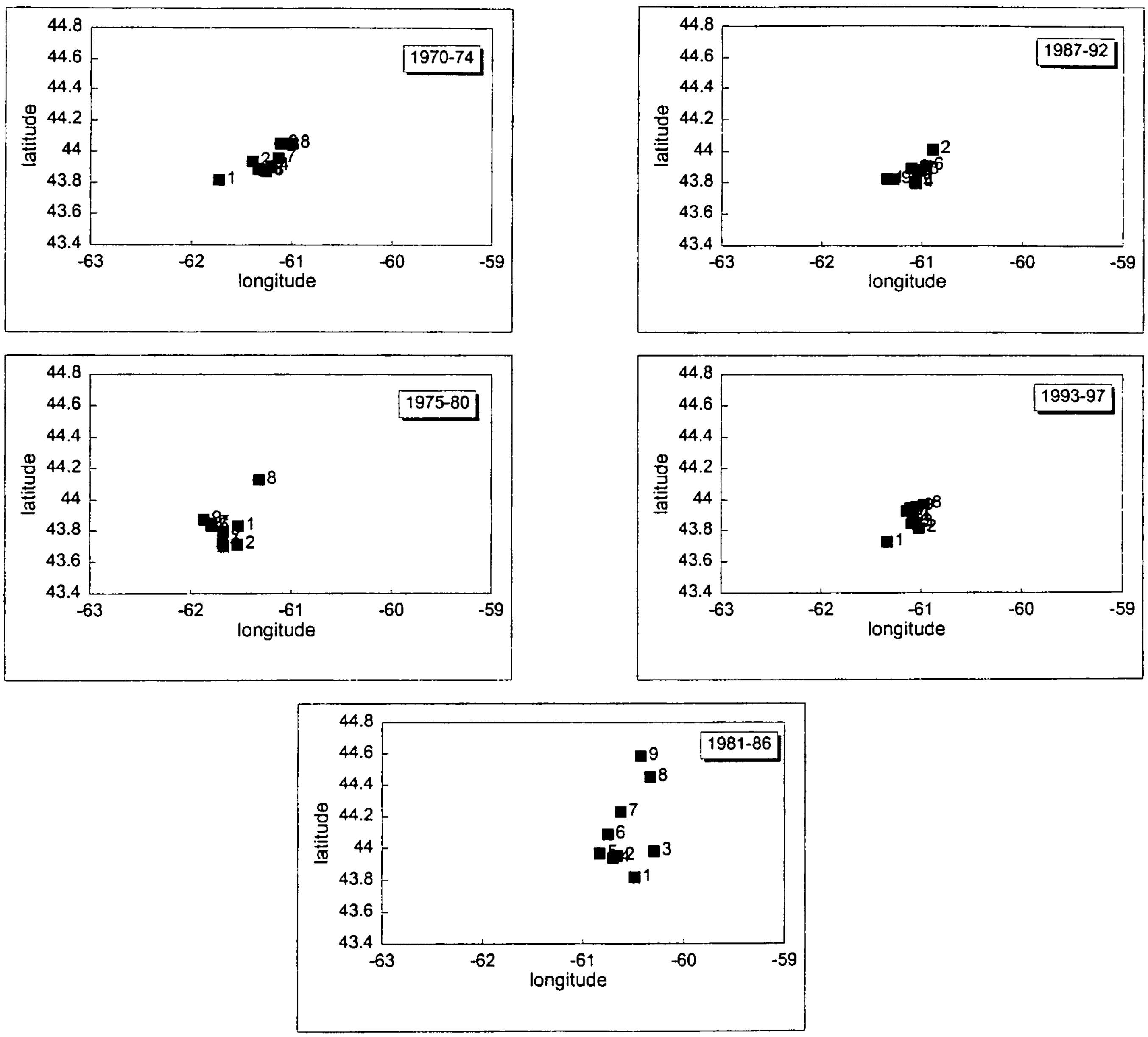


Figure 11. Total mortality rate of haddock from the July RV in the closed area and the two reference areas estimated as the logarithm of the ratio of ages 1-3 in year t to ages 2-4 in year t +1.

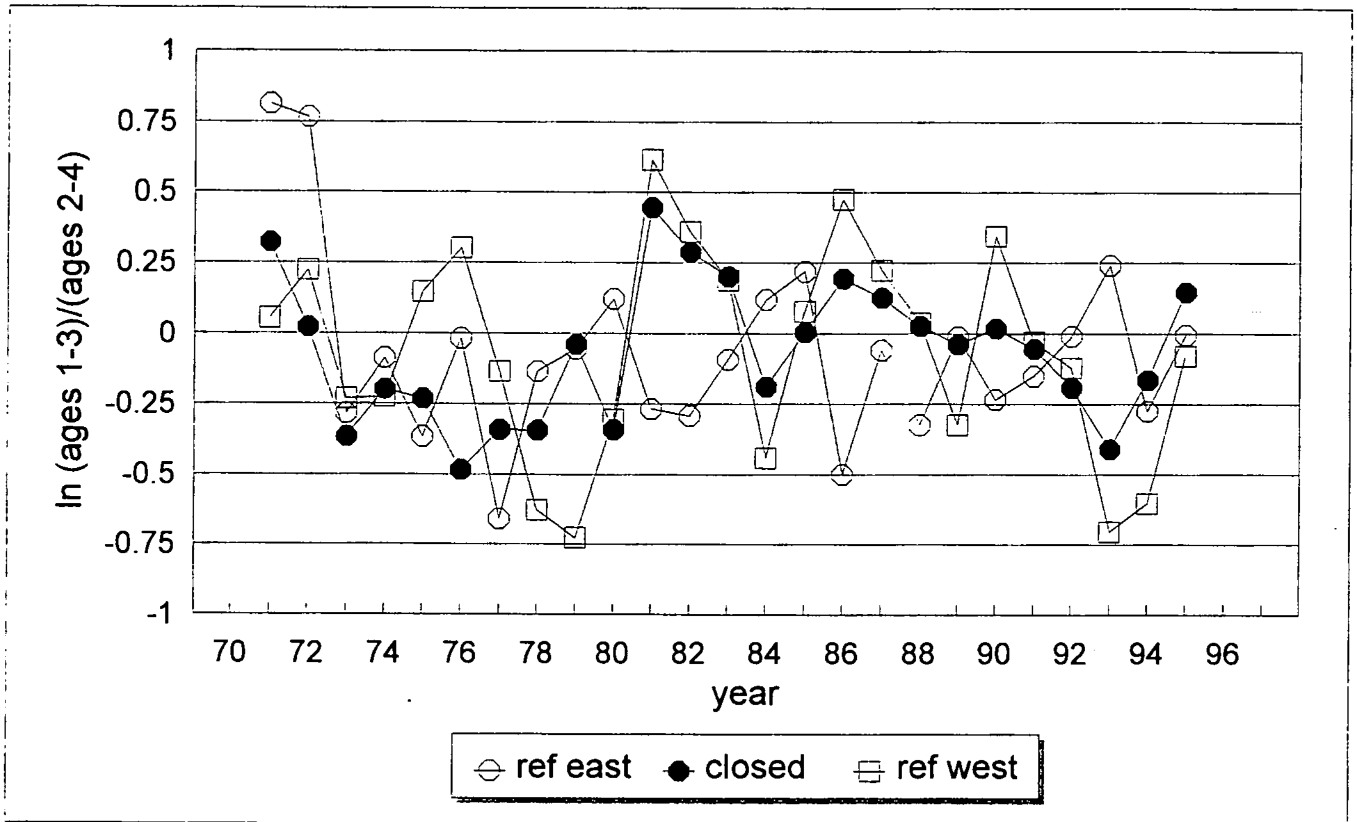


Figure 12. Total mortality rate of haddock from the July RV in the closed area and the two reference areas estimated as the logarithm of the ratio of ages 5-9 in year t to ages 6-10 in year t +1.

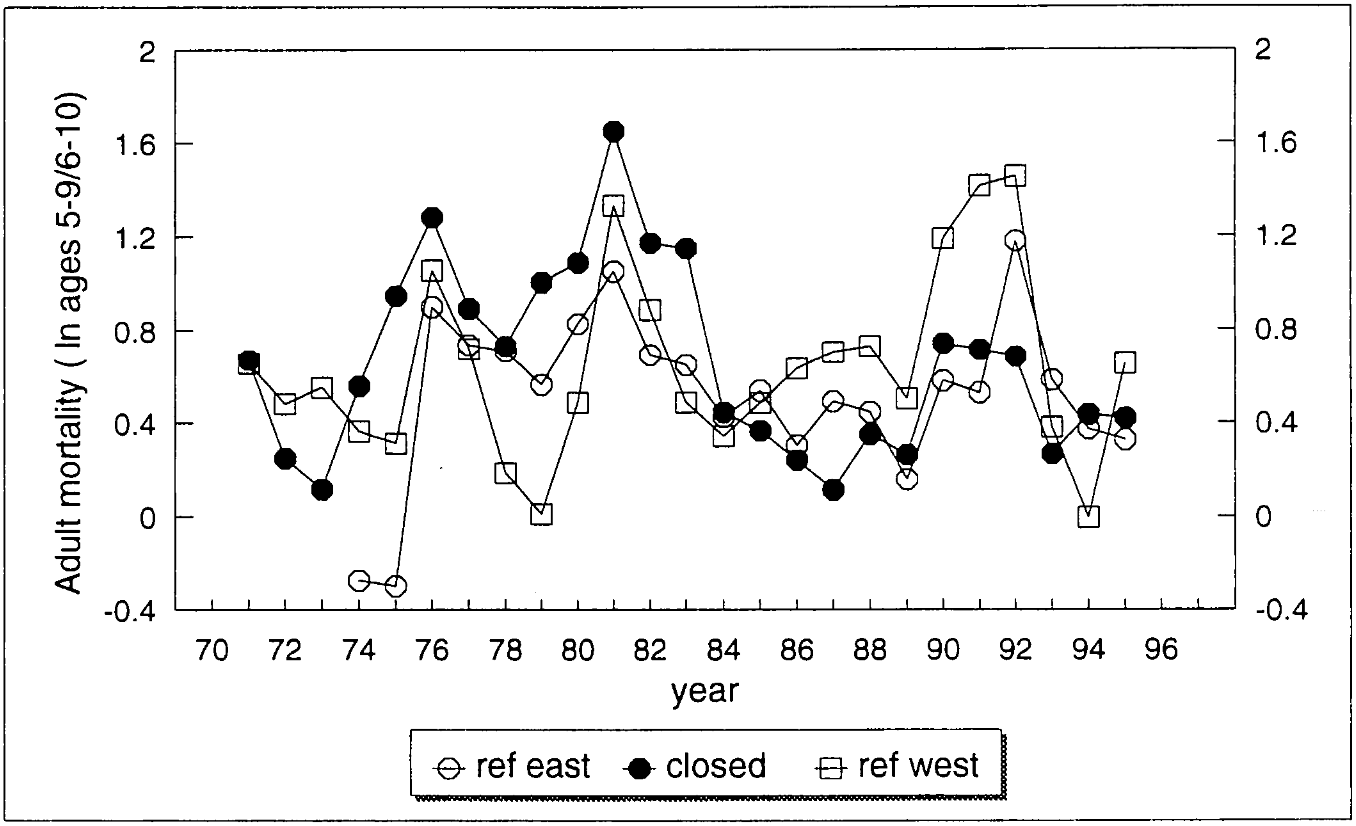


Figure 13. Catch curves for 22 yearclasses of haddock (1968-1979) based on the q-corrected mean number per tow at age for the closed area. Fitted regression lines and 95% confidence intervals are shown. Data are plotted on a logarithmic scale.

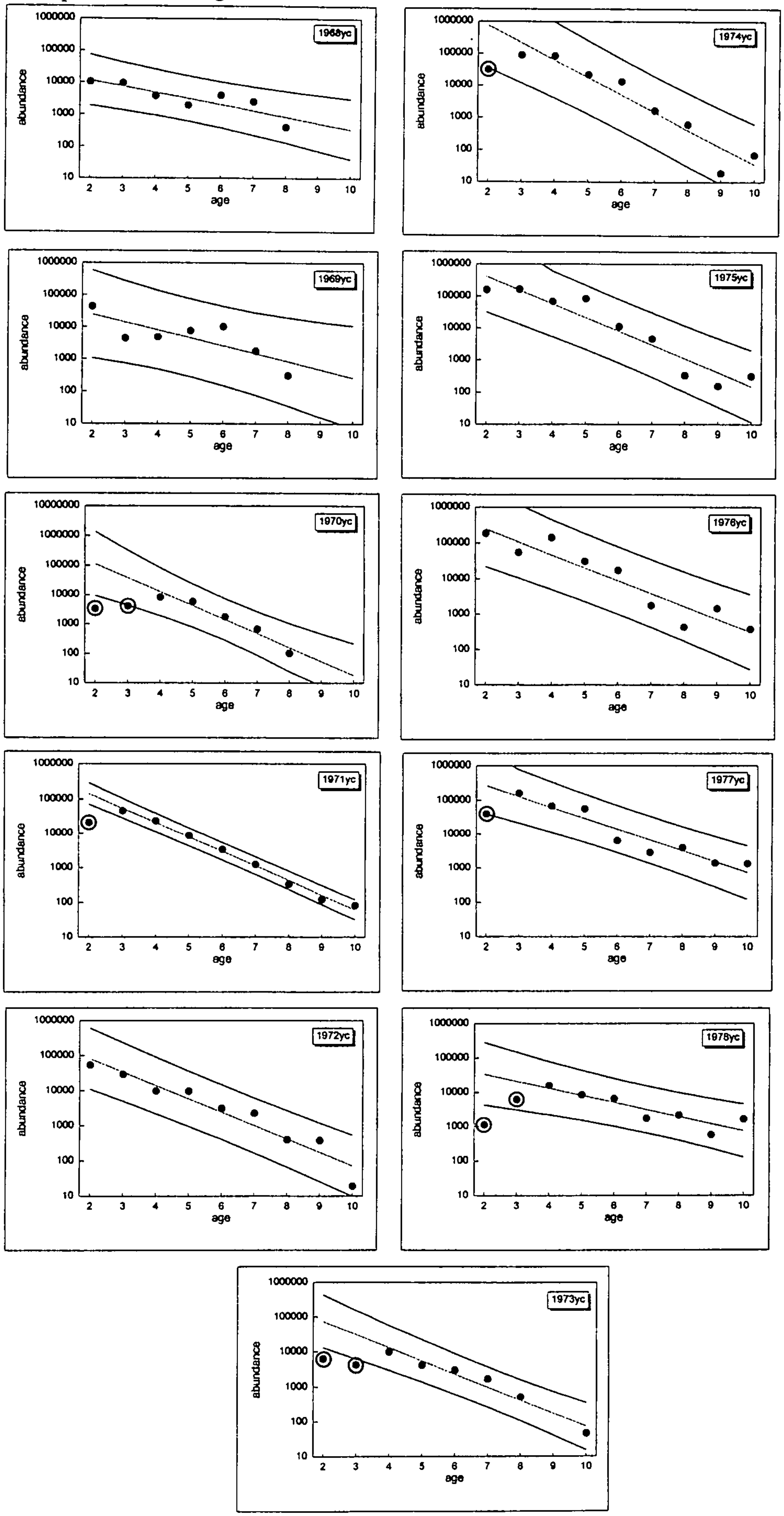


**Figure 13 cont'd**

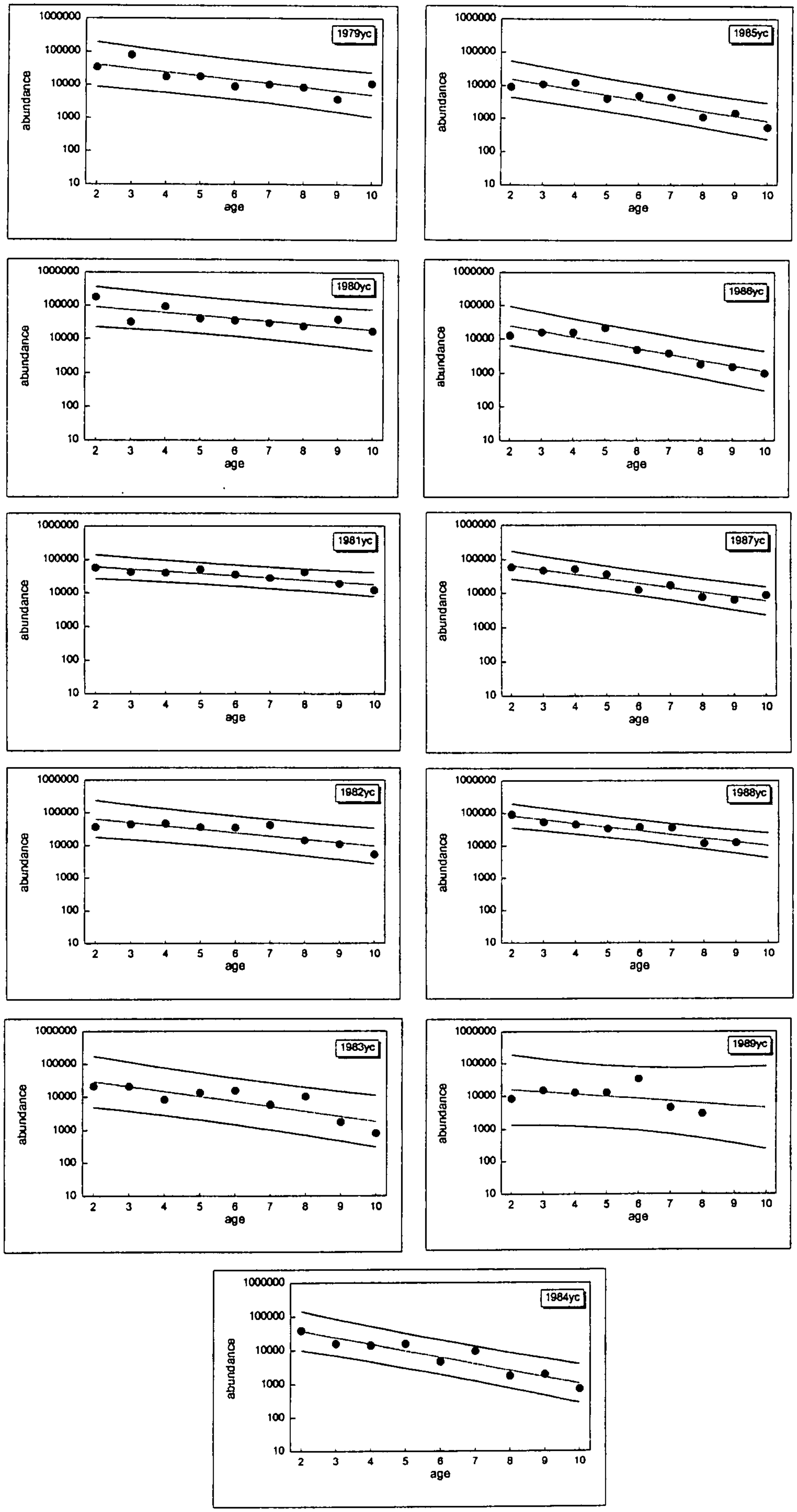


Figure 14. Catch curves for 22 yearclasses of haddock (1968-1979) based on the q-corrected mean number per tow at age for the eastern reference area. Fitted regression lines and 95% confidence intervals are shown. Data are plotted on a logarithmic scale.

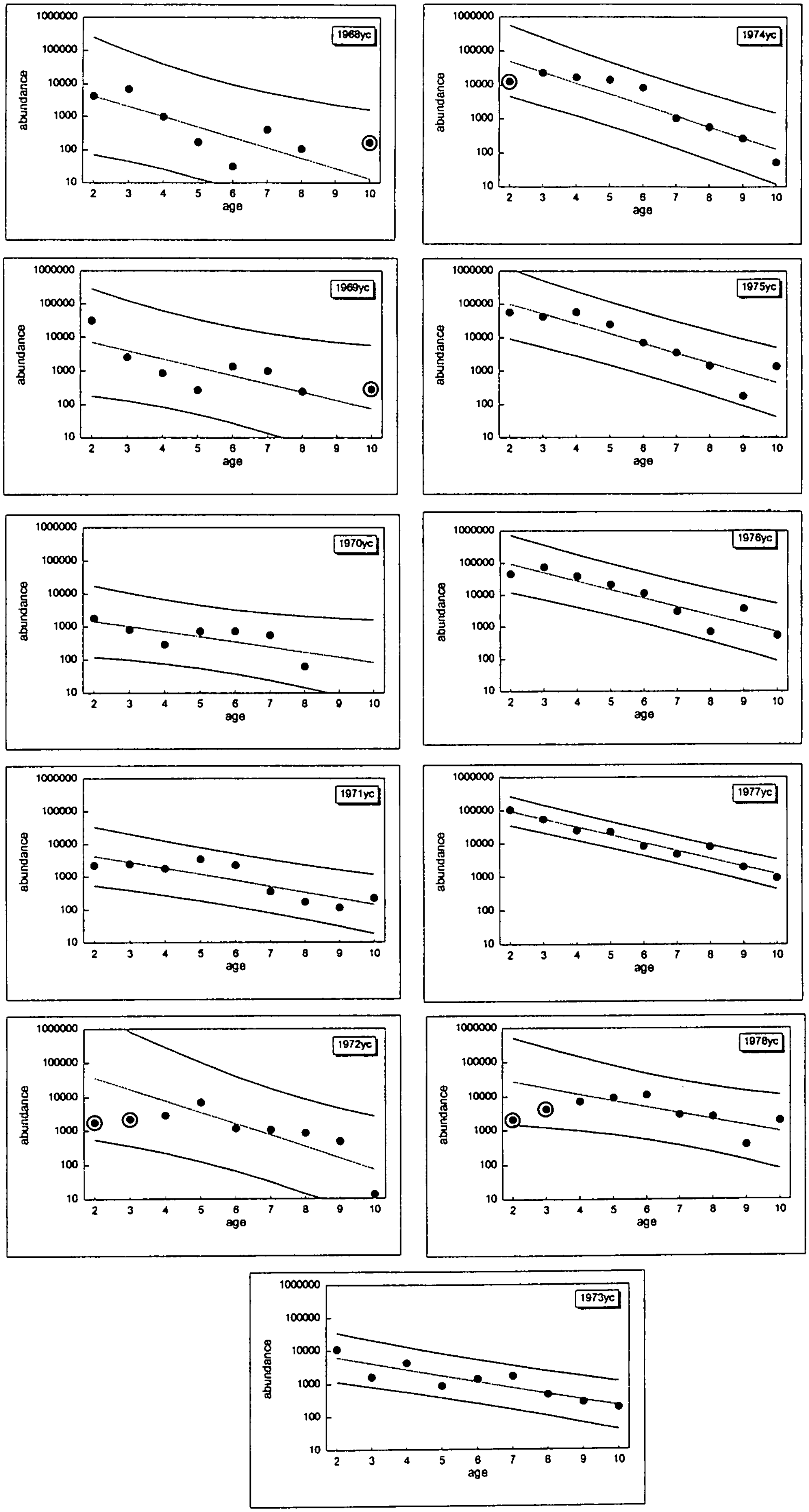


**Figure 14 cont'd**

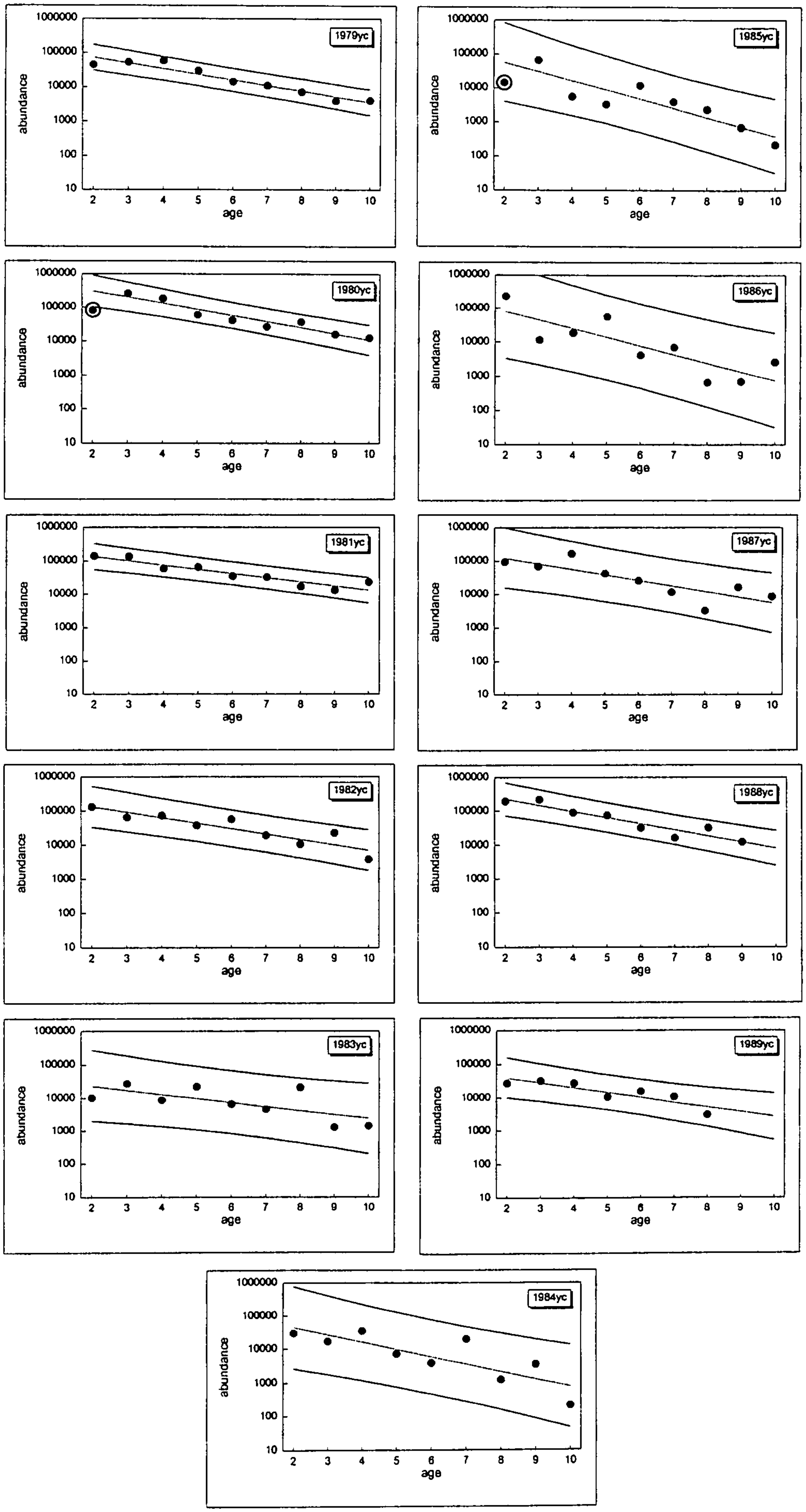


Figure 15. Catch curves for 22 yearclasses of haddock (1968-1979) based on the q-corrected mean number per tow at age for the western reference area. Fitted regression lines and 95% confidence intervals are shown. Data are plotted on a logarithmic scale.

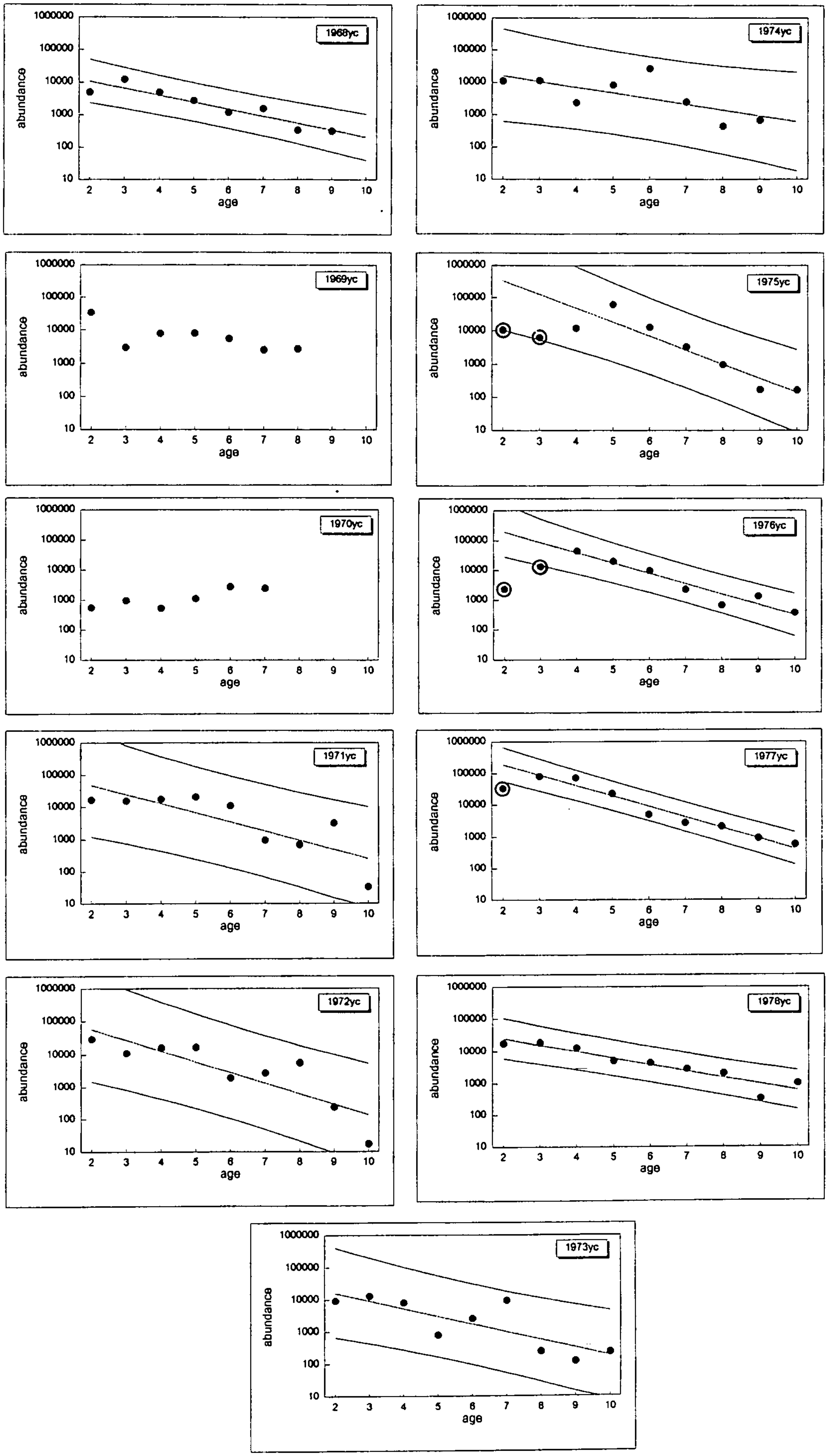


**Figure 15 cont'd**

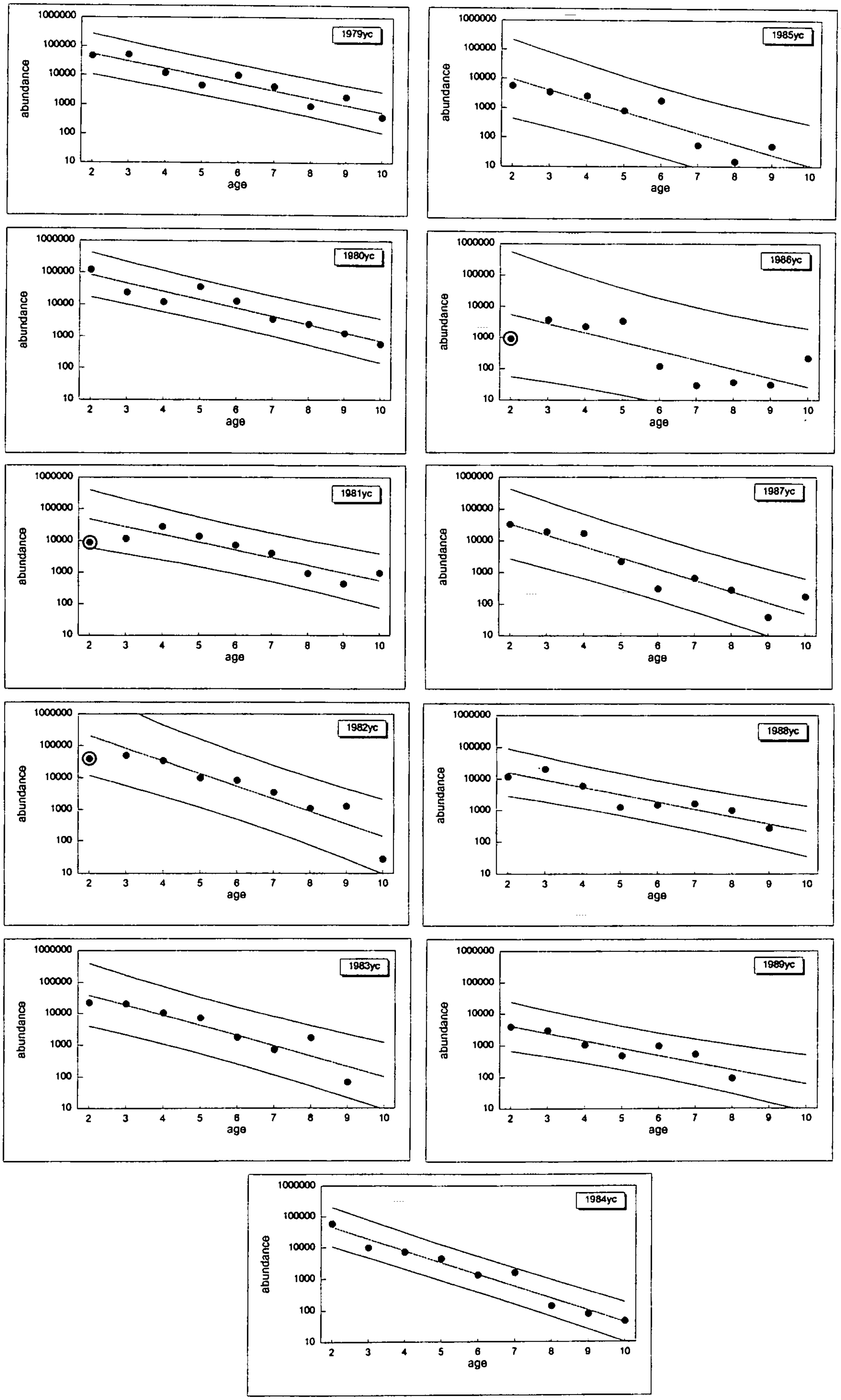


Figure 16. Comparison of the total mortality rate of haddock yearclasses from the closed area and the eastern reference area.

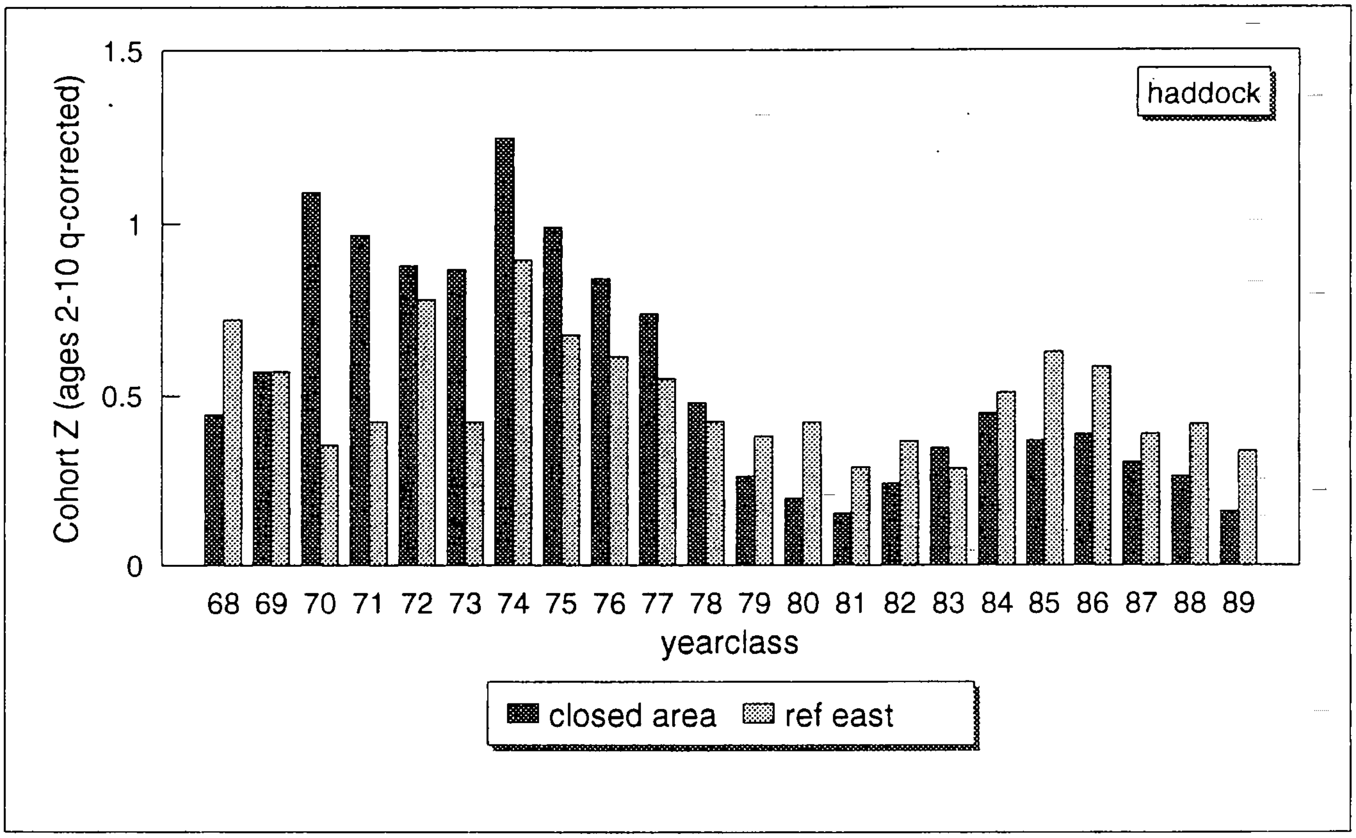


Figure 17. Comparison of the total mortality rate of haddock yearclasses from the closed area and the western reference area.

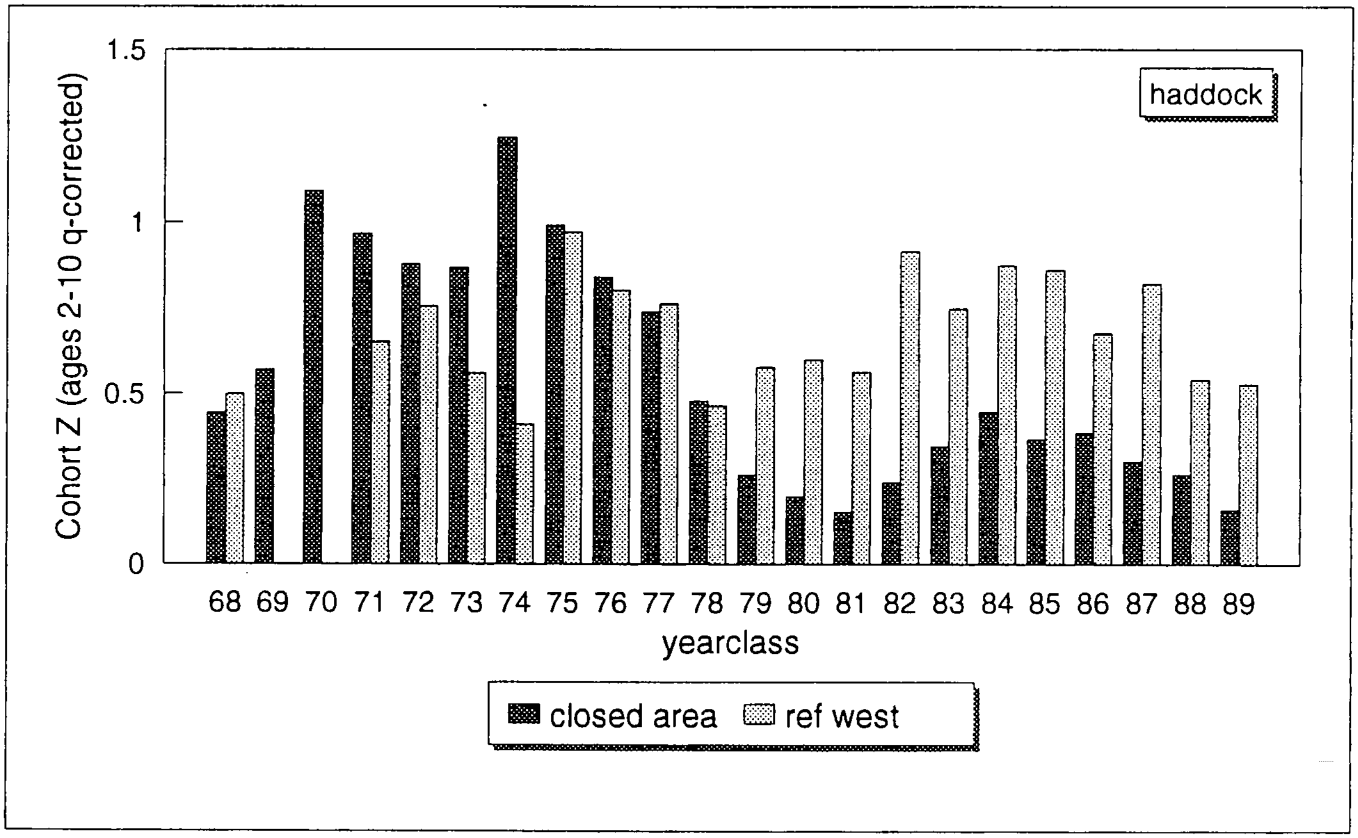
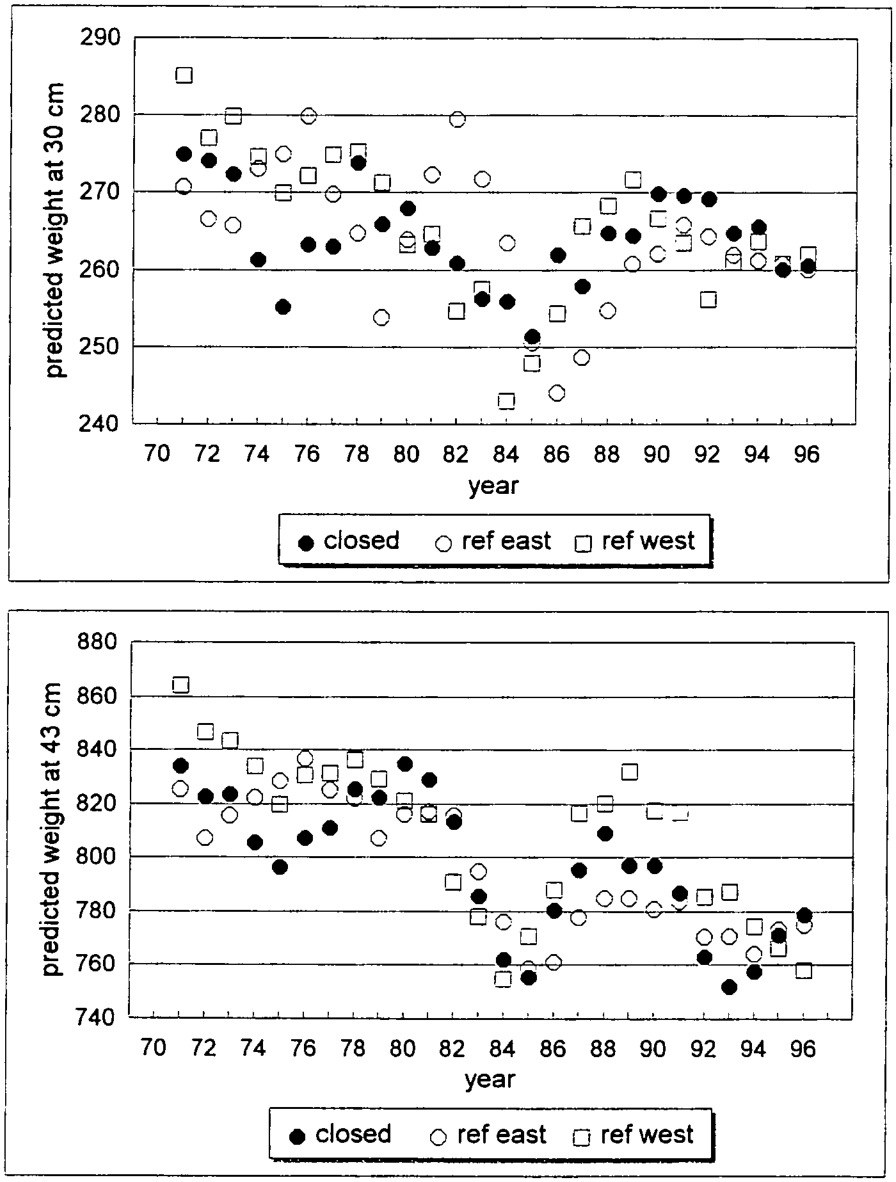


Figure 18. Predicted weight of juvenile (30 cm) and adult (43 cm) haddock from the closed area and the two reference areas.



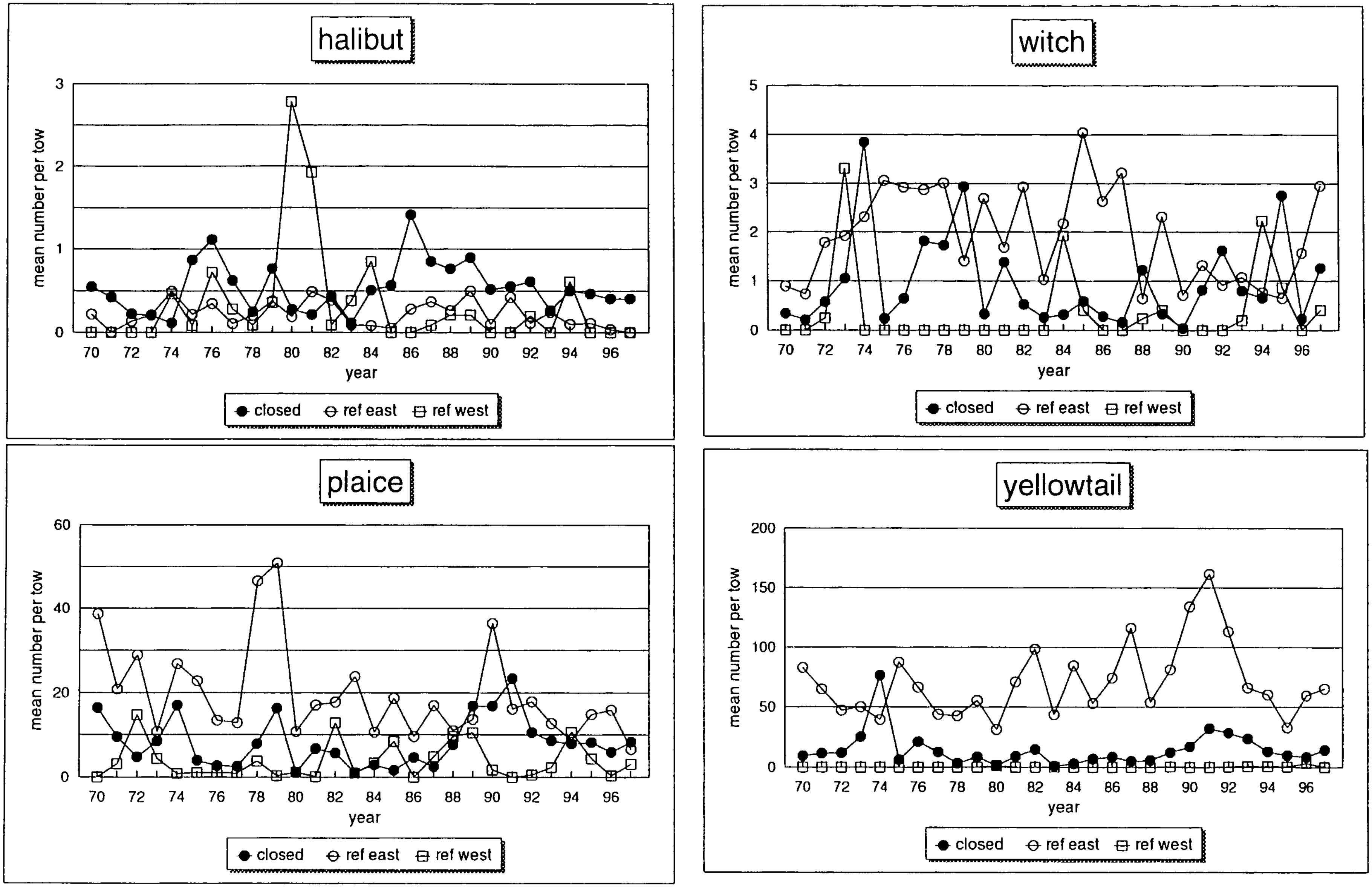



Figure 19. Mean number per tow of several different species collected during the July RV in the closed area and the two reference areas.

Figure 19 cont'd

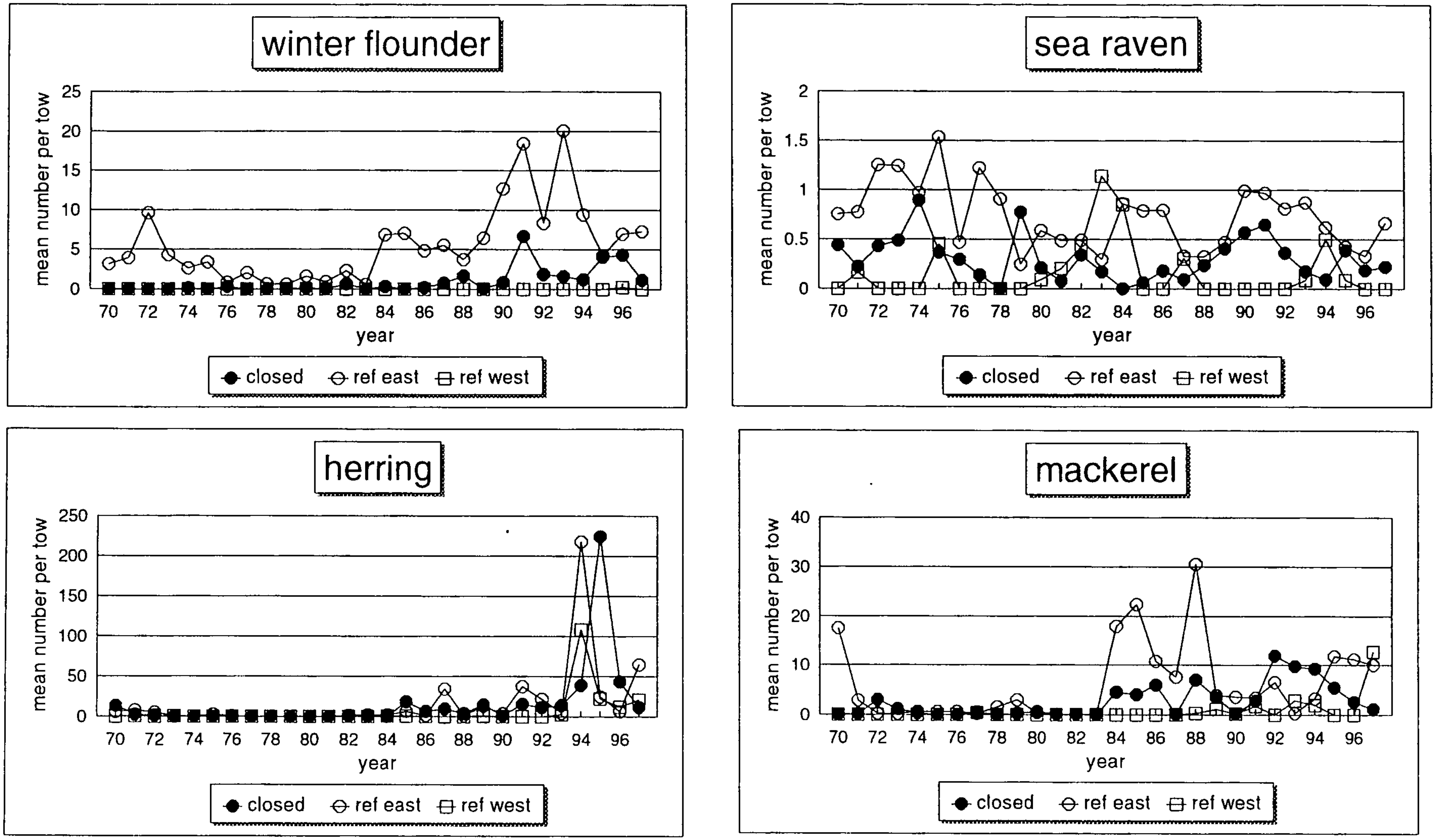
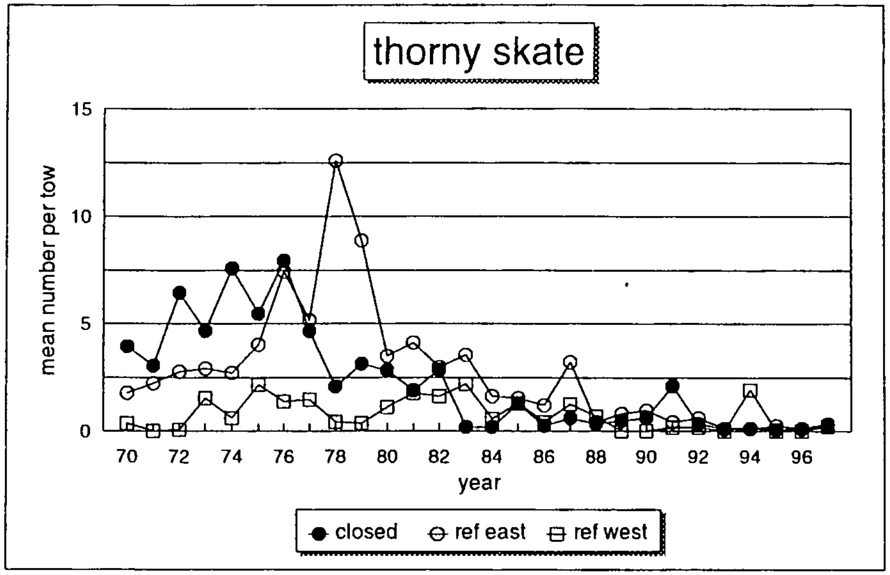
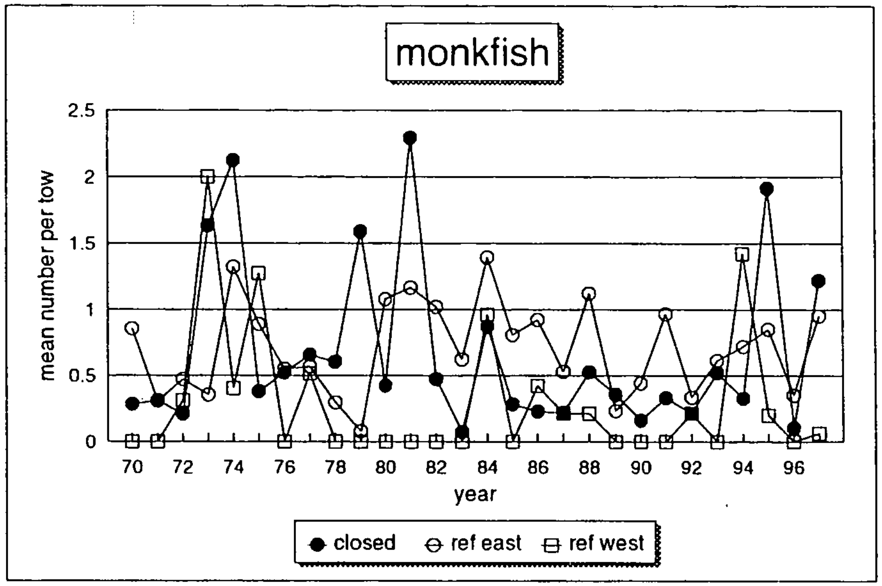
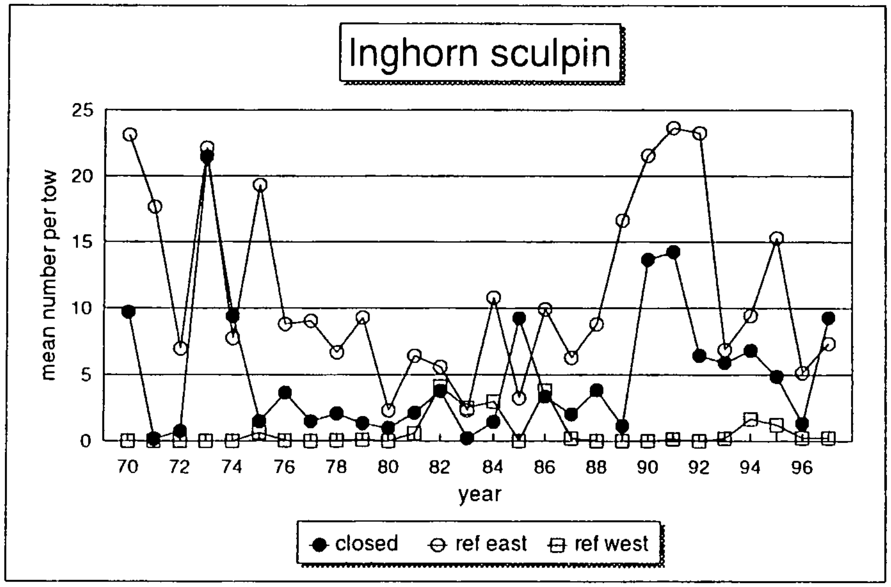


**Figure 19 cont'd**



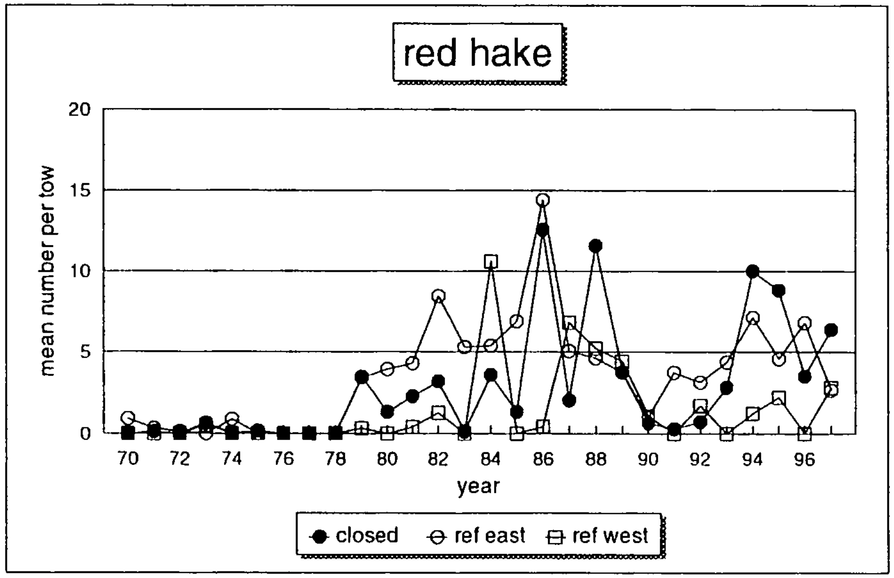



**Figure 19 cont'd**

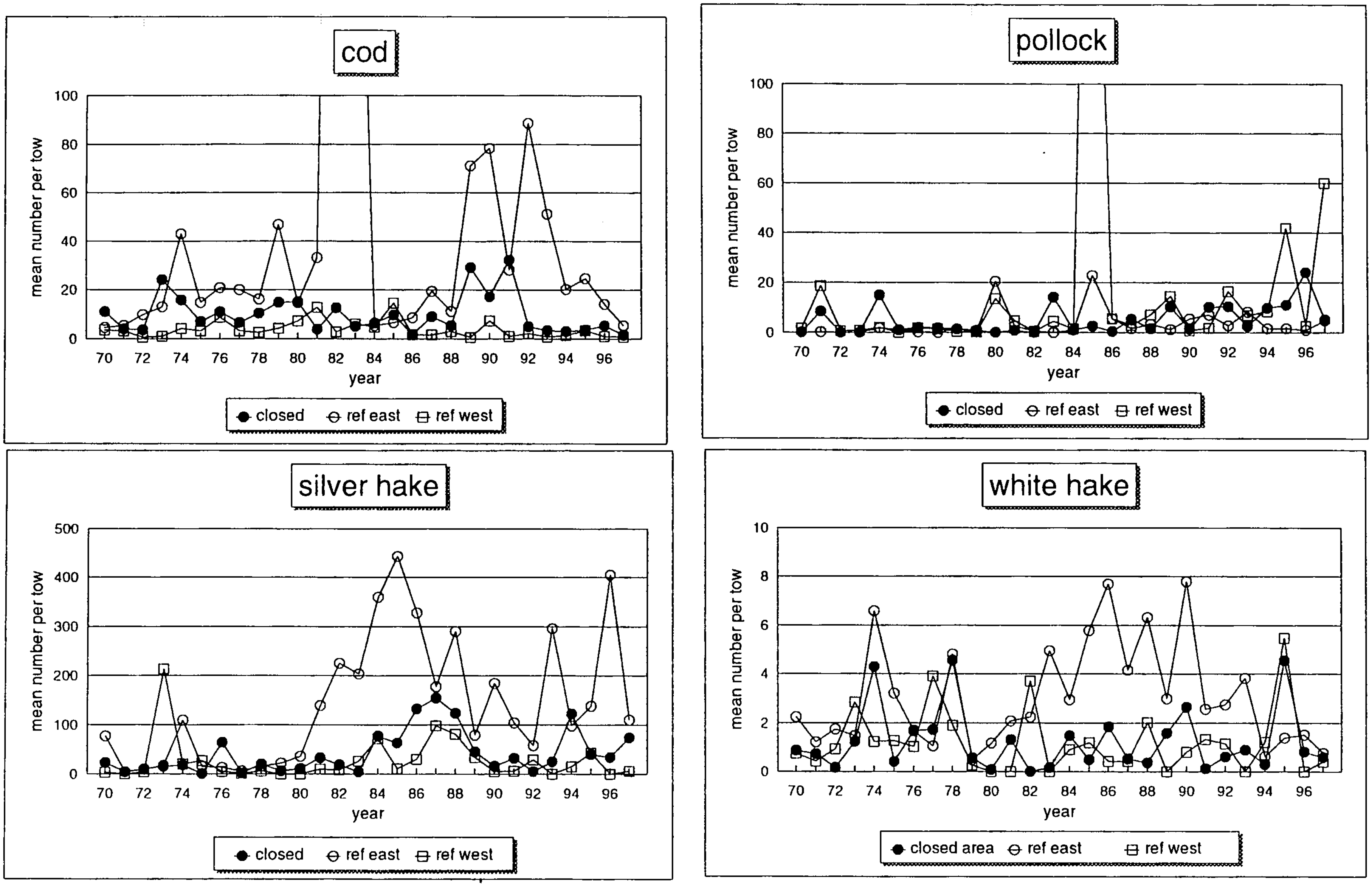


Figure 20. Abundance anomaly plots (annual mean number per tow - (1970-86) mean number per tow) for winter flounder, American plaice, red hake, yellowtail flounder, witch flounder, longhorn sculpin, sea raven and monkfish (i.e. those groundfish species whose centre of distribution lies within the vicinity of the closed area).

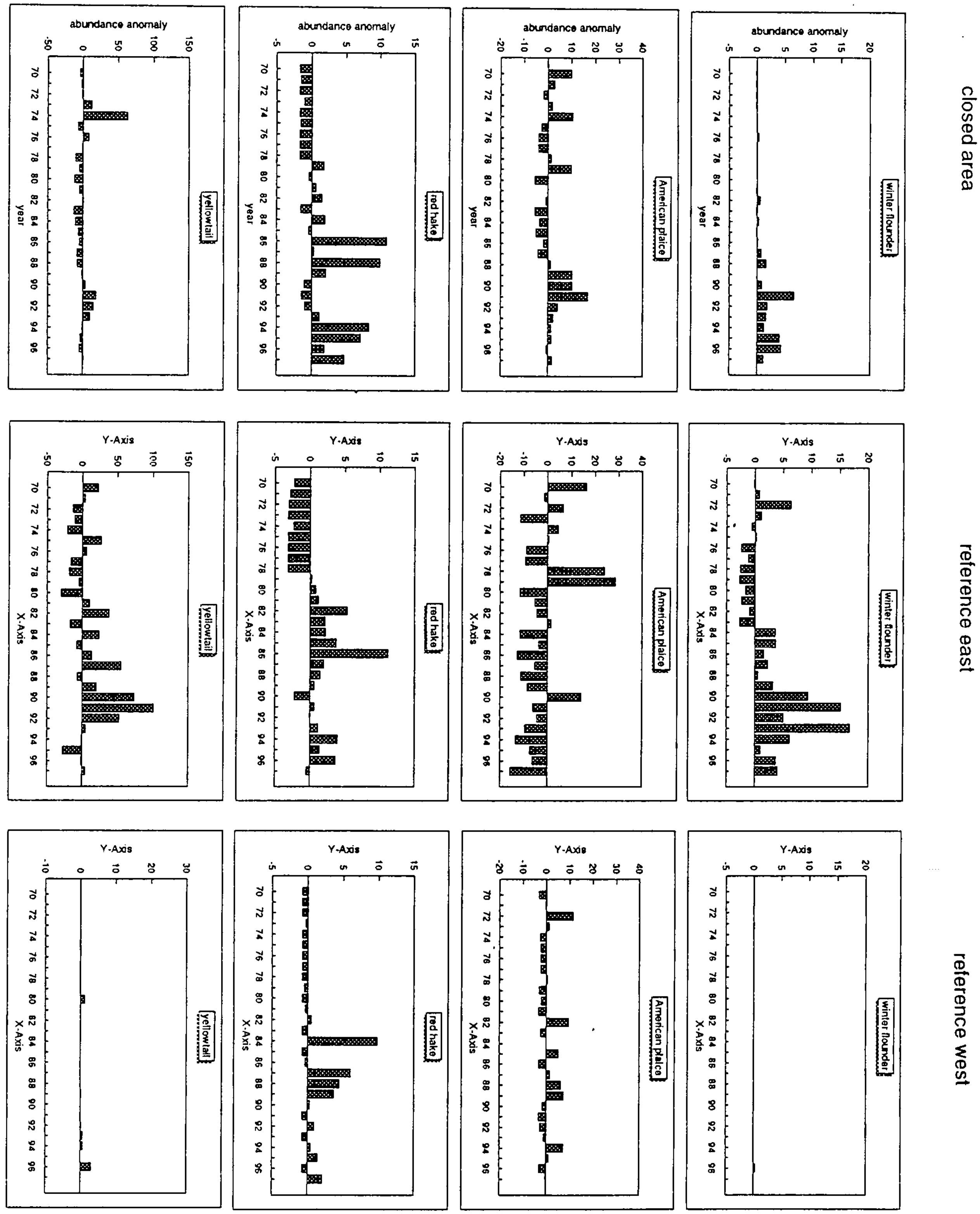


**Figure 20 cont'd**